Hydration knowledge and practices of long distance runners in the South African National Defence Force

Submitted in fulfilment of the requirements in respect of the Master of Science in Dietetics degree in the Department of Nutrition and Dietetics, Faculty of Health Sciences, University of the Free State

Lourika Benadie

2007017102

January 2016

Study leader: Dr R Lategan – Department of Nutrition and Dietetics

DECLARATIONS

1. I, Lourika Benadie, declare that the publishable, inter-related articles that I herewith submit to the University of the Free State, are my own independent work and that I have not previously submitted them for any qualification at another institution of higher education.

2. I, Lourika Benadie, hereby declare that I am aware that the copyright for this dissertation is vested in the University of the Free State.

3. I, Lourika Benadie, hereby declare that all royalties as regards intellectual property that was developed during the course of and/or in connection with the study at the University of the Free State, will accrue to the University.

4. I, Lourika Benadie, hereby declare that I am aware that the research may only be published with the Dean's approval.

L Benadie

29 January 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ADDENDA

LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
BMI	Body mass index
^{o}C	Degrees Celsius
cm	Centimetre
EAMCs	Exercise associated muscular cramps
EAH	Exercise- associate hyponatremia
g	Gram
g/h	Gram per hour
GI	Gastrointestinal
g/kg	Gram per kilogram
g/ml	grams per millilitres
GSSI	Gatorade Sports Science Institute
IAAF	International Association of Athletic Federation
IMMDA	International Marathon Medical Directors Association
Kg	Kilogram
kg/m^2	kilogram by the square of the height in meters
KJ	Kilojoules
Km	kilometres
L/h	litres per hour
m	Metre
mEq/L	milliequivalents of solute per litre
mg	Milligram
mg/L	milligram per litre
ml	millilitres
ml/h	millilitres per hour
mmol/l	Milimol per litre
mOsm/kg	milliosmoles per kilogram

NATA	National Athletic Trainers Association
%	Percentage
PV	Plasma volume
PVA	Plasma volume after
PVB	Plasma volume before
SANDF	South African National Defence Force
TBW	Total body water
USARIEM	US Army Research Institute of Environmental Medicine
$V0_2$	maximum volume of oxygen
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

The importance of restoring water and electrolytes lost during exercise, remains widely debated in the exercise sciences. Since the 1960's, fluid replacement recommendations have changed from "not drinking at all" to "drink as much as possible" (Beltrami et al., 2008:796). Adequate hydration is essential for a healthy human body. Whether male, female, old, or young, an optimal fluid intake is vital for the human body to operate to its fullest potential (Wilson, 2008:1).

Water is the most abundant substance in the human body and is stored in different compartments, but moves freely between the different compartments. The human body can live only a few days without water. Almost 60% of an average adult's weight is comprised by water (Dunford & Doyle, 2012:241-242). The total body fluid volume is daily regulated within ± 0.22% to 0.48% of total body weight, to obtain euhydration (Jusoh, 2010:6). Water provides an aqueous medium for chemical reactions, circulatory function, biochemical reactions, metabolism, substance transport across cellular membranes, facilitates thermoregulation and helps with numerous physiological processes (Dunford & Doyle, 2012:241-242; Armstrong, 2007:575).

The fluid in the body is separated into two main compartments, namely intracellular and extracellular fluid, with extracellular fluid divided into interstitial fluid and blood plasma. Total blood volume accounts for seven percent of body weight, distributed between plasma (±60%) and red blood cells (±40%). Body water can be challenged during prolonged training sessions, resulting in reduced performance, serious injury, medical emergency, and even death (Flynn, 2014:20; Duvillard et al., 2004:651).

Water in the body is lost through breathing, sweating, faeces, and urine. During prolonged exercise periods, as during training at the South African National Defence Force (SANDF), large volumes of water are lost through sweat (Casa et al., 2005:115-127). The loss of extracellular fluid causes an increase in plasma osmolality and a reduction in plasma volume, which cause a reduction in skin blood flow, leading to hyperthermia. It is estimated that about

2436 kJ is expended for every litre of sweat that evaporates (Duvillard et al., 2004:651-652). During a marathon, sweat losses may vary from less than 500 ml/hour to more than 2 litre/hour and sweat sodium concentrations may vary from less than 20 mmol/l (460 mg/l) to more than 80 mmol/l (1840 mg/l) (Casa et al., 2005:115-127).

Each kilogram of body weight loss during exercise reflects about one litre of fluid loss (Duvillard et al., 2004:651). Weight loss resulting from sweating during exercise can cause hypernatremia as a result of excessive water and sodium losses. In contrast, excessive fluid consumption during exercise causes weight gain and reduces serum sodium by diluting the whole body's sodium level because of the expanded volume of body water (Noakes et al., 2005:18550). Weight loss of only one percent of body weight can evoke stress on the cardiovascular system, accompanied by an increase in heart rate and inadequate heat transfer to the skin and the environment, increase plasma osmolality, decrease plasma volume, and may affect the intracellular and extracellular electrolyte balance (Duvillard et al., 2004:651). A weight loss of more than two percent has been linked to changes in haemorheology, metabolic dysregulation, heat intolerance, cardiovascular strain, and the subsequent inability to maintain exercise workload (Gordon et al., 2015:Online; Costa et al., 2013:Online). Two to three percent weight loss, causes decreased reflex activity, maximum oxygen consumption, physical work capacity, muscle strength, muscle endurance and impairs temperature regulation. At four to six percent weight loss further deterioration occurs in maximum oxygen consumption and physical work capacity, resulting in decreased endurance performance (Turocy et al., 2011:328).

Because the need for adequate hydration has such a great influence on training and performance, guidelines for optimal hydration need to be communicated to athletes. In 1997, the Gatorade Sports Science Institute (GSSI) recommended that athletes should start drinking fluids early and at regular intervals or drink as much as possible to replace fluid lost through sweat. In 1999 the GSSI recommended the intake of 500-2000 ml fluid per hour to prevent dehydration (Murray et al., 2003:3). On the other hand, the American College of Sports Medicine (ACSM) recommends an intake of 600-1200 ml per hour (Sawka et al., 2007:377). In 2000 the North American Trainer Association (NATA) recommended 200-300 ml every 10-20 minutes (600-1800 ml per hour). NATA also emphasised that athletes should hydrate according to their individual needs (Casa et al., 2000:212-224). In 2007, the ACSM recognised that athletes have different sweat rates and that sweat electrolyte levels differs. For this reason general fluid guidelines were not recommended. According to the ACSM the main goal of drinking fluid during exercise is to prevent dehydration (Beltrami et al., 2008:797). The latest recommendations suggest that athletes should drink according to thirst and strive for a weight loss not exceeding two to four percent, during endurance exercise. According to Hoffman et al. (2014:246) the recommendations to avoid weight loss of more than two percent promotes overconsumption of fluids. In general, researchers agree that fluid balance should be restored within 4-6 hours after an event (Burke & Cox, 2012:150).

Sweat is hypotonic to extracellular fluid, but contains electrolytes, primarily sodium chloride, potassium, calcium, and magnesium (Heneghan et al., 2012:346). Sweat sodium concentration averages 35 mmol/l (range 10–70 mmol/l) and varies depending upon diet, sweat rate, hydration level, and heat acclimation state. Sweat potassium concentration averages 5 mEq/L (range 3–15 mEq/L), calcium 1 mEq/L (range 0.3–2 mEq/L), magnesium 0.8 mEq/L (range 0.2–1.5 mEq /L), and chloride 30 mEq/L (range 5–60 mEq/L). A normal diet contains about 4 g of sodium per day, but can vary. When physical activity increases, the additional energy intake associated with increased activity usually covers the additional sodium required. For this reason, sodium supplementation is usually not necessary. If an athlete needs additional sodium, fluids containing 20 mEq/L of sodium can be consumed. Most sports drinks contain sodium at this concentration (Montain et al., 2006:2-3).

According to various position stands, the secret to providing rapid delivery of fluid and fuel and to maximise gastric tolerance and palatability, sports drinks should provide 4-8% (4-8 g/100 ml) carbohydrate and 23-69 mg (10-30 mmol/l) sodium. Replacing sodium is also a useful way to promote an athlete’s thirst sensation. Sodium concentrations of 10-25 mmol/l enhance the palatability and voluntary consumption of fluids consumed during exercise (Sawka et al., 2007:377-380).

1.2 PROBLEM STATEMENT

An optimal hydration status (euhydration) is essential for the well-being of the human body to operate to its fullest potential. Healthy individuals maintain euhydration in normal circumstances, but exercise poses a challenge to keep fluid homeostasis. Athletes are often unaware of the optimal amount of fluid to consume when exercising, and hydration knowledge influence the athlete’s hydration practices (Wilson, 2008:1). The degree to which athletes need to replace fluid losses during exercise remains debateable despite more than 60 years of research. Initially athletes were advised to “drink as much fluid as possible”, but recent studies suggest otherwise (Nolte, 2011:7).

The ACSM recommend that athletes should drink sufficient amounts of fluid to prevent weight loss of more than two percent body weight (Nolte et al., 2010:1). More recently the United States Army Research Institute of Environmental Medicine (USARIEM) published sweat loss prediction equations ranging from 575 g/h to 1092 g/h for different workloads, environmental conditions and clothing. These equations assistedto determine the amount of fluid that should be replaced during exercise more accurately (Nolte, 2011:7). The International Marathon Medical Directors Association (IMMDA) propose that athletes should drink according to thirst, regardless of weight loss. The IMMDA also warns that fluid intake should not be more than 800 ml/h, to reduce the risk of exercise-associated hyponatremia (EAH). The main controversy regarding fluid intake amongst athletes is that of the ACSM, stating that weight loss of more than two percent is associated with impaired exercise capacity. Although this evidence originates from laboratory-based studies, a number of field studies during competition have failed to show that the best athletes finish with a weight loss of less than two percent. Evidence actually suggests the opposite theory, namely that weight loss during exercise may increase performance, especially in weight bearing activities (Tam et al., 2011:218-219) such as distance running.

These contraindicating recommendations regarding fluid intake has special relevance to the military, since soldiers who drink according to thirst will drink less than soldiers encouraged drinking in order to lose less than two percent of their body weight. As hydration status impacts on performance, it is expected that an improvement in hydration knowledge should lead to better hydration practices (Nolte, 2011:7).

In this study, hydration knowledge and practices of long distance runners in the SANDF were investigated in order to develop interventions to improve hydration knowledge and practices in the future. The SANDF train and prepare their members not only for day to day activities and external deployments, but ultimately for any possible war situation. For this reason, the intensity of training and maintenance of fitness are of a very high standard and optimal hydration remains a constant challenge. When members undergo these intense training and exercise sessions, excessive fluid loss can compromise their ability to perform. Athletes are often uncertain about the optimal amount of fluid to consume when they exercise. Understanding the factors that influence rehydration practices of athletes, can help healthcare professionals to develop educational material in order to promote adequate fluid consumption (Wilson, 2008:1). The focus of this study wasl therefore based on hydration knowledge and fluid intake practices of athletes in the SANDF, in order to describe usual intake during exercise as well as factors that influence intake before, during, and after a race.

1.3 AIM AND OBJECTIVES

The aim of this study was to describe the knowledge and practices regarding fluid intake; before, during and after endurance exercise of athletes in the SANDF.

To reach the aim of the study, the following objectives were set:

- To describe the demographic background as well as anthropometric measurements of participants;
- To determine the knowledge of long distance runners in the SANDF regarding fluid intake and hydration practices;
- To determine the practices of these athletes regarding fluid intake before, during and after endurance exercise;
- To compare the fluid intake of these athletes with current available hydration recommendations for fluid intake before, during and after endurance exercise.

1.4 STRUCTURE OF THIS DISSERTATION

The research process is an advanced and exact decision-making process that aims to find answers to the research problem (Bothma et al., 2010:89). According to Brink (2006:50), the research process begins and ends with a problem. It however forms a coil creating new possibilities for more research. During this study, four interactive phases known as the conceptual, empirical, interpretive, and communication phase were included in order to guide the research process (Brink, 2006:50).

The conceptual or the thinking phase included development of the study proposal, study design and methodology. The empirical or doing phase included the literature study, pilot study and data gathering. The interpretive phase includes the results collected during the study, while the last phase, the communication phase, entails the reporting of results, conclusions and the formulation of recommendations (Burton et al., 2008:60; Brink, 2006:50-54). Figure 1.1 demonstrates the four phases of the research process as presented in the respective chapters.

Figure 1.1 The research process (Burton et al., 2008:60)

Conceptual phase 1

↓

Identify research problem

↓

Determine the purpose of the study and write a proposal

↓

Submission to Evaluation Committee

↓

Submission to Ethics Committee

↓

Approval of research

↓

Literature review, develop a framework

↓

Research method and design

↓

Specify subjects to be studied

↓

Empirical phase 2

↓

Pilot study, data gathering

↓

Interpretive phase 3

↓

Data analysis, interpretation of results

↓

Communication phase 4

↓

Reporting of research findings

↓

Recommendations

This dissertation is divided into six chapters. Chapter 1 includes the introduction and motivation for the study. The problem statement, aim and objectives of the study are stated, and the structure of this dissertation is described.

Chapter 2 is a literature review discussing the distribution of body water, what happens to body fluid while exercising, the physiological events of fluid loss and how to assess fluid loss. Chapter 2 also discusses the side effects of fluid loss and the fluid and electrolyte needs of athletes with special reference to various organisational recommendations.

Chapter 3, the methodology chapter, describes the type of study that has been performed as well as the population and sample that have been included. The inclusion and exclusion criteria are discussed to explain the sample selection. The methods and procedures used to execute the study are also explained in this chapter. Techniques used for data collection and statistical analysis are described as well as the ethical issues that has been taken into consideration during this study.

The four objectives, namely: to describe the demographic background as well as anthropometric measurments of participants, to determine the knowledge of long distance runners in the SANDF regarding fluid intake, hydration practices, to determine the practices of these athletes regarding fluid intake before, during and after endurance exercise, and to compare the fluid intake of these athletes with current hydration recommendations for fluid intake before, during and after endurance exercise,are reported in chapters 4 and 5. These two chapters are written in an article format, as approved by the University of the Free State. The articles are written according to the author's instructions for the specific journal, to which it will be submitted, with references according to the requirements of the University of the Free State. In each of the articles the methods, results and discussion of the results are presented. The data is interpreted by comparing it to other studies within the scope of the topic. Each article includes a conclusion and relevant recommendations.

Chapter 6 provides an overview of the conclusions and recommendations that have been made in this study. The research significance and limitations of the research study are described, and recommendations for future studies to optimize recommendations, are provided.

1.5 REFERENCES

Armstrong LE. 2007. Assessing hydration status: The elusive gold standard. Journal of the American College of Nutrition, 26(5):575–584.

Beltrami FG, Hew-Butler T, and Noakes TD. 2008. Drinking policies and exercise-associated hyponatraemia: is anyone still promoting over drinking. British Journal of Sports Medicine, 796-801.

Bothma Y, Greef M, Mulaudzi M, and Wright SCD. 2010. Research in Health Science. 1st edition. Cape Town: Pearson:89.

Brink H. 2006. Fundamentals of research methodology for health care professionals. 2nd edition. Cape Town:50-55.

Burke L and Cox G. 2012. The complete guide to food for sport performance. Australia: Allen & Unwin:136-275.

Burton N, Brundrett M, and Jones M. 2008. Doing your education research project. Los Angeles: Sage Publications Ltd:60.

Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, and Stone JA. 2000. National Athletic Training Association. Fluid replacement for athletes. Journal of Athletic training, 35:212-224.

Casa DJ, Clarkson P and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013].

Dunford M and Doyle JA. 2012. Nutrition for Sport and Exercise. 2nd edition. Belmont CA: Wadsworth: 240-277.

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Gordon RE, Kassier SM, and Biggs C. 2015. Hydration status and fluid intake of urban, underprivileged South African male adolescent soccer players during training. Journal of the International Society of Sports Nutrition. [Online].

Available from: www.jissn.com/content/12/1/21 [Accessed March 13th, 2013].

Heneghan C, Gill P, O'Neill B, Lasserson D, Thake M, and Thompson M. 2012.Mythbusting sports and exercise products. British Medical Journal, 345-484.

Hoffman MD, Hew-Butler T, and Schwellnus M. 2014. Regarding the Wilderness Medical Society Practice Guidelines for Heat-Related Illness. Wilderness and Environmental Medicine, 25(2):246-247.Josuh N. 2010. Hydration, thirst and fluid balance in resting and exercising individuals. Doctoral thesis: Laughborough University, 1-222.

Jusoh N. 2010. Hydration, thirst and fluid balance in resting and exercising individuals. Doctor of Philosophy degree. Loughborough University, 1-222.

Montain SJ, Cheuvront SN, Carter R, and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas: 1-8.

Murray B, Stofan J, and Eichner ER. 2003. Hyponatremia in Athletes. Gatorade Sports Science Institute, 16(1):1-6.

Noakes TD, Sharwood K, Speedy D, Hew T, Reid S, Dugas J, Almond C, Wharam P, and Weschler L. 2005. Three independent biological mechanisms cause exercise-associated hyponatremia: Evidence from 2135 weighed competitive athletic performances. Proceedings of the National Academy of Science of the United Stated of America, 102(51):18550-18555.

Nolte HW. 2011. Fluid, electrolyte and thermoregulatory responses to ad libitum water replacement during prolonged exercise. Doctoral thesis: University of Pretoria, 1-197.

Nolte HW, Noakes TD, and Van Vuuren B. 2010. Protection of total body water content and absence of hyperthermia despite 2% body mass loss (‘voluntary dehydration’) in soldiers drinking ad libitum during prolonged exercise in cool environmental conditions. British Journal of Sports Medicine, 1-7.

Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, and Stachenfeld NS. 2007. Exercise and fluid replacement. American College of Sports Medicine, 39(2):377-390.

Tam N, Nolte HW, and Noakes TD. 2011. Changes in total body water content during running races of 21.1 km and 56 km in athletes drinking. Clinical Journal of Sports Nutrition, 21(3):218–225.

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

Wilson CK. 2008. What is the relationship between hydration knowledge, exercise intensity, and hydration behaviours of college students in Southern Texas. Doctoral thesis: Lamar University, 1-71.

CHAPTER 2: HYDRATION AND OPTIMAL NUTRITION DURING ENDURANCE EXERCISE

2.1 INTRODUCTION

Endurance sports have recently become more popular amongst athletes (Flynn, 2014:1). More and more individuals are running half marathons (21.1km), full marathons (42.2km), ultra-marathons (>42km) and competing in endurance competitions. Most events are organized to last between 30 minutes and two hours, which are more than manageable for the beginner athlete (Jeukendrip, 2011:91) and therefore attract more interest.

Every time an athlete starts a race or exercise session, the need to adequately hydrate becomes a concern that will influence his/her performance (Rodriguez et al., 2009:710; Casa et al., 2005:115). The human body has the ability to closely regulate body water and electrolyte balance, as long as food and fluids are available. Exercise and environmental factors can, however, challenge this ability (Montain et al., 2006:1). While exercising, the human body produces heat because of muscle exertion. A natural cooling mechanism starts through sweating, where the evaporation of sweat from the skin's surface allows the releasing of heat and for the body to cool (Popkin et al., 2010:443; Casa et al., 2005:115). Replacement of fluid that is lost through sweat is an important factor athletes need to consider, as excessive body water or electrolyte losses can disrupt physiological homeostasis and threaten both health and performance (Montain et al., 2006:1). It has been advocated to athletes to drink as much fluid as possible during exercise or competitions to prevent dehydration, but more recent studies caution athletes to limit fluids in order to prevent potential health dangers (Casa et al., 2005:115) resulting from over hydration. According to Noakes (2003:309) athletes should drink according to thirst to prevent dehydration and limit their intake to no more than 400 ml to 800 ml fluid/hour. Recent recommendations, however, promote sufficient fluid intake before, during and after exercise to minimize weight loss during exercise and suggest that fluid intake during exercise should not exceed sweat losses, but rather prevent weight loss of more than two percent of body weight (Niemann, 2012:15; O'Neal et al., 2011:581).

Although avoidance of weight loss of more than two percent is widely recommended, Hoffmann et al. (2014:246) recently questioned the current strict water replacement strategies, based on the availability of body water, bound to glycogen, which is available for release during exercise. It is argued that approximately 1.5 kg of water is bound to the glycogen stored in the body, and that even with weight loss of more than three percent, euhydration may still be possible during prolonged exercise. The author further argues that athletes should be able to tolerate up to eight percent weight loss during endurance exercise and that athletes with a weight loss of more than three percent have better athletic performance (Hoffman et al., 2014:246) possibly due to a lighter body weight.

2.2 DISTRIBUTION OF BODY WATER

As discussed in chapter one, water plays a very important role in the human body with aproximately 60 percent of an adult's weight consisting of water (Dunford & Doyle, 2012:241-242; Popkin et al., 2010:439). Water provides an aqueous medium for chemical reactions, circulatory function, biochemical reactions, metabolism, and substance transport across cellular membranes; it facilitates thermoregulations, and assists with numerous physiological processes (Dunford & Doyle, 2012:241-242; Armstrong, 2007:575).

Lean body mass contributes a large percentage of total body water and for this reason the percentage body water decreases with age. Because total body water varies with the amount of fat in the body, woman and obese individuals usually have a lower amount of body water (Shirreffs & Sawka, 2011:41; Zubieta-Calleja & Paulev, 2004:Online). Males usually have a higher body water level than females, as men typically have more muscle mass and less body fat than women (Dunford & Doyle, 2012:241-242).

Water is divided in two compartments in the human body; intracellular and extracellular (Shirreffs & Sawka, 2011:39; Duvillard et al., 2004:651; Zubieta-Calleja & Paulev, 2004:Online). The intracellular compartment represents two thirds of body water and the extracellular compartment represents one third. Each cell in the human body has its own separate environment, and communicates with other cells through the extracellular space (Bailey et al., 2014:102). A permeable membrane separates the compartments from each other and regulates the flow of fluid between the compartments. The extracellular fluid is divided into interstitial volume, plasma volume, and trans-cellular water, which constitute 28 percent, eight percent and four percent respectively (Bailey et al., 2014:102). Total blood volume accounts for seven percent of total body weight, distributed between plasma (±60%) and red blood cells (±40%). The compartments also contain solutes with potassium as the main intracellular solute. Potassium is balanced by phosphate and anionic protein. The main extracellular solute is sodium chloride. Body fluid compartments have an osmolality of ± 300 mOsmol/kg water (Zubieta-Calleja & Paulev, 2004:Online).

Body water can be challenged during prolonged training sessions resulting in reduced performance, serious injury, medical emergency, or even death (Flynn, 2014:20; Duvillard et al., 2004:651).

2.3 BODY WATER AND EXERCISE

The largest part of blood plasma, muscles, and other tissues are made up of water. Normal body water levels are referred to as euhydration. Hyper hydration is caused by an excessive consumption of fluid, while hypo hydration results from consuming too little fluid (normally one percent deficit of body weight). Both hyper hydration and hypo hydration can impair thermoregulation and lead to reduced physical, cognitive, and mental performance (Casa et al., 2010:147-156; Kumley, 2010:23).

Fluid loss during exercise occurs mainly from sweat, produced from extracellular and intracellular fluid, which leads to increased plasma osmolality (Shirreffs & Sawka, 2011:44; Duvillard et al., 2004:652).

2.4 PHYSIOLOGICAL EVENTS OF WATER LOSS

The human body has a remarkable ability to regulate daily body water and electrolyte balance as long as adequate nutrition and hydration is available. However, exercise and environmental conditions can challenge the ability to regulate this balance (Montain et al., 2006:1).

Body water is mainly lost through breathing, sweating, faeces, and urine (Maughan et al., 2015:130; Duvillard et al., 2004:651; Meyer, 1993:3). During exercise, water loss occurs to regulate body temperature. Most water is lost through sweating, resulting when environmental temperature exceeds the skin temperature, causing evaporation that cools the body. If the body does not regulate temperature through sweating, the core temperature could increase at a rate of one degree Celsius every five minutes (Duvillard et al., 2004:651; Meyer, 1993:3).

Sweat rates vary from person to person. Some athletes sweat more than others and fitter individuals start sweating earlier during exercise and in larger volumes (Casa et al., 2005:116). Sweat production is not only influenced by environmental temperature, but also humidity, activity level and the type of clothes athletes wear during physical activity (Popkin et al., 2010:443). It also varies because of age, gender, body weight and body fat percentage. Given similar condtios, women lose less sweat than men. In athletes, adipose tissue makes up about ten percent of the body, compared to muscle tissue of almost 75 percent. Individuals with more muscles relative to fat have a greater water reservoir and are less affected by dehydration (Meltzer & Fuller, 2008:60-61). During a marathon, sweat rates may vary from less than 500 ml per hour to more than two litres per hour and the sweat sodium concentration may vary from less than 20 mmol/l (460 mg/l) to more than 80 mmol/l (1840 mg/l) (Casa et al., 2005:116).

2.4.1 PHYSIOLOGY OF SWEAT

Sweating is activated by central and peripheral responses (Meyer, 1993:3). The brain receives information from central osmoreceptors, central angiotensin II, and peripheral baroreceptors, when there is a change in body fluids. The information that is received is then sent to areas in the brain that is responsible to trigger the response necessary to maintain fluid balance. Only a two percent change in osmolality is required to trigger an increase in thirst and the hormone arginine vasopressin. Arginine vasopressin is responsible for stimulating renal free water retention and helps to avoid dehydration. Arginine vasopressin is also a vasoconstrictor which helps maintain blood pressure during periods of low blood volume (Stachenfeld, 2013:111).

Body fluid changes are also sensed by baroreceptors, situated in the atrium. Baroreceptors are triggered, when a ten percent change in body fluid is experienced. Baroreceptors sensitize the brain to stimulate thirst and the kidney to retain fluid in order to correct fluid balance (Stachenfeld, 2013:111).

Sweat is formed by the secretion of primary sweat by the secretory coil, followed by partial absorption of sodium chloride and water in the re-absorptive duct. When sweat is discharged over the skin, it is hypotonic compared to plasma, because of the sodium level. In the secretory coil the primary sweat is formed by the active secretion of sodium with the passive diffusion of water through the permeable membrane. Sodium enters the cell coupled with chloride and then it is pumped out in exchange for potassium across the baso-lateral membrane (Meyer, 1993:3-5).

The sweat sodium concentration during exercise can range from less than 20 mmol/l to more than 80 mmol/l or about 1 g to 5 g of salt per litre of sweat lost. An athlete with an average sweat rate of 1 l/h can therefore lose 2 g to 10 g of sodium chloride in a two hour exercise session. An endurance athlete with a sweat rate of 1 l/h, who exercise for five hours can lose up to 30 g of sodium chloride during an event (Casa et al., 2005:117).

2.5 DEHYDRATION

Dehydration refers to a body water deficit that often occurs during physical activity (Casa et al., 2005:115). Athletes dehydrate during physical activity or during exposure to hot weather, because of fluid non-availability or a mismatch between thirst and body water losses (Montain et al., 2006:1). Although body water is lost from both intracellular and extracellular fluid compartments, a relatively greater fluid loss comes from extracellular compartments, resulting in a drop in plasma volume. A reduction in plasma volume decreases venous return and stroke volume, while heart rate increases to maintain cardiac output. Water loss from the intravascular space and the displacement of a portion of blood volume toward the peripheral for cooling, decreases the effectiveness of the circulatory system in delivering blood flow both to the skin and working muscle. With the decreased blood flow to the skin and working muscle, thermoregulation is impaired and both the ability to perform aerobic and anaerobic exercise is decreased (Zoorob et al., 2013:477; Ray, 1997:1).

Researchers found that marathon runners generally lose 1.7% to 1.8% body weight during exercise (Costa et al., 2013: Online; Wilson, 2008:3-4). Each kilogram of weight loss reflects approximately one litre of fluid loss. As little as one percent weight loss increases core temperature, increase heart rate, causes inadequate heat transfer to the skin and environment, increase plasma osmolality, decrease plasma volume, and may affect the intracellular and extracellular electrolyte balance (Wilson, 2008:3-4; Montain et al., 2006:4; Duvillard et al., 2004:651).

A weight loss of more than two percent has been linked to changes in haemorheology, metabolic dysregulation, heat intolerance, cardiovascular strain, and the subsequent inability to maintain exercise workload (Costa et al., 2013:Online; Montain et al., 2006:4). Two to three percent weight loss causes decreased reflex activity, maximum oxygen consumption, decreased physical work capacity, decreased muscle strength, decreased muscle endurance and impairs temperature regulation. At four to six percent weight loss, further deterioration occurs in maximum oxygen consumption and physical work capacity, resulting in decreased endurance performance (Turocy et al., 2011:328).

2.5.1 ASSESSING HYDRATION STATUS

When athletes train in hot weather conditions or when wearing insulating clothing or equipment, a practical approach is necessary to monitor day to day fluid status (Casa et al., 2005:115-116). Total body water, weight changes, clinical signs, haematological analysis, urine composition and thirst will be discussed as measures to assess hydration status.

2.5.1.1 TOTAL BODY WATER

Total body water (TBW), in combination with a plasma osmolality measurement, is regarded as the gold standard for hydration assessment. TBW and body fluid spaces are measured with isotope dilution and neutron activation analysis techniques, which involves laboratory tests under controlled conditions (Armstrong, 2007:576). A known amount of non-radioactive isotope is consumed and a sample of body fluid is drawn to determine the concentration of the isotope. Once the isotope concentration is known, total body water can be determined. A lower concentration of isotope indicates a greater amount of total body water and appropriate hydration (Niemann, 2012:23).

Although considered to be the gold standard, TBW techniques have certain limitations. During daily activities, body fluids are not consistent and isotope dilution measurements require three to five hours for internal isotope equilibration and analysis. For this reason, isotope dilution techniques are impractical during daily activities and multiple measurements throughout one day. On the other hand, plasma osmolality may not validly represent a gain or loss of body water because measurements of plasma osmolality are influenced by numerous factors. Both methods can therefore only be regarded as optimal when performed under controlled laboratory conditions when body fluids are stable and equilibrated (Armstrong, 2007:576).

2.5.1.2 BODY WEIGHT CHANGES

The difference in pre and post activity body weight is a commonly used, safe technique that provides a good estimate of acute body water losses and an estimate of the volume of fluid replacement needed to euhydrate (Montain et al., 2006:3; Casa et al., 2005:115-116). When an athlete has a balanced energy intake, and provision is made for fluid and food intake and urinary and faecal losses, his/ her body weight loss reflects water loss. When weight loss is calculated with an interval of more than four hours, water exchange due to substrate oxidation and respiratory water loss becomes large enough that the body weight loss difference should be corrected for by these factors (Armstrong, 2005:44).

2.5.1.3 CLINICAL SIGNS

Clinical signs and symptoms of dehydration, including thirst, dizziness, headache, tachycardia, oral mucosal surface moisture and skin turgor should not be ignored, but are too vague and imprecise to accurately assess the hydration status of an athlete (Sedek et al., 2015:659; Casa et al., 2005:115-116).

2.5.1.4 HAEMATOLOGICAL ANALYSIS

Haematological analysis can also be used to assess hydration status. Plasma comprises about five percent of body mass. According to Niemann (2012:22), when a person is severely dehydrated, the plasma volume decreases. For this reason, when an athlete sweats, it is assumed that the fluid portion of sweat is a product of plasma and extracellular fluid. The concentration of plasma can be determined by assessing the haematocrit and haemoglobin concentration of a blood sample. Dehydration can thus be assessed by using an equation of plasma volumes (PV) obtained from haematocrit before (PVB) and after (PVA) to determine plasma volume change. This equation is quite popular due to its ease of use. Regardless of the ease of use and popularity, this equation has limitations. As venous blood samples are required, there is risk for infection, and the possibility of vessel damage exists (Niemann, 2012:23).

2.5.1.5 URINE COMPOSITION

Fluid balance and electrolyte turnover is constantly changing because of the loss of water through the lungs, skin and kidney, as well as the consumption of food and fluid. The kidneys control the retention and excretion of body fluid and sodium to ensure homeostasis (Armstrong, 2005:575).

Urine specific gravity, urine osmolality and urine colour are considered good screening measures of hydration status (O'Neal et al., 2011: 588; Turocy et al., 2011:327; Casa et al., 2005:115-116). A well hydrated athlete will have a urine specific gravity of less than 1.020, a urine osmolality of less than 700 mOsm/kg, and urine of a pale yellow colour (Turocy et al., 2011:330; Casa et al., 2005:115-116).

2.5.1.5.1 URINE SPECIFIC GRAVITY

Urine specific gravity refers to the density, namely the mass per volume, of urine compared to pure water. Any type of fluid that is denser than water will have a specific gravity more than a 1.000. A normal urine sample normally has a urine specific gravity of 1.013 to 1.029. When dehydration occurs, urine specific gravity will be greater than 1.030. Urine specific gravity can be measured quickly and accurately with a handheld refractometer. A few drops of urine are placed on the stage of the refractometer which is pointed towards a light source that passes through the sample (Armstrong, 2005:44).

2.5.1.5.2 OSMOLALITY

Fluids in the human body vary in composition due to the different substance content of these fluids, but the overall number of particles remains the same. The membranes of cells are semipermeable and water can move through freely to ensure that osmotic pressure stays the same on both sides (Gaw et al., 2008:13). Plasma osmolality is a common haematological analysis and is calculated based on plasma volume shifts and extracellular fluid. When an athlete starts to sweat, plasma and extracellular fluids decrease in concentration, changing the osmolality of blood. Niemann (2012:23) found that plasma osmolality is more sensitive to incremental changes in dehydration based on percent body weight loss during exercise compared to urine specific gravity and urine osmolality. Plasma osmolality can be calculated using either a freezing point or vapour pressure osmometer. Although plasma osmolality is considered useful and accurate, it is quite complicated and required extensive training for use and obtaining samples (Niemann, 2012:23).

2.5.1.5.3 URINE COLOUR

Armstrong (2005:44) as well as Casa et al. (2005:116) conducted studies to determine hydration status by using urine colour. They suggest that almost anyone could determine the need for hydration if urine colour was directly proportional to the level of hydration (Armstrong, 2005:45; Casa et al., 2005:115).

Armstrong's study included a urine colour scale ranging from pale yellow (1) to brownish green (8). Results from this study showed that an individual with pale yellow colour urine will be within one percent of euhydration status. Urine colour however does not have the same accuracy as urine specific gravity or osmolality (Armstrong, 2005:45).

Armstrong (2005:45) further demonstrated that urine colour follow the same pattern as fluid loss in a study where the effects of heavy physical training and large water turnover on urine colour was evaluated. Nine participants performed strenuous exercise in a hot environment, followed by a 21-hour period of rehydration. The change in body mass of members was the reference standard whereby hydration indices were evaluated.

Armstrong also observed that urine colour can be used interchangeably when measuring urine colour once a week during a six week exercise programme. This method however has limitations as fluid consumed during a short period of time, rapidly dilutes the blood causing the kidneys to excrete diluted urine over a range of hydration states. This also happens when dehydration occurs, as urine changes seems to mirror the volume of fluid consumed, rather than the amount of fluid retained in the body (Armstrong, 2005:45-56).

2.5.1.6 RATING OF THIRST

When no instruments or technical expertise is available, or when an estimate of hydration state is acceptable, the sensation of thirst can be used to determine hydration status. The rating of thirst can only be used if total weight loss is between one and two percent. Thirst can be measured using a numerical rating scale, where a value of one represents no thirst at all, and nine represents very thirsty. This rating was developed by Young et al. (1987:747), enabling an athlete to assume that he/she is mildly dehydrated with a score ranging from three (a little thirsty) to five (moderately thirsty). It is important to remember that numerous factors including; fluid palatability, older age, gender, and heat acclimation status, may alter the perception of thirst. For this reason, thirst rating is not regarded as accurate and can only be seen as an approximation (Armstrong, 2005:45-46).

2.5.2 THE EFFECT OF DEHYDRATION ON PERFORMANCE

When athletes exercise in heat and become dehydrated to a level of two percent weight loss or more, or when an athlete starts exercising in a dehydrated state, physiological strain increase and performance decrease (Shirreffs & Sawka, 2011:40; Casa et al., 2010:147). Dehydration increases heat accumulation and decreases an athlete's ability to tolerate exercise-induced heat strain. The increased heat accumulation is mediated by a lower sweat rate and reduced skin blood flow for a given core temperature. The reduced ability to tolerate exercise-heat-strain is likely due to an inability to sustain the required cardiac output and a reduction in maximal aerobic power, thus increasing the relative exercise intensity. Dehydration that causes more than two percent weight loss consistently degrades aerobic performance in temperate and warm environments. The warmer the environment, the greater aerobic performance degradation, resulting in a greater water deficit, which further lowers aerobic performance (Shirreffs & Sawka, 2011:40-41). As soon as an athlete starts to exercise in a hot environment, core body temperature will increase by 0.12 to 0.25 degrees Celsius and heart beat will increase three to five beats per minute for every one percent weight loss. Core temperature increases when water loss increases and this can lead to dehydration. If dehydration occurs, a series of events can happen where the blood volume decreases, followed by a compensatory increase in heart rate, and decrease in stroke volume because of the increased heart rate and decreased filling time for the heart (Casa et al., 2010:147).

2.5.3 DEHYDRATION AND HEAT ILLNESSES

Serious heat illness can occur when athletes train for endurance races and hydration is not optimal. Severe heat illnesses include heat exhaustion and heat stroke (Flynn, 2014:2; Casa et al., 2005:120). Exertional heat illness can occur during endurance exercise when the combination of heat gain from metabolic and environmental sources exceeds the body's capacity to remove the excess heat, resulting in an increase in core temperature. In other cases, heat illnesses can occur due to the increased susceptibility of body tissue to heat stress rather than the inability of thermoregulation (Casa et al., 2005:120).

2.5.3.1 EXERTIONAL HEAT STROKE

Exertional heat stroke can be defined by a core body temperature of more than 40 degrees Celsius. Heat stroke is associated with organ system failure and central nervous system suppression, when the body's thermoregulation system is unable to manage and dissipate heat. When dehydration occur with a weight loss of three to five percent, cooling mechanisms, including skin blood flow and sweat production decreases, decreasing the body's ability to dissipate heat. For this reason, dehydration is considered a risk factor for heat stroke (Niemann, 2012:6-7).

2.5.3.2 EXERCISE ASSOCIATED MUSCULAR CRAMPS

Exercise associated muscular cramps (EAMCs) can be defined as short term, painful, involuntary spasms of skeletal muscles that occur during or after prolonged, intense exercise, usually in the heat. EAMCs mostly occur in the legs, arms and abdomen (Niemann, 2012:6-7). EAMCs are also called 'heat cramps', because they occur more frequently during heat stress. The cause of muscle cramps during and after exercise is unknown, but is thought to be the result of sodium loss, dehydration, and muscle fatigue (Niemann, 2012:7; Casa et al., 2005:120). Other assumed causes include genetic metabolic abnormalities as well as a combination of the mentioned factors (Niemann, 2012:6-7).

Controversy exists because heat cramps occur both during winter and summer sports. Heat cramps in winter sports suggests that although the environmental temperature is cool, the microclimate of an athlete can be hot, and then heat cramps can be considered as sweat cramps. Another explanation can be that muscle fatigue, salt loss, and fluid loss caused by endurance exercise causes cramps and does not depend on environmental temperature (Casa et al., 2005:120).

2.5.3.3 EXERCISE ASSOCIATED HYPONATRAEMIA

Exercise- associate hyponatraemia (EAH) is a common complaint in athletes who participate in endurance exercise. The characteristics of EAH is a decrease in plasma sodium concentration, which decreases plasma osmolality, which leads to a fluid shift from extracellular to intracellular (Winger et al., 2011:646). EAH can occur when serum sodium concentrations reduce by more than five mmol/l during endurance exercise. This happens when athletes drink hypotonic fluids in larger quantities than they are able to excrete, or when they have unusually high sweat sodium losses resulting from large sweat volume losses (Stachenfeld, 2013:111-113).

The worst consequence of EAH is hyponataemic encephalopathy, characterised by symptoms of the central nervous system. If hyponatramic encephalopathy is not addressed, seizures, respiratory arrest and death can occur (Winger et al., 2011:646).

Hyponatremia is typically observed with serum sodium levels lower than 125-130 mmol/l, and often seen during marathon competitions, military training, and recreational activities (Bailey et al., 2014:108; Montain et al., 2006:4). In athletic events, hyponatremia is more likely to occur in female and slower competitors. The severity of the symptoms is related to the fall in serum sodium concentration and the rapidity with which it develops (Montain et al., 2006:4).

2.6 HYPERHYDRATION

Hyper hydration does not occur commonly, because over-consumption of water or carbohydrate/ electrolyte solutions produces a fluid overload, which is excreted by the kidneys.

A larger amount of fluid can be retained when fluids containing glycerol is consumed. Glycerol increases fluid retention by reducing free water clearance. Exercise and heat stress decrease renal blood flow and free water clearance and for this reason counteract glycerol's effectiveness as a hyper hydrating substance. Fluid intake can be increased by 1.5 litres and sustained for several hours by means of glycerol hyper hydration. However, glycerol does not have any advantages on cardiovascular or thermoregulatory over water consumption during exercise or heat stress (Sawka et al., 2007:381; Montain et al., 2006:5).

2.7 REHYDRATING THE BODY

Sufficient fluid intake during exercise is important to limit or prevent dehydration. Athletes should aim for minimal, but less than two percent of body weight loss. Sodium should be included in rehydration fluids when sweat losses are high, especially if exercise lasts more than two hours. Although athletes should drink enough fluid to maintain weight, they should also not drink so much that they gain and carry additional weight. When rehydrating the body, both sodium and water should be replaced during recovery (O'Neal et al., 2011: 581-591; Shirreffs & Sawka, 2011:42-43).

2.7.1 BEFORE EXERCISE

It is important for athletes to be well hydrated prior to an exercise session (Kumley, 2010:27). Athletes should drink five to seven millilitres of water or sports beverage per kilogram body weight, at least four hours before an event (Kumley, 2010:27; Rodriguez et al., 2009:718) to facilitate optimal hydration. By consuming this amount of fluid four hours before an event, enough time is allowed to optimize hydration status and to allow the excretion of excess fluids (Rodriguez et al., 2009:718). If however, an athlete is already dehydrated, the athlete needs to add an additional three to five millilitres of fluid per kilogram body weight two hours prior to exercise (Kumley, 2010:27). If an athlete consumes too much fluid, hyper hydration will cause expansion of extra- and intracellular spaces and this will cause the athlete to need to void during the race (Rodriguez et al., 2009:718).

2.7.2 DURING EXERCISE

Fluid intake during exercise is regarded as important to enhance performance, avoid thermal stress, maintain plasma volume, delay fatigue and prevent injuries (Duvillard et al., 2004:651). It is recommended that both sodium and water is consumed if exercise duration is more than two hours, when a significant amount of sodium is lost (3-4 g), or when the volume of fluid consumed is large enough that it may cause a significant reduction in plasma sodium concentration (Shirreffs & Sawka, 2011:42-43). The amount and rate of fluid replacement depends on an athlete's sweat rate, exercise duration, and opportunities to replace fluid during exercise. By measuring weight before and after exercise, athletes can determine how much fluid they need to consume. A general recommendation for athletes is to consume 150 to 200 millilitres of fluid every fifteen to twenty minutes of exercise (Kumley, 2010:28).

In 1997 the Gatorade Sports Science Institute (GSSI) recommended that athletes need to start drinking fluid as early as possible and at regular intervals to try and consume fluids at a rate sufficient to replace all water lost through sweating or to consume as much as possible. In 1999 the GSSI refined their recommendation to 500-2000 ml fluid per hour (Murray et al., 2003:3). In 2000 the National Athletic Trainers Association (NATA) suggested that 200-300 ml fluid should be consumed every ten to 20 minutes (Casa et al., 2000:212-224). In 2006, the International Marathon Medical Directors Association (IMMDA) recommended that athletes follow their physiological cues, like thirst, as a more individual approach (Hew-Butler et al., 2006:289). The International Association of Athletic Federation (IAAF) on the other hand, recommends that athletes drink beyond thirst. The American College of Sports Medicine (ACSM) in 2007 suggests that customized individual programmes should be followed. They recommend that the goal of drinking fluid is to prevent excessive weight loss (Sawka et al., 2007:377).

2.7.3 AFTER EXERCISE

Replacing fluid after exercise is very important when athletes exercise for more than one hour or if an athlete trains in extreme environmental conditions such as heat, cold, or at a high altitude (Kumley, 2010:29). Athletes who weigh themselves before and after exercise need to consume 450 to 675 millilitres of fluid for every 0.5 kilogram weight loss (Kumley, 2010:29; Rodriguez et al., 2009:718). There has been a large paradigm shift regarding fluid recommendations in the past decade. However, the position statement from the ACSM, and also from NATA, GSSI, and the Brazilian Society of Sports Medicine promote athletes to replace up to 150 percent of weight loss after exercise (Allen et al., 2013:734; Sawka et al., 2007:377; Murray et al., 2003:3; Casa et al., 2000:212) in order to achieve optimum recovery of water and electrolyte balance (Potgieter, 2013:8).

After exercise, the replacement of sodium and the restoration of sodium balance is a prerequisite for effective restoration and maintenance of euhydration and no other electrolytes have shown to play such a significant role (Shirreffs & Sawka, 2011:42-43). The main factors influencing rehydration are the content and volume of the fluid that is consumed. Plain water is not the best rehydration fluid if rapid and complete restoration of fluid balance is necessary. When consuming plain water, directly after exercise, a rapid fall in plasma sodium concentration occurs, which alters plasma osmolality and causes diuresis. These changes that occur decrease the thirst sensation and urine output and in this way delays rehydration (Singh, 2003:53). Slower introduction of the rehydration fluid to circulation can be achieved by controlling the drinking pattern or speed and by delaying gastric emptying by, for example, increasing the carbohydrate content of the drink (Shirreffs & Sawka, 2011:42-43).

2.8 MACRONUTRIENT DEMANDS OF ENDURANCE SPORTS

Most people see nutrition as a basic need for survival and does not realise the important role in day to day performance (Paugh, 2005:36). Nutrition before, during, and after exercise can determine the athlete's performance and can also help prevent injury (Zoorob et al., 2013:475). An athlete who is well nourished is healthier, and also able to train more intensely, compete more successfully and is less susceptible to fatigue and injury. Although dietary requirements differ from person to person, the basic principles remain the same, with a recommended macronutrient distribution of 40-60% carbohydrates, 20-30% protein and 15-20% fat (Turocy et al., 2011:329; Paugh, 2005:36).

Gastrointestinal complains (GI) are a common problem amongst athletes. GI problems are one of the main causes of poor performance in athletes. Almost 30 to 90 percent of endurance athletes experience intestinal problems related to exercise. Symptoms accompanying GI problems include; nausea, vomiting, abdominal angina and bloody diarrhoea (O'liveira, 2013:1). During exercise blood flow is diverted to s, while it would normally be directed to the stomach for proper digestion. Protein, fat and fibre slow down the digestive process and for this reason athletes need to avoid high intakes of these nutrients during a race to prevent stomach upsets (Dada, 2010:36).

2.8.1 CARBOHYDRATE

As soon as an athlete starts to train, energy needs increase, especially energy from carbohydrates. Carbohydrates are stored in the human body in small amounts and mainly as glycogen in the liver and muscles (Dada, 2010:36). Muscle glycogen and blood glucose are the primary energy sources for the working muscle (Flynn, 2014:4). For this reason, the more aerobic exercise is done, the more carbohydrates are needed. An athlete who participates in high-intensity training needs between seven and ten grams of carbohydrates per kilogram of body weight during normal training (Dada, 2010:36).

2.8.1.1 BEFORE EXERCISE

Carbohydrate intake before a race simply helps to fill up muscle glycogen stores and optimize blood glucose levels. If athletes don't consume carbohydrates before a race, they might not have adequate stores for the entire race (Paugh, 2005:36). The glycogen stores of the human body last between 90 minutes to three hours during moderate to high intensity exercise (Potgieter, 2013:8). The pre-race meal helps to prevent low blood glucose levels, which can interfere with an athlete's performance. The human brain obtains its energy almost exclusively from circulating blood glucose. If blood glucose is low, muscles will not contract effectively. By consuming a meal before a race, an athlete will have more energy, and will be able to concentrate more effectively during a race (Mahon et al., 2014:5; Paugh, 2005:36).

According to Zoorob et al. (2013:476) 75g of moderate glycaemic carbohydrate 45 minutes before exercise, lasting more than an hour, can improve endurance capacity by 10 to 16 percent. The amount and type of food an athlete needs to eat before exercise depends on how much time is left before a race, what they weigh, and the type of sport they will be performing. Athletes that weigh less and have less time before an event will have to consume smaller quantities of food. Even more important that the quantity, is the choice of food. Foods that digest quickly, such as juice, sports drink, fruit, or crackers are advised. Liquid meals shorten gastric emptying rate and lowers residual intestinal load, which may be beneficial for nervous athletes. Food choices should be high in carbohydrates, low in fat, fibre and protein, because the latter nutrients delay gastric emptying, increase the chances of gastrointestinal upset and delaying obtainability of energy availability (Mahon et al., 2014:5; Zoorob et al., 2013:476).

2.8.1.2 DURING EXERCISE

During exercise, an athlete needs to consume food consisting of easily digestible carbohydrates that is low in fat and low in protein. By consuming carbohydrate containing food/fluid while exercising, muscle glycogen is spared and an athlete's endurance capacity is increased. Carbohydrates during exercise is not necessary unless exercise is performed at 75% V02 max for less than an hour or the exercise duration will be more than two hours. Carbohydrates from a single source, such as glucose, can be oxidized at a rate of 60 gram per hour. On the other hand, when more than one type of carbohydrate is consumed, the oxidation rate can increase to 75 to 90 gram per hour. Although the oxidation rate increase when consuming a combination of two or more types of carbohydrates, athletes needs to be cautious because large amounts of carbohydrate may increase the risk of gastrointestinal symptoms because of the decreased mesenteric blood flow to the intestines during high intensity exercise. Another way to minimize gastrointestinal symptoms is to divide carbohydrates into 10-25 g portions every 15 minutes (Zoorob et al., 2013:478).

According to Zoorob et al. (2013:478) the American College of Sports Medicine, recommends an intake of 30 g to 60 g carbohydrates per hour during endurance exercise. The International Olympic Committee recommends that endurance athletes may benefit from a carbohydrate intake of up to 90 gram per hour. Popular food that athletes prefer to consume during a race include sports bars, sport drinks, energy gels, jelly beans, gummy bears, bananas and pretzels (Zoorob et al., 2013:478; Mahon et al., 2014:5).

2.8.1.3 AFTER EXERCISE

After exercise glycogen stores in the body need to be refuelled. When carbohydrates are consumed after exercise, the rate of glycogen synthesis is increased. Athletes that have exercised for more than 90 minutes need 1.5 gram of carbohydrates per kg body weight within 30 minutes of exercise. There is a short period after exercise when glycogen synthesis is higher, because the blood flow to the muscle is still copious and there is greater insulin sensitivity (Zoorob et al., 2013:482). High glycaemic carbohydrates are absorbed quicker and shift quicker into cells, resulting in an increase in blood glucose and insulin. This may lead to accelerated muscle glucose uptake as well as decreased mobilization and oxidation of free fatty acids during exercise (Little et al., 2009:368; Zoorob et al., 2013:482). Fructose is not considered an effective carbohydrate to restore muscle glycogen, because it is preferentially used by the liver for hepatic glycogen storage (Zoorob et al., 2013:482.

2.8.2 PROTEIN

Protein fulfils many functions in the human body, but athletes focus on protein for building and repairing muscle contractile and connective tissue (Flynn, 2014:7; Turocy et al., 2011:328). Protein provides eight to ten percent of the body's total energy needs and athletes who want to build fat free mass need more protein in their diet. Athletes who do aerobic exercise, need moderate amounts of protein in the diet. If an athlete consumes more protein than required, their hydration needs increase and the liver and kidneys are overburdened, which interferes with calcium absorption (Turocy et al., 2011:328).

Protein requirements differ between different sport activities. Endurance athletes, including marathon runners, may need more protein than a less active athlete to assist with muscle recovery (Flynn, 2014:7). Gender, age, intensity, duration and type of exercise, energy intake, as well as carbohydrate availability affects protein metabolism during and after exercise (Rodriguez et al., 2009:714). In general, protein requirements are 0.8 g/kg body weight per day or ten to 35 percent of total calories (Flynn, 2014:7; Rodriguez et al., 2009:710). As soon as an athlete starts to train, the requirements increase to 1.2 to 1.4 g/kg/body weight per day. Endurance athletes need protein to maintain nitrogen balance, repair muscles after exercise, and to a much lesser degree, use as fuel during exercise. Protein repair muscles after exercise by providing the essential amino acids to increase fractional synthetic rate of skeletal muscles and a positive protein balance (Flynn, 2014:7).

A moderate amount of protein should therefore be included after exercise, to promote protein synthesis and enhance muscle glycogen availability. Including 0.2 grams of protein per kg body weight improves muscle tissue repair more effectively than carbohydrate alone (Zoorob et al., 2013:482).

2.8.3 FAT

Fat has various roles in the human body. The most important role is to serve as an energy source and to provide essential components to cell membranes and associated nutrients. The recommendation for fat intake range from 20 to 35 percent of total energy intake. There is no benefit for athletes to consume more than 20 percent fat of total energy intake (Rodriguez et al., 2009:710). Fat also provides the means for delivery of necessary micronutrients, such as vitamins A, D, E, and K. These vitamins are necessary for metabolism, immune function, and cellular maintenance. Triglycerides are stored in adipose tissue and in muscle fibres. Triglycerides provide an endogenous fuel for oxidation during exercise. Fat is consumed mostly in the form of long-chain or medium-chain triglycerides. Long-chain triglycerides is absorbed in the intestines but is slowly delivered into the blood stream through the lymphatic system. Long-chain triglycerides enter the blood stream only two hours after digestion in the form of chylomicrons. For this reason, consuming fat during endurance exercise that lasts less than two hours is not recommended. The benefit of including long-chain triglycerides in an athlete’s diet to help with total energy production has not been established (Coyle, 2003:49).

Medium-chain triglycerides are digested more rapidly and have advantages due to their ease of passing through cell membranes and entering oxidative pathways. Although positive results have been found in consuming medium-chain triglycerides during endurance exercise, not all studies found them to benefit performance. It has been reported that a large dose of medium-chain triglycerides causes GI stress (Coyle, 2003:49).

2.9 ELECTROLYTES AND HYDRATION

Electrolytes can be defined as salts and minerals that conduct electrical impulses in the body. Electrolytes that play an important role in the human body, amongst others, includesodium, chloride, potassium, calcium, and sodium bicarbonate. Electrolytes have several functions in the human body, such as; controlling fluid balance, help with muscle contraction, energy generation, and help with almost every major biochemical reaction in the body (Olenhof et al., 2008:Online). Athletes need to replace important electrolytes lost during exercise, such as sodium and potassium. Sports beverages containing added sodium chloride and other electrolytes can be consumed to help prevent dehydration and hyponatraemia (Kumley, 2010:30-31).

Sodium is an important electrolyte to consider, particular for athletes with a high sweat rate. Most athletes require more sodium and chloride than the recommended upper limit (Rodriguez et al., 2009:710). Table 2.1 illustrates the electrolyte level of extracellular fluid, intracellular fluid and sweat.

Table 2.1 Human electrolyte level (Shirreffs & Maughan, 1998:97)

	Extracellular mmol/l	**Sweat mmol/l**	**Intracellular mmol/l**
Sodium	137-144	20-80	10
Potassium	3.5-4.9	4-8	148
Calcium	4.4-5.2	3-4	0-2
Magnesium	1.5-2.1	1-4	30-40
Chloride	100-108	30-70	2

2.9.1 SODIUM

Sodium is the dominant electrolyte in extracellular fluid and is measured to determine body fluid osmolality (Bailey et al., 2014:102). Sodium levels in extracellular fluid should be between 130 and 160 mmol/l to keep cells, tissue and organs functioning optimal. The human body adjusts water volume in relation to the amount of sodium in the body (Coyle, 2003:48). Sodium also assists in the acid-base balance, is essential to nerve impulse transmission and helps with muscle contraction. When sodium is consumed, it is absorbed by the intestinal tract, moves in the blood to the kidneys, where it filters out of the blood. In turn, the kidneys reabsorb and return the necessary amount of sodium back into the blood. As soon as an individual increases his sodium intake, thirst signals are activated which promotes fluid consumption. An individual will stop consuming fluid when sodium to water concentration is restored and excess sodium and water is secreted together (Rolfes, 2013:397).

Sodium is also the main electrolyte found in sweat. The sodium content of sweat, range from 20 to 80 mmol/l. Sodium levels in sweat are increased by high sweat rate and decreased with heat adaptation. Dehydration and hyponatraemia can result from prolonged heavy sweating and failure to replace sodium or even from drinking too much fluid (Kumley, 2010:30; Wilson, 2008:3;. If the blood sodium concentration is less than 130 mmol/l, it causes fluid to move to the brain, causing swelling with symptoms such as; mental confusion, general weakness, fainting, coma and death (Coyle, 2003:48).

Daily sodium needs vary widely depending on the activity level of a person. Normal sedentary people lose sodium mainly through urine. The kidneys control the level of sodium in blood. If sodium levels are too high, sodium are excreted through urine, if blood sodium levels are low, sodium is conserved by the kidneys. The Institute of Medicine recommends an adequate intake of 3.8 g salt/day (1.5 g sodium and 2.3 g chloride) to recover sweat sodium losses of active individuals; and a upper level of 5.8 g of salt per day (2.3 g sodium) (IOM, 2004:Online).

In most athletes that exercise for four to five hours, total sodium loss through sweat can reach ten percent which are still tolerated well by most athletes. Although this suggests that sodium replacement is not necessary, sodium inclusion has some benefits and few risks. Including sodium in sport drinks improves taste, stimulates voluntary drinking, thus minimizing involuntary dehydration. The absorption of fluids entering the intestine is more rapid when sodium is present, which also assists with the absorption of carbohydrates (Coyle, 2003:48).

2.9.2 POTASSIUM

Potassium is the major electrolyte in intercellular fluid and is stored in muscle fibres along with glycogen. Potassium is important for cellular and electrical function and the primary positively loaded ion found inside cells. Blood serum contains 4-5 mg potassium per 100 ml and red blood cells contain 420 mg (Haas, 2011:Online). Potassium helps sodium regulate electrolyte and fluid balance, promotes cell integrity, as well as acid-base balance in blood and tissue (Rolfes, 2013:398). Potassium enters the cell easier than sodium and starts the brief sodium-potassium exchange across cell membranes. In nerve cells, the sodium-potassium flux produces the electrical potential that facilitates the conduction of nerve impulses. As soon as potassium leaves the cell, it changes the membrane potential and allows the nerve impulse to develop. This electrical potential that is created by the sodium-potassium exchange helps produce muscle contractions and regulates heartbeat. The sodium-potassium pump also helps prevent the swelling of cells. If sodium is not exchanged with potassium and stays in cells, fluid accumulates within the cell and the cell can ultimately burst. Potassium is also an aid in cellular biochemical reactions and energy metabolism. Potassium participates in the synthesis of protein from amino acids within cells. No specific required daily allowance is developed for potassium, but a recommendation of 2 to 2.5 grams per day are needed or about 0.8 to 1.5 grams per 1000 calories (4200kJ) consumed (Haas, 2011:Online).

Potassium is mainly lost through urine and sweat. An average sweat loss with an osmolarity of 4-8 mmol/l contains 100-200 mg of potassium per hour in an active athlete. The risk for hyperkalaemia and heat stroke increases concomitant to fluid loss as the potassium within the cell increases in concentration (Kumley, 2010:31-32). Hypokalaemia is characterised with a serum potassium concentration of less than 3.5 mmol/l. The results of hypokalaemia are cardiac arrhythmias, muscle weakness and glucose intolerance. Moderate potassium deficiency can occur without hypokalaemia. Moderate potassium deficiency can be characterized by increased blood pressure, increased salt sensitivity, an increased risk of kidney stones and increased bone turnover (IOM, 2004:Online).

Potassium is consumed mostly through sports beverages, milk, vegetables, fruit, whole grains, beans and salt substitutes. To ensure an adequate dietary intake of potassium, a variety of fruit and vegetables and other food sources is recommended (Kumley, 2010:31-32). The Institute of Medicine recommends an adequate intake of 4.7 gram (120 mmol) potassium per day for adults (IOM, 2004:Online).

Potassium in fruit and vegetables is usually bound to citrate, which acts as a buffer to protect bones form acid-induced demineralization. Because most body potassium is found intracellular, with a large total body potassium pool, potassium in sweat only represents a small percentage of the available potassium (Rodriguez et al., 2009:710).

Excessive intake of potassium with potassium supplementation, other than diet, can cause gastrointestinal discomfort and ulceration of the gastrointestinal tract. The excessive intake of potassium results in hyperkalaemia and can lead to cardiac arrhythmias (IOM, 2004:Online).

2.9.3 CHLORIDE

Although sodium is considered to determine extracellular volume, total body chloride is regulated in the same proportion as sodium, which makes it difficult to measure the effect of chloride on extracellular fluid volume (Bailey et al., 2014:104). Chloride can move passively through cell membranes and also associates with potassium. Chloride assists in maintaining fluid and electrolyte balance. Chloride forms part of hydrochloride acid which is present in the stomach. Hydrochloride acid maintains the strong acidity of gastric juice (Rolfes, 2013:398).

2.10 CONCLUSION

A large percentage of the body consists of water. During endurance exercise, sweating causes fluid as well as electrolyte losses that need to be replaced. Sometimes fluid loss during exercise is more than fluid intake and dehydration can result. Dehydration not only affects exercise performance, but can be life threatening during endurance exercise. For this reason, athletes need to know how to regulate body fluids and electrolytes to ensure they stay in an euhydrated state. Individuals differ from one another and there is not one protocol for drinking or eating during endurance exercise that will work for all. Athletes therefore need to monitor their hydration status and develop a safe rehydration regime that fit their physiological needs.

Although there is different assessment techniques available to determine hydration status, no consensus exist on the best method that can be used in a practical setting. It is therefore important that athletes have the knowledge to employ optimal rehydration practices to protect their health and ensure optimal sport performance.

2.11 REFERENCES

Allen S, Miller KC, Albrecht J, Garden-Robinson J, and Blodgett-Salafia E. 2013. Ad libitum fluid intake and plasma response after pickle juice, hypertonic saline, or deionized water ingestion. Journal of Athletic Training, 48(6):734-740.

Armstrong LE. 2005. Hydration Assessment Techniques. Nutrition Reviews, 63(6):40-65.

Armstrong LE. 2007. Assessing hydration status: The elusive gold standard. Journal of the American College of Nutrition, 26(5):575–584.

Bailey JL, Sands JM, and Franch HA. 2014. Water, electrolytes and acid-base metabolism, in modern nutrition in health and disease. Ed. By Ross AC, Caballero B, Cousins RJ, Tucker KL, and Ziegler TR. 11th edition. Philadelphia: Lippincott Williams & Wilkins:102-129.

Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, and Stone JA. 2000. National Athletic Training Association. Fluid replacement for athletes. Journal of Athletic Training, 35:212-224.

Casa DJ, Clarkson P and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Casa DJ, Stearns RL, Lopez RM, Ganio MS, PhD, McDermott BP, Yeargin SW, Yamamoto LM, Mazerolle SM, Roti MW, Armstrong LE, and Maresh CM. 2010. Influence of Hydration on Physiological Function and Performance during Trail Running in the Heat. Journal of Athletic Training, 35:212-224.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013].

Coyle EF. 2003. Fluid and fuel intake during exercise. Journal of Sports Science, 22(1):39-55.

Dada JH. 2010. Runners need proper nutrition and hydration for the 26.2 mile stretch. Today's Dietician, 12(3):36.

Dunford M and Doyle JA. 2012. Nutrition for Sport and Exercise. 2nd edition. Belmont CA: Wadsworth: 240-277.

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Gaw A, Murphy MJ, Cowan RA, O'Reilly DSJ, Stewart MJ, and Shepherd J. 2008. Clinical Biochemistry. 4th edition. Elsevier: 13.

Haas EM. 2011. Role of Potassium in Maintaining Health. Periodic Paralysis International. [Online].

Available from: http://hkpp.org/patients/potassium-health [Accessed May 29th, 2015].

Hew-Butler T, Verbalis JG, and Noakes TD. 2006. Updated Fluid Recommendation: Position Statement from the International Marathon Medical Directors Association (IMMDA). Clinical Journal of Sport Medicine, 16:283–292.

Hoffman MD, Hew-Butler T, and Schwellnus M. 2014. Regarding the Wilderness Medical Society Practice Guidelines for Heat-Related Illness. Wilderness & Environmental Medicine, 25(2):246-257.

Institute of Medicine. 2004. Dietary reference intake. [Online].

Available from: http://www.iom.edu/activities/nutrition/summarydris/dri-tables.aspx [Accessed May 29th, 2015].

Jeukendrip AE. 2011. Nutrition for endurance sports: Marathon, triathlon, and road cycling. Journal of Sport Science, 29(1):91-99.

Kumley RF. 2010. Hydration and fluid replacement knowledge, attitudes, barriers and behaviours of NCAA division football players at Midwestern University. Master's Degree. Ball State University, 1-116.

Little JP, Chilibeck PD, Ciona D, Vandenberg A, and Zello GA. 2009. The effect of low and high glycemic index foods on high intensity intermittent exercise. International Journal of Sports Physiology and Performance, 367-380.

Mahon E, Hackett A, Stott T, George K, and Davies I. 2014. Macronutrient consumption prior to, and during, a mountain marathon. American Journal of Sports Science, 2(1):5-12.

Maughan RJ, Watson P, and Shirreffs SM. 2015. Implications of active lifestyle and environmental factors for water needs and consequences of failure to meet those needs. Nutrition Reviews, 73(2):130-140.

Meltzer S and Fuller C. 2008. The complete book of Sports Nutrition: a Practical Guide to Eating for Sport. New Holland:60.

Meyer F. 1993. Water and electrolyte losses and replenishment in children during prolonged exercise in the heat. Doctor of Philosophy, McMaster University: 1-155.

Montain SJ, Cheuvront SN, Carter R, and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas: 1-8.

Murray B, Stofan J, and Eichner ER. 2003. Hyponatremia in Athletes. Gatorade Sports Science Institute, 16(1):1-6.

Noakes TD. 2003. Fluid replacement during marathon running. Clinical Journal of Sports Medicine, 13(5):309-318.

Niemann A. 2012. The Effect of Instrument Type on the Measure of Hydration Status. Master's degree. Indiana State University, 1-73.

Olenhof D, Jeryan C, and Boyden K. 2008. The Gale Encyclopaedia of Medicine: A-B. [Online].

Available from: http://medical-dictionary.thefreedictionary.com/electrolytes [Accessed May 29th, 2015].

O'liveira EP. 2013. Nutrition recommendation to avoid gastrointestinal complains during exercise. Sport Science Exchange, 26(114):1-4.

O'Neal E, Wingo J, and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Paugh SL. 2005. Dietary Habits and Nutritional Knowledge of College Athletes, 36-86.

Popkin BM, D'Anci KE, and Rosenberg IH. 2010. Water, hydration and health. Nutrition Reviews, 68(8):439-458.

Potgieter S. 2013. Sport nutrition: A review of the latest guidelines for exercise and sport nutrition from the American College of Sport Nutrition, the International Olympic Committee and the International Society for Sports Nutrition. South African Journal of Clinical Nutrition, 26(1):6-16.

Ray ML. 1997. The effect of fluid composition on rehydration following heat and exercise induced dehydration. Dissertiation: Iowa State University: 1-96.

Rodriguez NR, DiMarco NM, and Langley S. 2009. Nutrition and Athletic Performance. American College of Sport Medicine, 709-731.

Rolfes W. 2013. Water and the major minerals. Understanding Nutrition. 13th edition. Wadswoth: 397.

Sawka MN, Burke LM, and Eichner ER. 2007. American College of Sports Medicine positions stand Exercise and fluid replacement. Medicine and Scientific in Sports and Exercise, 39:377–90.

Sedek R, Mohamad MM, and Kasim ZM. 2015. Knowledge, attitudes and practices on hydration and fluid replacement among endurance sports athletes in national university of Malaysia. Pakistan Journal of Nutrition, 14(10):658-665.

Shirreffs SM and Maughan L. 1998. Fluid and electrolyte loss and replacement in exercise. Sports Medicine. 2nd Edition. New York: Oxford University Press, 97-113.

Shirreffs SM and Sawka MN. 2011. Fluid and electrolyte needs for training, competition and recovery. School of Sport, Exercise and Health Science. Loughborough University: 39-46.

Singh R. 2003. Fluid Balance and Exercise Performance. Medical Journal of Nutrition, 9(1):53-74.

Stachenfeld NS. 2013. Assessing hydration in the laboratory and field. Sports Science Exchange, 26(111):1-4.

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ, and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

Young AJ, Sawka MN, Epstein Y, Decristofano B, and Pandolf KB. 1987. Cooling different body surfaces during upper and lower body exercise. Journal of Applied Physiology, 63(3):1218-1223.

Wilson CK. 2008. What is the relationship between hydration knowledge, exercise intensity, and hydration behaviours of college students in Southern Texas. Doctoral these: Lamar University, 1-71.

Winger JM, Dugas JP, and Dugas LR. 2011. Believes about hydration and physiology drive drinking behaviours in runners. Journal of Sport Medicine, 45(8):646-649.

Zoorob R, Parrish ME, O'Hara H, and Kalliny M. 2013. Sport nutrition needs before, during, and after exercise. Primary Care The Clinical Office Practice, 40(2):475-486.

Zubieta-Calleja G. and Paulev PE. 2004. Body fluids and regulation. New Human Physiology. 2nd edition. University of Copenhagen. [Online].

Available from: http://www.zuniv.net/physiology/book/ [Accessed May 29th, 2015].

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

Distance running becomes more popular by the day (Flynn, 2014:1). The majority of athletes that participate in distance running serve as their own coach when it comes to hydration and electrolyte replacement. As discussed in Chapter 1, a lack of consensus exists in the scientific community regarding hydration recommendations, and the information athletes receive varies greatly (O'Neal et al., 2011:582). In this chapter the study design, population, sample selection, study procedures and techniques, time frames, operational definitions, validity and reliability of measures as well as the limitations of the study will be described. The procedures and methods used for statistical analysis of the data are also described, as well as ethical considerations and approval obtained for this study.

3.2 STUDY DESIGN

A descriptive, observational study using a quantitative approach was performed on members from the South African National Defence Force (SANDF), participating in a half or full marathon in Oudtshoorn, Western Cape province, South Africa.

3.3 POPULATION

The study population consisted of males and females, older than 18 years and employed by the SANDF, that participated in the half or full marathon during the Cango race in Oudtshoorn during 2014. Members that provided informed consent were included in the study.

The population consisted of members from different military areas as well as different occupations within the SANDF, representing the Northern, Western, Southern, and Eastern Cape, with Afrikaans, English and Xhosa the main languages spoken.

3.4 SAMPLE

A convenience sample of male and female athletes, who registered for the half (21.1 km) or full marathon (42.2 km) at the SANDF Sports Club for the Cango Marathon (Oudtshoorn, Western Cape) in February 2014 were invited to participate in this study. Members that met the inclusion criteria were invited to participate voluntary in the study. Informed consent was obtained from each participant before inclusion in the study. To obtain a final sample of at least 100 athletes for adequate power of the study, 144 volunteers were recruited and included in the study to provide for possible drop-outs.

3.4.1 INCLUSION CRITERIA

The sample included apparently healthy, long distance runners, employed by the SANDF, who registered for a half or full marathon on the day of the study. Male and female participants, older than 18 years, who have provided informed consent, were included.

3.4.2 EXCLUSION CRITERIA

Participants not complying with the inclusion criteria or who did not volunteer to participate were excluded from this study.

3.5 DATA COLLECTION PROCEDURES

The researcher obtained approval for this study from Colonel S Stevens, Head of Sport in the SANDF (Addendum A), Warrant Officer R Hudges, Head of the South Coast Athletic Sports Club (Addendum B), as well as the Ethics Committee of the Faculty of Health Science, University of the Free State (ECUFS209/2013 Addendum C). Informed consent (Addendum D) in the languages of choice (English, Afrikaans and Xhosa) was obtained before inclusion in the study.

Before onset of the study, four professional helpers (Emergency Medical Practitioners registered with the Health Professions Counsel) were trained by the researcher to assist in taking anthropometric measurements. A pilot study to test the questionnaire and procedures were conducted before the main study and data collected were not included in the main study. No additional changes was made to the questionnaire after completion of the pilot study. Data for the main study were collected at the Cango marathon in Oudtshoorn. Environmental temperature, humidity and wind speed were recorded before and after the race. Weight and height were measured by the researcher and four helpers during registration on the day before the event. A structured, self-reporting questionnaire (Addendum F) was completed during registration by each participant to collect information on hydration knowledge and practices. On the day of the event, the weight of each participant was measured before and after the race to determine fluid and weight loss, after voiding. Before weight was measured, the participants had to towel dry to get rid of excess sweat. At the weighing stations, data were also recorded on the type and amount of fluid that were taken during the race, either carried by the athlete or consumed at the water tables. The fluid provided to all athletes at each water point was controlled to contain the same amount of fluid, to enable accurate reporting by participants. After the race, each participant in the study received a complementary voucher for a session with a physiotherapist.

3.6 OPERATIONAL DEFINITIONS AND TECHNIQUES

3.6.1 GENERAL DEMOGRAPHIC INFORMATION

The first part of the structured, self-reporting questionnaire (Addendum F) contained questions to collect information regarding demographics. This questionnaire was completed the day before the race at registration. Demographic information collected included gender, race, age, occupation in the SANDF, province of residence and number of years participating in races to indicate race experience.

3.6.2 ANTHROPOMETRIC STATUS

Anthropometry is defined as the measurement of body size, weight and proportions by means of standardized methods. These measurements are indicators of health and reflect nutritional status (Hammond, 2012:383). In this study anthropometric status were evaluated by measuring weight and height, which were used to calculate body mass index (BMI). The researcher and trained helpers measured weight and height and recorded this information on the questionnaire.

3.6.2.1 WEIGHT

Body weight is described as the total weight of bone, organs, muscles, adipose tissue and body fluids (Lysen & Israel, 2012:463). Weight was measured at registration, the day before the race, as well as directly before and after the race to determine fluid loss during the race. A body weight loss of 1 kg is regarded as equivalent to 1 litre of fluid lost during a race, which can be through sweat, breathing, or urine output (Duvillard et al., 2004:651). To ensure that participants did not have to wait and could be weighed quickly before and after the race, weight were measured by the researcher and trained professionals at five stations, using calibrated electronic platform Seca scales (model 220). The scales were placed on a hard, level surface, participants wore minimum clothes, removed their shoes, stood with their weight evenly distributed on both feet and held their head in a Frankfort plane. Body weight was recorded to the nearest 100 g as recommended by Lee and Nieman (2007:173). Weight before the race was taken after urination and after drying excess perspiration. Weight changes are considered as a useful indicator to evaluate hydration status during a race (Costa et al., 2013:Online). The difference in body weight before and after the race was used to provide an indication of the individual's hydration status after competing. A weight loss of more than two percent, has been linked to serious conditions such as changes in haemorheology, metabolic dysregulation, heat intolerance, cardiovascular strain, and the inability to maintain exercise workload (Costa et al., 2013:Online). Weight loss of more than two percent during the race was interpreted as inadequate fluid intake and poor hydration status after the race.

3.6.2.2 HEIGHT

Height is defined as the linear measurement from head to toe (Stedman, 1982:624). Height was measured during registration the day before the race, by the researcher and trained professionals with Seca stadiometers to the nearest 0.1 cm. Participants were measured without shoes, shoulders relaxed, feet flat, heels together and arms relaxed at each side. Participants stood with their spine against a sturdy vertical surface, shoulder blades, buttocks and heels touching the measuring surface, looking forward (Frankfort plane) and taking a deep breath before the measurement was taken (Lee & Nieman, 2007:171). Height was measured to interpret weight by calculating BMI.

3.6.2.3 BODY MASS INDEX (BMI)

BMI interprets weight in relation to height and provides an indication of body composition (WHO, 2012:Online). BMI was developed to predict the potential for developing chronic diseases associated with obesity and is considered an appropriate method to evaluate body size in the general population, but does not determine specific fat mass or fat free mass. BMI is considered less accurate for athletes and active individuals, who have a higher level of fat free mass. A sedentary person and active person may have the same weight and height, but their fat to fat free mass ratio may vary substantially (Turocy et al., 2011:327). BMI is calculated by dividing an individual's weight in kilogram by the square of the height in meters (kg/m^2) (WHO, 2012:Online). During this study, however, muscle mass was not controlled for. BMI values are categorized as follows:

Table 3.1 International Classification of adult weight status, according to BMI (WHO, 2012:Online)

Classification	BMI(kg/m^2)	
	Principal cut-off points	**Additional cut-off points**
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

3.6.3 KNOWLEDGE REGARDING FLUID REPLACEMENT

Many long distance runners believe that it is necessary to “drink as much fluid as possible” in order to prevent dehydration (Nolte, 2011:7). Most runners however use a more personal approach to rehydrate, drinking fluid as it worked for them personally in the past. With a lack of knowledge about optimal hydration practices, athletes struggle to achieve a balanced hydration status. Knowledge on hydration was determined at registration in the second section of the questionnaire by means of open questions, which were completed by each participating athlete. Knowledge questions included athletes’ knowledge regarding fluid intake and performance, impact of weight changes on performance, dehydration signs and symptoms, and the sources of knowledge regarding hydration.

3.6.4 PRACTICES REGARDING FLUID REPLACEMENT

Most athletes in the SANDF practice on their own and do not have professional coaches training them. In this study, hydration practices were reported in the third section of the questionnaire by recording usual hydration practices as well as the actual practices during the race. Data gathered included a description of the type of beverages athletes usually drink before, during and after exercise and competitions, how much fluids they consume, the timing of intake, how athletes provide for fluids during exercise (O’Neal et al., 2011:584); and what athletes do to minimize the likelihood of dehydration and hypernatremia. Factors influencing their hydration strategy and beverage choice were collected as well as the influence that environmental temperature usually have on their fluid intake.

To determine actual practices on the day of the competition, each participant recorded the type and quantity of fluid carried during the race. The amount of fluid in glasses or sachets at water points were standardised to contain 100 ml and controlled by the researcher before the race, as well as the type of fluids provided (Coke, sports drinks and/or water). Each participant was requested to remember how many units were consumed at water points and water bottles were checked before and after the race to calculate the amount of fluid consumed during the race. This information was recorded on the questionnaire.

3.7. VALIDITY AND RELIABILITY

3.7.1 ANTHROPOMETRY

3.7.1.1 WEIGHT AND HEIGHT

i. Validity

In this study validity was ensured by using the same calibrated scales, making sure the scale is set to zero before each athlete was weighed. Calibration of the scale was ensured by placing a known weight on the scale. Standard measuring procedures for measuring height were followed.

ii. Reliability

The researcher ensured reliability of data by training five professional helpers to take anthropometric measures, according to standardized procedures as described by Lee and Nieman (2007:171-173). Each measurement was repeated and recorded twice to ensure reliability of measures. Participants were requested to use the same anthropometric station for the three weight measurements.

3.7.2 KNOWLEDGE AND PRACTICES OF MARATHON ATHLETES

i. Validity

Validity was ensured by making use of a structured questionnaire (Addendum F) and including close-ended questions as well as open-ended questions according to the objectives of the study (Burton & Mazerolle, 2011:37). The questions were reviewed for readability and content by researchers in the field of sports nutrition.

Questions were based on literature and other study examples to address the objectives of the study. Each athlete completed their own questionnaire. The content of the questionnaire was tested among five representatives to ensure that athletes are able to comprehend the questions asked (Kingston, 2012:975).

iii. Reliability

Reliability was ensured by testing the questions in a pilot study. Some questions were repeated in different forms on the questionnaire, and compared to provide the same answer. Reliability were further improved by planning the study so that athletes provided the answers themselves and keeping the questionnaire as short as possible to prevent responder's fatigue.

3.8 TIME FRAME FOR IMPLEMENTATION OF STUDY

The study was conducted according to the following time schedule:

Table 3.2: Time schedule

January – October 2013	Planning of the research study and development of protocol.
November/ December 2013	Evaluation committee
December 2013/January 2014	Obtain ethical and SANDF approval for study and conduct the pilot study
January 2014	Complete pilot study and adapt questionnaire accordingly
January 2014	Copy questionnaires and information documents
February 2014	Complete data collection at the Cango marathon in Oudtshoorn
February - May 2014	Record study results and complete statistical analysis
May 2014 – January 2016	Writing of dissertation and research articles

3.9 PRACTICAL IMPLEMENTATION AND LIMITATIONS OF THE STUDY

The study relied on participants to report to the same weighing stations and return to be weighed. After the race, some of the athletes forgot to return to be weighed and some realised an hour after completing the race that they still had to be weighed, causing them to have already consumed fluids. These athletes were excluded from the study.

To keep the questionnaire short and easy to complete detailed information on practices was not included in the questionnaire, to ensure that the respondents' burden remain as low as possible.

3.10 STATISTICAL ANALYSIS

Data were entered in duplicate in an Excel spread sheet by the researcher and checked electronically by a biostatistician to verify accuracy. Statistical analysis was performed by the Department of Biostatistics, University of the Free State. Descriptive statistics were used to describe the sample. Means and standard deviations or medians and percentiles as appropriate were calculated to summarize continuous variables. Frequencies and percentages were calculated for categorical variables. Comparison of means was done using t-tests and comparison of medians was done using the appropriate non-parametric test. Chi-square or Fisher exact tests and two tailed Pearson or Spearman's correlations were used to describe and test associations between variables.

3.11 ETHICAL CONSIDERATIONS

Approval was obtained from the Ethics committee from the Faculty of Health Science and Warrant Officer R Hudges, head of the athletics sport club in the South Coast. All participants had to provide informed consent, before they were included in the study. Consent forms were completed and interviews were conducted in English, being the official language of the SANDF. With the consent form, an information document was provided to the participant where the study was explained in the language of their choice (Addendum E). All information regarding each participant was handled confidential during the study and no names were used on any data sheets. Participation was voluntary and participants could withdraw from the study at any stage. All participants were offered a complimentary session with a physiotherapist as an incentive to volunteer to participate.

3.12 CONCLUSION

In this chapter, the methodology for conducting this study has been described. Study sampling and selection, including the procedures and data collected during the study, have been outlined. The measures taken, to ensure validity and reliability and address limitations of the study, were also described. Practical implementation as well as ethical considerations and procedures used for statistical analysis were also discussed.

3.13 REFERENCES

Burton LJ and Mazerolle SM. 2011. Validity of a survey instrument examining athletic trainers' knowledge and practice believes regarding exertional heat stroke. Athletic Training Education, 6(1):36-45.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013].

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Hammond K. 2012. Chapter 14. Assessment: Dietary and Clinical Data, In Krause's food and nutrition care process. Ed. By Mahan KL, Escott-Stump S and Raymond JL. 12th edition. Philadelphia: W.B. Saunders Company: 599-603.

Kingston R. 2012. A Cross sectional survey on knowledge, attitude and practice of staff members towards daily water intake during working hours in international medical university, Malaysia. Asian Journal of Pharmaceutical and Clinical Research, 5(4): 974-2441.

Lee RD and Nieman DC. 2007. Nutritional Assessment. 4th edition. New York: McGraw-Hill Companies. [Online].

Available from:
http://highered.mheducation.com/sites/0078021332/information_center_view0/index.html
[Accessed May 2nd 2015].

Lysen LK and Israel DA. 2012. Chapter 22. Nutrition in weight management, In Krause's food and nutrition care process. Ed. By Mahan KL, Escott-Stump S and Raymond JL. 13th edition. Philadelphia: W.B. Saunders Company:462-488.

Nolte HW. 2011. Fluid, electrolyte and thermoregulatory responses to ad libitum water replacement during prolonged exercise. Doctoral thesis: University of Pretoria, 1-197.

O'Neal E, Wingo J, and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Stedman TL. 1982. Stedman"s Medical Dictionary. 24th edition. United States of America: Williams and Wilkins, 624

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ, and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

World Health Organisation. 2012. Obesity and overweight. [Online].

Available from: http://www.who.int/mediacentre/factsheet/fs311/en/ [Accessed April 18th, 2013].

CHAPTER 4: ANTHROPOMETRIC STATUS AND HYDRATION KNOWLEDGE OF LONG DISCTANCE RUNNERS IN THE SOUTH AFRICAN NATIONAL DEFENCE FORCE

This chapter is presented in an article format, with the purpose to report on findings from data collected according to the first and second objective set for this study, namely to describe the knowledge of long distance runners in the South African National Defence Force regarding fluid intake and hydration practices. This article also presents data on the anthropometric status of athletes in this study. The article will be submitted to the South African Journal of Sports Medicine (SAJSM) and is prepared according to the authors instructions (Addendum G). For the purpose of this dissertation, references will however be done according to the requirements of the Department of Nutrition and Dietetics, University of the Free State.

Authors

Lourika Benadie, BSc (Dietetics), Department of Nutrition and Dietetics, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa

Ronette Lategan, PhD (Dietetics), Department of Nutrition and Dietetics, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa

Jacques Raubenheimer, PhD (Research Psychology), Department of Biostatistics, Faculty of Health Sciences University of the Free Sate, Bloemfontein, South Africa

Corresponding author

Lourika Benadie

Department of Nutrition and Dietetics

Faculty of Health Sciences

University of the Free State

PO Box 339, Internal Box G24

Bloemfontein

9300

South Africa

Telephone: +27 51 401 2894

Fax: +27 51 401 2869

Email address: nutrition@ufs.ac.za

Abstract

Background: Hydration during endurance exercise plays an important role in optimal performance. Improving hydration knowledge of South African National Defence Force (SANDF) athletes can assist in developing strategies to improve practices in order to optimize physical performance.

Objectives: To describe the demographic background, anthropometric status and hydration knowledge of long distance runners in the SANDF.

Methods: A descriptive study amongst SANDF athletes, 18 years and older, participating in the Cango Marathon during 2014 were conducted. Weight and height were measured using standard techniques. Demographic information and knowledge regarding hydration practices were collected with a self-reporting questionnaire.

Results: The majority of the 144 participants were Black (40.5%), from the Western Cape (47.7%), with ages ranging between 19 and 60. According to body mass index (BMI) 36.0% was overweight/obese. Ninety five (66.0%) participants obtained hydration knowledge from books/magazines and 94 (65.3%) read labels on sports drinks. Although the majority (73.8%) of participants knew that fluid influences performance, 20 (13.9%) were not able to indicate why weight loss occurs during marathon participation and 38.9% were uncertain whether urine colour influences physical performance. Although 53.5% of participants knew that loss of fluid causes weight loss during exercise, 11.1% were not able to report symptoms of dehydration.

Conclusion: The majority of athletes had a normal BMI, but more than a third were overweight/ obese. Most athletes knew that fluid plays an important role in performance, but a few were unacquainted with symptoms of dehydration. Athletes should be able to identify dehydration early, understand the implications, and be equipped to restore hydration status in order to optimize performance.

Background

Optimal hydration is vital for the health and performance of endurance athletes. Athletes need adequate hydration before, during and after exercise to maintain body fluid homeostasis, in order to prevent dehydration and ensure optimal performance (Gordon et al., 2015:Online; Kumley, 2010:1). Healthy individuals can maintain body fluid homeostasis in spite of varying fluid needs and exposure to stressors. The only challenge is maintaining body fluid homeostasis during physical exercise. Most individuals however do not have adequate knowledge on how much fluid to consume and when to consume it during exercise (Wilson, 2008:1).

Fluid intake recommendations vary significantly between different sport governing organisations. Recommendations fluctuate from general to very specific. General recommendations include that athletes should start drinking fluid as early as possible and at regular intervals to replace sweat loss (Zoorob et al., 2013:478; Murray et al., 2003:3), following physiological cues like thirst (Tam et al., 2011:218; Hew-Butler et al., 2006:289) and drinking adequate fluids to prevent excessive weight loss (Sawka et al., 2007:377). More specific recommendations include 500-2000 ml fluid per hour (Murray et al., 2003:3); 200-300 ml every 10 to 20 minutes (Zoorob et al., 2013:478; Casa et al., 2000:212-224) and 450-675 ml of fluid per 0.5 kg of body weight lost during exercise (Sawka et al., 2007:377).

Body weight difference is the easiest method an athlete can use to determine hydration status. The percentage of body weight lost after an endurance race can indicate the level of dehydration in athletes. To calculate a body weight loss difference, an athlete must first determine euhydrated weight by weighting themselves before exercise for several days. As soon as an athlete knows their euhydrated weight, they can use their pre-race weight and post-race weight to determine how much they need to drink before a race. Weight difference in pre-; and post-race weight is mostly due to the loss of fluid through sweating. An athlete can therefore use weight difference to determine how much fluid to consume after the race, to adequately rehydrate (Flynn, 2014:17; Casa et al., 2010:147). Athletes generally lose 1.7% to 1.8% of body weight during exercise (Costa et al., 2013:Online; Wilson, 2008:3-4). Each kilogram of weight loss reflects approximately one litre of fluid loss. A weight difference of one to two percent can lead to decreased endurance performance as well as decreased physiological function, increase core temperature, increase plasma osmolality, decrease plasma volume, and may affect the intracellular and extracellular electrolyte balance (Gordon et al., 2015:Online; Casa et al., 2010:147; Wilson, 2008:3-4; Montain et al., 2006:4; Duvillard et al., 2004:651). A three percent weight loss can lead to a greater decrease in performance and possible heat illness (Casa et al., 2010:147).

By analysing urine, normal and pathological conditions can be determined. Urinary markers that indicate hydration status of athletes include urine volume, urine specific gravity, urine osmolality, and urine colour (Cheuvront & Sawka, 2014:Online). It has been suggested that almost anyone can determine the need for hydration if urine colour was directly proportional to the level of hydration (Armstrong, 2005:45; Casa et al., 2005:115). Urine colour is determined by the amount of uro-chrome, the product of hemoglobin breakdown, in urine. Armstrong (2005:45) made use of a urine colour scale ranging from pale yellow (1) to brownish green (8). Results from this study showed that an individual with pale yellow urine will be within one percent of euhydration status. The lighter urine colour is, the better hydrated a person will be. On the other hand, the darker the urine colour, the more dehydrated the person will be. Urine colour however does not have the same accuracy as urine specific gravity or osmolality.

The signs and symptoms that occur when an athlete dehydrates include; thirst, dizziness, headache, tachycardia as well as lower oral mucosal surface moisture and skin turgor, but these signs and symptoms are too vague and imprecise to accurately assess the hydration status of an athlete (Sedek et al., 2015:659; Casa et al., 2005:115-116). Urine colour is therefore still regarded as the simplest measurement to assess hydration status of an athlete. Athletes are recommended to observe their urine output during the day to determine if changes occur in urine colour or urine flow. The volume and frequency of urine output should be consistent and the colour should stay light (Heneghan et al., 2012:345).

According to a study by O'Neal et al. (2011:586), most athletes gain advice regarding beverage choice and hydration from other runners. Food labels can however also serve as a source of information for athletes; and according to Burke and Deakin (2010:685) health conscious athletes are the ones who generally read labels on sports drinks and food products.

Although knowledge does not necessarily predict or determine behaviour, the information individuals have does influence the decisions they make (Ajzen et al., 2011:116). In this study, knowledge was therefore determined to provide an indication of the knowledge base that exists and could reflect hydration practices.

Objectives

The objective of this study was to describe the demographic background, anthropometric status and hydration knowledge of long distance runners in the SANDF in relation to current hydration guidelines.

Methods

A descriptive, observational study was performed. Approval for the study was obtained from the Head of Sport and the Head of the Athletics club from the SANDF. Ethical approval was obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS209/2013). After approval was obtained, a pilot study was performed on five participants at the Tramonto Marathon in George. During the pilot study, measuring instruments were tested and questions in the questionnaire evaluated and adapted accordingly. Data from the pilot study were not included in this study. Four Emergency Medical Practitioners, registered with the Health Professions Council, employed by the SANDF, were trained by the researcher to assist in taking the anthropometric measurements.

The study population consisted of males and females, older than 18 years and employed by the SANDF, that participated in the half or full marathon during the Cango race in Oudtshoorn in 2014. A table was made available at the entrance of the registration area, where questionnaires could be filled in. Five stations were set up for registration in this study. Each station had the same model Seca scale and the stations were marked one to five. Participants were requested to use the same number station when weighing at the beginning and the end of the race to ensure accurate weight measurements. The race number of each participant was used as a reference to ensure confidentiality of participants. An information letter on the study was provided to participants, in the language of their choice, as part of pre-registration information. Participants were required to complete the consent form before inclusion in the study. Each participant was requested to complete the questionnaire during registration, where information on hydration knowledge was obtained. General demographic information as well as information on endurance event participation and hydration knowledge was collected from each participant using a structured, self-reporting questionnaire during registration.

On the day before the race, at registration, weight was measured on an electronic platform Seca scale, model 220. Body weight was recorded to the nearest 100 g. The participants wore minimum clothes, their shoes were removed and weight was distributed evenly between both feet. Weight was measured again on the day of the event, before and after the race after drying excess perspiration, to determine fluid loss. Height was measured by the researcher and trained helpers with a Seca stadiometer to the nearest 0.1 cm at registration. Participants were measured without shoes, shoulders relaxed, feet flat, heels together and arms relaxed at each side. Participants stood with the spine against a sturdy vertical surface, shoulder blades, buttocks and heels touching the measuring surface, looking forward while taking a deep breath before measurement and they stood with their head in a Frankfort plane. Weight and height measurements were used to calculate body mass index (BMI). A BMI of less than 18.5 kg/m^2 were used to define underweight, between 18.5 kg/m^2 and 24.9 kg/m^2 indicated a normal BMI, between 25 kg/m^2 and 29.9 kg/m^2 indicated overweight and 30 kg/m^2 or more defined obesity (WHO, 2012:Online).

Statistics

Statistical analysis was done by the Department of Biostatistics, University of the Free State. Software for data capturing and statistical analysis included Microsoft Excel (2010) for Windows 7 and SAS/STAT software, Version 12.4 of the SAS system for Windows (© 2010 SAS Institute Inc.). Data were entered in duplicate by the researcher and checked electronically to verify accuracy. Descriptive statistics were used to describe the sample. Means and standard deviations or medians and percentiles as appropriate were calculated to summarize continuous variables. Frequencies and percentages were calculated for categorical variables. Comparison of means was done using Student's t-tests and comparison of medians was done using the appropriate non-parametric test.

Results

Demographic information

The final sample consisted of 144 long distance runners who participated in the Cango Marathon in Oudtshoorn, Western Cape on 22 February 2014. Of the total sample 13 participants did not indicate their race. Of the participants who indicated their gender, 80.5% (n=107) were male, and 19.6% (26) female, and ages ranged between 19 and 60 years, with a mean age of 40 years. All athletes who participated registered either for the half (21.1 km) or full marathon (42.2 km) at the SANDF Sports Club. Table 4.1 summarizes the demographic information of the study sample and Table 4.2 summarize race experience of participants.

Table 4.1 Demographic information

Variable	**N**	**%**
Gender	133	
Male	107	80.5
Female	26	19.6
Race	131	
White	44	33.6
Black	53	40.5
Coloured	33	25.2
Asian	1	0.8
Occupation	79	
Administration	29	36.7
Operators	41	51.9
Managers	9	11.4
Province	128	
Western Cape	61	47.7
Eastern Cape	9	7.0
Free State	11	8.6
KwaZulu-Natal	7	5.5
Gauteng	26	20.3
Limpopo	14	10.9
Use coach or trainer	114	
Yes	18	14.5
No	106	85.5

Table 4.2 Race experience

Variable	N	Median	Range
Age (years)	127	40	19 – 60
Months participating in half marathons	15	67	13-365
Months participating in full marathons	4	97.5	42-175
Number of half marathons completed	74	20.8	1-150
Number of full marathons completed	49	27.7	1-150

Most participants were of black race (40.5%, n=53) and more than half (51.9%, n=41) of the study sample worked as operators, which include radar operators, mechanics, soldiers, fire fighters, operational emergency care practitioners and instructors. A total of 65 participants did not indicate their occupation. Almost half of the participants (47.7%, n=61) were from units situated in the Western Cape. Seventy four participants have completed half-marathons with one half marathon being the minimum and 150 half marathons the maximum completed. Forty nine participants have completed full marathons with one marathon the minimum and 150 marathons the maximum. Some athletes (16%) reported to have done both half; as well as full marathons during their athletic career.

Sixteen (14.2%) participants had a usual running time of less than one hour and fifty minutes for a half marathon and seven (22.6%) had a usual running time of less than four hours for a full marathon. Few athletes reported on how long they have been participating in half and full marathons. Participation in marathons ranged from 42 to 175 months and participation in half marathons ranged between 13 and 365 months. Most participants served as their own coach, with only 14.5% (n=18) who made use of a coach or trainer.

Anthropometry

Of the 144 participants who provided informed consent and indicated their gender, 126 participants reported at registration to be weighed and 125 for height measurement. Data on anthropometric measurements are reported in Table 4.3.

Table 4.3 Anthropometric measurements of participants

Variable	n	Mean	Range
Weight at registration:			
Males	102	72.5 kg	45 - 105.5 kg
Females	24	68.8 kg	50-96.4 kg
Height:			
Males	102	172 cm	154-190 cm
Females	23	169 cm	159-187 cm
Body mass index:			
Males	102	24.5 kg/m^2	17.4-36.1 kg/m^2
Females	23	23.5 kg/m^2	17.9-29 kg/m^2

The lowest recorded weight was for a male weighing 45 kg, classified as underweight, and the highest weight recorded was a male weighing 105.5 kg, classified as being obese. Height measurements ranged from 154 cm to 190 cm. BMI classification is reported in Table 4.4 for 102 males and 23 females.

Table 4.4 BMI classification of participants

Classification	n	%
Underweight (<18.5 kg/m^2)		
Total	4	3.2
Male	3	2.9
Female	1	4.4
Normal weight (18.5 – 24.9 kg/m^2)		
Total	76	60.8
Male	62	60.8
Female	14	60.9
Overweight (25 – 29.9 kg/m^2)		
Total	38	30.4
Male	30	29.4
Female	8	34.8

Obese class 1 (30 – 34.9 kg/m^2)		
Total	6	4.8
Male	6	5.9
Female	0	0
Obese class 2 (35 – 39.9 kg/m^2)		
Total	1	0.8
Male	1	1.0
Female	0	0
Obese class III (≥40.00 kg/m^2)		
Total	0	0
Male	0	0
Female	0	0

When interpreting BMI, 3.2% (n=4) from a total of 125 participants were classified as underweight, with the lowest BMI being 17.4 kg/m^2. The highest BMI recorded was 36.1 kg/m^2 and most participants (60.8%, n=76) had a BMI classified in the normal category. 36.0% of participants fell in the overweight to obese category, with a higher percentage of males being classified as overweight/obese.

Knowledge regarding hydration

The hydration knowledge of participants is summarized in Table 4.5.

Table 4.5 Hydration knowledge of participants

Variable	n	%
Does fluid intake during a race help you perform better?	132	
Yes	99	75.0
No	10	7.6
Unsure	23	17.4
Reasons why people weigh less after running a marathon:	144	
Unsure	20	13.9
Sweating	72	50.0

Dehydration	1	0.7
Hydration	4	2.8
Burn fat	8	5.6
Other reasons	17	11.8
Does urine colour have an effect of performance?	144	
Yes	40	27.8
No	34	23.6
Unsure	56	38.9
Not answered	14	9.7
Reasons why urine colour is sometimes darker:	103	
Loss of fluids	23	16.0
Drinking less water/Not enough water/Intake of fluids	23	16.0
Type of fluids	2	1.4
Unsure	32	22.2
Other	23	16.0
If urine colour is dark, is it linked to increased or decreased performance?	144	
Increase	17	11.8
Decrease	39	27.1
Unsure	71	49.3
Not answered	17	11.8
If urine colour is light, is it linked to increased or decreased performance?	144	
Increase	45	31.3
Decrease	11	7.6
Unsure	68	47.2
Not answered	20	13.9
Where did you learn about fluid intake during a race?	144	
Books/magazines	95	66.0
Television	28	19.4
Coaches/co runners	58	40.3
Friends	30	20.8
Other: Not specified	5	3.5
Other: Internet	2	1.4

Do you read the information on the label of a sports drink?	144	
Yes	94	65.3
No	39	27.1
Not answered	11	7.6
Information participants look for on the label of a sports drink:	144	
Sugar level/Carbohydrates	20	13.9
Energy content	17	11.8
Ingredients/ content	10	6.9
Expiry date	10	6.9
Nutrients	9	6.3
Sodium	6	4.2
Electrolytes	5	3.5
Other	31	21.5
Signs of dehydration listed:		
Signs of dehydration listed:	144	
Dizziness	35	24.3
Dry mouth	24	16.7
Don’t know	16	11.1
Weakness	15	10.4
Cramps	14	9.7
Sweating	10	6.9
Reduced sweating	9	6.3
Tired	9	6.3
Thirsty	8	5.6
Other*	7	4.9
	55	38.5

*Other included: Headache, nausea, urine colour, salt on face, cannot urinate, drowsiness, intake of water, pale skin, dryness, struggling to breathe, goose bumps, level of consciousness, feeling numbness, reduced pace, confused, dry skin, low blood pressure, hallucinations, cold, recovery, eeduced pain, white tongue, pale eyes, water to drink, vomiting, blurred vision, distance, salt, shallow eyes.

The majority of participants knew that fluid intake during a race will improve performance. Although not all participants completed this question, more than half of the participants knew that sweating causes weight loss during a race but 13.9% (n=20) were not sure why athletes lose weight during a race, while 5.6% (n=8) reported that fat burn causes the weight loss experienced during a race. Other reasons (11.8%, n=17) mentioned by participants why they think athletes lose weight during a race included: loss of protein, to check weight-loss, tiredness, excessive training, hard work, no food intake, heat, weight loss, endurance, burn energy and substance use.

Almost a quarter (22.2%, n=32) of participants were not able to explain why urine colour is sometimes darker than other times and although correct reasons were provided that reflected on fluid intake, various other reasons were also provided as reasons for darker urine, but were not related to fluid intake.. Half of the participants (49.3%, n=71) did not know whether dark or light urine colour will increase or decrease performance.

Of the 144 participants, 66.0% (n=95) obtained hydration advice from books and magazines as main source of information. 65.3% (n=94) participants read the labels of sport drinks that they use during a race and focus mostly on the carbohydrate or sugar level of the sports drink (13.9%, n=20). Although a large number of participants indicated that they read other information on the label, these varied widely and included: fat, quantity, acids, vitamins, banned substances, etc.

More than a tenth of participants indicated that they did not know the signs of dehydration (11.1%, n=16), and those who reported signs of dehydration, mostly listed dizziness (24.3%, n=35). Other signs listed were generally correct and the most listed signs included dry mouth, weakness, cramps, sweating, tiredness, thirst, headache, nausea and urine colour.

Discussion

The aim of this study was to determine the anthropometric status of athletes in the SANDF and describe their knowledge regarding fluid replacement during exercise. In this sample, the majority (80.5%) of participants were male with a mean age of 40 years, implicating experience and expecting a good knowledge base. Most of the participating athletes were residents of the Western Cape and working as operators, which can be expected, as the SANDF is situated in Oudtshoorn and operates as a training unit. When it comes to training and education, only a small number of participants make use of coaches to help them train and prepare for races. Participants reported that they mainly obtain knowledge on hydration practices from reading books and magazines. Most participants had a normal BMI, which can be expected as they are employed in a training unit and exercise regularly to compete in marathons. It was however unexpected that more than a third (36.0%) of participants were classified in the overweight to obese category, especially as they are athletes who seemingly participate regularly in races.

Most participants in this study (75%) knew that consuming fluids during a race will improve performance, which agrees with Jusoh (2010:59), reporting that 78 percent of athletes believed that they should drink fluid during a race for optimal performance. In the study by O'Neal et al., (2011:586), 70 percent of athletes believed that their performance decreased when they are dehydrated (O'Neal et al., 2011:586).

Most participants knew that weight loss during a race resulted from sweating, excessive training, dehydration and heat, the same symptoms reported by Casa et al., (2005:115-116). According to the American College of Sports Medicine (ACSM) guidelines, athletes should know that a decrease of two to three percent of body weight will decrease performance and that weighing before and after exercise provides a good assessment of hydration status (Rodriguez et al., 2009:710).

As urine colour is considered to be a good screening measure of hydration status (Casa et al., 2005:115-116) it is expected that experienced athletes should know that urine should have a pale yellow colour when optimally hydrated. In this study however, almost a quarter of participants did not know why urine colour is sometimes darker, and almost half of the participants were unsure whether dark urine colour increases or decreases performance. In a study by O'Neal et al. (2011:586), 20 percent of athletes monitored their hydration status by using urine colour and seven percent indicated that urine colour was the most often used method for checking hydration status.

The knowledge participants had regarding fluid replacement, came from various sources. Athletes in this study made more use of books or magazines (66%) than coaches or co-runners (40.3%), compared to the results of O'Neal et al. (2011:586), who reported that 64 percent of athletes make use of advice from other runners about beverage choice and hydration.

Participants, who indicated that they read product labels, mostly consulted the label for sugar or carbohydrate levels and ingredients and only a small number focussed on the electrolyte level. In the study of O'Neal et al., (2011:586), most athletes consulted the label for carbohydrate and electrolyte level, which according to the ACSM is necessary to provide electrolytes, energy and carbohydrates to replace muscle glycogen and ensure rapid recovery.

When identifying dehydration cues, it was a cause for concern that one out of ten athletes were not aware of the signs of dehydration, increasing the potential risk for heat-related illnesses. Dizziness and dry mouth were the most mentioned signs of dehydration, which is accurate (Casa et al., 2005:115-116). Many other reported signs were also correct and only tachycardia and skin turgor were not mentioned, indicating a relative good knowledge regarding the signs of dehydration.

Limitation of this study

The questionnaire used in this study was self-reported, which allows for honest anonymous feed-back, but resulted in missing data, as also described by Albert and Tullis (2013:126). Some participants did not return after the race to be weighed and although requested not to, some participants consumed beverages before they were weighed, resulting in these athletes to be excluded from the study sample and reducing the number of participants.

Conclusion and recommendations

Dehydration during endurance exercise can increase the risk of heat-related diseases like heat exhaustion, heat stroke and muscle cramping. Many studies have found that a body weight loss of more than two percent can result in decreased physical performance. Various research institutes have researched and studied the outcome regarding the type, time and amount of fluid athletes should consume before, during and after a race. As more and more people start to participate in endurance sports, more athletes have the risk of developing heat-related illnesses if they are not well informed.

The results of this study indicate that, although the majority of athletes from the SANDF had a normal BMI, more than a third was overweight or obese. Long distance runners from the SANDF may also be in need of more information regarding the identification of the symptoms of dehydration and how to make use of urine colour as marker for hydration, in order to rehydrate optimally. If members do not know the symptoms they will experience when dehydrated, they will not be able to address dehydration in time and performance will be negatively influenced. Participants use magazines and books as main resources to educate themselves and efforts can be made to ensure that adequate and correct information is distributed through these sources. Athletes do not generally make use of coaches, who can help educate them regarding fluid. A drive to inform members about the importance of optimal hydration during intense physical activity and how to use urine colour as indicator of hydration status could therefore be beneficial for marathon runners to improve physical performance and prevent health problems resulting from dehydration.

References

Ajzen I Joyce N, Sheikh S, and Cote NG. 2011. Knowledge and the Prediction of Behaviour: The Role of Information Accuracy in the Theory of Planned Behaviour. Basic and Applied Social Psychology, 116.

Albert W and Tullis T. 2013. Measuring the user experience. 2nd edition. Elsevier:126.

Armstrong LE. 2005. Hydration Assessment Techniques. Nutrition Reviews, 63(6):40-65.

Burke L and Deakin V. 2010. Clinical Sports Nutrition. 4th edition. McGraw- Hill, Australie:684-685.

Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, and Stone JA. 2000. National Athletic Training Association. Fluid replacement for athletes. Journal of Athletic Training, 35:212-224.

Casa DJ, Clarkson P, and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Casa DJ, Stearns RL, Lopez RM, Ganio MS, McDermott BP, Yeargin SW, Yananoto LM, Mazerolle SM, Roti MW, Armstrong LE, and Maresh CM. 2010. Influence of hydration on physiological function and performance during trail running in the heat. Journal of Athletic Training, 45(2):157-156.

Cheuvront SN and Sawka MN. 2014. Hydration assessment of athletes. Gatorade Sports Science Institute. [Online].

Available form: http://www.gssiweb.org/Article/sse-97-hydration-assessment-of-athletes [Accessed June 18th 2015].

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013]

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Gordon RE, Kassier SM, and Biggs C. 2015. Hydration status and fluid intake of urban, underprivileged South African male adolescent soccer players during training. Journal of the International Society of Sports Nutrition. [Online].

Available from: www.jissn.com/content/12/1/21 [Accessed March 13th, 2013].

Heneghan C, Gill P, O'Neill B, Lasserson D, Thake M, and Thompson M. 2012.Mythbusting sports and exercise products. British Medical Journal, 345-484.

Hew-Butler T, Verbalis JG, and Noakes TD. 2006. Updated Fluid Recommendation: Position Statement from the International Marathon Medical Directors Association (IMMDA). Clinical Journal of Sport Medicine, 16:283–292.

Jusoh N. 2010. Hydration, thirst and fluid balance in resting and exercising individuals. Doctor of Philosophy degree. Loughborough University, 1-222.

Kumley RF. 2010. Hydration and fluid replacement knowledge, attitudes, barriers and behaviours of NCAA division football players at Midwestern University. Master's Degree. Ball State University, 1-116.

Montain SJ, Cheuvront SN, Carter R, and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas: 1-8.

Murray B, Stofan J, and Eichner ER. 2003. Hyponatremia in Athletes. Gatorade Sports Science Institute, 16(1):1-6.

O'Neal E, Wingo J, and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Rodriguez NR, DiMarco NM, and Langley S. 2009. Nutrition and Athletic Performance. American College of Sport Medicine, 709-731.

Sawka MN, Burke LM, and Eichner ER. 2007. American College of Sports Medicine positions stand Exercise and fluid replacement. Medicine and Scientific in Sports and Exercise, 39:377–90.

Sedek R, Mohamad MM, and Kasim ZM. 2015. Knowledge, attitudes and practices on hydration and fluid replacement among endurance sports athletes in national university of Malaysia. Pakistan Journal of Nutrition, 14(10):658-665.

Tam N, Nolte HW, and Noakes TD. 2011. Changes in total body water content during running races of 21.1 km and 56 km in athletes drinking. Clinical Journal of Sports Nutrition, 21 (3):218–225.

World Health Organisation. 2012. Obesity and overweight. [Online].

Available from: http://www.who.int/mediacentre/factsheet/fs311/en/ [Accessed April 18th, 2013].

Wilson CK. 2008. What is the relationship between hydration knowledge, exercise intensity, and hydration behaviours of college students in Southern Texas. Lamar University, 1-59.

Zoorob R, Parrish ME, O'Hara H, and Kalliny M. 2013. Sport nutrition needs before, during, and after exercise. Primary Care The Clinical Office Practice, 40(2):475-486.

CHAPTER 5: HYDRATION PRACTICES OF LONG DISTANCE RUNNERS IN THE SOUTH AFRICAN NATIONAL DEFENCE FORCE

This chapter is presented in an article format, with the main purpose to report on findings from the first, third and fourth objectives of this study, namely to describe the dempgrapic background, anthropometric measurements and hydration practices of long distance runners in the South African National Defence Force in relation to current hydration recommendations. General demographic background and a description of the anthropometric measurements of participants are also reported. This article will be submitted to the Journal of the International Society of Sports Nutrition (JISSN) and is prepared according to the journal's authors instructions (Addendum H). Referencing however is done according to the requirements of the Department of Nutrition and Dietetics, University of the Free State.

Authors

Lourika Benadie, BSc (Dietetics), Department of Nutrition and Dietetics, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa

Ronette Lategan, PhD (Dietetics), Department of Nutrition and Dietetics, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa

Jacques Raubenheimer, PhD (Research Psychology), Department of Biostatistics, Faculty of Health Sciences University of the Free State, Bloemfontein, South Africa

Corresponding author

Lourika Benadie

Department of Nutrition and Dietetics

Faculty of Health Sciences

University of the Free State

PO Box 339, Internal Box G24

Bloemfontein

9300

South Africa

Telephone: +27 51 401 2894

Fax: +27 51 401 2869

Email address: nutrition@ufs.ac.za

Abstract

Background: Athletic performance is influenced by genetic as well as environmental factors. Endurance sports are challenging in terms of maintaining optimal hydration, especially when environmental conditions and temperatures vary to a large extent. Appropriate fluid replacement for athletes to maintain optimal hydration is regarded as a fundamental element for an athlete's physical performance. If adequate hydration does not occur during extreme exercise conditions, heat-related illness can develop in athletes. This study aimed to determined hydration practices of long distance runners from the South African National Defence Force (SANDF) in relation to current hydration guidelines.

Methods: A descriptive, observational study was conducted amongst SANDF athletes, 18 years and older who participated in the half (21.1 km) or full (42.2 km) Cango Marathon at the SANDF Sports Club in Oudtshoorn, South Africa during 2014. General demographic information and information regarding hydration practices were collected by means of a structured, self-reporting questionnaire. Weight and height were measured, using standard techniques to calculate body mass index (BMI).

Results: A sample of 144 participants were included, with the majority being black (40.5%) males (80.5%), with ages ranging between 19 and 60 years. A normal BMI was recorded for 59.9% of participants and more than a third (36%) were classified as overweight/ obese. Fifty five (42%) participants lost 2% or more of body weight during the race. Nine participants (6.3%) indicated that they do not consume extra fluids before, during or after a race. Fifty eight (40.3%) participants indicated that they consume extra fluids 10 minutes to 2 hours before a race. Mean fluid intake for the half marathon was 176 ml/hour, significantly higher (p=0.0001) than the mean fluid intake of 125 ml/hour for the full marathon. To rehydrate participants mostly preferred energy drinks (32.6%) before a race and water during (28.5%) and after (21.5%) a race. Most participants (78.5%) relied solely on fluids provided by the organisers during the race and few (13.19%) carried fluids with them. The amount of fluid consumed depended mostly (71.1%) on environmental conditions, with only 13.6% participants consuming more fluids due to dehydration cues. Most participants (61.8%) reported to drink according to thirst rather than to maintain weight or according to schedule and more than half (54.8%) reported that they never dehydrate during a race.

Conclusion: Fluid consumption per hour was significantly more for the half marathon than the full marathon. Although the majority (58.3%) of participants drink extra fluids during the race, a large percentage still lost more than 2% of body weight during the race, which may influence performance and increase the risk for heat-related illness. Participants mostly preferred water as rehydration fluid during and after the race, which is not ideal to replace electrolytes and replenish carbohydrates. Compared to existing hydration guidelines, athletes stilled need to be trained to monitor hydration status and develop an appropriate individualized rehydration strategy.

Keywords: Hydration practices; endurance athletes; fluid consumption; dehydration; fluid replacement.

Background

Fluid needs vary from person to person because of differences in body size, metabolic rate, environmental conditions, physical fitness and activity duration (Casa et al., 2005:115-127). Adequate hydration is essential to ensure optimal performance and to prevent heat-related-illness during endurance exercise (Flynn, 2014:20; Geijer et al., 2009:541). The human body has the ability to closely regulate body water and electrolyte balance, as long as food and fluids are available. Exercise and environmental factors can, however, challenge this ability (Montain et al., 2006:1). While exercising, the human body produces heat because of energy produced duringmuscle exertions. A natural cooling mechanism occurs through sweating, where evaporation of sweat from the skin's surface allows release of heat and the body to cool (Jeukendrip, 2011:91; Casa et al., 2005:115).

Replacement of body fluid lost through sweat is an important factor for athletes to consider, as excessive body water and/or electrolyte losses can disrupt physiological homeostasis and threaten both health and performance (Jeukendrip, 2011:91; Montain et al., 2006:1). Marathons and half marathons are some of the most challenging endurance events, with growing numbers in participation and where competitions often take place in extreme environmental conditions. A decline in athletic performance has been reported in warmer weather conditions and cooler weather conditions are associated with a better ability to maintain running pace (Helou et al., 2012:1).

Recent position papers for athletes promote sufficient fluid intake before, during and after exercise to minimize weight loss without exceeding sweat losses, with the ultimate goal to avoid fluid loss of more than two percent body weight (Gordon et al., 2015:Online; O'Neal et al., 2011:581; Kumley, 2010:1). The Gatorade Sports Science Institute (GSSI) initially recommended that athletes should start drinking fluids early and at regular intervals (Zoorob et al., 2013:478; Murray et al., 2003:3). The National Athletic Trainers Association's (NATA) recommendation 200-300 ml every 10 to 20 minutes (Zoorob et al., 2013:478; Casa et al., 2000:212-224) and 450-675 ml of fluid per 0.5 kg of body weight lost during exercise (Sawka et al., 2007:377), but the International Marathon Medical Directors Association (IMMDA) recommends a more individual approach and advise athletes to follow physiological cues, like thirst (Tam et al., 2011:218; Hew-Butler et al., 2006:289). In contrast, the International Association of Athletic Federations (IAAF) recommends that athletes should drink beyond thirst (Sawka et al., 2007:377). The American College of Sports Medicine (ACSM) also recommends a more customized individual approach, with the goal of drinking fluids to prevent excessive weight loss. Their current recommendation for optimal rehydration is 450-675 ml fluid for every 0.5 kg body weight that has been lost during exercise (Sawka et al., 2007:377). In summary, there has been a pronounced shift in paradigm with regard to hydration recommendations during the past decade. However, the latest position statements from the ACSM, as well as NATA, GSSI, and the Brazilian Society of Sports Medicine, encourage athletes to replace up to 150 percent of weight loss after exercise (Sawka et al., 2007:377; Murray et al., 2003:3; Casa et al., 2000:212).

The South African National Defence Force (SANDF) train and prepare soldiers to be fit and physically equipped for external deployments and possible war situations. The intensity of training and level of fitness required, often cause challenges in terms of hydration. When members undergo intense training and are exposed to extreme environmental conditions, fluid losses might compromise their ability to perform optimally. Because of the important effect of hydration on health and performance, this study was conducted to describe hydration practices of long distance runners in the SANDF in relation to current hydration recommendations.

Study design

A descriptive, observational study was performed amongst a population representing long distance runners of the SANDF.

Methods

Approval for this study was obtained from the Head of Sport and the Head of the Athletics club from the SANDF. Ethical approval was obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS209/2013). After approval was obtained, a pilot study was performed on five participants at the Tramonto Marathon in George, whose data were not included in this study. During the pilot study measuring instruments were tested and questions in the questionnaire evaluated and adapted accordingly. At study registration, a self-reporting questionnaire was provided to each participant, collecting information regarding the knowledge of athletes concerning hydration. Standard fluids were made available at each water station, with each cup containing 100 ml fluid as provided by the race organisers, so that participants could report on the amount of units they consumed during the race rather than the amount in millilitres, increasing accuracy of reporting.

Anthropometric measurements were recorded to report on body composition. For the purpose of this study, pre and post-race weight was measured and compared to reflect on the hydration status of participants. Although urine color, osmolality and other methods are available to indicate hydration status, weight change was a more practical method for this setting. Weight was measured twice on three occasions during this study, at registration, before the race and after the race. Weight was measured by the researcher and trained helpers, using an electronic platform Seca scale, model 220 and recorded to the nearest 100 g. Participants wore minimum clothing, shoes were removed, and weight was distributed evenly between both feet. Weight was measured the day before the race, at registration, as well as on the day of the event, before and after the race. Weight was measured at the end of the race to determine fluid loss, after drying excess perspiration. Height was measured to the nearest 0.1 cm at registration using a Seca stadiometer model 220. Participants were measured without shoes, shoulders relaxed, feet flat, heels together and arms relaxed at each side (De Bruyne et al., 2012:391; WHO, 2008:3-3-9). Weight and height measurements were used to calculate BMI. A BMI of less than 18.5 kg/m^2 was used to define underweight, between 18.5 kg/m^2 and

24.9 kg/m^2 indicated a normal BMI, between 25.0 kg/m^2 and 29.9 kg/m^2 indicated overweight and 30.0 kg/m^2 or more defined obesity (WHO, 2012:Online). General demographic information as well as information on marathon participation was collected using a structured, self-reporting questionnaire at race registration. Data were also collected on hydration practices, fluid preferences and identification of hydration cues and symptoms. In order to validate responses and obtain a better reflection of practices, some questions collected similar data.

Subjects

The study sample consisted of male and female athletes, aged 18 years and older, employed by the SANDF, who participated in the half or full marathon during the Cango race in Oudtshoorn, South Africa in 2014.

Procedures

On the day before the event, a registration table for the study was placed at the entrance of the race registration area, where questionnaires could be completed. An information letter on the study was provided to participants as part of pre-registration information and volunteers were asked to complete the consent form before inclusion in the study. Each participant was requested to complete the self-reporting questionnaire that collected data on hydration practices. To assist with data collection, the researcher trained four registered Emergency Medical Practitioners from the SANDF. These members were trained to assist with anthropometric measurements. Five data collection stations where set up and each station had the same model Seca scale, marked one to five. Participants were requested to use the same station number when weighing at the start and end of the race, to ensure that the same measuring equipment was used. The race number of each participant was used as reference to ensure confidentiality. Members managing the water stations during the race were informed regarding the study and fluid units.

Environmental conditions were recorded during the race on 22 February 2014. Temperature, humidity and wind speed for Oudtshoorn were obtained from the George Airport and documented at the beginning and the end of the race.

Statistical analyses

Statistical analysis was performed by the Department of Biostatistics, University of the Free State. Data capturing and statistical analysis programs used included Microsoft Excel (2010) for Windows 7 and SAS/STAT software, Version 12.4 of the SAS system for Windows (© 2010 SAS Institute Inc.). Data were entered in duplicate by the researcher and checked electronically by the biostatistician to verify accuracy. Descriptive statistics were used to describe the sample. Means and standard deviations or medians and percentiles as appropriate were calculated to describe continuous variables. Frequencies and percentages were calculated for categorical variables. Comparison of means was done using Student's t-tests and comparison of medians was done using the appropriate non-parametric test. Chi-square or Fisher exact tests and two tailed Pearson or Spearman's correlations were used to describe and test associations between variables.

Results

One hundred and forty four participants, employed by the SANDF, who provided informed consent, were included in this study. Athletes registered either for the half or full marathon. As the questionnaire was self-reported, not all questions were completed by all participants as indicated in the results.

Environmental conditions

During the race, environmental temperatures ranged between 13 degrees Celsius at 06:00 to 26 degrees Celsius at 12:00, with humidity ranging between 46% and 94%. Wind velocity varied between 7 km/h and 15 km/h.

Demographic information

Demographic information, including gender, race, age and history of race participation is provided in Table 5.1.

Table 5.1 Demographic information of participants

Variable	n	%	Median	Range
***Gender**	133			
Male	107	80.5		
Female	26	19.6		
Race	131			
White	44	33.6		
Black	53	40.5		
Coloured	33	25.2		
Asian	1	0.8		
Age	127		40	19-60
19-39	56	44.1		
40-60	71	55.9		
Duration of participation in half marathons (months)	15		67	13-365
Duration of participation in full marathons (months)	4		97.5	42-175
Number of half marathons completed	74		13.5	1-150
Male	58		12.0	1-150
Female	16		17.5	3-60
Number of full marathons completed*	49		12.0	1-150
Male	39		15.0	1-150
Female	9		12.0	3-50

* One participant not indicating gender

Of the 144 participants who provided informed consent, 133 specified their gender, with the majority of participants being male (80.5%, n=107) and of black race (40.5%, n=53). Participants were aged between 19 and 60 years, with a median age of 40 years. More than half of the participants were older than 40 years (55.9%, n=71). Few athletes reported on their previous race experience, with experience ranging between 13 and 365 months. Of the 101 participants who reported on previous race participation, 45.5% (n=46) completed ten or more half marathons and 35.6%(n=36) completed ten or more full marathons.

Anthropometry

During race registration, weight was measured for 133 and height for 132 participants. BMI ranged between 17.4 kg/m^2 and 36.1 kg/m^2. Table 5.2 provides the BMI classification of participants at registration.

Table 5.2 BMI classification of participants at registration

BMI classification	n	%
Underweight ($\leq$ 18.5 kg/m^2)	4	3.2
Normal weight (18.5 - 24.9 kg/m^2)	76	60.8
Overweight (25.0 kg/m^2 - 29.9 kg/m^2)	38	30.4
Obese ($\geq$30.0 kg/m^2)	7	5.6

A normal BMI was recorded for 59.9% (n=79) of participants and 36% (n=49) were overweight/obese. A total of 40.2% (n=53) participants, 4 underweight, 42 overweight and 7 obese, were therefore classified as outside the normal BMI range. Mean BMI for athletes participating in the half marathon did not differ significantly from the mean BMI of athletes participating in the full marathon (p=0.0601)

Weight changes during participation

Although all participants were weighed at registration, not all participants reported for weight measurements directly before and after the race. Table 5.3 reports on weight changes of athletes that reported at the weighing station before and after the race.

Table 5.3 Weight changes in participants before and after the race

Variable	n	%	Median	Range
Registration and pre-race weight difference (kg)	132		-0.000	-0.8 - 3.5
Pre-race and post-race weight difference (kg)	131		-1.2	-4.2 - 4.8

% Body weight change during the race:				
Males	101		-1.6	-6.4 – 1.9
Females	24		-1.5	-6.3 – 9.5
% Body weight change during the race:	131			
<2% body weight loss	76	58		
≥2% body weight loss	55	42		

A median weight difference of -0.000 kg was recorded between registration and pre-race, and a median weight difference of -1.2 kg between pre- and post-race. During the race, the largest weight loss was 4.2 kg and the most weight gained 4.8 kg. The maximum weight loss measured during the race, equalled a body weight loss of 6.36%. Almost half (42%, n=55) of participants for whom body weight was measured before and after the race (n=131), lost 2% or more of their body weight during the race.

Race times and fluid intake of participants

Participants were requested to report usual running time, personal best, current race running time as well as fluid intake before, during and after the race. Table 5.4 reports on the running times and fluid intake of participants for both the half- and full marathon.

Table 5.4 Race running times and fluid intake of participants

Variable	n	Mean	±SD	Median	Range
Half marathon					
Usual running time (hour:min)	113	1:40	0:19	1:40	1:03 – 2:30
Personal best (hour:min)	96	1:33	0:26	1:29	1:02 – 2:15
Current race running time (hour:min)	50	1:57	0:27	1:54	1:08 – 3:11
Current race pace (meter/second)	50	333.5	72.5	323.1	193.5 - 544
Marathon					
Usual running time (hour:min)	31	3:46	0:37	4:00	2:30 – 4:51
Personal best (hour:min)	30	3:28	0:34	3:40	2:30 – 4:15
Current race running time (hour:min)	85	3:35	0:33	3:30	2:22 – 5:11
Current race pace (meter/second)	85	306.4	47.4	298.6	202.1 – 442.1

Total fluid intake:					
Half marathon:					
Total fluid intake (ml)	13	2373.1	960	2250	1150 - 4300
Pre-race (ml)	32	701.9	502.6	500	200 – 2000
During race (ml)	23	680.4	978.1	500	100 – 5000
Post-race (ml)	24	933.3	533.6	1000	200 - 2000
Race hydration volume (ml/hour)	50	176	116	156	46 – 673
Race hydration (ml/kg)	13	32.5	14.4	29.6	15 – 68.9
Full marathon					
Total fluid intake	41	1966	1343.7	1700	400 - 9000
Pre-race (ml)	56	593.6	788.7	500	100 – 6000
During race (ml)	55	599.5	437.4	500	100 – 2000
Post-race (ml)	53	714.9	498.1	500	100 – 2000
Race hydration volume (ml/hour)	85	125	72	115	29 – 450
Race hydration (ml/kg)	40	28.2	23	23.5	6.1 - 150

With regard to race running time for the half marathon, the median current race running time were slightly slower than the median personal best and usual running time, but for the full marathon the median for current race running time was slightly faster than the median for personal best and usual running time. When comparing fluid intake per kg body weight, fluid intake varied between 15.0 ml/kg and 68.9 ml/kg for the half marathon and 6.1 ml/kg and 150 ml/kg for the full marathon, with no significant difference between athletes participating in the half and full marathon (p=0.083). Total fluid intake ranged between 1150 ml to 4300 ml for the half marathon and between 400 ml and 9000 ml for the full marathon. Mean total fluid intake of participants for the half marathon was significantly higher (p=0.0170) than for the full marathon, although it is a shorter distance and participants spend a shorter time on the road. The mean fluid intake per hour for the half marathon was also significantly more (p=0.0001) than for the full marathon (176 ml/hour vs. 125 ml/hour). As expected, running pace was significantly faster (p=0.0006) for participants of the half marathon compared to the full marathon. Median fluid intake for pre-race, during the race and after the race was the same at 500 ml. When comparing body composition (indicated by BMI) with fluid consumption during participation, athletes with a normal or underweight BMI classification had a significant higher (p=0.017) fluid intake per kg than participants with an overweight/obese BMI.

Table 5.5 Fluid intake before, during and after the race for males and females

	n			Mean			±SD			Median			Range			P-value
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Female	Total	Males	Females	
Intake before the race																
Fluid volume (ml)	94	76	17	627.7	572.5	881.8	683.7	368.3	1413.2	500	500	500	100-6000	100-2000	100-6000	<0.0001
Intake during the race																
Fluid volume (ml)	85	67	17	627.9	637.3	608.8	650.6	678.1	564.9	500	500	500	100-5000	100-5000	100-2500	0.4209
Intake after the race																
Fluid volume (ml)	83	64	18	778.8	816.3	661.1	524.9	518.6	554.8	500	500	500	100-2000	200-2000	100-2000	0.6706

Female participants consumed significantly more fluids (p=<0.0001) than males before the race; and although the mean fluid intake for males after the race was notably more than females, this difference was not statistically significant.

Hydration practices of participants before, during and after a race.

Participants were requested to indicate their hydration practices before, during and after race participation. Practices to ensure optimal hydration before, during and after a race are reported in Table 5.6.

Table 5.6 Hydration practices of participants before, during and after a race

Fluid intake	**n**	**%**
Drink extra fluids:		
Before race	80	55.6
During race	84	58.3
After race	70	48.6
No extra fluids	9	6.3
Timing of fluid consumption before a race:		
≤ 2 hours	58	40.3
≤ 30 minutes	23	16.0
>30 minutes – 1 hour	31	21.5
>1 hour - ≤ 2 hours	4	2.8
3 hours	1	0.7
6 hours - ≤ 12 hours	8	5.6
>12 hours	22	15.4
No extra fluids	18	12.5

Type of fluid athletes prefer before the race.		
Energy drink	47	32.6
Water	35	24.1
Coke	6	4.2
Lucozade	3	2.1
Rehydrate	2	1.4
Fruit and vegetable juice	2	1.4
Carbohydrate loader	2	1.4
Other	9	6.3
Type of fluid athletes prefer during the race.		
Water	41	28.5
Coke	26	18.1
Energy drink	15	10.4
Corn water	2	1.4
Rehydrate	1	0.7
Protein shake	1	0.7
Fruit and vegetable juice	1	0.7
Supplements	1	0.7
Game	1	0.7
Turbo energy	1	0.7
Type of fluid athletes prefer after the race.		
Water	31	21.5
Energy drink	22	15.3
Coke	13	9
Beer	6	4.2
Flavoured milk	2	1.4
Rehydrate	1	0.7
Protein shake	1	0.7
Carbohydrate loader	1	0.7
Mineral water	1	0.7
Flavoured water	1	0.7
Soft drink	1	0.7
Game	1	0.7
Milo	1	0.7
Play	1	0.7
Coffee	1	0.7

How participants obtain fluids during a race?		
Water tables during the race	113	78.5
Carry with athlete	19	13.2
Get fluids at end of race	8	5.6
Don't drink extra fluids	4	2.8
Friend	5	3.5
Other	2	1.4

More than half of participants reported that they drink extra fluids before the race (55.6%, n=80), and during the race (58.3%, n=84), with 9 (6.3%) participants reporting to consume no extra fluids before, during or after the race. With regard to timing of extra fluids, most participants (40.3%, n=58) consumed extra fluids within 2 hours prior to the race to ensure optimal hydration and 12.5% (n=18) indicated that they do not consume extra fluids before the race. The majority of participants preferred energy drinks before the race (32.6%, n=47) and 6.3% (n=9) of participants prefer other fluids such as; USN, supplements, Vooma, Berocca, Game, 32 GI, Turbo Energy, coffee and honey to hydrate. During the race (28.5%, n=41), as well as after the race (21.5%, n=31), participants mostly prefer water ashydration fluid. Most athletes (78.5%, n=113) rely on water tables during the race for their fluid needs and 13.2% (n=19) carried fluids with them. Four participants (2.8%) reported that they do not consume any fluids during the race.

Environmental conditions and beverage temperature

Environmental conditions affect physical performance and should be considered and evaluated during a race. Table 5.7 reports on the response of participants on how environmental and beverage temperature affect their fluid consumption.

Table 5.7 Effect of environmental conditions and beverage temperature on fluid consumption

Variable	n	%
Reasons why athletes consume more fluid:		
Environmental conditions	103	71.1
Speed/pace	2	1.4

Fluid consumption	3	2.3
Specific beverage consumption	2	1.4
Dehydration cues	18	13.6
Distance	2	1.4
Salt tablets	1	0.7
Just enough water in body	1	0.7
Recharge energy	1	0.7
Carb loading	1	0.8
Hangover	1	0.1
Nothing	1	0.1
Reasons athletes consume less fluid:	144	
Environmental conditions	81	56.4
Feeling ill	5	2.3
Consuming more fluids before the race/well hydrated	9	5.7
Short distance	4	2.8
Dehydration	3	2.1
Slow pace	2	1.4
Don't know	2	1.4
Unavailability of fluids	2	1.4
Nothing	2	1.4
Consuming too much of the supplement Gue	1	0.7
Not tired/Better preparation/ Being fit	3	2.1
To avoid cramps	1	0.7
Taste/Water temperature	2	1.4
Does fluid temperature affect how much participant drink?	132	
Yes	97	73.5
No	24	18.2
Unsure	11	8.3
Warm fluids cause participant to drink:	131	
Less	101	77.1
More	19	14.5
Unsure	11	8.4
Cold fluids cause participant to drink:	129	
Less	31	24.03
More	90	69.8

Unsure	8	6.20
Does fluid taste affect how much participant consume?	132	
Yes	90	68.2
No	32	24.2
Unsure	10	7.6
Taste of water cause participant to drink:	132	
Less	43	32.6
More	54	40.9
No change	35	26.5
Flavours they like cause participant to drink:	131	
Less	21	16.0
More	74	56.5
No change	36	27.5
Flavours they dislike cause participants to drink:	122	
Less	76	62.3
More	12	9.8
No change	34	27.9

Almost three quarters (71.1%, n=103) of participants indicated that their fluid intake increase and just more than half (56.4%, n=81) that their fluid intake decreases as a result of environmental conditions. Only 13.6% (n=18) of participants consumed more fluids in response to dehydration cues. Fluid temperature (73.5%, n=97) and taste (68.2%, n=90) affected the amount of fluids consumed and when fluid types is considered, most participants (79.8%, n=83) preferred sports drinks, with instant energy supply (26.4%) provided as the main reason for their choice.

Factors influencing hydration practices of participants

Table 5.8 summarise factors that participants reported to influence their hydration practices during endurance races.

Table 5.8 Factors influencing hydration practices of participants

Variable	n	%
Factors influencing choice of beverage:		
Experience	71	49.3
Take what's available at race	60	41.7
Recommended by scientific organisations	20	13.9
Recommended by other athletes	19	13.2
Coach advice	17	11.8
Advertised by sports drinks manufactures	13	9.0
Recommended by race organizers	9	6.3
Other	1	0.7
Effect of the type of fluids consumed on performance:	127	
Decrease performance	83	65.4
Increase performance	6	4.7
No change	38	29.9
Does environmental temperature influence fluid intake?	130	
Yes	123	94.6
No	6	4.6
Unsure	1	0.8
Effect of warm environment on fluid intake:	127	
Decreased intake	113	89
Increased intake	10	7.9
No change in intake	4	3.2
Effect of cold environment on fluid intake?	121	
Decrease	20	16.5
Increase	93	76.9
No change	8	6.6
Indications used to consume fluids.	144	
Maintain weight	14	9.7
According to schedule	38	26.4
Thirst	89	61.8
Other	10	6.9
Do you drink sports drinks?	104	
Yes	83	79.8
No	21	20.2

Why do you drink sports drinks?	144	
Energy/ nutrition value	57	39.7
Rehydration/sweat	28	19.5
Physical capacity	9	6.3
Electrolyte level	5	3.5
Taste of fluids	5	3.5
Influence on human body	4	2.8
Not good for health	1	0.7
Do you sometimes dehydrate?	124	
Never	68	54.8
Sometimes	53	42.7
Often	2	1.6
Always	1	0.8
Symptoms experienced during dehydration:	144	
Dizziness	16	11.1
Dry mouth	14	9.7
Cramps	8	5.6
No sweating	8	5.6
Tired	8	5.6
Thirsty	7	4.9
Weakness	5	3.5
Lots of sweating	5	3.5
Nausea	2	1.4
Headache	2	1.4
Dry skin	2	1.4
Urine colour change	1	0.7
Full bladder	1	0.7
Increased breathing	1	0.7
Vomiting	1	0.7
Don’t know	1	0.7
Hot flushes	1	0.7
Falling	1	0.7
Pale skin	1	0.7
Low vision	1	0.7
Goose bumps	1	0.7
Heat	1	0.7

Salt on skin	1	0.7
Loss of concentration	1	0.7
Do you sometimes overhydrate?	122	
Never	98	80.3
Sometimes	24	19.7
Symptoms of over hydration?	144	
Uncomfortable/ tired	14	9.8
Hydration/ urine discomfort (refers to bladder discomfort)	8	5.6
Dizziness	6	4.2
Nausea	3	2.1
Thirsty	2	1.4
Don't know	2	1.4
Cramps	2	1.4
Heat/ sweat increase	2	1.4
Sweat increase	1	0.7
Hungry	1	0.7
Urine colour change	1	0.7
Heat	1	0.7
Pale skin	1	0.7

When it comes to the type of beverage athletes choose to consume, there are various factors influencing their choice. From the results of this study, half (49.3%, n=71) of the participants reported to choose a beverage from what experience has taught them. Athletes believe that the types of beverage they choose will mostly (65.4%, n=83) decrease their performance and that the environmental temperature (94.6%, n=123) will influence their fluid intake during a race. Environmental conditions vary greatly amongst different races, from very cold to extremely hot. Participants reported that warm environmental temperature will decrease (89%, n=113) their performance and that cold temperature will increase (76.9%, n=93) performance. Participants indicated that they mostly drink fluids according to thirst (61.8%, n=89), and only 9.7% (n=14) participants' drink fluids to maintain weight. Three quarters of the participants reported to drink sports drinks during races, mostly (39.7%, n=57) for its energy and nutritional value. Participants were also asked if they have experienced dehydration or over hydration before. Of the total, 42.7% (n=53) reported that they have dehydrated before, indicating that dizziness (11.1%, n=16) and dry mouth (9.7%, n=14) as the most common signs of dehydration and 80.3% (n=98) of participants reported to never overhydrate, listing symptoms of an uncomfortable feeling (9.8%, n=14) and hydration/ urine discomfort (5.6%, n=8) as the main signs and symptoms of over hydration.

Discussion

This study aimed to describe the hydration practices of long distance runners in the SANDF in relation to current hydration recommendations in order to develop appropriate hydration guidelines for these athletes.

Although the Oudtshoorn region is known for extreme environmental conditions, conditions during the day of data collection were not extreme. The environmental temperature on the day of the race can be regarded as moderate and is not expected to cause excessive sweating resulting in poorer performance, as Helou et al. (2012:1) suggests.

A total of 144 participants gave informed consent and was included in the study. The results indicate that the majority of participants were male (80.5%), Black (40.5%) and aged between 19 and 60 years. Duration of participation ranged from 13 to 365 months, implicating that participants in general had good race experience.

More than half of the participants had a normal BMI and mean BMI did not differ significantly between athletes participating in the half and the full marathon, which can be expected as participants are employed in a training unit and exercise regularly to compete in marathons. The same results were found by Sedek et al. (2015:660) amongst endurance sports athletes, were the majority (76.3%) of participants also presented with a normal BMI. It was however unexpected that more than a third (36.0%) of participants were classified in the overweight to obese category, especially as they are athletes who seemingly participate regularly in races. Sedek et al. (2015:660) reports a lower incidence (16.3%) of overweight/obesity from their study, probably because of a younger sample. BMI classification are not always regarded as accurate for athletes, because of an increased muscle mass (Garrett & Kirkendall, 2000:322), however, runners tend to have a leaner physique as a lighter, leaner body can improve running time (Sedeaud et al., 2014: 1-7).

Although individual weight differences was observed in participants as measured at registration and before commencement of the race, no mean weight difference was observed for the group. Weight changes do not only reflect fluids consumed or lost during the night or prior to the race, but can also be due to various other reasons (Casa et al., 2005: 115-127), such as fluid retention resulting from dietary intake or hormonal changes.

According to Popkin et al. (2010:443), it is not surprising for athletes to lose 6-10% body weight during physical activity. During this study, a maximum weight loss of 4.8 kg was recorded after the race, reflecting a body weight loss of 6.36%. It is concerning that almost half (42%) of athletes experienced a weight loss of two percent or more, which is described by most researchers as the maximum percentage of weight loss allowed to sustain optimal performance (Costa et al., 2013:Online; Zoorob et al., 2013:477; O'Neal et al., 2011:587; Turocy et al., 2011:328). A high percentage of athletes therefore probably consumed less fluids during the race than what was needed to replace fluids and maintain optimal performance. Fluid intake (ml/hour) was considerably higher during the half marathon than during the full marathon. The same results were found by Neumann (2001:103). Fluid intake per kilogram bodyweight was significantly higher in athletes with a normal or underweight BMI than participants with an overweight/obese BMI.

With regard to race running times, the median race running time for the current half marathon were slightly slower than the median personal best and usual running time, but for the full marathon the median for current race running time was slightly faster. Race running pace differed significantly between the half and full marathon, with running pace being faster for the half marathon. This can be expected as athletes running the full marathon tend to start at a slower pace to save energy for the whole distance.

Mean fluid intake per hour as well as mean total fluid intake was higher for the half marathon than the full marathon. This was not expected as these athletes competing in the full marathon are participating for longer periods of time. Fluid consumption before, during and after the race, indicated that female athletes consumed more fluids before the race, but during and after the race, there was no significant difference between male and female athletes.

With regard to consuming extra fluids, more than half (58.3%) of participants reported to drink extra fluids during a race, and most (28.5%) preferred water. It is recommended that athletes consume fluids containing electrolytes as well as carbohydrates to ensure optimal performance (Flynn, 2014:8; O'Neal et al., 2011: 581-591; Shirreffs & Sawka, 2011:42-43; Kumley, 2010:28). Kumley (2010:27) suggests that it is important for athletes to be fully hydrated prior to an exercise session and recommends that well hydrated athletes should drink 5 ml to 7 ml of water or sports drinks per kilogram of body weight at least four hours prior to an event. The ACSM on the other hand recommends that athletes should drink 500 ml of fluid two hours before an event. During the study, the majority of participants reported to drink water during and after the race, which is not sufficient to replace electrolytes as well as carbohydrate losses. Participants competing in the half marathon, consumed between 46 ml and 673 ml of fluid per hour, while athletes running the full marathon, consumed 29 ml to 450 ml per hour. A general recommendation is to consume 600 ml to 800 ml of fluid per hour of exercise (Dunford & Doyle, 2012:241-242; Kumley, 2010:28; Noakes (2003:Online). This recommendation is more than the mean reported intake of 176 ml per hour for the half marathon and 125 ml per hour for the full marathon. It is also more than the upper quartile mean of 194 ml per hour for the half marathon and 151 ml for the full marathon. Participants in this race therefore probably did not consume adequate amounts of fluids for optimal hydration, which can be one of the reasons for the large number (42%) of athletes losing two percent or more of their body weight during the event.

Most participants consumed extra fluids before, during as well as after the race to ensure optimal hydration, which is according to the recommendation of Jeukendrup (2011:93), who states that fluid consumption before exercise is important to avoid dehydration, which can alter exercise performance. In this study, more than a third of participants prefer extra fluids 10 minutes to 2 hours before a race. Jeukendrup (2011:93) suggest that when hydrating before exercise, athletes should consume fluids at least four hours before an event. Although the majority (n=59; 41.0%) of participations adhered to this guideline, a third (33.5%) consumed either no extra fluids or consumed the extra fluids longer than 6 hours before the race.

The ACSM advises that athletes should start drinking early in the race and at regular intervals to replace fluid losses at a sufficient rate (Sawka et al., 2007:377). A total of 6.3% of participants reported that they do not consume extra fluids before, during or after a race and 12.5% of participants reported to not consume fluids before a race, which can lead to serous health problems like dehydration. According to Jeukendrup (2011:93), athletes should consume 5 to 7 ml of fluid per kilogram of body weight to optimally replace fluid losses during a race. In this study mean fluid intake was 32.5 ml/kg for the half marathon and 28.2 ml/kg for the full marathon, which indicates that participants consumed enough fluids per kilogram body weight during the race.

After the race, almost one out of five participants preferred water as rehydration fluid. According to Shirreffs and Sawka (2011:42-43) the replacement of sodium is a prerequisite for an effective restoration and maintenance of euhydration and therefore water would not qualify as optimal rehydration fluid. The majority of athletes do not carry fluid with them during a race and relied on what was available at the water tables, which restricts their timing and choice of beverages. A total of 71.1% participants reported that they drink more fluids during varied environmental conditions and 56.4% reported that they drink fewer fluids also due to different environmental conditions, which correspond with Montain et al. (2006:1) reporting that athletes dehydrate during physical activity or during exposure to hot weather because of fluid non-availability or because of a mismatch between thirst and body water losses. According to Burke and Deakin (2010:352-353), the temperature of an fluid will affect the consumption, this correlated with the findings of the study where participants reported that warm fluids will cause them to drink less and that they will drink more if fluids are cold.

The taste of sports drinks, play an important role in rehydration and the amount of fluids consumed, as the sensation of thirst is not very sensitive and thirst only occurs when dehydration has already taken place (Burke & Deakin, 2010:344-345). In this study 68.2% of participants reported that the taste of fluids will influence the amount they consume.

More than half of the participants (61.8%) reported that they drink according to thirst to prevent dehydration, which agrees with Winger et al. (2011:646) who reported that 57% of participants in their study consumed fluids according to thirst. According to Casa et al. (2005:115-116), clinical signs and symptoms of dehydration includes thirst, dizziness, headache, tachycardia, oral mucosal surface dry, and skin turgor. Although 68 (54.8%) suggest they never dehydrate during a race, 16 (11.1%) knew that dizziness is a sign of dehydration. Only a few participants (9.7%) reported that they have overhydrated before, indicating that stomach pain (4.2%) and dizziness (4.2%) are the main signs and symptoms of over hydration, this agrees with the signs and symptoms reported by Winger et al. (2011:646) diziziness and stomach cramping. These results sugest that athletes do have some knowledge regarding hydration.

Participants were more concerned that the type of beverage they consume during an event could decrease performance and mostly drank fluid according to their previous experience (49.3%, n=71). Most participants reported that environmental temperature will affect their fluid intake, with a warm environment to decrease intake and a cold environment to increase intake. This is contradictory to their higher physiological needs for fluids during warmer environmental temperatures.

Limitation of this study

Limitations of this study were that the questionnaire was self-reported, which does allow for honest anonymous feed-back, but resulted in missing data, as also described by Albert and Tullis (2013:126). Results relied on the accuracy and honesty of participants and the researcher acknowledge this limitation.

Some athletes failed to return after the race to be weighed and although requested not to, some athletes consumed fluids before they were weighed, resulting in these athletes to be excluded from the study sample and reducing the number of participants.

Conclusion

Water is considered to be the most important nutrient in the human body. With no available water, a person can decease within days. During exercise, muscle exertions produce heat that needs to be released by sweat in order for the human body to cool down (Dunford & Doyle, 2012:241-242; Casa et al., 2005:115-127). During the body's natural cooling mechanism, not only fluid is lost, but also electrolytes which can lead to heat-related illnesses if not replaced. For this reason, this study evaluated the hydration practices of endurance athletes in the SANDF in order to develop more specific guidelines.

Although the Oudtshoorn area is known for extreme environmental conditions, conditions were moderate during study implementation, suggesting a lower risk for dehydrating and heat-related illnesses.

Demographic data indicated a large age range amongst participants with the majority in the older category, aged 40 years and older, suggesting more experience and knowledge. As expected, most participants had a normal weight classification, but a concern is that more than a third were overweight to obese. Athletes need to be informed about the advantages of having a leaner physique in order to improve endurance performance by not having to carry extra body weight during a race.

Athletes need to know how to monitor hydration status to prevent heat-related illness and ensure optimal performance. To prevent large fluid losses and dehydration, it is a good practice for athletes to weigh themselves before and after a race, to provide an indication of how much fluid is lost through sweat and how much fluid they need to consume to replace fluid lost. In this study it was concerning that almost half of participants lost 2% or more of their body weight during the race, increasing their risk for heat-related illnesses and possibly decreasing performance. Athletes need to be made aware of the importance of preventing excessive weight loss during a race. Standard advice is difficult as athletes have different physiological responses, race times, run different distances and in different environmental temperatures, which results in sweat rates varying significantly. Athletes should be encouraged to ensure adequate hydration before exercise, to ensure a fluid homeostasis which will ensure optimal performance. A more individualised hydration approach will help athletes to decrease the occurrence of heat-related illnesses and could increase performance. Athletes also need to be aware that monitoring urine colour is an easy method to evaluate hydration status.

Most participants consumed extra fluids before, during and after the race to ensure optimal hydration, but alarmingly still 6.3% of participants reported to not consume any extra fluids. Timing and amount of fluid consumption is of the utter most importance for athletes to stay hydrated and prevent decreased performance. Guidelines including the timing and amount of fluid, need to be developed in order to promote extra fluids.

Mean fluid intake per hour as well as mean total fluid intake was higher for the half marathon than for the full marathon, but mean fluid intake per kilogram body weight did not differ significantly between the half and full marathon.

When it comes to hydration during endurance exercise, fluid should ideally be consumed at rates that match sweat rates. By consuming too little fluid, dehydration will occur and be consuming too much fluid, over hydration can occur. Athletes need to know that consuming too much fluid will not only cause over hydration, leading to hypernatremia, but it will also result in carrying more weight during the race and decreasing performance. It is also important for athletes to know that water alone is not ideal to replace sweat losses during endurance exercise, as electrolytes and glycogen also need replacement. For this reason athletes need to consider the labels of sports drink and know what to consider when reading labels. Participants also need to keep in mind that warmer environmental temperature will cause an increase in sweat rates and will therefor require a larger intake of fluid to prevent heat-related illnesses. During this study it was observed that athletes mainly rely on water stations (with unpredictable availability) to rehydrate, with only a few athletes carrying fluids with them. Scientific recommendations state that athletes need to consume fluid every few minutes, and therefore relying solely on water stations is not sufficient. Race organisers therefore should be encouraged to make more water stations available and provide optimal types of fluids to ensure optimal performance of athletes. Alternatively coaches should encourage athletes to carry fluids with them to prevent dehydration.

Another important factor for athletes to consider is signs and symptoms of dehydration as well as over hydration. Being able to identify these signs and symptoms, athletes will be able to manage fluid intake better and possibly increase performance. As recommended earlier, monitoring urine colour frequently, will enable athletes to know when they are dehydrated, and therefor know when they need extra fluids.

Although reasonable hydration practices were followed by athletes in this study, important training areas were identified. The main areas that should receive attention during training, include advantages of maintaining a normal body weight; timing and the amount of fluids to consume before, during and after exercise; using urine colour as monitor for hydration status; not using thirst alone as a rehydration cue; as well as optimal rehydration fluids to consider.

References

Albert W and Tullis T. 2013. Measuring the user experience. 2nd edition. Elsevier:126.

Burke L and Deakin V. 2010. Clinical Sports Nutrition. 4th edition. Australia: McGraw-Hill PTY Ltd:341-353.

Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, and Stone JA. 2000. National Athletic Training Association. Fluid replacement for athletes. Journal of Athletic Training, 35:212-224.

Casa DJ, Clarkson P, and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013].

De Bruyne LK, Pinna K and Whitney E. 2012. Nutrition and Diet Therapy. 8th ed. USA: Wadsworth. [Online].

Available from: http://books.google.co.za [Accessed 30 December 2015].

Dunford M and Doyle A. 2012. Nutrition for Sport and Exercise. 2nd edition. Wadsworth: 241-242.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Garrett WE and Kirkendall DT. 2000. Exercise and Sport Science, Lippincott Williams and Wilkins, 322.

Geijer JR, Pitney WA, and Brandenburg J. 2009. Fluid replacement knowledge and sources of hydration information among Illinois high school athletic coaches: a pilot study. The Internet Journal of Allied Health Sciences and Practice, 7(3):540-580.

Gordon RE, Kassier SM, and Biggs C. 2015. Hydration status and fluid intake of urban, underprivileged South African male adolescent soccer players during training. Journal of the International Society of Sports Nutrition. [Online].

Available from: www.jissn.com/content/12/1/21 [Accessed March 13th, 2013].

Helou NEI, Tafflet M, Barthelot G, Tolaini J, Marc A, Guillaume M, Hausswirth C, and Toussaint JF. 2012. Impact of Environmental Parameters on Marathon Running Performance. Biomedical Research Institute of Sports Epidemiology, 7(5):1-7.

Hew-Butler T, Verbalis JG, and Noakes TD. 2006. Updated Fluid Recommendation: Position Statement from the International Marathon Medical Directors Association (IMMDA). Clinical Journal of Sport Medicine, 16:283–292.

Jeukendrup AE. 2011. Nutrition for endurance sports: Marathon, triathlon, and road cycling. Journal of Sports Sciences, 29(1):92-99.

Kumley RF. 2010. Hydration and fluid replacement knowledge, attitudes, barriers and behaviours of NCAA division football players at Midwestern University. Master's Degree. Ball State University, 1-116.

Montain SJ, Cheuvront SN, Carter R, and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas:1-8.

Murray B, Stofan J, and Eichner ER. 2003. Hyponatremia in Athletes. Gatorade Sports Science Institute, 16(1):1-6.

Neumann G. 2001. Nutrition in Sport, Oxford: Meyer & Meyer Sport, 103.

Noakes TD. 2003. Fluid replacement during marathon running. Clinical Journal of Sports Medicine, 13(5):309-318.

O' Neal E, Wingo J, and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Popkin BM, D'Anci KE, and Rosenberg IH. Water, hydration and health. 2010. Nutrition Reviews, 68(8):439-458.

Sawka MN, Burke LM, and Eichner ER. 2007. American College of Sports Medicine positions stand Exercise and fluid replacement. Medicine and Scientific in Sports and Exercise, 39:377–90.

Sedeaud A, Marc A, Marck A, Dor F, Schipman J, Dorsey M, Haida A, Berthelot G, Toussaint JF. 2014. BMI, a performance parameter for speed improvement. Public Library of Science, 9(2): 1-7.

Sedek R, Mohamad MM, and Kasim ZM. 2015. Knowledge, attitudes and practices on hydration and fluid replacement among endurance sports athletes in national university of Malaysia. Pakistan Journal of Nutrition, 14(10):658-665.

Shirreffs SM and Sawka MN. 2011. Fluid and electrolyte needs for training, competition and recovery. School of Sport, Exercise and Health Science. Loughborough Univeristy:39-46.

Tam N, Nolte HW, and Noakes TD. 2011. Changes in total body water content during running races of 21.1 km and 56 km in athletes drinking. Clinical Journal of Sports Nutrition, 21(3):218–225.

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ, and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

World Health Organisation. 2012. Obesity and overweight. [Online].

Available from: http://www.who.int/mediacentre/factsheet/fs311/en/ [Accessed April 18th, 2013].

World Health Organization (WHO). 2008. WHO Steps Surveillance Manual. [Online]

Available from: http://www.who.int/chp/steps/manual/en/index7.html [Accessed April 18th 2014].

Winger JM, Dugas JP, and Dugas LR. 2011. Believes about hydration and physiology drive drinking behaviours in runners. Journal of Sport Medicine, 45(8):646-649.

Young AJ, Sawka MN, Epstein Y, Decristofano B, and Pandolf KB. 1987. Cooling different body surfaces during upper and lower body exercise. Journal of Applied Physiology, 63(3):1218-1223.

Zoorob R, Parrish ME, O'Hara H, and Kalliny M. 2013. Sport nutrition needs before, during, and after exercise. Primary Care The Clinical Office Practice, 40(2):475-486.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This study described the hydration knowledge and practices of long distance runners from the South African National Defence Force (SANDF), who participated in the Cango Marathon in Oudtshoorn, Western Cape, during 2014. The previous chapters described the research problem, methods used to conduct the study; and in an article format reported on data obtained from the study as well as conclusions made according to the objectives set for this study. This current chapter will therefore provide an overview of the conclusions and recommendations from the study in order to highlight focus areas for implementation and identify opportunities for further research. The research significance and limitations of the study are also described.

6.2 ENVIRONMENTAL CONDITIONS

During the study, environmental conditions were moderate with no extreme environmental conditions. For this reason no excessive sweating or decreased performance was expected as Helou et al. (2012:1) suggests.

6.3 DEMOGRAPHIC INFORMATION

Participants included athletes who participated in the Cango Marathon in Oudtshoorn, Western Cape on 22 February 2014. Athletes registered either for the half (21.1 km) or full marathon (42.2 km), were mostly Black (40.5%, n=53) males (80.5%, n=107), and worked as operators (51.9%, n=41). More than half of the participants were older than 40 years (55.9%, n=71) and had previous race experience (13-365 months). With regards to race running times, 14.2% participants had a usual running time of less than one hour and fifty minutes for a half marathon and seven (22.6%) had a usual running time of less than four hours for a full marathon.

6.4 ANTHROPOMETRY

According to Sedek et al. (2015:660), athletes are expected to have normal anthropometric measurements, as they participate regularly in physical exercise. It was also likely that athletes who participated in this study would have a normal BMI because they are employed in a training unit, exercise regularly and reported to work as operators. However, during the study, anthropometric measurements indicated that four (3.2%) participants were underweight with the lowest BMI being 17.4 kg/m^2, 36.0% were overweight to obese with the highest BMI of 36.1 kg/m^2. As expected, most participants (60.8%, n=76) had a BMI classified in the normal category, which correlates with the results found by Sedek et al. (2015:660). Mean BMI for athletes participating in the half marathon did not differ significantly from the mean BMI of athletes participating in the full marathon (p=0.0601). Since all of the participants are working in a training unit and exercise regularly, it gives the impression that participants would be fit and lean, but alarmingly more than a third of the participants were overweight to obese, which can cause athletes to run slower.

6.5 WEIGHT CHANGES DURING PARTICIPATION

Weight loss during exercise can be due to a number of reasons, namely: sweating, excretion of faeces, and urine (Casa et al., 2005: 115-127). As long as an athlete has a balanced energy intake, food and fluid is consumed and urinary and faecal losses considered, his/her body weight loss reflects water loss (Armstrong, 2005:44). For this reason, body weight loss during exercise can be used as a screening tool for hydration during endurance exercise and can be used to determine rehydration (Montain et al., 2006:3; Casa et al., 2005:115-116). General recommendations suggest that fluid intake during exercise should not exceed sweat losses, but rather avoid weight loss of more than two percent body weight (Costa et al., 2013:Online; Zoorob et al., 2013:477; O'Neal et al., 2011:587; Turocy et al., 2011:328). During this study, a maximum weight loss of 4.2 kg was recorded during the race, which equalled a body weight loss of 6.36%. Nearly half (42%, n=55) of participants for whom body weight was measured before and after the race (n=131) lost 2% or more of their body weight during the race. This is worrying because each kilogram of weight loss reflects approximately one litre of fluid loss and a weight change of one to two percent can lead to decreased endurance performance as well as decreased physiological function, increase core temperature, increase plasma osmolality, decrease plasma volume, and may affect the intracellular and extracellular electrolyte balance (Gordon et al., 2015:Online; Casa et al., 2010:147; Wilson, 2008:3-4; Montain et al., 2006:4; Duvillard et al., 2004:651).

6.6 HYDRATION KNOWLEDGE OF SANDF ATHLETES

According to Duvillard et al. (2004:651) as well as a study by Jusoh (2010:59), fluid intake during exercise is regarded as important to improve performance, avoid thermal stress, maintain plasma volume, delay fatigue and prevent injuries. In this study, the majority of participants (75.0%) knew that consuming fluids during a race will improve performance, 7.6% believed that it will not affect performance and 17.4% were unsure whether consuming fluids will have any effect on performance. These results suggest that most athletes would have consumed fluids during the race to prevent dehydration and to ensure optimal performance, but a few still had the possibility of not consuming fluids ultimately leading to decreased performance and heat-related illnesses.

Urine colour is considered to be a good screening measure of hydration status (Casa et al., 2005:115-116). As soon as the human body has a fluid insufficiency, urine production decrease and urine becomes more concentrated. For this reason, urine colour can be used as a predictor of hydration status (Turocy et al., 2011:328). In this study, 27.8% of participants knew that urine colour will have an effect on performance, 22.2% participants were unsure why urine is sometimes darker and 49.3% were unsure if dark urine will increase or decrease performance, giving the idea that athletes do not know that urine can be used as an indicator of hydration status and increasing the possibility of heat-related illnesses.

Both food and beverages provide fluid to the human body to help maintain hydration status, but the composition of these food and fluids can influence fluid requirements. Drinking fluids that contain carbohydrates can delay mental fatigue, and improve cognitive function, mood, motor skill performance and apparent physical exertion better than drinking water (Casa et al., 2005:117-119). Most participants (65.3%) reported to read labels information on beverages, mostly observing carbohydrates (13.9%) and energy level (11.8%). This suggests that athletes know what to look for and what to consume to ensure optimal performance.

When dehydration is considered, some signs and symptoms must be known. Dehydration can cause irritability, general discomfort, headache, weakness, dizziness, cramps, chills, vomiting, nausea, head or neck heat sensations, disorientation and decreased performance (Casa et al., 2005:115-116). During this study, quite a few participants indicated that they did not know the signs of dehydration (11.1%, n=16), increasing the potential risk for heat-related illnesses. Those who reported signs of dehydration, mostly listed dizziness (24.3%, n=35) and dry mouth. Other signs listed were generally correct and the most listed signs included dry mouth, weakness, cramps, sweating, tiredness, thirst, headache, nausea and urine colour. These results indicate that athletes have a relative good knowledge regarding the signs of dehydration.

6.7 HYDRATION PRACTICES OF SANDF ATHLETES

As soon as an athlete starts to train, energy and fluid needs increase. Adequate hydration before, during and after exercise is important for athletes to ensure optimal performance and to prevent heat-related-illness during endurance exercise (Flynn, 2014:20; Geijer et al., 2009:541). General recommendations suggest that athletes consume fluid containing electrolytes as well as carbohydrates to ensure optimal performance (Flynn, 2014:8; O'Neal et al., 2011: 581-591; Shirreffs & Sawka, 2011:42-43; ; Kumley, 2010:28). Glycogen which is stored in muscles as well as blood glucose is the main energy sources for muscle exertion. The more physical performance is done, the more carbohydrates are needed for energy supply (Dada, 2010:36). The results indicate that the majority of participants choose to drink energy drinks (32.6%) before a race, water (28.5%) during the race as well as after the race (21.5%). According to Kumley (2010:28) both fluids and electrolytes are needed to optimally replace sweat loss and water are not always the ideal rehydration fluid, especially if exercise occurs for longer than one hour (Hoeger et al., 2016:248). It was reported that the majority of athletes consumed extra fluids before (55.6%) and during (58.3%) the race and only 41.0% of participants consumed extra fluids within four hours of the race.

A general recommendation is to consume 600 to 800 ml of fluid per hour of exercise (Dunford & Doyle, 2012:241-242; Kumley, 2010:28) or five to seven millilitres of fluid per kilogram body weight (Kumley, 2010:27; Rodriguez et al., 2009:718). Participants competing in the half marathon, consumed between 46 ml and 673 ml of fluid per hour (15 to 68.9 ml/kg), while athletes running the full marathon, consumed 29 to 450 ml per hour (6.1 to 150 ml/kg). Race fluid volume before the race was significantly more for female athletes than for male athletes, but during and after the race, race volume did not differ significantly. These results indicate that athletes did not consume enough fluids to adequately hydrate, which agrees with the large proportion of athletes losing more than 2% of their body weight during the race.

According to Montain et al. (2006:1), athletes dehydrate during physical exercise or during exposure to hot environmental conditions because of fluid non-availability or because of a mismatch between thirst and body water losses. During this study, a total of 71.1% participants reported that they drink more fluids during varied environmental conditions and 56.4% reported that they drink fewer fluids also due to different environmental conditions.

Burke and Deakin (2010:352-353) suggest that the temperature of a fluid will affect the consumption. This proposal correlates with the findings of the study where participants reported that warm fluids will cause them to drink less and that cold fluids will cause them to consume more.

The taste of sport drinks, play an important role in rehydration and the amount of fluids consumed, as the sensation of thirst is not very sensitive and thirst only occurs when dehydration has already taken place (Burke & Deakin, 2010:344-345). These results also correlate with the results of the study where 68.2% participants reported that the taste of a fluid will influence the amount they consume. These results can direct race organisers to the type of fluids to provide at hydration stations.

Kumley (2010:27) suggests that it is important for athletes to be fully hydrated prior to an exercise session and recommends that well hydrated athletes should drink five to 7 ml of water or sports drinks per kilogram of body weight at least four hours prior to an event. On the other hand, the ACSM recommends that athletes should drink 500 ml of fluid two hours before an event. Sports beverages containing added sodium chloride and other electrolytes can be consumed to help prevent dehydration and hyponatraemia (Kumley, 2010:30-31). Three quarters of the participants reported to drink sports drinks during races, mostly (39.7%, n=57) for its energy and nutritional value, suggesting that they do have knowledge regarding hydration and what to look for.

According to Casa et al. (2005:115-116), clinical signs and symptoms of dehydration, including thirst, dizziness, headache, tachycardia, oral mucosal surface moisture and skin turgor should not be ignored, but are too vague and imprecise to accurately assess the hydration status of an athlete (Casa et al., 2005:115-116). A total of 89 (61.8%) participants reported that they drink according to thirst. Although 68 (54.8%) suggest they never dehydrate during a race, 16 (11.1%) reported dizziness as a sign of dehydration. Only 24 (9.7%) sometimes overhydrate with stomach pain (4.2%) and dizziness (4.2%) as symptoms. More education is needed to inform athletes regarding symptoms, this will help increase their performance and help illuminate possible heat-related injuries.

6.8 RESEARCH SIGNFICANCE

An increase in health awareness has caused more and more individuals to participate in endurances races, both for fun and competition, with the number of athletes participating in races visibly increasing. As seen from other research, as well as results from this study, athletes often do not have adequate knowledge and/or implement adequate practices to ensure optimal hydration, although they rely on experience and read books and magazines containing scientific information. As friends, magazines, websites, and coaches have the potential to provide credible nutrition and hydration recommendations and information, they also have the potential to provide fad or out-dated information. Practical measures must therefore be taken to improve the hydration knowledge and practices of athletes in order to ensure optimal performance. This study investigated the knowledge and practices of endurance athletes and identified the following areas that need to be addressed when planning training programmes for endurance athletes within the SANDF:

Athletes need to be informed regarding the importance of rehydrating. It is essential that athletes consume sufficient amounts of fluid during exercise to maintain euhydration. Athletes need to be advised not to consume fluid according to thirst, because thirst only occurs after the body has lost a significant amount of fluid. Dehydration signs and symptoms should be known.

Athletes need to know that there are various hydration assessment techniques they can use to prevent them from dehydrating during a race, for example urine colour and weight changes. Urine colour should be regulated. Urine colour should have a pale yellow colour and if urine colour is darker than normal, athletes should consume more fluids. Weighing before and after exercise can give athletes an idea of how much fluid is lost during exercise. One kilogram of weight loss reflects one litre of sweat loss, which gives an idea of how much fluid an athletes should consume to adequately rehydrate.

Athletes need to train themselves to consume fluid regularly during the race to prevent a weight loss of more than 2% and to consume more fluids in warmer environmental temperatures, in order to prevent dehydration. However, it is also important not to encourage excessive fluid intakes that could lead to over hydration.

Although water is a healthy fluid, athletes' need to understand that water alone is not sufficient to replace sweat losses during endurance events and that electrolyte replacement is important. Athletes need to be informed that when sweating, electrolytes are lost. Athletes therefore need to be aware of how to read labels on sports drink and understand the information provided on carbohydrates and electrolytes.

6.9 LIMITATIONS OF THIS STUDY

To improve future studies in this field, the following limitations are acknowledged:

The questionnaire used in this study was self-reported, which allows for honest anonymous feed-back, but resulted in missing data, as also described by Albert and Tullis (2013:126). It is recommended that during future studies, each participant should be supported by a field worker to ensure that all questions are completed.

The study relied on participants to report at the same weighing stations at registration, before the race as well as after the race to ensure accuracy. This resulted in logistical difficulty with the large numbers arriving at the same time, which could have been eased by using colour coded arm bracelets or race numbers.

After the race, some of the athletes forgot to return to be weighed and some have already consumed fluids, causing these athletes to be excluded from the study. Additional field workers identifying study participants or a more visible reminder at the finish line could have addressed this problem and increased the number of study participants.

To keep the questionnaire short and easy to complete and to keep respondent burden as low as possible, detailed information on practices could not be included in the questionnaire. It is recommended that future studies consider an electronic tick list at registration with a prize draw offered for all fully completed entries. This will however also increase the cost of the study to a large extent.

6.10 RECOMMENDATIONS

It is recommended that a structured training programme for athletes within the SANDF be implemented addressing the following issues as identified in this study:

A large proportion of the athletes BMI fell in the overweight/obese category, b ut as indicated in chaper 3, muscle mass was not controlled for. It is recommended that the health implications as well as the impact of carrying additional weight during endurance exercise be addressed.

Nearly half of the participants lost 2% or more of their body weight during the race. Due to the effect of dehydration on performance, it is important that a training programme address the effect of dehydration and also teach athletes ways and methods to determine their optimal intake and hydration status.

Although most of the participants knew that fluid intake will influence performance, it is essential that athletes are sensitised regarding the effect fluid have on performance. Athletes need to consider the following when planning rehydration; sweat rate, environmental factors, exercise duration and intensity. During the completion of this study, these factors were not controlled for.

To prevent dehydration, athletes should be encouraged to start an exercise in an euhydration state. This includes consuming fluids at least four hours prior to an exercise session.

Most participants knew that weight loss during a race resulted from sweating, excessive training, dehydration and heat, for this reason weighing before and after exercise provide a good assessment of hydration status and athletes need to be encouraged to use this technique for assessment.

Almost a quarter of participants did not know why urine colour is sometimes darker, and almost half of the participants were unsure whether dark urine colour increases or decreases performance. Urine colour can be considered as a good screening measure of hydration status and athletes needs to be taught how to monitor their hydration status by using urine colour.

Some participants indicated that they read product labels, mostly consulted the label for sugar or carbohydrate level and ingredients and only a small number focussed on the electrolyte level. Athletes need to be advised to read labels and check for carbohydrate as well as electrolyte level.

When identifying dehydration cues, it was a cause for concern that one out of ten athletes were not aware of the signs of dehydration, increasing the potential risk for heat-related illnesses. It is important when athletes are trained, that the signs and symptoms of both over- and under hydration are highlighted in order to ensure optimal performance and decrease the possibility of heat-related illnesses.

With regard to consuming extra fluids, more than half (58.3%) of participants reported to drink extra fluids during a race, and most (28.5%) preferred water. General recommendations should point out that endurance athletes need to consume fluid containing both electrolytes and carbohydrates to ensure optimal performance.

A total of 6.3% of participants reported that they do not consume any extra fluids before, during or after a race and 12.5% of participants reported to not consume fluids before a race. According to Jeukendrup (2011:93), athletes should consume 5 to 7 ml of fluid per kilogram of body weight to optimally replace fluid losses during a race. General recommendations should be set for athletes including timing and amount of fluids they need to consume for optimal performance.

After the race, 21.5% of participants used water as rehydration fluid. According to different researchers the replacement of sodium is a requirement for an effective restoration and maintenance of euhydration and therefore water would not qualify as an optimal choice for rehydration. Athletes need to be encouraged to consume fluids containing both carbohydrates and electrolytes to optimally replace losses.

A total of 71.1% participants reported that they drink more fluids during varied environmental conditions and 56.4% reported that they drink fewer fluids also due to different environmental conditions. Athletes need to consider, not only race distance, but also the environmental temperature when the amount and type of fluid is considered. Warmer environmental temperature will require a higher fluid consumption in order to stay euhydrated.

It can be seen that most athletes has some knowledge regarding correct hydration practices, but not enough to prevent heat-related illnesses overall. Athletes will therefore benefit from hydration training to ensure optimal performance and health.

6.11 REFERENCES

Albert W and Tullis T. 2013. Measuring the user experience. 2nd edition. Elsevier:126.

Armstrong LE. 2005. Hydration Assessment Techniques. Nutrition Reviews, 63(6):40-65.

Burke L and Deakin V. 2010. Clinical sports nutrition. 4th edition. McGraw- Hill, Australie:684-685.

Casa D, Clarkson P and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Casa DJ, Stearns RL, Lopez RM, Ganio MS, PhD, McDermott BP, Yeargin SW, Yamamoto LM, Mazerolle SM, Roti MW, Armstrong LE, and Maresh CM. 2010. Influence of Hydration on Physiological Function and Performance during Trail Running in the Heat. Journal of Athletic Training, 35:212-224.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed November 13th, 2015].

Dada JH. 2010. Runners need proper nutrition and hydration for the 26.2 mile stretch. Today's Dietician, 12(3):36

Dunford M and Doyle JA. 2012. Nutrition for Sport and Exercise. 2nd edition. Belmont CA: Wadsworth: 240-277.

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Geijer JR, Pitney WA, and Brandenburg J. 2009. Fluid replacement knowledge and sources of hydration information among Illinois high school athletic coaches: a pilot study. The Internet Journal of Allied Health Sciences and Practice, 7(3):540-580.

Gordon RE, Kassier SM, and Biggs C. 2015. Hydration status and fluid intake of urban, underprivileged South African male adolescent soccer players during training. Journal of the International Society of Sports Nutrition. [Online].

Available from: www.jissn.com/content/12/1/21 [Accessed November 13th, 2015].

Helou NEI, Tafflet M, Barthelot G, Tolaini J, Marc A, Guillaume M, Hausswirth C, and Toussaint JF. 2012. Impact of Environmental Parameters on Marathon Running Performance. Biomedical Research Institute of Sports Epidemiology, 7(5):1-7.

Hoeger WWK, Hoeger SA, Fawson AL and Hoeger CI. 2016. Fitness and Wellness. 12th edition. Cengage learning, 248.

Jusoh N. 2010. Hydration, thirst and fluid balance in resting and exercising individuals. Doctor of Philosophy degree. Loughborough University, 1-222.

Kumley RF. 2010. Hydration and fluid replacement knowledge, attitudes, barriers and behaviours of NCAA division football players at Midwestern University. Master's Degree. Ball State University, 1-116.

Montain SJ, Cheuvront SN, Carter R, and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas:1-8.

O' Neal E, Wingo J and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Rodriguez NR, DiMarco NM, and Langley S. 2009. Nutrition and Athletic Performance. American College of Sport Medicine, 709-731.

Sedek R, Mohamad MM, and Kasim ZM. 2015. Knowledge, attitudes and practices on hydration and fluid replacement among endurance sports athletes in national university of Malaysia. Pakistan Journal of Nutrition, 14(10):658-665.

Shirreffs SM and Sawka MN. 2011. Fluid and electrolyte needs for training, competition and recovery. School of Sport, Exercise and Health Science. Loughborough University: 39-46.

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ, and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

Wilson CK. 2008. What is the relationship between hydration knowledge, exercise intensity, and hydration behaviours of college students in Southern Texas. Doctoral these: Lamar University, 1-71.

Zoorob R, Parrish ME, O'Hara H, and Kalliny M. 2013. Sport nutrition needs before, during, and after exercise. Primary Care The Clinical Office Practice, 40(2):475-486.

BIBLIOGRAPHY

Ajzen I Joyce N, Sheikh S, and Cote NG. 2011. Knowledge and the Prediction of Behaviour: The Role of Information Accuracy in the Theory of Planned Behaviour. Basic and Applied Social Psychology, 116.

Albert W and Tullis T. 2013. Measuring the user experience. 2nd edition. Elsevier:126.

Allen S, Miller KC, Albrecht J, Garden-Robinson J, and Blodgett-Salafia E. 2013. Ad libitum fluid intake and plasma response after pickle juice, hypertonic saline, or deionized water ingestion. Journal of Athletic Training, 48(6):734-740.

Armstrong LE. 2005. Hydration Assessment Techniques. Nutrition Reviews, 63(6):40-65.

Armstrong LE. 2007. Assessing hydration status: The elusive gold standard. Journal of the American College of Nutrition, 26 (5):575–584.

Bailey JL, Sands JM, and Franch HA. 2014. Water, electrolytes and acid-base metabolism, in modern nutrition in health and disease. Ed. By Ross AC, Caballero B, Cousins RJ, Tucker KL, and Ziegler TR. 11th edition. Philadelphia: Lippincott Williams & Wilkins:102-129.

Beltrami FG, Hew-Butler T, and Noakes TD. 2008. Drinking policies and exercise-associated hyponatraemia: is anyone still promoting over drinking. British Journal of Sports Medicine, 796-801.

Bothma Y, Greef M, Mulaudzi M, and Wright SCD. 2010. Research in Health Science. 1st edition. Cape Town: Pearson:89.

Brink H. 2006. Fundamentals of research methodology for health care professionals. 2nd edition. Cape Town:Juta:50-55.

Burkes L and Cox G. 2012. The complete guide to food for sport performance. Australia: Allen & Unwin:136-275.

Burke L and Deakin V. 2010. Clinical sports nutrition. 4th edition. McGraw- Hill, Australie:684-685.

Burton N, Brundrett M, and Jones M. 2008. Doing your education research project. Los Angeles: Sage Publications Ltd:60.

Burton LJ and Mazerolle SM. 2011. Validity of a survey instrument examining athletic trainers' knowledge and practice believes regarding exertional heat stroke. Athletic Training Education, 6(1):36-45.

Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, and Stone JA. 2000. National Athletic Training Association. Fluid replacement for athletes. Journal of Athletic training, 35:212-224.

Casa DJ, Clarkson P and Roberts W. 2005. American College of Sports Medicine roundtable on hydration and physical activity. Current Sports Medicine Reports, 4(3):115-127.

Casa DJ, Stearns RL, Lopez RM, Ganio MS, PhD, McDermott BP, Yeargin SW, Yamamoto LM, Mazerolle SM, Roti MW, Armstrong LE, and Maresh CM. 2010. Influence of Hydration on Physiological Function and Performance during Trail Running in the Heat. Journal of Athletic Training, 35:212-224.

Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, and Thake CD. 2013. Water and sodium intake habits and status of ultra-endurance runners during a multi stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutritional Journal. [Online].

Available from: http://www.nutritionj.com/content/12/1/13 [Accessed March 13th, 2013].

Coyle EF. 2003. Fluid and fuel intake during exercise. Journal of Sports Science, 22(1):39-55.

Cheuvront SN and Sawka MN. 2014. Hydration assessment of athletes. Gatorade Sports Science Institute. [Online].

Available form: http://www.gssiweb.org/Article/sse-97-hydration-assessment-of-athletes [Accessed June 18th 2015].

Dada JH. 2010. Runners need proper nutrition and hydration for the 26.2 mile stretch. Today's Dietician, 12(3):36

Dunford M and Doyle JA. 2012. Nutrition for Sport and Exercise. 2nd edition. Belmont CA: Wadsworth: 240-277.

De Bruyne LK, Pinna K and Whitney E. 2012. Nutrition and Diet Therapy. 8th ed. USA: Wadsworth. [Online].

Available from: http://books.google.co.za [Accessed 30 December 2015].

Duvillard SP, Braun WA, Markofski M, Beneke R, and Leithauser R. 2004. Fluids and hydration in prolonged endurance performance. Nutrition, 20(7/8):650-656.

Flynn L. 2014. Marathon Runners and their Nutrition Views, Practices, and Sources of Nutrition Information. Master's Degree. Syracuse University, 1-45.

Garrett WE and Kirkendall DT. 2000. Exercise and Sport Science, Lippincott Williams and Wilkins, 322.

Gaw A, Murphy MJ, Cowan RA, O'Reilly DSJ, Stewart MJ, and Shepherd J. 2008. Clinical Biochemistry. 4th edition. Elsevier: 13.

Geijer JR, Pitney WA, and Brandenburg J. 2009. Fluid replacement knowledge and sources of hydration information among Illinois high school athletic coaches: a pilot study. The Internet Journal of Allied Health Sciences and Practice, 7(3):540-580.

Gordon RE, Kassier SM, and Biggs C. 2015. Hydration status and fluid intake of urban, underprivileged South African male adolescent soccer players during training. Journal of the International Society of Sports Nutrition. [Online].

Available from: www.jissn.com/content/12/1/21 [Accessed March 13th, 2013].

Haas EM. 2011. Role of Potassium in Maintaining Health. Periodic Paralysis International. [Online].

Available from: http://hkpp.org/patients/potassium-health [Accessed May 29th, 2015].

Hammond K. 2012. Chapter 14. Assessment: Dietary and Clinical Data, In Krause's food and nutrition care process. Ed. By Mahan KL, Escott-Stump S and Raymond JL. 12th edition. Philadelphia: W.B. Saunders Company: 599-603.

Helou NEI, Tafflet M, Barthelot G, Tolaini J, Marc A, Guillaume M, Hausswirth C, and Toussaint JF. 2012. Impact of Environmental Parameters on Marathon Running Performance. Biomedical Research Institute of Sports Epidemiology, 7(5):1-7.

Heneghan C, Gill P, O'Neill B, Lasserson D, Thake M, and Thompson M. 2012.Mythbusting sports and exercise products. British Medical Journal, 345-484.

Hew-Butler T, Verbalis JG, and Noakes TD. 2006. Updated Fluid Recommendation: Position Statement from the International Marathon Medical Directors Association (IMMDA). Clinical Journal of Sport Medicine, 16:283–292.

Hoeger WWK, Hoeger SA, Fawson AL and Hoeger CI. 2016. Fitness and Wellness. 12th edition. Cengage learning, 248.

Hoffman MD, Hew-Butler T, and Schwellnus M. 2014. Regarding the Wilderness Medical Society Practice Guidelines for Heat-Related Illness. Wilderness and Environmental Medicine, 25(2):246-247.

Institute of Medicine. 2004. Dietary reference intake. [Online].

Available from: http://www.iom.edu/activities/nutrition/summarydris/dri-tables.aspx [Accessed May 29th, 2015].

Jeukendrip AE. 2011. Nutrition for endurance sports: Marathon, triathlon, and road cycling. Journal of Sport Science, 29(1):91-99.

Josuh N. 2010. Hydration, thirst and fluid balance in resting and excising individuals. Doctoral thesis: Laughborough University, 1-222.

Kingston R. 2012. A Cross sectional survey on knowledge, attitude and practice of staff members towards daily water intake during working hours in international medical university, Malaysia. Asian Journal of Pharmaceutical and Clinical Research, 5(4): 974-2441.

Kumley RF. 2010. Hydration and fluid replacement knowledge, attitudes, barriers and behaviours of NCAA division football players at Midwestern University. Master's Degree. Ball State University, 1-116.

Lee RD and Nieman DC. 2007. Nutritional Assessment. 4th edition. New York: McGraw-Hill Companies. [Online].

Available from:
http://highered.mheducation.com/sites/0078021332/information_center_view0/index.html
[Accessed May 2nd 2015].

Little JP, Chilibeck PD, Ciona D, Vandenberg A, and Zello GA. 2009. The effect of low and high glycemic index foods on high intensity intermittent exercise. International Journal of Sports Physiology and Performance, 367-380.

Lysen LK and Israel DA. 2012. Chapter 22. Nutrition in weight management, In Krause's food and nutrition care process. Ed. By Mahan KL, Escott-Stump S and Raymond JL. 13th edition. Philadelphia: W.B. Saunders Company:462-488.

Mahon E, Hackett A, Stott T, George K, and Davies I. 2014. Macronutrient consumption prior to, and during, a mountain marathon. American Journal of Sports Science, 2(1):5-12.

Maughan RJ, Watson P, and Shirreffs SM. 2015. Implications of active lifestyle and environmental factors for water needs and consequences of failure to meet those needs. Nutrition Reviews, 73(2):130-140.

Meltzer S and Fuller C. 2008. The complete book of Sports Nutrition: a Practical Guide to Eating for Sport. New Holland:60.

Meyer F. 1993. Water and electrolyte losses and replenishment in children during prolonged exercise in the heat. Doctor of Philosophy, McMaster University: 1-155.

Montain SJ, Cheuvront SN, Carter R and Sawka MN. 2006. Human water and electrolyte balance. Present Knowledge in Nutrition, Kansas: 1-8.

Murray B, Stofan J, and Eichner ER. 2003. Hyponatremia in Athletes. Gatorade Sports Science Institute, 16(1):1-6.

Neumann G. 2001. Nutrition in Sport, Oxford: Meyer & Meyer Sport, 103.

Niemann A. 2012. The Effect of Instrument Type on the Measure of Hydration Status. Master's degree. Indiana State University, 1-73.

Noakes TD. 2003. Fluid replacement during marathon running. Clinical Journal of Sports Medicine, 13(5):309-318.

Noakes TD, Sharwood K, Speedy D, Hew T, Reid S, Dugas J, Almond C, Wharam P, and Weschler L. 2005. Three independent biological mechanisms cause exercise-associated hyponatremia: Evidence from 2135 weighed competitive athletic performances. Proceedings of the National Academy of Science of the United Stated of America, 102(51):18550-18555.

Nolte HW. 2011. Fluid, electrolyte and thermoregulatory responses to ad libitum water replacement during prolonged exercise. Doctoral thesis: University of Pretoria, 1-197.

Nolte HW, Noakes TD, and Van Vuuren B. 2010. Protection of total body water content and absence of hyperthermia despite 2% body mass loss ('voluntary dehydration') in soldiers drinking ad libitum during prolonged exercise in cool environmental conditions. British Journal of Sports Medicine, 1-7.

Olenhof D, Jeryan C, and Boyden K. 2008. The Gale Encyclopaedia of Medicine: A-B [Online].

Available from: http://medical-dictionary.thefreedictionary.com/electrolytes [Accessed May 29th, 2015].

O'liveira EP. 2013. Nutrition recommendation to avoid gastrointestinal complains during exercise. Sport Science Exchange, 26(114):1-4.

O'Neal E, Wingo J, and Richardson M. 2011. Half marathon and full marathon runners' hydration practices and perceptions. Journal of Athletic Training, 46(6):581-591.

Paugh SL. 2005. Dietary Habits and Nutritional Knowledge of College Athletes, 36-86.

Popkin BM, D'Anci KE, and Rosenberg IH. Water, hydration and health. 2010. Nutrition Reviews, 68(8):439-458.

Potgieter S. 2013. Sport nutrition: A review of the latest guidelines for exercise and sport nutrition from the American College of Sport Nutrition, the International Olympic Committee and the International Society for Sports Nutrition. South African Journal of Clinical Nutrition, 26(1):6-16.

Ray ML. 1997. The effect of fluid composition on rehydration following heat and exercise induced dehydration. Dissertiation: Iowa State University: 1-96.

Rodriguez NR, DiMarco NM, and Langley S. 2009. Nutrition and Athletic Performance. American College of Sport Medicine, 709-731.

Rolfes W. 2013. Water and the major minerals. Understanding Nutrition. 13th edition. Wadswoth: 397.

Sawka MN, Burke LM, and Eichner ER. 2007. American College of Sports Medicine positions stand Exercise and fluid replacement. Medicine and Scientific in Sports and Exercise, 39:377–90.

Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, and Stachenfeld NS. 2007. Exercise and fluid replacement. American College of Sports Medicine: 39(2):377-390.

Sedeaud A, Marc A, Marck A, Dor F, Schipman J, Dorsey M, Haida A, Berthelot G, Toussaint JF. 2014. BMI, a performance parameter for speed improvement. Public Library of Science, 9(2): 1-7.

Sedek R, Mohamad MM, and Kasim ZM. 2015. Knowledge, attitudes and practices on hydration and fluid replacement among endurance sports athletes in national university of Malaysia. Pakistan Journal of Nutrition, 14(10):658-665.

Shirreffs SM and Maughan L. 1998. Fluid and electrolyte loss and replacement in exercise. Sports medicine. 2nd Edition. New York: Oxford University Press, 97-113.

Shirreffs SM and Sawka MN. 2011. Fluid and electrolyte needs for training, competition and recovery. School of Sport, Exercise and Health Science. Loughborough University: 39-46.

Singh R. 2003. Fluid Balance and Exercise Performance. Medical Journal of Nutrition, 9(1):53-74.

Stachenfeld NS. 2013. Assessing hydration in the laboratory and field. Sports Science Exchange, 26(111):1-4.

Stedman TL. 1982. Stedman"s Medical Dictionary. 24th edition. United States of America: Williams and Wilkins, 624.

Tam N, Nolte HW, and Noakes TD. 2011. Changes in total body water content during running races of 21.1 km and 56 km in athletes drinking. Clinical Journal of Sports Nutrition, 21(3):218–225.

Turocy PS, DePalma BF, Horswill CA, Laquale KM, Martin TJ, Perry AC, Somova MJ and Utter AC. 2011. National Athletic Trainers' Association Position Statement: Safe weight loss and maintenance practices in sport and exercise. Journal of Athletic Training, 46(3):322-336.

Wilson CK. 2008. What is the relationship between hydration knowledge, exercise intensity, and hydration behaviours of college students in Southern Texas. Doctoral these: Lamar University, 1-71.

Winger JM, Dugas JP, and Dugas LR. 2011. Believes about hydration and physiology drive drinking behaviours in runners. Journal of Sport Medicine, 45(8):646-649.

World Health Organisation. 2012. Obesity and overweight. [Online].

Available from: http://www.who.int/mediacentre/factsheet/fs311/en/ [Accessed April 18th, 2013].

World Health Organization (WHO). 2008. WHO Steps Surveillance Manual. [Online].

Available from: http://www.who.int/chp/steps/manual/en/index7.html [Accessed April 18th 2014].

Young AJ, Sawka MN, Epstein Y, Decristofano B, and Pandolf KB. 1987. Cooling different body surfaces during upper and lower body exercise. Journal of Applied Physiology, 63(3):1218-1223.

Zoorob R, Parrish ME, O'Hara H, and Kalliny M. 2013. Sport nutrition needs before, during, and after exercise. Primary Care The Clinical Office Practice, 40(2):475-486.

Zubieta-Calleja G. and Paulev PE. 2004. Body fluids and regulation. New Human Physiology. 2nd edition. University of Copenhagen [Online].

Available from: http://www.zuniv.net/physiology/book/ [Accessed May 29th, 2015].

SUMMARY

Endurance exercise has recently become more popular, but requires optimal hydration to ensure peak performance. The human body regulates fluid homeostasis as long as food and fluids are available. As soon as an athlete starts to train, muscle exertion and environmental factors challenge the ability of the human body to regulate fluid homeostasis. A weight loss of more than two percent during exercise has been linked to changes in haemorheology, metabolic dysregulation, heat intolerance, cardiovascular strain, and the subsequent inability to maintain exercise workload. In this study the hydration knowledge and practices of long distance runners in the South African National Defence Force was determined in relation to current hydration recommendations. The study followed a descriptive, observational design, using a self-reporting questionnaire and anthropometric measurements as data collection techniques.

Of the 144 participants included in the study, the majority was black (40.5%) males (80.5%), mostly from the Western Cape (47.7%), who works as operators (51.9%). Participants had a mean age of 40 (±8.636 SD) years. According to the body mass index (BMI), four (3.2%) participants were underweight, 36.0% overweight/obese and 60.8% had a normal weigh, with no significant difference between the mean BMI of half and full marathon (p=0.0601). With more than a third of athletes being overweight/obese, athletes need to be informed regarding the health implications of being overweight or obese, as well as the impact of overweight and obesity during endurance exercise on performance.

Reported race experience, ranged between 13 and 365 months. A mean weight loss of 0.002 kg (±0.404 SD) was recorded between registration and pre-race, with the largest weight loss being 0.8 kg and the most weight gained 3.5 kg. Nearly half (42%, n=55) of participants for whom body weight was measured before and after the race lost 2% or more of their body weight during the race. A maximum weight loss of 4.2 kg was measured during the race, which equalled a body weight loss of 6.36%. This put the athletes at risk for serious health risks and implicates that athletes need to be educated regarding the dangers of fluid losses during activity.

With regard to hydration *knowledge*, 66.0% of participants obtain hydration knowledge mainly from reading books and magazines and 94 (65.3%) participants indicated that they read labels

on sports drinks, focussing mostly on carbohydrate level. Athletes need to be counselled to focus on electrolyte levels as well. Although the majority (73.8%) of participants knew that fluid influences performance, 20 (13.9%) were not able to indicate why weight loss occurs during marathon participation and 38.9% were uncertain whether urine colour influences physical performance. Although most participants had a reasonable good general knowledge regarding hydration, training is needed in important areas such as the effect fluid have on performance and how to assess hydration status using urine colour and weight change during training and competitions. Alarmingly 11.1% of participants were not able to report symptoms of dehydration, which is important to prevent heat-related illnesses. Athletes should be able to identify dehydration as well as over hydration early, understand the implications, and be equipped to restore hydration status in order to optimize performance.

With regard to hydration *practices* nine participants (6.3%) indicated that they do not consume extra fluids before, during or after a race, which is a cause for concern considering the health risks associated with dehydration. Athletes need to be aware of the implication of not consuming sufficient amounts of fluids when participating in endurance events. Fourty one percent participants consumed extra fluids at least four hours before the race. For athletes participating in the half marathon, mean fluid intake was significantly higher than for the full marathon. There was however no significant difference in fluid intake per kilogram body weight between the half; and full marathon. Participants preferred energy drinks (32.6%) before a race and water during (28.5%) and after (21.5%) a race. Most participants (78.5%) relied solely on fluids provided by the race organisers and few (13.2%) carried fluids with them. The amount of fluid consumed depended mostly on environmental conditions (71.1%), with only 13.6% participants consuming more fluids due to dehydration cues. Most participants (61.8%) reported to drink according to thirst rather than to maintain weight or according to schedule and more than half (54.8%) reported that they never dehydrate during a race. More attention should be given to educate runners on how to monitor hydration status, emphasizing that thirst is not the only hydration cue and is not sufficient to prevent dehydration. Athletes should be taught how to use different techniques to assess hydration status and need to learn how to develop an appropriate individualized rehydration strategy comprising the amount as well as time of fluid intake.

OPSOMMING

Langafstand wedlope word meer gewild onder atlete, maar optimale hidrasie is noodsaaklik om optimale prestasie te verseker. Solank as wat vloeistof en voedsel beskikbaar is, reguleer die menslike liggaam vloeistofbalans, maar sodra ŉ atleet begin oefen, sal die werkende spier en omgewingsfaktore die vermoë van die menslike liggaam beproef om vloeistofbalans te reguleer. Massaverlies van meer as 2% tydens oefening veroorsaak veranderinge in bloedsamestelling, abnormale metaboliese werking, hitte onverdraagsaamheid, kardiovaskulêre stremming, asook die onvermoë om oefening vol te hou. Tydens die uitvoer van hierdie studie is die hidrasiekennis en -praktyke van soldate in die Suid Afrikaanse Nasionale Weermag bepaal en vergelyk met bestaande riglyne. 'n Beskrywende, waarnemingsstudie is uitgevoer en ŉ vraelys wat deur deelnemers self voltooi is, asook antropometriese metings is gebruik om data in te samel.

Van die 144 deelnemers wat ingesluit is by die studie, was die meerderheid swart (40.5%) mans (80.5%), woonagtig in die Wes-Kaap (47.7%). Deelnemers het 'n gemiddelde ouderdom van 40 jaar (±8.636 SD) gehad. Liggaamsmassa indeks (LMI) het aangedui dat vier (3.2%) deelnemers ondermassa was, 36.0% oormassa; en 60.8% het 'n normale massastatus gehad. Daar was geen statistiese verskil tussen die gemiddelde LMI van atlete wat aan die halfmaraton en die volle maraton deelgeneem het nie (p=0.0601). Met meer as 'n derde van die deelnemers oormassa/ vetsugtig, is dit belangrik om atlete in te lig oor die gesondheidsimplikasies van oormassa, asook die effek wat ekstra massa het op prestasie tydens uithou oefeninge.

Wedloopondervinding van deelnemers het gewissel tussen 13 en 365 maande. 'n Gemiddelde gewigsverlies van 0.002 kg (± 0.404 SD) is gemeet tussen wedstrydregistrasie en voor die wedloop, met die grootste verlies 0.8kg en die meeste massa opgetel 3.5 kg. Amper die helfte van deelnemers (42%, n=55) vir wie massa voor en na die wedloop gemeet is, het 2% of meer massa verloor tydens die wedren. ŉ Maksimum massaverlies van 4.2 kg is gemeet tydens die wedloop, wat ekwivalent is aan ŉ gewigsverlies van 6.36%. Hierdie vogverlies hou ŉ ernstige gesondheidsrisiko vir die atleet in en impliseer dat atlete ingelig moet word aangaande die gevare van vloeistofverliese tydens aktiwiteit.

Indien na die hidrasiekennis van atlete gekyk word, het 66.0% van die deelnemers aangedui dat hul hidrasiekennis vanaf boeke en tydskrifte bekom en 94 (65.3%) van die deelnemers het

aangedui dat hul etikette op sportdrankies lees. Deelnemers het aangedui dat hul veral oplet na die koolhidraatinhoud. Atlete behoort opgelei te word om ook aandag te gee aan die elektrolietinhoud van drankies. Alhoewel die meeste deelnemers (73.8%) bewus was dat vloeistofinname hul prestasie sal beïnvloed, was 20 (13.9%) deelnemers nie in staat om aan te dui waarom massaverlies tydens wedlope plaasvind nie en 38.9% was onseker of urienkleur ‘n invloed op fisiese prestasie sal hê. Alhoewel die meeste deelnemers ‘n redelike goeie algemene kennis oor hidrasie gehad het, is opleiding steeds nodig aangaande die invloed wat vloeistof op prestasie het en hoe om hidrasiestatus te bepaal deur urienkleur en gewigsveranderinge tydens oefening en kompetisies te gebruik. Dit is ontstellend dat 11.1% van die atlete nie in staat was om die simptome van dehidrasie aan te dui nie. Atlete behoort in staat te wees om die verskillende simptome van oor- sowel as dehidrasie te kan onderskei ten einde optimale prestasie te verseker.

Wat hidrasiepraktyke betref, het nege deelnemers (6.3%) aangedui dat hul geen ekstra vloeistowwe voor, tydens of na ‘n wedloop gebruik nie, wat uiters gevaarlik is wanneer die gesondheidsimplikasies geassosieer met dehidrasie in ag geneem word. Atlete moet bewus wees van die implikasies van onvoldoende vloeistofinname tydens uithou-wedlope. 41% van die deelnemers het ekstra vloeistowwe ten minste vier ure voor die wedloop ingeneem. Vir atlete wat aan die halfmaraton deelgeneem het, was die gemiddelde vloeistofinname statisties meer as vir atlete wat aan die volle maraton deelgeneem het. Daar was egter geen betekenisvolle verskil in vloeistofinname per kilogram liggaamsmassa tussen die half- en die volle maraton nie. Deelnemers het energiedrankies (32.6%) voor deelname en water tydens (28.5%) en na deelname (21.5%) verkies. Die meeste deelnemers (78.5%) het staatgemaak op vloeistowwe wat deur die wedlooporganiseerders verskaf word en slegs ’n paar (13.2%) het vloeistof saam met hul gedra. Die hoeveelheid vloeistof wat ingeneem word, het meestal afgehang van omgewingstoestande (71.1%) met slegs 13.6% van deelnemers wat meer vloeistowwe ingeneem het as gevolg van dehidrasie tekens. Die meeste deelnemers (61.8%) het aangedui dat hul vloeistowwe drink volgens dorssensasie, eerder as wat hul poog om massa te handhaaf of volgens ’n bepaalde skedule vloeistof drink. Meer as die helfte (54.8%) het aangedui dat hul nooit tydens ’n wedloop dehidreer nie. Meer nadruk is nodig om atlete op te lei oor hoe om hidrasiestatus te monitor, met die klem daarop dat dors nie die enigste hidrasieteken is nie en ook nie voldoende is om dehidrasie te voorkom nie. Atlete moet opgelei word hoe om verskillende tegnieke te gebruik om hidrasiestatus te bepaal asook hoe om ’n eie, geïndividualiseerde rehidrasie strategie saam te stel wat die hoeveelheid sowel as die tydsberekening van vloeistofinname insluit.

ADDENDUM A: APPROVAL LETTER HEAD OF SPORT CLUB

RESTRICTED

Telephone: (044) 203-4215
SSN: 840 4215
Facsimile: (044) 203 4179
E-mail: infantryschool@telkomsa.net
Enquiries: Lt Col N.E Stevens

Infantry School
Private Bag X643
Oudtshoorn
6620

7 November 2013

CANGO MARATHON PARTICIPATION

1. Authority is hereby granted to use the Cango Marathon as part of your study.

2. Please be advised that all members from the SANDF that participates must do so voluntary and information of the member be handled confidential.

3. Please contact this office for any assistance.

4. For your further action.

(N.E STEVENS)
WING COMMANDER PHISICAL TRAINING, SPORTS AND RECREATION: LT COL

RESTRICTED

ADDENDUM B:	APPROVAL LETTER HEAD OF SOUTH COAST ATHLETIC CLUB

RESTRICTED

AMHU WC/C/104/10/5

the sandf
Department:
Defence
REPUBLIC OF SOUTH AFRICA

Telephone: 044 203 4006
SSN: 840 4006
Facsimile: 044 203 4077
E-mail: infantryschool@telkomsa.net
Lotus: OC/Inf Sch/Inf/Army/DOD
Enquiries: WO2 R.P Hughes

Infantry School
Private Bag X 643
Oudtshoorn
6620

12 November 2013

STAFF TEST DEURING CANGO MARATON

1. Discussion between Lt. L. Stander and myself has reference.

2. Permission is hereby granted to use the Cango marathon presented by Infantry School to do your assessments as required.

3. Please take note that all runners must volunteer for your study and feedback must be given to me of the successes that you achieved.

R. Hughes

(R.P HUGHES)
PHYSICAL TRAINING AND SPORTS RECREATIONAL WARRENT OFFICER: WO2

ADDENDUM C: APPROVAL FROM THE ETHICS COMMITTEE OF THE FACULTY OF HEALTH SCIENCE, UNIVERSITY OF THE FREE STATE

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

Internal Post Box G40
☎(051) 4052812
Fax (051) 4444359

E-mail address: StraussHS@ufs.ac.za

Ms H Strauss/hv

2014-04-14

REC Reference nr 230408-011
IRB nr 00006240

MS L STANDER
C/O DR R LATEGAN
DEPT OF NUTRITION AND DIETETICS
FACULTY OF HEALTH SCIENCES
CR DE WET BUILDING 208
UFS

Dear Ms Stander

ECUFS NR 209/2013
MS L STANDER **DEPT OF NUTRITION AND DIETETICS**
PROJECT TITLE: HYDRATION KNOWLEDGE AND PRACTICES OF LONG DISTANCE RUNNERS IN THE SOUTH AFRICAN NATIONAL DEFENCE FORCE.

1. You are hereby kindly informed that the Ethics Committee approved the following at the meeting on 8 April 2014:

   - *Amendment to the protocol*

2. Committee guidance documents: Declaration of Helsinki, ICH, GCP and MRC Guidelines on Bio Medical Research. Clinical Trial Guidelines 2000 Department of Health RSA; Ethics in Health Research: Principles Structure and Processes Department of Health RSA 2004; Guidelines for Good Practice in the Conduct of Clinical Trials with Human Participants in South Africa, Second Edition (2006); the Constitution of the Ethics Committee of the Faculty of Health Sciences and the Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines.

3. Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

4. The Committee must be informed of any serious adverse event and/or termination of the study.

5. All relevant documents e.g. signed permission letters from the authorities, institutions, changes to the protocol, questionnaires etc. have to be submitted to the Ethics Committee before the study may be conducted (if applicable).

6. A progress report should be submitted within one year of approval of long term studies and a final report at completion of both short term and long term studies.

7. Kindly refer to the ETOVS/ECUFS reference number in correspondence to the Ethics Committee secretariat.

University of the Free State | Universiteit van die Vrystaat, 205 Nelson Mandela Drive/Rylaan, Park West/Parkwes, Bloemfontein 9301, South Africa/Suid-Afrika
P.O. Box/Posbus 339, Bloemfontein 9300, South Africa/Suid-Afrika
T: +27 (0) 51 401 9111, www.ufs.ac.za

ADDENDUM D: CONSENT FORM

Ethics committee reference number: ECUFS209/2013

DEPARTMENT OF NUTRITION AND DIETETICS, FACULTY OF HEALTH SCIENCES

Hydration knowledge and practices of long distance runners in the South African National Defence Force

CONSENT FORM TO PARTICIPATE IN A RESEARCH STUDY

I have been asked to participate in the above mentioned research study and the study has been explained to me by ___________________________________

Please tick the following if you agree:

1	I have read and understand the Participant Information document for the above mentioned study and had the opportunity to ask questions.	
2	I understand that I am free to choose whether to participate or not in the research study and that I can withdraw from it at any time without any reason, without discrimination or any of my rights affected.	
3	I understand that the researchers can decide to end the study or my participation at any time, without my consent.	
4	I understand that regulatory authorities may inspect the research records for quality control and that data analysis will be done anonymously and hereby provide access to my data and study records to these authorities and scientists.	
5	I understand that the results from this research study will be presented as oral or written reports and understand that I will not be identified by name in any reports or publications.	
6	I understand what will be expected from me in this research study and voluntarily agree to participate.	

Research participant:	Name:	
	Signature:	
	Date:	
Researcher:	Name:	
	Signature:	
	Date:	
Witness	Name:	
	Signature:	
	Date:	

ADDENDUM E: INFORMATION DOCUMENT

DEPARTMENT OF NUTRITION AND DIETETICS

UNIVERSITY OF THE FREE STATE

INFORMATION SHEET FOR RESEARCH PARTICIPANTS

Hydration knowledge and practices of long distance runners in the South African National Defence Force

Dear SANDF athlete

I am a postgraduate dietetic student at the department of Nutrition and Dietetics, University of the Free State and would like to invite you to participate in my research project. Before you decide whether you would be willing to participate, I want to make sure that you understand what the study is all about by explaining to you why I am doing the research study and what the research study entails. Please read through the following information sheet and feel free to ask me any questions.

Why do I want to do this research study?

As postgraduate dietetics student, I have to conduct a research project as part of my studies. Research is very important to develop society and I regard health research as an important tool to improve health and wellbeing of all SANDF members.

Athletes have different ideas and practices regarding fluid and electrolyte replacement and I would like to evaluate these knowledge and practices. The SANDF is an institute where exercise in different environmental conditions takes place. Members have to run long distances in heat as well as other adverse conditions.

Why is it important to know how much fluid and electrolytes a person consumes?

There are many controversies regarding fluid intake during exercise. Over-; and under-; hydration is a problem with serious health and performance implication.

Do I really have to participate in the research?

I would really appreciate it if you decide to participate in the study, but remember that participation is voluntary. No costs will be asked or given to participate in this study. You can decide whether or not to take part and are free to withdraw from the research study at any time if you decide to do so, without having to provide a reason. If you decide to participate I will leave this form with you and ask you to sign a form where you provide consent to participate in the research. You will not be discriminated against if you decide not to participate in the research.

What will happen during the research?

I need at least 125 athletes for this project. Participation will not take longer than 30 minutes of your time. If you decide to participate, please report to one of the five registration tables. The stations will be numbered one to five, you need to go to the same station every time. One of the team members will measure your weight and height and we will ask you to answer a few questions on a questionnaire. On the day of the event, we will weigh you again. After the race, we will weigh you again and ask a few questions on the fluids that you consumed during the race.

What do I have to do?

If you agree to participate, I will ask the following from you:

- To complete a short questionnaire honestly and to the best of your ability (10 minutes);
- To allow the team to measure your weight and height before the race at registration (3 minutes);
- To allow the team to measure your weight before the race (3 minutes); and
- To allow the team to measure your weight after the race again and answer a few questions (5 minutes).

Are there any risks, side effects or discomfort that I can expect?

There are no risks or side effects expected in this research study.

What are the benefits of participating in the study?

Research always provides benefit by developing the world. You will however also benefit from the study as you will receive feed-back on your weight status, as well as fluid intake, which can assist you in optimizing your performance. To thank you, I will provide each participant a voucher for a free massage by the physiotherapists.

What will I do with the results of the study?

All results from the study will be handled confidentially and your name will not be placed on any reports. It will not be possible to identify you as a participant of the study in any research reports. My records might be inspected for quality control and statistical analysis and all efforts will be made to keep personal information confidential. Absolute confidentiality however cannot be guaranteed. The results of the study may be published in medical journals and/or presented at scientific meetings, but confidentiality will be maintained. You can request a copy of the study results from us after the study have been completed.

Who can I contact for more information?

You are welcome to ask me any questions you may have concerning the study and your participation in it. If you have any other questions after the research, you are welcome to contact me at 0714620299. You are also welcome to contact my lecturer Dr Lategan at 051-4012894. If you have any problems or complaints with the study, you can contact the secretary of the Ethics Committee of the Faculty of Health Sciences, UFS at telephone 051-4052812.

Thank you for your time and considering taking part in this research study!

Kind regards

(LT L. BENADIE)

DIETICIAN - HEALTH CENTRE SOUTH COAST: CAPT

ADDENDUM F: REGISTRATION QUESTIONNAIRE

ADDENDUM G: AUTHOR'S INSTRUCTIONS FOR SOUTH AFRICAN JOURNAL OF SPORTS MEDICINE (SAJSM)

AUTHOR INSTRUCTIONS

Named authors must consent to publication. Authorship should be based on substantial contribution to: (i) conception, design, analysis and interpretation of data; (ii) drafting or critical revision for important intellectual content; and (iii) approval of the version to be published. These conditions must all be met (uniform requirements for manuscripts submitted to biomedical journals; refer to **www.icmje.org**).

Manuscripts

Short items are more likely to be accepted for publication, owing to space constrains and reader preferences.

- All manuscripts must include an ***abstract*** not exceeding 250 words.
- ***Manuscript*** should not exceed 4000 words in total all contents inclusive.
- ***Original articles*** of 3 000 words or less, with up to 6 tables or illustrations, should normally report observations or research of relevance to the field of sports medicine and exercise science.
- ***References*** should preferably be limited to no more than 15.

Technical Manuscript preparation

- ***Research articles*** should have a structured abstract not exceeding 250 words comprising: Objectives, Design, Setting, Subjects, Outcome measures, Results and Conclusions.
- Refer to articles in recent issues for the presentation of headings and subheadings.
- ***Abbreviations*** should be spelt out when first used and thereafter used consistently.
- ***Scientific measurements*** should be expressed in SI units except: blood pressure should be given in mmHg and haemoglobin values in g/dl. Litres are denoted with a lowercase 'l' e.g. 'ml' for millilitres. Units should be preceded by a space (except for %), e.g. '40 kg' and '20 cm' but '50%'. Greater/smaller than signs (> and <) should be

placed immediately preceding the relevant number, i.e. 'women >40 years of age'. The same applies to ± and º, i.e. '35±6' and '19ºC'

- ***Illustrations.*** All illustrations/figures/graphs must be of **high resolution/quality**: 300 dpi or more is preferable but images must not be resized to increase resolution. Unformatted and uncompressed images must be attached as '**supplementary files**' upon submission (not embedded in the accompanying manuscript). TIFF and PNG formats are preferable; JPEG and PDF formats are accepted, but authors must be wary of image compression. Illustrations and graphs prepared in Microsoft Power point or Excel must be accompanied by the original workbook.
- ***Tables*** may be embedded in the manuscript or provided as **'supplementary files'**. They must be numbered in Arabic numerals (1,2,3...) and referred to consecutively in the text (e.g. 'Table 1'). Tables should be constructed carefully and simply for intelligible data representation. Unnecessarily complicated tables are strongly discouraged. Tables must be cell-based (i.e. not constructed with text boxes or tabs), and accompanied by a concise title and column headings. Footnotes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || then ** †† ‡‡ etc.
- ***Figures*** must be numbered in Arabic numerals and referred to in the text e.g. '(Fig. 1)'. Figure legends: Fig. 1. 'Title...'

  6. If any tables or illustrations submitted have been published elsewhere, written consent to republication should be obtained by the author from the copyright holder and the author(s).
- ***References***. Authors must verify references from the original sources. *Only complete, correctly formatted reference lists will be accepted.* Reference lists must be generated manually and **not** with the use of reference manager software***.*** Citations should be inserted in the text as superscript numbers between square brackets, e.g. These regulations are endorsed by the World Health Organization, and others. All references should be listed at the end of the article in numerical order of appearance in the **Vancouver style** (not alphabetical order). Approved abbreviations of journal titles must be used; see the List of Journals in Index Medicus. Names and initials of all authors should be given; if there are more than six authors, the first three names should be given followed by et al. First and last page, volume and issue numbers should be given.
- Manuscripts must be provided in ***UK English***
- ***Numbers*** should be written as grouped per thousand-units, i.e. 4 000, 22 160.

- ***Quotes*** should be placed in single quotation marks: i.e. The respondent stated: '...'
- Round ***brackets*** (parentheses) should be used, as opposed to square brackets, which are reserved for denoting concentrations or insertions in direct quotes.
- ***General formatting***. The manuscript must be in Microsoft Word or RTF document format. Text must be single-spaced, in 12-point Times New Roman font, and contain no unnecessary formatting (such as text in boxes, with the exception of Tables).

ADDENDUM H: AUTHOR'S INSTRUCTIONS FOR JOURNAL OF THE INTERNATIONAL SOCIETY OF SPORTS NUTRITION (JISSN)

AUTHOR INSTRUCTIONS

Manuscripts must be submitted by one of the authors of the manuscript, and should not be submitted by anyone on their behalf. The submitting author takes responsibility for the article during submission and peer review. To facilitate rapid publication and to minimize administrative costs, *JISSN* prefers online submission.

Technical Manuscript Preparation:

- ***Word limit***. Abstract should not exceed 350 words and must be structured into separate sections: **Background,** the context and purpose of the study; **Methods**, how the study was performed and statistical tests used; **Results**, the main findings; **Conclusions**, brief summary and potential implications. Please minimize the use of abbreviations and do not cite references in the abstract.
- If ***abbreviations*** are used in the text they should be defined in the text at first use, and a list of abbreviations can be provided, which should precede the competing interests and authors' contributions.
- All ***references***, including URLs, must be numbered consecutively, in square brackets, in the order in which they are cited in the text, followed by any in tables or legends. Each reference must have an individual reference number. Only articles, clinical trial registration records and abstracts that have been published or are in press, or are available through public e-print/preprint servers, may be cited; unpublished abstracts, unpublished data and personal communications should not be included in the reference list, but may be included in the text and referred to as "unpublished observations" or "personal communications" giving the names of the involved researchers. Obtaining permission to quote personal communications and unpublished data from the cited colleagues is the responsibility of the author.
- ***Illustrations*** should be provided as separate files, not embedded in the text file. Each figure should include a single illustration and should fit on a single page in portrait format. If a figure consists of separate parts, it is important that a single composite illustration file be submitted which contains all parts of the figure. There is no charge for the use of color figures.

- The ***legends*** should be included in the main manuscript text file at the end of the document, rather than being a part of the figure file. For each figure, the following information should be provided: Figure number (in sequence, using Arabic numerals- i.e. Figure 1, 2, 3 etc.); short title of figure (maximum 15 words); detailed legend, up to 300 words.
- Each ***table*** should be numbered and cited in sequence using Arabic numerals (i.e. Table 1, 2, 3 etc.). Tables should also have a title (above the table) that summarizes the whole table; it should be no longer than 15 words. Detailed legends may then follow, but they should be concise. Tables should always be cited in text in consecutive numerical order.
- Manuscripts should be written in English. Spelling should be US English or British English, but not a mixture
- ***Abbreviations*** should be used as sparingly as possible. They should be defined when first used and a list of abbreviations can be provided following the main manuscript text.
- ***SI units*** should be used throughout (litre and molar are permitted, however).

Addendum E
Registration Questionaire

Part 1: Demographic information

FOR OFFICE USE

Race number			1-5
Please mark the appropriate block with an X			
1. Gender	M / F		6
2. Race Group			
white			7
black			
coloured			
asian			
3. Age		Yrs	8-9
4. Occupation in the SANDF			10-11
5. Province			
Western Cape			12
Free State			
KZN			
Gauteng			
Limpopo			
6.1. Months/years of participation in half marathons		Months	13-15
		Yrs	
6.2. Months/years of participating in marathons		Months	16-18
		Yrs	
6.3. Number of half marathons completed		Nr	19-20
6.4. Number of marathons completed		Nr	21-22
7.1. Ususal running time for a half marathon	H : M M		23-27
7.2. Ususal running time for a marathon	H : M M		28-32
8.1. Personal best running time for a half marathon	H M M S S		33-37
8.2. Personal best running time for a marathon	H M M S S		38-42
9. As part of your training, do you utilize a coach/trainer	Y / N		43

Addendum E
Registration Questionaire

Part 2: Knowledge regarding hydration and electrolyte replacements

1. Does fluid intake during a race help you perform better? Y / N / Unsure — 44
2. Why do people weigh less after running a marathon?
   ______________________ — 45-46
   ______________________ — 47-48
   Unsure — 49
3. Why is urine colour sometimes darker than other times?
   ______________________ — 50-51
   Unsure — 52
4. Does urine colour have an effect on athletic performance? Y / N / Unsure — 53
5. If urine colour is dark, does it increase (↑) or decrease(↓) performance? ↑ / ↓ / Unsure — 54
6. If urine colour is lighter, does it increase (↑) or decrease(↓) performance? ↑ / ↓ / Unsure — 55
7. Where did you learn what you know about fluid intake during exercise?
   Books/ Magazines — 56
   Television — 57
   Coaches / co runners — 58
   Friends — 59
   Other — 60
   specify ______________________ — 61-62
8. Do you read the information on the label of a sports drink? Y / N — 63
9. If yes, what do you consider on the label/What do you look for on the label?
   ______________________ — 64-65
   ______________________ — 66-67
10. List the signs that indicate dehydration
   ______________________ — 68-69
   ______________________ — 70-71
   ______________________ — 72-73
   Don't know — 74

Addendum E
Registration Questionaire

Part 3: Rehydration and electrolyte replacement practices.

1. When do you drink extra fluids?

Before the race	☐	☐	1
During the race	☐	☐	2
After the race	☐	☐	3
No extra fluids	☐	☐	4

2. How long before the race do you start drinking extra fluids? ____________ 5-9

Don't drink extra fluids ☐ 10

3. Approximately how much fluid do you drink before the race and how long before the race?

☐☐☐☐☐	ml	11-15
☐☐	min	16-17

4. What beverage do you prefer and approximately how much?

Before the race	____________		18-19
Amount	☐☐☐☐☐	ml	20-24
During the race	____________		25-26
Amount	☐☐☐☐☐	ml	27-31
After the race	____________		32-33
Amount	☐☐☐☐☐	ml	34-38

5. How do you usually get fluids during a half marathon

Carry it with you	☐	39
Rely on the water tables	☐	40
Wait till the end of the race	☐	41
Do not drink during the race	☐	42
Friends	☐	43
Other	☐	44
Specify	____________	45-46

6.1. List what will cause you to drink more fluids than normal during a half marathon

____________ 47-48

____________ 49-50

____________ 51-52

____________ 53- 54

6.2. List what will cause you to drink less fluids than normal ____________ 55-56

during a half marathon	______				57-58
	______				59-60
	______				61-62
7. Does the temperature of the drink have an effect on how much you drink?	Y	N	Unsure		63
8. If the temperature of the drink is warm, do you drink less or more?	Less	More	Unsure		64
9. If the temperature of the drink is cold, do you drink less or more?	Less	More	Unsure		65
10.1. Does the taste of the drink have an effect on how much you drink?	Y	N	Unsure		66
10.2. Does the taste of water let you drink less or more	Less	More	Not inflence		67
10.3. Does flavours you like more, let you drink less or more	Less	More	Not inflence		68
10.4. Does flavours you like less, let you drink less or more	Less	More	Not inflence		69
11. What influences your choice in the beverages you drink during a race?					
Nothing- I take what I get at the race					70
I take what experience has shown works for me					71
Coach's advice					72
Recommendations by other athletes					73
Recommendations by Race organizers					74
Advertising by Sports drinks manufacturers					75
Recommendations by Scientific organizations					76
Other					77

Addendum E
Registration Questionaire

12. Does the type of fluids you take during a race increase (↑), decrease (↓), or have no effect on your performance?		↑	↓	No effect	78
13. Does the environmental temperature while running influence your fluid intake?		Y	N	Unsure	79
14. Does warm temperature increase (↑) or decrease(↓) your fluid intake?		↑	↓	No effect	80
15. Does cold temperature increase (↑) or decrease(↓) your fluid intake?		↑	↓	No effect	81
16. What indication do you use to drink fluids during a race?					
To maintain weight					1
Schedule					2
Thirst					3
Other					4
17. Do you drink sports drinks? If yes, why?		Y	N		5
Reason ________					6-7
________					8-9
18. Do you sometimes dehydrate during a race?	Never	Sometimes	Often	Always	10
19. What symptoms do **you personally** get from dehydrating? ________					11-12
________					13-14
________					15-16
20. Do you sometimes overhydrate?	Never	Sometimes	Often	Always	17
21. What symptoms do **you personally** get from overhydrating? ________					18-19
________					20-21
________					22-23

Addendum E

Resgistration Measurements

Race number					
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5
					1-5

Height 1					
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10
			.		6-10

Height 2					
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15
			.		11-15

Weight 1					
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20
			.		16-20

Weight 2					
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25
			.		21-25

Addendum E
Pre Race Questionaire

Race number		Weight 1		Weight 2		Type of fluid carried with you			Volume		
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23
	1-5	.	6-10	.	11-15			16-17		ml	18-23

Addendum E
Post Race Questionaire

Race number		Weight 1		Weight 2		Today's running time:		Fluid units taken at drinks tables	Fluid		Amount of fluid left in own bottle (if used)		
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			
									Sportsdrink	26-27			
	1-5	.	6-10	.	11-15	M M M . S S	16-21		Water	22-23		ml	28-32
									Coke	24-25			

Addendum E

Post Race Questionaire

		Sportsdrink	26-27

Start of race

1. Humidity			%	1-2
2. Temperature			◦C	3-4
3. Wind direction			km/h	5-7
4. Wind strength			knots	8-10

End of race

1. Humidity			%	11-12
2. Temperature			◦C	13-14
3. Wind direction			km/h	15-17
4. Wind strength			knots	18-20