THE HYDRATION STATUS, FLUID AND CARBOHYDRATE INTAKE OF MALE ADOLESCENT SOCCER PLAYERS DURING TRAINING IN PIETERMARITZBURG, KWAZULU-NATAL

by

RENO GORDON

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ABSTRACT

Adolescent athletes of this era are more pressurized than adolescents of previous generations to perform at an optimum level (Micheli & Jenkins 2001, p49). The importance of winning can result in adolescent athletes developing inappropriate nutritional practices such as neglecting hydration and consuming insufficient carbohydrate (Micheli & Jenkins 2001, p57). Consuming insufficient fluid leads to dehydration which reduces a soccer player's ability to continue training. Consuming inadequate carbohydrate reduces performance and blood glucose levels during training. This study aimed to determine the hydration status, fluid and carbohydrate intake of male, adolescent soccer players during training.

A cross-sectional study was conducted among 122 amateur male, adolescent soccer players (mean age = 15.8 ± 0.8 years; mean BMI = 20.4 ± 2.0 kg/m^2). The players' hydration status before and after training, was measured using urine specific gravity and percent loss of body weight. Their carbohydrate intake, as well as the type and amount of fluid consumed, were assessed before, during and after training. A questionnaire was administered to determine the players' knowledge regarding the importance of fluid and carbohydrate for soccer training.

The study had an 87.1% response rate. The mean environmental conditions did not predispose players to heat illness. However, the players were at risk of developing heat illness during six of the 14 training sessions. Although the mean urine specific gravity indicated that players were slightly dehydrated before and after training, 43.8% of players were very or extremely dehydrated before training and 53.6% after training. A few (3.3%) were extremely hyperhydrated before training and after training (7.0%). On average players lost less than 1% of body weight during training and less than 3% of players dehydrated more than 2%.

Players consumed mainly water before (289.17 ± 206.37 ml), during (183.20 ± 158.35 ml) and after (259.09 ± 192.29 ml) training. More than 90% stated that water was the most important fluid to consume before, during and after training. Very few (4.7%) correctly stated that carbohydrate should be consumed before, during and after training.

Players were found to be slightly dehydrated before and after training and therefore were not consuming enough fluids during training. Players consumed inadequate amounts and types of fluid and carbohydrate. This not only compromises their performance but also health. Players were not aware of the importance of fluid and carbohydrate for soccer training.

This study is unique in that it focused on the carbohydrate and hydration practices of socio-economically disadvantaged adolescent soccer players during training. The study sample therefore represents a high risk group about which there is limited published data both locally and internationally. This study generated important baseline information which was lacking before on the hydration status, fluid and carbohydrate intake of adolescent soccer players in South Africa.

PREFACE

The experimental work described in this dissertation was carried out in the School of Agricultural, Earth & Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, from February 2010 to December 2012, under the supervision of Chara Biggs and Susanna Maria Kassier.

The study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

DECLARATION – PLAGIARISM

I, Reno Gordon declare that

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Signed:________________________ Date: 12/04/13

Reno Gordon

Signed:________________________ Date: 8th April 2013

Chara Biggs (Supervisor)

Signed:________________________ Date: 12/04/13

Susanna Maria Kassier (Co-Supervisor)

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DEDICATION

This dissertation is dedicated to the memory of my father, Marc Gordon (1964-2009) and my uncle Authur Wood (1966-2009). I know you have found rest in the arms of Jesus.

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1.1 IMPORTANCE OF THE STUDY

Adolescent athletes of this era are more pressurized than adolescents of previous generations to perform at an optimum level (Micheli & Jenkins 2001, p49). The importance of winning can result in adolescent athletes developing inappropriate nutritional practices such as neglecting hydration and consuming insufficient carbohydrate (CHO) (Micheli & Jenkins 2001, p57).

Inadequate fluid consumption can result in dehydration which reduces a soccer players' drive to continue training and increases core body temperature (Ali, Gardiner, Foskett & Gant 2010; Edwards, Mann, Marfell-Jones, Rankin, Noakes & Shillington 2007). Consuming CHO before training has been shown to enhance performance, while CHO intake during training is important to maintain athletic performance and CHO consumption after training is needed to replenish muscle glycogen levels (Rosenbloom 2012; Rodriguez, DiMarco, Langley 2009; Sawka, Burke, Eichner, Maughan, Montain & Stachenfeld 2007). Although athletes can hydrate on water alone, this is not the best practice to meet either the hydration or CHO requirements to protect health and optimise performance (Hoffman & Maresh 2011; Kirkendall 2004; Maughan, Lieper & Shirreffs 1997).

Although a good hydration status enhances athletic performance and is essential for effective thermoregulation, hydration is often ignored as an important aspect of both training and competitive matches (Prado, Barroso, Gois & Reinert 2009; Volpe, Poule & Bland 2009; Micheli & Jenkins 2001, p59). Adolescent athletes are at particular risk as they differ from adults in that they do not produce sweat as efficiently and are therefore at greater risk of developing heat illness (Micheli & Jenkins 2001, p59).

Published literature on CHO and hydration mainly focus on adult soccer players and their nutritional practices during matches and not during training. As adolescent soccer players are still growing and developing, it is important to protect their health and therefore examine their nutrition and hydration practices during training. This is because training exposes them to a greater risk of dehydration as they spend more time training than playing matches.

This study is unique as it focused on the CHO and hydration practices of socio-economically disadvantaged adolescent soccer players during training as opposed to matches. The study sample therefore represented a high risk group about which there is limited published data both locally and internationally. The study generated much needed baseline information on hydration practices and CHO intake of adolescent soccer players in South Africa. This information could serve as a guideline for nutrition education programmes targeted at socio-economically disadvantaged soccer players and be the basis of further research among South African adolescent soccer players.

1.2 PURPOSE OF THE STUDY

The study investigated the hydration status of male, adolescent soccer players before and after training as well as their change in hydration status during training. The type and amount of CHO and fluid consumed before, during and after training was also assessed. In addition the study also examined the knowledge of players regarding the importance of CHO and fluid to enhance performance during training. The study was carried out among players from Pietermaritzburg and surrounding areas.

1.3 STUDY OBJECTIVES

The objectives were to determine the:

1.3.1 hydration status before, during and after training
1.3.2 type and amount of fluid consumed before, during and after training.
1.3.3 type and amount of CHO consumed before, during and after training.
1.3.4 knowledge regarding the importance of fluids and CHO before, during and after training.
1.3.5 knowledge regarding the type and amount of fluids and CHO to consume before, during and after training.

1.4 STUDY PARAMETERS

The study included amateur Black, Indian and Coloured male, adolescent soccer players from disadvantaged socio-economic backgrounds playing for teams in the Pietermaritzburg and District Soccer Association (PADSA) under 17 league. Data was collected between February and August 2011.

1.5 ASSUMPTIONS

It was assumed that:

1.5.1 The training sessions observed were representative of the normal training sessions which the soccer players train under.
1.5.2 The soccer players consumed fluids and CHO before, during, and after training.
1.5.3 The soccer players brought drink bottles containing fluid to training.
1.5.4 There was a tap at the training site.
1.5.5 Before and after training the soccer players would have sufficient urine to provide urine samples.
1.5.6 The urine samples which the soccer players provided were their own and they did not substitute another players' urine sample for their own.
1.5.7 The soccer team would train on the days provided by the coach and the players would report for training regularly and cooperate with the principal researcher and research assistants.
1.5.8 The soccer players were truthful when completing the questionnaire.
1.5.9 The research assistants recorded the data accurately and they consistently performed the measurements as they had been trained to do.
1.5.10 The players participated in training sessions of similar length and intensity each day.

1.5.11 The recording of measurements did not significantly interfere with either the length of training sessions or completion of tasks during training.

1.5.12 The weather during the period of the study was reflective of the weather conditions which normally occur at that time of year.

1.6 DEFINITION OF TERMS

Adolescent	: for the purposes of this study an adolescent will refer to an individual aged 14-17 years of age.
Athlete	: for the purpose of this study an athlete is defined as an individual participating in sports such as soccer, American football and hockey.
Ambient temperature	: temperature of the surrounding medium such as gas or liquid which comes into contact with the apparatus (Parker 1994, p75).
Body Mass Index	: an index of weight-for-height used to classify overweight and obesity in adults (World Health Organisation 2012a).
Carbohydrate-electrolyte beverage	: a beverage containing a source of CHO such as glucose, sucrose and dextrose, at a concentration of 6 to 8% per 100 ml and also contains electrolytes such sodium and potassium (Casa, Armstrong, Hillman, Montain, Reiff, Roberts & Stone 2000).
Conduction	: the transfer of heat from warmer to cooler objects through direct physical contact (Binkley, Beckett, Casa, Kleiner & Plummer 2002).
Convection	: the transfer of heat to or from the body to air (Binkley *et al* 2002).
Dehydration	: a process during which water is lost from the body (Shirreffs 2003).
Dry bulb temperature	: the temperature of a gas measured by a thermometer shielded from radiation (International Union of Physiological Sciences Thermal Commission 2001).
Euhydration	: a condition of neutral water balance (Shirreffs 2003).
Frankfort horizontal plane	: the horizontal line connecting the upper ear opening and the

lower edge of the eye socket (World Health Organization 2004).

Heat cramps : severe, painful, involuntary muscular contractions due to dehydration or electrolyte imbalances which can occur during or after intense training (Binkley *et al* 2002).

Heat exhaustion : collapse due to physiological exhaustion (Armstrong, Casa, Millard-Stafford, Moran, Pyne & Roberts 2007).

Heat illness : a condition that includes heat cramps, heat exhaustion, and heat stroke (Binkley *et al* 2002).

Heat stroke : a condition occurring in athletes during training when the core temperature is greater than 40°C and is associated with signs of organ failure caused by hyperthermia (Binkley *et al* 2002).

Hyperhydration : a condition of positive water balance (Shirreffs 2003).

Hyperthermia : overheating of the body with core body temperature above 40°C (Armstrong *et al* 2007).

Hypohydration : a condition of negative water balance (Shirreffs 2003).

Matric : the matriculation examination conducted by the matriculation board (Higher Education South Africa 2011).

Mouthful : the amount of water which the individual could hold comfortably in their mouth at a time.

Percent change in body weight : this is the difference in body weight measurements before and after training expressed as a percentage of the weight before training.

Poverty rate : the percentage of people who are below the poverty line (United States Census Bureau 2012).

Radiation : the transfer of energy to or from the body (Binkley *et al* 2002).

Rating of perceived exertion : the extent of strain resulting from physical activity determined by the Borg rating of perceived exertion scale (Borg 1998, p9).

Refractometer : an instrument which measures the extent to which light is bent when it travels from air into a sample and is used to determine the index of refraction of a liquid (Hansen 2003).

Rehydration : a process during which the body regains lost fluids (Shirreffs 2003).

Relative humidity : the ratio of moisture in the air in relation to the amount needed for saturation at the same temperature (Porteous 2000, p522).

Severely wasted : a very low weight-for-height classified by a Z-score which is below minus two standard deviations from the median World Health Organisation growth standards (World Health Organisation 2012b).

Urine specific gravity : the density of urine compared to the density of water (Oppliger & Bartok 2002).

Voluntary dehydration : although fluids are available, an individual does not consume enough fluids to adequately replace that which has been lost (Zetou, Giatsis, Mountaki & Komninakidou 2008).

Wet bulb temperature : the temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it, all latent heat being supplied by the parcel (Parker 1994, p2163).

1.7 ABBREVIATIONS

BMI : Body Mass Index

CHO : Carbohydrate

cm : Centimetres

g : Gram

g/ml : Grams per millilitre

kg : Kilogram

kJ : Kilojoule

KZN : KwaZulu-Natal

l : Litre

LIST	: Loughborough Intermittent Shuttle Test
LSPT	: Loughborough Soccer Passing Test
LSST	: Loughborough Soccer Shooting Test
m	: Metre
ml	: Millilitre
ml/kg	: Millilitre per kilogram
m/s	: Metres per second
PADSA	: Pietermaritzburg and District Soccer Association
RH	: Relative Humidity
SPSS	: Statistical Package for the Social Sciences
UKZN	: University of KwaZulu-Natal
U_{SG}	: Urine specific gravity
VO_{2max}	: Maximal oxygen uptake
WHO	: World Health Organisation

1.8 CONCLUSION

Adolescent soccer players are still growing and developing, therefore an inadequate fluid and CHO intake may not only impact on their athletic performance but also on their health. An inadequate fluid intake results in dehydration which causes a decrease in both physical performance and in the drive to continue training (Ali *et al* 2010; Edwards *et al* 2007). An inadequate CHO consumption decreases performance during training, lowers blood glucose levels and results in a depleted muscle glycogen levels after training (Rosenbloom 2012; Rodriguez *et al* 2009; Sawka *et al* 2007; Ostojic & Mazic 2002). These consequences are preventable by an appropriate intake of both fluid and CHO. Therefore, it is important to examine their hydration status, fluid and CHO intake to determine if adolescent soccer players are consuming adequate fluid and CHO for soccer training.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Soccer is the most popular sport in South Africa especially among township adolescents and is therefore regarded as a "black sport" or a sport of the poor (McKinley 2009a; McKinley 2009b).

It is therefore important to ensure that adolescents in South Africa are training safely and that their nutrition practices, such as their fluid and CHO intake, are not negatively impacting on their health and performance. Adolescent athletes are pressured to perform at high levels consistently (Micheli & Jenkins 2001, p49). The focus on winning in sport can result in adolescent athletes neglecting hydration and consuming insufficient CHO during training (Micheli & Jenkins 2001, p57).

Fluid consumption during training is important to replace the fluid lost through sweating, to lessen the degree of dehydration incurred and to prevent heat illness (Edwards *et al* 2007; Casa, Clarkson & Roberts 2005). Carbohydrate consumption during training is important to sustain blood glucose levels for continued performance (Casa *et al* 2000). In spite of the established importance of fluid and CHO intake in adult players, there is a lack of knowledge surrounding the needs of the adolescent soccer player and very little data on their nutrition practices during training

This literature review will explore unemployment, poverty, food insecurity, crime and soccer in South Africa as well as the importance of thermoregulation, effects of dehydration on athletic performance and hydration practices of soccer players. In addition, this review will also explore the effect of CHO on athletic performance, recommendations for optimum fluid and CHO intake for athletes and lastly the knowledge of athletes regarding the importance of fluid and CHO. As there is a substantial amount of literature on adult athletes, this review will document the limited published literature on adolescent athletes.

2.2 THE SOUTH AFRICAN SITUATION

2.2.1 Unemployment, poverty, food insecurity and crime

Unemployment, poverty, food insecurity and crime are social conditions affecting many South Africans. The unemployment rate in South Africa during the third quarter of 2012 was 25.5% and was 21.3% in KwaZulu-Natal (KZN) (Statistics South Africa 2012a). Also, 27.1% of male youths (aged 15 to 24 years) in South Africa were unemployed and not in education and training institutes (Statistics South Africa 2012a). The unemployment rate during the third quarter of 2012 was 29.1% among Blacks, 24.5% among Coloureds, 11.7% among Indians and 5.9% among Whites (Statistics South Africa 2012a).

Pietermaritzburg, a city in KZN has a poverty rate of 54.3% (The Provincial Decision-Making Enabling Project 2005). In KZN the poverty rates among Indian, Coloured and Blacks was 8.0%, 17.2% and 64.4% respectively (The Provincial Decision-Making Enabling Project 2005). Due to unemployment and poverty 14.6% of households in South Africa and 13.1% in KZN had inadequate access to food (Statistics South Africa 2012b). As the majority of the current study population was Black, which is the group that had the highest rates of both poverty and unemployment, food insecurity would probably impact on both the hydration and CHO intake of the players.

An observational, cross-sectional study conducted among secondary school learners (males aged 14 to 17 years) attending public schools in South Africa concluded that 34.5% did not engage in physical activity at school or after school as they felt unsafe and 90.8% were members of a gang (Reddy, James, Sewpaul, Koopman, Funani, Sifunda, Josie, Masuka, Kambaran & Omardien 2010). Furthermore, 94.7% carried a knife and 42.5% carried a gun (Reddy *et al* 2010). The social environment in South Africa therefore may pose many barriers such as unemployment, poverty, crime and food insecurity to economically disadvantaged adolescent soccer players to train effectively and safely.

2.2.2 Soccer in South Africa

Soccer is the most popular sport in South Africa especially among township adolescents (McKinley 2009a; McKinley 2009b).

Apartheid denied millions of black South African youth the facilities and opportunities to progress in sport (McKinley 2009a). Although apartheid ended in 1994, South African soccer still bears the scars of the past as sports such as rugby and cricket that were supported financially during apartheid have some of the best global facilities when compared to the inadequate soccer facilities in many rural areas and townships (McKinley 2009a). Basic soccer equipment (soccer balls and training kits) and development programmes for adolescents have been provided by individuals, community groups and the private sector rather than by the government but no programmes have included components of sports nutrition (McKinley 2009a). Without including nutrition practices in developmental programmes for adolescent soccer players they may be predisposed to risks such as compromised thermoregulation.

2.3 THERMOREGULATION

Endogenous heat production from basal metabolism and exercise, and exogenous heat transfer from the environment and surrounding objects, can increase core body temperature if not effectively dissipated (Giesbrecht 2011). A rise in core temperature can lead to heat illness which includes heat cramps[1] heat exhaustion, and heat stroke. Heat exhaustion occurs when the athlete can no longer continue to train due to a combination of heavy sweating, dehydration and sodium loss. Heat stroke occurs when the core body temperature is greater than 40°C. This is associated with signs of organ failure caused by hyperthermia (Binkley *et al* 2002). As there is limited published data on adolescents, data on children needs to be considered. This data suggests that children have a lower thermoregulatory capacity during training compared to adults, resulting in the earlier onset of impaired athletic performance and increased risk of heat illness (Kavouras & Arnaoutis 2012). To protect core temperature heat needs to be dissipated.

The evaporation of sweat, radiation, conduction, and convection are four methods in which the body dissipates heat, with sweat being the main method of heat loss (Rodriguez *et al* 2009; Casa *et al* 2000). The effectiveness of these methods is influenced by atmospheric temperature, relative humidity (RH), wind speed and radiant energy (Casa *et al* 2000). As the environmental temperature increases, heat lost by convection and conduction decreases, and heat loss from radiation becomes nearly insignificant (Casa *et al* 2000).

The environmental conditions in Pietermaritzburg can predispose adolescent soccer players to heat illness, as although the mean daily temperature from February to August is 20.9°C, the daily temperature can be as high as 35.6°C with a mean afternoon RH of 71% (Weather24 2011). These conditions can significantly impact on heat dissipation particularly through the compromised evaporation of sweat as for every ml of water evaporating from the body, 2.43 kJ of heat is lost (Rodriguez *et al* 2009; Wendt, van Loon & van Marken Lichtenbelt 2007; Casa *et al* 2000).

Sweat rate varies and is influenced by a number of factors. This includes the intensity of training, heat acclimatization, fitness, and the amount and type of clothing worn by the athlete (Casa *et al* 2000). Training enhances the amount of sweat produced by increasing the sensitivity of the sweat glands. As a result, well trained and acclimatized athletes begin sweating earlier (Brouns in Williams & Devlin 1992, p182). Adolescent athletes differ from adults both physiologically and metabolically and do not sweat as effectively as adults, and are therefore at a greater risk of developing heat cramps, heat exhaustion, and heat stroke making appropriate hydration strategies

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[1] Heat cramps: are severe, painful, involuntary muscular contraction due to dehydration or electrolyte imbalance can occur during or after intense training (Binkley *et al* 2002).

even more important (Montfort-Steiger & Williams 2007; Micheli & Jenkins 2001, p59). Sweating results in fluid loss which needs to be replaced in order to prevent dehydration (Casa *et al* 2000).

2.4 DEHYDRATION

Dehydration should be limited to a body weight loss of less than 2% in adults and less than 1% in children (Turocy, DePalma, Horswill, Laquale, Martin, Perry, Somova & Utter 2011; Maughan & Shirreffs 2007; Casa *et al* 2005). Although there are no specific recommendations for adolescents, dehydration can be particularly detrimental as in the case of children, this could also be true for adolescents as they are also still developing physically (Shirreffs 2003).

The effects of dehydration are varied and include a decrease in the drive to continue training as well as an increase in core body temperature and in the rating of perceived exertion (Ali *et al* 2010; Edwards *et al* 2007). Dehydration can result in a decrease in cognitive performance, such as attention, which is important as the ability of player to concentrate on important cues during a match is crucial (Weinberg & Gould 1995, p335).

Edwards *et al* (2007) conducted a randomized cross-over trial to investigate the effect of a 1.5 to 2.0% loss of body weight on the cognitive and physical performance of 11 moderately active adult male soccer players (mean age 24 years). The authors did not state whether the players were professional or amateur. Each player randomly performed one of three trials (fluid intake, mouth rinse only and non-fluid intake) on three separate occasions. All consumed water two hours before the trial to ensure similar levels of euhydration and thereafter followed the fluid protocol of their respective trials (Edwards *et al* 2007). Water was given to the fluid intake group in accordance with 80% of calculated individual weight loss (2% loss of body weight). The total amount given was divided by three (Edwards *et al* 2007). This corresponded with the three drinking opportunities in a soccer match which are before a match, at half-time and after a match. Players were given 25% of the total fluid allocation 15 minutes before the 45 minute cycle, 50% immediately after the 45 minute cycle, and 25% immediately after the 45 minute match. In the mouth rinse trial, players were given 2 ml/kg body weight of water at the same times that the players in the fluid intake group consumed water. Players rinsed their mouth with the water and spat it out while being careful not to swallow any of it (Edwards *et al* 2007).

Urine samples were collected before and after the exercise protocol to determine both osmolality and urine specific gravity (U_{SG}) (Edwards *et al* 2007). Players were weighed before and after the exercise protocol. The authors did not state what clothing the players were weighed in.

Players exercised on cycle ergometers for 45 minutes at 24 to 25°C and 47 to 55% RH (Edwards *et al* 2007). They then rested for 15 minutes before participating in an eight-a-side 45 minute soccer match on a full size astroturf pitch at 19 to 21°C and 46 to 57% RH. These environmental conditions are similar to those experienced during the study. After the match, players performed a yo-yo intermittent recovery test consisting of running 20 m shuttles separated by a 10 second jog. Following the yo-yo intermittent recovery test, players performed a mental concentration test where they had to identify as many numbers as possible from 1 to 100 within a minute on a randomized grid. Players were given a different random grid for each of the three trials (Edwards *et al* 2007).

The non-fluid intake group was 2.4% dehydrated, the mouth rinse group was 2.1% dehydrated and the fluid intake group was 0.7% dehydrated after exercise (Edwards *et al* 2007). The U_{SG} increased significantly from before to after the trial in the non-fluid intake group, but there was no significant change in the mouth rinse group or the fluid intake group. There was no significant difference between the three groups on performance of the mental concentration test, although the mean core body temperature was significantly higher in the non-fluid group than in the fluid intake group. In addition, the mouth rinse group had a lower core body temperature than the non-fluid group (Edwards *et al* 2007).

Ratings of perceived exertion in the non-fluid group were significantly higher than the fluid group, but not significantly higher than the mouth rinse group (Edwards *et al* 2007). This indicates that the non-fluid group felt as though they experienced greater strain during the physical activity than the fluid group. Post-match performance of the yo-yo intermittent recovery test was significantly impaired when fluid was denied as players in the fluid intake group covered the greatest distance compared to those in the mouth rinse and non-fluid group. Therefore, although mental concentration was not impaired, body temperature, ratings of perceived exertion and physical performance was significantly impaired among those not receiving adequate fluid (Edwards *et al* 2007).

Ali *et al* (2010) conducted a cross-over trial to investigate the influence of fluid intake on the sprint and soccer-specific skill performance among 10 professional female, adult soccer players (mean age 26 years) during a 90 minute Loughborough Intermittent Shuttle Test (LIST). Before, and every 15 minutes during the LIST, players performed the Loughborough Soccer Passing Test (LSPT). Players performed two 90 minute trials of the LIST which were a week apart. Players were weighed semi-nude before and after LIST. This was the only method used to assess hydration status. In the first trial, players consumed water every 15 minutes to maintain euhydration, while no fluid was given during the second trial. Players in the non-fluid trial were 2.2% dehydrated after 90 minutes of the LIST while players in the fluid trial were 1.0% dehydrated (Ali *et al* 2010).

Findings were that a 2.2% loss of body weight significantly increased core body temperature, cardiovascular strain, blood lactate concentrations and ratings of perceived exertion and reduced the drive to continue training although there was no significant difference in either the sprint performance or LIST (Ali *et al* 2010). Both Ali *et al* (2010) and Edwards *et al* (2007) reported that a 2.2 to 2.4% level of dehydration resulted in an increase in core body temperature and ratings of perceived exertion.

2.5 HYDRATION PRACTICES OF SOCCER PLAYERS

As there is limited published data on the hydration practices of adolescent soccer players, studies conducted on adult soccer players were reviewed.

2.5.1 Adult soccer players

In an observational, cross-sectional study conducted among Dutch soccer players, the fluid and electrolyte balance of 17 male, professional soccer players (mean age 24 years) was examined (Maughan, Shirreffs, Merson & Horswill 2005). Data was gathered from one training session only. Players trained in a cooler and more humid environment (5°C and 81% RH) than those in the current study. Sweat loss was assessed by weighing the players before and after training in their underwear. This was the only method used to determine hydration status.

Fluid intake was monitored during training, as players had access to water in individually labelled bottles (Maughan *et al* 2005). Only water was provided at frequent drink breaks during training as this was characteristic of the habitual training sessions. The timing of the drink breaks was not stipulated. Players became 1.6% dehydrated and consumed 423 ml of water during training, which lasted one hour and 40 minutes. Only 33% of the fluid loss was replaced despite regular drink breaks and the cool environment. The low environmental temperature (5°C) may have negatively impacted on fluid intake as the players possibly did not feel that they needed to consume fluids. A summary of the results published by Maughan *et al* (2005) is presented in Table 2.1 along with similar studies evaluating the hydration practices of adult and adolescent soccer players.

Table 2.1: Hydration practices of adult and adolescent soccer players during training and matches

Investigators		Environmental temperature (°C)	Relative humidity (%)	Amount of fluid consumed during training or competitive matches (l)	Percentage of fluid replaced (%)	Percentage loss of body weight (%)
Studies conducted among adult soccer players						
Maughan *et al* (2005)		5.0	81.0	0.423 (water)	33.0	1.6
Shirreffs, Aragón-Vargas, Chamorro, Maughan, Serratosa & Zachwieja (2005)		32.0	20.0	0.972 (7% CHO-electrolyte beverage and mineral water)	79.0	1.6
Aragón-Vargas, Moncada-Jiménez, Hernández-Elizondo, Barrenchea & Monge-Alvarado (2009)		26.6 (wet bulb temperature)	35.4	1.948 (type of fluid not stipulated)	44.0	3.4
Kurdak, Shirreffs, Maughan, Ozgünen, Zeren, Korkmaz, Yazici, Ersöz, Binnet & Dvorak (2010)	Match 1	34.3	64.0	1.653 (water)	53.0	2.2
	Match 2	34.4	65.0	1.521 (water)	49.0	2.2
				1.347 (CHO-electrolyte beverage and water)	45.0	2.6
Studies conducted among adolescent soccer players						
Silva, Mündel, Natali, Filho, Lima, Alfenas, Lopes, Belfort & Marins (2011)	Day 1	33.1	43.4	1.610 (water)	57.0	1.8
	Day 2	29.7	60.3	1.140 (water)	79.0	0.4
	Day 3	27.6	75.0	0.650 (water)	52.0	0.8
Da Silva, Mündel, Natali, Filho, Alfenas, Lima, Belfort, Lopes & Marins (2012)		31.0	48.0	1.120 (10 players involved in the match consumed water and a 6% CHO-electrolyte beverage)	50.0	1.6 (10 players involved in the match)

Shirreffs *et al* (2005) conducted an observational, cross-sectional study investigating the sweat rate of 26 professional male, adult soccer players from a Spanish football team (mean age 26 years) training in the heat (32°C and 20% RH). Data was gathered during a 90 minute pre-season training session, the second training session of the day (Table 2.1). Prior to data collection, players were allowed to recover from the first training session during which there was unlimited access to food and fluids. The author did not specify how recovery was determined before commencement of the second training session. To calculate the percent loss of body weight, players were weighed in the nude before and after training. This was the only method used to assess hydration status (Shirreffs *et al* 2005).

Two flavours of a 7% CHO-electrolyte beverage (Gatorade), as well as mineral water were offered during training as these drinks were available during habitual training sessions (Shirreffs *et al* 2005). In accordance with the players' typical training routine, regular drink breaks were scheduled although the frequency of the breaks was not stipulated. Fluid intake was monitored during and after training (Shirreffs *et al* 2005).

The amount of fluid lost varied and was not related to playing position but may have been related to differences in physiology (Shirreffs *et al* 2005). The most popular drink was the CHO-electrolyte beverage (Gatorade) as the majority (92%) consumed this. The players consumed a mean of 972 ml of fluid, were 1.6% dehydrated and replaced 79% of the fluid lost (Shirreffs *et al* 2005). Players in the studies conducted by both Maughan *et al* (2005) and Shirreffs *et al* (2005) were 1.6% dehydrated despite differences in environmental conditions and the availability beverages.

Aragón-Vargas *et al* (2009) conducted an observational, cross-sectional study among 17 male, Costa Rican professional soccer players (mean age 26 years) to evaluate their hydration status before and during a match (Table 2.1). Data was gathered during one match only. One hour before the match urine samples were collected to measure U_{SG}. The authors did not state why urine samples were collected one hour before the match. Players were weighed in the nude before and after the match or once they were substituted. Both percent weight loss and U_{SG} were used to determine the hydration status, improving the validity of results. During the match, players consumed fluid from individually labelled bottles (Aragón-Vargas *et al* 2009). The type of fluid consumed was not specified.

The mean wet bulb temperature was 26.6°C and mean RH was 35.4% which was a similar temperature but less humid conditions than the current study environment (Aragón-Vargas *et al* 2009).

The mean U_{SG} before the match was 1.018 g/ml indicating euhydration with 41% of players being slightly dehydrated (U_{SG} 1.021 to 1.024 1.020 g/ml) (Armstrong, Pumerantz, Fiala, Roti, Kavouras, Casa & Maresh 2010; Aragón-Vargas *et al* 2009). Players lost a mean of 4.448 l of sweat, consumed 1.948 l of fluid and were 3.4% dehydrated (Aragón-Vargas *et al* 2009). They consumed more fluid, lost more sweat and were more dehydrated after the match than those in the previous studies which assessed hydration practices during training (Maughan *et al* 2005; Shirreffs *et al* 2005).

Kurdak *et al* (2010) conducted a non-randomized observational study examining the sweat loss and thermoregulatory responses of 22 male, adult Turkish soccer players (mean age of 20 years) during matches (Table 2.1). The authors did not state if the players were professional or amateur. Players played two soccer matches, two weeks apart at the same time of day (Kurdak *et al* 2010).

Players were weighed before and after the match in their underwear (Kurdak *et al* 2010). Urine samples were obtained only before the match to determine their hydration status. Water was the only beverage available during the first match and players were neither encouraged nor discouraged to consume water. During the second match only water was available for one team while the other team had access to both water and an 8% CHO-electrolyte beverage (Powerade). Only the team given both water and a CHO-electrolyte beverage were told they could drink as much as they desired. It is unclear why only one team was encouraged to drink fluids as this may have introduced bias. The mean temperature and RH were comparable between the two matches (34.4°C and 64% RH during first match, 34.4°C and 65% RH during second match) which was similar but less humid than the current study conditions.

During the first match, players consumed 1.653 l of water replacing 53% of lost fluids and were 2.2% dehydrated (Kurdak *et al* 2010). The mean U_{SG} before the first match showed the players were euhydrated (U_{SG} 1.011 g/ml). Only three players were dehydrated (U_{SG} > 1.020 g/ml). During the second match the team consuming water consumed 1.521 l, thereby replacing 49% of fluid loss and were 2.2% dehydrated. The mean U_{SG} was 1.012 g/ml (euhydrated) and two players were dehydrated (U_{SG} > 1.020 g/ml). The team consuming water and a CHO-electrolyte beverage consumed 1.347 l of fluid, thereby replacing 45% of lost fluids and were more dehydrated (2.6%). The mean U_{SG} before the match was 1.006 g/ml (extreme hyperhydation) and no players were dehydrated (U_{SG} > 1.020 g/ml). Players who had access to water only replaced more fluid than those having access to water and a CHO-electrolyte beverage. These results are contrary to what would have been expected as players consuming water and a CHO-electrolyte beverage would be expected to replace more fluid. It is possible that the soccer players were not used to consuming CHO-electrolyte beverages during matches (Kurdak *et al* 2010).

During both training sessions and matches, adult soccer players consumed inadequate fluid (Kurdak *et al* 2010; Aragón-Vargas *et al* 2009; Maughan *et al* 2005; Shirreffs *et al* 2005). Male, adult professional soccer players seem to dehydrate more during matches (> 2%) than during training (< 2%) (Kurdak *et al* 2010; Aragón-Vargas *et al* 2009; Maughan *et al* 2005; Shirreffs *et al* 2005). This could be explained by the fact that during matches the temperature was higher than during training and there were fewer opportunities to drink.

2.5.2 Adolescent soccer players

Silva *et al* (2011) conducted an observational study assessing the hydration status of 20 male, adolescent Brazilian soccer players (mean age 17 years) from a first division professional team.

Data was collected during a two and a half hour training session on three consecutive days. Before training, urine samples were collected to determine U_{SG} and players were then weighed in the nude. During training players were instructed to collect any urine they passed in containers to estimate the amount of fluid lost (Silva *et al* 2011) (Table 2.1).

Only water, which players were allowed to consume freely, was provided as this was normally available during training (Silva *et al* 2011). Regular drink breaks according to their habitual training routine were scheduled. Labelled drink bottles were weighed before and after every refill. Players were instructed to consume from their own drink bottles only and not to spit out any water or use it to splash their faces. Separate bottles were available for the players to splash their faces. At the end of the training session, players provided urine samples, were towel dried and weighed in the nude before being allowed to drink any water (Silva *et al* 2011).

The mean temperature was 30.1°C and RH was 59.6% which was within the range experienced during the current study (Silva *et al* 2011). Over the three days the players replaced a mean of 61% of lost fluids, consumed 1.13 l, lost 1.84 l of sweat and were 1.0% dehydrated after training (Silva *et al* 2011). They were slightly dehydrated before (mean U_{SG} 1.023 g/ml) and after training (mean U_{SG} 1.024 g/ml) according to the classification by Armstrong *et al* (2010).

Da Silva *et al* (2012) conducted an observational, cross-sectional study assessing the fluid intake and fluid losses of 15 male, adolescent professional Brazilian soccer players playing for a first division soccer team during a match (Table 2.1).

Data was collected during one match consisting of two 40 minute halves separated by a 15 minute half-time break as opposed to a standard match of two 45 minute halves (Da Silva *et al* 2012). Before the match, each player provided a urine sample and was weighed in the nude. After the match, players provided urine samples and were then weighed after being towel dried (Da Silva *et al* 2012).

During the match, water was provided in individually labelled bottles as water was normally available during matches (Da Silva *et al* 2012). Players were allowed to consume water freely during the match but were not allowed to spit the water out or use it to splash their faces. The drink bottles were weighed before being given to the players and again after every refill. Players were also instructed to consume 200 ml of a 6% CHO-electrolyte beverage 30 minutes before the match, 400 ml during the match and 200 ml during the half-time break (Da Silva *et al* 2012). This is unlike the study conducted by Silva *et al* (2011) who only gave players water during training and did not instruct the players on the amount of fluid to consume.

The mean temperature and RH during the match was 31°C and 48% which is similar to the conditions in the current study (Da Silva *et al* 2012). Players who played the full duration of the match were on average 1.6% dehydrated and consumed a mean of 1.12 l of fluid during the match. The mean pre-match U_{SG} was 1.020 g/ml indicating euhydration (Da Silva *et al* 2012; Armstrong *et al* 2010). The mean post-match U_{SG} was 1.016 g/ml indicating well hydrated (Da Silva *et al* 2012; Armstrong *et al* 2010).

Based on these limited studies, on average, adolescent soccer players (1.3% dehydrated) appear to dehydrate less than adults (2.2% dehydrated) both during training and matches possibly because adolescents do not produce sweat as efficiently as adults do (Micheli & Jenkins 2001, p59). Both the adult and adolescent soccer players tend to be more dehydrated after matches than training. From the above studies it is evident that most soccer players consumed water rather than CHO-electrolyte beverages during training and soccer matches (Da Silva *et al* 2012; Silva *et al* 2011; Kurdak *et al* 2010; Aragón-Vargas *et al* 2009; Maughan *et al* 2005; Shirreffs *et al* 2005).

2.6 CARBOHYDRATE AND ATHLETIC PERFORMANCE

Consuming CHO containing beverages during training is important as they may improve the intestinal absorption of sodium and water thereby contributing to optimal hydration and sustaining blood glucose levels (Casa *et al* 2000). Consuming CHO-electrolyte beverages during intermittent activity lasting 45 to 50 minutes has been shown to improve performance in comparison to consuming the same amount of water (Casa *et al* 2005). These beverages can also reduce the negative effects of fatigue on performance and may also improve soccer-specific skill performance (Ali, Williams, Nicholas & Foskett 2007; Shirreffs *et al* 2005; Ostojic & Mazic 2002).

Ostojic & Mazic (2002) conducted a randomized controlled study investigating the effect of a CHO-electrolyte beverage on soccer specific tests and soccer performance among 22 professional male soccer players (mean age 23 years) from the Yugoslavian National League (Table 2.2). For seven days before the study the players ensured that 55% of their total energy consumed was from CHO to ensure optimal muscle glycogen storage. In addition, the players abstained from prolonged exercise for 72 hours before the study (Ostojic & Mazic 2002).

On the day of the study, a standard breakfast was consumed four hours before the start of the study and after breakfast, water was consumed freely (Ostojic & Mazic 2002). Players were weighed in the nude before the match, after the first half, after the match and one hour after the end of the match. This was the only method used to assess hydration status. Players were randomly allocated to receive either a 7% CHO-electrolyte beverage or plain water at 5 ml/kg body weight immediately before the match and at 2 ml/kg every 15 minutes during a 90 minute soccer match. This is unlike a conventional soccer match during which players do not have the opportunity to consume fluids every 15 minutes. The mean temperature (24.5°C) and RH (57%) was within the range experienced during the current study (Ostojic & Mazic 2002).

Heart rate and ratings of perceived exertion were measured before the match, at half-time, at the end of the match, one minute after the match, and one hour after commencement of the relaxation period (Ostojic & Mazic 2002). Immediately after the match, players performed four soccer-specific skills tests which included dribbling, precision, coordination and a power test (Ostojic & Mazic 2002).

Players consuming water only were significantly more dehydrated (1.81%) than those consuming the CHO-electrolyte beverage (1.16%). The CHO-electrolyte beverage resulted in significantly higher blood glucose concentrations, significantly shorter dribble test times, significantly improved precision tests and significantly lower ratings of perceived exertion. Players consuming plain water tended to have a non-significantly higher heart rate during the match. The CHO-electrolyte beverage however, did not improve coordination or improve performance of the power test (Ostojic & Mazic (2002) (Table 2.2).

Table 2.2: Summary of studies evaluating the efficacy of carbohydrates for athletic performance

Investigators	Subjects	Experimental design	Factors assessed	Findings
Ostojic & Mazic (2002)	Soccer players	Randomized non cross-over allocation to either water (placebo) or 7% CHO-electrolyte beverage.	Rating of perceived exertion, blood glucose concentration, heart rate and soccer-specific skills test.	CHO-electrolyte beverage resulted in: -significantly higher blood glucose concentrations, -significantly shorter dribble test times, -significantly improved precision tests, -significantly lower ratings of perceived exertion, - non-significantly lower heart rate, -no improvement on the coordination or power test.
Welsh, Davis, Burke & Williams (2002)	College athletes	Randomized cross-over allocation to either flavoured water or a 6% CHO-electrolyte beverage.	Physical and mental function during intermittent high-intensity activity	CHO-electrolyte beverage: -significantly improved 20 m sprint performance, -significantly enhanced speed and agility of whole body motor skills, -significantly improved reported perceptions of fatigue during the third and fourth quarter, -significantly delayed fatigue in the intermittent high-intensity run after the fourth quarter.
Guerra, Chaves, Barros, Tirapegui (2004)	Soccer players	Randomized non cross-over allocation to either 6% CHO-electrolyte beverage or non CHO-electrolyte beverage	Loss of body weight, time spent running, number of sprints performed.	CHO- electrolyte beverage resulted in: significantly better hydration, -significantly more time running in the first half, -significantly more sprints in the first half.
Ali *et al* (2007)	Soccer players	Randomized cross-over allocation to either 6.4% CHO-electrolyte beverage or sweetened water (placebo).	Performance on LIST, LSST, LSPT. Plasma glucose and insulin concentration	Players consuming CHO-electrolyte beverage -were significantly able to maintain soccer shooting performance, -sprinted faster than those consuming the placebo, - were able to maintain plasma glucose concentrations.

Welsh *et al* (2002) conducted a randomized cross-over trial among 10 non-professional college athletes (five men and five women mean age 24 years) (Table 2.2) investigating the effects of consuming a CHO-electrolyte beverage on both the physical and mental performance during intermittent high-intensity activity. The athletes participated in two experimental trials a week apart and were randomly assigned to consume either a CHO-electrolyte beverage or flavoured water (placebo) (Welsh *et al* 2002).

During each trial the athletes performed a 60 minute intermittent high-intensity shuttle run at various levels of VO_{2max} (walking, jogging, running, sprinting, and jumping) intended to replicate the demands of a competitive sporting match (Welsh *et al* 2002). The 60 minute experimental protocol was divided into four 15 minute quarters including a 20 minute halftime break. After the intermittent high-intensity shuttle run the athletes performed a shuttle run to fatigue. Six physical and mental tests were performed during the 60 minutes. These included a 20 m sprint, 10 repetition maximal vertical jumps during a 30 second period, a whole body motor skill test, a Stroop Colour-Word cognitive test, and a mood evaluation test (Welsh *et al* 2002).

The authors did not state the environmental conditions under which the athletes trained (Welsh *et al* 2002). Fifteen minutes before the warm up preceding the training, athletes consumed 5 ml/kg body weight of either a 6% CHO-electrolyte beverage or flavoured water. This is the same amount of fluid which Ostojic & Mazic (2002) gave their players before exercise. Athletes were also given 3 ml/kg body weight of either a 6% CHO-electrolyte beverage or flavoured water after the first quarter, after halftime, after the third quarter, and after the fourth quarter. In addition immediately before half time, athletes consumed 5 ml/kg body weight of either an 18% CHO-electrolyte beverage or flavoured water. It is not clear why the authors chose to give the athletes an 18% CHO-electrolyte beverage at half-time and a 6% CHO-electrolyte beverage on other occasions (Welsh *et al* 2002).

The CHO-electrolyte beverage significantly improved 20 m sprint performance, enhanced speed and agility of whole body motor skills, improved reported perceptions of fatigue during the third and fourth quarter, and significantly delayed fatigue in the intermittent high-intensity run after the fourth quarter (Welsh *et al* 2002).

Guerra *et al* (2004) conducted a randomized non-crossover trial to examine the effects of a CHO-electrolyte beverage on adolescent soccer performance (Table 2.2). Twenty male, adolescent soccer players (mean age 16 years) participated in the trial. Players were randomly allocated to either the intervention group who consumed a 6% CHO-electrolyte beverage or the control group who did not consume a CHO-electrolyte beverage. The intervention group consumed 300 ml of the CHO-electrolyte beverage every 15 minutes during the match which is more than the amount recommended by Burke & Deakin (2006, p613) for adolescents. During the half-time break all players had unrestricted access to water. Players then participated in a match comprising of one 45 minute half, a 15 minute half-time break and another 30 minute half even though a normal soccer match consists of two 45 minute halves (Guerra *et al* 2004).

The temperature during the match was 28°C which is similar to that experienced during the study (Guerra *et al* 2004). Relative humidity during the match was not measured. Players were weighed before and after the match in minimal clothing (Guerra *et al* 2004). This was the only method used to assess hydration status.

Players in the intervention group were significantly less dehydrated (1.7% versus 2.6%), spent significantly more time running and performed a significantly greater number of sprints in the first half (Guerra *et al* 2004).

Ali *et al* (2007) conducted a randomized cross-over trial to examine the effect of consuming a CHO-electrolyte beverage on soccer performance among 16 male, adult soccer players (mean age 21 years). Players were either, semi-professional, ex-professional or university level and performed two trials, a week apart, with each trial taking place over two days. On the first day the players cycled to reduce their muscle glycogen stores and consumed a low CHO meal (1 g/kg body weight) at 8 pm, their last meal of the day. On the second day, players were given either a 6.4% CHO-electrolyte beverage or artificially sweetened water (placebo) at 5 ml/kg body weight before exercise and 2 ml/kg body weight every 15 minutes during exercise in a similar fashion to the studies conducted by Ostojic & Mazic (2002) and Welsh *et al* (2002). Players then performed the LIST for 90 minutes (Table 2.2).

The authors did not report the environmental conditions during the LIST. Blood samples for glucose and insulin were obtained before, after 30 minutes, 60 minutes, and 90 minutes. Players performed the LSPT and the Loughborough Soccer Shooting Test (LSST) before and after the LIST (Ali *et al* 2007).

Although there was no statistically significant difference in the performance of the passing test, players consuming the CHO-electrolyte beverage were significantly better able to maintain soccer shooting performance and sprinted faster. In the CHO-electrolyte trial, blood glucose concentrations were maintained and blood insulin concentration was not significantly higher. The findings of Ali *et al* (2007) are similar to those reported by Ostojic & Mazic (2002) and Welsh *et al* (2002).

Consuming CHO-electrolyte beverages during exercise significantly improved blood glucose levels, sprint performance, speed and agility and significantly delayed the onset of fatigue and the rating of perceived exertion during both training and matches (Ali *et al* 2007; Guerra *et al* 2004; Welsh *et al* 2002; Ostojic & Mazic 2002). Carbohydrate consumption enhances performance by maintaining blood glucose levels and high levels of CHO metabolism, and sparing endogenous glycogen (Jeukendrup 2004).

2.7 RECOMMENDATIONS FOR OPTIMUM FLUID AND CARBOHYDRATE INTAKE

2.7.1 Recommendations before training

The timing, amount and type of CHO consumed should be appropriate to the training session and individual preference (Burke, Hawley,Wong & Jeukendrup 2011). In events lasting more than one hour such as soccer training / matches, it is recommended that athletes consume 1 to 4 g of CHO/kg body weight one to four hours before activity (Burke *et al* 2011).

Adult athletes should start training in a well hydrated state by either consuming 5 to 7 ml/kg body weight of water or CHO-electrolyte beverage (6-8% CHO) at least four hours before training, or 500 to 600 ml of water or CHO-electrolyte beverage 2 to 3 hours before training (Rodriguez *et al* 2009; Casa *et al* 2000). No published recommendations for adolescent athletes on the pre event meal or CHO consumption or fluid intake were found. However, Burke & Deakin (2006, p613) states that male and female adolescent athletes aged 15 years need to consume 300 to 400 ml of fluid 45 minutes before training. The type of fluid was not stipulated.

2.7.2 Recommendations during training

Athletes must start consuming CHO within 15 to 20 minutes of training commencing (Rodriguez *et al* 2009). During training athletes can consume CHO from various sources such as CHO-electrolyte beverages and non-carbonated soft drinks containing 6 to 8% of CHO (Burke & King 2012; Sawka *et al* 2007). This ensures that adequate CHO and water are consumed to sustain athletic performance and prevent extreme dehydration (Sawka *et al* 2007). For adults athletes, consuming CHO at a rate of 30 to 60 g per hour is important for training lasting one to two and a half hours as this has been shown to maintain blood glucose levels and sustain athletic performance (Burke *et al* 2011; Rodriguez *et al* 2009; Sawka *et al* 2007). Consuming more than 60 g of CHO can result in gastrointestinal distress (Rosenbloom 2012). It is recommended that athletes consume CHO every 10 to 30 minutes during training (Coyle 2004). This recommendation is particularly important when the athlete has not consumed foods or beverages before training (Casa *et al* 2000). Consuming 500 to 1000 ml of a 6 to 8% CHO-electrolyte beverage will provide 30 to 80 g of CHO per hour (Sawka *et al* 2007).

Consuming a drink containing more than 8% CHO reduces gastric emptying, resulting in decreased CHO absorption (Sawka *et al* 2007). It is suggested that in events which require increased delivery of CHO to the muscle, beverages containing multiple transportable CHO's can be beneficial (Australian Institute of Sport Sports Nutrition 2011). These CHO's include glucose and fructose which use different intestinal transporters (Australian Institute of Sport Sports Nutrition 2011). The multiple transportable CHO's may overcome the limitation of gut absorption of CHO (Australian Institute of Sport Sports Nutrition 2011).

Kirkendall (2004) stated that the amount of fructose in the rehydration beverage should not exceed 3 to 4% as it may decrease absorption causing gastrointestinal distress. Glucose is oxidised rapidly as it requires no digestion and is readily absorbed (Jeukendrup 2008). Maltodextrins also seem to be effective in sustaining athletic performance during training (Rodriguez *et al* 2009).

The CHO guidelines for adults may not apply to adolescents as CHO metabolism during training may differ in adolescents compared to adults (Montfort-Steiger & Williams 2007). This may require the nutrient content of CHO-electrolyte beverages to be adjusted to match the requirements of adolescents (Montfort-Steiger & Williams 2007).

Fluid lost through sweat needs to be replaced (Casa *et al* 2005). However, the amount of fluid consumed should not exceed the amount of fluid lost as it can result in weight gain, increased plasma volume, may cause discomfort during training and can increase the risk of an athlete having to void during training (Rodriguez *et al* 2009; Casa *et al* 2005).

Ideally an individualized fluid replacement programme in accordance with each athlete's unique requirements should be planned by assessing changes in body weight during training (Sawka *et al* 2007). However, as this is not always practical, general recommendations for fluid intake are normally followed. These recommendations need to consider the athletes' sweating rate, duration of the training session and availability of drink breaks (Sawka *et al* 2007).

It is recommended that 15 year old athletes consume 150 to 200 ml of fluid (type not stipulated) every 15 minutes during training (Burke & Deakin 2006, p613). This is less than the recommended amount for adults. However, the American Academy of Pediatrics, Committee on Sports Medicine and Fitness (2000) recommended that adolescents weighing 60 kg should consume 250 ml of fluid every 20 minutes during training.

2.7.3 Recommendations after training

After training, adequate fluid, electrolyte and CHO consumption is needed to replace muscle glycogen and ensure rapid recovery (Rosenbloom 2012; Rodriguez *et al* 2009).

The intake of CHO is important, as depending on the duration and intensity of the training session, muscle glycogen stores may be depleted and need to be replenished before the next training session especially if there is little recovery time between sessions (Rodriguez *et al* 2009: Burke 1998, p118).

For adults athletes, post training diets high in CHO (> 65% CHO or 0.8 to 1.0 g CHO/kg body weight/hour) increases both blood glucose and insulin levels and enhances muscle glycogen synthesis (Rodriguez *et al* 2009). For the first 30 minutes post training, 1.0 to 1.5 g of CHO/kg body weight is recommended and then every two hours for four to six hours to adequately replace glycogen stores (Rodriguez *et al* 2009). No published data was found on the CHO recommendations for adolescent athletes after training.

It is recommended that athletes consume adequate fluids to account for sweat loss during training (Rodriguez *et al* 2009). Therefore, athletes may consume 450 to 675 ml of fluid for every 0.5 kg of body weight lost during training (Rodriguez *et al* 2009). If there is no access to a meal between training sessions, consuming a CHO-electrolyte beverage (6 to 8%) is important (Hoffman & Maresh 2011). Consuming water alone results in decreased osmolality and desire to drink, and may increase the amount of urine passed (Hoffman & Maresh 2011)

If there is sufficient recovery time between training sessions, the consumption of normal meals and beverages will re-establish euhydration and restore fluid and electrolytes (Rodriguez *et al* 2009). Although these recommendations have been shown to be effective, they still need to be adapted to the individual athlete's needs, likes and dislikes (Rodriguez *et al* 2009).

2.8 KNOWLEDGE OF ATHLETES REGARDING THE IMPORTANCE OF FLUID AND CARBOHYDRATE

Literature on the nutrition knowledge of adolescent athletes was not found therefore data on college athletes will be presented.

In general, athletes do not have adequate nutrition knowledge which may be due to the sources of information (Cotunga, Vickery &McBee 2005). Nutrition misconceptions have been observed among athletes regarding fluids and hydration (Cotunga *et al* 2005).

Rosenbloom, Jonnalagadda & Skinner (2002) used a questionnaire to assess the nutrition knowledge of 237 male and 91 female adult college athletes. It was found that 22% of men and 21% of women stated that sports drinks were better than water. It was reported that 12% of men and 3% of women stated that they rely on thirst to ensure fluid replacement. Furthermore, 63% of men and 71% of women stated that sugar eaten before exercise will negatively impact on performance. From this it is evident that college athletes did not have adequate knowledge on the importance of fluid and CHO for sport (Rosenbloom *et al* 2002).

Jessri, Jessri, RashidKhani & Zinn (2010) used a questionnaire to assess the nutrition knowledge of 109 male and 98 female adult Iranian college basketball and football players. It was found that 27.3% of men and 32.9% of women were aware that thirst is not a good indicator of fluid requirements. Only 12% of women and 8.2% of men were knowledgeable of the amount of fluid needed for a two hour training session. It was reported that 1.3% of women and 0.6% of men knew the recommended range of CHO in a CHO-electrolyte beverage.

Therefore, from the above studies it is evident college athletes were not knowledgeable of the importance of fluid and CHO for sport (Jessri *et al* 2010; Rosenbloom *et al* 2002).

2.9 CONCLUSION

Unemployment, poverty, food insecurity and crime are social conditions affecting many South Africans and may possibly impact on the hydration and CHO practices of soccer players. This is because players may not have the finance to afford adequate food and players may not even have food at home.

Thermoregulation is important to protect core body temperature as the heat accumulated during exercise / training needs to be dissipated to prevent heat illness. As there is limited data on adolescents, data on children suggest that they have a lower thermoregulatory capacity during training compared to adults, resulting in impaired athletic performance and increased risk of heat illness.

Dehydration results in a decrease in performance, and in the drive to continue training and an increase in core body temperature, ratings of perceived exertion and heart rate. Adult soccer players dehydrated a mean of 2.2% during training and matches and had a mean U_{SG} of 1.014 g/ml and 1.006 g/ml before and after match. Adolescents dehydrated 1.3% during training and matches and had a mean U_{SG} of 1.022 g/ml and 1.020 g/ml before and after training and matches.

Consuming CHO-electrolyte beverages during exercise improved blood glucose levels, sprint performance, speed, agility and significantly delayed the onset of fatigue and the rating of perceived exertion during both training and matches

Before training it is recommended that athletes consume 1 to 4 g of CHO per kg body weight in events lasting more than an hour. Adolescent athletes are recommended to consume 300 to 400 ml of fluid 45 minutes before training. During training it is recommended that adolescent athletes consume 150 to 200 ml of fluid every 15 minutes during training. The suggested fluid during training is a 6 to 8% CHO-electrolyte beverage. After training athletes may consume 450 to 675 ml of fluid for every 0.5 kg of body weight lost during training. During the first 30 minutes after training, 1.0 to 1.5 g of CHO/kg body weight is recommended and then every two hours for four to six hours to adequately replace glycogen stores. Many of these guidelines are for adult athletes and there is a lack of guidelines for adolescent athletes. The lack of published data on the behaviour of the high risk adolescent group makes this study imperative to establish the hydration and CHO practises of adolescent soccer players. Athletes were found to not knowledgeable of the importance of fluid and CHO for sport.

CHAPTER 3: STUDY METHODOLOGY

3.1 INTRODUCTION

The amount of clothing worn, intensity of training sessions and hot environmental conditions predispose adolescent soccer players to dehydration. A 2% or greater loss of body weight reduces athletic performance and overall health of soccer players (Montain 2008). A lack of fluid consumption can further aggravate dehydration. This study was important to ascertain the hydration status, fluid and CHO intake of adolescent soccer players. This chapter will explore the design of the study and describe the study population and sample selection. In addition, the characteristics of the training sessions, data collection instruments and techniques will be described. The training of the research assistants, pilot study and how the data was collected will be explained. The chapter will also explore how the data was captured, edited and cleaned in addition to how bias was reduced, the variables included, data analysis and how permission was obtained to conduct the study and ethics approval.

3.2 STUDY DESIGN

An observational, cross-sectional study was conducted among 14 to 17 year old male, adolescent soccer players in Pietermaritzburg and surrounding areas from March (autumn) to August (winter) 2011.

The advantages of cross-sectional study designs are that:

- They are inexpensive to conduct, relatively quick and a good way for determining the prevalence of a condition (Mann 2003).
- Data on all variables is collected once off (Public Health Action Support Team 2011).
- They are useful for descriptive analysis and for generating hypotheses (Public Health Action Support Team 2011).
- Various outcomes and exposures can be studied (Public Health Action Support Team 2011).

The disadvantages of cross-sectional designs are that:

- The study design does not provide cause and effect (Mann 2003).
- They are not suitable for researching rare conditions of a short duration (Public Health Action Support Team 2011).
- It is not possible to measure incidence of conditions (Public Health Action Support Team 2011).
- The identified associations may be difficult to interpret (Public Health Action Support Team 2011).
- They are susceptible to bias due to a low response rate (Public Health Action Support Team 2011).

3.3 STUDY POPULATION AND SAMPLE SELECTION

3.3.1 Study population

The study population included Black, Indian and Coloured amateur male, adolescent soccer players aged 14 to 17 years, playing in the PADSA under 17 league from March to August 2011. No White players participated in the study as there were no White players in the PADSA under 17 league in 2011. The PADSA under 17 league was selected as it was a well-established, popular junior soccer league in Pietermaritzburg. The soccer players resided in the socially disadvantaged areas in and surrounding Pietermaritzburg (Imbali, Edendale, KwaShange).

3.3.2 Sample selection

The PADSA under 17 league consisted of 11 teams. The coaches of all teams were contacted telephonically and invited to participate. Two teams declined (no reason was given) and two were not training at the time of data collection. Not all the teams trained from March to August 2011 as some stopped training for one week during the Easter school break and for three weeks during the winter school break. As a result, seven teams were recruited.

3.3.3 Selection of players

All soccer players in each team who met the inclusion criteria and who were willing to participate were included in the study sample.

Inclusion criteria included:

- soccer players aged 14 to 17 years
- playing for an under 17 soccer team in the PADSA league
- giving written informed consent to participate.

A total of 122 players were recruited.

3.4 CHARACTERISTICS OF TRAINING SESSIONS

The training sessions started after school at half past four in the afternoon. The players trained two to three times per week. The sessions generally lasted one and a half hours during the autumn months (March, April and May). In winter (June, July and August) the sessions lasted only one hour due to limited daylight hours and a lack of floodlights at the training site.

During training the players generally first stretched, performed sit ups and did drills such as sprints and slalom for approximately 20 minutes after which they participated in a game until the end of training.

3.5 DATA COLLECTION INSTRUMENTS AND TECHNIQUES

Data collection instruments included a questionnaire developed for the purpose of the study, a stadiometer, a body weight scale, a urine refractometer, an electronic kitchen scale to measure fluid and CHO, and an automatic weather station.

3.5.1 Questionnaire

An open-and-close-ended questionnaire was used to collect socio-demographic data (age, race, and playing position) (Appendix A). The same questionnaire was used to determine the players' knowledge regarding the importance of CHO / fluids for training as well as the amount and type of CHO / fluid needed for training.

3.5.2 Height

A portable Seca Leicester stadiometer with a range of 20 to 207 cm and graduations of 1 mm was used to measure height. Soccer players were asked to remove their shoes and socks before stepping onto the centre of the baseboard with their feet slightly apart and facing forward with their back against the height stick. Their heels were positioned against the back of the base board with their buttocks and upper back in contact with the height stick (World Health Organisation 2004). Their head was positioned in the Frankfort horizontal plane position (World Health Organisation 2004). They were instructed to stand straight with their arms and shoulders relaxed and to inhale deeply (World Health Organisation 2004). The head board was lowered onto the player's head and the inhaled height was recorded on the data sheet (Appendix B) in centimetres to the last millimetre. The players were then allowed to exhale. The height was then measured a second time and recorded. If the two measurements differed by 0.2 cm, a third measurement was taken and the mean of the two closest measurements were recorded.

3.5.3 Body weight

Portable Masskot UC-300 scales were used to measure body weight. The scale has a capacity of 50 g to 200 kg with an accuracy of 50 g. It was placed on a level area, switched on, zeroed and calibrated using a known five kilogram weight before each series of data collection commenced.

Players were weighed by the principal researcher in minimal clothing (underpants) after urinating before and after training. Before training, the scale was switched on, players were instructed to stand on the centre of the scale platform with their feet slightly apart, and asked to look directly ahead (World Health Organisation 2004). The weight measurement was recorded on the data sheet (Appendix B) and the soccer players were then requested to step off the scale which was then zeroed. The soccer players were reweighed and the second weight measurement was recorded on the data sheet (Appendix B). If the two measurements differed by a 100 g, a third weight was taken. The mean of the two closest measurements was used as the final weight. The same procedure was followed after training except that the players towelled off sweat using their t-shirts before being weighed.

3.5.4 Calculation of the change in hydration status

The body weight measurements taken before and after training were used to assess the change in hydration status by calculating the percent change in body weight from the following equation: [(Pre-training body weight (kg) – Post-training body weight (kg)) / Pre-training body weight (kg)] × 100 (Silva *et al* 2011). Table 3.1 depicts an example of how the change in hydration status was calculated.

Table 3.1: Calculation of the change in hydration status

Weight before training (kg)	Weight after training (kg)	Equation	Percent change of body weight	Interpretation
55	53.5	[(55 kg – 53.5 kg) / 55 kg] x 100	2.73	Dehydrated
57	58	[(57 kg – 58 kg) / 57 kg] x 100	-0.02	Overhydrated

Based on the percent change in body weight, the soccer players were classified as being either dehydrated or overhydrated. As there were no definite categories in the scientific literature to define either dehydration or overhydration clearly among adolescent soccer players according to percentage loss of body weight, a classification based on published studies on adults was compiled (Table 3.2). No studies were found which categorized the gain of percent body weight.

Table 3.2: Classification of percent change in body weight

Percentage dehydration	Effect	Reference
< 1%	Considered to be euhydration.	Sawka *et al* (2007)
1% to 2%	Reduces aerobic performance.	Casa *et al* (2005)
> 2% to 3%	Increases the subjective perception of exercise difficulty.	Casa *et al* (2005)
3% to 5%	Reduces sweat production and skin blood flow.	Armstrong *et al* (2007)

3.5.5 Calculation of the Body Mass Index

Height and weight measurements were used to calculate the body mass index (BMI) (World Health Organisation 2004) using the following equation:
BMI = body weight / $(\text{height})^2$.
For example, a player with a height of 1.82 m and weight of 69 kg will have a BMI of 20.8 ($69/1.82^2$).
To interpret the BMI, the World Health Organisation (WHO) BMI-for-age charts for boys aged 5-19 years were used. The age and BMI were plotted on the BMI-for-age chart to determine the Z-score. These Z-scores were then classified according to the WHO reference ranges (Table 3.3). A normal BMI was defined as a Z-score between -2 and 1.

Table 3.3: Classification of body mass index-for-age

Z-score	Classification
Above 3	Obese
Above 2	Overweight
Above 1	Possible risk of overweight
0 (median)	Normal range
Below -1	Normal range
Below -2	Wasted
Below -3	Severely wasted

(World Health Organization 2008)

The BMI of soccer players, who according to their U_{SG} measurements were hyperhydrated or dehydrated before training, was possibly inaccurate as their measured weight before training may not have been their actual (dry) weight at euhydration.

3.5.6 Urine specific gravity

Urine samples were collected immediately before and after training prior to weight being measured. Each player was given an empty urine sample bottle labelled with their unique identification number. They were instructed to let a little urine pass before half filling the bottle to ensure a mid-stream sample was obtained. They were asked to close the bottle tightly with the lid before returning it to the research assistant.

A portable digital urine refractometer (the Atago Uricon UG-1 D20) was used to measure the U_{SG}. The refractometer had a measuring range of 1.000 to 1.050 g/ml, and a temperature range of 10-35°C. The average temperature during the study was 20.1°C which was within the temperature range of the refractometer. Before each series of measurements the machine was cleaned using tissue paper and calibrated by covering the prism surface area with a few drops of distilled water.

The ZERO setting button was then pressed. As soon as the measurement of 000 appeared, the refractometer was switched off and the distilled water wiped off the prism surface with a piece of tissue paper.

Before measuring the urine samples the principal researcher put on a pair of disposable gloves. A plastic spoon was used to place enough urine on the refractometer to cover the prism surface area. The plastic spoon was rinsed with distilled water and dried with tissue paper before each measurement. The Start/Off button was then pressed and the U_{SG} measurement was taken and then recorded on the data sheet. The refractometer was then switched off by pressing the Start/Off button. The prism surface area was then cleaned with tissue paper. The urine sample was then measured again and recorded on the data sheet (Appendix B). If the measurements differed by 0.001 g/ml, a third measurement was taken and an average of the two closest measurements was used.

As no clear instructions are given as to how soon the U_{SG} needs to be measured before the urine sample deteriorates, the principal researcher measured test urine samples every 10 minutes for two and a half hours. During this time the U_{SG} did not change, thereby indicating that the urine sample did not deteriorate. The U_{SG} was measured within 30 minutes of the urine samples being taken.

The classification for adults by Armstrong *et al* (2010) was used to determine the hydration status using U_{SG} (Table 3.4). There was no information on the interpretation of U_{SG} measurements for adolescent athletes (Armstrong *et al* 2010). This classification included overhydration unlike the percent loss of body weight classification.

Table 3.4: Classification of hydration status using urine specific gravity

Hydration category	Urine specific gravity (g/ml)
Extremely hyperhydrated	<1.012
Slightly hyperhydrated	1.012-1.014
Well hydrated	1.015-1.017
Euhydrated	1.018-1.020
Slightly dehydrated	1.021-1.024
Very dehydrated	1.025-1.027
Extremely dehydrated	>1.027

(Armstrong *et al* 2010)

3.5.7 Fluid intake

For players consuming fluids from drink bottles, the research assistant weighed the bottles before and after the fluid was consumed using a portable Soehnle electronic scale. Drink bottles were also weighed before and after each refill. The weight and type of fluid was recorded on a data sheet

(Appendix B). The scale had a capacity of 10 kg and an accuracy of 2 g and was placed on a stable flat surface before being switched on. The scale was calibrated before each training session using a known one kg weight. The scale was switched on, zeroed and then the drink bottle was placed on the centre of the scale and the measurement was recorded to the nearest 2 g. At the end of training the bottle was reweighed. The weight after training was subtracted from the initial weight and the difference was the amount of fluid consumed, assuming that 1 g was equal to 1 ml of fluid.

Most players did not drink from bottles and consumed water directly from the tap. For the players consuming water from the tap the mean volume of a mouthful was measured. After the second training session, soccer players were instructed to drink a mouthful of water but instead of swallowing it were asked to spit it into a cup. This was carefully transferred to a 100 ml measuring cylinder and the volume measured. Each soccer player provided three mouthfuls and the average mouthful volume was calculated using the following equation:

Mean volume of a mouthful = sum of all three mouthful volumes / number of mouthfuls.

To determine the amount of water consumed from the tap, the number of mouthfuls consumed was multiplied by the average mouthful volume of the corresponding soccer player (Table 3.5).

Table 3.5: Calculation of mean mouthful volume

Mouthful volumes	Equation	Mean volume of a mouthful	Number of mouthfuls consumed	Equation	Amount of water consumed
58 ml	(58 ml + 66 ml + 59 ml) / 3	61 ml	5	61 ml x 5	305 ml
66 ml					
59 ml					

3.5.8 Automatic weather station and calculation of heat index

An automatic weather station was used to measure the environmental conditions during the training sessions.

The weather station consisted of:

- A RM Young Wind Sentry comprising of a three cup anemometer and a wind vane. The anemometer had a range of 0 to 50 m s^{-1}, a gust survival of 60 m s^{-1}, and an accuracy of ± 0.5 m s^{-1}. The vane had a range of 360° mechanical, 355° electrical (5° open), and an accuracy of ± 5°.

- A LI-COR pyranometer measured short wave radiation.

- A Vaisala and CS500 humidity / temperature sensor measured RH and air temperature. The sensor was placed in a 6-plate radiation shield, which allowed air to pass freely to the sensor keeping it at or near ambient temperature. For RH, the sensor had an operating range of 0-100% RH. In the 0-10% range the accuracy of the sensor was not specified. In the 10-90% range the accuracy of the sensor was ± 3.0% and in the 90-100% range the accuracy of the sensor was ± 6.0%. For measuring temperature the sensor had a measuring ranging of -40 to 60°C.

- A battery powered CR200 data logger stored the data received from various instruments that included wind speed, wind direction, temperature, RH, and short wave radiation. However, for the purpose of this study only temperature and RH was considered. The CR200 data logger was set to record data every minute, it recorded data once the battery had been connected and stopped recording when the battery was disconnected. The battery was connected at the start of each training session and disconnected at the end of the training sessions.

The weather station was set up using the PC200W software and tested before data collection. The test was conducted to determine if all the instruments were functional and if the weather station was collecting the necessary environmental data. During the training sessions, the weather station was placed in the open, not in the shade or under trees, about 5 m from the side touchline of the soccer field.

Heat index was calculated from the following equation (Rothfusz 1990):

Heat index = - 42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 x 10-3T2
- 5.481717 x 10-2R2 + 1.22874 x 10-3T2R + 8.5282 x 10-4TR2 - 1.99 x 10-6T2R2

In the equation T represents the ambient temperature in degrees Fahrenheit (°F) and R represents the RH.

The heat index was then used to classify the risk for heat illness. Table 3.6 indicates how the heat index was used to determine the risk for heat illness among the soccer players. A heat index greater than 130 °F or 54.4°C represents an extreme danger for developing heat illness (National Weather Service Weather Forecast Office 2010).

Table 3.6: Classification of the risk of heat illness according to heat index

Heat index		Risk of Heat Illness	Possible effects
°F	°C		
< 80	< 26.7	No Risk	No risk for developing heat illness
80 to 89	26.7 to 31.7	Caution	Fatigue possible with continued exposure and physical activity
90 to 104	32.2 to 40	Extreme caution	Sunstroke, heat cramps, and heat exhaustion possible
105 to 129	40.6 to 53.9	Danger	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible
>130	> 54.4	Extreme danger	Heat stroke highly likely with prolonged exposure

(National Weather Service Weather Forecast Office 2010)

3.6 TRAINING OF RESEARCH ASSISTANTS

The research team consisted of the principal researcher (registered nutritionist) and 12 research assistants, most of whom were either undergraduate or postgraduate dietetic students. The principal researcher trained the research assistants at the Discipline of Dietetics and Human Nutrition at the Pietermaritzburg campus of the University of KwaZulu-Natal (UKZN) in January 2011.

During the study the research assistants were responsible for weighing the participants, measuring their height, monitoring their fluid and CHO intake and weighing their drink bottles. All research assistants except two had been trained previously to measure both weight and height as part of their undergraduate training.

The research assistants were trained on how to measure weight and height using the techniques from the World Health Organisation Multicentre Growth Reference Study anthropometric training video (World Health Organisation 2004). The research assistants watched the video. The principal researcher then demonstrated the technique on one of the research assistants and demonstrated how to calibrate the scale using a known 5 kg weight. Each research assistant then measured each other's weight and height. The measurements taken by the research assistant were then compared to the measurements taken by the principal researcher to determine if the measurement was accurate. This ensured that the measurements of the research assistants were reliable and valid. If the measurement was identical to that of the principal researcher or differed by less than 100 g the research assistant was considered to be competent. Only when all research assistants were competent, the technique of measuring height was demonstrated. The research assistants measured each other's height and were considered to be competent when their measurements were either identical to or differed by less than 0.2 cm from those taken by the principal researcher.

The principal researcher used a drink bottle to demonstrate to the research assistants how to use the portable Soehnle electronic scale. The research assistants were shown how to calibrate the scale using a known 1 kg weight and then how to weigh the drink bottle before and after fluid was consumed. Each research assistant had an opportunity to weigh the drink bottle. The measurements of the research assistants were compared to that of the principal researcher. The research assistants had to demonstrate competence which was a measurement identical to that of the principal researcher or differing by no more than 2 g. Research assistants were shown how to complete the data sheets (Appendix B) for body weight, height and fluid intake.

3.7 PILOT STUDY

To test the equipment, the questionnaire (Appendix A) and to identify any potential problems that might occur in the main study, a pilot study was conducted by the principal researcher in November 2010. Six players (aged 11 to 12 years), who would not be playing in the PADSA under 17 league in 2011 were selected by the coach from an under 15 male PADSA soccer team to participate in the pilot study. This team was selected for the pilot study as they were the only team training in November 2010.

Using the same procedures as was followed in the main study, the players' weights, heights, U_{SG} and fluid intakes were measured on four separate occasions. The soccer players were given the questionnaire to take home and complete. The only problem encountered during the pilot study was the poor return of completed questionnaires. It was therefore decided that for the main study players would complete the questionnaires at the training site.

3.8 DATA COLLECTION

Before the study commenced the principal researcher phoned an official from the PADSA under 17 league describing the study, its importance, and potential benefit to the soccer players and requested permission to conduct the study on the teams in the PADSA under 17 league. Upon being granted permission, the PADSA official was asked for a list of teams in the league and the contact details of the respective coaches. Each coach was contacted telephonically and informed of the study, its importance and potential benefit for the soccer players.

The principal researcher arranged a meeting with the coach and players of the seven teams which agreed to participate in the study. At the meeting soccer players were informed of the purpose of the study, assured that participation was voluntary and that they could withdraw at any time without any consequences. The soccer players were given an opportunity to ask any questions which were addressed by the principal researcher. The consent form was explained to all the soccer players (Appendix C). Players who were willing to participate in the study signed the consent form and returned it. Players were only allowed to keep the first page of the consent form which explained the importance of the study and what was expected of them.

Following each meeting, the principal researcher arranged to attend two training sessions to assess the hydration status as well as the fluid and CHO intake of the soccer players.

Before training the automatic weather station was set up 5 m from the touchline of the soccer field away from trees in the open and connected to a battery. The weather station gathered data on temperature, RH, wind speed, wind direction and radiation before it was disconnected from the battery and removed after training.

Upon arrival at the training site the coach sent soccer players to the principal researcher who placed a sticker on the players' forearm with their identifying code. During the study the players were referred to by their codes and not their names. No record was kept of their names.

The soccer players then proceeded to the first work station where a research assistant presented them with a urine bottle labelled with their identifying code and explained how to collect a mid-stream urine sample. After the soccer players returned the urine bottles, the research assistant placed the bottles in a polystyrene box stored away from direct sunlight.

The soccer players proceeded to the second work station where two research assistants measured and recorded the player's weight in their underwear.

The amount and type of fluid consumed 15 minutes before training was monitored and recorded by the research assistants. Some research assistant's monitored consumption from the tap while others monitored consumption at the third work station with the drink bottles. For soccer players who drank water from a tap, the number of mouthfuls of water consumed was monitored and recorded. For soccer players drinking fluids from drink bottles, the bottles were weighed before and after consuming fluids and the type and amount of fluids consumed were also recorded. The soccer players were instructed not to spit out the fluid from the bottle, or pour it on their heads to cool down or throw any fluid away.

The soccer players then trained as normal. During the training session, the principal researcher measured the U_{SG} of the samples while the research assistants monitored the fluid intake of the players.

Once the coach had signalled the end of the training session, the soccer players were instructed to stop consuming fluids. The players were then allowed to consume fluids and their fluid intake for 15 minutes after training was monitored and recorded by the research assistants.

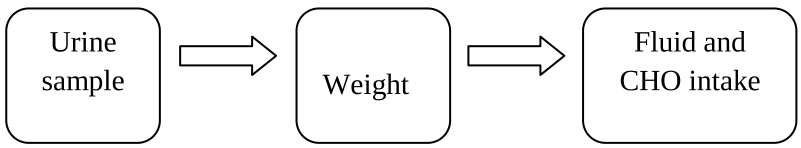
The players reported to the fourth work station where they were again given a urine bottle and were again instructed on how to provide a mid-stream sample.

On provision of the urine sample, the players moved to the fifth work station where they towelled off sweat from their bodies using their t-shirts and were then weighed in their underwear. Players reported to the sixth work station where their height was measured. The players were then allowed to consume fluids and their fluid intake for 15 minutes after training was monitored and recorded by the research assistants.

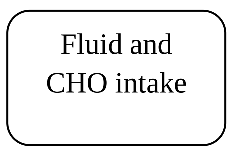
The same procedure was followed for both training sessions except that the players height was measured only once during the two training sessions.

Figure 3.1 illustrates the sequence in which data was collected before, during and after training.

Data collected before training



Data collected during training



Data collected after training

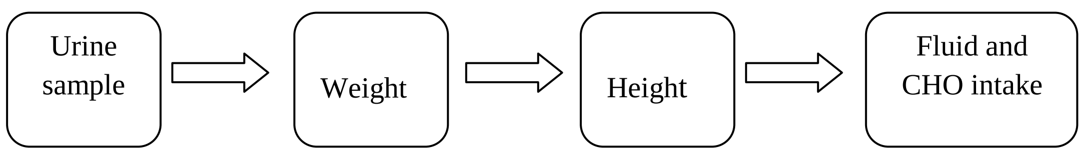


Figure 3.1: Data collected before, during and after training

Before leaving the training site after each training session the principal researcher checked the data sheets to ensure all the data had been collected and was entered correctly. If a measurement was not performed or not entered correctly the principal researcher called the research assistant to explain the discrepancy and if possible the measurement was repeated.

Following the second training session, the principal researcher arranged a suitable training session with the coach when the questionnaire (Appendix A) could be administered at the training site. The soccer players completed the questionnaire as a group and were not allowed to interact with each other during the process. The principal researcher explained each question and clarified any queries. As each soccer player submitted the questionnaires after completion, the principal researcher checked the questionnaire to ensure that it had been completed correctly. If the questionnaire was not completed correctly the player was asked to clarify his response and the corrected response was recorded.

Data was gathered from seven teams from March 2011 to August 2011. Table 3.7 illustrates the months during which data was collected from each team. Data was gathered from each team for two months. Data was gathered during different seasons for each team, for example data was collected from team one during March and April (autumn) and from team seven during July and August (winter).

Table 3.7: Data collection schedule from each soccer team

	Months					
	March	**April**	**May**	**June**	**July**	**August**
Teams	1	1	3	4	6	7
	2	2	4	5	7	
		3	5	6		

3.9 DATA CAPTURING, EDITING AND CLEANING

Data such as weight, height and U_{SG} were measured twice to ensure validity. If the two measurements differed significantly a third measurement was taken. The final value entered into the database was the mean of the two closest measurements. The data sheets and questionnaires were checked after the training sessions. If there were any seemingly inaccurate values they were measured again. For inappropriate questionable questionnaire responses, the corresponding player was called and asked to explain the response.

Within a week of the data being collected the principal researcher entered the data into the Statistical Package for the Social Sciences (SPSS) version 19 for windows. The principal researcher entered the same data again a month later and compared it to the original entry to ensure it had been entered accurately.

The principal researcher checked the data file for errors by checking each variable for values that were out of range. If any values were found to be out of range, the value was regarded as being an error. The data file was checked to find where the error occurred and corrected or deleted it. The database was checked for any missing values which were cross checked against the corresponding data sheet or questionnaire. Subsequently the statistician reviewed the SPSS data base and felt that no additional cleaning of the data was necessary. This improved the accuracy and validity of the data.

3.10 REDUCTION OF BIAS

3.10.1 Training

Bias was reduced by training the research assistant's before the study commenced to ensure that they were competent in the use of the measuring equipment and the recording of the data. The training also ensured that the research assistants could gather data in a standard manner.

3.10.2 Pilot study

A pilot study was conducted to circumvent difficulties related to the data collection process once the main study commenced. The pilot study allowed the principal researcher the opportunity to test the manner in which data would be collected and determine the best data collection sequence.

3.10.3 Equipment

The same equipment that was used in the pilot study was also used in the main study. The scale for measuring players' weight was routinely calibrated during the course of the main study with a known 5 kg weight. The urine refractometer was calibrated with distilled water before the measurement of each series of urine samples. The electronic scale was calibrated using a known 1 kg weight.

3.10.4 Standardised questionnaire

The questionnaire was administered by the principal researcher only, ensuring that data was gathered in a uniform manner. The questionnaire was piloted to identify any possible problems.

3.10.5 Response rate

All the players in the PADSA under 17 league were sampled and out of a possible 140 players, 122 participated thereby, translating into a response rate of 87.1%.

3.11 VARIABLES INCLUDED IN THE STUDY AND ANALYSIS

In order to analyse the data, variables were defined for each objective and analysis applied to the variables. Table 3.8 states the objectives of the study, the variables associated to each objective and the associated statistical test.

Table 3.8: Analysis of data

Objectives	Variables	Statistical tests
1.1 To determine the hydration status during training sessions.	• Body weight of soccer players before and after training. • Change in body weight measurements before and after training • U_{SG} before and after training. • Difference between U_{SG} measurements before and after training. • Difference between the amount of players extremely hyperhydrated, slightly hyperhydrated, well hydrated, euhydrated, slightly dehydrated, very dehydrated and extremely dehydrated before and after training	-Descriptive statistics. -Paired samples t test. -Chi-square test.
1.2 To determine the type and amount of fluid consumed before, during, and, after training sessions.	• Type of fluids consumed 15 minutes before, during, and, 15 minutes after training. • Amount of fluids consumed before, during, and, after training.	-Descriptive statistics.
1.3 To determine the type and amount of CHO consumed before, during, and, after training sessions.	• Type of CHO which the soccer players consumed 15 minutes before, during, and 15 minutes after training. • Amount of CHO which the soccer players consume 15 minutes before, during, and, 15 minutes after training.	-Descriptive statistics.
1.4 To examine the knowledge regarding importance of fluids and CHO before, during and after training.	• Knowledge of soccer players regarding the importance of fluids and CHO before, during and after training.	-Descriptive statistics.
1.5 To examine the knowledge regarding the type and amount of fluids and CHO to consume before, during and after training.	• Knowledge of soccer players regarding the importance of fluids and CHO before, during and after training.	-Descriptive statistics.

3.12 PERMISSION TO CONDUCT THE STUDY AND ETHICS APPROVAL

Ethical clearance was obtained from Human and Social Sciences Ethical Committee of UKZN (Protocol HSS/1297/2010 M) (Appendix D). Permission was obtained from an official of the PADSA league and from the coaches of the soccer teams. During the meeting with the soccer players before the data was collected, the players were informed of the purpose of the study, how the study would benefit them and what would be required of them. The principal researcher went through the consent form (Appendix C) with all the soccer players and addressed any queries or concerns. Written informed consent was obtained from each soccer player and consent was obtained from the players for photographs to be taken during the study. During the meeting none of the players were pressurized to participate in the study.

To ensure confidentiality, each soccer player was given a sticker with a unique identification code to place on their forearm. These codes matched those on the urine sample bottles, questionnaires and data sheets. No record was kept of their names.

The questionnaire and data sheets will be kept locked up in the Discipline of Dietetics and Human Nutrition at the Pietermaritzburg campus of UKZN for five years. During this period only the principal researcher and the supervisors will have access to the questionnaires and after five years they will be shredded. After data was gathered from each team, the coaches were given a two page document reporting the findings of their respective teams and recommendations on how their CHO and fluid intake can be improved.

3.13 CONCLUSION

An observational, cross-sectional study was conducted among 14 to 17 year old male, adolescent soccer players in Pietermaritzburg and surrounding areas from March (autumn) to August (winter) 2011. The study population included Black, Indian and Coloured male soccer players playing in the PADSA under 17 league. Seven out of a possible 11 teams participated.

Data collection instruments included a questionnaire developed for the purpose of the study, a body weight scale, a stadiometer, a urine refractometer, an electronic kitchen scale to measure fluid and CHO, and an automatic weather station to measure environmental conditions.

An open-and-close-ended questionnaire was used to collect socio-demographic data and to determine their knowledge regarding the importance of CHO / fluids for training as well as the amount and type of CHO / fluid needed for training. Body weight and height were measured and used to determine BMI. Dehydration was calculated as percent loss of body weight across the training session as well as from U_{SG} readings before and after training. Fluid intake was determined by weighing water bottles before and after consumption and monitoring fluid consumed from the taps.

The research team consisted of a registered nutritionist (principal researcher) and 12 trained research assistants. A pilot study using the identical techniques to be used in the main study was conducted among six soccer players from the PADSA league who were not included in the main study. The only problem that arose was that the questionnaires were not returned by the players once they were taken home for completion. As a result, it was decided that the players would complete the questionnaire at the training site.

After receiving permission from the PADSA official and the coaches the principal researcher met with the players to explain the consent form and answer any questions. The players signed informed consent forms if they were willing to participate in the study. Data was gathered on three non-consecutive days. Data on weight, height, U_{SG} and fluid intake was collected on two occasions while the questionnaire was completed on the other day. Players were identified using a code and no record was kept of their names. On arrival at training they gave a mid-stream urine sample, were weighed and had their CHO and fluid intake recorded. During training research assistants monitored their fluid intake while the principal researcher determined the U_{SG} readings. After training urine samples were collected, weight, height and remaining fluid was measured. The U_{SG} was measured within 30 minutes of the samples being taken. Data sheets were checked at the end of the training session before the players went home and any discrepancies were corrected.

Data such as weight, height and U_{SG} were measured twice to ensure validity. Data was entered twice into SPSS to ensure accuracy. The data was cleaned, edited and reviewed by a statistician. Bias was reduced by training the research assistants, the pilot study, using the same equipment which was regularly calibrated, having only one person administer the questionnaire and by the high response rate.

Ethical consent was received from the Human and Social Sciences Ethical Committee of the UKZN (Protocol HSS/1297/2010 M) (Appendix D) and a strict process of obtaining informed consent was followed.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

This study investigated the hydration status, fluid and CHO intake of male, adolescent soccer players during training. Hydration status was determined from U_{SG} measurements. A U_{SG} measurement greater than 1.020 g/ml signifies dehydration, which in turn reduces a players' ability to perform effectively on the field (Armstrong *et al* 2010; Edwards *et al* 2007). The knowledge of players regarding the importance of fluid and CHO for soccer performance was also assessed. The intensity of training sessions and environmental conditions predispose soccer players to developing heat illness and dehydration. As a result, the environmental conditions during training were also assessed. This chapter presents the results of the current study according to the objectives outlined in chapter one.

4.2 SAMPLE CHARACTERISTICS

Table 4.1 represents the sample characteristics. One hundred and twenty two players out of a possible 140 participated in the study, translating into an 87.1% response rate. The dropout rate between the first and second training session was approximately 34%. The majority (67.2%) were black with a normal weight-for-height (66.4%) although 27.0% were severely wasted.

Table 4.1: Sample characteristics

Sample characteristics	
Mean age (years)	15.8 ± 0.8
Race	
• Black	67.2% (82/122)
• Coloured	27.0% (33/122)
• Indian	5.7% (7/122)
Mean height (cm)	166.9 ± 6.2
Mean weight (kg)	56.6 ± 5.6
Mean BMI	20.35 ± 2.0
Weight status classified according to BMI-for-age [a]	
• Obese	0% (0/122)
• Overweight	0% (0/122)
• Possible risk of overweight	6.6% (8/122)
• Normal range	66.4% (81/122)
• Wasted	0% (0/122)
• Severely wasted	27.0% (33/122)

a: World Health Organisation (2008).

4.3 ENVIRONMENTAL CONDITIONS DURING TRAINING

Table 4.2 represents the environmental conditions during training. As the mean heat index was less than 26.7°C the players on the whole were not at risk of developing heat illness. However, the environmental conditions during six of the 14 training sessions did predispose to heat illness. The mean temperature and RH during the study was 20.1°C and 58.8% respectively.

Table 4.2: Mean temperature, relative humidity and heat index during training

	Temperature (°C)	Relative Humidity (%)	Heat index (°C)	Risk for Heat Illness [a]
Training session 1	20.4 ± 5.3	59.2 ± 14.9	< 26.7	No risk
Training session 2	19.6 ± 6.5	63.3 ± 16.0	<26.7	No risk
Study mean	20.1	58.8	<26.7	No risk
Highest recorded	34.1	93.7	34.1	Extreme caution [b]
Lowest recorded	10.2	24.9	16.4	No risk

a: National Weather Service Weather Forecast Office (2010)
b: Extreme caution: Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity. Heat index of between 32.2°C and 40.6°C.

4.4 HYDRATION STATUS

4.4.1 Mean urine specific gravity

Table 4.3 represents the U_{SG} of the soccer players before and after training. Before and after both training sessions, the mean U_{SG} indicated slight dehydration (1.023 to 1.024 g/ml). There was no significant difference (p=0.892) in mean U_{SG} pre training between the first and second training sessions and after training (p=0.300) between the first and second training sessions. Nor was there a significant difference in the U_{SG} measurements before and after the first training session (p=0.340) and before and after the second training session (p=0.279).

There was no significant difference (p=0.484, 0.157, 0.848, 0.988) in the hydration status before and after of players training at sites with taps and players training at sites without taps.

Table 4.3: Urine specific gravity before and after training

Variables	Training session 1	Difference between measurements before and after training (p-value)	Training session 2	Difference between measurements before and after training (p-value)	Difference between the first and second training sessions (p-value)
Mean U_{SG} before training (g/ml)	1.023 ± 0.006	0.340 *	1.023 ± 0.006	0.279 *	0.892 *
Mean U_{SG} after training (g/ml)	1.023 ± 0.007		1.024 ± 0.006		0.300 *
Before training					
• Extremely hyperhydrated	4.1% (5/122)	1.000 #	2.5% (2/79)	1.000 #	1.000 #
• Slightly hyperhydrated	4.9% (6/122)	1.000 #	5.1% (4/79)	1.000 #	1.000 #
• Well hydrated	4.9% (6/122)	1.000 #	10.1% (8/79)	1.000 #	0.880 #
• Euhydrated	13.1% (16/122)	0.231 #	11.4% (9/79)	0.919 #	0.244 #
• Slightly dehydrated	27.0% (33/122)	0.377 #	29.1% (23/79)	0.474 #	0.025 #
• Very dehydrated	20.5% (25/122)	0.121 #	13.9% (11/79)	0.158 #	1.000 #
• Extremely dehydrated	25.4% (31/122)	1.000 #	27.8% (22/79)	0.920 #	0.209 #
After training					
• Extremely hyperhydrated	9.0% (11/122)		4.9% (4/81)		0.948 #
• Slightly hyperhydrated	4.1% (5/122)		6.2% (5/81)		1.000 #
• Well hydrated	2.5% (3/122)		3.7% (3/81)		1.000 #
• Euhydrated	12.3% (15/122)		6.2% (5/81)		0.613 #
• Slightly dehydrated	25.4% (31/122)		18.5% (15/81)		0.002 #
• Very dehydrated	21.3% (26/122)		30.9% (25/81)		0.000 #
• Extremely dehydrated	25.4% (31/122)		29.6% (24/81)		0.000 #

*: Paired samples t test

#: Chi-square test

4.4.2 Hydration status according to urine specific gravity

Despite the mean U_{SG} indicating slight dehydration, 45.9% and 41.7% were very or extremely dehydrated before the first and second training sessions. After the first and second training sessions, 46.7% and 60.5% were very or extremely dehydrated.

Despite the mean U_{SG} indicating slight dehydration, 4.1% and 2.5% were extremely hyperhydrated before the first and second training sessions. After the first and second training sessions, 9.0% and 4.9% were extremely hyperhydrated.

4.4.3 Percent change in body weight

Table 4.4 represents the percent change in body weight during training. The mean percent change in body weight was less than 1% (Table 4.4). Less than 3% of players lost 2% or more of body weight during training, while less than 17% gained weight during training.

Table 4.4: Percent change in body weight

Variable	Training session 1	Training session 2	Difference between the first and second training sessions (p-value)
Mean weight loss (kg)	0.368 ± 0.3	0.393 ± 0.4	0.564 *
Percentage change of body weight	0.650 ± 0.5	0.702 ± 0.7	0.483 *
Percentage of players who lost ≥ 2% or more of body weight	0.8% (1/122)	2.5% (2/79)	1.000 #
Percentage of players who gained body weight	5.7% (7/122)	16.5% (13/79)	0.486 #

*: Paired samples t test
#: Chi-square value

4.5 FLUID CONSUMPTION

Table 4.5 represents the players' fluid consumption. Players consumed mainly water before, during and after training. The only other fluid consumed was pure fruit juice, which was consumed before (7.15 and 289.17 ml) and during (5.82 and 0 ml) the two training sessions. Those who trained at sites with no taps tended not to bring any water / fluid to training and therefore did not consume anything during training. At most players consumed 578.33 ml of fluid before, 183.20 ml during and 259.09 ml after training.

Table 4.5: Fluid consumption

Variables	Training session 1		Training session 2		Difference between the first and second training sessions (p-values)
Percentage of players consuming water					
Before training	24.6% (30/122)		3.8% (3/79)		0.760 #
During training	43.4% (53/122)		81.0% (64/79)		0.000 #
After training	31.2% (38/122)		27.2% (22/81)		0.158 #
Mean water consumption of players consuming water (ml and ml/kg)					
	Mean and SD (ml)	**ml/kg**	**Mean and SD (ml)**	**ml/kg**	**P-values**
Before training	5.77 ± 7.34	0.10	289.17 ± 206.37	5.11	0.136 *
During training	178.15 ± 89.69	3.15	183.20 ± 158.35	3.24	0.372 *
After training	107.41 ± 91.14	1.90	259.09 ± 192.29	4.58	0.008 *
Percentage of players consuming pure fruit juice					
Before training	24.6% (30/122)		3.8% (3/79)		0.760 #
During training	23.8% (29/122)		0% (0/79)		- #
After training	0% (0/122)		0% (0/81)		- #
Mean pure fruit juice consumption of players consuming pure fruit juice					
	Mean and SD (ml)	**ml/kg**	**Mean and SD (ml)**	**ml/kg**	**P-values**
Before training	7.15 ± 11.00	0.13	289.17 ± 206.37	5.11	0.137 *
During training	5.82 ± 10.30	0.10	0	0	- *
After training	0	0	0	0	- *
Mean fluid intake of players consuming fluid					
	Mean and SD (ml)	**ml/kg**	**Mean and SD (ml)**	**ml/kg**	**P-values**
Before training	11.59 ± 9.85	0.21	578.33 ± 412.75	10.22	0.137 *
During training	178.03 ± 90.61	3.15	183.20 ± 158.35	3.24	0.382 *
After training	107.41 ±91.14	1.90	259.09 ± 192.29	4.58	0.008 *

*: Paired samples t test
#: Chi-square value
-: No result could be found as n < 5.

4.6 CARBHYDRATE CONSUMPTION

Table 4.6 represents the players' CHO consumption. Pure fruit juice was the only CHO containing food or drink consumed by the players before, during and after training. From table 4.6 it is evident that players consumed at most 99.84 g of CHO.

Table 4.6: Carbohydrate consumption from pure fruit juice

Variable	Training session 1		Training session 2		Difference between the first and second training sessions (p-values)
Mean carbohydrate consumption from pure fruit juice					
	Mean and SD (g)	g/kg	Mean and SD (g)	g/kg	
Before training	0.83 ± 1.28	0.002	99.84 ± 110.81	1.764	0.260 *
During training	0.69 ± 1.20	0.002	0	0	- *
After training	0	0	0	0	- *

*: Paired samples t test
-: No result could be found as n < 5.

4.7 KNOWLEDGE REGARDING THE IMPORTANCE OF FLUIDS

4.7.1 Type of fluid

Table 4.7 represents the knowledge of the players regarding the type of fluid to consume for soccer training. The majority (> 90.0%) stated that water was the most important fluid to consume before, during and after training. Approximately one third thought that energy drinks and non-fizzy drinks were important before training although only 15.6% to 21.1% thought that they were important during and after training. Other CHO containing drinks such as pure fruit juice, recovery drinks, high energy caffeine drinks and fizzy drinks were not considered to be important for training by the majority of players.

Table 4.7: Knowledge regarding the type of fluid to consume for soccer training

Variables	Response
Water	
• Before training	91.1% (41/45)
• During training	94.2% (49/52)
• After training	93.8% (60/64)
Energy drinks	
• Before training	31.1% (14/45)
• During training	21.1% (11/52)
• After training	15.6% (10/64)
Non-fizzy drinks	
• Before training	28.9% (13/45)
• During training	13.5% (7/52)
• After training	15.6% (10/64)
Pure fruit juice	
• Before training	15.6% (7/45)
• During training	7.7% (4/52)
• After training	10.9% (7/64)
Recovery drinks	
• Before training	6.7% (3/45)
• During training	3.9% (2/52)
• After training	10.9% (7/64)
High energy caffeine drinks	
• Before training	4.4% (2/45)
• During training	3.9% (2/52)
• After training	1.6% (1/64)
Fizzy drinks	
• Before training	2.2% (1/45)
• During training	0% (0/52)
• After training	3.1% (2/64)

4.7.2 Amount of fluid

Table 4.8 represents the players' knowledge regarding the amount of fluid to consume for training. The largest proportion of players (> 34.0%) stated that 500 to 1000 ml of fluid should be consumed before, during and after training, while 31.8% of players stated that 200 to 500 ml of fluid should be consumed before training and 25.6% stated 0 to 200 ml should be consumed during training. Just over 10% stated 200 to 500 ml should be consumed after training.

Table 4.8: Knowledge regarding the amount of fluid to consume for soccer training

Responses to amount of fluid to consume	Questionnaire
0 to 200 ml	
• Before training	6.8% (3/44)
• During training	25.6% (11/43)
• After training	8.2% (4/49)
200 to 500 ml	
• Before training	31.8% (14/44)
• During training	25.6% (11/43)
• After training	10.2% (5/49)
500 to 1000 ml	
• Before training	45.5% (20/44)
• During training	34.9% (15/43)
• After training	71.4% (35/49)
1100 to 2000 ml	
• Before training	15.9% (7/44)
• During training	14.0% (6/43)
• After training	10.2% (5/49)

4.8 KNOWLEDGE REGARDING THE IMPORTANCE OF CARBOHYDRATE

The majority (73.9%) stated that CHO was important for soccer training. Table 4.9 represents the knowledge regarding when CHO should be consumed. The largest proportion of players (39.5%) stated that CHO should only be consumed before training. Only two players stated that CHO should be consumed before, during and after training.

Table 4.9: Knowledge regarding when carbohydrate should be consumed

Variables	Questionnaire
Knowledge regarding when CHO should be consumed for soccer training	
Before training only	39.5% (17/43)
After training only	25.6% (11/43)
During training only	0% (0/43)
Before, during and after training	4.7% (2/43)
Before and after training only	30.2% (13/43)
During and after training only	0% (0/43)

All players stated that CHO should be consumed within two hours before training and 91.7% stated that CHO should be consumed within two hours after training.

4.9 CONCLUSION

One hundred and twenty two players participated in the study although a third of the players dropped out from the first to second training session. The majority were black with a normal BMI, although some were severely wasted. The mean environmental conditions did not predispose the players to heat illness (temperature 20.1°C, RH 58.8%) but six of the 14 training sessions were high risk for heat illness. On average players were found to be slightly dehydrated (U_{SG}) before and after training. Despite the mean U_{SG} indicating slight dehydration, at least 41% were very or extremely dehydrated before and after training. The majority lost less than 1% of their body weight. Some were extremely hyperhydrated before (2.5% to 4.1%) and after (4.9% to 9.0%) training. Players consumed mainly water before, during and after training and consumed the largest amount of fluid before training (578.33 ml). Some training sites did not have taps or any alternative source of fluid available.

The majority stated that water was the most important fluid to consume in the quantity of 500 to 1000 ml before, during and after training. Pure fruit juice was the only CHO containing fluid consumed. Less than third knew the appropriate amounts to drink before, during and after training.

Although the majority stated that CHO was important for soccer training and that CHO should be consumed within two hours before and after training very few put this into practice. They believed that CHO containing drinks should mainly be consumed before training and only two correctly stated that they were important before, during and after training. Therefore, the importance of CHO during training was not appreciated.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

The intensity of training, inadequate fluid and CHO consumption predisposes adolescent soccer players to dehydration and impairs performance. The aim of the study was to determine the type and amount of fluid consumed by soccer players before, during and after training. The study also determined the CHO intake before, during and after training as well as the hydration status of soccer players.

5.2 SAMPLE CHARACTERISTICS

The high response rate of the study indicates that the results are representative of the actual practices of adolescent soccer players in the PADSA league. However, the loss of a third of the subjects before the second training session was probably due to the players not feeling safe as they arrived home after dark and players needed to catch lifts / public transport to get home in time (Reddy *et al* 2010). Also there were no change rooms at the training site and some of the players were not comfortable being weighed publically in their underwear and there was no much privacy for them to provide urine samples.

Common assault and robbery with aggravating circumstances are crimes prevalent in KZN. In South Africa in 2012, 17.6% of common assaults and 18.3% of robbery with aggravating circumstances occurred in KZN making it the province with the second highest rate of robbery with aggravating circumstances (South African Police Service 2012a; South African Police Service 2012b). The players may have been unaware before commencement of the first training session of the impact the study would have on them getting home on time and this may have influenced their decision not to participate in the second session.

Although most players were of a normal nutritional status as classified by BMI-for-age, approximately a quarter were defined as being severely wasted. This is not surprising as the rates of unemployment, poverty and food insecurity are highest amongst the Black population of South Africa who made up the majority of the study population (Statistics South Africa 2012a; Statistics South Africa 2012b; The Provincial Decision-Making Enabling Project 2005). Players who were severely wasted were a particularly high risk group as they were probably not getting sufficient energy and CHO to grow let alone to meet their nutritional needs for growth and performance.

5.3 ENVIRONMENTAL CONDITIONS

Although the mean environmental conditions did not predispose players to heat illness there were high risk training sessions during the study. Therefore, it is important that the dangers of dehydration and heat illness should not be overlooked. Players / coaches need to be vigilant as the risk of heat illness is a real threat particularly when dealing with adolescents as they do not sweat as effectively as adults putting them at a greater risk of developing heat illness (Micheli & Jenkins 2001, p59).

5.4 HYDRATION STATUS

5.4.1 Mean urine specific gravity

The majority of players were slightly dehydrated before and after training. A comparable study by Silva *et al* (2011) on adolescent soccer players during training found similar results. Therefore, players arrived at training in a less than optimal hydration state and were not addressing this during training by drinking adequately or by hydrating adequately after training.

5.4.2 Hydration status according to urine specific gravity

Nearly half of the players were very or extremely dehydrated before and after training. This was not found in previous studies conducted on soccer players as Aragón-Vargas *et al* (2009) found that only 41% of adult soccer players in their study were dehydrated ($U_{SG} \geq 1.020$ g/ml) before training. This level of dehydration could have resulted in an increase in the rating of perceived exertion and core body temperature, a decrease in the drive to continue training and hypernatraemia (Ali *et al* 2010; Sallis 2008; Edwards *et al* 2007). Conversely a few players (< 10%) were extremely hyperhydrated before and after training and had therefore consumed too much fluid. Kurdak *et al* (2010) found that in their study on adult soccer players, the team consuming water and a CHO-electrolyte beverage during the second match were found to be extremely hyperhydrated according to the mean U_{SG}. Consuming too much fluid usually stimulates urine production which rapidly returns the body to a state of euhydration. However, this compensatory mechanism is less effective during exercise and increases the risk of dilutional hyponatraemia (Sawka *et al* 2007). Hyponatraemia can negatively impact on exercise performance, and result in illness or even death (Sawka *et al* 2007). Therefore, it is evident that both dehydration and to a lesser extent hyperhydration coexisted in the same sample and players therefore need to be educated on the importance of adequate hydration to prevent both dehydration and hyperhydration.

5.4.3 Percent change in body weight

The degree of dehydration experienced by the majority of players was within acceptable limits as it was less than 1% loss of body weight (Turocy *et al* 2011). Relatively few players incurred levels of dehydration (> 2%) that were significant enough to impair their performance and impact on their health (Ali *et al* 2010; Edwards *et al* 2007). The actual level of dehydration however, could have been underestimated as approximately half were very or extremely dehydrated before training commenced.

The results of the current study are similar to those of Silva *et al* (2011) who found that adolescent soccer players were on average 1% dehydrated during training. However, this is different from what was found among adult soccer players as they were found to be 1.6% to 3.4% dehydrated (Kurdak *et al* 2010; Aragón-Vargas *et al* 2009; Maughan *et al* 2005; Shirreffs *et al* 2005). A possible reason why adolescent soccer players dehydrated less than their adult counterparts is because adolescents differ from adults physiologically and metabolically and do not sweat as effectively. As a result, they are at a greater risk of developing heat illness making appropriate hydration strategies even more important (Montfort-Steiger & Williams 2007; Micheli & Jenkins 2001, p59).

Of those who gained weight during training, the amount of weight gained was less than 1% of body weight. This weight gain is due to excessive fluid consumption resulting in overhydration and can result in decreased urine output and increased risk of dilutional hyponatraemia (Sawka *et al* 2007). Excessive water consumption can lead to hyponatraemia which can be life threatening. There were no standards to determine the severity of effect of the percent of weight gained during training.

5.5 FLUID CONSUMPTION

5.5.1 Type of fluid

The majority of players consumed water as in the studies by Silva *et al* (2011), Ali *et al* (2010), Kurdak *et al* (2010), Edwards *et al* (2007) and Maughan *et al* (2005). Although not optimal for rehydration purposes, consuming water is better than not consuming any fluid at all and is appropriate in cool weather conditions during moderate training (Hoffman & Maresh 2011; Kirkendall 2004). However, consuming water only leads to a decrease in osmolality and in the desire to drink and may result in an increase in urine output (Hoffman & Maresh 2011). Three teams did not have a tap at their training sites and players from these teams tended to not bring drink bottles with fluid to training. The players were not asked why they did not bring fluid along as they would have access to fluids at home as all came from areas with piped tap water. This is possibly because players from these teams did not know the importance of fluid for soccer training. However, players from these teams were not found to be more dehydrated than those training at training sites with taps.

Consuming water can enhance athletic performance but when CHO at a concentration of 6 to 8% and electrolytes are added, the improvements in performance are much greater (Shirreffs 2009; Sawka *et al* 2007). Carbohydrate consumption enhances performance by maintaining high levels of CHO metabolism, and sparing endogenous glycogen (Jeukendrup 2004). Carbohydrate containing beverages are important as they may improve the intestinal absorption of sodium and water during training, thereby contributing to optimal hydration and sustaining blood glucose levels (Casa *et al* 2000). Consumption of CHO containing beverages also results in lower ratings of perceived exertion and heart rate, improves hydration, enhances speed and agility and helps maintain blood glucose levels (Ali *et al* 2007; Guerra *et al* 2004; Ostojic & Mazic 2002; Welsh *et al* 2002). Unlike previous studies by Da Silva *et al* (2012), Kurdak *et al* (2010) and Shirreffs *et al* (2005), players in the current study did not consume CHO-electrolyte beverages although these beverages were available in local stores. This is possibly due to their lack of knowledge regarding the importance of CHO-electrolyte beverages and their poor socio-economic status. Although socio-economic status dictates that specialist CHO-electrolyte beverages are probably beyond the means of these players, simple fruit cordials such as Oros (an 8% CHO solution) which is inexpensive and culturally acceptable would be a very effective as a practical alternative.

5.5.2 Amount of fluid consumed

In the current study players consumed at most 578 ml of fluid (water and pure fruit juice) before training, an amount greater the recommended amount of 300 to 400 ml 45 minutes prior to training (Rodriguez *et al* 2009; Burke & Deakin 2006, p613). This could have contributed to the hyperhydration observed before training. As previous published research did not report the fluid intake of adolescent soccer players before training a comparison of the current study with similar studies was not possible.

In the current study players consumed at most 183 ml of fluid during the 60 to 90 minutes of training instead of 150 to 200 ml of fluid every 15 minutes (Burke & Deakin 2006, p613). This intake is substantially less than that reported by Silva *et al* (2011) who found on average that adolescent soccer players consumed a total of 1133 ml of water during the regular drink breaks that were scheduled according to their normal training routine. The low fluid intake could in part be attributed to no regular scheduled drink breaks as in the current study only one team had planned drink breaks. Other contributing factors included players not bringing drink bottles containing fluids to training and a lack of taps at the training sites.

Fluid consumption during training is important to replace the fluid lost through sweat and reduce the amount of dehydration incurred (Edwards *et al* 2007; Casa *et al* 2005). Despite consuming less fluid than reported by Silva *et al* (2011), players in the current study were less dehydrated possibly because they trained at a lower temperature for shorter periods of time.

After training it is recommended that athletes consume 450 to 675 ml of fluid for every 0.5 kg of body weight lost to ensure rapid recovery (Rodriguez *et al* 2009). As an average of 0.38 kg of body weight was lost during training, an intake of 342 to 513 ml of fluid was required to compensate for this loss. However, players consumed at most 259 ml of fluid after training which is below the recommended amount. This could result in inadequate rehydration by the subsequent training session which could compromise athletic performance. However, this may not be an adequate reflection of intake as fluid consumption was measured during the first 15 minutes after training ceased and players then went home. Previously published research conducted on adolescent soccer players did not report the amount of fluid consumed after training or matches.

5.6 CARBOHYDRATE CONSUMPTION

The only fluid consumed which contained CHO was pure fruit juice although very few players consumed this. In addition, the amount consumed was not sufficient to supply significant amounts of CHO. Pure fruit juice has a CHO content of greater than 8% which exceeds the concentration of 6 to 8% recommended by the Sawka *et al* (2007). Consuming a drink containing more than 8% CHO reduces gastric emptying resulting in decreased CHO absorption (Sawka *et al* 2007).

Players consumed at most 1.8 g of CHO/kg body weight before training. In training sessions lasting more than one hour it is recommended that athletes consume 1 to 4 g of

CHO/kg body weight (Burke *et al* 2011). Therefore, players consumed adequate amounts of CHO before training.

Players consumed at most 0.69 g of CHO during training. Consuming 30 to 60 g of CHO per hour is important for training lasting one to two and a half hours as this has been shown to maintain blood glucose levels and sustain athletic performance (Burke *et al* 2011; Rodriguez *et al* 2009; Sawka *et al* 2007). During exercise sessions of less than 45 minutes CHO consumption is not needed (Burke, Hawley, Wong & Jeukendrup 2011). Also for most recreational athletes eating during an exercise session which lasts less than an hour is not necessary (Rosenbloom 2012). Fluids containing 6 to 8% CHO are not recommended for exercise sessions lasting less than one hour (Rodriguez *et al* 2009).

During the winter months players in the current study trained for one hour due to limited daylight and 20 minutes of these training sessions was spent stretching. Therefore, the players would have trained for approximately 40 minutes resulting in CHO intake not being required.

Players also did not consume CHO immediately after training but may have consumed it when they got home. Carbohydrate consumption after training is important to replenish muscle glycogen stores and ensure rapid recovery (Rosenbloom 2012). The players in the current study had one or two days rest between training sessions and therefore do not have to practice nutrient timing with regards to glycogen replacement (Rodriguez *et al* 2009). Players however, still need to consume sufficient CHO 24 hours after training (Rodriguez *et al* 2009). Consuming a meal or snack soon after training is important to ensure that the CHO and energy requirements of athletes are met (Rodriguez *et al* 2009).

5.7 KNOWLEDGE REGARDING THE IMPORTANCE OF FLUID

5.7.1 Type of fluid

The majority of players incorrectly believed that water was the most important beverage to consume before, during and after training. Only one third thought that energy drinks and non-fizzy drinks were important before training and even less thought that they were important during and after training. This lack of knowledge needs to be corrected as energy drinks with a CHO content of 6 to 8% taken during training have been shown to provide both adequate fluid and CHO to sustain performance and prevent dehydration while supplying all the benefits of CHO (Sawka *et al* 2007). The potential benefit of recovery drinks was also overlooked. This illustrates the need for a nutrition education programme targeting adolescent soccer players, parents and coaches on the importance of fluid and CHO intake for soccer training.

5.7.2 Amount of fluid

Approximately a third of the players identified the correct amount of fluid to consume before training, a quarter during training and only one tenth identified the correct amount to consume after training. This lack of knowledge can be detrimental to health as simple changes such as consuming the correct type (6 to 8% CHO) and amount of fluid (300 to 400 ml before, 150 to 200 ml every 15 minutes during and 342 to 513 ml after training) can protect their health and maximise performance (Welsh *et al* 2002).

5.8 KNOWLEDGE REGARDING THE IMPORTANCE OF CARBOHYDRATE

Although the majority of players stated that CHO was important for soccer training none of them implemented their knowledge and consumed CHO, except for a few players who consumed inadequate amounts of pure fruit juice. Players did not know the importance of CHO consumption before, during and after training. This contradicts their knowledge that CHO was important for soccer training. The players' lack of knowledge is possibly due to a lack of developmental programmes especially those which include a nutrition component. This illustrates the importance of nutrition education targeting players, coaches and parents on both the role of CHO for soccer training as well as on affordable culturally acceptable sources of CHO. None of the players knew that CHO should be consumed during training, a time when CHO consumption is needed to sustain athletic performance, blood glucose levels and prevent extreme dehydration (Burke *et al* 2011; Sawka *et al* 2007). In the current study few of the players consumed CHO before and after training. This is possibly because CHO intake was monitored 15 minutes before and after training and some players may have consumed CHO at home. Insufficient CHO consumption would not only impact on normal growth and development but on soccer performance and emphasizes the importance of a sufficient intake of affordable CHO before, during and after training (Ali *et al* 2007).

5.9 CONCLUSION

The high response rate indicates that the results are representative of the actual practices of adolescent soccer players in the PADSA league. The high attrition rate could have been due to fear as crime is very prevalent in KZN. However, the reasons for drop out were not investigated.

Despite the majority of players having a normal BMI, some were found to be severely wasted which could be due to the high prevalence of food insecurity in the region. During some of the training sessions the players were at risk for developing heat illness which is a real danger to adolescents as they do not produce sweat as effectively as adults.

According to the mean U_{SG}, players were slightly dehydrated before and after training therefore were not hydrating adequately in between training sessions. However, according to the U_{SG} categories nearly half of the players were very or extremely dehydrated before and after training. In addition, a few players were extremely hyperhydrated before and after training. Therefore, in this study extreme dehydration and extreme hyperhydration was found amongst the same group of players. The degree of dehydration incurred during training was less than 1% and not enough to impact on the performance of the players. However this could have been underestimated because players were already dehydrated when they arrived at the training site.

Players mainly consumed water, similar to previous studies on adult soccer players. Fluid consumption was inadequate during and after training. A possible reason was that some of the teams did not have a tap at their training site, many did not bring fluid to training and there were no scheduled drinks breaks. Insufficient amount and types of CHO was consumed before, during and after training. The only CHO containing fluid was pure fruit juice which was consumed by a minority of players in insufficient amounts to contribute to overall CHO intake and performance.

The majority of players incorrectly believed that water was the most important fluid to consume before, during and after training. The players were unaware of the important role of 6 to 8% CHO beverages before, during and after training. Most believed they were more important before training and few believed that they should be taken during training. Also less than a third knew the correct amount of fluid to consume before, during and after training.

The majority of players stated that CHO was important for soccer training yet very few consumed CHO. This is possibly because many of the players did not see the importance of CHO before, during and after training. The inadequate and practices of players surrounding an adequate fluid and CHO consumption indicates the importance of a nutrition education programme focusing on the importance of fluid and CHO for soccer training.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The intensity of training, inadequate fluid and CHO consumption predisposes adolescent soccer players to dehydration and impairs performance. The aim of the study was to determine the type and amount of fluid consumed before, during and after training. The study also determined the CHO intake before, during and after training as well as the hydration status of soccer players. The knowledge of players regarding the importance of CHO and fluid consumption for soccer training were also assessed.

6.2 CONCLUSIONS

Adolescent soccer players in KZN are from a background of both poverty and food insecurity. Some may not have had sufficient food for growth and development, let alone the extra demands of the sport, as approximately a quarter of players were found to be severely wasted. This finding was not documented by other studies conducted on adolescent soccer players. Nearly half of the training sessions put these adolescent players at a risk of heat illness therefore appropriate hydration strategies were very important as a preventative measure and players and coaches need to pay more attention to this. Three of the teams did not a tap at their training site, thereby illustrating the lack of adequate facilities to train effectively emphasizing the need to campaign for the improvement of training facilities for the socio-economically challenged.

Most players were arriving at and leaving training in a slightly dehydrated state indicating that they were not drinking adequately after training to have fully rehydrated by the next training session. According to the U_{SG} measurements nearly half of the players in the current study were very or extremely dehydrated before and after training. This was not reported in previous studies of a similar nature. Conversely a few players were extremely hyperhydrated before and after training. Therefore, a unique finding of extreme dehydration and extreme hyperhydration was found in the same study sample. Both practices endanger the performance and health of the adolescent players and education strategies need to be designed which emphasize the consumption of an adequate fluid intake without promoting an excessive intake. According to percent loss of body weight the majority did not dehydrate sufficiently to significantly impair either health or performance. However, the level of dehydration could have been underestimated by the technique of the percent loss of body weight as approximately half were not in a state of euhydration before training commenced.

Players consumed inadequate amounts of fluids during and after training even when fluid in the form of water was available. This is possibly because no drinking breaks were scheduled and the coaches did not encourage fluid consumption. The inadequate fluid consumption could have contributed to the extreme dehydration experienced by players after training. The importance of fluid consumption is related to replacing fluid lost through sweat and reducing the amount of dehydration incurred. The majority of players consumed water before, during and after training and although better than nothing, this is not the appropriate fluid to consume as it lacks much needed CHO to sustain athletic performance. Also consuming water alone leads to a decrease in osmolality and in the desire to drink and may increase the volume of urine passed.

An important finding of this study is that players did not consume sufficient CHO before, during and after training in spite of CHO being important for athletic performance. In addition CHO contributes to the maintenance of blood glucose levels, sprint performance, speed, and agility as well as significantly delaying the onset of fatigue. Inadequate consumption of CHO in the form of a beverage (6 to 8% CHO) during training may increase the degree of dehydration incurred by adolescent soccer players. Players possible could not afford CHO-electrolyte beverages (6 to 8%) due to their poor socio-economic background. However, fruit cordials such as Oros (an 8% CHO solution) which is inexpensive and culturally acceptable would be a very effective and practical solution.

This study was unique in that it simultaneously investigated the practices and knowledge of the players regarding the importance of fluid and CHO for soccer training. The majority of players believed that water was the most important fluid to consume before, during and after training. However, as water does not contain CHO it is not the ideal solution to consume before, during and after training. In addition the overconsumption of water can lead to hyponatraemia. Less than a third of players identified CHO containing (6 to 8%) beverages as being important before, during and after training. Less than a third knew the correct amounts of fluids to be consumed before, during and after training. The players' lack of knowledge regarding the importance of the type and amount of fluid to consume indicates the importance of nutrition education on the importance of adequate fluid and CHO consumption for soccer training.

Although the majority of players stated that CHO was important for soccer training, however few players stated that it should be consumed before, during and after training. Probably the reason why players did not consume CHO before, during and after training was that they did not believe it was important.

The incorrect knowledge of players regarding the importance of fluids and CHO for soccer training illustrates the vital role that targeted nutrition education can play in dispelling myths among players, coaches and parents. There also is need to involve key stakeholders in improving the training facilities to enable players to train in safety such as ensuring there is a tap at the training site.

6.3 RECOMMENDATIONS FOR ADOLESCENT SOCCER PLAYERS TO TRAIN SAFE IN PIETERMARITZBURG

6.3.1 There should be training sessions where adolescent soccer players can be weighed before and after training so they can determine how much weight they lost and therefore how much fluid they need to consume.

6.3.2 Coaches should schedule and enforce regular drink breaks during each training session.

6.3.3 Players should bring their own drink bottles to training containing a CHO beverage such as Oros or if they cannot afford it, water.

6.3.4 Players, coaches and parents should receive nutrition education from registered nutritionists or dietitians, supported by the South African Football Association on the importance as well as on the type and amount of fluids and CHO to consume before, during and after training.

6.3.5 The municipality should ensure that at least one tap should be installed at each soccer training site.

6.4 STRENGTHS OF THE STUDY

This study's results were reliable and valid due to:

6.4.1 the large number of players (n=122) participating in this study compared to other studies such as the ones conducted by Da Silva *et al* (2012), Silva *et al* (2011), Kurdak *et al* (2010), Aragón-Vargas *et al* (2009), Maughan *et al* (2005), Shirreffs *et al* (2005).

6.4.2 the use of two validated techniques namely percent change in body weight and U_{SG} to determine hydration status. This ensured a more accurate measurement of hydration status and allowed the comparison of results generated by this study to other studies conducted amongst soccer players. In addition, previous studies only used percent change in body weight to determine hydration status (Ali *et al* 2010; Maughan *et al* 2005; Shirreffs *et al* 2005; Guerra *et al* 2004; Ostojic & Mazic 2002).

6.4.3 the use of two training sessions to determine the hydration status, fluid and CHO intake of players. Most other studies used only one training session or match to determine hydration status, fluid and CHO intake of players (Da Silva *et al* 2012; Aragón-Vargas *et al* 2009; Maughan *et al* 2005; Shirreffs *et al* 2005).

6.4.4 the use of an automatic weather station to measure the environmental conditions at the training site instead of relying on data from the South African Weather Bureau which would supply data on Pietermaritzburg in general and not data applicable to the actual training site.

6.5 LIMITATIONS OF THE STUDY

6.5.1 Inability to study all the teams in the PADSA under 17 league.

6.5.2 Attrition rate between the two training sessions

6.5.3 The response rate for the questionnaire assessing the players' knowledge regarding the importance of fluid and CHO for soccer training.

6.5.4 Classifying hydration status according to U_{SG} categories based on research conducted on adult athletes and not adolescents.

6.5.5 Assessing fluid and CHO intake 15 minutes before and after training as opposed to two hours before and after training.

6.6 RECOMMENDATIONS FOR FUTURE RESEARCH

6.6.1 To investigate the impact of educating players, parents and coaches on the importance of fluid and CHO intake to enhance performance during soccer training and determine if this will improve the fluid and CHO intake related to training sessions and matches.

6.6.2 To determine the reason/s why soccer players do not consume adequate amounts of fluid before, during and after training.

6.6.3 To determine whether improved fluid and CHO intake among adolescent soccer players impacts on training performance.

6.6.4 To determine the core body temperature and rating of perceived exertion among adolescent soccer players during training.

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APPENDIX A: Questionnaire examining soccer players knowledge regarding the consumption of fluid and carbohydrate for soccer training

<u>KNOWLEDGE ABOUT ADEQUATE HYDRATION AND CARBOHYDRATE INTAKE FOR SOCCER TRAINING TRAINING.</u>

When filling in this questionnaire please tick your answer in the relevant box. You may tick more than one box for each question. Do not worry about the numbers written in the boxes. These numbers are for coding the data for research.

Code:	For official use only

1.Please fill in your date of birth	

2.Race	African black 1	Coloured 2	Indian 3	White 4

3. Playing position	Goalkeeper 1	Defender 2	Midfielder 3	Striker 4

4. Should you drink fluids two hours before the start of training?		
Yes 1	No 2	Do not know 3
5. If yes, what type of fluids should you drink before training (you may tick more than one block)?		
Water 1	Fizzy drinks eg. Coke 2	Non-fizzy drinks eg. Oros 3
Pure fruit juice eg. Liquifruit 4	Energy drinks eg. Energade 5	Recovery drinks eg. USN Recover Max 6
High caffeine, energy drinks eg. Red Bull 7		
6. If other please write it in the block below.		
6		
7. If you should drink before training, how much should you drink?		

8. If you don't think that you should drink before training please write the reasons why.

9. Should you drink fluids during training?		
Yes $_1$	No $_2$	Do not know $_3$
10. If yes, what type of drinks should you drink during training (you may tick more than one block)?		
Water $_1$	Fizzy drinks eg. Coke $_2$	Non-fizzy drinks eg. Oros $_3$
Pure fruit juice eg. Liquifruit $_4$	Energy drinks eg. Energade $_5$	Recovery drinks eg. USN Recover Max $_6$
Red Bull $_7$		

11. If other write it in the block below.
6
12. If you should drink fluids during training, how much fluid should you drink?
13. If you don't think that you should drink during training please write the reasons why.

14. Should you drink fluids after training?		
Yes 1	No 2	Do not know 3
15. If yes, what type of drinks should you drink after training (you may tick more than one block)?		
Water 1	Fizzy drinks eg. Coke 2	Non-fizzy drinks eg. Oros 3
Pure fruit juice eg. Liquifruit 4	Energy drinks eg. Energade 5	Recovery drinks eg. USN Recover Max 6
High caffeine energy drinks eg. Red Bull 7		
16. If other write it in the block below.		
6		

17. If you should drink fluids after training, how much fluid should you drink?
18. If you don't think that you should drink after training please write the reasons why.

19. Do you eat carbohydrate rich foods such as bread, before, during or after training?		
Yes 1	No 2	
20. If you answered yes to question 26, do you think carbohydrate rich foods that you eat before, during, or after training can affect your performance?		
Yes 1	No 2	Do not know 3
21. If yes, how can what you eat affect your performance?		
22. If you answered no to question 27, then why would carbohydrate rich foods not affect your performance?		
23. When is it most important to eat carbohydrate rich foods?		
Before training 1	During training 2	After training 3
24. If you eat carbohydrate rich foods before training, how soon before training do you eat them?		

25. If you eat carbohydrate rich foods after training, how soon after training do you eat them?

APPENDIX B: DATA SHEETS USED IN THE STUDY

Weight before training Team 1, Day 1

*Do two measurements if they differ by 100 g do a third measurement.

Participant code	Measurement 1	Measurement 2	Measurement 3	Mean
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Weight after training

*Do two measurements if they differ by 100 g do a third measurement.

Participant code	Measurement 1	Measurement 2	Measurement 3	Mean
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Urine Specific Gravity before training

*Do two measurements if they differ by 0.001 g/ml then do a third measurement.

Participant code	Measurement 1	Measurement 2	Measurement 3	Mean
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Urine Specific Gravity after training

*Do two measurements if they differ by 0.001 g/ml then do a third measurement.

Participant code	Measurement 1	Measurement 2	Measurement 3	Mean
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Height after training

*Do two measurements if they differ by 0.2 cm do a third measurement.

Participant code	Measurement 1	Measurement 2	Measurement 3
121			
122			
123			
124			
125			
126			
127			
128			
129			
130			
131			
132			
133			
134			
135			
136			
137			
138			
139			
140			

Fluid intake from bottles before training

Code	Time	Type	WB4	WA	Time	Type	WB4	WA
121								
122								
123								
124								
125								
126								
127								
128								
129								
130								
131								
132								
133								
134								
135								
136								
137								
138								
139								
140								

WB4: weight before

WA: weight after

Fluid intake from bottles during training

Code	Time	Type	WB4	WA	Time	Type	WB4	WA
121								
122								
123								
124								
125								
126								
127								
128								
129								
130								
131								
132								
133								
134								
135								
136								
137								
138								
139								
140								

WB4: weight before

WA: weight after

Fluid intake from bottles after training

Code	Time	Type	WB4	WA	Time	Type	WB4	WA
121								
122								
123								
124								
125								
126								
127								
128								
129								
130								
131								
132								
133								
134								
135								
136								
137								
138								
139								
140								

WB4: weight before

WA: weight after

Fluid intake from the tap before training

Code	Time	Number of mouthfuls	Time	Number of mouthfuls
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Fluid intake from the tap during training

Code	Time	Number of mouthfuls	Time	Number of mouthfuls
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

Fluid intake from the tap after training

Code	Time	Number of mouthfuls	Time	Number of mouthfuls
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				

APPENDIX C: Informed consent form

UNIVERSITY OF KWAZULU-NATAL

School of Agricultural Sciences

& Agribusiness

Dietetics & Human Nutrition

Private bag X01

3290 Scottsville

Tel +27 (0) 33 2605428

Fax +27 (0) 33 2606270

E-mail maikoor@ukzn.ac.za

Informed Consent Form

The change in hydration status, as well as the carbohydrate and fluid intake of male soccer players during training.

I am a master's student from the Discipline of Dietetics and Human Nutrition at the University of KwaZulu-Natal (Pietermaritzburg) South Africa and am doing a research study to find out what the change in your hydration status, as well as your carbohydrate and fluid intake during training. I am asking male soccer players playing for clubs in the PADSA league to take part. The results of my study will be presented as a Masters of Science thesis and also presented at a congress. My findings will be given to you after the study in the form a report.

Ethical approval will be obtained from the Human and Social Sciences Ethics Board of the University of KwaZulu-Natal.

Your participation in the study is voluntary and you will not be punished if you refuse to participate or decide to stop at any time. The results of the study will be confidential as you will not put your name on the questionnaire. With your permission, photographs taken during the study may be used in written and oral presentations. If you agree to participate in the study, you will be required to provide urine samples before and after training, your weight will be measured before and after training, and your height will be measured only before training. The amount of fluid you drink during the training sessions will be monitored. You will also be required to complete a questionnaire during the course of the study. Your identity will be kept anonymous and your information will be treated in a confidential manner.

The study will be beneficial to you as you will obtain accurate and reliable information on the hydration and carbohydrates in relation to soccer performance.

If you have further questions please contact the researcher, Reno Gordon (074 616 8571) or one of the supervisors, Chara Biggs (033 260 6153) or Susanna Kassier (033 260 5431).

INFORMED CONSENT

The research study, including the above information, has been described to me orally. I understand what my involvement in the study means and I voluntarily agree to participate.

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Signature of participant Date

--- -----------------

Signature of Witness Date

CONSENT FORM FOR TAKING PHOTOGRAPHS

Participants Name:____ Age: ____________________

Name of principal investigator/research assistant/doctor: ____________________________________

I the undersigned have explained to the participant in full that his/her images may be used for educational/presentation purposes. I have also explained that the participant has the right to remain anonymous.

Signature: ___________________________ Principal investigator/research assistant/doctor

Date: _______________________________ Photograph number: ___________________

Participant name in full:____

I the undersigned fully understand and consents to the bearer of this document for the taking of photographs of me for educational/presentational use. I understand that I have the right to remain anonymous.

Photo including face: Allowed Not allowed

Photo excluding face: Allowed Not allowed

Participants signature: ____

UNIVERSITY OF KWAZULU-NATAL

School of Agricultural Sciences

& Agribusiness

Dietetics & Human Nutrition

Private bag X01

3290 Scottsville

Tel +27 (0) 33 2605428

Fax +27 (0) 33 2606270

E-mail maikoor@ukzn.ac.za

Dear Parent or Guardian,

This letter serves to inform you that study is being carried out by a Masters student of the University of KwaZulu-Natal. The study aims to examine the change in the hydration status, as well as the fluid and carbohydrate intake of adolescent male soccer players during training. Your son has voluntary agreed to participate in this study.

Your son will be required to provide urine samples before and after the training session's n order to determine his hydration status before and after training. His weight will be measured before and after training to determine his change in hydration status during the training. His height will be taken only before the training sessions. He will be required to complete a questionnaire to assess his knowledge regarding hydration and carbohydrate consumption for optimal soccer performance. The amount of fluid which he consumes during the training sessions will be monitored.

The identity of your son will be kept anonymous and his information will be treated in a confidential manner. The study will be beneficial to your son as he will obtain accurate and reliable information on the hydration and carbohydrates in relation to optimal soccer performance.

If you have further questions please contact the researcher, Reno Gordon (074 616 8571) or one of the supervisors, Chara Biggs (033 260 6153) or Susanna Kassier (033 260 5431).

APPENDIX D: Letter of ethics approval

UNIVERSITY OF KWAZULU-NATAL

University of KwaZulu-Natal
Research Office
Govan Mbeki Centre
Westville Campus
University Road
Chiltern Hills
Westville
3629
South Africa
Tel No: +27 31 260 3587
Fax No: +27 31 260 2384
E-mail :naidoos4@ukzn.ac.za

10 November 2010

Mr R Gordon
School of SASA
PIETERMARITZBURG

Dear Mr Gordon

PROTOCOL: Hydration status of male adolescent soccer players before and after training sessions, and their fluid and carbohydrate intake during training sessions
ETHICAL APPROVAL NUMBER: HSS/1297/2010 M: Faculty of Agriscience adn Agribusiness

In response to your application dated 10 November 2010, Student Number: **206512621** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL.**

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Professor Steve Collings (Chair)
HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE

SC/sn

cc: C Biggs (Supervisor)
cc: Ms. M Francis

Postal Address:
Telephone: Facsimile: Email: Website: www.ukzn.ac.za
Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville