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The Importance of Hydration for Soccer Athletes

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Abstract When playing soccer, the main mechanism for removing heat energy from the body is the evaporation of sweat from the surface of the skin. Although this mechanism is essential in regulating body temperature, this sweating process can often lead to dehydration. Dehydration is the process of losing water in the body and is often explained as a change in body mass during acute exercise. For example, 2% water dehydration is defined as a 2% body mass deficit. Thermoregulation in sweating is the main source of loss of body mass during acute exercise / exercise, but there are other contributing factors, namely loss of water and carbon dioxide through the respiratory tract produced by the substrate oxidation pathway. To get around the state of dehydration soccer players must immediately be rehydrated. Rehydration is an important part of the recovery process, good rehydration must be done both before, and especially after exercising, if the players have a body mass deficit, they must replace it with fluids and electrolytes in preparation for training or the next match.

Keywords: football, water, dehydration, rehydration, thermoregulation.

INTRODUCTION

Football is a team sport that is characterized by a series of sprints with high intensity and short duration, while also requiring specific soccer abilities in a match. The game has a duration of 90 minutes plus an extension of time (if needed) which is divided into 2 rounds x 45 minutes with a 15 minute break between each round (Kirkendall, 2000). The total distance of players running in a regular match ranges from 8 to 13 kilometers. The variation in distance that can be traveled by soccer players is due to several factors including the player's fitness, position in the game, level of match, tactics used and weather conditions (Da Silva et al., 2012; Duffield et al., 2012; Maughan et al., 2007; Mohr et al., 2012). Estimated energy loss from soccer players in a regular match is around 16 kcal / minute, with an average oxygen consumption of 75% of maximum levels (Bangsbo et al., 2006; Bangsbo, 2014). This high energy requirement can mean the production of high levels of body heat metabolism, which is ~ 75-80% of chemical energy in the form of ATP turned into heat energy in the muscles that work (Shirreffs et al., 2005). At high ambient temperatures, higher than skin temperature (ie ~ 33 ° C when resting and reaching ~ 36 ° C during exercise) will add to the body's burden on heat.

When exercising, the main mechanism of removing heat energy from the body is the evaporation of sweat from the surface of the skin. Although this mechanism is essential in the regulation of body temperature, this process of sweating causes dehydration (Maughan et al., 2007). Dehydration is the process of losing water in the body and is often explained as a change in body mass during acute exercise. For example, 2% water dehydration is defined as a 2% body mass deficit. Thermoregulation in sweating is the main source of loss of body mass during acute exercise / exercise, but there are other factors that contribute to the loss of water and carbon dioxide through the respiratory tract produced by the substrate oxidation pathway (Stachenfeld, 2013).

Sweat rate and dehydration level can be influenced by environmental conditions, but there are other variables involved, for example the intensity of the exercise and the clothes used. The variations presented in the data of the players can be wider in different environmental conditions. For example elite players who train at 32.3 ± 3 ° C and a relative humidity of 20 ± 5%, produce a sweat rate of 1.46 ± 0.24 L / hr (M ± s; range 1.12-2.09 L / hr), and achieve mass dehydration levels body 1.59 ± 0.61% (range 0.71-3.16%) (Shirreffs et al., 2005); in another research group elite soccer players practicing at an ambient temperature of 5.1 ± 0.7 ° C and an humidity of 81 ± 6% resulting in a sweat production rate of 1.13 ± 0.30 L / hr (range 0.71-1.77 L / hr), with a dehydration level of 1.62 ± 0.55 % (range 0.87-2.55%) (Maughan et al., 2005). Mild dehydration may not be crucial in order to undergo training or competition in a cooler environment (Coyle, 2004), it is known that more dehydration can affect physical performance in athletes during training or competition in hot temperatures (Armstrong, Casa, Millard-Stafford , Moran, Pyne, & Roberts, 2007; Casa, Armstrong, Hillman, Montain, Reiff, Rich, et al., 2000; Coyle, 2004; Sawka & Pandolf, 1990; Sawka, Burke, Eichner, Maughan, Montain, & Stachenfeld , 2007).

It is well known that dehydration increases physiological problems in carrying out the same workload of sports, especially those that occur in hot weather (Sawka et al., 2007; Sawka & Coyle, 1999). Water loss of more than 2% of body weight in several studies is known to affect endurance sports studied in the laboratory (Cheuvront, Carter, & Sawka, 2003; Gonzalez-Alonso, Mora-Rodriguez, Below, & Coyle, 1997) and also field research (Carvalho et al., 2011; Casa et al., 2010; Dough-Liberty, Baker, Chow, & Kenney, 2006; Stearns et al., 2009), as well as mental performance in hot environments (Casa, Clarkson, & Roberts , 2005; Ganio et al., 2011; Shirreffs, 2009). Several studies conducted on professional soccer players show that the best teams in the world can also experience dehydration similar to that observed in endurance sports. However, this can be overcome by the availability of fluid intake and regular rest periods for hydration needs throughout the course of the game (Maughan, Merson, Broad, & Shirreffs, 2004; Maughan, Shirreffs, Merson, & Horswill, 2005; Shirreffs, Aragon-Vargas, Chamorro, Maughan, Serratosa, & Zachwieja, 2005).

The process of fluid ingestion is the only way to replace the loss of water from the body and to reduce the level of dehydration. In football, the opportunity to get fluid intake during a match is during recess at the turn of the half or impromptu breaks during the match, for example, when a player is injured and gets medical attention. Interestingly, the world soccer body has implemented this hydration-related regulation in its application at the 2014 Brazil World Cup and the upcoming 2022 Qatar. This has something to do with the host's hot environment, so that players get an additional opportunity 2 times to drink "cooling breaks" (~ 1.5 minute duration) after the 30th minute and in the second half if the global temperature exceeds 31 ° C in the game environment (FIFA , 2015).

This review study was made to describe dehydration related to sporting events (training sessions, friendly matches and competitions) summarized from the latest scientific journals related to dehydration in soccer players, especially in young players, female and adult male soccer players so that the hydration interests of players become one of the determinants in sports performance can be explained very well.

METHODS

This scientific paper article is explained by the observation method of Literature study by collecting articles from scientific journals obtained from a number of Sport Science Open Source internet data archives related to hydration on soccer players.

The purpose of this mini review is to explain the effects of dehydration on soccer players' performance, discuss the latest hydration applications for soccer players and the latest related issues and finally to present a hydration strategy that can be implemented by Indonesian football coaches and players to ensure hydration needs are met before, during and after training / matches. It is also hoped that the increase in scientific journals related to sports science circulating in his beloved country will be accompanied by an increase in the achievements of Indonesian sports, especially soccer.

DISCUSSION

Dehydration in young soccer players

A paper by McDermott et al. (2009) showed in a football camp that children come in a state of hypohydration and when undergoing training camps remain that way. Similar results were stated by Decher et al. (2008) observed that more than 50% of participants experienced hypohydration in concentrating sports camps during the summer even though they had experienced increased awareness of hydration during the camp. In the subsequent results described, the increase in knowledge related to hydration did not have an effect on the level of hydration in the children attending the camp. While the discovery by Kavouras et al. (2012) at a summer sports camp, a fairly simple program related to hydration interventions can improve the hydration status of children within a 2 day observation period.

It is widely known that fluid losses can occur in soccer players while undergoing training or matches, with the response to the rate of perspiration increasing as the temperature of the environment increases (Maughan, Merson, Broad, & Shirreffs, 2004; Maughan, Shirreffs, Merson, & Horswill, 2005; Ozgunen et al., 2010; Shirreffs, 2010; Shirreffs et al., 2005). Da Silva et al. (2012) reported sweat loss of approximately 2.5 L in young soccer players during one match played in hot temperatures (31.0 ± 2.0 ° C). These researchers also observed that the players were less able to replace their body fluid losses of less than 50%, there was a real water deficit in soccer players, even though sports drinks were available, this was indicated as involuntary dehydration (Kurdak et al., 2010).

The high incidence of dehydration is also similar in other studies (Decher et al., 2008; McDermott et al., 2009; Stover, Zachwieja, Stofan, Murray, & Horswill, 2006). In the 2006 publication Stover et al. (2006) found consistent results that young soccer players were found to be in a state of hypohydration similar to Kavouras et al. (2012) ~ 60% of the subjects studied were still dehydrated after an intervention in the form of a hydration teaching program, on the other hand in terms of the perception of the players they felt fine with hydration 9.0 ± 1.9 out of 10 players were given a questionnaire and stated they were in a condition good hydration.

The high percentage of young soccer players classified as dehydrated makes some methods of measuring dehydration questionable, because it is not clear how far dehydration suffered by the players (Casa et al., 2000; Sawka et al., 2007). But in 2010 as can be seen in table 1 Armstrong et al. (2010) published the reference value of euhidrasi which was finally used until now by using urine specific gravity which at that time was tried to find out the hydration status in active men whose results were presented varied from each individual. Urine samples were collected, and urine color was compared with specimen containers that contained an ideal urine color scale (Armstrong et al., 1994; Armstrong et al., 1998). Then an evaluation is carried out in a room with good lighting and temperatures ranging from 20–22 ° C with samples placed on clear glass tubes against a white background. Urine samples are usually taken before breakfast to standardize the procedure and for day to day comparison needs.

Table 1. Hydration status classification using urine specific gravity (Armstrong et al., 2010)

Extreme hyperhydration	<1.012 1.012-1.014
A bit hyperhydration	1.015-1.017
Good hydration	1.018-1.020
Normal / moderate hydration	1.021-1.024
A little dehydration	1.025-1.027
Severe dehydration	>1.027

A more recent study by Arnaoutis et al. (2013) as the results in **Figure 1** show, explain the hydration status of 107 young soccer players (age 13 ± 2 years, range 11-16 years) in a training camp at hot temperatures (27-29 ° C, 54- 61% relative humidity). Based on first morning sampling 89% of players were found to be dehydrated (USG> 1,020 g / ml). After training, 96% of players become dehydrated even though they have the opportunity to drink fluids while training. When we compare it with the findings in adult soccer players it was also found to start the game in dehydration conditions (USG> 1,020 g / ml) in the temperature of the match environment (35 ° C, 35% relative humidity) found a dehydration rate of 3.4% (Aragón-Vargas et al., 2009).

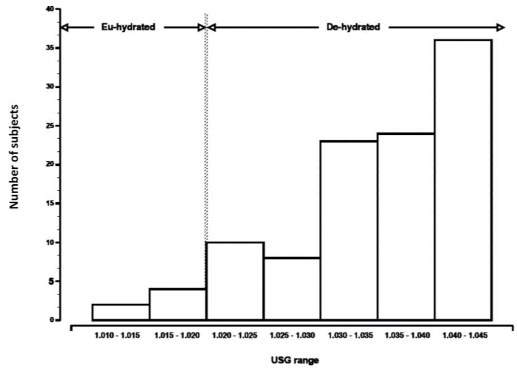

Figure 1. Distribution of participants' hydration status with urine specific gravity (USG).

Similar findings were observed at official competitions of young Brazilian soccer players (Da Silva et al., 2012). Dehydration levels are influenced by environmental conditions, in the publication of this study found higher levels of dehydration in hot climates and low in cold weather. However there are other factors that contribute to fluid loss which results in increased levels of dehydration, such as the intensity of exercise / sport and even clothing used

(Aragón-Vargas et al., 2009). While another factor that is no less important is the knowledge / insight of the players regarding the importance of hydration intake, in a study explaining these young soccer players actually already understand the importance of this fluid intake, but they still fail to apply it on the field (Decher et al. , 2008).

The hydration status of an athlete depends on the initial effort of the intake of fluid that enters before (Wingo et al., 2004) and also the intake of nutrition during and after competitions and training sessions (Sawka et al., 2007). Studies published the majority of these players (young and adult) began training sessions in a state of hypohydration (Aragón-Vargas et al., 2009; Castro-Sepúlveda et al., 2015; Phillips et al., 2014). Things that increase pre-exercise dehydration are caused by environmental factors such as temperature and humidity; the importance of the sports event being raised (whether in training sessions, friendly matches, or competitions). The state of hypohydration can be evaluated using biological tests using osmolality of fluid, urine specific gravity or weight (changes before and after exercise), with urine specific gravity (USG) is the most frequently used test focusing on soccer players (Aragón-Vargas et al., 2009; Castro-Sepúlveda et al., 2015; Phillips et al., 2014).

The only advice that can be given when exercising for young players in a fairly high environmental heat triggers mild to severe dehydration status is to drink immediately when feeling thirsty (Goulet, 2011; Noakes, 2007, 2010). The fact is that most young players who are dehydrated (81.8% and 74.6% after undergoing 2x training sessions) experience a decrease in total body weight, even though the availability of fluids on the field is sufficient. So that the player's awareness in this matter becomes important to help his own hydration before, during and after practicing / competition independently on the field, when he gets a chance to immediately hydrate.

Dehydration in female soccer players

Currently there is a significant increase in the number of female soccer players around the world. However information related to fluid and electrolyte balance in female footballers is still limited to studies conducted during training; no data is available when the actual match takes place (Gibson et al., 2012; Kilding et al., 2009). A comparative study of the responses of female soccer players in 2 different training sessions on 2 separate days (Kilding et al., 2009). The results show the rate of sweat and electrolyte loss is relatively low when practicing football in cold environmental conditions. Other studies measure iodine fluids and balance in young elite female soccer players when training in cold environments (Gibson et al., 2012). An interesting finding in this study was that 45% of the 34 female soccer players studied were dehydrated (USG> 1,020 g / ml). But on the other hand the rate of dryness and loss of sodium while practicing was found to be low, collaborated with the study of Kilding et al. (2009). These findings are in line with previous studies which stated women had lower sweat rates and electrolyte loss compared with men (Bar-Or, 1998).

The first study that indicated physiological, metabolic and anthropometric needs in women and men alike was carried out 15 years ago (Davis et al., 1993). Then found the fact that the variables that affect soccer's performance are the same, one of them is hydration status. Dehydration is one of the variables that can have a negative impact on performance in the field (Bandelow et al., 2010; Maughan et al., 1994; McGregor et al., 1999). Mild dehydration in women can affect the lactate threshold (Moquin et al., 2000) and the mood of the athlete (Armstrong et al., 2012), which triggers the athlete's reluctance to give the best performance in the match.

Gibson et al. (2012) evaluated 34 young female players and showed data of 45.4% who were present at training sessions experiencing hypohydration (USG> 1,010). Kilding et al. (2009) observed 13 female professional soccer players in 2 friendly matches and indicated an average value of USG 1,014 ± 0.005 and 1,011 ± 0.005 both showing dehydration of drinks during the match. The most recent research related to the dehydration of female professional soccer players was presented by (Castro-Sepúlveda et al., 2016) as can be seen in **Figure 2** and **Figure 3** in 2016 entitled "Prevalence of Dehydration Before Training Sessions, Friendly and Official Matches in Elite Female Soccer Players "are conducted at professional women's football in the United States to find out the difference in hydration status in 3 different sporting events. Signs of danger of serious dehydration dehydration during training and official competition matches with percentage values above 50%.

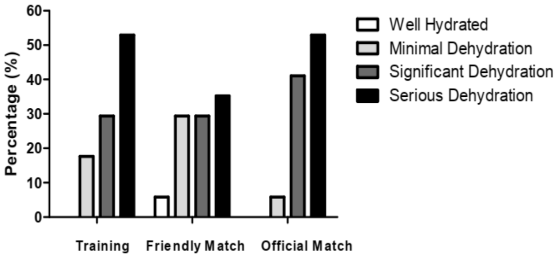

Figure 2. Percentage distribution of dehydration states indicated by using urine specific gravity (USG) at a training session, a friendly match, and an official match of female professional soccer players. The ultrasound classification refers to Casa et al. (2000) 1,010 (well hydrated), 1,010-1,020 (minimum dehydration), 1,021-1,030 (significant dehydration),> 1,030 (serious dehydration). (Castro-Sepúlveda et al., 2016).

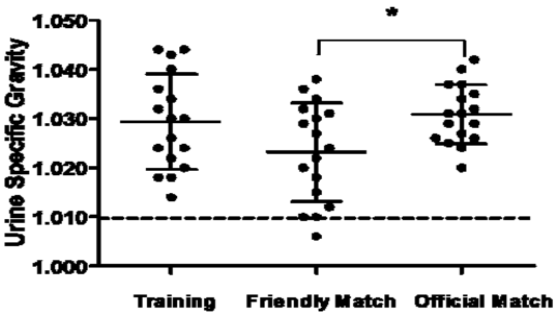

Figure 3. Differences in urine specific gravity results shown in training sessions, a friendly match, and an official match for professional female soccer players *Significant differences between these conditions, p <0.05. (Castro-Sepúlveda et al., 2016).b

Eijsvogels et al. (2013) explained that men suffer more loss of body mass after exercising compared to women. This is due to hormonal activity and also the differences in body composition between men and women which cause differences in sweat rate. In mild dehydrated women it decreases the lactate threshold, thereby decreasing work activities (Moquin et al., 2000), decreasing performance in intermittent sports such as soccer (Bangsbo et al., 2007). Plus mild dehydration can negatively affect mood in women, reduce stamina and increase the sensation of fatigue, headaches and loss of concentration, plus decrease performance (Armstrong et al., 2012).

Impact of dehydration on soccer performance

Football performance can be given by a player depending on many physical functional aspects which include endurance, strength, power, and abilities specific to the sport. Dehydration can have a negative impact on endurance performance, especially when dehydration is combined with heat stress. There are individuals who are slightly less sensitive to dehydration, the level of dehydration that can make degenerative performance in the range of > 2% decrease in body mass (Sawka et al., 2007).

Other variables of exercise performance are muscle strength and anaerobic performance are less likely to be affected by dehydration (Ali & Williams, 2013; Cheuvront & Kenefick, 2014). Some authors have argued that reduced body mass (dehydration) when playing football will actually increase the production force and height of the vertical jump to head the ball (Viitasalo et al., 1987). In an example of another publication, 2.5% body mass reduction did not have a significant effect on sprints and power performance (Watson et al., 2005). It seems that until now there was no correlation between decreasing body mass and vertical jump height (Watson et al., 2005), and it can be concluded that dehydration is not beneficial for the needs of playing football.

McGregor et al. (1999) were the first authors to publish the impact of dehydration on specific soccer performance. In this study the value of perceived exertion (RPE) were found to increase at the end of the 90-minute Loughborough Shuttle Running Test (LIST) protocol (13-20 ° C, 57% relative humidity) when there was no fluid intake given to the players (causing 2.5% dehydration) compared to subjects given fluid intake (1.4% dehydrated). 2.5% dehydration makes the subject of players slower in taking the sprint compared to those who experience 1.4% dehydration. This study also presents soccer specific performance data such as dribbling ability decreased by 5% in subjects who did not get fluid intake, but in subjects who drank fluid intake their dribbling ability was maintained. But the results of this publication also state that 2.5% dehydration has no impact on the mental concentration of football players at the end of the LIST protocol.

In another study Edwards et al. (2007) demonstrated results after a match (90-minutes; 21-24 ° C, 55% relative humidity),

the performance of the Yo-Yo Intermittent Recovery Test (YYRT) was disrupted when no fluid intake was given to the players causing 2.4% dehydration compared to players who are given fluids (0.7% dehydrated). Contrary to the results obtained by Owen et al.

(2013) showed in **table 2** which observed the effects of dehydration on football's technical abilities such as baiting and shooting and high-intensity running performance after 90 minutes of LIST protocol in an environment with a temperature of 19 ° C, 59% relative humidity.

Although there were differences in fluid intake from 2 different experimental groups causing 3 dehydration status conditions (2.5%, 1.1% and 0.3%, respectively), football technical ability and high intensity running performance in these 3 conditions obtained results that did not differ much. These results contradict some other publications which state that dehydration can affect football's sprints and technical performance (Edwards et al., 2007; McGregor et al., 1999). This explanation of conflicting results is likely to occur because the performance tests used are different. Performance tests conducted in McGregor et al. (1999) consisted of procedural dribbling past cone obstacles, while Owen et al. (2013) uses a test that involves the ability to pass and shoot the ball.

In a study in which ad libitum fluid intake was allowed to drink, the total distance traveled and the number of high-intensity running football players experienced a significant reduction when the match took place under hot weather (43 ° C, 15% relative humidity) compared by comparison in control conditions (21 ° C, 55% relative humidity); which is more noticeable reduction seen in the second half (Mohr et al., 2012). In this study the sweat rate was higher during matches in hot environments (4.1 ± 0.1 L / h) compared to those carried out under lower temperature conditions (2.6 ± 0.1 L / h). However the players were found to drink more liquid in matches that took place in hot weather (2.6 ± 0.2 L) compared to the control conditions (1.1 ± 0.1 L), making the dehydration conditions almost similar (heat = 1.9%; control = 1.8%). Other results in this publication are

Table 2. The trial results before and after the procedure protocol for Loughborough Soccer Passing, Loughborough Soccer Shooting and Yo-Yo Intermittent Recovery test without fluid, ad libitum and with a number of replacement fluids with lost sweat. Owen et al. (2013).

Trials				Without fluid intake		Ad libitum's fluid			With fluid intake			
Time	Before		After		Before		After		Before		After	
Loughborough Soccer Passing Test												
Time (d)	45.2	+2.5	47.9	+4.1*	45.3	+3.1	48.4	+2.3*	45.1	+2.5	47.5	+2.7*
Penalty time (d)	3.2	+2.3	6.7	+2.1*	2.7	+1.8	6.8	+2.2*	2.8	+2.1	5.8	+2.0*
Total time (d)	48.5	+4.1	54.6	+4.2*	48.0	+4.5	55.3	+3.2*	48.0	+3.5	53.3	+3.8*
Loughborough Soccer Shooting Test												
Time needed (s)	7.9	+0.3	8.2	+0.3*	7.9	+0.3	8.2	+0.3*	7.9	+0.3	8.2	+0.3*
Shooting velocity (km/h)	78.7	+6.1	76.4	+5.2*	79.8	+5.2	76.1	+4.9*	76.9	+4.7 [b]	75.1	+4.2*
Point per shoot	1.4	+0.9	1.2	+0.6	1.3	+0.9	1.1	+0.5	1.5	+0.6	1.3	+0.6
Yo-Yo Intermittent Recovery Test												
Distance covered (m)	606	+59	330	+47*	612	+55	342	+35*	609	+47	345	+42*

that there is a negative effect of heat stress on football performance, which can be seen from the players' hydration status.

Cardiovascular physiology becomes the main mechanism that can explain dehydration associated with decreased performance in the field. Due to the reduced blood volume due to hydration, the blood decreases and oxygen decreases so that the active skeletal muscles and skin are disturbed by the process of thermoregulation. Another explanation is that the function of the central nervous system is disrupted, having an impact on metabolic function as explained by Cheuvront et al. (2010) and Cheuvront & Kenefick (2014).

Rehydration for recovery purposes

Rehydration is an important part of the recovery process after exercise. If the players have a body mass deficit, they must replace it with fluids and electrolytes in preparation for training or the next match. If dehydration becomes worse (> 5% of body mass) or when rehydration is immediately needed (for example <24 h before training or competing) the recommended fluid intake is ~ 1.5 L of fluid for every 1 kg body mass deficit (Shirreffs & Sawka, 2011) .In almost every situation, water and sodium can be unknowingly consumed from daily food and drinks. Sodium-containing drinks and sodium-containing foods can replace the sodium lost from sweating, stimulate thirst and replace it with fluid ingestion (Shirreffs & Sawka, 2011).

Studies have reported electrolyte loss and sweating while practicing (Duffield et al., 2012; Gibson et al., 2012; Kilding et al., 2009; Shirreffs et al., 2005; Williams & Blackwell, 2012) or during matches (games) Da Silva et al., 2012; Maughan et al., 2007). Dehydration is seen commonly in footballers (Aragón-Vargas et al., 2009; Arnaoutis et al., 2013; Da Silva et al., 2012). Sweat loss has been reported in the following studies (Da Silva et al., 2012; Duffield et al., 2012; Maughan et al., 2007; Mohr et al., 2012). Maughan et al. (2007) describes the loss of fluid from sweat on soccer players in an environmentally friendly 6-8 ° C match. Even though the ambient temperature of the game is cold, fluid loss varies from 820 ml to 2270 ml after 90 minutes of play. This shows that a considerable amount of liquid can occur in a match even if it is running at cold temperatures, so rehydration is also needed as important when playing at hot temperatures.

Knowing the status of body fluid balance becomes a practical application to determine the individual's need for fluid intake for fluid loss when practicing or competing. Replacement of lost electrolytes is closely related to hydration because the replacement of lost sodium can increase fluid retention retention (Shirreffs & Sawka, 2011). There have been several published studies regarding fluid and electrolyte balance in men (Duffield et al., 2012; Shirreffs et al., 2005; Williams & Blackwell, 2012;) and women (Gibson et al., 2012; Kilding et al., 2012). ., 2009) soccer players and even referees (Da Silva et al., 2011; Da Silva & Fernandez, 2003).

CONCLUSION

Dehydration in excess of > 2% of body mass deficits explained in the discussion above can affect football's specific performance, such as high-intensity sprints as well as dribbling skills. Players usually only get fluids to replace ~ 50% of the fluid lost from total needs during practice and competition, which can lead to dehydration of %2%, especially in hotter environmental conditions. Not to mention observations obtained when at the beginning of training and competition found the players were already in a state of dehydration, possibly the result of the dehydration accumulation of previous exercises. Therefore, giving daily fluid intake is an important strategy in competition. Research shows the rate of dehydration occurs before competitive matches begin, which is correlated with the players' perception of the interests of the match, so that it can interfere with the specific performance of football. Not only physically that can be disturbed but also the risk of injury and other illness due to the hot environment.

REFERENCES

Ali, A, and C. Williams (2013). Isokinetic and isometric muscle function of the knee extensors and flexors during simulated soccer activity: effect of exercise and dehydration. J Sports Sci. 31(8):907-16.

Aragón-Vargas, L.F., J. Moncada-Jiménez, J. Hernándes-Elizondo, A. Barrenechea, Monde-Alvarado (2009) Evaluation of pre-game hydration status, heat stress, and fluid balance during professional soccer competition in the heat. Eur. J. Sport. Sci. 9:269–276.

Armstrong, L.E., Maresh, C.M., Castellani, J.W., Bergeron, M.F., Kenefick, R.W., & LaGasse, K.E. (1994). Urinary indices of hydration status. *International Journal of Sport Nutrition, 4*(3), 265–279. PubMed

Armstrong, L.E., Soto, J.A., Hacker, F.T., Jr., Casa, D.J., Kavouras, S.A., & Maresh, C.M. (1998). Urinary indices during dehydration, exercise, and rehydration. *Interna-tional Journal of Sport Nutrition, 8*(4), 345–355. PubMed

Armstrong, L. E., Casa, D. J., Millard-Stafford, M., Moran, D. S., Pyne, S. W., & Roberts, W. O. (2007). American College of Sports Medicine position stand. Exertional heat illness during training and competition. *Medicine & Science in Sports & Exercise, 39*, 556-572.

Armstrong LE, Pumerantz AC, Fiala KA, Roti MW, Kavouras SA, Casa DJ, et al. Human hydration indices: Acute and longitudinal reference values. Int J Sport Nutr Exerc Metab. 2010;20(2):145–53.

Armstrong LE, Ganio MS, Casa DJ, Lee EC, McDermott BP, Klau JF, Jimenez L, Le Bellego L, Chevillotte E, Lieberman HR. Mild dehydration affects mood in healthy young women. *J Nutr,* 2012; 142: 382-8

Arnaoutis, G., S.A. Kavouras, Y.P. Kotsis, Y.E. Tsekouras, M. Makrillos, C.N. Bardis (2013) Ad libitum fluid intake does not prevent dehydration in suboptimally hydrated young soccer players during a training session of a summer camp. Int. J. Sport Nutr. Exerc. Metab. 23(3):245-51.

Bandelow S, Maughan R, Shirreffs S, Ozgünen K, Kurdak S, Ersöz G, Binnet M, Dvorak J. The effects of exercise, heat, cooling and rehydration strategies on cognitive function in football players. *Scand J Med Sci Sports,* 2010; 20: 148-60

Bangsbo, J., M. Mohr, P. Krustrup (2006) Physical and metabolic demands of training and match play in the elite player. J. Sports Sci. 24:665-674.

Bangsbo J, Iaia FM, Krustrup P. Metabolic response and fatigue in soccer. *Int J Sports Physiol Perform*, 2007; 2:111-27.

Bangsbo. J (2014). Physiological Demands of Football. Sports Science Exchange #1. www.gssiweb.com.

Bar-Or, O (1998) Effects of age and gender on sweating pattern during exercise. Int J Sports Med. 19 (suppl. 2); 106-107.

Casa, D. J., Armstrong, L. E., Hillman, S. K., Montain, S. J., Reiff, R.V., Rich, B. S. E., et al. (2000). National Athletic Trainers´ Association position statement: Fluid replacement for athletes. *Journal of Athletic Training,* 35, 212-224.

Castro-Sepúlveda M, Astudillo S, Álvarez C, Zapata-Lamana R, Zbinden-Foncea H, Ramírez-Campillo R, Jorquera C. Prevalence of dehydration before training in professional Chilean soccer players. *Nutr Hosp,* 2015; 32: 308-11.

Castro-Sepulveda, Javier Astudillo, Pablo Letelier, Hermann Zbinden-Foncea1. (2016) Prevalence of Dehydration Before Training Sessions, Friendly and Official Matches in Elite Female Soccer Players Journal of Human Kinetics volume 50/2016, 79-84 DOI: 10.1515/hukin-2015-0145.

Davis JA, Brewer J. Applied physiology of female soccer players. *Sports Med,* 1993; 16: 180-9.

Cheuvront, S.N., R.W. Kenefick (2014) Dehydration: Physiology, Assessment, and Performance Effects. Compr Physiol. 4:257-285.

Cheuvront, S.N., R.W. Kenefick, S.J. Montain, MN Sawka (2010) Mechanisms of aerobic performance impairment with heat stress and dehydration. J Appl Physiol. 109:1989-1995.

Coyle, E. F. (2004). Fluid and fuel intake during exercise. *Journal of Sports Sciences, 22,* 39-55.

Da Silva, A.I., L.C. Fernandes, R. Fernandez (2011) Time motion analysis of football (soccer) referees during official matches in relation to the type of fluid consumed. Braz. J. Med. Biol. Res. 44(8):801-9.

Da Silva, A.I., R. Fernandez (2003) Dehydration of football referees during a match. Br. J. Sports Med. 37(6):502-6.

Da Silva, R.P., T. Mündel, A.J. Natali, M.G.B. Filho, R.C.G. Alfenas, J.R.P. Lima, F.G Belfort, P.R.N.R. Lopes, Marins JCB (2012) Pre-game hydration status, sweat loss, and fluid intake in elite Brazilian young male soccer players during competition. J. Sports Sci. 30(1): 37-42.

Decher, N.R., D.J. Casa, S.W. Yeargin, M.S. Ganio, M.L. Levreault, C.L. Dann, C.T. James, M.A. McCaffrey, C.B. Oconnor, S.W. Brown (2008) Hydration status, knowledge, and behavior in youths at summer sports camps. Int J Sports Physiol Perform. 3(3):262-78.

Duffield R., A. McCall, A.J. Coutts, J.J Peiffer (2012) Hydration, sweat and thermoregulatory responses to professional football training in the heat. J. Sports Sci. 30(10):957-965.

Edwards, A.M., M.E. Mann, M.J. Marfell-Jones, D.M Rankin, T.D. Noakes, D.P. Shillington (2007) Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. Br. Sports Med. 41(6):385-91. FIFA. http://www.fifa.com/aboutfifa/footballdevelopment/medical/playershealth/risks/heat.html assessed in May 7th 2014.

Eijsvogels TM, Scholten RR, van Duijnhoven NT, Thijssen DH, Hopman MT. Sex difference in fluid balance responses during prolonged exercise. *Scand J Med Sci Sports*, 2013; 23: 198-206

Gibson, J.C., L.A. Stuart-Hill, W. Pethick, C.A. Gaul (2012) Hydration status and fluid and sodium balance in elite Canadian junior women's soccer players in a cool environment. Appl. Physiol. Nutr. Metab. 37(5):931-7.

Goulet, E.D. (2011). Effect of exercise-induced dehydration on time-trial exercise performance: A meta-analysis. *British Journal of Sports Medicine, 45*(14), 1149–1156. PubMed doi:10.1136/bjsm.2010.077966.

Kavouras, S.A., Arnaoutis, G., Makrillos, M., Garagouni, C., Nikolaou, E., & Chira, O. . . . Sidossis, L.S. (2012). Educational intervention on water intake improves hydra-tion status and enhances exercise performance in athletic youth. *Scandinavian Journal of Medicine & Science in Sports, 22*(5), 684–689. PubMed doi:10.1111/j.1600-0838.2011.01296.x

Kilding, A.E., H. Tunstall, E. Wraith, M. Good, C. Gammon, C. Smith (2009) Sweat rate and sweat electrolyte composition in international female soccer players during game specific training. Int. J. Sports Med. 30(6):443-7.

Kirkendall, D.T. (2000) Physiology of soccer. In. Exercise and Sports Science, edited by E. William, E. Garret, Jr., and D.T. Kirkendall. Lippincott Williams & Wilkins, Philadelphia.

Kurdak, S.S., Shirreffs, S.M., Maughan, R.J., Ozgunen, K.T., Zeren, C., & Korkmaz, S. (2010). Hydration and sweating responses to hot-weather football competition. *Scandinavian Journal of Medicine & Science in Sports, 20*(Suppl. 3), 133–139. PubMed *doi:10.1111/j.1600*-0838.2010.01218.x

Maughan RJ, Leiper JB. Fluid replacement requirements in soccer. *J Sports Sci,* 1994; 12: 29-34.

Maughan, R.J., Merson, S.J., Broad, N.P., & Shirreffs, S.M. (2004). Fluid and electrolyte intake and loss in elite soccer players during training. *International Journal of Sport Nutri-tion and Exercise Metabolism, 14*(3), 333–346. PubMed.

Maughan, R. J., Shirreffs, S. M., Merson, S. M., & Horswill, C. A. (2005). Fluid and electrolyte balance in elite male football (soccer) players training in a cool environment. *Journal of Sports Sciences, 23,* 73-79.

Maughan, R.J., S.M. Shirreffs, J.B. Leiper (2007) Errors in the estimation of hydration status from changes in body mass. J Sports Sci 25:797-804.

McDermott, B.P., Casa, D.J., Yeargin, S.W., Ganio, M.S., Lopez, R.M., & Mooradian, E.A. (2009). Hydration status, sweat rates, and rehydration education of youth football campers. *Journal of Sport Rehabilitation, 18*(4), 535–552. PubMed

McGregor, S.J., C.W. Nicholas, H.K. Lakomy, C. Williams (1999) The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. J Sports Sci. 17(11):895-903.

Mohr, M., L. Nybo, J. Grantham, S. Racinais (2012) Physiological responses and physical performance during football in the heat. PLoS One. 7(6):e39202.

Moquin A, Mazzeo RS. Effect of mild dehydration on the lactate threshold in women. *Med Sci Sports Exerc,* 2000; 32: 396-402.

Noakes, T.D. (2007). Hydration in the marathon: Using thirst to gauge safe fluid replacement. *Sports Medicine (Auckland, N.Z.), 37*(4-5), 463–466. PubMed *doi:10.2165/00007256*-200737040-00050

Noakes, T.D. (2010). Is drinking to thirst optimum? *Annals of Nutrition & Metabolism, 57*(Suppl. 2), 9–17. PubMed doi:10.1159/000322697

Owen, J.A., S.J. Kehoe, S.J. Oliver (2013) Influence of fluid intake on soccer performance in a temperate environment. J. Sports Sci. 31(1):1-10.

Ozgunen, K.T., Kurdak, S.S., Maughan, R.J., Zeren, C., Kork-maz, S., & Yazici, Z. (2010). Effect of hot environmental conditions on physical activity patterns and temperature response of football players. *Scandinavian Journal of Medicine & Science in Sports, 20*(Suppl. 3), 140–147. PubMed doi:10.1111/j.1600-0838.2010.01219.x

Phillips SM, Sykes D, Gibson N. Hydration status and fluid balance of elite European youth soccer players during consecutive training sessions. *J Sports Sci Med*, 2014; 13: 817-22

Sawka, M. N., & Pandolf, K. B. (1990). Effects of body water loss on physiological function and exercise performance. In C. V. Gisolfi, & D. R. Lamb (Eds.), *Perspectives in exercise science and sports medicine: Fluid homeostasis during exercise* (pp. 1-38). Carmel, IN: Brown & Benchmark.

Sawka, M.N., & Coyle, E.F. (1999). Influence of body water and blood volume on thermoregulation and exercise per-formance in the heat. *Exercise and Sport Sciences Reviews, 27,* 167–218. PubMed

Sawka, M.N., L.M. Burke, E.R. Eichner, R.J. Maughan, S.J. Montain, N.S. Stachenfeld (2007) American College of Sports Medicine position stand: Exercise and fluid replacement. Med Sci Sports Exerc. 39:377-390.

Shirreffs, S.M., L.F. Aragon-Vargas, M. Chamorro, R.J. Maughan, L. Serratosa, J.J. Zachwieja (2005) The sweating response of elite professional soccer players to training in the heat. Int. J. Sports Med. 26(2):90-5.

Shirreffs, S.M., M.N. Sawka, M. Stone (2006) Water and electrolyte needs for football training and match play. J. Sports Sci. 24, 699-707.

Shirreffs, S.M. (2010). Hydration: Special issues for playing football in warm and hot environments. *Scandinavian Journal of Medicine & Science in Sports, 20(Suppl. 3), 90–94. PubMed*

Shirreffs, S.M., M.N. Sawka (2011) Fluid and electrolyte needs for training, competition, and recovery. J Sports Sci. 29 Suppl 1:S39-46.

Stachenfeld N. Assessing hydration in the laboratory and field. Sports Science Exchange (2013) Vol. 26, No. 111, 1-4.

Stover, E.A., Zachwieja, J., Stofan, J., Murray, R., & Horswill, C.A. (2006). Consistently high urine specific gravity in adolescent American football players and the impact of an acute drinking strategy. *International Journal of Sports Medicine, 27*(4), 330–335. PubMed doi:10.1055/s-2005-865667

Viitasalo, J.T., H. Kyröläinen, C. Bosco, M. Alen (1987) Effects of rapid weight reduction on force production and vertical jumping height. Int. J. Sports Med. 8(4):281-5.

Watson, G., D.A. Judelson, L.E. Armstrong, S.W. Yeargin, D.J. Casa, C.M. Maresh (2005) Influence of diuretic-induced dehydration on competitive sprint and power performance. Med. Sci. Sports Exerc. 37(7):1168-74.

Williams, C.A., J. Blackwell (2012) Hydration status, fluid intake, and electrolyte losses in youth soccer players. Int. J. Sports Physiol. Perform. 7, 367-374.

Wingo JE, Casa DJ, Berger EM, Dellis WO, Knight JC, McClung JM. Influence of a pre-exercise glycerol hydration beverage on performance and physiologic function during mountain-bike races in the heat. J *Athl Train,* 2004; 39: 169-175