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Water and electrolyte needs for football training and match-play

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Abstract

The high metabolic rates sustained by soccer players during training and match-play cause sweat to be produced in both warm and temperate environments. There is limited published information available on the effects of this sweat loss on performance in soccer. However, this limited information, together with knowledge of the effects of sweat loss in other sports with skill components as well as endurance and sprint components, suggests that the effects of sweating will be similar to the effects in these other activities. Therefore, the generalization that a body mass reduction equivalent to 2% should be the acceptable limit of sweat losses seems reasonable. This amount, or more, of sweat loss reflected in body mass loss is a common experience for some players. Sodium is the main electrolyte lost in sweat and the available data indicate considerable variability in sodium losses between players due to differences in sweating rate and sweat electrolyte concentration. Additionally, the extent of sodium loss is such that its replacement will be warranted for some of these players during training sessions and matches. Although soccer is a team sport, the great individual variability in sweat and electrolyte losses of players in the same training session or match dictates that individual monitoring to determine individual water and electrolyte requirements should be an essential part of a player's nutritional strategy.

Keywords: *Water balance, electrolyte balance, sweating, hydration, sodium*

Introduction

In the 1994 Consensus Conference held in Zurich, Maughan and Leiper (1994) reviewed "Fluid loss in soccer", providing information available from soccer players during both training and match-play. They then discussed issues relating to "Fluid and carbohydrate replacement". This discussion was largely from a non-soccer-specific point of view but did cover issues relating to "Fluid replacement for competition", "Fluid replacement in recovery from training and competition", and "Fluid loss and intake in training". The final focus of the review was to consider issues related to "Training and competition in the heat" and to provide "Practical recommendations".

In the 2005 Consensus Conference, the more extensive programme, with twelve rather than eight papers, means that this current update focuses only on the water and electrolyte needs for training and match-play. Data were collected for soccer players during training, match-play or during simulated soccer activity, and when possible only publications from 1994 onwards were used. Readers should consult Maughan and Leiper's (1994) review to gain relevant background information and should consider the paper of Armstrong (1996) on "Nutritional strategies for soccer" in this volume to be of particular relevance.

An in-depth discussion of the rationale and requirements for water and electrolyte intake before, during, and after exercise took place at the June 2003 International Olympic Committee Consensus Conference. The outcomes of the conference were published in the January 2004 edition of the *Journal of Sports Sciences*, with the papers by Coyle (2004) and Shirreffs *et al.* (2004) being especially relevant. Therefore, these topics will not be covered again here as there is no good evidence to suggest that the physiological or nutritional requirements of soccer players, with regard to their water and electrolyte requirements, differ significantly from those of other athletes.

This review focuses on the water and electrolyte needs of soccer players during training and

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match-play. Data for adult and adolescent male and female players are reviewed and recommendations are proposed. The recommendations can be used by players themselves, coaches, and clubs, or indeed by governing organizations when considering the rules and regulations of the game.

Water and electrolyte losses in soccer

Methods of assessing water loss

It is common practice to use changes in body mass as an index of body water content changes and thus of hydration status. Many publications providing advice to athletes from all types of sports contain statements along the lines that exercise performance is impaired when dehydration exceeds about 2% of the pre-exercise body mass, especially in warm environments. These statements are based on the assumption that 1 kg of mass loss is equal to 1 litre of sweat loss. Clearly, any fluid intake and urine or faecal loss needs to be accounted for and appropriate corrections made. The initial pre-exercise body mass should be obtained from early morning measurements established for several days before any glycogen loading procedures (if used for competition). Glycogen loading can cause water bonding and therefore modest hyperhydration. The dehydration level should be calculated as the reduction below the baseline body weight. The sweating rate should be calculated as the change in body weight (with appropriate corrections) during the training session, regardless if baseline or not.

Potential sources of error in using change in body mass to quantify sweat loss include loss of water and therefore mass from the respiratory tract and mass loss due to substrate oxidation. Although individually these losses may be small, their overall effects are of significance in many exercise contexts. The decision of whether to correct for substrate oxidation and respiratory water loss is usually based on the relative magnitude of the different avenues of mass loss, the precision required in the expression of the data, and the purpose for which it is being determined. Indeed, respiratory water loss and metabolic water produced are generally of similar magnitude and more or less cancel each other, minimizing the need for correction.

Methods of assessing electrolyte loss

The main routes of electrolyte loss from the human body are the urine, faeces, and sweat, although vomiting also result in significant losses. Large amounts of electrolytes are also temporarily secreted from the body into the gastrointestinal tract, but these are largely reabsorbed later in the system. It is sweat electrolyte losses that have the potential to set exercisers apart from non-exercisers and will therefore be the focus for consideration here.

A wide range of values for all of the major sweat electrolytes has been reported in the literature, reflecting variations between individuals, differences due to the experimental conditions, and differences due to the collection methods. The latter may be due to errors caused by contamination or to incomplete collection of the sample, or it may reflect a real difference induced by the collection site (e.g. arm vs. chest). The composition of sweat has been examined using a variety of sampling methods. The crudest method is simply to collect sweat as it drips from the skin surface, meaning there will have been a variable amount of evaporation from the skin surface, leading to an unknown degree of concentration of the sample and the possibility of contamination with skin cells. The two main methods that have been used in attempts to overcome these difficulties involve collection of sweat from a specific body region using some form of enclosing bag, capsule or absorptive patch, or a variation on the whole body-washdown technique. The enclosing bag approach can eliminate the problem of evaporation of water from the skin surface, but the method itself may lower the local sweat rate and thus alter electrolyte composition.

Sweat glands will reabsorb electrolytes (e.g. sodium) as the precursor fluid moves down the duct. The amount of electrolytes reabsorbed is dependent on sweat rate, such that at low sweat rates more sodium is reabsorbed so the secreted sweat sodium concentration is lowered. There also appear to be regional variations in sweat composition, as evidenced by the different values obtained when the composition of sweat obtained from different parts of the body is compared (Costa, Calloway, & Margen, 1969). In addition, regional sweat collection procedures provide higher sweat electrolyte concentrations than from the whole body-washdown technique (Lemon, Yarasheski, & Dolny, 1986; Patterson, Galloway, & Nimmo, 2000; Shirreffs & Maughan, 1997; Van Heyningen & Weiner, 1952). The higher electrolyte concentrations with local sweat collection procedures than whole-body washdown are probably due to an alteration in composition caused by the restriction of sweat evaporation. The difficulties caused by the restriction of evaporation can be overcome by using a ventilated capsule or chamber: the water in the effluent air is trapped in a cold trap, and the electrolytes are recovered at the end of the study period by washing out the enclosing apparatus. This does not, however, help to overcome the difficulties caused by regional differences in the composition of sweat.

A number of variations on the whole-body sweat collection method have been developed. In most of these, total sweat loss is calculated from the change in body mass. In early studies when participants exercised in a desert environment, it was assumed that there was no electrolyte loss from the skin surface due to sweat dripping, so the participants were washed before exercise, the body and the clothes worn were washed after exercise with distilled water, and the electrolyte content of that water was measured. Alternatively, thorough washing and drying of the individual, who then wears an absorbent suit to absorb sweat secreted onto the skin, has been reported. Forced convection has also been used to maximize sweat evaporation, or participants have worn minimal clothing and then been dried at regular intervals with towels that were then added to the washdown water. Enclosing participants within a close-fitting plastic bag and exposing them to a hot humid environment to stimulate sweating is a method that has been used in non-exercise settings. Finally, having participants exercise within a large plastic bag that forms a "small room" around them has been used successfully in laboratory studies (Shirreffs & Maughan, 1997).

Most published data for soccer players have been obtained using absorbent patches to collect sweat. While this is not a particularly difficult technique, clubs and players wanting to determine their sweat electrolyte losses are likely to need specialized help to do so (Burke, 2005). Besides providing approximate sweat electrolyte losses, this approach, at a minimum, identifies those athletes with electrolyte-rich ("salty") sweat and who need to pay particular attention to electrolyte replacement. When it is not possible to determine electrolyte losses in this way, it may be possible to identify subjectively players with very high salt losses. That is, they may complain of the very salty taste of sweat in their mouth, that they experience irritation when salt gets in their eyes, or salt stains may be visible on clothing worn during training or matches.

New data and developments in soccer research since 1994: Adult male players

In recent years, several papers have reported the results of "in-the-field" hydration monitoring, sweat collection, and subsequent estimation of sweat electrolyte losses in adult male professional soccer players (Maughan, Merson, Broad, & Shirreffs, 2004; Maughan, Shirreffs, Merson, & Horswill, 2005; Shirreffs *et al.*, 2005). In this section, the findings from players training with three European professional soccer clubs, all of which were competing in the highest league in their country, are summarized. This represents data from 67 players. Except where otherwise stated, the following methodology has been used to establish fluid and electrolyte losses and guidelines for the replacement. For a more detailed description of the methodologies used, the original papers should be consulted (Maughan *et al.*, 2004, 2005; Shirreffs *et al.*, 2005).

Data were collected during training sessions of approximately 90 min duration. With the exception of goalkeepers, all the players tested within each club completed very similar training sessions. Players were weighed nude or wearing only underpants before and after each training session. Between these two weighing periods, all urine excreted was collected and weighed and all drink consumed was accounted for by weighing drinks bottles. In the few instances when solid food was consumed, the appropriate correction was applied to the player's body mass. Sweat losses were estimated by correcting the change in body mass for drinks consumed and urine passed. After appropriate cleaning of the skin, four absorbent patches were applied to the right side of the player's body on the forearm, thigh, upper back, and chest ($n = 48$). These were removed during or at the end of the training session for subsequent analysis. Researchers attempted to make as few changes as possible to the normal training ground procedures at each club. This ensured that the data collected represented the player's normal behaviour as closely as possible. The environmental conditions in which the training sessions took place are shown in Table I.

Water balance

The average calculated sweat losses, fluid intake, and percent change in body mass for the players (Table II) are in agreement with those previously reported in the literature for adult males (Burke, 1997; Burke & Hawley, 1997; Maughan & Leiper, 1994). This

Table I. Temperature and relativity humidity at each of the three clubs during 90 min training sessions (mean ± *s*).

	Temperature (°C)	Relative humidity (%)
Club 1	5 ± 1	81 ± 6
Club 2	27 ± 2	55 ± 6
Club 3	32 ± 3	20 ± 5

Table II. Sweat loss, fluid intake, and percent change in body mass of players at each of the three soccer clubs during 90 min training sessions (mean ± *s*).

	Sweat loss (litres)	Fluid intake (ml)	% Decrease in body mass
Club 1 ($n = 17$)	1.7 ± 0.4	420 ± 220	1.6 ± 0.6
Club 2 ($n = 24$)	2.0 ± 0.4	970 ± 300	1.4 ± 0.5
Club 3 ($n = 26$)	2.2 ± 0.4	970 ± 340	1.6 ± 0.6
Overall ($n = 67$)	2.0 ± 0.4	830 ± 380	1.5 ± 0.5

translates into mean (± *s*) sweat losses and drinking rates of 1.3 ± 0.3 and 0.6 ± 0.3 l · h^{-1} respectively, with a significant relationship between the two ($r^2 = 0.13$, $P = 0.003$; Figure 1). However, these mean values detract from the considerable variation in both sweating response and drinking behaviour within the clubs. As shown in Table III, there is a substantial variation in responses and behaviour between players. This variation was not due to the difference in body size between players as illustrated in Figure 2, where there is no relationship between body mass and either sweat loss ($P = 0.160$) or volume of liquid consumed ($P = 0.770$). Therefore, factors such as activity rate (metabolic rate), heat acclimatization status, and genetic differences probably contribute to this large variability.

The percentage change in body mass was, on average, the same ($P = 0.426$) in the players training in the cool conditions (Club 1) and the temperate (Club 2) and warm (Club 3) conditions. In the cool environment, players sweated only slightly less than those in the temperate and warm environment (1.7 ± 0.4 vs. 2.1 ± 0.4 litres; $P = 0.002$), most likely because of the additional clothing they wore. However, they drank only about half the volume that was consumed by the players in the temperate and warm environments (420 ± 220 vs. 970 ± 320 ml; $P = 0.000$).

For 38 of the players, an estimate of pre-training hydration status was obtained by collecting a urine sample and determining its osmolality (Shirreffs & Maughan, 1998). Most of the players appeared to start training in a euhydrated state, with a urine osmolality less than 900 mOsmol · kg^{-1} (Figure 3). However, urine osmolality had no influence on the sweat losses that subsequently occurred during training, although in the players training in a cool environment, high urine osmolality tended to be associated with a greater volume of liquid consumed during training ($r^2 = 0.21$, $P = 0.062$).

Electrolyte balance

The main electrolyte lost in sweat is sodium, with chloride being present in slightly smaller amounts. The other electrolytes present (e.g. potassium, calcium, magnesium) are at vastly lower concentrations (Lentner, 1981; Shirreffs & Maughan, 1997). For the purpose of this review, only sodium is considered in detail.

The average sweat sodium concentration measured in players at each of the clubs is shown in

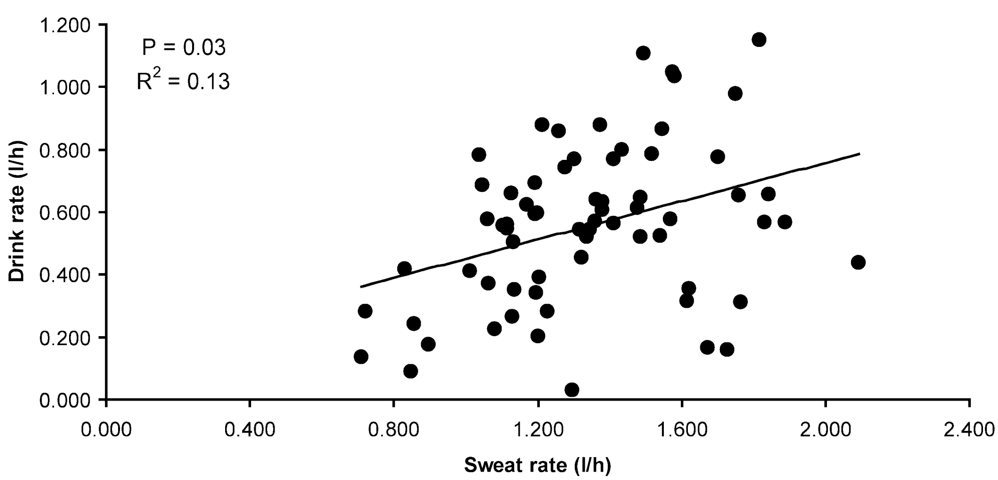
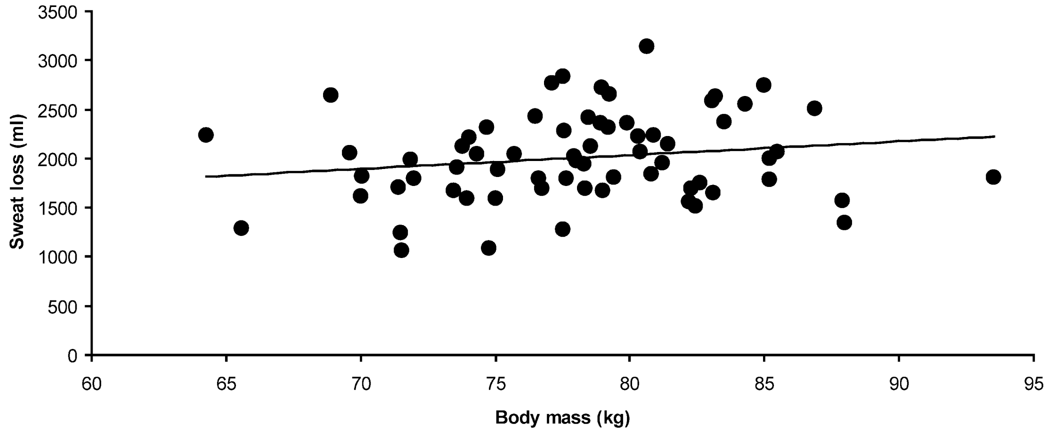


Figure 1. The significant relationship between sweat rate and drinking rate.

Table III. Minimum and maximum sweat loss, fluid intake, and percent change in body mass of players at each of the three soccer clubs during 90 min training sessions.

	Sweat loss (litres)		Fluid intake (ml)		% Decrease in body mass	
	min.	max.	min.	max.	min.	max.
Club 1 (*n* = 17)	1.1	2.6	40	950	0.9	2.8
Club 2 (*n* = 24)	1.3	2.8	270	1660	0.5	2.6
Club 3 (*n* = 26)	1.7	3.1	240	1720	0.7	3.2
Overall (*n* = 48)	1.1	3.1	40	1720	0.5	3.2



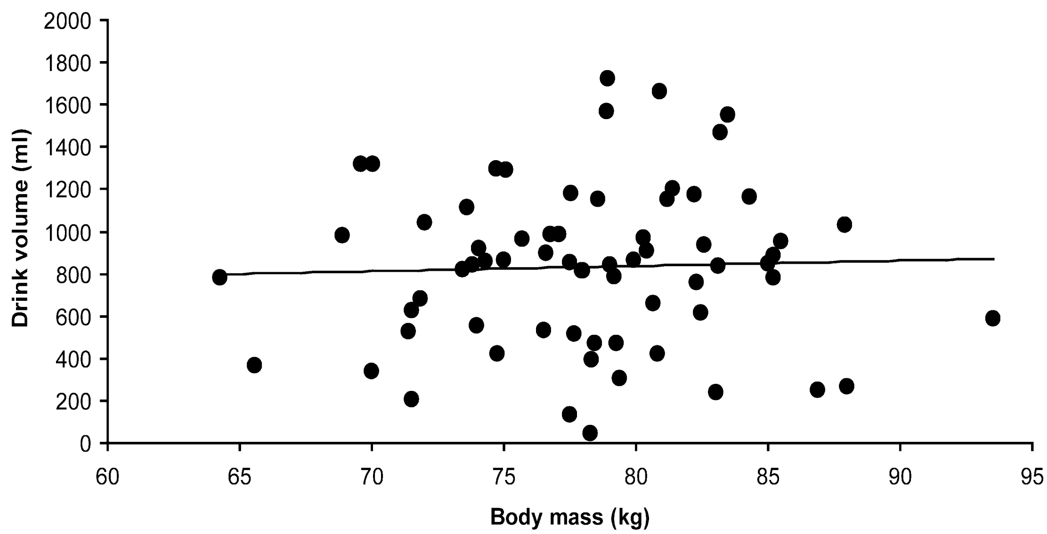


Figure 2. There is no relationship between body mass and either sweat loss (upper panel) or volume of liquid consumed (lower panel).

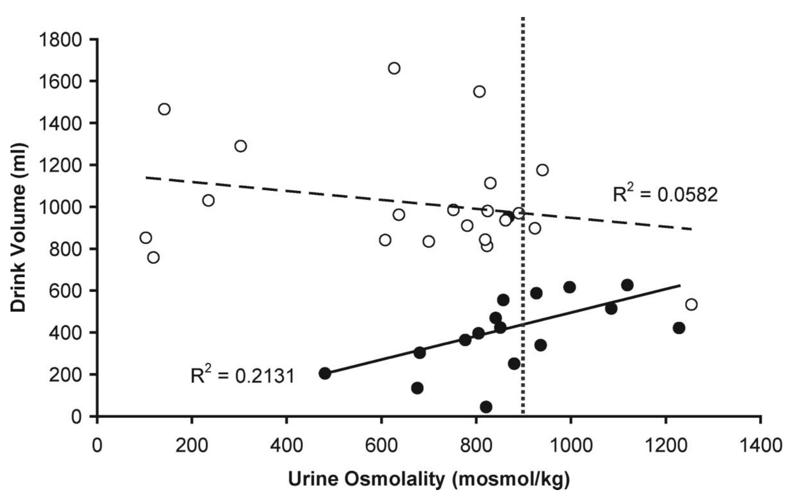


Figure 3. The relationship between pre-training osmolality and volume of liquid consumed during training. The vertical dotted line indicates an osmolality of 900 mOsmol · kg⁻; values above this line may indicate pre-training hypohydration (Shirreffs & Maughan, 1998). ●, data for players at Club 1; ○, data for players training in a warm environment.

Table IV and did not differ from the normal range reported in the literature. The mean values are similar to those expected for a heat-acclimatized athlete. However, the mean values detract from the considerable variation in sweat sodium concentration and sodium losses between players. As shown in Table V, some players lose about five times as much sodium as others.

It is important to remember that these data have been determined from localized collection of sweat from four sites on the body. From the limited evidence available, this procedure may lead to an overestimation of whole-body sweat sodium losses by approximately 30 – 40 % (Patterson *et al.*, 2000; Shirreffs & Maughan, 1997). If this is the case, the actual sweat sodium concentrations and losses and estimated salt losses would be more closely represented by the data shown in Table VI, which employs a 35% reduction of local values as a correction to represent whole-body losses.

New data and developments in soccer research since 1994: Adolescent players

There are limited published data on water and electrolyte losses in adolescent players. Broad, Burke, Cox, Heeley and Riley (1996) examined the sweat volume losses and drinking practices of thirty-two 16- to 18-year-old male players. However, this study did allow comparisons to be made between training and competitive games, or between cool winter (9 – 10°C) and warmer summer (25°C) conditions. The mean sweat rates (winter: $0.7 \pm 0.3 1 \cdot h^{-1}$ in training, $1.0 \pm 0.3 1 \cdot h^{-1}$ in a match; summer: $1.0 \pm 0.3 1 \cdot h^{-1}$ in training, $1.2 \pm 0.3 1 \cdot h^{-1}$ in a match) and drinking rates (winter: $0.3 \pm 0.3 1 \cdot h^{-1}$ in training, $0.4 \pm 0.2 1 \cdot h^{-1}$ in a match; summer: $0.4 \pm 0.3 1 \cdot h^{-1}$ in training, $0.5 \pm 0.3 1 \cdot h^{-1}$ in a match) of the players were, on average, slightly lower than those of the adult male players described above.

Mao, Chen and Ko (2001) were concerned with a possible relationship between profuse sweating, sweat iodine losses, and iodine deficiency. They studied thirteen 16- to 18-year-old male players to determine their sweat volume losses during training sessions by monitoring changes in body mass, and also collected sweat samples from the players' chest and back. They reported mean sweat sodium concentrations of $55 \pm 27\,\text{mmol} \cdot l^{-1}$, with sweat volume losses averaging 1.54 ± 0.57 litres over a one-hour training match. The authors noted that one player lost an estimated 5.9 g of salt during this period.

Based on the results of these two studies, it would appear that 16- to 18-year-old male soccer players do not differ significantly from adult male players in terms of their sweat volume and sodium losses during training sessions.

Table IV. Sweat sodium concentration and calculated sodium and "salt" (sodium chloride)* losses at each of the three soccer clubs during 90 min training sessions (mean ± *s*).

	Sweat sodium concentration ($\text{mmol} \cdot l^{-1}$)	Sweat sodium loss (mmol)	"Salt" loss (g)
Club 1 (*n* = 17)	43 ± 13	73 ± 31	4. 3± 1.8
Club 2 (*n* = 24)	49 ± 12	99 ± 24	5.8 ± 1.4
Club 3 (*n* = 7)	30 ± 19	67 ± 37	3.9 ± 2.2
Overall (*n* = 48)	44 ± 15	85 ± 32	5.0 ± 1.8

*"Salt" loss is estimated sodium chloride loss based on the assumption that all sodium is lost as sodium chloride.

New data and developments in soccer research since 1994: Female players

Broad *et al.* (1996) examined the sweat losses and drinking practices of female soccer players using similar methods to those used for the adolescent male players described above. Although the environmental conditions were slightly warmer (25 – 30°C), the sweat rates ($0.8 \pm 0.2 1 \cdot h^{-1}$ in training, $0.8 \pm 0.2 1 \cdot h^{-1}$ in a match) and drinking rates ($0.4 \pm 0.2 1 \cdot h^{-1}$ in training, $0.4 \pm 0.2 1 \cdot h^{-1}$ in a match) tended to be lower. These rates are in general agreement with comparisons showing lower sweat

Table V. Minimum and maximum sweat sodium concentration and calculated sodium and salt losses at each of the three soccer clubs during 90 min training sessions.

	Sweat sodium concentration ($\text{mmol} \cdot l^{-1}$)		Sweat sodium loss (mmol)		"Salt" loss (g)	
	min.	max.	min.	max.	min.	max.
Club 1 (*n* = 17)	16	66	29	121	1.7	7.0
Club 2 (*n* = 24)	26	67	53	133	3.1	7.8
Club 3 (*n* = 7)	16	66	26	129	1.5	7.6
Overall (*n* = 48)	16	67	26	133	1.5	7.8

Table VI. Minimum and maximum sweat sodium concentration and calculated sodium and salt losses, corrected for the possible 35% overestimation of losses due to the method used at each of the three soccer clubs during 90 min training sessions.

	Sweat sodium concentration ($mmol \cdot l^{-1}$)		Sweat sodium loss (mmol)		"Salt" loss (g)	
	min.	max.	min.	max.	Min.	max.
Club 1 ($n = 17$)	10	43	19	79	1.1	4.5
Club 2 ($n = 24$)	17	44	34	86	2.1	5.1
Club 3 ($n = 7$)	10	43	17	84	1.0	4.9
Overall ($n = 48$)	10	44	17	86	1.0	5.1

rates in women than men across most activities for which data are available (Burke & Hawley, 1997).

To our knowledge, there are no published data on the electrolyte losses of female players during either training or matches. However, unpublished observations of both under-21 England women players ($n = 14$) during training and senior England women internationals ($n = 25$) during a friendly match concur with Broad *et al.* (1996) that sweat rates and therefore volume losses tend to be lower than for their male counterparts. Additionally, the sweat sodium losses of these players were less than those of their male counterparts, but were due solely to smaller volume losses: the sodium concentrations were similar ($44 \pm 18\, mmol \cdot l^{-1}$; mean $\pm$ *s*).

Current practice and practical recommendations

From observations of training sessions and matches at different soccer clubs and discussion with staff and players with different clubs, the impression obtained is that the water and electrolyte requirements of players receive minimal attention. Many clubs have sponsorship agreements with drinks manufacturers, which may limit the range of drinks (sports drinks, soft drinks, and even water) that are available to players either at training or in matches. Furthermore, many players will find different drinks being available to them when they are playing for their club and when they are playing for their country. These different drinks are sometimes not to the liking of players.

Water requirements

There are limited data on the effects of a body water deficit on performance in soccer (McGregor, Nicholas, Lakomy, & Williams, 1999), and there is no information on elite players. From the limited information available, it would appear that there is little likelihood that any negative effects of dehydration on soccer performance would be different from those in other intermittent-activity sports or endurance sports, and indeed there is no reason why this should be so. That is, it is unlikely that any negative effects would be seen until hypohydration reaches a level equivalent to a 2% loss of body mass (Cheuvront, Carter, & Sawka, 2003), and perhaps even greater losses could be tolerated in cool environments (Cheuvront, Carter, Castellani, & Sawka, 2005).

From estimated sweat volume losses, it is apparent that although many players (39 of the 48 adult male players described above) match their drinking sufficiently closely to their sweat losses to restrict their body mass losses to less than 2% of their pre-exercise mass, individual monitoring of players – even in the same training session – is necessary if these guidelines are to be followed correctly. However, the type of intermittent activity during soccer games and training has been shown to slow the rate of gastric emptying of carbohydrate-electrolyte sports drinks (Leiper, Prentice, Wrightson, & Maughan, 2001), raising the possibility that feelings of stomach fullness may limit the volumes players can comfortably consume. Some further practical recommendations are provided in Table VII. It should be noted that no data have been collected in hot weather ($> 35°C$) when sweat losses are likely to be highest. Athletes participating in hot weather competition should not only pay additional attention to drinking, but should undertake a formal heat acclimatization programme (Montain, Maughan, & Sawka, 1996). Heat acclimatization will improve fluid consumption to help match fluid loss requirements.

Electrolyte requirements

Available evidence indicates substantial variation in sweat sodium losses during soccer training. Most players (43 of the 48 adult players, 12 of the 13 male adolescent players, and 36 of the 39 female players described above) had sodium losses of less than 3–4 g during a training session or match, so replacement would not be essential during the training session (Coyle, 2004). For the remaining few players, some consideration must be given to consuming drinks containing sodium during training

Table VII. Some practical recommendations to establish water and electrolyte needs in soccer, and some practical recommendations regarding water and electrolyte consumption.

Monitoring fluid/electrolyte status in players

- Treat each player is as an individual.
- Measure body mass changes during training and matches as a player-education tool.
- Educate players on their likely individual sweat losses during training and matches.
- Identify salty sweaters (taste, eye irritation, salt stains on clothing) to identify possible problem players.
- If feasible, monitor each player individually (in varying environmental conditions) in training and in match-play to assess water and electrolyte losses.

Water and electrolyte intake

- To ensure adequate hydration during training or matches, drink approximately 500 ml or the equivalent of 6 – 8 ml per kilogram of body mass (e.g. water, sports drink, or other soft drink) 2 h before the start. Water required by the body will be retained and the excess will be excreted as urine over the 2 h period.
- Consume plain water at this time only if some solid food is consumed with it; this will provide electrolytes and in particular sodium to retain the consumed water.
- When appropriate, ensure each player has suitable drinks available during training and matches.
- During training and matches, limit body mass loss (due to sweat loss) to about 2% of body mass.
- When drinking is deemed necessary, choose a drink with a composition that has a minimal slowing effect on gastric emptying rate.
- During training and matches, consume a drink containing some sodium if significant amounts (3 – 4 g) are likely to be lost.
- When the environmental conditions are such that large sweat losses are likely in some or most players, consider specific drink break opportunities for all players during each half of the match.
- Between periods provide small salted snacked (e.g. pretzels, crackers) with beverages.

sessions and matches. Consumption of sports drinks will help to maintain serum sodium concentrations during periods of high sweat losses (Montain, Cheuvront, & Sawka, 2006).

It is clear that high salt losses are a factor in the aetiology of muscle cramps and heat illness in industrial settings and that these can be alleviated by the ingestion of salt-containing drinks (Brockbank, 1929; Oswald, 1925), but it is less clear whether this applies to the generally smaller losses that occur in the sporting environment. There is some limited evidence that American Football players who have high sweat sodium concentrations may be especially susceptible to muscle cramps (Stofan *et al.*, 2003). Bergeron (1996, 2003) has also published reports and case studies suggesting that failure to replace sweat salt losses predisposes to muscle cramps in tennis and that these can be prevented by ensuring an adequate salt intake. Symptomatic hyponatraemia (low serum sodium) has not been reported in soccer players.

Conclusions

Based on knowledge of the effects of water and electrolyte losses on athletes undertaking other forms of activity and sport, it is prudent to recommend that soccer players consider the benefits of limiting their body mass reduction due to water loss during both training sessions and matches to less that about 2%. Body water deficits equivalent to less than 2% of body mass have been clearly associated with reduced aerobic exercise performance. However, the activity pattern in soccer may make this recommendation difficult for players in some circumstances, in which case careful consideration must be given to providing drinks that are palatable and to encouraging drinking.

During matches and training sessions, some players will lose considerable quantities of electrolytes – particularly sodium – and may need to replace these during the match or training session. If sodium-containing beverages do not suffice, athletes may want to consume small amounts of salted snacks between periods to replace salt losses and stimulate drinking.

Finally, the inter-individual variation between players in the same team taking part in the same training session or match is so great that players must be treated as individuals with regard to their water and electrolyte needs.

Disclaimer

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