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CREATINE, CARBS, AND FLUIDS: HOW IMPORTANT IN SOCCER NUTRITION?

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KEY POINTS

- Because so much of the running in soccer is at less than maximal sprinting speed, creatine supplementation likely provides no benefit to match performance.
- Overwhelming evidence proves that a diet rich in carbohydrates can fill muscles with glycogen, and glycogen is critical to optimal performance in soccer.
- Soccer players' diets, especially in the days before hard training or competition, should include 8-10 grams of carbohydrate per kilogram of body weight (3.5-4.5 g/lb). Cereals, fruits, vegetables, breads, and pastas are good sources of carbohydrates.
- Refueling of muscle with carbohydrates should begin as soon as possible following a match or a strenuous training session.
- Inadequate replacement of fluids lost in sweat can lead to poor soccer performance and heat illness. Players should aim to drink enough during training sessions and matches so that their body weights after play are within about 1 kg (2.2 lb) of their starting weights.
- For a light workout or an easy match, especially when the weather is cool, water can be an adequate fluid replacement, if enough is ingested. But when play is strenuous and the weather is hot, carbohydrate-electrolyte sports drinks do a better job of maintaining body fluids.

INTRODUCTION

As with most sports, nutrition can have a major impact on performance in soccer. The focus in this review will be on nutritional items—creatine, carbohydrate foods, and fluid replacement drinks— for which there is substantial research literature related to performance in actual soccer play or to performance in tests designed to mimic skills required in soccer. As with any sport, it is extremely difficult to determine the effects of nutritional manipulations on performance in actual soccer matches. Variability in opponents, weather, field characteristics, game strategies, individual playing time, injuries, and penalty time makes detection of potentially small but important effects of nutrition very problematic. Therefore, there are relatively few reported studies of actual soccer performance; extrapolation of results from other types of research to match play must be done with caution.

RESEARCH REVIEW

The Nature of the Game

In 1976, Reilly and Thomas published time-motion information on English professionals from the Everton Football Club and determined that players ran just over 8500 m in a match. They estimated these distances with notes written or dictated by trained observers and with videotape analysis (a very tedious endeavor). About 2/3 of the 8500- m distance was at the lower intensities of walking and jogging, around 800 m at sprint speeds, and the remaining at what the authors defined as a cruise ("running with manifest purpose and effort" - faster than a jog, but slower than a sprint). Reilly and Thomas pointed out that there were 800-1000 distinct changes of movement speed or direction, one occurring every 5-6 s.

Withers et al. (1982) and others have replicated and expanded on the work of Reilly and Thomas. Current estimates, based on videotapes as well as global-positioning satellite technology, indicate that the running distance for men is about 10,000 m (Bangsbo, 1994a,1994b; Bangsbo et al., 1991) and for women is around 8500 m (unpublished observations).

Depending on the level of play and the activity involved, soccer practice and competition can be largely aerobic (for the lowerintensity activities of walking and jogging, especially during recovery from high-intensity runs) or more anaerobic (for the higher-intensity activities of cruising, sprinting, dribbling, jumping, tackling, and shooting). Interestingly, dribbling increases energy demand by about 15%; (Reilly & Ball, 1984). Nearly all aspects of fitness, especially agility, are required in soccer play.

Another aspect of soccer that can make nutrition a challenge is the scheduling of matches. In soccer, a high-school team might play five matches in a two-week period because governing organizations limit the length of the season. In addition, there may be tournaments in which multiple abbreviated games are played in 2-3 days. This means that many games are scheduled with minimal time for recovery.

CREATINE SUPPLEMENTATION

There are no published scientific reports of the effects of creatine supplementation on soccer performance during an actual match, but several articles have reported creatine effects on soccer-related performance tests. In a study of 18 college-age men and women, most of whom were either field hockey or soccer players, Redondo et al. (1996) did not detect any effects of 7 days of creatine loading on performance of three repeated 60-m sprints, each sprint separated by a 2-min rest period. It could be argued that this study is not directly applicable to soccer match play because it would be unlikely that a player would sprint maximally for 60 m, rest for 2 min, and then repeat the sprint.

Using a similar study design, Mujika et al. (2000) recruited 17 highlytrained, college-age, male soccer players to study creatine effects on six maximal 15-m sprints with running starts, each sprint separated by 30 s of recovery. After 8 min of recovery from the series of sprints, the subjects attempted to cover as much distance as possible in a 16.5-min test of intermittent running for 15 s at high intensity and 10 s at low intensity while moving alternately forward, backward, and sideways in a circuit around a soccer penalty area. Before and after these two running tests, the subjects performed maximal vertical jumps designed to partially mimic heading skills in soccer. All 17 subjects performed the tests twice, once before supplementation and once following 6 days of creatine supplementation (n = 8) or placebo (n = 9). Comparing pretest to posttest results within groups, more players in the creatine group improved maximal sprint times than did those in the placebo group. Unfortunately, the authors reported only the statistical analyses of the within-group data and not an analysis of the overall effects of creatine versus placebo, which presumably would have detected no effect of creatine supplementation on sprint times. Moreover, no pretest-posttest creatine effects were found for the intermittent running test or for the vertical jumps.

Twelve members of the Australian Women’s National Soccer Team participated in a study of creatine effects on various soccer-like performance tests, including repeated maximal 20-m sprints from a standing start, agility runs (forward, backward, sideways), and kicking a rolling ball into a target in a soccer goal (Cox et al., 2002). Following baseline testing, six of the women underwent 6 days of supplementation with either creatine or placebo, and final testing was performed on the seventh day. The creatine group improved in 9 of 55 maximal sprints, whereas the placebo group improved in two sprints. The creatine group improved in 3 of 10 agility runs and the placebo group in 1 of 10, but the average times for all 10 runs were not improved in either group. Ballkicking precision was also unaffected by supplementation. Once again, only pretest-posttest results within each group were reported; no overall comparisons of creatine versus placebo were reported, and it is doubtful that such an analysis would have detected any benefits of creatine supplementation on any variable measured.

Finally, creatine supplementation was tested in 14-19 year-old male soccer players from the 1st Yugoslav Junior League (Ostojic, 2004). Before and after 7 days of supplementation with either creatine or placebo, 10 players in each group performed a timed soccer-dribbling test around cones set 3 m apart, a sprint-power test that lasted about 3 s, a vertical-jump test, and a shuttle endurance run that lasted about 11 min. In contrast to the two previously cited studies of soccer skills, the authors correctly reported overall effects of creatine versus placebo, not simply pretest-posttest results within groups. The creatine group was significantly better than placebo for the dribbling test, the sprint test, and the vertical jump. Not surprisingly, creatine had no effect on the shuttlerun endurance test. A drawback of this report is that no test-retest reliability data were provided. Knowledge of test reliability is especially important because the creatine group made such dramatic improvements—2.8 s better than the initial score of 13 s in the dribbling test, 0.5 s better than the initial 2.7 s in the sprint test, and 5.9 cm better than the initial 49.2 cm in the vertical jump. It seems unlikely that such extreme results are reproducible.

In summary, there is no persuasive evidence that creatine supplementation has any beneficial effects on soccer play. Even assuming complete validity of the few positive results in the above reports of creatine supplementation, one must be cautious in extrapolating the results of “soccer-like” performance tests to performance in an actual soccer match, when players will cover up to 1000 m in sprints of 10-30 m, most of which are spaced every 60-90 s over 90 min and separated by various distances of lower-speed running (Reilly & Thomas, 1976). Moreover, soccer players rarely ‘sprint’ as one might imagine in a 100-m event in track and field. Soccer players usually must achieve a speed that will allow them to control the ball; they rarely, if ever, reach top speed given the limited distance of a sprint in soccer. Thus, it seems unlikely that creatine supplementation could play anything other than a very minor role in soccer nutrition; the focus should be on food and water.

Dietary Carbohydrate and Soccer Performance

By the late 1960’s and early 1970’s, the fundamental role of carbohydrate metabolism in athletic performance had been established, and the literature of this time focused on glycogen depletion and repletion (Bergstrom et al., 1967). In particular, it was known that exhaustive exercise to deplete glycogen followed by light exercise and a high-carbohydrate diet for several days (“carbohydrate loading”) could dramatically increase muscle glycogen stores (“glycogen supercompensation”) (Bergstrom & Hultman, 1972). However, even though soccer is the most popular sport in the world, few studies on soccer nutrition were forthcoming. In one such investigation, Agnevik (1970) took biopsy samples from eight players to examine glycogen depletion and showed some interesting findings (Figure 1). First, the muscles of players were nearly emptied of glycogen after a match. Second, the greatest amount of glycogen depletion occurred in the first half of the match. This correlated well with the results of Reilly and Thomas (1976), who demonstrated that players ran less in the second half than in the first half, presumably because they were running out of fuel. During the second half, players were probably playing at glycogen levels consistent with volitional exhaustion (Bergstrom et al., 1967). (Interestingly, injury surveys in U.S. youth soccer and the English Football Association showed that nearly 25% of all injuries occur in the last 15-20 min of a game (Hawkins et al., 2001)). But Agnevik's data showed a third point often missed in the discussion of nutrition and soccer. The initial level of muscle glycogen in the players at the start of the game was unimpressive—minimally different from that of an untrained person—and this was at a time when the effects of glycogen supercompensation were under intense scrutiny and when we already knew that training and nutritional intervention could lead to elevated pre-exercise levels of glycogen (Bergstrom et al., 1967). Obviously, these soccer players weren't getting the message about the importance of dietary carbohydrates.

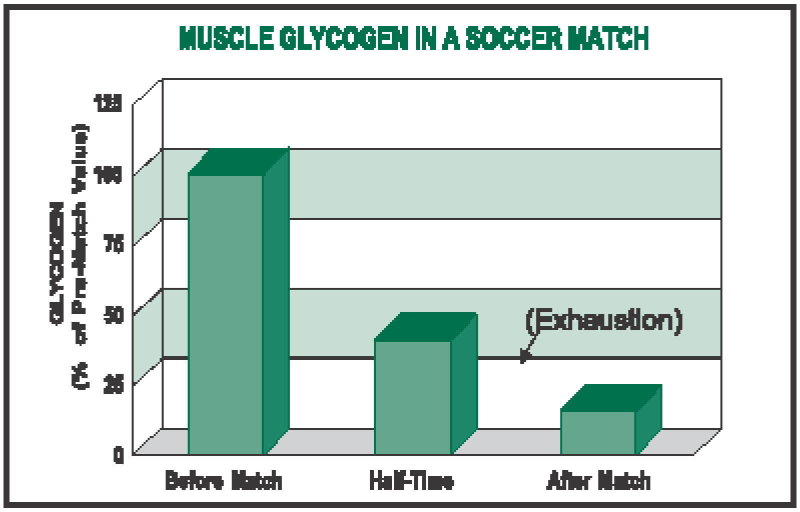

FIGURE 1. Effect of match play in soccer on stores of glycogen in leg muscles. Modified from Agnevik (1970).

High-Carbohydrate Diets in the Days Before and After Soccer Training and Competition

Costill et al. (1971) demonstrated the need for a high-carbohydrate diet in endurance athletes when they showed that during successive days of run training, the typical athlete's diet containing about 40% of energy (calories) as carbohydrate could not totally replenish muscle glycogen in 24 hours, whereas a 70% carbohydrate diet could. Anecdotally, most soccer injuries seem to occur late in the week during preseason training camps as players presumably become fatigued from the progressive daily reduction in muscle glycogen. Costill's group also demonstrated that a 24-hour intake of carbohydrate in a typical runner should total about 600 g (20 oz) or 7-10 g/kg body weight to maximize muscle glycogen storage after exhaustive running (Figure 2) (Costill et al., 1981; Sherman & Costill, 1984). Later, Ivy et al. (1988) found that glycogen repletion occurred at an accelerated rate when carbohydrate feedings commenced immediately after exhaustive exercise compared to the rate when carbohydrate intake was delayed until the beginning of the third hour of recovery. Thus, athletes should begin consuming carbohydrate-rich foods and beverages immediately after exhaustive training or competition to optimize glycogen replenishment. The importance of post-match refueling in preparation for the next match cannot be stressed enough. The team that neglects to refuel in the hour or two after a match will likely end up losing the next one.

In a practical test of a single day of carbohydrate loading before competition, Saltin (1973) described a very interesting project on the effects of pre-match glycogen levels and eventual performance in a soccer match. Half the players trained hard the day prior to the match while the other half trained little. This second group was given a high-carbohydrate diet during the last day to elevate their muscle glycogen levels. Pre-match biopsies showed that the first group had substantially less glycogen at kickoff. Game films were used to track the players during segments of each half. As expected, the highcarbohydrate group ran farther than the other group. But, importantly from a coaching and tactical viewpoint, in the second half, the control group covered 50% of their distance at a walk; hardly an intensity consistent with success in a game where late-game goals can determine the outcome.

Balsom et al. (1999) asked soccer players to play two 90-min matches (four players on each team), once after following a 30% carbohydrate diet and once after a 65% carbohydrate diet. As in the Saltin (1973) study, when the players consumed the high-carbohydrate diet they were able to perform 33% more high-intensity running in the soccer match.

In a study of diets that might optimize recovery from exhaustive intermittent running designed to mimic running in a soccer match, Nicholas et al. (1997) required subjects to complete 70-min of intermittent sprinting, running, and walking followed by a test of intermittent sprinting and running to exhaustion that lasted about 15- min. During 22 hours of recovery from this initial exercise trial, the subjects consumed either a normal-carbohydrate diet (5.4 g/kg body weight) or a high-carbohydrate diet (10 g/kg) before repeating the exercise trial. The high-carbohydrate diet allowed the subjects to improve their intermittent running times by 3.3 min, nearly 20%. As exemplified by the studies cited above, there is ample evidence that increasing the consumption of dietary carbohydrate can enhance performance of endurance activities, including team sports like soccer that involve intermittent running at various intensities. However, with few exceptions (Rico-Sanz et al., 1998), many soccer players—males and females, at all levels of competition—continue to consume too little carbohydrate in their diets (Brewer, 1994; Clark et al., 2003; Jacobs et al., 1982; LeBlanc et al., 2002; Kirkendall, 1993; Maughan, 1997).

Carbohydrate Drinks Before and During Soccer Matches

Research publications in the middle 1970's continued to document the facts that carbohydrate is the fuel of choice for high-intensity activities, that fats are used mainly during lower-intensity exercise, that carbohydrate stores in the body are limited, and that as glycogen is depleted, running intensity is reduced. About this time, the use of drinks containing glucose or maltodextrins (glucose polymers) as a carbohydrate source became popular. David Muckle, an athletic trainer (physiotherapist) for an English professional team supplemented his players' 24-hour high-carbohydrate diets with a 46% concentrated glucose syrup 30 min before each of 20 soccer matches and then gave no supplements for the next 20 games. He tracked some tactical features of their play such as shots on goal, goals for and against, and touches on the ball (Muckle, 1973). In the 20 matches with the carbohydrate supplement, his team scored more goals and conceded fewer in the last half compared to the 20 matches when the team was without carbohydrate. Moreover, under the carbohydrate condition, the team had more touches on the ball and more shots on goal—especially in the last 1/3 of the game. Unfortunately, the diet for the team when undergoing the "no supplement" condition was not reported, so differences in carbohydrate content of the diets and not the glucose syrup may have been responsible for the differences in performance. Still, the pattern of success after the carbohydrate feeding seems clear.

Leatt and Jacobs (1989) compared placebo versus carbohydrate drinks in 10 soccer players, five per group. Players who drank 500 ml (16.9 oz) of a 7% glucose polymer solution 10 min before the start of a match and again during intermission were able to run farther with a reduced depletion of glycogen from their vastus lateralis muscles during the match and store more glycogen following the match.

My colleagues and I (Kirkendall et al., 1988) gave 400 ml (13.5 oz) of a 23% glucose-polymer drink or placebo before and at half-time of outdoor matches and showed that the carbohydrate supplement increased overall running distance by 20%, with an incredible 40% increase in distance run at speed (cruise and sprint) during the second half. Most players in our experiment could perceive a difference in performance between drinks.

Ostojic and Mazic (2002) investigated the effects of a placebo compared to a carbohydrate-electrolyte beverage on performance of four "soccer-specific" tests completed immediately following a 90- min soccer match with two matched teams from the First Yugoslav National League. The experimental beverage contained an unspecified type of carbohydrate at a concentration of 7% plus sodium-chloride and potassium, and the players drank 5 ml/kg body weight immediately before the match and 2 ml/kg every 15 min thereafter during the match. The team using the carbohydrateelectrolyte drink scored better than their placebo-drinking counterparts on the soccer-dribbling test and the "precision" test, but there were no differences in sprinting power or "coordination" test results. Interpretation of the results of this study is clouded by the assignment of different teams to the two drinks without having each team tested under both placebo and experimental drink conditions.

In a study reported by Nicholas et al. (1995), nine soccer players completed two trials of an intermittent running test, once with placebo and once with a 6.9% carbohydrate beverage. The trials were separated by at least 7 days. The subjects completed five 15-min periods of standardized intermittent sprinting, running, and walking, followed by a performance test—intermittent running at a standardized tempo to exhaustion. The beverages were consumed immediately before the beginning of exercise (5 ml/kg body weight) and every 15 min thereafter (2 ml/kg). Each player consumed a total volume of about 1167 ml (39 oz) in each trial. When players consumed the carbohydrate beverage, they were able to continue running 33% longer (8.9 versus 6.7 min) during the performance test than when they consumed the placebo drink. In

one of the few studies to include tests of mental performance, Welsh et al. (2002) recruited five men and five women who were competitive soccer or basketball players to participate in three practice and two experimental trials, each consisting of four 15- min periods of intermittent running, walking, sprinting and jumping. A 20-min rest period separated the second and third periods. In the first experimental trial, half the subjects ingested a carbohydrate-electrolyte solution, whereas the other subjects drank a placebo; in the second trial, the treatments were reversed. The carbohydrate drinks included a 6% carbohydrate solution (5 ml/kg immediately before and 3 ml/kg after each 15-min period) and an 18% carbohydrate beverage (5 ml/kg during halftime). Tests performed during the 15-min periods included shuttle runs to fatigue, 20-m maximal sprints, repeated vertical jumps, a wholebody motor-skill test, a profile of mood states, and a mental acuity test. Carbohydrate ingestion caused a 37% improvement in run time to fatigue, a faster 20-m sprint time during the final 15-min period, improved motor skills near the end of exercise, and lesser perceptions of fatigue as measured in the profile of mood states.

In contrast to the positive results cited above, Zeederberg et al. (1996), who fed maltodextrins before a soccer match and at half time, unexpectedly found that the carbohydrate ingestion did not improve heading, dribbling, or shooting ability and actually worsened tackling ability. How carbohydrate ingestion could decrease tackling ability in a soccer match is mystifying.

The Bottom Line on Carbohydrates for Soccer: Players Are Not Getting Enough

Practically every year for the past 20 years, there have been presentations at the annual meeting of the American College of Sports Medicine describing the poor dietary habits, poor food choices, and inadequate carbohydrate intake of soccer players. Some of the elite clubs of the world—Manchester United, Juventus, Arsenal, Real Madrid, Bayern Munich, Ajax Amsterdam, Sao Paulo, and others in the same class of performance (and wealth) ensure that their multi-million-dollar players are well fed and cared for, but other teams, even teams in the same leagues, pay little or no attention to nutrition. Usually, it isn't until a player makes it to one of the elite clubs that he is given any real guidance about nutrition. A national team nutritionist of a 1994 World Cup country told me that half their starting players felt that what they put in their mouths had no impact on performance. So what we see happening on the field, from high school to the professionals, is that either the carbohydrate message is not getting to the players or the players are ignoring the message. Endurance athletes in individual sports like running and cycling absorbed the message right away, but many athletes in team sports, including soccer, ice hockey, basketball, field hockey, and lacrosse, still have not adopted the appropriate dietary concepts and practices.

Fluid Requirements for Soccer Players A loss of as little as 2% of body weight, e.g., 1.4 kg (3.1 lb) in a 70 kg (154 lb) athlete, caused by failure to replace sweat losses during exercise can cause deterioration of continuous (Armstrong et al., 1985) and intermittent running (Maxwell et al., 1999) and can worsen the performance of soccer skills (McGregor et al., 1999). Unfortunately, most athletes do not drink enough during exercise to replace those fluid losses (Burke, 1997). Depending on the climatic conditions and the intensity of the match, sweat losses among individual soccer players can range from less than 1 L (~1 qt) to as much as 4 L (4.2 qt), and various studies have reported that on average, players replace anywhere from 0% to 87% of that sweat loss during the match (Burke, 1997; Maughan et al., 2004).

To test the importance of hydration on the performance of highintensity shuttle running, speed of dribbling a soccer ball around cones, and performance on a test of mental concentration, McGregor et al. (1999) recruited nine semi-professional soccer players to participate in two 90-min exercise trials, one without fluids and one with flavored water (5 ml/kg body weight immediately before the trial and 2 ml/kg every 15 min thereafter). Performance on the dribbling test deteriorated in the no-fluid condition but remained stable when the players drank water, but mental concentration was not affected. Also, in the no-fluid condition, the players' heart rates were higher, and they perceived the exercise trial to be harder. These adverse effects occurred with a sweat loss of less than 2.4% of body weight.

Many people believe that providing adequate fluids to a soccer player during a match is an impossible challenge because the game consists of 90 min of non-stop running. The reality is that the ball is in play for only 60-70 min (Kirkendall, 1985; Reilly & Thomas 1976; Withers et al., 1982). There is plenty of time in soccer for drinking, such as when the ball goes out of bounds, is kicked over the goal, after a goal is scored, and during an injury stoppage. The wise team will place well-marked, cooled containers of beverages for the individual players about every 15-20 m along the sideline and in each goal. The biggest challenge is providing fluids to the player(s) who are in the middle of the midfield positions, i.e., those farthest from the sidelines and the goal where water can be placed.

Water or Sports Drinks? Water is better than nothing and is often appropriate for training or competition in cool weather when the intensity of play is light to moderate. However, as discussed earlier in the section on carbohydrate feedings during exercise, for intense training or competition, carbohydrate-electrolyte drinks, i.e., "sports drinks," have been proven to be superior in the majority of soccer-related studies (Leatt & Jacobs, 1988, 1989; Nicholas et al., 1995; Ostojic & Mazic, 2002; Welsh et al., 2002). There are several reasons why sports drinks are usually superior to water for rehydration during exercise. These drinks contain sodium-chloride (table salt) and carbohydrates such as sucrose and glucose. Compared to water alone, more water is taken up faster from the intestine into the blood when the salt and carbohydrates are in the intestine (Greenleaf et al., 1988; Shi et al., 1995). The carbohydrates, of course, can supply extra energy, especially in the late stages of a match. Also, some soccer players lose large amounts of salt in their sweat (Maughan et al., 2004), and that salt must be replaced if hydration is to be maintained. In addition to its beneficial effect on enhancing water uptake from the intestine, the salt in sports drinks works in the brain to stimulate thirst and encourage drinking and in the kidneys to minimize urine formation, thus improving the body's ability to hold water. Finally, when athletes are hot and sweaty, they will usually drink more of a pleasantly flavored sports drink compared to plain water (Passe et al, 2004).

Glucose, sucrose, fructose, and maltodextrins (glucose polymers, which are digested to glucose), are appropriate types of carbohydrates for inclusion in sports drinks. In fact, because each type of carbohydrate enhances fluid absorption from the intestine by different means, having several types of carbohydrate in a fluidreplacement beverage can be beneficial (Shi et al., 1995). However, fructose should not be the only carbohydrate in a sports drink because it is slowly absorbed from the intestine and can produce abdominal discomfort, nausea, or diarrhea in concentrations greater than about 3-4%. The total concentration of carbohydrates in sports drinks should be 5-7%, i.e., 5-7 grams in every 100 ml of the beverage (12-17 g/8 oz). Lower concentrations are less likely to provide a performance benefit, and higher concentrations are emptied from the stomach more slowly, tending to cause abdominal distress. Sodium is the most important electrolyte in sports drinks because it is the one lost most in the sweat and has the most powerful effect on stimulating rehydration. Potassium, calcium, magnesium, and other electrolytes are relatively minor players in the rehydration story, but sports drinks include at least some of them in small amounts.

Rehydration After Training or Competition. It is important for soccer players, especially those involved in tournaments requiring rapid recovery between matches, to replace sweat losses that were not matched by drinking during the game. Because drinking fluids stimulates urine formation, players should drink a greater volume during recovery than the weight lost. The current recommendation is to drink about 50% more in volume than the amount of weight lost, e.g., 1.5 L/kg of weight lost or 1.5 pints/lb (Shirreffs et. al, 1996). Sports drinks are best for rehydration after exercise because they replace water, carbohydrates, and electrolytes and because they stimulate thirst and minimize urine production.

SUMMARY

There is no persuasive evidence that creatine supplementation is beneficial to soccer play. Because most of the running in soccer is at less than maximal speed, it is unlikely that creatine supplementation would have any important benefits. On the other hand, soccer is a glycogen-dependent sport, making carbohydrate feedings repletion of critical importance. Therefore, the ability to sustain late-game running speed and goal-scoring and to avoid injuries are dependent on glycogen levels. Adequate dietary carbohydrate in the days and hours before strenuous training and competition is critical to maintaining adequate glycogen levels in the muscles. Similar to the detrimental effect of inadequate carbohydrate intake, even slight dehydration can be detrimental to impair performance in soccer, and sports drinks containing moderate amounts of carbohydrate and electrolytes, especially sodium, are better than plain water in maintaining hydration during soccer play and in rehydrating during recovery. Soccer players typically do not eat enough carbohydrate and begin soccer matches with less than optimal stores of muscle glycogen. Moreover, they usually do not drink enough fluids during practice and competition to adequately replace their sweat losses. Coaches and athletic trainers must continually reinforce the need for dietary carbohydrate and fluid replenishment, ensure that fluids are available on the sidelines, and, when possible, supervise the eating and drinking behavior of the players. All levels of play can benefit by following sound nutritional guidelines.

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MYTHS ABOUT SOCCER NUTRITION

Myth #1 – What I eat and drink doesn't affect my soccer performance.
The truth is that if you are not careful about what you eat and drink, you will run less, run more slowly, make bad decisions, touch the ball less, score fewer goals, and give up more goals late in the match.

Myth #2 – If any type of food is critical in soccer nutrition, it's protein, not carbs.
With rare exceptions, soccer players in developed countries get plenty of protein in their normal diets. But players on most teams eat too little carbohydrate, the most important nutrient in the successful soccer player's diet. Hard sprinting and running in soccer rapidly uses up the stored glycogen (carbohydrate) in your muscles and liver. To replace that glycogen, you should emphasize carbohydrate foods in your daily diet, especially during the 24 hours before a match and during the first few hours of recovery from matches or hard training sessions. Here are some guidelines:

- Your in-season daily diet should include 8-10 grams of carbohydrate per kilogram of body weight (3.5-4.5 g/lb). Cereals, fruits, vegetables, breads, and pastas are good sources of carbs.
- About 4 hours before a match, eat a meal that includes plenty of easily digestible, carbohydrate-rich foods. Avoid fried foods and foods with fatty sauces because fats are slowly digested. If you tend to be nervous before a match, consider an easy-to-digest liquid meal such as a nutrition shake that contains 60-70% of its calories as carbohydrate.
- About 2 hours before a training session or match, drink about 500-600 ml (16-20 oz) of a carbohydrate-electrolyte sports drink that contains 5-7% carbohydrate. This will provide some last-minute carbohydrate and body fluids insurance.
- During stoppages for injuries and penalties and during half-time, drink as much of a carbohydrate-electrolyte sports beverage as you can comfortably consume.
- As soon as possible after a match or hard training session, start consuming carbohydrate-rich foods and beverages to rapidly begin replacing glycogen stores. Energy drinks that contain 18-20% carbohydrate (18-20 g/100 ml or 43-48 g/8 oz) can be a good source of easily digested carbs. A little protein

is good, but don't go overboard. Aim to consume plenty of carbohydrates (8-10 g/kg) in the 24 hours following strenuous play.

Myth #3 – Drinking fluids during practice and matches is for sissies.

If you play hard in practice and in matches, you lose lots of sweat, especially when it's hot and humid. Some of the water in that sweat comes from your blood, and the last thing you want to do is reduce your blood volume. Blood carries oxygen and nutrients to your muscles, removes lactic acid and other substances, and transfers heat away from your muscles to your skin, where the heat is released to the air. If you do not replace most of the fluids you lose in sweat, your performance will deteriorate and you may become susceptible to muscle cramps, heat exhaustion, and even heat stroke. Each player should have individualized, chilled, well-marked fluid containers, and teams should place those containers about every 20 meters along the sidelines, readily available for a quick drink during play stoppage.

Myth #4 Water is the best fluid-replacement beverage.

Although water is better than nothing, research studies have shown definitively that replacing sweat losses with a carbohydrate-electrolyte sports drink has real advantages over water. The carbohydrates supply energy, and the carbs plus electrolytes stimulate thirst and accelerate the restoration of body fluids when compared to water.

Myth #5 – As long as I drink whenever I'm thirsty, I'll get plenty of fluids.

Thirst is not a good indicator of fluid needs, so you must force yourself to drink early and often, whenever there are stoppages in play. Your goal should be to never lose more than about 1.5% of your body weight in a practice or match. In other words, if before practice or a match you weigh 70 kg (154 lb), you should not lose more than 1.05 kg (2.3 lb) after play. To find out more precisely how much you should be drinking, weigh yourself before and after practice and measure the volume of fluid you drink, if any. If you lose more than 1.5% of your body weight, you will need to drink more. If you actually gain body weight, you should drink less. To rapidly replace fluids and electrolytes like sodium and potassium after practice or a match, you should drink about 50% more fluids than you lost. (The reason for this is that drinking stimulates urine formation, and additional fluids are needed to make up for that loss.) Again, sports drinks are better than water for rapid rehydration because they encourage drinking and cause less urine production.

Myth #6 – To perform my best, I need to supplement my diet with creatine.

There is no persuasive evidence that creatine supplementation has any noticeable effect on soccer performance. In fact, any gain in body weight—a common side effect of creatine supplementation—may actually be harmful to running performance in soccer. Moreover, soccer performance has a large endurance component, and creatine does nothing to enhance endurance.

Myth #7 – When the team travels to an away match and the game is over, it's O.K. to eat whatever I want at restaurants.

Even when your team is taken to a buffet restaurant or a food court where good selections are available, many players will make poor choices, but you can be smarter. The idea is to get ready for the next match. Proper food choices—lots of carbs, little fat—will put more energy in your muscles, which means better performance in the next game. If your opponent isn't as enlightened as you, then you will be at an advantage. If you are unsure about which foods are high in carbs and low in fats, ask for help. If you have a team nutritionist, that would be best. A team physician or athletic trainer or coach may also be able to give you sound advice. Also, some fast-food restaurants have printed materials available that list the nutritional contents of their foods; just ask.

SUGGESTED ADDITIONAL RESOURCES

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