The American Journal of Orthopedics

Nutrition-Related Considerations in Soccer: A Review

Publish date: December 3, 2018
Authors:
Rikki Keen, MS, RD, CSSD, CSCS
Author Affiliation | **Disclosures**

Ms. Keen is Team Performance Nutritionist for Orlando City Soccer Club (MLS, NWSL), and a Sports Nutrition Consultant to US Womens National Soccer Team.

Authors' Disclosure Statement: The author reports no actual or potential conflict of interest in relation to this article.

Address correspondence to: Rikki Keen, Orlando City SC, 845 Lake Markham Rd, Sanford, FL 32771 (tel: 808-345-6258, email: rkeen@orlandocitysc.com).

Take-Home Points:

- Nutrition plays a vital role in keeping the player healthy, reducing risk for injury, speeding up recovery, and enhancing training adaptations.
- Average energy expenditure during a training day is ~3500-3600 kcal for elite male soccer players and ~2700-2800 kcal for elite female soccer players.
- Carbohydrate needs should reflect the work required/demand to produce optimal performance.
- Vitamin D and iron are two common nutrients of concern for soccer players.
- Studies have shown that most players do not drink sufficiently during a match to optimize hydration, replacing only ~40% to 45% of their sweat losses. Soccer players can also lose large amounts of sodium: between 700 and 1500 mg of sodium/L of sweat.

Soccer is the world's most popular sport. As the sport has grown, so have the physical demands and the search for ways to edge out the competition with the use of sports science and nutrition. The demands, which include intense training, ≥90 minutes matches, congested fixtures, and travel, lead to increased energy and nutrient requirements, stress on the body, and risk of impaired sleep cycles. Identifying key areas to enhance a player's performance is an ongoing effort because of individual differences. Moreover, new information is being discovered via research, and advancing technology to measure performance is always evolving. This article focuses on the core nutrition principles known to lay the foundation for a better soccer player. These principles are obvious for some; however, nutrition and hydration are often undervalued, leaving the individual player with the responsibility to eat right. This review addresses the most applicable nutrition-related recommendations for soccer players.

Technical, tactical, and physical skills are key factors in a soccer player's performance. However, energy demands of matches and training sessions require adequate fuel and hydration to maximize those key factors. Athletes may need to manage carbohydrates, protein, and fat separately to achieve optimal body size and body composition, and to maximize performance.

Nutrition plays a vital role in keeping the player healthy, reducing risk of injuries, speeding up recovery, and enhancing training adaptations. Research has shown what we eat and when we eat can significantly impact skeletal muscle adaptation, inflammation, immune response, and energy metabolism. These are all essential nutrition considerations for soccer players.

Energy Metabolism in Soccer

Understanding energy demands will help determine energy requirements: type, amount, and timing of macronutrients and micronutrients. Soccer utilizes both aerobic and anaerobic energy systems. Soccer is an intermittent team-based sport; thus, it contains various high-intensity movements, such as sprinting, jumping, dribbling, and frequent changing of direction performed in between numerous low-intensity slow movements. The high intense movements collectively account for about 30% of match play, whereas 70% is walking, jogging, and standing. Although sprinting and jumping are not a large part of the 90 minutes of match play, they have a huge impact on the outcome of the match. Distance covered in the last 15 minutes of match play decreases by 14% to 45% compared with the first 15 minutes of play.[1] Krustrup and colleagues[2] found muscles in the quadriceps to be empty or nearly empty of glycogen (stored carbohydrates) after match play. This phenomenon can help explain a significant decrease in sprinting, jumping, and intermittent movements toward the end of a match—energy demands that rely on glycogen as the primary fuel source. Being well-fueled and hydrated and having the ability to delay fatigue can place a team at a performance advantage.

Energy Expenditure

Beyond training load or match intensity, a soccer player's body composition, gender, age, and position can affect energy needs. Position differences in elite soccer players show that the greatest total distance covered is by central midfielders and wide midfielders (~12 km –13 km), whereas central defenders cover the least area of the field players (≤~10 km).[3,4] The environment can also play a role in energy expenditure. To further understand calorie needs, total daily energy expenditure in soccer players has been measured using doubly labeled water and estimated using heart rate, global positioning system, video match analysis, and activity records.[5,6] One study estimated that energy expended during a training day for elite male soccer players is between 3442 kcal and 3824 kcal.[6] Another study using doubly labeled water concluded that mean energy expenditure of elite male soccer players is 3566 kcal over a 7-day period, which included 5 training days and 2 matches.[7] In terms of energy expenditure for elite female soccer players, the mean values for match day, training days, and rest days were 2914, 2783, and 2213 calories, respectively.[8]

Fueling the Soccer Player

Depending on the match fixture, proper fueling can be a challenge due to the number of matches, travel time, and limited recovery time. Macronutrients will provide the mainstay of fuel for a player, specifically carbohydrates and fats. Carbohydrates are the preferred source of fuel for the majority of the calories consumed. Using body weight (kg) is a more current and accurate method of recommending the amount of each macronutrient an individual player should eat as compared to using a percentage of total daily calories.

- Carbohydrates: 5–10 g/kg/day
- Protein: 1.2–2.0 g/kg/day

- Fat: 0.8–1.5 g/kg/day

Carbohydrate and Soccer Performance

Carbohydrates are a limited supply of fuel compared with fat stores. They are an important fuel source for soccer players, as muscle glycogen is vital to performance during high intense training and match play (**Table 1**). Yet current research shows that a high carbohydrate intake is not required to be followed every day due to varied energy demands.[9] This newer strategy is referred to as "training low," allowing the athlete to train at a low-moderate intensity in a low glycogen state. The glycogen status of the muscle can alter the training adaptations through cellular changes in the mitochondria. Therefore, carbohydrate needs should reflect the work required or demand for optimal performance. However, on high-training load days or 24 hours pre-match, carbohydrate intake should be increased to maximize muscle glycogen stores. Soccer players need to consume up to 8-10 g/kg body weight during the 24 hours before a match.[10] On low or rest days, carbohydrate intake should be reduced to reflect the decreased training load. For example, recent research has demonstrated potential training adaptations when muscle glycogen stores are not consistently high[11] or intentionally kept low depending on the training load. Adjusting carbohydrate intake to the physical demands of an athlete is a strategy called nutrition periodization.

However, if glycogen stores are not well supplied before a match >90 minutes, then the muscles and the brain will become fatigued and lead to poor performance. Glycogen depletion contributes to fatigue toward the end of a match.[10] In the early 1970s, Saltin and colleagues[12] showed that players with high muscle glycogen stores (~400 mmol/kg dry wt) achieve higher movement intensities and cover more total distance than those players who start the match with low glycogen stores (~200 mmol/kg dry wt). Another study examined pre-match diets of male soccer players (65% vs 30% daily carbohydrate intake) to determine the effect on performance outcomes and glycogen concentrations. Results showed high-muscle glycogen concentrations in the 65% carbohydrate diet and a significantly higher amount of intense exercise bouts. More acutely, studies have shown a meal containing 200 to 300 grams of carbohydrates 2 to 4 hours before exercise prolongs endurance.[13-15] Ideally, consuming fast-digesting carbohydrate sources during or at half time will help maintain blood glucose concentrations and spare muscle glycogen reserves. The majority of literature shows a 6% to 8% solution of combined fast-digesting carbohydrates (ie, glucose, fructose, sucrose, or maltodextrin) at a rate of 30 to 60 g/h enhances at least 1 aspect of performance in soccer.[16-18] These performance benefits include increased running time, improved time to fatigue, and enhanced technical skills. Regarding recovery, soccer players should begin consuming carbohydrate-rich foods and beverages immediately after exhaustive training or a match to optimize glycogen reloading. Ingesting post-exercise carbohydrates stimulates muscle and liver glycogen synthesis up to tenfold compared with post-intake of no carbohydrates.[19] This recovery period becomes vital when there are <8 hours between training sessions or another match, such as in youth tournaments. The form of carbohydrate, solid or liquid, can be based on preference and tolerance, as long as the source provides a large glycemic and insulin response.

An easy way to adjust daily carbohydrate intake is to schedule carbohydrate-rich foods at meals or snacks around important training sessions or before/during/after on match day. Anderson and colleagues[10] looked at training loads for 1, 2, and 3 matches per week, recommending high carbohydrate intake match day minus 1, on match day, and match day plus 1 for 1 and 2 matches per week and lower carbohydrate intake on the other days. During a 3-match week, lowering carbohydrates any day of that week is not recommended. More research is needed to determine the best strategy for performance regarding carbohydrate periodization in soccer.

Protein and Soccer Performance

Protein is important to soccer players for muscle tissue repair, strength, bone health, and the immune system (**Table 2**). The American College of Sports Medicine, the Academy of Nutrition and Dietetics, and the Dietitians of Canada recommend 1.2 to 2.0 g/kg/day.[20] Most soccer players meet the daily protein requirements; however, the key to optimizing the total daily amount is focusing on the source/amino acid profile, timing, and amount per feeding. Consuming divided doses of protein (20 g to 40 g) every 3 to 4 hours gives the body a continuous flow of amino acids to support muscle synthesis and recovery. In terms of body size, the recommendation is 0.25 to 0.4 g/kg every 3 to 4 hours, which includes pre-training/match and post-training/match. Protein/amino acids consumed around strength training and high-intensity sessions can promote muscle adaptations, minimize tissue breakdown, and speed recovery. Soccer matches lead to significant muscle damage[21] especially at 2 sessions/day or multiple matches in a week. Protein is not a priority during training or matches, as its role is not to provide energy, and the primary goal during soccer activities is energy production. Research supports an intake of 30 to 40 g of casein, which is a slow digesting protein, at night before bed when a strength-training session has been performed that day.[22,23]

Fat and Soccer Performance

Fat is the primary source of energy at rest and at low-training intensities, such as walking or jogging for soccer players (**Table 3**). Besides providing slow, long-lasting energy, fat helps absorb vitamins A, D, E, and K; produce hormones; protect organs; and support the cell membrane structure. The dietary recommendations of total fat intake for athletes are similar to or slightly greater than those recommended for non-athletes. The total amount required depends on the training demands and the players' goals. The recommended amount of dietary fat is between 20% and 35% of total daily energy intake.

The key to gaining performance benefits from dietary fat depends on the type of fat selected. Some fats in excess, such as omega-6 fatty acids and saturated fats, may promote inflammation, hinder recovery, and affect brain health. Other types can help reduce inflammation, enhance muscle recovery, and improve brain health. These types include polyunsaturated omega-3 fatty acids, which are essential for the health of the athlete, allowing for a balanced fatty acid profile.[23] Specific omega-3 fatty acids (EPA and DHA) have shown an improvement in the function of the mitochondria, enhancing energy cell metabolism. They also have potential to be highly anti-inflammatory, benefit rehabilitation during soft-tissue injury, and help decrease secondary damage from a concussion.

In addition, research shows that omega-3 may enhance the energy production of the mitochondria, resulting in less oxidative damage to the muscle cell.[25] More research is needed on the effects of performance on soccer players. Given the slow digestion and absorption of fats, fat intake must be limited leading up to or during training sessions or matches, which may risk gastrointestinal issues and displacement of carbohydrates. Low to moderate monounsaturated and polyunsaturated fats in a recovery meal have not been shown to inhibit muscle glycogen reloading or muscle protein synthesis.[26,27] In regard to fat intake post-match, fat is not a key nutrient of concern for muscle recovery, as it can be included in the next balanced meal.

Micronutrients, vitamins, and minerals

Exercise stresses many of the metabolic pathways where vitamins and minerals are required. High-level training demands may also increase the turnover rate of vitamins and minerals. As a result, greater dietary intakes of vitamins and minerals may be warranted. Soccer players at the greatest risk for poor vitamin and mineral levels are those who skip meals, who eliminate ≥1 of the food groups from their diet (such as vegans), or who consume unbalanced and highly processed foods. In soccer players, the micronutrients of concern include iron and vitamin D. In young female soccer players, calcium intake must be assessed along with adequate energy intake for optimal bone density. Vegetarians, vegans, and/or athletes who do not consume meat, eggs, and/or dairy in their diet are at risk for vitamin B12 deficiency. The key to obtaining all the vitamins and minerals an athlete will need is to eat a wide variety of nutrient-dense foods.

Iron

Iron deficiency, with or without anemia, may impair muscle function and limit exercise capacity. Adequate iron intake in athletes with iron deficiencies and/or anemia can improve exercise capacity. Iron depletion is 1 of the most common nutrient deficiencies observed among endurance athletes. Foot strike hemolysis can destroy red blood cells during activities such as running. Research has shown that 30% of professional male soccer players have ferritin levels <30 mcg/L at the end of a soccer season.[28] Thus, fatigue and poor recovery time place soccer players at risk of an iron imbalance.[29,30]

Landahl and colleagues[31] found that iron deficiency and iron deficiency anemia are common in female soccer players at the elite level. In their study of 28 female national soccer players, 57% had iron deficiency and 29% presented with iron deficiency anemia 6 months before the FIFA Women's World Cup. Testing hemoglobin alone is insufficient to detect relative anemia. Regular monitoring of hemoglobin and ferritin concentrations may be necessary to determine appropriate iron needs.

Vitamin D

Vitamin D is required for optimal bone health, as it helps regulate calcium and phosphorus. Further research shows a link between vitamin D and non–bone-related functions, such as muscle health, immune support, and anti-inflammatory roles, which may be linked to performance. Soccer players with low levels of vitamin D (<30 ng/mL) may be more at risk for musculoskeletal injuries and stress fractures.[34] In other sports, vitamin D may enhance muscle strength; however, no association between vitamin D and muscle strength has been found in soccer players.[34,35] The geographic location of an athlete seems to be irrelevant to serum levels, as insufficient levels can be found at various latitudes.[34,36-38]

Evidence has shown that vitamin D may improve athletic performance in vitamin D-depleted athletes, thereby improving vertical jumps, lowering risks of muscle injury/strains and stress fractures, and reducing risk of colds/flu. In 2013, researchers showed for the first time a link between vitamin D and muscle aerobic metabolism by studying the energy efficiency of the mitochondria.[32] Athletes with low vitamin D levels increased their ATP production within the muscle with vitamin D supplementation over 10 weeks to 12 weeks.[33]

Calcium

Soccer players present with stronger and denser bones than non-athletes due to running and jumping in their sport. Weight-bearing sites such as lumbar spine, hip, femoral neck, trochanter, intertrochanteric region, and both legs are sensitive to the impact of soccer movements.[39] Calcium and vitamin D are also important for muscle contraction.

Given the variation in genetics, sports, and gender, optimal performance requires a healthy eating plan tailored to the individual athlete. A healthy eating plan allows an athlete to train longer and harder, delay the onset of fatigue, and speed recovery. Nutrition supports optimal performance through real food, proper hydration, nutrient timing, and supplementation.

Fluid Requirements for Soccer Players

Many athletes overlook the importance of hydration on performance, either assuming they are hydrated or they miscalculate fluid and electrolyte needs to actual sweat losses. Numerous factors play a part in optimal hydration such as sweat rate, environment, training intensity, duration, body size, and body composition. Soccer players have fewer breaks to consume fluids during a match compared with basketball, baseball, or American football players. These breaks include a 15-minute half between coming off the pitch to the locker room and back, as well as time spent with coaches reviewing strategies; this short window of time must be maximized to rehydrate. Fluids with a carbohydrate concentration of 4% to 8% at 5 to 10 ounces and breaks every 15 to 20 minutes are optimal to maximize uptake while avoiding gastric intolerance.

Studies have shown that most players do not drink sufficiently during a match to optimize hydration, replacing only ~40% to 45% of their sweat losses.[40, 41] Maughan and colleagues measured high levels of urine osmolality in some soccer players, thereby indicating that the players started their training session dehydrated.[41] Soccer players must begin training or a match well hydrated due to the limited opportunities after kick-off. The athlete should drink at least 4 hours prior to exercise; if no urine is produced or urine is dark in color, then the athlete should drink again 2 hours prior.

Changes in body mass, urine color, and thirst offer clues to the need for rehydration. Advanced hydration measurement includes testing urine specific gravity (USG) values. For example, testing pre-training or pre-match can be conducted to determine hydration status and trending changes from day to day. A USG value >1.020 is considered dehydrated in accordance with the NATA position statement.[42] Calculating a sweat rate is a practical approach to determining individual hydration needs (see **Table 4**). Sweat rates will vary between soccer players based on their position and intensity of play, along with total match time.[39] Soccer players will lose ~1.5 to 4.5 liters during match play.[43-46] In general, athletes, including soccer players, should limit body weight loss to ≤2% to 3% to maintain performance. Studies have shown that >2% body mass loss can hinder soccer-specific performance, such as dribbling skills and intermittent high intensity sprinting.[49-51]) **Table 5** outlines the detrimental effects dehydration has on performance. Urine-specific gravity values between 1.021 and 1.030 may reflect 3% to 5% change in body weight.

Electrolytes

Sodium is the primary electrolyte lost in sweat. Other electrolytes (potassium, magnesium, and calcium) are lost at much lower levels and typically replaced through diet. Soccer players can lose large amounts of sodium; between 700 and 1500 mg of sodium/L of sweat has been reported in several studies.[42-44] Studies of professional male soccer players have shown potassium losses in the range of 165 mg/L to 234 mg/L.[42,51,52] Sodium in a sports drink or in food aids with water uptake from the intestines and enhances the thirst mechanism in the brain, resulting in additional fluid being retained in the body.

Rehydration After Training or Competition

Within 2 hours after training or competition, the rehydration strategy should provide water to restore body fluid status, carbohydrates to replenish glycogen (fuel) stores, and electrolytes to speed rehydration (**Table 6**). The volume of fluids and type of fluids over the next 24 hours dictate the hydration status prior to the next day's training session. It is a continuous cycle. Over time, an athlete increases the risk of being in a chronic dehydrated state, resulting in lack of motivation, risk of injury, and illness, fatigue, and poor performance. The current recommendation is to drink ~50% more in volume than the amount of weight lost, such as 22 to 24 ounces/pound lost.[52]

Key Info

Figures/Tables

Figures / Tables:

Table 1. Carbohydrates

Timing	**Amount**	**Application**
Daily	5–7 g/kg/day	Low–moderate training load. Match amount to training session intensity. Adjust to individual goals; body composition, metabolic adaptations.
Pre-Training/Match 3-4 h < 1 h	1–4 gm/kg ~30 g	Adjust to players' tolerance, preferences and training load.
During Training	0–30 g/h 30–60 g/h	Light training session High training session
Recovery/After Training	Balance meal 1.0–1.2 g/kg/h, ASAP.	Light training: < 2 h Heavy training/2 sessions/day
Match day -1, match day, match day +1	7–10 g/kg/d	Adjust to players' tolerance, preferences.
During/half time	30–60 g/h	High glycemic carbohydrates
Recovery/after match	1.0–1.2 g/kg/h	High glycemic carbohydrates

Table 2. Protein

Timing	**Amount**	**Application**
Daily	1.2–2.0 g/kg	High quality sources; chicken, lean meats, fish, seafood, eggs, dairy, beans, soy
Pre-training/match; 1-4 h	20–40 g or 0.25–0.40 g/kg	Meal/snack
During training/match	None needed	If training session <3 h
Recovery/after training	20–40 g	<30–60 min, whey, casein/whey, pea, soy protein
Night-time feeding	20–40 g	Casein (slow-absorbing protein), strength training days

Table 3. Fat		
Timing	**Amount**	**Application**
Daily	0.8–1.5 g/kg	Include well balanced meals, primarily polyunsaturated and monounsaturated fats.
Pre-Training/Match; 1–4 h	~10–30 g/meal	Limit amount. Avoid digestion and gastrointestinal issues.
During Training/Match	None needed	Risk of gastrointestinal intolerances.
Recovery/After Training	~10–30 g	Include well-balanced meals, primarily polyunsaturated and monounsaturated fats.

Table 4. Sweat Rate Calculation Steps
1. Release bladder/bowels, if needed. 2. Obtain pre-weight. Weigh with minimal clothing. 3. Start exercise. Record duration, intensity, weather and measure fluids consumed. 4. End exercise. Wipe/towel dry sweat off skin. Remove any clothing saturated in sweat. 5. Obtain post-weight. 6. Add weight of fluid consumed (ie, water and sports drinks) in ounces to weight lost. 7. Divide the total sweat loss by the duration of exercise to provide an estimation of the rate of sweat loss.

Table 5. Performance Outcomes at Various Dehydration Levels
• Heart rate increases 3 to 5 beats/minute for every 1% of body weight lost. • Core body temperature during exercise rises an additional 0.25°F to 0.40°F for every 1% of body weight lost. • Maximal aerobic power usually decreases with >3% of body weight lost. • Gastric emptying slows at ≥4% of dehydration, leading to gastrointestinal upset. • Muscle strength generally declines ≥5% of dehydration.

Table 6. Hydration		
Timing	**Amount**	**Application**
Daily	3.7 L adult males 2.7 L adult females + sweat rate	Monitor urine color.
Pre-training/match; 4 h 2 h 10–15 min	16 oz or 5–7 mL/kg 16 oz or 3–5 mL/kg 8 oz	Monitor urine production and color Fluids (carbohydrates, moderate protein, low fat): milk, 100% juice, sports drink. Sodium (450-1150 mg/L)

During training/match < 1 h > 1 h	13–28 oz/h (400-800 mL)*	Every 15–20 min. *Dependent on sweat rate. Sports drink (9-19 g Carbohydrate/8 oz) Sodium (~500-1000 mg/L)* Potassium (80–200 mg/L)
Recovery/after training (immediately up to 6 h post to replace 150% of fluids lost)	22–24 oz/1 lb body weight lost	Water + food (carbohydrates/electrolytes) or Sports drink • Sodium (~500–1000 mg/L) • Potassium (80–200 mg/L) • Protein 10–25 g

References

References

1. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci*. 2003;21:519-528.
2. Krustrup P, Mohr M, Steensberg A, Bencke J, Kjaer M, Bangsbo J. Muscle and blood metabolites during a soccer game: implications for sprint performance. *Med Sci Sports Exerc*. 2006;38:1165-1174.
3. Di Salvo V, Gregson W, Atkinson G, Tordoff P, Drust B. Analysis of high intensity activity in Premier League soccer. *Int J Sports Med*. 2009;30:205-212.
4. Di Salvo V, Baron R, Tschan H, Calderon Montero FJ, Bachl N, Pigozzi F. Performance characteristics according to playing position in elite soccer. *Int J Sports Med*. 2007;28:222-227.
5. Reilly T, Thomas V. Estimated daily energy expenditures of professional association footballers. *Ergonomics*. 1979;22:541-548.
6. Osgnach C, Poser S, Bernardini R, Rinaldo R, di Prampero P.E. Energy cost and metabolic power in elite soccer: A new match analysis approach. *Med Sci Sports Exerc*. 2010;42:170-178.
7. Anderson L, Orme P, Naughton RJ, Close, GL, Milsom J, Rydings D, et al. Energy intake and expenditure of professional soccer players of the English Premier League: evidence of carbohydrate periodization. *Int J Sport Nutr Exerc Metab*. 2017;1-25.
8. Mara JK, Thompson KG, Pumpa KL. Assessing the energy expenditure of elite female soccer layers: a preliminary study. *J Strength Cond Res*. 2015;2780-2786.
9. Bartlett JD, Hawley JA, Morton JP. *Eur J Sport Sci*. 2015;15(1):1, 3-12.
10. Anderson L, Orme P, Di Michele R, Close GL, Morgans R, Drust B, Morton JP. Quantification of training load during one-, two- and three-game week schedules in professional soccer players from the English Premier League: implications for carbohydrate periodisation. *J Sports Sci*. 2016;34;1250-1259.
11. Hawley JA, Morton JP. Ramping up the signal: promoting endurance training adaptation in skeletal muscle by nutritional manipulation. *Clin Exp Pharmacol Physiol*. 2014;41:608-613.
12. Saltin B. Metabolic fundamentals in exercise. 1973;:137-146.
13. Balsom PD, Wood K, Olsson P, Ekblom B. Carbohydrate intake and multiple sprint sports: With special reference to football (soccer). *Int J Sports Med*. 1999;20:48-52.

14. Neufer PD, Costill DL, Flynn MG, Kirwan JP, Mitchell JB, Houmard J. Improvements in exercise performance: Effects of carbohydrate feedings and diet. *J Appl Physiol*. 1987;62:983-988.
15. Sherman WM, Brodowicz G, Wright DA, Allen WK, Simonsen J, Dernbach A. Effects of 4 h preexercise carbohydrate feedings on cycling performance. *Med Sci Sports Exerc*. 1989;21:598-604.
16. Baker LB, Rollo I, Stein KW, Jeukendrup AE. Acute effects of carbohydrate supplementation on intermittent sports performance. *Nutrients.* 2015;7:5733-5763.
17. Goedecke JH, White NJ, Chicktay W, Mahomed H, Durandt J, Lambert MI. The effect of carbohydrate ingestion on performance during a simulated soccer match. *Nutrients.* 2013;5:5193-5204.
18. Nicholas CW, Williams C, Lakomy HK, Phillips G, Nowitz A. Influence of ingesting a carbohydrate-electrolyte solution on endurance capacity during intermittent, high-intensity shuttle running. *J Sports Sci*. 1995;13:283-290.
19. Burke LM, van Loon LJC, Hawley JA. Post-exercise muscle glycogen resynthesis in humans. *J Appl Physiol*. 2016;122:1055-1067.
20. Rodriquez NR, DiMarco NM, Langley S. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *J Am Diet Assoc*. 2009;109(3):509-527.
21. Romagnoli M, Sanchis-Gomar F, Alis R, Risso-Ballester J, Bosio A, Graziani RL, Rampinini E. Changes in muscle damage, inflammation, and fatigue-related parameters in young elite soccer players after a match. *J. Sports Med Phys Fit*. 2016;56:1198-1205.
22. Res PT, Groen B, Pennings B, Beelen M, Wallis GA, Gijsen AP, et al.Protein ingestion before sleep improves postexercise overnight recovery. *Med Sci Sports Exerc*. 2012;44:1560-1569.
23. Snijders T, Res PT, Smeets JSJ, Van Vliet S, Van Kranenburg J, Maase K, et al.Protein ingestion before sleep increases muscle mass and strength gains during prolonged resistance-type exercise training in healthy young men. *J Nutr*. 2015;145:1178-1184.
24. Simopoulos AP. Omega-3 fatty acids and athletics. *Curr Sports Med Rep*. 2007;6230-236.
25. Peoples GE, McLennan PL, Howe P, Groeller H. Fish oil reduces apparent myocardial oxygen consumption in trained cyclists but does not change time to fatigue. Presented at the Fourth International Conference on Nutrition and Fitness; May 25-29, 2000; Ancient Olympia, Greece.
26. Burke LM, Collier GR, Beasley S.K, Davis PG, Fricker PA, Heeley P, et al. Effect of coingestion of fat and protein with carbohydrate feedings on muscle glycogen storage. *J Appl Physiol*. 1995;78:2187-2192.
27. Roy BD, Tarnopolsky MA. Influence of differing macronutrient intakes on muscle glycogen resynthesis after resistance exercise. *J Appl Physiol*. 1998;84:890-896.
28. Reinke S, Taylor W.R, Duda GN, von Haehling S, Reinke P, Volk H-D et al. Absolute and functional iron deficiency in professional athletes during training and recovery. *Int J Cardiol*. 2012;156:186-191.
29. Escanero JF, Villanueva J, Rojo A, Herrera A, del Diego C, Guerra M. Iron stores in professional athletes throughout the sports season. *Physiol Behav*. 1997;62:811-814.
30. Heisterberg MF, Fahrenkrug J, Krustrup P, Storskov A, Kjær, M, Andersen JL. Extensive monitoring
31. Landahl G, Adolfsson P, Borjesson M, Mannheimer C, Rodjer S. Iron deficiency and anemia: a common problem in female elite soccer players. *Int J Sport Nutr Exerc Metab*. 2005;15(6):689-694.
32. Sinha A, Hollingsworth K, Ball S, Cheetham T. Improving the vitamin D status of vitamin D deficient adults is associated with improved mitochondrial oxidative function in skeletal muscle. *Endocrine Abstracts*, 2013;31.OC1.6
33. Shuler FD, Wingate MK, Moore GH, Giangarra C. Sports health benefits of vitamin D. *Sports Health*. 2012;4:496-501.

34. Hamilton B, Whiteley R, Farooq A, Chalabi H. Vitamin D concentration in 342 professional football players and association with lower limb isokinetic function. *J Sci. Med Sport*. 2014;17:139-143.
35. Ksiażek A, Zagrodna A, Dziubek W, Pietraszewski B, Ochmann B, Słowińska-Lisowska M,25(OH)D3 levels relative to muscle strength and maximum oxygen uptake in athletes. *J Hum Kinet*. 2016;50:71-77.
36. Kopeć A, Solarz K, Majda F, Słowińska-Lisowska M, Medraś M. An evaluation of the levels of vitamin D and bone turnover markers after the summer and winter periods in Polish professional soccer players. *J Hum Kinet*. 2013;38:135-140.
37. Vander Slagmolen G, van Hellemondt FJ, Wielders JPM. Do professional soccer players have a vitamin D status supporting optimal performance in winter time? *J Sports Med Doping Stud*. 2014,4:2.
38. Morton JP, Iqbal Z, Drust B, Burgess D, Close GL, Brukner PD. Seasonal variation in vitamin D status in professional soccer players of the English Premier League. *Appl Physiol Nutr Metab*. 2012;37:798-802.
39. Lozano-Berges G, Matute-Llorente A, Gonzalez-Aguero A, Gomez-Bruton A, Gomez-Cabelloa A, Vincente-Rodriguez G, Casajus JA. Soccer helps build strong bones during growth: a systematic review and meta-analysis. *Eur J Pediatr*. 2018;177(3):295-310.
40. Burke LM. Fluid balance during team sports. *J Sports Sci*. 1997;15:287-295.
41. Maughan RJ, Merson SJ, Broad NP, Shirreffs SM. Fluid and electrolyte intake and loss in elite soccer players during training. *Int J Sport Nutr Exerc Metab*. 2004;14:333-346.
42. Brendon P, McDermott, P, Anderson SA, Armstrong LE, Casa DJ, Cheuvront SN, et al. National Athletic Trainers' Association Position Statement: Fluid Replacement for the Physically Active. *J Athl Train*. 2017;52(9):877-895.
43. Shirreffs SM, Aragon-Vargas LF, Chamorro M, Maughan RJ, Serratosa L, Zachwieja JJ. The sweating response of elite professional soccer players to training in the heat. *Int J Sports Med*. 2005;26: 90-95.
44. Maughan RJ, Watson P, Evans GH, Broad N, Shirreffs SM. Water balance and salt losses in competitive football. *Int J Sport Nutr Exerc Metab*. 2007;17:583-594.
45. Aragón-Vargas LF, Moncada-Jiménez J, Hernández-Elizondo J, Barrenechea A,Monge-Alvarado M. Evaluation of pre-game hydration status, heat stress, and fluid balance during professional soccer competition in the heat. *Eur J Sport Sci*. 2009;9:269-276.
46. Maughan RJ, Shirreffs SM, Merson SJ, Horswill CA. Fluid and electrolyte balance in elite male football (soccer) players training in a cool environment. *J Sports Sci*. 2005;23:73-79.
47. Duffield R, McCall A, Coutts AJ, Peiffer JJ. Hydration, sweat and thermoregulatory responses to professional football training in the heat. *J Sports Sci*. 2012;30:957-965.
48. Shirreffs SM, Aragon-Vargas LF, Chamorro M, Maughan RJ, Serratosa L, Zachwieja JJ. The sweating response of elite professional soccer players to training in the heat. *Int J Sports Med*. 2005;26:90-95.
49. Edwards AM, Mann ME, Marfell-Jones MJ, Rankin DM, Noakes TD, Shillington DP. 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 J Sports Med*. 2007;41:385-391.
50. McGregor SJ, Nicholas CW, Lakomy HK, Williams C. The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. *J Sports Sci*. 1999;17:895-903.
51. Maughan RJ, Merson SJ, Broad NP, Shirreffs SM. Fluid and electrolyte intake and loss in elite soccer players during training. *Int J Sport Nutr Exerc Metab*. 2004;14:333-346.
52. Shirreffs SM, Sawka MN, Stone M. Water and electrolyte needs for football training and match-

play. *J Sports Sci*. 2006;24:699-707.

Multimedia

Product Guide

Product Guide

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

×
×

Citation

Rikki Keen, MS, RD, CSSD, CSCS . Nutrition-Related Considerations in Soccer: A Review. Am J Orthop.
Publish date: December 3, 2018

```
Rikki Keen, MS, RD,
CSSD, CSCS
```