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Sport-specific nutrition: Practical strategies for team sports

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Abstract

Implementation of a nutrition programme for team sports involves application of scientific research together with the social skills necessary to work with a sports medicine and coaching staff. Both field and court team sports are characterized by intermittent activity requiring a heavy reliance on dietary carbohydrate sources to maintain and replenish glycogen. Energy and substrate demands are high during pre-season training and matches, and moderate during training in the competitive season. Dietary planning must include enough carbohydrate on a moderate energy budget, while also meeting protein needs. Strength and power team sports require muscle-building programmes that must be accompanied by adequate nutrition, and simple anthropometric measurements can help the nutrition practitioner monitor and assess body composition periodically. Use of a body mass scale and a urine specific gravity refractometer can help identify athletes prone to dehydration. Sports beverages and caffeine are the most common supplements, while opinion on the practical effectiveness of creatine is divided. Late-maturing adolescent athletes become concerned about gaining size and muscle, and assessment of maturity status can be carried out with anthropometric procedures. An overriding consideration is that an individual approach is needed to meet each athlete's nutritional needs.

Keywords: *Dietary intake, anthropometry, hydration, supplementation, soccer, rugby, hockey, football, basketball, volleyball, handball*

Introduction

Delivering optimum nutrition to team sport athletes presents unique challenges in that several cultural, economic, and psychological factors may interfere with the process (Burke, 2007). Nutrition support personnel must use an array of social skills that complement those that are nutrition-specific in the daily interaction with team players and coaching and medical staff. Common-sense judgement and knowledge of the sport's cultural environment must accompany decisions weighing the emotional and physiological gains and losses in situations of conflict. Establishing nutrition policies and procedures on hydration, supplementation, nutritional recovery, and physique assessment that can be implemented on a daily basis is critical to the success of nutrition interventions, since the sports dietitian may have to work with up to 30–40 team-sport athletes simultaneously.

Structure of team sports

Team sports may be classified as field or court (indoor) (Burke, 2007). Field games can be subdivided into: (1) strength-and-power sports, such as American gridiron football, rugby union, and rugby league; (2) more endurance-based sports, such as soccer, field hockey, Australian and Gaelic football, and lacrosse; and (3) batting sports, such as cricket, baseball, and softball. Nutritional requirements for training and competition are determined by the rules of each sport, which vary in playing arena size, duration and frequency of matches, season length, training phase, number of players, and substitutions allowed. Position-specific tasks and physique requirements, weather characteristics, as well as playing level, gender, and age issues further affect nutrient requirements. Throughout team sports, the overriding characteristic is the pattern of intermittent activity between bursts of high-intensity play followed by rest pauses or periods of low activity – the stop-and-go sports (Gabbett, King, & Jenkins, 2008; Hoffman, 2008; Reilly & Borrie, 1992). This pattern taxes both the aerobic system (carbohydrate and fat) and the so-called anaerobic systems (phosphagen and anaerobic glycolysis), highlighting carbohydrate intake as a dietary

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priority because it is a fuel for both energy systems (Burke, Loucks, & Broad, 2006). Strength-and-power team sport athletes tend to cover less running distance, with frequent bursts of short sprints ending in contact, with additional energy spent in scrimmaging and tackling bouts (Duthie, Pyne, & Hooper, 2003). Players in endurance-based field sports usually cover the greatest distances during games, with estimates of $\sim$10 km (Mohr, Krustrup, & Bangsbo, 2003) and up to 15 km or more in Australian Rules Football (Gray & Jenkins, 2010). A significant portion of the distance is covered at high speeds, placing a burden on glycogen repletion and hydration strategies (Burke, 1997). Batting sports, although not very demanding in energy requirements, may require players to spend many hours in the sun during summer months, shifting attention to hydration concerns (Soo & Naughton, 2007). Maintaining adequate glucose to fuel the brain for attention and decision-making is also a concern in these sports, thus carbohydrate intake during games would also be helpful (Winnick et al., 2005). Court sports are characterized by smaller playing arenas, games of shorter duration, and frequent substitutions. This allows players to play 2–3 games on consecutive days, but with the encumbrance of spending much time travelling and in hotels. This disrupts the normal routine including nutrition, with the possibility of glycogen and fluid depletion over successive daily efforts. Training routines during the competitive calendar are generally less exhausting than actual matches, but during pre-season training, when twice-daily sessions are commonplace, physical exertion is very high.

Dietary intake of team sport athletes

Unique to team sports is the fact that no two games are alike (Gregson, Drust, Atkinson, & Salvo, 2010), which creates problems for scientists trying to measure nutritional strategies to increase performance, a scenario where standardization of effort conditions is important (Hopkins, Hawley, & Burke, 1999). Therefore, much of the team sport information for optimizing performance must be drawn from studies with exertion protocols that do not resemble competitive play, and sports practitioners must also rely on inference, experience, and rudimentary trial-and-error. Perhaps a good starting point is to analyse the dietary intake of team sport athletes published in the last 30 years (Tables I and II), taking into consideration the limitations of such surveys (Magkos & Yannakoulia, 2003). Weighted averages for energy intake are 15.3 MJ $\cdot$ day^{-1} (3660 kcal) and 8.6 MJ $\cdot$ day^{-1} (2064 kcal) for males ($n = 819$) and females ($n = 283$) respectively. The mean macronutrient percentages for carbohydrates, proteins, and fats are 49, 17, and 34% for males and 50, 15, and 35% for females respectively. It can be seen that pre-season intakes are greater than in-season intakes; that larger athletes consume more energy, and that, in general, carbohydrate intake at around 49% energy is below some past recommendations of 55–65% (Clark, 1994). Relative to body mass, male team sport athletes reported eating an average of 5.6 ± 1.3 g $\cdot$ kg^{-1} $\cdot$ day^{-1} carbohydrates, and females 4.0 ± 0.7 g $\cdot$ kg^{-1} $\cdot$ day^{-1} (Tables I and II), which are again below expert committee recommendations of 6–10 g $\cdot$ kg^{-1} $\cdot$ day^{-1} (Rodriguez, DiMarco, & Langley, 2009a, 2009b). In fact, only a few studies report carbohydrate intakes above 8 g $\cdot$ kg^{-1} $\cdot$ day^{-1}, and only in soccer players (Hickson, Johnson, Schrader, & Stockton, 1987; Jacobs, Westlin, Karlsson, Rasmusson, & Houghton, 1982; Rico-Sanz, 1998). In women team athletes, the highest carbohydrate intake of 5.2 g $\cdot$ kg^{-1} $\cdot$ day^{-1} was also reported for a group of soccer players (Clark, Reed, Crouse, & Armstrong, 2003). The published literature (Burke, Cox, Culmmings, & Desbrow, 2001) as well as on-field experience in working with team sport athletes indicates that these averages seem to be appropriate amounts, coinciding with the FIFA/FMARC 2006 soccer recommendation of 5–7 g $\cdot$ kg^{-1} $\cdot$ day^{-1} (Consensus Statement, 2006). Unfortunately, data are lacking for some sports such as rugby union and cricket, and there is a need to collect data on the dietary intake of athletes on match days, since most of the published data relate to training days.

Size, physique, and body composition issues

Strength-and-power athletes are usually very large and muscular, endurance-based players are smaller and carry little body fat, batting sport team members tend to be tall and powerful, and court sports like basketball, volleyball, handball, and netball are characterized by tall and muscular participants, except players in futsal (indoor soccer), who resemble their field counterparts but are shorter. Athletes have been increasing in size during the last century, as sport becomes more competitive (Nevill, Holder, & Watts, 2009; Olds, 2001; Yamamoto, Yamamoto, Yamamoto, & Yamamoto, 2008), leading to exercise and nutritional strategies to increase muscle mass.

Position-specific anthropometric reference standards for elite athletes in each sport are useful for athlete profiling (Holway & Garavaglia, 2009) and decision-making regarding dietary intervention. The sports dietitian must bear in mind that there may be a normal 3–4% variation in body fat concomitantly with each training macro-cycle (Gore, 2000), and

Table I. Reported energy and macronutrient intakes of male team sport athletes.

Sport	Level	Country	n	Mass (kg)	Energy (MJ)	Energy (kcal)	CHO (g)	CHO ($g \cdot kg^{-1}$)	CHO (%)	PRO (g)	PRO ($g \cdot kg^{-1}$)	PRO (%)	FAT (g)	FAT (%)	Reference	Survey method	Notes
Aussie rules	professional	Australia	15		13.6	3250	410	4.7	48	138	1.6	21	116	31	Wray et al. (1994)		
Aussie rules	professional	Australia	10		14.0	3346	489	5.9	57	148	1.8	19	88	24	Grahan & Jackson (1998)		
Aussie rules	professional	Australia	40	86.2	13.2	3155	415	4.8	52	139	1.6	18	104	29	Schockman (1999)	4-day	
baseball	professional	USA	11		19.5	4654	523		45	219		18	195	37	Grandjean (1989)	3-day	
baseball	college	USA	13	89.4	13.2	3161									Malinauskas (2007)		
basketball	college	USA	8		16.3	3886	421		43	152		16	169	39	Short & Short (1983)	3-day	season
basketball	college	USA	13		23.3	5571	584		42	212		15	254	41	Short & Short (1983)	3-day	season
basketball	college	USA	16	83.0	14.9	3561	437	5.3	47	159		17	139	34	Nowak et al. (1988)	3-day	
basketball	professional	USA	11		17.1	4076	448		44	160		15	189	41	Grandjean (1989)	3-day	
basketball	professional	Spain	16	96.0	17.9	4278	380		45	211		19	211	36	Schröder et al. (2000)	24-h	
basketball	professional	Spain	55	93.0	17.7	4230		4.6	40		2.3	20		39	Schröder et al. (2004)		
football	college	USA	33	96.0	20.4	4871	550	5.7	44	201	2.0	16	208	38	Short & Short (1983)	3-day	offensive
football	college	USA	23	94.0	20.3	4840	528	5.6	43	191	2.0	16	218	41	Short & Short (1983)	3-day	defensive
football	college	USA	11	108.1	15.0	3593	329	3.0	39	190	1.8	22	158	39	Hickson et al. (1987)	3-day	
football	professional	USA	30		16.0	3826			45			16		39	Grandjean (1989)	3-day	other positions
football	professional	USA	25		16.6	3961			48			16		36	Grandjean (1989)	3-day	linemen
football	college	USA	35	99.0	15.9	3793	443	4.5	45	157	1.6	17	130	35	Millard-Stafford et al. (1989)	3-day	
football	college	USA	28	110	13.8	3293	392	3.6	53	169	1.5	22	103	23	Cole et al. (2005)	3-day	
gaelic	county	Ireland	12	83.0	12.5	2995	432		52	120		16	86	26	Reeves & Collins (2003)	3-day	
gaelic	club	Ireland	13	80.9	12.2	2907	360		49	105		14	96	30	Reeves & Collins (2003)	3-day	
hockey	elite	Holland	8	75.0	13.9	3322	365	4.9	42	105	1.4	22	132	36	van Erp-Baart et al. (1989)	4-day	
hockey	elite	USA	8		15.6	3721	343	4.2	39	156	1.9	18	155	39	Grandjean & Ruud (1994)		
lacrosse	college	USA	10		17.5	4173	542		46	140		14	145	40	Short & Short (1983)	3-day	pre- season
lacrosse	college	USA	10		15.5	3709	398		43	154		17	130	40	Short & Short (1983)	3-day	season
rugby league	professional	Australia	18	98.4	18.0	4309		6.0	52		1.9	18		23	Lundy et al. (2006)	4-day	forwards

(*Continued*)

Table I. (*Continued*).

Sport	Level	Country	*n*	Mass (kg)	Energy (MJ)	Energy (kcal)	CHO (g)	CHO ($g \cdot kg^{-1}$)	CHO (%)	PRO (g)	PRO ($g \cdot kg^{-1}$)	PRO (%)	FAT (g)	FAT (%)	Reference	Survey method	Notes
rugby league	professional	Australia	16	85.5	17.3	4142		6.0	49		2.1	18		27	Lundy et al. (2006)	4-day	backs
soccer	professional	Sweden	15	74.0	20.7	4947	596	8.1	47	170	2.3	14	217	29	Jacobs et al. (1982)	3-day	
soccer	college	USA	8		12.4	2961	320		43	113		16	135	41	Short & Short (1983)	3-day	
soccer	college	USA	17	72.0	18.7	4469	596	8.3	52			14		34	Hickson et al. (1987)	3-day	conditioning
soccer	college	USA	8	72.0	15.9	3805	487	6.8	52			16		32	Hickson et al. (1987)	3-day	season
soccer	college	USA	9	72.0	12.8	3057	306	4.2	42			16		42	Hickson et al. (1987)	3-day	season
soccer	elite	Holland	20	74.5	14.5	3466	420	5.6	47	111	1.5	18	134	35	van Erp-Baart et al. (1989)	4-day	
soccer	professional	Italy	33	76.0	12.8	3062	449	5.9	56						Caldarone et al. (1990)	3-day	
soccer	professional	Denmark	7	77.0	15.7	3752	426	5.5	46	144	1.9	16	152	38	Bangsbo et al. (1992)	3-day	
soccer	professional	Italy	16	74.0	13.4	3212	454	6.1	57	86	1.2	19	90	24	Schena et al. (1995)	3-day	
soccer	professional	Italy	25	71.0	15.3	3647	532	7.4	56						Zuliani et al. (1996)	4-day	
soccer	professional	Scotland	26	80.1	11.0	2629	354	4.4	51	103	1.3	16	93	32	Maughan (1997)		
soccer	professional	Scotland	25	74.6	12.8	3059	397	5.3	48	108	1.4	14	118	35	Maughan (1997)		
soccer	Olympic	Puerto Rico	8	63.0	16.5	3948	526	8.3	53	143	2.3	14	142	32	Rico-Sanz (1998)	3-day	pre-season
soccer	professional	Japan	7	70.0	13.0	3107									Ebine et al. (2002)	3-day	
soccer	professional	UK	21	74.0	12.8	3066	437	5.9	57	115	1.6	1	94	28	Reeves & Collins (2003)	3-day	
soccer	professional	Brazil	15	83.9	12.4	2961			59			20		26	do Prado (2006)		centre backs
soccer	professional	Brazil	28	70.8	8.3	1989			52			19		34	do Prado (2006)		midfielders
soccer	professional	Brazil	8	83.9	16.3	3903			57			13		30	do Prado (2006)		goalkeepers
soccer	professional	Brazil	18	72.1	15.2	3641			54			18		30	do Prado (2006)		strikers
soccer	professional	Brazil	17	69.7	14.1	3361			52			19		26	do Prado (2006)		last defenders

Note: CHO = carbohydrate, PRO = protein.
Adapted from Burke (2007).

Table II. Reported energy and macronutrient intakes of female team sport athletes.

Sport	Level	Country	*n*	Mass (kg)	Energy (MJ)	Energy (kcal)	CHO (g)	CHO $(g \cdot kg^{-1})$	CHO (%)	PRO (g)	PRO $(g \cdot kg^{-1})$	PRO (%)	FAT (g)	FAT (%)	Reference	Survey method	Notes
basketball	college	USA	9	71.0	13.6	3250	379	5.3	46	108	1.5	14	145	40	Short & Short (1983)	3-day	
basketball	college	USA	13	68.0	8.4	2003									Hickson et al. (1986)	24-h	
basketball	college	USA	10	72.0	7.2	1728	229	3.2	51	68			63		Nowak et al. (1988)	3-day	
basketball	college	USA	9	70.0	7.5	1797	227	3.3	48	69	1.0	15	52	26	Risser et al. (1990)	24-h	
handball	elite	Holland	8	63.2	9.0	2151	251	4.0	45	76	1.2	14	101	42	van Erp-Baart et al. (1989)	4-day	
handball		Turkey	10	62.0	7.3	1745	229	3.7	53	51	0.8	12	68	35	Ersoy (1995)	3-day	
hockey	elite	Holland	9	62.1	9.0	2151	264	4.3	46	42	1.0	19	85	35	van Erp-Baart et al. (1989)	4-day	
hockey	college	USA	8	60.0	8.2	1955	228	3.8	47	76	1.3	16	84	39	Tilgner & Schiller (1989)	3-day	
hockey	college	USA	9	64.0	6.4	1518	213	3.4	54	57	0.9	15	45	27	Nutter (1991)	3-day	season
hockey	college	USA	9	64.0	6.0	1432	213	3.0	54	57	0.9	16	47	30	Nutter (1991)	3-day	post-season
lacrosse	college	USA	7		9.3	2228	257		50	89		16	95	35	Short & Short (1983)	3-day	
netball	elite	Australia	10	66.1	11.0	2619		4.8	47		1.7	17		33	Heaney et al. (2010)		
soccer	college	USA	14	61.6	9.6	2297	320	5.2	55	87	1.4	15	75	29	Clark et al. (2003)	3-day	season
soccer	college	USA	14	61.6	7.8	1871	263	4.3	57	59	1.0	13	66	31	Clark et al. (2003)	3-day	post-season
soccer	elite	USA	11		8.4	2015			55			15		30	Mullinix et al. (2003)		
soccer	college	USA	15	59.0	8.5	2022				71	1.3	14			Gropper et al. (2003)	3-day	
soccer	elite	UK	16	61.5	8.0	1904	252	4.1	54	74	1.2	17	55	29	Martin et al. (2006)	3-day	
softball	college	USA	6	66.0	7.7	1828				64	1.0	14			Gropper et al. (2003)	3-day	
softball	elite	Australia	14	74.8	9.0	2144		3.3	44		1.2	18		32	Heaney et al. (2010)		
volleyball	college	USA	11		10.3	2455	314		49	103		16	95	34	Short & Short (1983)	3-day	season
volleyball	college	USA	7		7.6	1819	244		53	61		13	69	34	Short & Short (1983)	3-day	season
volleyball	elite	Holland	9	66.0	9.4	2247	263	4.0	46	73	1.1	17	92	37	van Erp-Baart et al. (1989)	4-day	
volleyball	college	USA	12	66.0	6.7	1609	216	3.3	51	70	1.1	17	54	30	Risser et al. (1990)	24-h	
volleyball	elite	Greece	8	64.6	9.8	2346			50			13		39	Hassapidou & Manstrantoni (2001)		
volleyball	elite	Greece	16	66.0	8.5	2020	228	3.5	45	67	1.0	15	98	41	Papadopoulou et al. (2002)	3-day	
volleyball	elite	Australia	8	70.0	10.8	2574		4.1	44		1.6	17		36	Heaney et al. (2010)		

Note: CHO = carbohydrate, PRO = protein.
Adapted from Burke (2007).

must not stress competition levels of body composition at all times during the year. Furthermore, there are always exceptions to the rule, where players who do not conform to size and body composition standards still perform well. Detailed tables are not always easy to find or are non-existent or limited in information. However, when available, the sports dietitian can measure height, weight and, depending on time and equipment available, anthropometric skinfolds as proxies for adiposity, skinfold-corrected girths for muscle mass, and breadths and lengths for skeletal structure (Norton & Olds, 1996). High-technology body composition assessment apparatus such as dual-energy X-ray absorptiometry machines and plethysmography chambers are good for research settings but usually beyond the budget of most sports nutrition practitioners, and are not transportable. Low-cost bioimpedance analysis equipment suffers from the limitation that it estimates body composition rather than measures it, as can be deducted from the multiple-regression equations it uses (Lukaski, Johnson, Bolonchuk, & Lykken, 1985). Notwithstanding the need for practice, standardization and assessment of error or measurement, anthropometry can provide an inexpensive, transportable tool to objectively assess up to 40 variables related to body dimensions.

If an athlete must change his or her size and body composition, it must be realized that change takes time, and that these modifications must take place preferably away from the competitive season when they might interfere with tapering or sport-specific technical skills. Some sports such as professional soccer have long competition seasons that complicate the process of implementing body composition changes, thus it is advantageous if these changes take place in the youth divisions. Other sports like power-and-strength team sports allow several months per year for an improvement in muscle mass. In some positions in gridiron football, the amount of body mass (including large quantities of skeletal muscle and body fat) required to perform better might be harmful to the player's health (Jonnalagadda, Rosenbloom, & Skinner, 2001; Tucker et al., 2009), although not all authors agree (Allen, Vogel, Lincoln, Dunn, & Tucker, 2010). This presents an ethical dilemma for the sports dietitian, but it is the reality of sport.

Nutrition for training and competition

Coaches working with team sports usually plan three macro-cycles each year for their teams, consisting of pre-season training (lasting from 3 weeks in soccer to 4–5 months in rugby, for example), competition, and off-season or transition phase. Athletes in pre-season training may have high energy needs that double their resting energy requirements for twice-daily training, while during the competitive period they require less (Clark et al., 2003). Many teams stage pre-season training at a camp or residence setting away from home, and weekly-cycle menu planning is important, not only to help the athletes recover from intense training, but also because food can become one of the few sources of gratification during a tough training regimen. In our experience, we have found that: (1) menu plans that are very low in fat encourage junk-food smuggling (junk food to be eaten in dormitories); (2) if menus are too high in fruit and fibre, many gastro-intestinal episodes may occur; (3) athletes tend to prefer a more repetitive food schedule of familiar foods as opposed to abundant variety; (4) many day-to-day grievances are channelled through complaints about the menu; (5) after a week, complaints reach a peak and it is best to plan a different meal activity, like staging a hamburger and fries outdoor cookout or visiting a restaurant and eating ice-cream for dessert.

Energy expenditure and carbohydrate requirements on match days tend to be higher than on weekly training days (Burke et al., 2006), but in our experience we find that team sport athletes tend to eat less on these days because of game stress and/or the travel and match schedule altering the normal eating pattern. In sports where games are played once a week, athletes have sufficient time to recover nutritionally during the week, but some sports may play for three days in a row, with matches lasting several hours and away from home (Burke, 1995). In these instances, progressive fluid and glycogen depletion may hamper performance in the latter days of competition, thus aggressive strategies to promote adequate fluid and carbohydrate are imperative (Reilly & Ekblom, 2005). Circumstances are more difficult when travelling (on the road) where the proper selection of eating venues and menu choices must include good sources of high-carbohydrate, low-fat choices (Burke, 2007). Snacking can be a very effective way to aid nutritional recovery.

Studies on glycogen depletion in team sport athletes are scarce and difficult to carry out because coaches would rather avoid match-day distractions but one available study reported a marked glycogen depletion pattern (Bangsbo, Iaia, & Krustrup, 2007). This must be put into perspective when addressing the carbohydrate needs of weekly training as team sport members do not, on a daily basis, need the amount of carbohydrates that they would on a match day or that an endurance athlete requires. A high-carbohydrate diet can best be left for the day before a match (Williams & Serratosa, 2006), and this strategy would have to be compensated by a lower intake of protein and, more especially, fats, lest the total energy intake exceed requirements. Since the training load is tapered prior to matches, maintaining a normal carbohydrate intake can also result in adequate glycogen synthesis and subsequent supercompensation to cover match requirements.

Pre-match meals are a highly individual matter, with some stressed athletes needing a low-bulk liquid meal supplement, and others not being able to tolerate any food. In general, an easily digestible meal supplying carbohydrate sources, eaten 2–4 h before a game, seems to be the best alternative (Williams & Serratosa, 2006). Some teams prefer to add low-fat protein source to provide more satiety, but it is suggested that high-fibre foods be avoided to prevent gastrointestinal discomfort and that high-fat foods also be avoided as they may delay digestion (Williams & Serratosa, 2006). Fluid intake, like water or sports beverages, is encouraged at this stage and leading up to game time (Burke, 2007). During matches, fluid and glycogen losses can be replaced via the administration of sports beverages, and aided by other easily digested carbohydrate sources such as sports gels and bars (Mujika & Burke, 2010). This strategy can aid performance in the latter stages of the game (Williams & Serratosa, 2006), but game rules may restrict the occasions for fluid and carbohydrate intake; however, it is recommended that athletes take advantage of half-time and game-stoppage opportunities to drink and/or eat. The amount of fluid and carbohydrate recommended varies according to type of sport, positional role, weather conditions, and inter-individual differences.

Following matches, nutritional recovery strategies can start at the training table in the locker room, and include sports drinks, carbohydrate-dense drinks and/or gels, energy bars, and fruit, followed by a carbohydrate-rich meal a couple of hours later (Ryan, 2005). Ideally, co-ingestion of protein with $1.2\ g \cdot kg^{-1} \cdot day^{-1}$ carbohydrate as soon as possible after the match has been shown to accelerate protein synthesis (Howarth, Moreau, Phillips, & Gibala, 2009), and so foods and/or supplements containing both macronutrients benefit recovery (Beelen, Burke, Gibala, & van Loon, 2010). Replacement of lost fluids should aim to match amounts lost during training and competition (Rodriguez et al., 2009a, 2009b). A free day usually follows match-days in most football codes, which also allows athletes to recover further, but court and batting sports usually have two or three games on successive days, whereby recovery nutrition is indispensable. It is important that enough carbohydrates are eaten on this day, which is not very hard to accomplish with normal meals provided, as they include starches, fruits, and vegetables. However, in practice we find that many athletes eat far too little on these days or indulge in high-fat foods, preferring to sleep more or rest psychologically from a sports menu.

Dietary planning

In the process of converting energy and macronutrients into food and portions that the athlete can relate to and understand, a common problem surfaces with team sport players: if the carbohydrate dose is calculated as $7–8\ g \cdot kg^{-1} \cdot day^{-1}$, these foods also cover much of the protein requirement and leave little room. Male team sport athletes prefer to eat between 1.2 and $2.3\ g \cdot kg^{-1}$ protein daily (Tables I and II), amounts that would not allow a high carbohydrate intake on a moderate energy budget. This conundrum between sports science research and practice needs to be bridged with more modest daily carbohydrate recommendations, such as $5–7\ g \cdot kg^{-1} \cdot day^{-1}$ for team sport athletes during the competitive season. During pre-season training, these amounts can be surpassed, as energy expenditure is higher, and perhaps on game-day or the preceding day a higher-carbohydrate/lower-protein diet can be implemented. To improve athletes' understanding of portion sizes, it is useful, when circumstances permit, to employ or weigh with small inexpensive electronic kitchen scales for a few days the prescribed foods and/or to use food models.

Nutrition education strategies can be implemented at several levels, from individual counseling to team talks, fact sheets, and supermarket tours, although being present at meal venues and interacting with athletes is also effective in delivering information.

Assessing and implementing hydration strategies

In the most rudimentary conditions, weighing athletes before and after practice and identifying those exceeding 2% weight loss, a level beyond which performance can be hampered (Rodriguez et al., 2009a, 2009b), can yield important information on fluid losses. Going a step further, simple urine specific gravity (USG) measurements with a hand-held refractometer can be used to assess hydration status (Volpe, Poule, & Bland, 2009). Many athletes are known to show up for practice or games in a hypohydrated state (Burke & Hawley, 1997; Maughan & Shirreffs, 2010). Where there is more time, consuming $\sim$600 mL of water or sports drink will bring the athlete into the euhydrated zone within 30–45 min (Palmer, Logan, & Spriet, 2010). Urine specific gravity data can be plotted against published percentile standards of hydration (Armstrong et al., 2010) and players prone to dehydration can be identified. In our experience, baseline USG values for players can be obtained from regular training sessions and be used to assess hydration status where inter-individual differences exist and may not always conform to established standards.

Other techniques to assess hydration status include the use of urine colour charts (Armstrong et al., 1998), although urine colour may be confounded by intake of vitamin supplements. While it may be difficult to measure team members on match day, because coaches prefer to avoid any distractions, these data can be valuable and in our experience are often different from data obtained at friendly matches and training sessions. Sweat losses can be high when games are played in hot climates (Kurdak et al., 2010). We have found that game-day stress may alter players' drinking practices, leading to over- or under-hydration. Drinking at half-time varies widely, with some players drinking two cans of energy drink and some tentatively sipping water. Nevertheless, most adapt comfortably to half a litre or more of sports beverages. Team sports without a formal half-time break such as baseball can take advantage of time off the field to refuel with fluids. Sports teams with limited funding have had success preparing their own homemade sports drink with sugar and/or maltodextrin, table salt, water, and a flavouring agent. To identify heavy salt sweaters, training with dark-coloured clothing can be used to identify contrasting white salt stains. More sophisticated methods include the application of sweat patches to assess the extent of electrolyte loss (Shirreffs, Sawka, & Stone, 2006). Although still an issue of debate, some authors suggest that increasing salt intake may help some athletes prone to cramping (Eichner, 2007). Lastly, availability of drinking opportunities and accessibility of drinking bottles are helpful strategies in providing fluids to athletes (Murray, 2006).

Supplements and ergogenic aids in team sports

The most popular and beneficial supplements for team sports in our experience are sports beverages (Rodriguez et al., 2009a, 2009b) and caffeine (Spriet & Gibala, 2004). Creatine is also popular among team sport athletes but a controversial item to both scientists (Hespel, Maughan, & Greenhaff, 2006; Lemon, 2002) and practitioners. Creatine alone or combined with protein powders is very popular in strength-and-power sports, although some players complain about tight muscles or muscle tears when on creatine, in spite of published evidence to the contrary (Greenwood, Kreider, Greenwood, & Byars, 2003a; Greenwood et al., 2003b). As a strategy to prevent unwanted purported side-effects, European professional soccer teams sometimes supplement creatine in low doses of 2–3 $g \cdot day^{-1}$, avoiding the acute loading phase of 20 g daily for 5 days (R. Maughan, personal communication). Until further research clears many of the controversial anecdotal reports regarding this supplement, it is best to individualize creatine supplementation, targeting only players who acknowledge benefits without mischief, and to educate and advise athletes about the potential risks versus benefits.

Youth team sport athletes

Among youth athletes, one of the main concerns of parents, coaches, and managers is when a player fails to grow at the pace of his or her team-mates. The most common underlying reason is that this young athlete may be a late maturing adolescent in a competitive youth sport where a high incidence of success for early maturing athletes prevails. Assessment of maturity status using simple anthropometric measures such as height, weight, sitting height together with decimal age (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002) can aid when deciphering whether a growth problem exists or whether it is a case of late maturation. In 13- to 15-year-old soccer players, we (F. Holway, unpublished data) have found that that a difference of up to 10 kg of muscle mass can co-exist within stage two of the Tanner maturation scale (Tanner, 1981); hence we find this method of maturity assessment lacks the resolving power to identify differences in size and strength in these young athletes. Another growing concern in young athletes is overweight and obesity. Ironically, excessive intake of starches and sugars is one of the causes (Speiser et al., 2005); thus the recommendation for a high-carbohydrate diet in youth athletes must perhaps be placed in the context of the energy and carbohydrate demands of training and match-play schedules.

Conclusions

Nutrition for team sports requires knowledge of the sport-specific physiology of training and competition coupled with social skills to be able to implement dietary recommendations within the framework of a multi-professional sport science and medicine group and coaching staff. An overriding reality, even when working with team sport athletes, is that an individual approach is needed to meet each athlete's nutritional and hydration needs.

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