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Nutrition Status of Junior Elite Canadian Female Soccer Athletes

Jennifer C. Gibson, Lynneth Stuart-Hill, Steven Martin, and Catherine Gaul

Context: Adolescent female team-sport athletes are faced with the challenge of meeting nutrition requirements for growth and development, as well as sport performance. There is a paucity of evidence describing the dietary adequacy of this population in respect to these physiological demands. Therefore, the aim of this study was to comprehensively evaluate the nutrition status of junior elite female soccer athletes. ***Method:*** A total of 33 athletes (15.7 ± 0.7 yr) completed anthropometric assessment, 4-day food records analyzed for macro- and micronutrient intake, and hematological analysis. Energy expenditure was estimated using predictive equations. ***Results:*** Mean sum of 7 skinfolds was 103.1 ± 35.2 mm, and body-mass index was 22.7 ± 2.7. Mean energy intake was 2,079 ± 460 kcal/day, and estimated energy expenditure was 2,546 ± 190 kcal/day. Of the athletes, 51.5% consumed <5g/kg carbohydrate, 27.3% consumed <1.2g/kg protein, and 21.2% consumed <25% of energy intake from fat. A large proportion of athletes did not meet Dietary Reference Intakes for pantothenic acid (54.5%), vitamin D (100%), folate (69.7%), vitamin E (100%), and calcium (66.7%). Compared with recommendations for athletes, 89.3% and 50.0% of participants had depleted iron and 25-hydroxyvitamin D, respectively. ***Conclusion:*** A high proportion of players were not in energy balance, failed to meet carbohydrate and micronutrient recommendations, and presented with depleted iron and vitamin D status. Suboptimal nutrition status may affect soccer performance and physiological growth and development. More research is needed to understand the unique nutrition needs of this population and inform sport nutrition practice and research.

Keywords: adolescent, exercise physiology, assessment, diet

The 2006 FIFA "Big Count" Football Worldwide Survey revealed that 26 million women in 132 countries play soccer, with 405,000 female youth players (<18 years old) registered in Canada (FIFA Big Count, 2006). Nutrient needs are higher during adolescence than any other time in the life cycle, regardless of activity level, because of rapid gains in height and weight, development of secondary sex characteristics, and continued neural development (Otten, Hellwig, & Meyers, 2006; Petrie, Stover, & Horswill, 2004; Rosenbloom, Loucks, & Ekblom, 2006). Compared with males, female athletes may feel greater social influences to maintain a low body weight (Rosenbloom et al., 2006) and as a result may be at greater risk for restricting their energy and carbohydrate intake to suboptimal levels (Loucks, 2004; Maughan & Shirreffs, 2007; Rosenbloom et al., 2006). Female athletes are also at increased risk for iron depletion and deficiency, which may have performance and health implications (Rodriguez, DiMarco, & Langley, 2009; Rosenbloom et al., 2006).

The repeated high-intensity bouts of activity needed for soccer performance require high energy expenditure with a heavy reliance on carbohydrate as an energy source (Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Rosenbloom et al., 2006; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2001). Published nutrition research describing the dietary intake of soccer athletes (mostly in male players and adult women) has demonstrated suboptimal energy (Clark, Reed, Crouse, & Armstrong, 2003) and carbohydrate intake (Clark et al., 2003; Iglesias-Gutiérrez et al., 2005; Martin, Lambeth, & Scott, 2006). In addition, intakes of Vitamin E and D, folate, calcium, magnesium, zinc (Clark et al., 2003; Iglesias-Gutiérrez et al., 2005), vitamin A (Martin et al., 2006), and iron (Clark et al., 2003; Martin et al., 2006) have been shown to be below recommended reference ranges.

Adolescent female soccer athletes are thus faced with the complex challenge of consuming adequate nutrition to fuel sport performance, as well as growth and development (Maughan & Shirreffs, 2007; Petrie et al., 2004; Rosenbloom et al., 2006). Inadequate nutrition could compromise athletic performance, influence hormonal patterns, and affect growth and bone development (Loucks, 2004). Despite the current growing body of evidence in male soccer players, there is a paucity of nutrition assessment data in junior elite female athletes. The purpose of this study was therefore to comprehensively evaluate the nutrition status of Canadian junior elite female soccer athletes and compare this with available sport and population health nutrition recommendations.

The authors are with the School of Exercise Science, Physical and Health Education, University of Victoria, Victoria, British Columbia, Canada.

Methods

Participant Characteristics

A total of 33 female junior elite soccer athletes (15.7 ± 0.7 years, range 14.6–17.3) were recruited from teams playing at the highest regional competitive level in Victoria, British Columbia, Canada. Athlete and parental informed consent were obtained before any data collection after institutional research ethics approval from the University of Victoria Human Research Ethics Board and Biosafety Committee.

Table 1 provides participant characteristics. All participants were healthy, postmenarcheal, with no self-reported significant chronic illness, injury, or history of amenorrhea. All completed the anthropometric- and nutrition-assessment aspects of the study, and 28 participants completed the hematological analysis. The 5 participants who did not participate in the hematological assessment reported fear of the blood test or scheduling conflicts restricting their ability to attend the medical laboratory. Very few participants reported the use of dietary supplements on a regular basis (multivitamins, $n = 2$; herbal cold/flu remedy, $n = 1$; and a fatty-acid supplement, $n = 1$).

Mean sum of seven skinfolds was 103.1 ± 35.2 mm (range 46.5–181.5) and body-mass index was 22.7 ± 2.7 (range 18.3–29.0). Self-reported estimated time spent in soccer-specific sport training and competition was 12.4 ± 5.1 hr/week (range 4.5–23.5). Most participants (66.7%) reported additional physical activity and competitive sport outside of soccer, including field hockey (12.1%), track and field (15.2%), and physical education classes in school (33.3%).

Experimental Design

A descriptive, cross-sectional research design was implemented during the spring months of 2010. Using the restricted profile of the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Olds, Stewart, & Carter, 2006), height (Tanita HR 100 stadiometer), body mass (AND digital scale model FG-150K, Island Scales, Victoria, BC, Canada), and skinfold thickness at seven sites (Harpenden skinfold calipers; biceps, triceps, subscapular, supraspinale, abdominal, calf, and thigh) were collected. Anthropometrics were taken in duplicate by two Level 1 anthropometrists (1 year experience, technical error of measurement = 2.0%; 3 years experience, technical error of measurement = 1.2%). Body-mass index was determined using the formula BMI = body weight/height^2 (kg/m^2).

Table 1 Participant Anthropometric Characteristics and Self-Reported Weekly Training Volume ($n = 33$)

Variable	*M* ± *SD*	Range
Age (years)	15.7 ± 0.7	14.6–17.3
Weight (kg)	60.9 ± 8.2	48.4–76.2
Height (cm)	163.8 ± 5.9	150.7–179.7
Body-mass index (kg/m^2)	22.7 ± 2.7	18.3–29.0
Sum of seven skinfolds (mm)	103.1 ± 35.2	46.5–181.5
Training (hr/week)	12.4 ± 5.1	4.5–23.5

Energy expenditure was calculated using the protocol reported by Caccialanza, Cameletti, and Cavallaro (2007). Mean daily energy expenditure was calculated to reflect the same days for which foods consumed were recorded (1 rest day, 2 training days, and 1 game day) using the Dietary Reference Intake (DRI) method for female adolescents 9–18 years old. For the rest day a physical activity factor of 1.5 (low active) was used (Otten et al., 2006). For the 2 training and 1 competition days, the additional energy costs for soccer training (7 kcal · kg^{-1} · hr^{-1}—"soccer casual/general") and soccer games (10 kcal · kg^{-1} · hr^{-1}—"soccer competitive") were accounted for using metabolic equivalents. A mean estimated energy expenditure from the 4 days was then determined.

To assess dietary intake, participants recorded time, description, and quantity of all food, fluid, and supplements consumed during the 4 days. All participants and their parents were required to attend a group seminar where they received education from the primary investigator, a registered dietitian, regarding food recording and the estimation of portion sizes using household measures (i.e., cups, ml, oz). In addition to their food-recording sheets, participants were given a serving-size reference handout to use as a guide during recording. The 4 days of recording were nonconsecutive within a single week. Participants were encouraged to maintain their typical intake throughout the full week.

Food records were analyzed using Food Processor software (version 10.2.6, 2010, ESHA Research, Salem OR) and the 2007 Canadian Nutrient File database where possible. In cases of missing data (i.e., serving size, brand name of food item), participants were contacted by the primary investigator for clarification. Missing nutrient data were retrieved from product manufacturers' Web sites and manually added to the nutrient totals. Micronutrient supplements were omitted from dietary analysis so that intake would be representative of food sources. Total energy; carbohydrate; fiber; protein; fat; B vitamins (B_1, B_2, B_3, folate, B_5, B_6, and B_{12}); vitamins A, E, C, and D; calcium; magnesium; phosphorus; copper; zinc; and sodium were determined. Macro- and micronutrient results were compared with known DRIs for females 14–18 years old (Institute of Medicine, 2010; Otten et al., 2006) and sport nutrition recommendations (Burke, Kiens, & Ivy, 2004; Tipton & Wolfe, 2004).

Blood samples were collected from participants by a trained phlebotomist at a community medical laboratory. To control for exercise-induced influences on results, participants were asked to refrain from physical activity 24 hr before blood collection and to present in a hydrated

and fasted state. Samples were analyzed for hematology profile (hemoglobin, hematocrit, red blood cells, white blood cells, platelet count, and differentials), serum ferritin, total iron-binding capacity, transferrin saturation, 25-hydroxyvitamin D, and prealbumin at an accredited biomedical laboratory. Samples were tested in singlet, with any abnormal results repeated to verify the result. The laboratory monitored accuracy and precision of samples; assays had to be within 2 *SD* of the target value before test results were released (95% confidence limits).

The data were analyzed using SPSS (version 17.0, 2010, SPSS Inc., Chicago IL) software. All nutrition and hydration data are expressed as $M \pm SD$. Mean intakes of micronutrients were compared with DRI reference values and analyzed for significant differences using one-sample *t* tests ($p \leq .05$).

Results

Energy Balance and Physical Attributes

As seen in Figure 1, mean daily energy intake (2,079 ± 460 kcal/day, range 1,292–3,231) was significantly lower than mean estimated energy expenditure (2,546 ± 190 kcal/day, range 2,272–2,916; $p \leq .05$). The mean relative energy intake was 35 ± 10 kcal/kg, which was significantly lower than the range of 47–60 kcal/kg for adult female soccer players suggested by Martin et al. (2006; $p \leq .05$). Relative energy expenditure was 42 ± 3 kcal/kg (range 38–47).

All players reported a regular menstrual cycle. Anthropometric data collected were not suggestive of players being underweight or overly lean. When plotting athletes on height-for-age growth charts, no players fell below the 5th percentile, with 22 (67%) greater than the 50th percentile, 9 (27.3%) in the 25th to 50th percentiles, and 2 (6.0%) in the 5th to 15th percentiles (World Health Organization, 2007).

Macronutrient, Micronutrient, and Fluid Intake

Table 2 describes the mean macronutrient intake of the participants compared with DRIs for females 14–18 years of age, as well as with adult sport nutrition recommendations. Participants reported a large interindividual variability of daily fluid intake. Mean fluid intake was 2,260 ± 713 ml/day (range 779–3,586). Mean macronutrient intakes relative to body weight were 5.0 ± 1.6 $g \cdot kg^{-1} \cdot day^{-1}$ and 1.4 $g \cdot kg^{-1} \cdot day^{-1}$ for carbohydrate and protein, respectively. Compared with adult sport nutrition recommendations for carbohydrate, 17 participants (51.5%) consumed less than the recommended 5 $g \cdot kg^{-1} \cdot day^{-1}$

Table 3 describes player micronutrient intake compared with the applicable DRI values. Not one of the participants met DRI values for vitamin D and vitamin E.

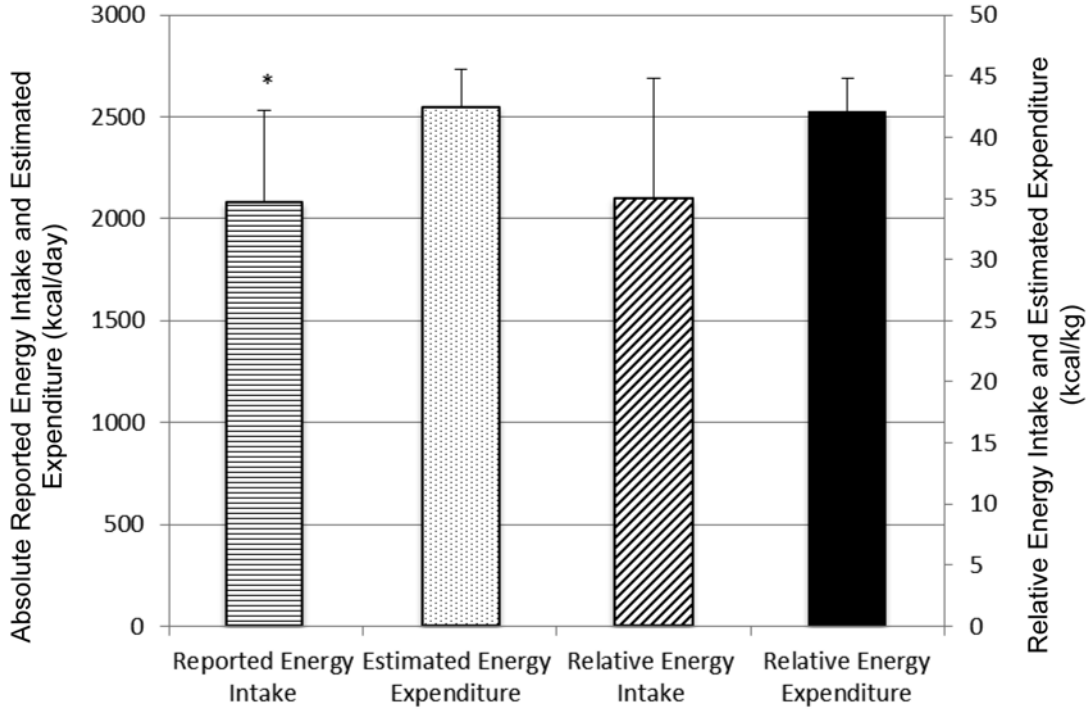

Figure 1 — Mean absolute energy intake and estimated energy expenditure, relative energy intake, and relative energy expenditure of study participants. *Significantly different then absolute estimated energy expenditure, $p \leq .05$.

Table 2 Macronutrient Intake and the Proportion of Participants Not Meeting Dietary Reference Intakes (DRIs) and Sport Nutrition Recommendations

Macronutrient	*M* (*SD*)	Range	Participants consuming <DRI, % (*n*)	DRI or sport nutrition recommendation
Carbohydrate				
total g	294 (84.8)	143–534	0 (0)	100 g[a]
fiber g	23 (19.6)	11–38	75.8 (25)	26 g/day[b]
g/kg body weight	5.0 (1.6)	2.0–9.9	51.5 (17)	5–7 $g \cdot kg^{-1} \cdot day^{-1}$,[c]
% total energy intake	56.1 (7.9)	38.0–67.7	6.1 (2)	45–65%[d]
Protein				
total g	82.2 (19.1)	44.6–122.2	—	—
g/kg body weight	1.4 (0.3)	0.8–2.3	27.3 (9); 0(0)	1.2 $g \cdot kg^{-1} \cdot day^{-1}$,[e]; 0.71 $g \cdot kg^{-1} \cdot day^{-1}$,[d]
% total energy intake	16.1 (3.3)	9.5–25.3	3.3 (1)	10–30%[d]
Fat				
total g	69 (19.6)	36–112	—	—
% saturated fat	10.1 (2.6)	6.1–16.7	36.4 (12)	<10% total energy[d]
g/kg body weight	1.2 (0.4)	0.60–2.3	—	—
% total energy intake	29.9 (5.8)	20.6–41.7	21.2 (7)	25–35%[d]

[a]DRIs: estimated average requirement (Otten et al., 2006). [b]DRIs: adequate intake (Otten et al., 2006). [c]Burke et al. (2004). [d]DRIs: acceptable macronutrient distribution range (Otten et al., 2006). [e]Tipton & Wolfe (2004).

Table 3 Player Micronutrient Intake Compared With the Applicable DRI Values

Micronutrient	Intake, *M* (*SD*)	Intake, % DRI, *M* (*SD*)	% below AI (*n*)	% below EAR (*n*)	DRI[a]
Vitamin B_1 (mg/day)	1.7 (0.8)	186.7 (89.3)	—	12.1 (4)	0.9
Vitamin B_2 (mg/day)	1.8 (0.6)	195.8 (68.3)	—	6.1 (2)	0.9
Niacin (mg/day)	17.7 (5.4)	156.6 (48.9)	—	18.2 (6)	11
Pantothenic acid (mg/day)	4.7 (1.6)	94.1 (32.4)	54.5 (18)	—	5
Vitamin B_6 (mg/day)	1.7 (0.6)	166.9 (58.7)	—	15.1 (5)	1.0
Vitamin B_{12} (µg/day)	3.1 (1.1)	152.5 (55.1)	—	21.2 (7)	2.0
Folate (µg/day)	273 (94.9)	82.9 (28.7)*	—	69.7 (23)	330
Vitamin A (µg/day)	713.9 (343.4)	147.2 (70.8)	—	27.3 (9)	485
Vitamin D (IU/day)	163.3 (94.7)	40.8 (23.7)	—	100 (33)	400
Vitamin C (mg/day)	79.6 (29.6)	251.3 (142.1)	—	15.2 (5)	56
Vitamin E (mg/day)	5.3 (2.5)	44.2 (21.2)*	—	100 (33)	12
Calcium (mg/day)	931 (351.1)	84.7 (31.9)	—	66.7 (22)	1,100
Phosphorus (mg/day)	1,237 (374.6)	117.3 (35.5)	—	27.3 (9)	1,055
Magnesium (mg/day)	303.8 (111.3)	101.3 (37.1)	—	47.5 (16)	300
Iron (mg/day)	16.2 (5.9)	205.0 (74.3)	—	6.1 (2)	7.9
Zinc (mg/day)	9.5 (2.9)	129.9 (40.3)	—	21.2 (7)	7.3
Copper (µg/day)	1,399.7 (469.0)	204.3 (68.5)	—	3.0 (1)	685

Note. DRI = Dietary Reference Intake; AI = Adequate Intake; EAR = Estimated Average Requirements. Dietary intake of micronutrients relative to DRI.

[a]For females 14–18 years old (Otten et al., 2006; Institute of Medicine (2010).

*Mean intake significantly lower than DRI, $p \leq .05$.

Furthermore, a substantial proportion of participants did not meet their DRI for magnesium (47.5%), phosphorus (27.3%), vitamin A (27.3%), vitamin B_{12} (21.2%), and zinc (21.2%).

Hematological Assessment

Mean serum hematological results are provided in Table 4 and are compared with clinical reference values (LifeLabs Inc., 2010). Because of limitations with blood analysis, total iron-binding capacity, transferrin saturation, and plasma iron level were analyzed for only 16 participants, and prealbumin status was assessed in only 23. A small proportion of participants had measures below the reference values for hemoglobin (3.6%), hematocrit (3.6%), red blood cells (7.1%), white blood cells (3.6%), serum ferritin (7.1%), and transferrin saturation (25%).

Discussion

The current study is the first comprehensive assessment of the nutrition status of junior elite Canadian female soccer players. The findings of this study identify important nutrition inadequacies in adolescent female soccer athletes. Although there is a paucity of research in female youth soccer players with which our findings can be compared, the results from this investigation can be used to inform future research in this population and the development of specific sport nutrition guidelines.

Energy Balance

The results from this study reveal mean daily energy intake of the players to be consistent with findings in adult female soccer athletes (Clark et al., 2003; Martin et al., 2006). Players had a mean energy deficit of 462 ± 549 kcal. The mean relative energy intake (35 ± 10 kcal/kg) was also significantly lower than the range of 47–60 kcal/kg for adult female soccer players suggested by Martin et al. (2006; $p \leq .05$). These data are also similar to those reported by Heaney, O-Connor, Gifford, and Naughton (2010), who found suboptimal relative energy intakes in adolescent female water polo (40 ± 14 kcal/kg), volleyball (36 ± 18 kcal/kg), and netball athletes (40 ± 14 kcal/kg). Although it is tempting to conclude that players were not in energy balance, underreporting of dietary intake has been previously identified in adolescent athletes, and overestimation of energy expenditure can occur with predictive equations (Caccialanza, Cameletti & Cavallaro, 2007). All players reported a regular menstrual cycle, and the anthropometric data collected were not suggestive of players' being below age-for-height population ranges, underweight, or overly lean.

Macronutrient Intake

Carbohydrate is the primary fuel used in soccer performance, and a daily intake of 5–7 g/kg has been suggested for adult soccer athletes to meet the needs of activity, as well as recovery from training (Burke et al., 2004; Maughan & Shirreffs, 2007; Rosenbloom et al., 2006). In the current study, 51.5% of players consumed less than 5 g/kg, which concurs with previously reported intakes in adult female players (Clark et al., 2003; Martin et al., 2006), adolescent male soccer athletes (Iglesias-Gutiérrez et al., 2005), and adolescent female athletes in other sports (Heaney et al., 2010). The carbohydrate demands of normal adolescent growth and development in the adolescent players of the current study may further exacerbate the insufficiency of their reported carbohydrate intake.

The repeated high-intensity bouts of activity needed for soccer performance indicate a heavy reliance on carbohydrate as an energy source (Rico-Sanz et al., 1999; Zehnder et al., 2001). Rico-Sanz et al. (1999) found a net muscle glycogen depletion of 36% during a soccer-specific fatigue test in elite male adolescent soccer

Table 4 Participants' (*n* = 28) Hematological Parameters of Iron-Related Indices, Vitamin D, and Prealbumin

Parameter	*M* (*SD*)	% Below normal range (*n*)	Reference value[a]
Hemoglobin (g/L)	130.2 (8.1)	3.6 (1)	117–149
Hematocrit	0.39 (0.02)	3.6 (1)	0.35–0.44
Red blood cells ($\times 10^{12}$/L)	4.36 (0.29)	7.1 (2)	4.00–4.87
White blood cells ($\times 10^{9}$/L)	6.5 (1.7)	3.6 (1)	3.9–10.2
Serum ferritin (µg/L)	22.5 (9.2)	7.1 (2)	12–83
Total iron-binding capacity (µmol/L)[b]	59.6 (9.9)	0	32–72
Transferrin saturation (%)[b]	0.28 (0.10)	25 (4)	0.2–0.55
Plasma iron (µg/L)[b]	17.8 (7.0)	6.2 (1)	10–33
25-hydroxyvitamin D (nmol/L)	75.4 (18.5)	0	25–135
Prealbumin (mg/L)[c]	261.8 (26.5)	0	150–360

[a]LifeLabs Inc., 2010. [b]Measured in 16 participants. [c]Measured in 23 participants.

athletes. Suboptimal carbohydrate intake could result in premature muscle glycogen depletion during training or competition, as well as insufficient glycogen resynthesis after exercise, leading to compromised performance (Rico-Sanz et al., 1999; Zehnder et al., 2001). Zehnder et al. found that a habitual intake of 4.8 ± 1.8 g · kg^{-1} · day^{-1} replenished only ~90% of muscle glycogen stores to pretest levels in adolescent male elite players. Optimizing carbohydrate intake is an important consideration for training and meeting the needs for youth soccer tournaments, which frequently have several matches scheduled in a single day (Rico-Sanz et al., 1999; Rosenbloom et al., 2006; Zehnder et al., 2001).

In this study, 27.3% of participants consumed less than 1.2 g · kg^{-1} · day^{-1} of protein. Protein intake of 1.2–1.7 g · kg^{-1} · day^{-1} has been suggested as a guideline for soccer athletes and those involved in intermittent high-intensity sport to support muscle protein synthesis and repair (Boisseau, Vermorel, Rance, Duché, & Patureau-Mirand, 2007; Tipton & Wolfe, 2004). Protein is a critical macronutrient needed in adolescent athletes to help accommodate rapid growth and development, stimulate lean-tissue growth and remodeling, and provide a potential energy source for performance (Boisseau et al., 2007; Petrie et al., 2004). Consequently, dietary consultation aimed at optimizing protein intake is likely warranted in this adolescent athlete population.

When examining fat intake relative to total energy intake, we found that 21.2% of the players in this study consumed less than the DRI macronutrient distribution range (25–35% of total energy intake) and may benefit from dietary counseling (Otten et al., 2006). Dietary fat helps with the absorption of critical fat-soluble vitamins and carotenoids. It provides an essential fuel source for the aerobic training and competition demands of soccer performance, as well as the increased growth needs of adolescents (Petrie et al., 2004).

Micronutrient Intake

An important finding of this study was the high proportion of athletes with micronutrient intakes below DRI recommendations. Pantothenic acid and folate are critical B vitamins involved in energy metabolism, red blood cell production, protein synthesis, and tissue repair and maintenance (Rodriguez et al., 2009). Deficiencies in folate have been linked to reductions in endurance performance and anemia (Rodriguez et al., 2009).Vitamin E is a powerful antioxidant that plays a critical role in cell-membrane protection from oxidative damage (Rodriguez et al., 2009).

None of the athletes in this study met the 2010 DRI for vitamin D intake (Institute of Medicine, 2010). It is well known that in northern latitudes, seasonal variations in serum vitamin D occur. Previously, vitamin D insufficiency has been demonstrated in young Canadian women irrespective of diet (Vieth, Cole, Hawker, Trang, & Rubin, 2001). Willis, Peterson, and Larson-Meyer (2008) suggest a circulating concentration of 75–80 nmol/L to support optimal health and disease prevention. When this recommendation is applied to the current study, only half of the participants reached optimal values and none met DRI levels. Calcium and vitamin D are involved in the development, maintenance, and repair of bone, as well as regulation of muscle contraction, blood clotting, and nerve conduction (Rodriguez et al., 2009). Inadequate intake could place these adolescent female athletes at risk for lower bone-mineral density and for stress fractures (Rodriguez et al., 2009). Seasonal serum vitamin D screening, nutrition education aimed at increasing dietary intake of vitamin D, and medically supervised supplementation are likely warranted during this time.

Hematological Assessment of Iron Status

Hematological analyses revealed that most athletes in the current study were within normal clinical ranges. Although controversial, research has demonstrated improved performance markers with iron supplementation in depleted athletes with serum ferritin levels of <20 µg/L and <35 µg/L (Hinton, Giordano, Brownlie, & Haas, 2000). When applying these cutoff values to the current results, most athletes (89.3%) had serum ferritin values <35 µg/L, and almost half (46.4%) had values <20 µg/L.

Female adolescent athletes are at high risk for iron depletion and deficiency because of the combination of high iron turnover required for growth, loss from menses, suboptimal dietary intake of energy and iron, and the requirements from intense physical training (Nielsen & Nachtigall, 1998). Because iron is involved in many essential functions (oxygen storage and transport, energy production and metabolism, and immune and central nervous system function), the athletes in the current study could be candidates for high-iron diet interventions and, in some individual cases, supplementation (Nielsen & Nachtigall, 1998). Iron status in adolescent females may be confounded by increased plasma volume with growth spurts, training responses such as inflammation, dietary intake of iron, and acute and chronic disease (Woolf et al., 2009). Assessment of stage of pubertal development in addition to using more robust iron measures (i.e., transferrin-transceptor index) could be employed in future studies.

The findings from this study provide valuable insight into the nutritional status of junior elite female soccer athletes, but there are several limitations to the study. Longitudinal measurement of anthropometrics, dietary intake, and hematological parameters would help better inform our understanding of athlete nutrition status and how phase of training season affects these variables. Because of limitations with blood analysis, the low number of samples tested for total iron-binding capacity, transferrin saturation, and plasma iron level restrict the generalizability to the entire group. When using a dietary-recall method, errors such as underreporting, recall bias, change of habitual intake, and noncompliance can occur (Bingham, 1985). Using weighed-food records, a longer period of time for food recording, and

repeated measures of dietary quantitative measures of energy expenditure (indirect calorimetry, pedometers, or accelerometry) could also increase accuracy of energy-intake and -expenditure data.

Conclusion

The dietary intake of female adolescent soccer athletes must serve the dual purpose of fueling growth and development, as well as optimal performance (Petrie et al., 2004; Rosenbloom et al., 2006). Given the large proportion of participants with suboptimal intake of vitamin D and calcium, as well as low serum hydroxyvitamin D, more robust measures of bone development, such as dual-energy X-ray absorptiometry, would be warranted. In addition, hematological assessment of sex hormones and assessment of pubertal stage could offer more in-depth assessment of the sexual development of these athletes.

A high proportion of athletes had poor serum iron storage and hydroxyvitamin D status and did not meet sport nutrition or DRI recommendations for macro- and micronutrients. Although soccer performance was not directly assessed in this study, these findings suggest that players had suboptimal sport nutrition practices, which could affect energy metabolism, immune function, and fuel availability, all of which are needed to optimize soccer performance and recovery.

The evidence from this study supports the recommendation for nutritional and hematological screening of adolescent female athletes. Targeted nutrition monitoring could lead to enhanced training adaptations and performance, as well as improved nutrition status into adulthood. Interpretation of data in this population is limited by a lack of population-specific guidelines for young female players. However, additional research involving female adolescent soccer athletes is recommended to support these preliminary findings and develop a strong base of evidence on which to formulate dietary recommendations specific to this population. With the growing number of female soccer athletes worldwide, a better understanding of the unique needs of this population is essential to inform sport nutrition practice, enhance performance, and maintain the health of these developing athletes.

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