Evaluation of Nutritional Intake in Canadian High-Performance Athletes

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Objective: To determine the nutritional intake of Canadian high-performance athletes.

Design: Prospective survey study.

Setting: Canadian sport center athletes.

Participants: Three hundred twenty-four high-performance athletes (114 males and 201 females; mean age 21.3 ± 13 years) from 8 Canadian sport centers participated in the study.

Intervention: Subjects prospectively completed 3-day dietary records, reporting all food, fluid, and supplement consumption.

Main Outcome Measures: Dietary records were analyzed for total calories, macronutrients, and micronutrients for food alone and food plus supplements for all subjects collectively and according to gender and competitive event.

Results: Average daily energy intake was 2533 ± 843 Kcal/day with males consuming more calories than females (2918 ± 927 and 2304 ± 713 Kcal/day, respectively; $P < 0.05$). Both genders consumed below recommended levels. Carbohydrate, protein, and fat accounted for 53%, 19%, and 28% of daily calorie intake, respectively. Average daily carbohydrate and protein intake was 5.1 ± 1.8 and 1.8 ± 0.6 g/kg body weight, respectively. Protein intake, but not carbohydrate intake, met recommendations. Supplementation significantly increased athletes' energy, total carbohydrate, protein, and fat intake. Of 17 micronutrients assessed, intake ranged between 120% and 366% of recommended daily intake with food alone and between 134% to 680% of recommended daily intake with supplements.

Conclusions: Canadian high-performance athletes do not consume adequate energy or carbohydrates. However, their intake of micronutrients exceed current recommended daily intakes, even when supplements are not considered, indicating that athletes make high-quality food choices. Supplementation significantly increased energy, macronutrient, and micronutrient intake.

Key Words: dietary intake, macronutrients, micronutrients, athletes, Canadian

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INTRODUCTION

Appropriate nutrition through adequate dietary intake of total calories, macronutrients, and micronutrients is an essential component of optimizing the performance of all elite athletes. However, previous studies have reported that elite athletes from various countries and from different competitive events are often deficient in their intake of total calories, carbohydrate, protein, and micronutrients.[1–6] The dietary intake of Canadian elite athletes has not been adequately assessed. From unpublished data of dietary evaluations of 50 Canadian national team speed skaters between 2003 and 2004, 26 athletes were found to consume inadequate amounts of calcium, iron, and vitamins A and D.[7] In addition to potentially inadequate intake of nutrients, it is well known that Canadian athletes often consume dietary supplements without knowledge of a true deficiency in macro- or micronutrients to justify these supplementation practices.[8,9] To compensate for real or perceived inadequacies in performance or health, competitive athletes commonly consume dietary supplements in an effort to enhance performance and health.[8–13] No previous studies have determined the effect of dietary supplements on dietary intake of elite athletes in Canada.

Therefore, the purpose of this study was to determine the nutritional intake (with and without supplements) of Canadian elite athletes. This information will assist dietitians, physicians, and coaches in properly counseling athletes regarding their dietary intake.

METHODS

Participants and Methods

This study was approved by the University of Calgary Conjoint Bioethics Committee. Elite male and female subjects were recruited from 8 Canadian sport centers (Greater Vancouver, Greater Victoria, Calgary, Saskatchewan, Manitoba, Montreal, Ontario, and Atlantic, Canada). Subjects were considered elite if they were affiliated with a Canadian sport center. Acquiring this affiliation is contingent on athletes competing at least at a national, but usually at an international, level. Dietitians from each of eight Canadian sport centers invited athletes to consider participating in this study during nutrition workshops or during individual nutrition consultations. After an explanation of the study, athletes agreeing to participate in the study signed informed consent. Subjects completed a basic demographic questionnaire, including identifying their sport and the number of times that they had previously consulted a dietitian. Subjects prospectively completed a 3-day dietary log of all foods and beverages that were consumed (including supplements). For the purpose of this study, supplements were defined according to the 1994 Dietary Supplement Health and Education Act as an orally consumed product intended to supplement dietary intake. More specifically, the definition of dietary supplements by the Dietary Supplement Health and Education Act includes: vitamins, minerals, herbs or botanicals, amino acids, enzymes, organ tissues, glandulars, metabolites, extracts, or concentrates. Supplements could be in the form of tablets, capsules, liquids, powders, bars, soft gels, or gel caps.[14]

Subjects were given verbal and written instructions for completion of their dietary log, including pictures of serving sizes. The validity and reliability of this type of dietary review has been previously reported.[15] Subjects were also asked to document how their food was prepared (eg, boiled, fried, and so on), the time of day that they ate, and their use of condiments.

Subjects returned their food records to the dietitian affiliated with their sport center who then forwarded the records to the study coordinator (coauthor, K.A.E.). Food records were analyzed by two research assistants using Food Smart nutrition software (Version 2, Envision Health Networks Inc, North Vancouver, British Columbia, Canada) for the following: 1) total caloric intake; and 2) total macronutrient intake (protein, carbohydrate, fat, and fiber) and total micronutrient intake (nine vitamins and eight minerals). Intake was analyzed for food alone and food plus supplements based on all subjects, gender, and type of competitive event. Based on recommendations of an exercise physiologist, sports were grouped into one of four types of competitive events: power, intermittent, judged, and endurance. Power events were considered as competitive events of less than 3 minutes in duration with a substantial rest interval (eg, sprinting and ice hockey). Intermittent events were defined as stop–start sports such as basketball and volleyball. Judged sports included gymnastics, figure skating, and so on, whereas endurance sports were competitive events that exceeded 3 minutes, nonstop duration.

Data Analysis

The data were analyzed with the Statistical Package for Social Sciences (Version 15.0; SPSS Inc., Chicago, Illinois). Descriptive analysis was performed on subject baseline information. Paired independent *t* tests were used to compare the mean food intake of males versus females as well as for comparisons of food versus food plus supplements for all subjects, males, and females. Analysis of variance and subsequent post hoc testing with Tukey honestly significant difference were used to compare the dietary intakes of the 4 competitive events.

RESULTS

Participant Characteristics

A total of 324 subjects completed the 3-day diet logs. Food records were collected from February 2006 to April 2007. Subject characteristics, based on all subjects, gender, and competitive event type, are presented in Table 1. The average age of the subjects was 21.3 ± 13 years, which was not significantly different between genders and between competitive events except for judged sports, in which the average age was significantly younger at 16.7 ± 4.1 years. Male subjects were significantly heavier and taller compared with female subjects ($P < 0.05$). Judged sport athletes were significantly lighter compared with other competitive event athletes ($P < 0.05$). Endurance-trained subjects reported significantly more daily training hours relative to the other competitive event categories. A total of 172, 41, 68, and 26 athletes competed in power, intermittent, judged, and endurance-type competitive events, respectively. A list of all sports according to competitive event type is presented in Table 2. Athletes in endurance sports trained significantly more hours (6.3 ± 4.2 hours) compared with the other competitive events. The number of athletes participating from each Canadian sport center was: Greater Victoria (8), Greater Vancouver (11), Calgary (107), Saskatchewan (12), Manitoba (2), Montreal (110), Ontario (60), and Atlantic (14).

Dietary Analysis

The caloric intake of athletes according to all subjects, gender, and competitive event type with and without supplements is summarized in Table 3. The average daily caloric intake of all subjects without supplements was 2533 ± 843 Kcal/day. Of the 324 subjects, 251 (77.5%) reported taking supplements.

Dietary supplementation significantly increased the average caloric intake reported by subjects. Males consumed

TABLE 1. Characteristics of Study Participants: All Subjects by Gender and by Competitive Event (CE)

	N	Age (y)	Height (cm)	Weight (kg)	Hours Training per Day
All subjects	324	21.3 (13.0)	173.3 (9.1)	68.4 (11.6)	5.5 (3.1)
Females only	201	21.5 (15.8)	169.8* (7.2)	64.5* (9.1)	5.5 (3.0)
Males only	114	21.0 (5.5)	180.0* (8.4)	75.8* (11.8)	5.5 (3.4)
CE–power	172	22.3* (4.8)	174.5 (8.9)	71.3* (11.2)	5.7* (3.1)
CE–intermittent	41	20.2* (6.6)	174.2 (8.8)	67.0* (9.8)	4.8* (3.2)
CE–judged	68	16.7* (4.1)	170.5 (9.2)	63.1* (11.4)	5.0* (2.7)
CE–endurance	26	20.9* (4.3)	170.9 (8.7)	64.8* (11.4)	6.3* (4.2)

Values are reported as mean (standard deviation). CE category n = 307; age n = 286; weight n = 304; height n = 299; gender n = 315.

*A significant difference ($P < 0.05$) for weight and height differences between genders; weight differences between judged sports and all other CEs; daily training hour differences between endurance sports and other CEs.

TABLE 2. Categorization of Sports Into Competitive Events and Number of Subjects (in Parentheses) for Each Particular Competitive Event and Sport

Competitive Event Type	Sport
Power (172)	Soccer (49), hockey (31), long-track speed skating (19), alpine ski (16), some athletics (14), short-track speed skating (13), swimming (8), luge (8), skeleton (6), wrestling (4), bobsleigh (1), rugby (1), sprint cycling (1), weightlifting (1)
Intermittent (41)	Volleyball (20), basketball (10), beach volleyball (4), squash (2), racquetball (2), softball (2), rugby (1)
Judged (68)	Figure skating (16), snowboard (13), gymnastics and trampoline (10), freestyle ski-aerials (8), curling (6), tae kwon do (6), ski jumping (5), archery (4)
Endurance (26)	Rowing (8), kayak (3), some athletics (3), biathlon (3), sailing (2), triathlon (2), mountain bike (2), cross-country ski (2), pentathlon (1)

significantly more calories compared with females relative to diet alone and diet with supplementation ($P < 0.05$). Three different methods were used to estimate the recommended daily caloric intake using average height, weight, and gender of the subjects (Table 3). The caloric intake of both male and female subjects fell below the estimated daily energy requirements, even with dietary supplementation.[16–18] When compared by competitive event, endurance sport athletes consumed significantly fewer calories than the other 3 competitive events with supplementation.

Macronutrient intake (Table 4) is presented as absolute intake (in grams), intake relative to body mass (grams per kilogram per day), and as a percent contribution to total energy intake. On average, without supplements, carbohydrates, protein, and fat intake accounted for 53.3% ± 7.5%, 18.9% ± 4.1% and 27.5% ± 6.1% of total caloric intake. When considered relative to body weight, intake of carbohydrate and protein without supplements was 5.1 ± 1.8 and 1.8 ± 0.6 g/kg per day, respectively. Supplement use significantly increased the intake of carbohydrate (expressed as percent of total calories and grams per kilogram per day), protein (total grams, percent of total calories, and grams per kilogram per day), and fat (total grams). Analysis of diet with supplements revealed a significant gender difference for absolute grams of fat, protein, and carbohydrate as well as protein expressed as grams per kilogram per day. Athletes in power events had the greatest intake of percent fat (diet alone) and total amount of dietary protein (diet alone). Endurance-trained subjects consumed significantly more percent carbohydrates (diet and diet with supplements) compared with the other events. Athletes from judged sports were found to have low intakes of dietary fiber both with and without supplementation.

Vitamin and mineral intakes are presented in Tables 5 and 6, respectively, according to all subjects and gender and by competitive event in Tables 7 and 8. Vitamin consumption ranged from 217.8% to 365.5% (B3 and vitamin C, respectively) of the recommended daily intake (RDI)[19] with food alone. When analyzed with supplements, vitamin intake ranged from 239.5% to 680.4% (vitamin A and vitamin B12, respectively) of the RDI. Intake of minerals ranged from 120.1% and 232.1% (calcium and phosphate, respectively) of the RDI with food alone. When analyzed with supplements, mineral intake ranged from 134.4% and 451.1% (calcium and zinc, respectively) of the RDI. With the exception of vitamins B1, B2, B6, and B12, there was a significant increase in the intake of all vitamins and minerals when analyzed with supplements. From diet alone, females consumed significantly less sodium, potassium, phosphorus, selenium, and vitamins B2, B3, B6, B9, C, and D than males. Of the different competitive events, athletes in power events consumed significantly greater amounts of sodium, potassium, magnesium, selenium, and vitamins B9 and B12 from dietary intake without supplements. Judged and endurance athletes consumed the lowest amount of iron, sodium, potassium, zinc, selenium, and vitamin B9 from diet alone. Supplementation resulted in significantly greater intakes of sodium, potassium, phosphorus, selenium as well as vitamins A, C, and B3 for the power event athletes.

DISCUSSION

This is the first study to prospectively assess the nutritional intake of a large cross-section of Canadian elite athletes. Moreover, this is the first study to examine the

TABLE 3. Average Daily Caloric Intake for Food Alone (F) and Food with Supplements (F+S) for All Subjects, Gender, and Competitive Event Type

	F or F+ S	All Subjects	Females Only	Males Only	Competitive Event			
					Power	Intermittent	Judged	Endurance
Caloric intake, Kcal/day†	F	2532.5 (843.2)	2303.6* (712.6)	2918.1* (926.7)	2611.1 (915.0)	2647.8 (752.8)	2395.7 (786.2)	2190.1 (710.7)
Caloric intake, Kcal/day†	F+S	2652.4 (883.7)	2403.7* (726.7)	3077* (987.0)	2773.6* (953.7)	2737.5* (818.9)	2456.4* (798.2)	2244.5* (746.0)
DRI,[18] requirements, Kcal/day†	F		2811.5	3421.7				
FAO/WHO,[16] requirements, Kcal/day†	F		2888.3	3677.5				
Harris-Benedict,[17] requirements, Kcal/day†	F		2673.4-2970.4	3359.3-3732.5				

Values are reported as mean values (standard deviation).
*A significant difference ($P < 0.05$) for females compared with males and endurance sports compared with all other sports.
†1 kJ = 4.2 kcal.

TABLE 4. Average Daily Macronutrient Intake for Food Alone (F) and Food with Supplements (F+S) for All Subjects, Gender, and Competitive Event Type

Macronutrient	F or F+S	All Subjects	Females Only	Males Only	Competitive Event–Power	Competitive Event–Intermittent	Competitive Event–Judged	Competitive Event–Endurance
CHO, g	F	344.5 (122.9)	318.8 (106.6)	389.1 (139.9)	344.9 (133.1)	372.1 (116.5)	338.9 (115.4)	315.1 (106.9)
	F+S	364.3 (124.7)	336.9* (109.8)	412.9* (144.9)	371.4 (138.1)	387.0 (125.6)	351.1 (114.9)	321.5 (111.7)
CHO, %	F	53.3 (7.5)	53.9 (7.4)	52.5 (7.8)	51.9* (7.3)	55.0* (6.5)	54.5* (8.3)	56.4* (6.5)
	F+S	53.9 (7.3)	54.7 (7.2)	52.8 (7.4)	52.7* (7.3)	55.3* (6.0)	55.5* (7.7)	56.1* (6.4)
CHO, g/kg	F	5.1 (1.8)	5.1 (1.8)	5.3 (1.9)	4.9* (1.7)	5.7* (1.8)	5.5* (1.9)	4.9* (1.7)
	F+S	5.4 (1.8)	5.3 (1.8)	5.6 (1.9)	5.3 (1.8)	5.9 (2.0)	5.7 (1.9)	5.0 (1.8)
Protein, g	F	120.4 (42.1)	106.5* (30.2)	143.6* (49.5)	126.9* (44.2)	120.1* (42.6)	108.6* (34.8)	102.8* (42.0)
	F+S	129.8 (53.2)	114.7* (46.9)	155.4* (55.1)	137.1 (49.8)	125.2 (45.0)	120.2 (67.6)	108.8 (48.9)
Protein, %	F	18.9 (4.1)	18.6 (3.9)	19.6 (4.3)	19.5 (4.2)	17.8 (3.0)	18.2 (3.7)	18.4 (5.3)
	F+S	19.2 (4.4)	18.6 (4.3)	20.1 (4.5)	19.8 (4.5)	18.0 (3.1)	18.3 (4.2)	18.9 (5.6)
Protein, g/kg	F	1.8 (0.6)	1.7 (0.5)	1.9 (0.6)	1.8 (0.5)	1.8 (0.6)	1.8 (0.6)	1.6 (0.6)
	F+S	1.9 (0.6)	1.8* (0.5)	2.1* (0.7)	1.9 (0.6)	1.9 (0.6)	1.8 (0.7)	1.7 (0.6)
Fat, g	F	80.1 (36.1)	72.8* (32.0)	92.1* (39.8)	85.7* (39.7)	81.8* (29.8)	72.6* (32.0)	63.4* (27.1)
	F+S	81.7 (36.6)	74.0* (32.0)	94.5* (40.8)	87.8* (40.2)	83.1* (30.3)	73.4* (32.5)	64.4* (27.0)
Fat, %	F	27.5 (6.1)	27.4 (6.0)	27.6 (6.3)	28.6* (6.0)	27.2* (5.5)	26.4* (5.8)	25.1* (6.6)
	F+S	26.8 (5.8)	26.7 (5.9)	26.8 (5.8)	27.6 (5.8)	26.7 (5.1)	25.8 (5.6)	25.0 (6.5)
Fiber, g	F	26.2 (12.6)	24.8 (11.2)	28.5 (14.5)	27.7* (12.9)	29.2* (14.6)	21.0* (7.2)	25.3* (14.2)
	F+S	26.9 (12.8)	25.4 (11.5)	29.4 (14.6)	28.6* (13.0)	29.6* (15.0)	21.2* (7.4)	25.9* (14.6)

Values are reported as mean values (standard error).
*A significant difference ($P < 0.05$) in carbohydrate (percent of total calories and g/kg per day), protein (total grams, percent of total calories, and g/kg per day), and fat (total grams) intake between F and F+S; gender differences for absolute grams of fat, protein, and carbohydrate and protein (g/kg per day); power event athletes compared other CEs for percent fat and percent CHO; endurance sports for total dietary protein (grams) and fat (grams); power and endurance subjects for CHO (g/kg) compared with other CEs; dietary fiber intake for judged sports compared with all other CEs.

impact of dietary supplementation on the nutritional intake of elite athletes.

Previous studies examining the nutritional intake of elite athletes have generally focused on athletes in a specific sport. Two studies, however, have studied a cross-section of multiple sports at one time: Australian and National Collegiate Athletic Association Division I collegiate athletes.[1,2,20] These studies form the basis for

TABLE 5. Average Daily Vitamin Intake for Food Alone (F) and Food with Supplements (F+S) for All Subjects and by Gender

Vitamins	F or F+S	All Subjects Absolute	All Subjects %RDI	Females Only Absolute	Females Only %RDI	Males Only Absolute	Males Only %RDI
A, RE	F	1997.4 (88.4)	223.6 (9.5)	2065.5 (118.8)	229.0 (12.5)	1897.4 (137.3)	216.4 (15.6)
	F+S	2157.3 (9.9)	239.5 (10.0)	2167.8 (125.2)	238.0 (13.2)	2160.5 (148.5)	244.6 (16.5)
B1, mg	F	3.1 (0.6)	222.2 (5.4)	3.2 (1.0)	212.2* (6.3)	2.9 (0.2)	237.5* (10.0)
	F+S	7.3 (1.4)	479.6 (56.8)	6.1 (1.6)	383.3* (47.5)	9.7 (2.5)	658.5* (136.6)
B2, mg	F	2.6 (0.1)	229.8 (5.5)	2.4* (0.1)	225.8* (6.5)	3.0 (0.1)	237.1* (10.6)
	F+S	7.8 (1.4)	505.2 (55.0)	6.5 (1.7)	424.4* (49.7)	10.3 (2.5)	658.1* (128.5)
B3, NE	F	32.0 (0.8)	217.8 (5.0)	28.5* (0.8)	204.5* (5.5)	37.7 (1.6)	239.7* (10.1)
	F+S	40.1 (1.7)	271.8 (11.4)	35.6 (2.0)	254.6* (14.5)	47.9 (3.1)	301.3* (19.3)
B6, mg	F	2.8 (0.1)	225.4 (6.7)	2.5* (0.08)	203.9* (7.9)	3.3 (0.2)	259.8* (11.7)
	F+S	9.7 (1.4)	630.8 (61.2)	8.1 (1.7)	514.1* (60.2)	12.7 (2.6)	834.7* (135.6)
B9, μg	F	510.0 (11.6)	NA	475.7* (12.8)	NA	561.2* (22.7)	NA
	F+S	774.0 (26.5)	NA	691.7* (28.9)	NA	899.7* (51.3)	NA
B12, μg	F	5.8 (0.3)	236.9 (9.4)	4.9* (0.3)	204.7* (10.7)	6.9* (0.4)	290.3* (17.2)
	F+S	20.9 (3.5)	680.4 (48.5)	19.9 (5.3)	566.6* (53.8)	22.4 (3.1)	854.7* (93.8)
C, mg	F	272.7 (10.4)	365.5 (14.1)	256.4 (12.9)	367.6 (19.2)	300.9 (18.0)	363.3 (21.2)
	F+S	464.2 (22.6)	586.7 (25.2)	440.3 (30.0)	578.2 (33.7)	510.2 (35.7)	607.7 (39.8)
D, μg	F	202.3 (11.6)	NA	172.2 (13.3)	NA	252.6 (21.6)	NA
	F+S	222.1 (13.3)	NA	184.8* (15.0)	NA	286.3* (25.7)	NA

Values are reported as mean values (standard error).
*A significant difference ($P < 0.05$) for females compared with males only.
RDI, recommended daily intake; NA, information not available.

TABLE 6. Average Daily Mineral Intake for Food Alone (F) and Food with Supplements (F+S) for All Subjects and by Gender

		All Subjects		Females Only		Males Only	
Minerals	F or F+S	Absolute	%RDI	Absolute	%RDI	Absolute	%RDI
Calcium, mg	F	1300.1 (40.1)	120.1 (4.0)	1239.6 (53.3)	113.2 (5.1)	1410.7 (67.6)	132.1 (6.6)
	F+S	1454.6 (42.7)	134.4 (4.2)	1375.5 (55.5)	125.9 (5.4)	1599.9 (69.2)	149.3 (7.1)
Iron, mg	F	20.2 (0.4)	171.3 (6.0)	18.8* (0.5)	117.9* (3.8)	22.6* (0.8)	257.7* (9.7)
	F+S	29.7 (2.0)	217.3 (8.1)	30.4* (3.2)	155.1* (8.1)	28.4* (1.2)	319.0* (12.5)
Sodium, mg	F	3543.4 (81.8)	NA	3290.5 (96.1)	NA	3927.3 (146.1)	NA
	F+S	3630.7 (85.7)	NA	3358.3* (99.6)	NA	4054.7* (155.4)	NA
Potassium, mg	F	4196.6 (89.4)	NA	3893.6* (99.5)	NA	4695.4* (169.6)	NA
	F+S	4376.6 (92.1)	NA	4038.4* (101.9)	NA	4947.7* (174.2)	NA
PO4, mg	F	1900.1 (41.2)	232.1 (6.6)	1724.0* (43.5)	204.2* (6.7)	2192.4* (79.8)	277.2* (13.3)
	F+S	2013.2 (43.9)	247.6 (7.2)	1808.4* (45.0)	215.9* (7.1)	2357.3* (85.6)	299.8* (14.4)
Zinc, mg	F	15.1 (0.5)	156.5 (3.4)	13.4 (0.6)	150.5 (4.0)	17.9 (0.7)	164.2 (6.4)
	F+S	43.4 (2.9)	451.1 (29.0)	33.9* (3.0)	403.4 (36.3)	58.5* (5.8)	523.0 (49.5)
Mg, mg	F	463.3 (15.9)	133.7 (4.8)	436.3 (21.9)	135.7 (7.1)	510.5 (22.6)	130.9 (5.7)
	F+S	532.6 (18.8)	151.9 (5.6)	492.8 (25.4)	152.3 (8.2)	602.7 (27.8)	151.7 (6.5)
Selenium, μg	F	117.1 (2.8)	216.6 (5.2)	104.2* (2.7)	191.9* (5.1)	135.8* (5.4)	252.8* (9.9)
	F+S	117.8 (2.8)	217.5 (5.2)	104.7* (2.7)	192.7* (5.1)	136.6* (5.4)	254.3* (10.0)

Values are reported as mean values (standard error).
*A significant difference ($P < 0.05$) for females compared with males only.
RDI, recommended daily intake; NA, information not available.

the most meaningful comparison to the results of our current study.

Study Subjects

The average age of subjects in this study was 21.3 years, which was similar to the results in Hinton et al[20] but younger than those in Burke et al.[1] One potential effect of a younger study population is the possibility that their diets are more readily influenced by parents and peers.[9] In addition, over half of our subjects participated in power-type sports, which likely increased the overall total energy and protein intake reported. Our study is likely an accurate

TABLE 7. Average Daily Vitamin Intake for Food Alone (F) and Food with Supplements (F+S) by Competitive Event (CE) Type

		CE–Power		CE–Intermittent		CE–Judged		CE–Endurance	
Vitamins	F or F+S	Absolute (SE)	%RDI (SE)	Absolute (SE)	%RDI (SE)	Absolute (SE)	%RDI (SE)	Absolute (SE)	%RDI (SE)
A, RE	F	2207.7 (131.0)	240.1 (13.5)	1965.8 (257.4)	218.9 (28.5)	1588.3 (136.7)	188.0 (17.5)	1948.0 (325.5)	216.3 (36.2)
	F+S	2426.2* (141.0)	266.8* (14.7)	2067.1* (259.2)	221.4* (28.2)	1634.4* (137.0)	193.7* (17.1)	2038.6* (331.9)	226.5* (36.9)
B1, mg	F	2.6 (0.1)	221.9 (7.1)	2.5 (0.2)	220.4 (15.0)	5.3 (2.9)	226.8 (12.8)	2.4 (0.2)	207.5 (20.9)
	F+S	8.4 (4.4)	546.2 (78.9)	5.7 (2.5)	490.7 (208.8)	2.7 (0.1)	258.9 (14.5)	8.4 (4.0)	710.7 (336.4)
B2, mg	F	2.6 (0.1)	227.2 (6.0)	2.6 (0.2)	219.7 (16.3)	2.6 (0.2)	256.0 (17.6)	2.4 (0.2)	203.3 (17.3)
	F+S	9.0 (2.0)	577.3 (78.4)	6.1 (2.5)	498.8 (194.9)	3.1 (0.2)	300.9 (20.6)	8.8 (4.1)	698.7 (314.4)
B3, NE	F	33.8 (1.2)	229.9 (7.4)	28.6 (1.9)	190.0 (12.2)	29.0 (1.4)	207.2 (9.6)	29.6 (2.8)	194.0 (17.4)
	F+S	43.1* (2.6)	293.2 (17.7)	36.6* (4.3)	239.7 (27.6)	31.2* (1.5)	221.2 (10.7)	40.5* (6.0)	263.2 (37.0)
B6, mg	F	2.8 (0.1)	220.9 (8.1)	3.0 (0.3)	249.2 (25.3)	2.6 (0.2)	216.3 (19.5)	2.7 (0.3)	205.6 (19.4)
	F+S	10.9 (2.1)	715.8 (87.5)	8.4 (2.7)	626.3 (209.1)	4.1 (0.4)	338.8 (36.3)	11.6 (4.4)	894.5 (339.7)
B9, μg	F	537.8* (18.1)	NA	519.0* (28.2)	NA	440.0* (16.6)	NA	476.3* (39.3)	NA
	F+S	840.1* (34.1)	NA	809.9* (113.4)	NA	547.5* (32.4)	NA	786.9* (78.6)	NA
B12, μg	F	6.2* (0.4)	248.3 (11.6)	5.1* (0.6)	238.3 (37.3)	4.8* (0.4)	215.1 (22.0)	4.7* (0.5)	194.1 (21.6)
	F+S	20.4 (2.4)	786.3* (68.6)	15.2 (3.6)	629.2* (150.8)	23.1 (14.8)	369.4* (53.6)	19.6 (5.5)	815.6* (229.8)
C, mg	F	280.3 (15.6)	354.6 (19.0)	296.1 (30.1)	397.1 (44.4)	252.3 (17.3)	386.6 (25.6)	228.9 (20.9)	286.8 (25.3)
	F+S	511.3* (33.2)	630.7 (36.5)	510.8* (84.1)	592.7 (88.4)	331.4* (23.4)	499.2 (35.9)	422.4* (67.2)	523.0 (83.9)
D, μg	F	212.1 (16.4)	NA	176.0 (26.2)	NA	185.3 (28.7)	NA	201.2 (30.1)	NA
	F+S	245.4 (20.5)	NA	180.2 (26.1)	NA	190.3 (29.0)	NA	205.7 (30.4)	NA

Values are presented as mean values (standard error).
*A significant difference ($P < 0.05$) between CE.
RDI, recommended daily intake; NA, information not available.

TABLE 8. Average Daily Mineral Intake for Food Alone (F) and Food with Supplements (F+S) by Competitive Event (CE) Type

Minerals	F or F+S	CE–Power		CE–Intermittent		CE–Judged		CE–Endurance	
		Absolute	%RDI	Absolute	%RDI	Absolute	%RDI	Absolute	%RDI
Calcium, mg	F	1326.1 (50.9)	128.1 (5.2)	1353.0 (164.5)	120.5 (16.2)	1243.7 (96.8)	101.2 (7.5)	1260.2 (118.5)	116.3 (11.5)
	F+S	1519.5 (52.8)	146.6* (5.5)	1477.9 (171.3)	132.6* (17.0)	1306.0 (98.3)	105.7* (7.6)	1455.0 (125.5)	135.4* (12.8)
Iron, mg	F	20.8* (0.6)	167.3* (7.8)	22.7* (1.6)	205.0* (15.7)	17.8* (0.8)	143.2* (10.8)	19.4* (1.8)	180.5* (22.5)
	F+S	31.3 (2.7)	226.1* (11.4)	35.9 (8.1)	246.6* (25.8)	25.0 (4.8)	160.5* (12.7)	25.4 (2.4)	237.7* (27.9)
Sodium, mg	F	3728.1* (112.4)	NA	3508.7* (276.0)	NA	3344.1* (162.5)	NA	2775.6* (195.5)	NA
	F+S	3845.0* (118.6)	NA	3572.6* (301.2)	NA	3403.5* (161.3)	NA	2792.3* (197.0)	NA
Potassium, mg	F	4376.5* (129.2)	NA	4291.0* (268.4)	NA	3721.3* (160.5)	NA	3868.8* (287.8)	NA
	F+S	4613.0* (133.9)	NA	4371.4* (273.4)	NA	3860.5* (158.7)	NA	3968.5* (308.4)	NA
PO4, mg	F	1971.5 (57.4)	264.4* (9.2)	1874.3 (125.5)	205.6* (20.4)	1756.1 (85.7)	162.0* (8.4)	1779.4 (150.4)	223.8* (24.6)
	F+S	2120.0* (61.5)	285.5* (10.0)	1948.1* (130.4)	218.1* (21.5)	1815.6* (88.0)	166.5* (9.1)	1877.7* (163.4)	236.9* (26.7)
Zinc, mg	F	15.5* (0.6)	165.5* (4.5)	18.5* (2.3)	162.4* (13.3)	12.5* (0.6)	136.0* (5.9)	12.9* (1.1)	131.5* (11.3)
	F+S	47.2* (4.3)	511.7* (43.8)	43.9* (8.8)	399.3* (84.3)	26.3* (3.6)	283.5* (37.5)	55.7* (10.5)	540.0* (96.2)
Mg, mg	F	478.7* (20.8)	140.1 (6.2)	559.3* (80.2)	150.9 (24.4)	377.5* (15.0)	114.0 (5.7)	436.1* (38.9)	119.8 (11.8)
	F+S	567.3* (24.3)	164.0* (7.0)	612.1* (93.7)	163.2* (29.4)	407.7* (18.0)	122.1* (6.6)	487.2* (42.6)	133.5* (13.1)
Selenium, μg	F	126.0* (4.0)	229.1* (7.3)	110.2* (6.5)	207.0* (11.4)	99.8* (4.3)	194.1* (10.2)	99.2* (9.3)	180.5* (16.8)
	F+S	127.0* (4.1)	230.8* (7.4)	110.4* (6.6)	209.7* (11.3)	100.3* (4.4)	193.2* (10.3)	99.2* (9.3)	180.5* (16.8)

Values presented as mean values (standard error).
*A significant difference ($P < 0.05$) between CE.
RDI, recommended daily intake; NA, information not available.

reflection of the current dietary intake of Canadian elite athletes with 367 subjects participating compared with 167 in Burke et al[1] and 350 in Hinton et al.[20]

Caloric Intake

The average daily caloric intake of all subjects with and without supplements was lower than the recommended energy intake that is estimated from the average height, weight, and gender of our participants using 3 different methods.[16–18] It should be noted that these are rough estimates of caloric need and that energy requirements can vary depending on competitive sport types, an athlete's periodization plan, and individual goals for weight change. However, this finding does indicate that Canadian athletes generally do not self-report adequate energy intakes, even with supplementation. This finding is consistent with Hinton et al,[20] who reported inadequate total caloric intake in National Collegiate Athletic Association athletes. Given the established benefits to performance of matching overall energy intake with energy expenditure,[21,22] achieving energy balance in elite athletes may do more to improve overall health and performance than any increment seen with increased or excessive micronutrient intake. This is perhaps especially applicable to endurance athletes, who in this study reported the most training hours but lowest total caloric intake.

Macronutrient Intake

On average, carbohydrate, protein, and fat accounted for 53.3%, 18.0%, and 27.5% of energy intake. Relative to body weight, average carbohydrate and protein intake without supplements was 5.1 and 1.8 g/kg per day, respectively. The current recommendations from the American College of Sports Medicine, the American Dietetic Association, and the Dietitians of Canada Nutrition and Athletic Performance position paper[23] suggest that dietary fat intake should be in the range of 20% to 25% of total energy intake, carbohydrate intake at 6 to 10 g/kg per day, and protein intake at 1.2 to 1.4 g/kg per day for endurance athletes and 1.6 to 1.7 g/kg per day for power athletes. Compared with these recommendations, subjects in the current study had slightly higher fat and lower carbohydrate intakes but met the recommendation for dietary protein (relative to body weight). Based on these recommendations, athletes in this study had adequate protein intake, but increased carbohydrate intake should be emphasized more strongly in this population. Inadequate carbohydrate intake has previously been reported by Burke et al[1] when reporting the dietary habits of elite female endurance athletes.

Micronutrient Intake

The intake of all vitamins and minerals exceeded their respective RDI by at least 20% with food alone. Micronutrient intake was further increased with supplementation. This finding is similar to that reported by Hinton et al,[20] who found that athletes consumed greater than recommended amounts of micronutrients except for vitamin E and magnesium. The absolute intake of all vitamins and minerals in this study exceeded intakes reported by Hinton et al.[20] This finding would suggest that although the subjects in our study may not consume adequate total energy, they chose nutrient-dense foods, which allowed them to have sufficient intake of micronutrients even without supplementation. Although the recommended micronutrient requirements of athletes are generally not different when compared with the general population, the requirements in athletes for some micronutrients may be increased as a result of increased energy demands. These include riboflavin, vitamin B6, and vitamin B12.[24] However, even when this increased requirement is considered, the athletes in this study had excessive intakes of all micronutrients that were assessed. Relative to competitive event, there was a trend for power athletes to have greater intake of micronutrients compared with the other competitive event athletes. This finding is probably associated with the greater energy intake of the power athletes compared with athletes in other competitive events.

In this study, the average intake of vitamins and minerals reached up to 680.4% and 451.1% of their RDIs (vitamin B12 and zinc, respectively). In comparison to established Tolerable Upper Intake Levels[19] for key micronutrients, some subjects exceeded the upper levels for magnesium, zinc, and vitamins B3 and D. The upper level values have been established as maximum safe levels of nutrients to caution against excessive intake that can be harmful or toxic. For example, excessive intake of magnesium can lead to diarrhea, whereas chronic overconsumption of zinc may lead to a deficiency in copper. A known side effect of exceeding upper intake levels of vitamin B3 may include flushing of the face.[19] The current upper level for vitamin D, however, is controversial and therefore many of our athletes might not be expected to experience any negative consequences in regard to their elevated intake of this micronutrient.[25]

CONCLUSIONS

Our large representative sample of Canadian high-performance athletes did not consume adequate energy or carbohydrates based on self-reported food record submissions. However, the athletes were making quality food choices given that all micronutrient intakes exceeded current RDI values, even when supplementation is not considered. The use of supplements significantly increased the overall intake of energy, macronutrient, and micronutrient intakes by the athletes. Taken together, these data would suggest that dietitians, coaches, and other professionals involved in training of elite athletes need to emphasize the importance of meeting overall energy and carbohydrate needs and provide practical advice on how to achieve these requirements. Furthermore, athletes' diets should be assessed on a regular basis, especially before adding supplementation.

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ERRATUM

Evaluation of Nutritional Intake in Canadian High Performance Athletes: Erratum

In the above article published in the September 2009 issue of the Journal, an error concerning how the intake of vitamin D was reported as identified by a reader. The authors would like to address this matter as follows:

The vitamin D intakes of our subjects was reported as mcg but should have been presented in International Units (IU), as seen in Table 5 of the article. This error led to a significant over-estimation of the vitamin D intake, as the conversion factor is 40 IU to 1 mcg. The mean intakes in IU (SE) of all subjects (n=324) was 202.3 IU (11.6) from dietary intakes alone, and 222.1 IU (13.3) from diet with supplementation. Compared to a recommended DRI requirement of 200 IU (based on the needs of 18- to 50-year-olds), the female subjects on average did not meet their DRI from their diet and from their diet with supplementation which was determined to be 172.2 IU (13.3) and 184.8 IU (15.0), respectively. However, the male subjects met their DRI with 252.6 IU (21.6) from diet alone, as well as from their dietary intake with supplementation with 286.3 IU (25.7). In conclusion, overall the 324 subjects' mean intake of vitamin D was sufficient relative to diet and diet with supplementation. However, on average, the female subjects failed to meet their daily requirement for vitamin D from diet as well as from diet with supplements.

The authors wish to thank the reader for bringing this matter to their attention.

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