

# Nutrient Intake of Elite Male and Female Nordic Skiers

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**In brief:** This study of 13 male and 14 female members of the US Nordic Ski Team was conducted to analyze the nutrient content of their diet. The skiers recorded four sets of three-day dietary data during a year of training and competition. The results showed high calorie intake, as expected. However, fat intake was higher and carbohydrate intake lower than recommended amounts for optimal health and athletic performance. Iron intake by female skiers consistently failed to meet recommended levels, while cholesterol intake exceeded levels considered optimal. Intake of other nutrients reviewed in this report easily met recommended levels.

**A**thletes are bombarded with a wide variety of recommendations for modifying their diet. This advice comes from many sectors, including scientific literature, advertisements, coaches, friends, and competitors. For every nutrient there are many opinions regarding the amount of intake that will improve or detract from performance. Only some of these opinions are based on scientific knowledge of nutritional needs, and many recommendations are contradictory. Even estimates of calorie need vary. Calculations of energy expenditure indicate that male cross-country skiers with an average weight of 67.5 kg need approximately 6,105 calories per day,<sup>1</sup> while Haymes<sup>2</sup> suggests the average calorie intake during training should be 4,000 calories per day for male skiers and 3,000 calories per day

*continued*

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**Table 1. Nutrient Intake of Nordic Skiers During the 1981-82 Season (Group Mean  $\pm$  SD)**

Nutrient	Recording Session (Men)			
	1 (n = 13)	2 (n = 9)	3 (n = 8)	4 (n = 8)
Calories	4,593 $\pm$ 905	3,492 $\pm$ 948	5,450 $\pm$ 1,188	4,406 $\pm$ 1,249
Protein (gm)	167 $\pm$ 39	125 $\pm$ 29	153 $\pm$ 46	153 $\pm$ 40
Fat (gm)	219 $\pm$ 53	156 $\pm$ 50	234 $\pm$ 69	167 $\pm$ 64
Carbohydrates (gm)	457 $\pm$ 97	388 $\pm$ 117	618 $\pm$ 153	567 $\pm$ 158
Sucrose* (gm)	61 $\pm$ 27	70 $\pm$ 62	129 $\pm$ 50	131 $\pm$ 77
Starch (gm)	179 $\pm$ 56	158 $\pm$ 43	232 $\pm$ 87	215 $\pm$ 41
Other carbohydrate† (gm)	209 $\pm$ 57	153 $\pm$ 34	249 $\pm$ 66	212 $\pm$ 71
Alcohol (gm)	18 $\pm$ 15	5 $\pm$ 7	22 $\pm$ 9	4 $\pm$ 7
Cholesterol (mg)	1,210 $\pm$ 351	655 $\pm$ 269	916 $\pm$ 506	813 $\pm$ 438
Thiamine (mg)	3.0 $\pm$ 0.7	3.0 $\pm$ 0.9	3.6 $\pm$ 1.3	3.7 $\pm$ 1.1
Riboflavin (mg)	4.3 $\pm$ 1.2	3.4 $\pm$ 0.9	5.3 $\pm$ 1.8	4.8 $\pm$ 1.4
Niacin (mg)	41.4 $\pm$ 6.3	32.9 $\pm$ 7.6	49 $\pm$ 16.3	48 $\pm$ 11
Vitamin C (mg)	261 $\pm$ 135	242 $\pm$ 98	232 $\pm$ 85	371 $\pm$ 157
Iron (mg)	27.8 $\pm$ 5.2	22.6 $\pm$ 5.7	26.6 $\pm$ 6.7	33.8 $\pm$ 12.9
Calcium (mg)	1,966 $\pm$ 913	1,364 $\pm$ 502	2,782 $\pm$ 928	1,948 $\pm$ 695

\*Known refined sugar.

†Natural simple carbohydrates (mainly fructose, lactose, glucose, and natural sucrose).

for females. However, data on the dietary habits of elite endurance athletes during off-season, training, and competition are scarce. We examined the nutrient intake of a group of elite cross-country skiers at selected times during the year and compared their intake with dietary recommendations for optimal health and sports performance.

#### Methods

We studied 13 male and 14 female members of the US Nordic Ski Team during a year of training and competition. The men ranged from 18 to 28 years old with a mean of 22. Their mean height and weight were 177 cm and 73 kg, respectively. The women ranged from 15 to 31 years old with a mean of 20. Their mean height and weight were 163 cm and 57 kg, respectively. Four sets of three-day dietary records were collected at three- to four-month intervals. The first and third set of records were completed at training camps. The first training camp was held in May after a one- to two-month break following the previous competitive season. The second set of records was collected in August and September while the skiers were training but eating on their own. The third set was collected in November at a training camp held shortly before the beginning of the competitive season. The final set of records was collected in Jan-

uary and February during competition.

The skiers recorded the dietary information on forms small enough to fit in a pocket and thus be carried all day. At the first training camp a nutritionist taught the skiers how to complete a dietary record. A ruler and 2- and 3-in. circles were printed on the forms to help determine the dimensions of foods as accurately as possible. Between the first and second recordings the skiers were given personalized instructions based on a review of the first set of records to help them record their intake more accurately. At the third recording session a nutritionist encouraged the skiers to complete the forms and again helped them accurately record their intake. The nutritionist also collected detailed information from the chefs on menu items, ingredients, and portion sizes at the first and third visits. When additional detail was needed to clarify recorded information, restaurants in which participants had eaten during any recording session were asked to provide the desired information.

We analyzed each set of three-day records to determine the skiers' mean daily intake of 15 nutrients. We also calculated the mean daily intake for each group of skiers at each recording session. In our analyses we reviewed total calories, protein, total carbohydrate, sucrose (known refined sugar), starch, other carbohydrates (natural simple carbohydrates—mainly

Nutrient	Recording Session (Women)			
	1 (n = 14)	2 (n = 10)	3 (n = 7)	4 (n = 5)
Calories	3,181 ± 715	2,414 ± 340	3,963 ± 688	3,250 ± 558
Protein (gm)	114 ± 30	84 ± 26	125 ± 17	108 ± 18
Fat (gm)	146 ± 42	101 ± 25	178 ± 32	121 ± 25
Carbohydrates (gm)	333 ± 66	287 ± 53	423 ± 125	414 ± 117
Sucrose* (gm)	34 ± 15	32 ± 16	69 ± 12	57 ± 17
Starch (gm)	124 ± 40	119 ± 33	191 ± 97	205 ± 101
Other carbohydrates† (gm)	167 ± 42	131 ± 35	157 ± 34	146 ± 27
Alcohol (gm)	12 ± 10	2 ± 6	25 ± 10	11 ± 4
Cholesterol (mg)	736 ± 238	369 ± 142	556 ± 314	425 ± 171
Thiamine (mg)	2.1 ± 0.7	1.8 ± 0.6	2.4 ± 0.5	2.1 ± 0.5
Riboflavin (mg)	3.0 ± 1.1	1.9 ± 0.6	3.1 ± 0.5	2.7 ± 0.5
Niacin (mg)	28.9 ± 9.4	21.6 ± 6.7	31.8 ± 6.0	30.8 ± 6.5
Vitamin C (mg)	210 ± 96	173 ± 90	220 ± 93	181 ± 128
Iron (mg)	19.2 ± 6.0	15.1 ± 3.7	71.3 ± 3.5	17.5 ± 2.1
Calcium (mg)	1,188 ± 467	881 ± 331	1,600 ± 282	1,225 ± 429

fructose, lactose, glucose, and natural sucrose), fat, alcohol, vitamin C, thiamine, riboflavin, niacin, calcium, iron, and cholesterol. We chose these nutrients because of their pertinence to the health and performance of elite endurance athletes.

All 14 female subjects were cross-country skiers training for and competing in 5-, 10-, and 20-km races. Nine of the 13 men were strictly cross-country racers competing in 15-, 30-, and 50-km events and relay races with 10-km legs. The other four competed in Nordic combined events, including ski jumping and 15-km cross-country races. The group dietary analyses include all the male skiers, because they all reported similar intensity and duration of training. However, not all the skiers were available at all recording sessions. Therefore, only the skiers who received instruction for completing the forms at the first session and had recorded information were considered for group analyses at subsequent sessions.

We used a modified version of the National Heart, Lung, and Blood Institute dietary data base and data collection and processing system to transcribe, code, and analyze records.<sup>3</sup> The system was designed specifically for cardiovascular disease research and therefore focuses on the amount of fat in foods. This special focus allows comprehensive and detailed recording of dietary fat intake, thus increasing

the accuracy of both total fat consumption and calorie level. All nutrient analyses presented here are based on intake from food sources only, not supplements.

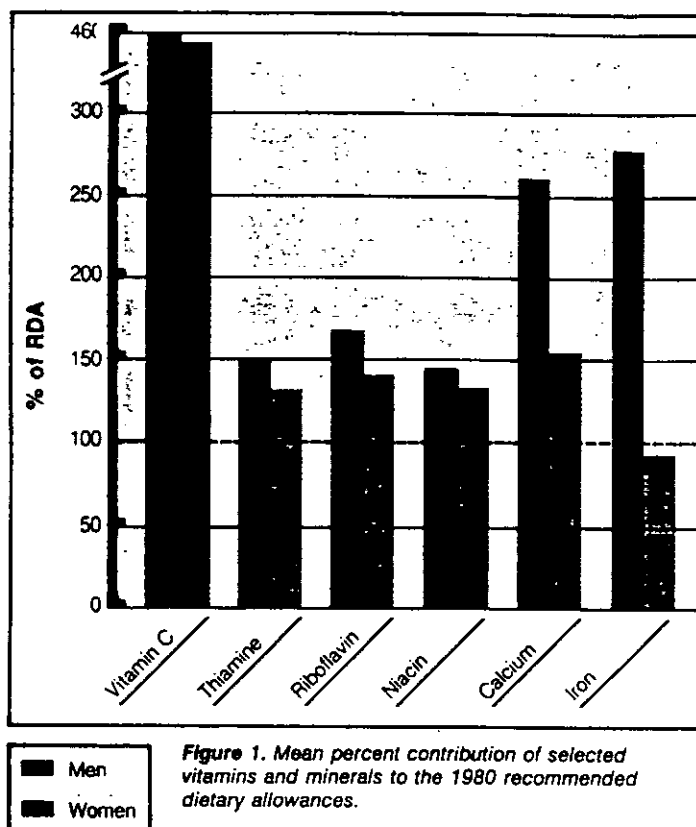
We used recommended dietary allowances (RDAs) as reference values for comparing vitamin and mineral intakes of the skiers.<sup>4</sup> These recommendations were based on a group average, so they may not apply to all individuals. However, the RDA is estimated to exceed the requirements for most individuals for all nutrients except energy needs. Therefore, intakes below the RDA are not necessarily inadequate, but the risk of inadequate intake increases when nutrient intake persistently falls below the RDA. It is unclear whether the RDA are sufficient to meet the needs of endurance athletes for all nutrients; however, they constitute the best available guideline.

## Results

Mean ± SD for each nutrient at each recording session are presented in table 1. Annual means show that the skiers consumed a diet high in fat and relatively low in carbohydrate.<sup>5</sup> Their intake of vitamin C, thiamine, riboflavin, niacin, and calcium easily exceeds recommended quantities. Of the vitamins and minerals considered in this analysis, only iron intake by female skiers routinely fell short of the recommended intake (figure 1).

*continued*

**nutrient intake continued**



**Figure 1.** Mean percent contribution of selected vitamins and minerals to the 1980 recommended dietary allowances.

Nutrient intake varied considerably from one recording session to the next. Because of this variation, we report here on the range of intake from session 2 (at home), which was usually the session of least intake, to session 3, (at training camp), which was usually the session of highest intake. Several factors could account for these session-to-session differences:

1. Skiers at sessions 2, 3, and 4 are different subsets of the skiers at sessions 1.
2. The amount of training varied from session to session.
3. A nutritionist assisted and supervised the data collection at the training camps but not the other two sessions.
4. Foods were weighed and measured only at the third session.
5. At the third session a nutritionist encouraged the skiers to decrease fat intake and increase carbohydrate intake.
6. The last record was collected during competition, which may have generated special dietary considerations for the skiers.

Despite the fluctuations these factors may

have caused in the data, consistent patterns of intake appear for several nutrients that are particularly important for cross-country skiers.

**Calorie Intake.** Mean calorie intake for the men ranged from a low of  $3,492 \pm 948$  calories at the second recording session to a high of  $5,450 \pm 1,188$  calories at the third recording session, when the heaviest training occurred. Adjusted per kg of body weight, intake ranged from 49 to 76 kcal per kg at recording sessions 2 and 3, respectively. Similarly, mean calorie intake for the women ranged from  $2,414 \pm 340$  calories to  $3,963 \pm 688$  (42 to 71 kcal per kg) at recording sessions 2 and 3, respectively.

**Protein, Fat, and Carbohydrate.** The percentage of calories derived from protein remained similar at all recording sessions. The range for the male skiers was 13.2% to 14.2%; for the female skiers 12.7% to 14.3%. The contribution of fat to calories ranged from 33.6% to 42.5% for men and 33.7% to 40.9% for women. Carbohydrate contributed 39.9% to 51.7% of calories for men and from 42.2% to 50.3% of calories for women per recording session (figure 2). Alcohol provided 0.6% to 3.0% of calories for men and 0.6% to 4.5% for women, with the greater intake occurring during group training sessions. All the male skiers consumed more than 30% of their calories from fat and less than 55% from carbohydrate at the first three sessions. Only one male skier reported less than 30% of calories from fat and more than 55% from carbohydrate at the fourth session. From 80% to 100% of the female skiers consumed more than 30% of calories from fat and less than 55% from carbohydrate at each recording session.

Carbohydrates were derived from different foods for male and female skiers. For males, mean starch intake was similar at all recording sessions, averaging 39% of carbohydrate intake. Known refined sugar intake increased from the first to the fourth recording sessions, ranging from 13% to 23% of carbohydrate intake. The remaining carbohydrate intake consisted of natural simple carbohydrates. The carbohydrate composition of the diet of female skiers differed, with starch increasing from 37% at the first recording session to 50% at the fourth session. Known refined sugar intake varied from a low of 10% of carbohydrate intake to a high of 16% at the third recording

session. Intake of natural simple carbohydrates decreased from 50% of carbohydrate intake at recording session 1 to 35% at session 4.

**Thiamine, Riboflavin, Niacin, and Vitamin C.** The skiers easily met the RDA for thiamine, riboflavin, and niacin as well as for vitamin C (currently 60 mg per day). Group means  $\pm$  SD per recording session show that vitamin C intake ranged from  $232 \pm 85$  mg to  $371 \pm 157$  mg for the men and from  $173 \pm 90$  mg to  $220 \pm 93$  mg for the women.

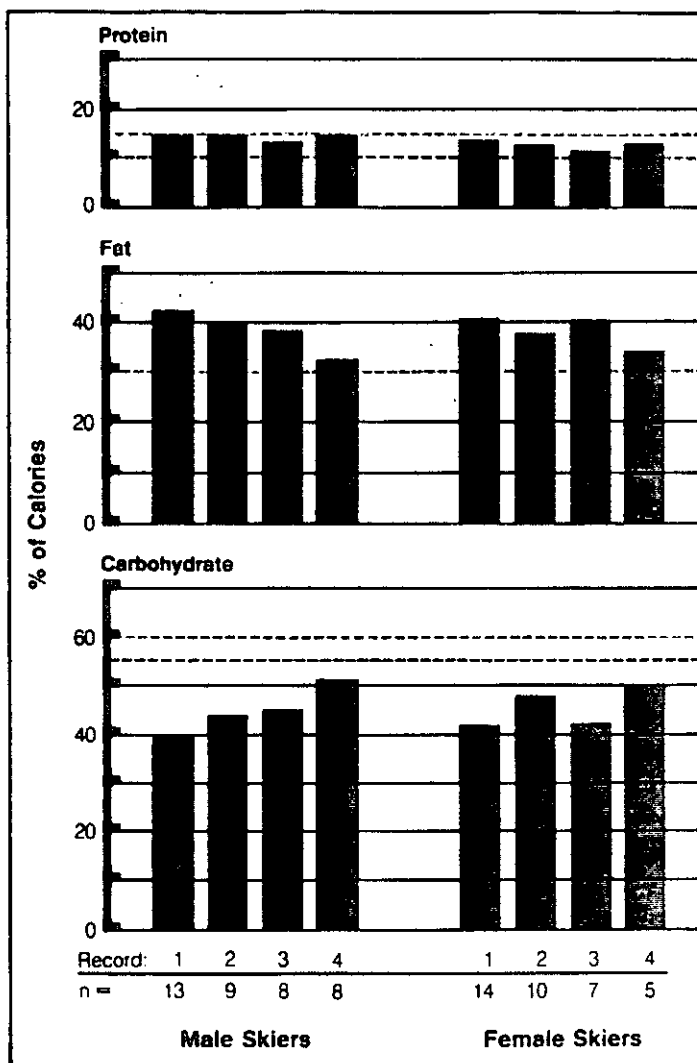
**Calcium.** Recording session means  $\pm$  SD for calcium intake for male skiers ranged from  $1,364 \pm 502$  mg to  $2,782 \pm 928$  mg. All but two met the RDA of 800 mg for all nutrients recorded. For the female skiers, calcium intake ranged from  $881 \pm 331$  mg to  $1,600 \pm 282$  mg. Approximately 20% of the women at the first and second recording sessions and 40% at the fourth session consumed less than the recommended 800 mg of calcium.

**Iron.** The male skiers easily surpassed the recommended iron intake of 10 mg per day. However, most of the female skiers, like many US women, fell short of the recommended 18 mg per day.<sup>4,6</sup> At recording sessions 1 through 4, 36%, 70%, 43%, and 60%, respectively, failed to meet the RDA. Only two of the women who completed more than one three-day record consumed an average of 18 mg per day or more of iron. Mean iron intake for the others was slightly below the RDA, ranging from 15.5 to 17.4 mg.

**Cholesterol.** We noted a high intake of cholesterol. Group means  $\pm$  SD for men per recording session ranged from  $655 \pm 269$  mg to  $1,210 \pm 351$  mg per day. Women consumed from  $369 \pm 142$  mg to  $736 \pm 238$  mg.

## Discussion

**Calorie Intake.** As expected, calorie intake for both male and female skiers was high. The RDA suggested range for men aged 19 to 50 doing light work is 33 to 47 calories per kg of body weight and for women aged 15 to 50 doing light work is 22 to 55 calories per kg of body weight.<sup>4</sup> By contrast, the men consumed 49 to 76 calories per kg of body weight and the women 42 to 71 calories per kg of body weight. Calculations of energy expenditure indicate that male cross-country skiers need 90 calories per kg of body weight.<sup>1</sup> However, only



----- Recommended intake range

Figure 2. Percent contributions of protein, fat, and carbohydrate to total calorie intake at four periods during a year of training and competition.

two men in this study consumed that amount or more at any recording session.

**Protein.** The mean weight of the male and female skiers in this study was 73 kg and 57 kg, respectively. Based on the RDA, the average protein need was 58 gm for the men and 46 gm for the women. Mean protein consumption was 156 gm for men and 108 gm for women—more than double the recommended amounts. Protein intake contributing only 10% of the skiers' calorie intake would exceed the RDA, providing an average of 112 gm of pro-

nutrient intake continued

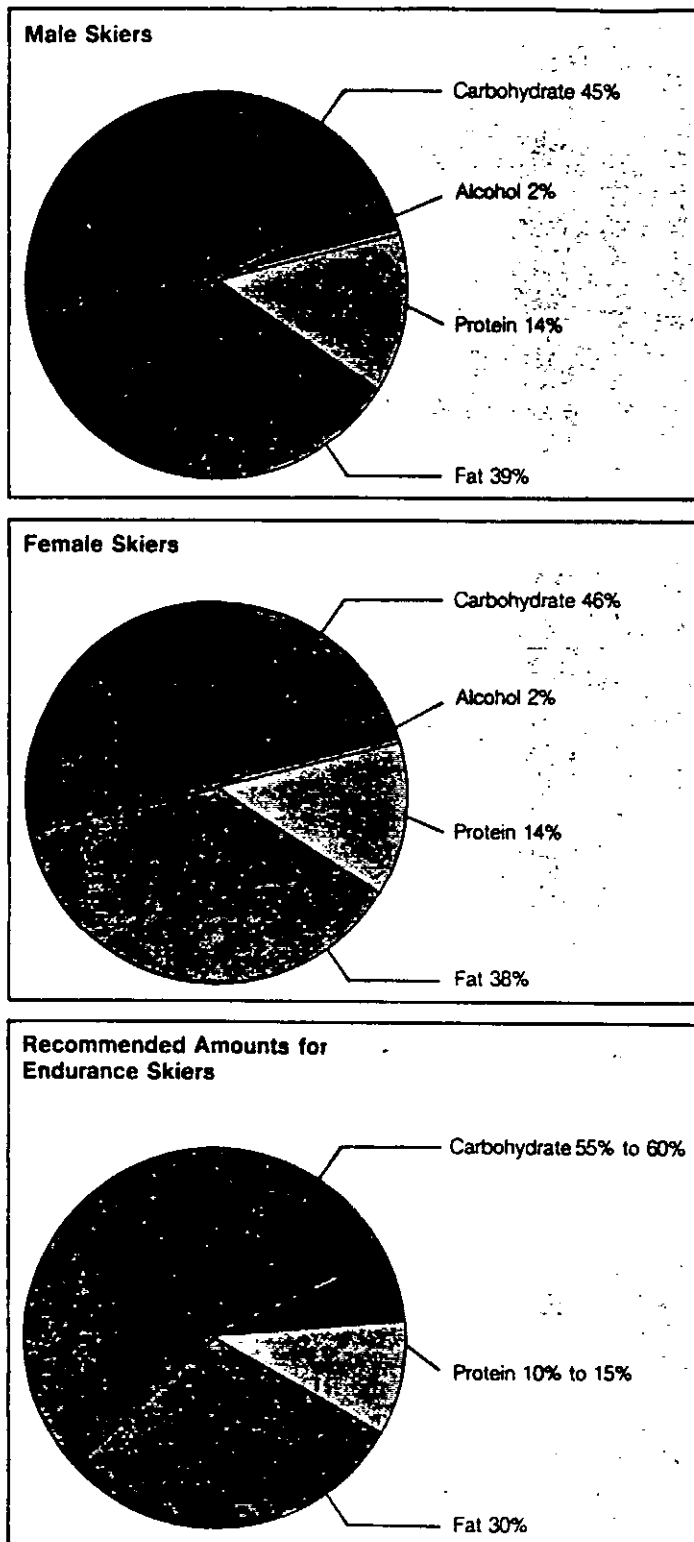


Figure 3. Mean percent contribution of protein, fat, carbohydrate, and alcohol to total calorie intake compared with the recommended amounts for endurance skiers.<sup>2,7\*</sup>

tein for men and 78 gm for women.

All athletes need protein to build and repair tissue; young athletes need it for growth as well. The RDA for protein for adults is 0.8 gm per kg of body weight.<sup>4</sup> Protein requirements for athletes are debated, but it has not been satisfactorily shown that protein intake greater than 0.8 gm per kg of body weight improves performance. Lemon and Nagle<sup>7</sup> suggest that prolonged exercise may increase the need for protein, because the body draws energy from protein stores when muscle and liver glycogen stores are depleted. Other studies<sup>8,9</sup> suggest that a diet sufficiently high in carbohydrate with carbohydrate loading before competition may provide glycogen stores sufficiently high to prevent depletion. Butterfield<sup>10</sup> reports that physically active men can produce sufficient lean tissue when they are consuming as little protein as 0.57 gm per kg of body weight if they consume enough calories.

**Carbohydrate and Fat.** Although these skiers consumed a variety of foods, this dietary analysis shows that these skiers eat a typical American diet—high in fat and relatively low in carbohydrate.<sup>5</sup> A diet composed of 10% to 15% of calories from protein, 30% from fat, and 55% to 60% from carbohydrate is recommended for athletes.<sup>2,11</sup> A high carbohydrate diet has been shown to improve endurance by increasing muscle glycogen content.<sup>12</sup> Our data show that 97% of all the three-day records collected from male skiers had an average intake of less than 55% of calories from carbohydrate and more than 30% from fat. Similarly, 92% of the female skiers' records showed carbohydrate intake below the recommended amount and fat consumption above the recommendation (figure 3).

A comparison of the percent of calories from carbohydrate and fat at training camps with records collected when skiers were choosing their own food shows an interesting trend. In general, fat consumption increased and carbohydrate consumption decreased at the training table. To find out if the differences were significant, data from skiers with at least one three-day record from a training camp and one record from a nontraining camp session were included in a group comparison analysis (paired t-test). The mean intake of six days was used when a skier had two three-day records

continued

## **nutrient intake** continued

Whether iron deficiency is more common in athletes than in nonathletes is debated.

from either situation. For the female skiers the percent of calories from carbohydrate was significantly higher ( $p < .01$ ) and from fat significantly lower ( $p < .005$ ) when they ate on their own rather than at a training camp. Similarly, the percent of calories from carbohydrate was significantly higher ( $p < .02$ ) for the male skiers when they ate on their own. The proportion of calories from fat is not significantly different ( $p < .10$ ) between the two situations but shows a similar trend. This trend may be biased because of some efforts to carbohydrate load during competition or because of the effect of the nutritionist present during training camps. However, it may point out that training camp food does not necessarily reflect the food of personal choice for these skiers. This suggests that if fewer high-fat foods and more carbohydrate foods were available at training camps, the skiers would readily consume a diet much closer to that recommended for athletes.

**Vitamin B, Vitamin C, Calcium, and Iron.** Athletes may have special needs for certain vitamins and minerals. We compared the intake of B vitamins, vitamin C, calcium, and iron with the RDA, which is established at a level believed to cover the needs of most people, including the physically active (figure 1).

The B vitamins are used to produce energy and therefore are especially important to the athlete. The recommended intake for riboflavin, niacin, and thiamine depends on calorie intake. Riboflavin is set at 0.6 mg per 1,000 calories, niacin at 6.6 niacin equivalents per 1,000 calories, and thiamine at 0.5 mg per 1,000 calories.<sup>3</sup> No pattern of inadequate intake was found in any of the skiers. Improved performance has not been shown with intakes of these vitamins in greater amounts than the RDA.<sup>13</sup>

Vitamin C has been publicized as having many roles, including reducing fatigue and muscle soreness. Scientific studies imply that it helps absorb iron.<sup>4</sup> Although the RDA was recently raised from 45 to 60 mg per day, all skiers in the study easily met the RDA, and many ingested two to three times the recommended amount.

Calcium is important to the athlete because it is necessary for muscle contractility and plays an important role in controlling the excitability of peripheral nerves and muscle.

Many factors have been reported to affect the absorption of calcium. High protein intake can increase calcium excretion,<sup>14,15</sup> and calcium can be lost in sweat.<sup>4</sup> However, calcium absorption may be enhanced by an adequate intake of vitamin D,<sup>16</sup> and exercise in elderly women has been shown to increase bone mineral retention.<sup>17</sup> Also, the body adjusts to the level of calcium intake, absorbing more when lower levels are ingested regularly.

The RDA for calcium is 800 mg, which is high enough to account for the high protein intake consumed in the United States.<sup>4</sup> Overall, the skiers in the study met the recommended levels of calcium. That is, all the skiers with two or more sets of three-day records had a mean intake of calcium easily surpassing the RDA. However, 27% of individual three-day records collected from female skiers were below the RDA. Because of the high protein intake of these skiers, and since it is unclear which set of three-day records is most representative of usual intake, the skiers should learn which foods contain calcium. Broccoli, tofu, and dairy products such as lowfat or nonfat milk, yogurt, cheese, and cottage cheese are all good sources of calcium that should be readily available at training camps.

The iron consumed by the women was the only nutrient reviewed that was consistently but only slightly below the RDA. Two of the ten female skiers who completed more than one three-day record consumed an average of 18 mg per day or more. The average for the others was 15.5 to 17.4 mg per day. Although this is greater than the amount of iron generally consumed by US women (probably because of high calorie intake),<sup>6</sup> it may still be too low to maintain iron stores in some skiers.

Whether iron deficiency is more common in athletes than in nonathletes is debated.<sup>18-22</sup> Low absorption of iron and higher rates of iron loss have been detected in long-distance runners,<sup>23</sup> and the expansion of plasma volume in athletes may contribute to low hemoglobin concentration.<sup>24</sup> Iron deficiency among women who exercise vigorously has been seen in several studies.<sup>18-21</sup> Because inadequate intake of iron can lead to depleted iron stores and iron-deficiency anemia, the level of intake seen here may contribute to iron deficiency in some skiers.



Iron plays a major role in oxygen transport to tissue cells. Iron deficiency decreases aerobic capacity, which leads to fatigue. Studies suggest that even depletion of tissue iron may affect performance.<sup>25,26</sup> For the female skiers the implications of this marginally low intake of iron can be tested only by periodic blood tests of hematocrit, hemoglobin, and iron storage. If needed, adequate iron intake could be met through greater awareness of foods containing iron or with moderate iron supplementation. Because of their high calorie intake, these skiers come much closer to meeting the RDA than most US women. Thus the task of meeting the RDA should be more easily achievable. A slightly higher intake of lean meat, poultry, fish, cooked dry beans, peas, broccoli, whole-grain or enriched cereals, grains, and bread could enhance their iron intake to meet the RDA.

**Cholesterol.** Cholesterol intake is high, especially in the male skiers. Eating habits begin at an early age, as does the onset of atherosclerosis.<sup>27</sup> Although endurance athletes have greater high-density lipoprotein cholesterol than sedentary individuals<sup>28</sup> (which may mitigate the effect of this high cholesterol intake), recommendations for a healthy diet suggest an intake close to 300 mg per day.<sup>29</sup> Decreased intake of egg yolks, high-fat red meat, cheese, and whole milk would lower cholesterol intake as well as total fat consumption. Alternative suggestions include increased intake of cereals (which are also high in carbohydrate and iron); eating lean cuts of meat, poultry, or fish; and drinking low or nonfat milk.

**Summary**

This analysis of up to 12 days of dietary records from skiers on the US Nordic Ski Team showed fat intake well above 30% of total calorie intake. Similarly, the proportion of calories from carbohydrate was well below 55%. Fat intake was particularly high and carbohydrate consumption especially low at training camps, whereas food choices made in other settings came closer to achieving recommended proportions. Cholesterol consumption considerably exceeded the recommended intake for a healthy diet and should be reduced if possible. We recommend that the members and coaching staff of the ski team provide

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## **nutrient intake continued**

greater input into planning the training table menus and work toward increasing carbohydrate intake and decreasing fat consumption both at home and at training camps.

Of the vitamins and minerals reviewed, only iron intake of the female skiers systematically failed to meet recommended levels. Their average intake was only slightly below the RDA, but since intakes were repeatedly below this level throughout the year, a chronic deficiency may exist in some of the skiers. Periodic blood tests for hematocrit, hemoglobin, and iron

storage are recommended to determine if this intake level is reflected in reduced iron stores.

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