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The Role of Adequate Nutrition For Performance and Health For Female Cross-Country Skiers

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INTERNATIONAL SKI FEDERATION
Marc Hodler Haus;
CH- 3653 Oberhofen / Thunersee; Switzerland

Phone:	+41 (33) 244 61 61
Fax:	+41 (33) 244 61 71
Website:	www.fis-ski.com

Chairwoman Sub-Committee for Ladies Cross-Country

Mrs.
Koyama Poppe Midori
Carl Kjelsens vei 15
NO-0860 Oslo
NOR

e-Mail: midori.poppe@bluezone.no
Phone home: +47 22 23 70 66

Authors:

Nanna L. Meyer, PhD, RD, Research Associate and Sports Dietitian at The Orthopedic Specialty Hospital (TOSH) in Salt Lake City, UT, USA
Susie Parker-Simmons, MS, RD Sports Dietitian at the United States Olympic Training Center (USOC), Colorado Springs, CO, USA
Julia M. Erbacher, BS, Sports Dietetics Graduate Student Intern at The Orthopedic Specialty Hospital and Division of Nutrition, University of Utah in Salt Lake City, UT, USA

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INTRODUCTION

Female athletes have been involved in elite sports for a much shorter period than their male counterparts. In winter sports particularly, female Olympians represent less than one fourth of the female Olympians typically involved in summer sports. Thus, it is not surprising that nutrition research in several areas pertaining to the health and performance of female winter sport athletes, and the application into practice on the level of coaching is delayed. Nevertheless, data are available, although limited, to summarize sport nutrition concepts for female winter sport athletes. In addition, extrapolating from studies conducted in elite summer sports has greatly enhanced our understanding of the issues related to female-specific nutrition as they apply to winter sports.

This brochure is intended to provide updated knowledge and strategic approaches in nutrition that can be applied to the health and performance of female cross-country skiers. Chapter 1 introduces the topics of energy expenditure, body composition, and selective fuel use during exercise under normal and environmentally challenging conditions for the female cross-country skier.

Chapter 2, 3, and 4 represent the body of this brochure with focus on macronutrients (carbohydrate, protein, fat), micronutrients (vitamins, minerals, and trace elements), and fluid intake. In addition to current knowledge in sport nutrition, each chapter provides a variety of practical strategies for the female cross-country skier to use for training and competition.

Chapter 5 addresses nutritional factors related to fatigue. Chapter 6 discusses The Female Athlete Triad and illustrates issues of low energy availability, disordered eating, menstrual irregularities, and consequences on bone health. This chapter provides key issues in the process of identification of athletes with the Triad and strategies for treatment and prevention. Chapter 7 gives an overview of dietary supplements and offers details on creatine, caffeine, and sodium bicarbonate followed by a large section on sports foods, fluids, gels, and bars with guidelines for use during training and competition. Finally, Chapter 8 focuses on the athlete traveling during training and competition. The last part of this brochure is dedicated to resources including a large Appendix (A - H) with tools, lists, and menu examples for the practitioner to use when working with the female cross-country skier.

1. ENERGY METABOLISM AND BODY COMPOSITION

Training increases the rate of energy (calorie) expenditure, which must be balanced by a higher energy intake. Daily energy requirements are not only met by eating three regular meals, but also by eating frequent snacks and using sports foods and fluids before, during, and after exercise.

Daily energy expenditure is the sum of resting metabolic rate, the thermic effect of food (increased oxygen consumption due to digestion, absorption, and metabolism after eating), and the thermic effect of activities, some of which include spontaneous activities such as walking, standing, and eating, with the largest part, however, coming from planned exercise such as training and competition. In fact, the energy expended through exercise makes up a large part of the daily energy requirement in the athlete, contributing sometimes up to 70% of total daily energy expenditure.

The most accurate method of measuring daily energy expenditure in a controlled environment involves 24-hour whole-body indirect calorimetry using a metabolic chamber. Whole-body calorimeters are expensive, limited in availability, and cannot measure habitual exercise in the field. Consequently, laboratory and field studies are commonly conducted to measure energy expenditure of a specific activity using stationary or portable metabolic equipment. The results of these studies provide the practitioner with valuable data to estimate energy cost of a variety of activities. Appendix A provides energy expenditure rates in METs (Metabolic Equivalent) and calories per minute based on previous research for various training modes related to cross-country skiing.

Training for many elite winter sports often creates a greater caloric challenge compared to the competition setting. The cross-country skier, however, seems to require similarly high-energy intakes under both conditions. Considering that resting metabolic rate and the thermic effect of food account for about 1500 to 1800 kcal per day, depending on the size of the athlete, it is not uncommon to see daily energy expenditure of female cross-country skiers of around 4000 kcal per day, with energy expended through exercise alone ranging from 2000 to 3000 kcal. Injury, stress, environmental extremes, the luteal phase of the menstrual cycle, and medications can increase total daily energy expenditure in the athlete.

Research has shown that during intense, on-snow training, daily energy expenditure of elite female cross-country skiers is around 4400 calories (18.3 MJ) or close to 80 kcal per kilogram of body weight (kcal/kg/d). For female athletes, this is one of the highest measured energy expenditures ever reported in the literature. The Swedish researchers of this study employed the gold standard for measuring energy turnover called the doubly-labelled water technique and found that the skiers were in energy balance (energy intake = energy expenditure), neither gaining nor losing weight. In fact, skiers were able to eat enough food to maintain energy balance during the course of a 2-week training camp. Studies using less sophisticated techniques to estimate daily energy expenditure as illustrated above attest that athletes often do not consume enough calories to balance energy expenditure (average intake is around 40 kcal/kg/d), whereas intakes of 45 kcal/kg/d have been recommended as minimal levels during intense training of approximately 90-minute duration.

The reason for this mismatch between energy intake and expenditure in athletes may be due to deliberate underreporting or under-eating when recording food intake. In addition, female athletes who maintain weight despite a negative energy balance (energy intake < energy expenditure) might have become more efficient in their use of calories using restrictive eating behaviors.

Clearly, being in chronic negative energy balance has consequences on both performance and health. In most athletes, energy-deficient diets result in weight loss (fat and muscle) and low intakes of most nutrients including carbohydrate, protein, fat, iron, zinc, calcium, magnesium, and the B-vitamins. In addition, low energy availability (eating less calories than expended from exercise) is linked to the female endocrine system and the development of The Female Athlete Triad.

Meeting energy requirements for female cross-country skiers can be a challenging issue, particularly in those athletes who also keep tight weight ranges aiming for fat loss and muscle gain to optimize body composition and increase their power-to-weight ratio. In most sports, the elite athletes form a select group who have the highest lean and lowest fat tissue mass for their sport disciplines. However, optimal body composition is only one component that makes an athlete successful. Optimal performance is dependent on many other factors some of which are the athlete's physiology, psychology, and nutrition combined with optimal coaching and training opportunities.

Body Composition

In 1927, cross-country skiers were described as tall and lean individuals, while in the 1950s they were reported as muscular and having average height. From 1967 to 1987, research findings have reported a range for mean height and weight from 1.61 to 1.68 m and 55 to 61 kg, respectively. In addition, percent body fat ranged from 16 to 22%.

It appears that the physical structure of cross-country skiers has changed over the last twenty years. However, no normative data for international and national level cross-country skiers are presently available.

Assessment Protocol

Anthropometry involves the application of physical measurements to appraise human size, shape, body composition, maturation and gross function. The International Society for the Advancement of Kinanthropometry (ISAK) provides global anthropometric standards that aid in the prediction of individuals' body composition. It assists in monitoring athletes, tracking growth, predicting health status, and in linking physical activity and diet to changes in body size and composition. Adoption of a global profile and methodology allows comparisons to be made nationally and internationally among sample groups.

The measurements are divided into five broad categories: basic, skinfolds, girths, lengths and breadths. Basic measurements include body mass, stature, and sitting height. Skinfold measurement sites include: triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf. Girth measurements include arm relaxed, arm flexed, waist, hip, mid-thigh and calf.

A skinfold measurement is commonly used in sport because the technique is non-invasive, cheap, and accessible. A skinfold reading measures the compressed thickness of a double layer of skin and the sub-cutaneous adipose tissue. The sum of 4 to 7 skinfold measures is commonly used in female athletes to predict fat mass and percent body fat. This method may not always be valid because regression equations are population-specific and may not apply to the sample studied. It is now recommended to use absolute values such as a skinfold sum to monitor an athlete over time (see Appendix B for further information and guidelines).

Fuel Use During Exercise

Training for cross-country skiing requires energy from all macronutrients (carbohydrate, protein and fat); however, carbohydrates and fats are the predominant energy source used during exercise. Particularly carbohydrate, stored in the muscle as glycogen, is the body's quickest energy source.

Both exercise duration and intensity determine fuel selection. Increased exercise duration shifts fuel use from muscle glycogen to sources located outside of the muscle (liver, blood, and adipose tissue). In the liver, the process of gluconeogenesis (formation of new glucose) is essential for the maintenance of blood glucose later during exercise. With increased exercise intensity, muscle glycogen (carbohydrate stored in muscle) becomes the primary fuel for muscle contraction. However, due to the limited glycogen availability in muscle, when depleted, exercise intensity must be reduced, as the body shifts its predominant fuel source from carbohydrate to fat. Aerobically trained athletes have a higher capacity to use fat during exercise. In fact, both male and female endurance athletes use fats from adipose (fat) tissue as well as fats stored in muscle.

The contribution of protein to energy expenditure is rather small, at least under normal conditions. However, in athletes who restrict energy intake, oxidation of protein (muscle) can be accelerated, especially under intense and/or prolonged training conditions.

Female athletes appear to use more fat as a fuel during exercise compared to their male counterparts at the same relative intensity, and there is good evidence that fuel selection fluctuates in concert with changes in estrogen and progesterone levels throughout the menstrual cycle. Women appear to oxidize more fat compared with carbohydrate at a given submaximal intensity, and thus, may spare muscle glycogen during prolonged exercise in the luteal phase (phase prior to bleeding phase or menses) of the menstrual cycle. Therefore, female athletes may present with a more optimal carbohydrate availability during prolonged exercise, particularly during the third phase of the menstrual cycle. However, a recent review discussing the effect of the menstrual cycle on performance in female athletes stressed the large inter-individual variability. The authors underlined the relatively small effect of cycle phase and oral contraceptive use on performance when compared with nutritional factors, such as carbohydrate's effect on performance that occurs independent of menstrual cycle phase.

Although the menstrual cycle should not be neglected, female athletes do best if monitoring their own cycles and log subjective information related to the effect of cycle phase (e.g., pre-menstrual phase) on their mental and physical well-being and performance. Such information can be valuable when consulting with a physician individually for the management of issues related to mood disturbances, heavy menstrual bleeding, or cramping (for more information, see review by Constantini et al, 2005). For years, gold medals have been won by athletes during various phases of the menstrual cycle. Thus, female athletes are encouraged to have a positive attitude toward the menstrual cycle, as it is part of a healthy and successful athlete.

Environmental Factors

Environmental conditions can vary in the sport of cross-country skiing and it is, therefore, important to note that energy expenditure, fuel utilization, and fluid balance may also change.

Heat and Humidity
In a hot and humid environment, greater fluid loss from sweat is inevitable, increasing the risk of dehydration and possibly accelerating the rate of energy expenditure and glycogen utilization. Under such conditions, fatigue does not coincide with glycogen depletion, as is usually the case in prolonged exercise at ambient temperatures. This is because hyperthermia typically occurs before glycogen depletion.

Altitude and Cold
Altitude exposure results in increased ventilation and an initial reduction in total body water and plasma volume. Due to the fact that the air at altitude is also cold and dry, greater water loss occurs through breathing. Both altitude and cold lead to diuresis or greater urinary loss. Hence, maintaining hydration status and effective thermoregulation when exercising in these environments represents a major challenge in the training athlete.

With increased exposure to altitude and cold, energy expenditure rates can rise substantially. This is further complicated by a marked decrease in appetite when ascending to a high altitude environment, possibly leading to energy imbalance and weight loss. Although possible in the female cross-country skier, these data have been reported from studies on mountaineers. Nevertheless, skiers should be aware of these potential side effects when engaging in training or sleeping at altitude.

It has previously been demonstrated that fuel selection shifts to a greater use of blood glucose in men both at rest and during exercise compared to sea level. The predominant use of blood glucose, without sparing muscle glycogen, represents a challenge for male athletes training for long hours in these environments. In contrary to men, women appear to rely on fat as a fuel to a greater extent when exposed to altitude, at least during submaximal efforts, with lower use of blood glucose and glycogen compared to sea level. This may be an advantage, especially in the early stages of acclimatization. Once acclimated, exercise intensity relative to sea level appears to be the most important determinant of fuel selection in both males and females, although more research is warranted in this area.

In the cold, there is evidence that carbohydrates are the predominant fuel source for metabolic heat production (shivering thermogenesis). In cross-country skiers, however, muscle contraction probably maintains blood flow and core temperature, even in the cold, with a relatively low risk for hypothermia under exercising conditions.

One major limitation of the research presented above is the fact that most studies at altitude have been conducted in extreme environments at elevations greater than 4000 m (> 12,000 ft). For cross-country skiers, however, training at altitude usually occurs at elevations between 1800 and 3200 m. Nevertheless, current and future knowledge on women's responses to altitude and cold may suggest that nutrition for athletes training at altitude needs to be gender-specific.

2. MACRONUTRIENTS

Training and competition in cross-country skiing requires a high-energy intake, with at least 60% provided by carbohydrates, 12 to 15% by protein, and around 20 to 25% by fat. Early recommendations for macronutrients were expressed in percent of total energy intake. When energy intake is low, however, a percent value similar to the recommended ranges for carbohydrate, protein, and fat does not correspond to adequate intakes of these macronutrients. More specific values are expressed in total grams or grams per kilogram of body weight per day (g/kg/d).

Although most studies demonstrate adequate intakes of protein and fat, it appears that carbohydrate intake is often suboptimal to support repetitive intense training and competition. This chapter will focus on macronutrients, current research in endurance sports, and practical examples to fuel the female cross-country skier for training and competition.

Carbohydrates

Functions

Carbohydrates are not only crucial for physical performance but also play an important role in fueling the brain. Carbohydrate stored in the muscle is the primary source of energy during exercise, whereas carbohydrate stored in the liver helps to maintain blood glucose levels and provide fuel for the brain. Unfortunately, glycogen stores in both muscle (200 - 600 g) and liver (80 - 120 g) as well as blood glucose are limited, and thus, require daily repletion through dietary means. Therefore, under most training conditions, the female cross-country skier will need to focus on replenishing carbohydrate stores after training to ensure adequate recovery.

Further, adequate carbohydrate also appears to protect the immune system. It has been shown that carbohydrate availability attenuates the stress-related immune response during and after intense exercise. Low carbohydrate availability may lead to an increased level of circulating stress hormones (particularly cortisol) and cytokines, possibly increasing the risk for infection, as well as delaying the recovery process.

Currently, conflicting ideas about adequate carbohydrate availability and training adaptation exist. It may not always prove beneficial to supply the muscle with optimal amounts of carbohydrate to ensure availability at all times. Researchers have shown that the increased stress response when training under low carbohydrate availability may possibly lead to better training adaptation. To date, these studies are limited to laboratory studies in untrained subjects that will need to be confirmed in the training athlete in the field. Nevertheless, these results suggest that more attention needs to be paid to feeding strategies that are synchronized with the periodized training and competition plan. Specific recommendations, taking these new findings into consideration, await further research.

Sources and Requirements

Carbohydrates include glucose, fructose, sucrose, maltose, lactose, galactose, starch, and fiber. Nutritious, carbohydrate-rich foods include pasta, rice, potatoes, cereals, whole grains, breads, fruit, starchy vegetables, legumes, and sweetened and fruit-based dairy products. In addition, the category of sports foods and fluids belongs to high-carbohydrate sources for the athlete. Finally, sugar and sugary foods also provide carbohydrates and can be used to add extra fuel to a high-carbohydrate diet.

Carbohydrates are often classified using the glycemic index (GI). The GI is defined as the rate at which glucose levels rise in the blood after the ingestion of 50 grams of a particular carbohydrate-containing food. The GI was first developed to help to determine which foods were best for people with diabetes. Research on the GI shows that different carbohydrate foods have different effects on blood glucose levels (see Appendix C for examples). Whereas there is little benefit of using the GI for planning breakfast, lunch, and dinner, the GI may find its best application when eating and drinking within 30 to 60 minutes before, during, and after exercise. Foods and fluids consumed before exercise may preferentially come from sources with a lower GI to prevent rebound hypoglycemia (low glucose levels coinciding with the onset of exercise after ingesting high GI foods), at least in those athletes who are more sensitive to high GI foods. Although it has been shown that this transient hypoglycemia occurs and often coincides with the onset of exercise, there is no evidence that it negatively affects performance. More important is the ingestion of high GI items during and after exercise to ensure quick digestion, absorption, and transport of glucose to the muscle. Although carbohydrate alone can stimulate rapid glycogen resynthesis after exercise, it appears that the addition of protein may have an additive effect.

Meeting daily carbohydrate requirements is essential to support repetitive, intense training periods or tight competition schedules in cross-country skiers. To replenish lost fuels after training and competition, the athlete needs to consume a high carbohydrate diet. It may take between 24 to 48 hours to replenish depleted glycogen stores after prolonged exercise (≥ 90 minutes). It has been clearly established that low or moderately low carbohydrate diets will not suffice to replete glycogen stores on a daily basis. Over the course of a training camp, such diets may result in a lower capacity to endure both prolonged and high-intensity exercise. Once glycogen stores are depleted, intensity must be reduced because fuel provision changes to a greater proportion being supplied by fat. Thus, during periods of intense training in which the focus is on training quality, meeting dietary carbohydrate requirements must be a top priority for cross-country skiers.

Table 1. Carbohydrate requirements for female cross-country skiers

Training Condition	**Recommended**
Daily needs for repetitive training ≤ 90 minutes	5 - 7 g/kg body weight
Daily needs for repetitive training days 90 - 120 minutes	7 - 12 g/kg body weight
Daily needs for period of highly intense and prolonged cross-country ski training > 120 minutes	10 - 12 g/kg body weight

*See Appendix C for sources and amounts of carbohydrates

Carbohydrate Intake Before, During, and After Exercise

Eating before Training or Competition

Eating 1 to 4 hours prior to exercise helps to optimize liver glycogen levels and ensures gastric (stomach) emptying. More digestion time may be needed before running and high-intensity skiing or roller ski training.

A pre-exercise meal should be:

- Rich in carbohydrates
- Familiar
- Easily digestible
- Adequate in fluid

Target Amount before Exercise: 1 - 4 g / kg

Carbohydrate Loading:

Carbohydrate loading is a strategy that involves changes in training and diet prior to an endurance event (30 and 50 km cross-country skiing event). The aim is to maximize carbohydrate stores, which may enhance endurance performance by 2 to 3%. The traditional method of carbohydrate loading involved three days of depletion (via a low carbohydrate diet and exhaustive training) followed by a 3 to 4 day loading phase (high carbohydrate diet and rest or minimal training). The modified method of carbohydrate loading, which is the recommended procedure adopted today, involves a 3 to 4 day exercise taper followed by a high carbohydrate diet for the 3 days leading up to the event.

Target Amount for Carbohydrate Loading: 10 - 12 g / kg

An example of a carbohydrate loading diet can be seen in Appendix C. There has been limited research on the female's response to carbohydrate loading; however, recent data have shown that female athletes have similar capabilities to carbohydrate load as their male counterparts if calorie intake is sufficient.

Carbohydrate Intake During Exercise

It has long been known that carbohydrates ingested during exercise can delay fatigue and improve endurance performance in time-trial settings. The maintenance of blood glucose through continuous carbohydrate delivery is the most likely factor contributing to this enhanced performance effect. Environmental extremes such as high altitude and cold temperatures as well as dehydration in the heat have the potential to further deplete muscle glycogen stores during exercise. Therefore, using carbohydrates in either liquid or solid form during training or competition in these environments should be encouraged.

Carbohydrate supplementation during exercise is recommended for training or competition lasting longer than 60 minutes. Recent data have also shown that carbohydrate supplementation during high-intensity exercise below 60 minutes in duration can increase performance. The mechanisms, however, are likely to be different. As there is not an endless supply of glycogen fuel, the decision to consume these feeds will depend on the following considerations:

- Intensity of exercise: the higher the intensity, the faster the glycogen reserves are used
- Duration: the longer the event, the more glycogen is used
- Dietary intake prior to training or competition: the more carbohydrates are consumed prior to training or competition, the greater the carbohydrate availability

Target Amount during Exercise: 30 - 60 g / per hour

Sport drinks can be used to provide the necessary fluid, carbohydrates, and electrolytes that facilitate fluid absorption, delivery, and fuel replacement (see Chapter 3). When solid foods are required they should be of an individual's choice. Examples of products that provide 30 to 60 g of carbohydrates include: sport gel or bar, honey sandwich, or hard candy (see Chapter 7).

Recently, the sport drink industry has emphasized the addition of protein to improve performance, reduce muscle damage, and enhance recovery between training sessions. Several studies have been conducted showing conflicting results on performance. If sport drinks with protein are used during exercise, they may be best integrated during long and/or intense workouts. Although there may not be a performance benefit, it is possible that the protein helps to reduce muscle damage.

Carbohydrate Repletion After Exercise
After prolonged exercise, glycogen stores may be depleted. Adequate recovery involves quick refueling of the body immediately after exercise. The rate of glycogen synthesis is between 7 to 8% per hour if carbohydrates are ingested within the first 2 hours after exercise, whereas it is reduced to 5% per hour after this initial time period. Although carbohydrate alone can stimulate rapid glycogen resynthesis after exercise, it appears that the addition of protein may also have a favorable effect on glycogen synthesis.

To replace glycogen stores after exercise, it is recommended that a sport drink or water be combined with a snack eaten within 1 to 2 hours after exercise if training or competition occurs once per day and within the first 20 to 30 minutes if training or competition occurs twice per day. The repletion of glycogen stores when less than 24 hrs are available until the next workout or competition is best achieved by eating 1 - 1.2 g/kg of carbohydrate every 30 to 60 minutes for up to 4 hours post-exercise. The type of carbohydrate may also enhance glycogen resynthesis. Carbohydrate should be in the form of easily digestible starches and should be moderately high to high in the GI, such as white rice and white pasta.

Target Carbohydrate Amount after Exercise: 1 - 1.2 g / kg

Examples of 50 - 75 g carbohydrate recovery snacks include (see appendix for more carbohydrate examples):

- 32 oz or 1 liter sport drink (depends on carbohydrate concentration)
- 16 oz or 500 ml water or sport drink + 1 banana sandwich
- 16 oz or 500 ml water or sport drink + 1 honey sandwich
- 16 oz or 500 ml water or sport drink + carbohydrate sport bar
- 16 oz or 500 ml water or sport drink + 50 g hard candy

Protein

Functions

Adequate protein intake in female athletes ensures the delivery of essential and non-essential amino acids necessary for a variety of functions in the body. Proteins are necessary for the synthesis of muscle cells, enzymes, hormones, and transport proteins. Fluid and electrolyte balance is dependent on protein content in the plasma. Protein is also integral to acid-base balance and immune function.

Achieving Protein Balance

In training athletes, achieving a positive protein balance on a daily basis should be one of the nutritional goals. Several conditions can leave the athlete with a greater protein breakdown compared to synthesis (building), resulting in a negative protein balance or muscle wasting. The following exercise-related factors can negatively affect protein balance and lead to increased use of body protein in the endurance athlete:

- Prolonged exercise
- High-intensity exercise
- Exercising in the fasted state
- Repeated exercise in an energy- and carbohydrate-deficient state

Thus, nutritional care of an athlete during repetitive days of training should include proper feeding strategies. These may consist of eating balanced meals at breakfast, lunch, and dinner with adequate amounts of protein, using carbohydrate-containing sport drinks during prolonged and high-intensity exercise, combining snacks, foods, and fluids for recovery, and balancing energy intake with energy expenditure.

Sources and Requirements

Protein sources can be divided into animal and plant protein.

Table 2. Examples of animal and plant protein

Animal Protein	**Plant Protein**
Meats	Soy products
Poultry	Legumes
Fish	Nuts & seeds
Eggs	Whole grains
Dairy products	Meat alternatives

Protein requirements for vegetarians are slightly higher due to the lower bioavailability and amino acid content of plant proteins. However, individuals on well-balanced vegetarian diets that include eggs, dairy, and soy products usually have no different protein requirements than non-vegetarians. For both, vegetarian and non-vegetarian cross-country skiers, protein needs are on the order of 1.2 to 1.6 g/kg/d, although intakes of 2 g/kg/d may also apply in special circumstances (injury, weight loss, growth, or ultra-endurance training).

Daily Target Amount: 1.2 - 1.6 g/kg/d

*see Appendix C for sources and amounts

These recommendations are higher than those for the general public. In general, athletes' diets easily meet protein needs. However, in energy-restricting athletes, the risk of low protein intake may be more apparent. Current protein recommendations favor the inclusion of smaller servings ingested multiple times throughout the training day, with amounts being higher for breakfast, lunch, and dinner and smaller for snacks in between meals and recovery foods after exercise. This grazing nature of food intake also appears to be a more feasible way to achieve protein balance in female athletes.

Protein Intake After Exercise

Protein plays an important role in the recovery process after exercise. Adding protein to carbohydrate-rich recovery foods and fluids can contribute to the positive hormonal milieu that exists following exercise, typically leading to greater positive protein balance. As discussed in the carbohydrate section, protein can also maximize the rate of glycogen resynthesis after exercise, although this depends on the total amount of carbohydrate consumed. Thus, including protein in small amounts in the athlete's recovery foods/fluids after exercise should be encouraged in cross-country skiers. Recovery foods should provide between 10-15 g of protein, whereas larger amounts of protein (20 to 40 g) are typically eaten at meal-times.

Examples for recovery foods to add to a sport drink:

- 1 low-fat yogurt + 1 cup of cereal
- 1 cup of milk + 1 cup of cereal
- 1 Sandwich (1.5 oz or ~ 40 g of turkey, tuna, lean ham, mustard)
- 1 sports bar containing 10 g of protein or recovery beverage (see Chapter 7)

Fat

Functions

Fat is an important contributor to total energy intake in cross-country skiers. Athletes with a high-energy turnover will need to include fats as a more dense energy source to meet high-energy requirements during intense training. Fat contains more than twice as many calories than protein and carbohydrate. Fat is an important energy source during prolonged exercise and can be supplied from both adipose and muscle tissue (from intramuscular triglycerides).

Although fat from fat stores other than muscle tissue is not a limited energy source, recent findings show that fat stores within the muscle can become depleted in aerobically trained athletes and require repletion in the days following prolonged exercise. Apart from fueling the body with energy, fats are an integral part of cell membranes, help in the formation of sex steroid hormones, aid in the transport and absorption of the fat-soluble vitamins A, E, D, and K, and play an important role in inflammatory processes.

Sources and Requirements

Fats are found in both animal and plant foods. Animal fats are rich in saturated fats and often contain high amounts of cholesterol.

Table 3. Common fat sources in foods

Common High Fat Sources
Red untrimmed meats
Poultry with skin, thigh from poultry
Sausages and other processed forms of meat
Whole milk dairy products, cheese
Fried foods, fast foods, convenient foods
Sauces, dressings, condiments
Desserts and sweets

Vegetable fats are rich in poly- (PUFA) and monounsaturated (MUFA) fats. These fats can have a variety of chemical structures. Polyunsaturated fats contain essential fatty acids that the body cannot make but need to be supplied by the diet. Some of these fats play an important role in reducing inflammatory processes but this is dependent on the balanced intake of these fats. Reducing fats from Table 3, choosing leaner and lower fat options, and increasing fats from Table 4, especially those of the omega-3 and omega-9 families, may assist in maximizing the anti-inflammatory as well as anti-oxidant benefits of dietary fats.

Table 4. Examples of foods high in unsaturated fats

Omega-6 Fatty Acids	Omega-3 Fatty Acids	Omega-9 Fatty Acids
Sunflower seed oil	Salmon, mackarel, tuna, sardines	Olive oil
Safflower and corn oil	Green leafy vegetables	Canola oil
Soybean oil	Flax seeds/oil and canola oil	Pecans, almonds
Avocado	Walnuts	Peanuts

Although endurance athletes need to focus on a low-fat diet in order to achieve a high carbohydrate and moderate protein intake, it may not be wise to maintain chronic low-fat eating habits throughout the year. In fact, it has been shown that a moderate amount of dietary fat (50 to 100 g) per day may help the endurance athlete to replete lost fats from muscle tissue after prolonged exercise. It appears that the Mediterranean diet could be implemented to provide a greater proportion of essential fatty acids (omega-9 fatty acids from vegetable oils and omega-3 fatty acids from fish, flax, and walnuts) and a higher proportion of MUFA from olive oil and nuts. Other strategies may include more frequent consumption of soy-based foods and drinks as well as nuts, providing a good source of essential fats from a variety of plant-based foods. In the cross-country skier with a high-energy requirement, it is relatively easy to achieve a higher fat intake, without compromising carbohydrate and protein adequacy. In addition, the occasional increase in fat consumption from plant and fish sources could have potential benefits on blood lipid profiles (i.e., cholesterol) and antioxidant status due to the vitamin E content of such oily foods. Although not an immediate goal of dietary interventions in endurance athletes, adding certain types of fat to the menu plan occasionally after prolonged exercise could be an effective strategy to 1) replete intramuscular fats, 2) provide antioxidant and anti-inflammatory substances, and 3) confer cardiovascular protection.

Daily Target Amount: ≥ 0.8 - 1.5 g/kg/d

In the athletic setting, however, further research is certainly needed to confirm the benefits of higher fat diets on performance, as most of the long-term fat loading trials, even when changed to a high-carbohydrate diet prior to a performance trial, have not been shown to improve exercise performance over the traditional high-carbohydrate approach. Nevertheless, a diet with a higher fat content at certain times may cater certain benefits to the athlete with regards to the up-regulation of oxidative enzymes as well as the provision of a natural anti-inflammatory and antioxidant protection.

Female athletes with very low fat diets (<10 to 15 % of total calories) are usually those athletes who also restrict overall calories. These athletes are at risk for decreased fat-soluble vitamin absorption, low essential fatty acid provision, and possibly impaired hormone functions.

In conclusion, female cross-country skiers require a high-energy intake with adequate amounts of carbohydrate, protein, and fat. Carbohydrate, protein, and fat counters (Appendix C) provide useful tools to determine whether a female cross-country skier meets her daily requirements. Individual needs, however, depend on body mass, level of training, time of day relative to training sessions, the environment, training/competition phase, and phase of the menstrual cycle.

Table 5 Estimated macronutrient requirements for female cross-country skiers

Training Day	**Calories (kcal/kg/d)** (total calories for 60 kg female)	**Carbohydrates (g/kg/d)** (calories from carbohydrates for 60 kg female)	**Protein (g/kg/d)** (calories from protein for 60 kg female)	**Fat (g/kg/d)** (calories from fat for 60 kg female)
Easy day (1 easy session ≥ 90 min.)	~ 40 (2400)	5 - 7 (1200-1680)	1.2 - 1.6 (288 - 384)	~ 1 (540)
Moderate to hard day (1-2 sessions; moderate intensity)	45 - 50 (2700 - 3000)	7 - 12 (1680 - 2880)	1.2 - 1.6 (288 - 384)	~ 1.4 (756)
Hard day (2 intense sessions) and carbohydrate loading	55 - 80 (3300 - 4800)	10 - 12 (2400 - 2880)	1.2 - 2 (288 - 480)	1.5 - 2 (810 - 1080)

*see Appendix A for estimations of energy expenditure for various activities calculated by weight

Table 6 Ten strategies to meet energy and macronutrient requirements

1. Eat frequent small meals (5 to 6 per day).
2. Balance breakfast among carbohydrate, protein, and fat: emphasize carbohydrates but don't forget proteins and fats.
3. Use carbohydrate-containing snacks and sports foods/fluids before, during, and after your moderate to hard and prolonged training sessions.
4. Add a small source of protein (low-fat or non-fat yogurt, low-fat or skim milk, deli meats, non-fat chocolate milk, low-fat cottage cheese, ½ protein bar, ½ protein drink, nuts, or carbohydrate bar with around 10 g of protein) to your recovery foods and fluids after moderate and hard workouts and after the first workout on double-workout days.
5. Consider a Mediterranean meal containing carbohydrates (pasta/rice/breads), lean protein (chicken, fish, lean red meat), vegetables, and olive oil after prolonged exercise.
6. Eat an after-dinner snack or dessert on intense training days.
7. Use meal replacement drinks for travel or stressful times. They provide a balanced source of calories (~ 300 calories per serving) and are fortified with vitamins and minerals.
8. Pick a rest day to plan your dietary strategies for the following week.
9. Use sport foods/drinks and occasional sweets to meet carbohydrate requirements during intense training.
10. Adapt your foods and fluids to the environment. Eat and drink cool items in the heat and include soups, warm meals, and warm fluids in the cold.

3. FLUID

Functions

Water accounts for 50 to 60% of body mass, and 75% of muscle is composed of water. In the athlete, maintaining fluid balance is important for many reasons. When energy turnover is high, the body needs to dissipate the heat generated through muscle contraction. Sweat rates in endurance athletes can be substantial and range from 1 to 2 liters per hour. Fluid replacement is essential to minimize dehydration because only a small loss of 2% of body weight via body water can lead to decrements in performance.

Maintaining fluid balance is also important for nutrient and waste delivery. In addition, more recently, it has been suggested that cell swelling through proper hydration may play a key role in effective glycogen resynthesis and protein synthesis after exercise.

Adequate fluid replacement during exercise is imperative in hot and humid environments, in which sweat rates can exceed 1.5 to 2 liters per hour. An elevation in core temperature increases strain on the cardiovascular system, increases perceived exertion, and reduces performance. In the cold and low-humidity, high-altitude environment, however, it is often believed that fluid losses are miniscule. Although the drive to drink may be suppressed in these environments, fluid losses are nevertheless substantial, with a large part contributed by respiratory fluid loss through the humidifying of inspired cold, dry air. Voluntary hypohydration may also occur due to increased diuresis (larger urinary volume), lack of restroom facilities, and a decreased drive to drink in these environments. Female athletes in particular may choose not to drink under such conditions, and thus, run the risk of dehydration and subsequent performance decrements.

Adequate fluid intake from both fluids and foods is key in preventing dehydration. Fluid replacement in athletes depends on sweat rate. A variety of factors influence sweat rate:

- Ambient temperature and humidity
- Intensity and duration of exercise
- Training status and acclimatization
- Body size and composition
- Body surface area
- Gender

For female cross-country skiers, high-volume training in the hot summer months impose the most challenging environment to maintain daily fluid balance. It is possible that certain long-distance run or roller ski training sessions over a 2 to 3 hour time period occur at temperatures of up to 35 ° C. Recent unpublished data from American skiers showed a mean sweat loss of 1.9 liters which ranged from 0.8 to 2.9 liters and resulted in an average body weight loss of 2 % (0.9-2.5%) compared with pre-exercise values after a 2-hour trail run at 25° C, an altitude of 2,200 m, and humidity of 25%. Such environmental factors, therefore, demonstrate relatively high fluid requirements in cross-country skiers in the summer months.

Heat dissipation is not the primary concern in the cold; however, maintaining total body water is important in minimizing competition for blood flow among active muscle, organs, tissues, and the skin during cold exposure. In male skiers, data have shown that fluid loss can be significant during cross-country ski races. In fact, several studies have indicated that despite the colder environment and fluid intake, 2 to 3% of body weight may be lost from fluid loss in 15 to 30 km races. Female athletes are known to sweat less than their male counterparts; however, this gender difference appears to be, at least in part, influenced by training status and acclimatization. Whether a 2 % body weight loss from sweat loss during exercise in the cold has an effect on mental or physical performance is currently unknown. Skiing is often performed at altitude which escalates urine output and respiratory water loss. The intake of fluid, and especially sport drinks, during training and races lasting longer than 15 km is required to help reduce physiological stress and maintain fluid balance. Carrying large volumes of fluid onto the ski course and maintaining fluid temperature between 10 and 20 ° C can be challenging. It is recommended that warm sport drinks be carried in leak-proof containers with thermal covers. Hypothermia, problems with breathing, and local cold injury are further complications incurred by cross-country ski racers.

Due to a large intra-individual variability in the sweat response to exercise and daily fluid requirements, it is essential that female athletes assess fluid balance in a variety of different training conditions. Monitoring fluid loss through exercise can be managed by monitoring weight changes before and after exercise, taking into account fluid volumes ingested via drinks and excreted via urine during exercise (see Appendix D for fluid balance test). Other forms of monitoring include the color test where urine should be pale and transparent. Strongly colored urine may indicate dehydration.

Fluid Requirements

Although reported for many years, no evidence is currently available to support the recommendations of drinking 8 cups of fluid per day. Recommendations for athletes may be more fragmented into fluids ingested with meals, snacks, and before, during, and after exercise, especially if two training sessions are scheduled in one day. Athletes should be encouraged to drink water throughout the day, with sources such as milk, juice, herbal tea, occasional sodas, coffee, black and green teas counted as additional fluids. Sport drinks and water consumed before, during, and after exercise should be counted separately. Guidelines for consumption are detailed below.

Fluid Intake Before, During, and After exercise

Many professional organizations have published written materials for proper fluid replacement before, during, and after exercise. Most of these materials are available on-line and can be downloaded free of charge (see Appendix H for resources). On the opposite spectrum of dehydration, increased instances of hyponatremia (dilution of blood sodium levels due to over-consumption of fluid) have been seen in athletics, particularly in summer sports. Whereas proper hydration is important for performance, excessive consumption of fluids without replacement of sodium can be detrimental. To date, no recommendations exist for fluid replacement in the cold. The best strategy to identify individual needs in the cold is to measure sweat rate by monitoring body weight before and after exercise. It is generally recommended to replace at least 80% of fluid lost during exercise and between 125 to 150% after exercise. Weight loss from fluid loss should be minimized, especially when training in the heat, as performance decrements have been reported with a body weight loss of as little as 2%. However, a 2% body weight loss may be tolerated in cold environments without a decrement in performance.

Fluid Intake Before Exercise
Athletes should attempt to begin the training session in a well-hydrated state. Most guidelines suggest 17 - 20 oz (~ 500 - 600 ml) of fluid within 2 to 3 hours prior to exercise and 10 - 12 oz (~300 - 360 ml) within 10 minutes of exercise. In a hot environment, an additional 16 oz (~ 500 ml) are recommended. For racing, it may be advantageous to ingest around 6 - 8 oz (~200 ml) of sport drink 10 minutes prior to race start.

Target Amount before exercise:
2 to 3 hours prior: 17 - 20 oz or ~ 500 - 600 ml
0 to 10 min prior: 10 – 12 oz or ~300-360 ml (heat)
10 min prior: 6 - 8 oz or 200 - 250 ml (cold; racing)

Fluid Intake During Exercise
In general, fluid replacement during prolonged exercise should be considered for training or competition lasting 45 to 60 minutes or longer. For training sessions under normal ambient conditions, athletes should carry bottles or waist belts with leak-proof containers. In the cold, it may be more feasible to have staff available on the track to hand warm fluids to training athletes. When racing, similar strategies may be applied. A general fluid replacement routine may be to ingest fluids every 3.5 to 5 km during racing and after each heat in sprint events.

Fluid replacement should begin early during exercise and should continue every 15 to 20 minutes. Amounts vary and are likely based on individual differences. Although 5 - 8.5 oz (~ 150 - 250 ml) are recommended, most athletes hardly meet the lower range of this recommendation, but typically drink an average of 16 oz (~ 500 ml) per hour. In the cold, the fluid balance test should be used to identify individual needs with the goal of minimizing weight loss from sweat loss that exceeds 2 % of initial body weight. Dilution of blood sodium levels from excessive fluid consumption and/or a sodium deficit from sweat losses can lead to hyponatremia. Symptoms of hyponatremia are similar to dehydration. Previously high fluid recommendations may have contributed to the increase in cases seen. Whereas hyponatremia is relatively rare, it is more commonly seen in slower-paced athletes, and female athletes appear to be at a greater risk of developing hyponatremia, particularly in hot environments. This could be due to their attentiveness to consume fluid, fluid intake exceeding their sweat rate and because a smaller body mass can be more easily affected by over-drinking. Fluid and electrolyte replacement recommendations vary considerably across and even within sports and athletes because there are sport-specific and intra-individual differences that influence fluid loss. Determination of sweat rates, ad-libitum drinking and the re-acceptance of thirst as an indicator to drink are more recent recommendations for fluid consumption during prolonged exercise.

Target Amount during exercise:
13 – 23 oz or 400 - 800 ml/hr (10 - 23 oz or 300 - 700 ml/hr in cold)

Fluid Intake After Exercise
Rehydration strategies are important for restoring fluid balance after exercise, especially if a second training session is scheduled in the next 24 hours. Recommendations are based on the amount of weight lost. Each pound or kilogram lost should be replaced by approximately 125-150% (where each pound lost equals 16 oz of fluid and each kilogram lost equals 1 liter of fluid). Spacing ingestion of fluid is more beneficial for rehydration than consuming a large volume of fluid immediately after activity. According to the 2005 American College of Sports Medicine (ACSM) *Roundtable on Hydration and Physical Activity* (see resources for reference), 2 liters of fluid, ingested in 500 ml amounts every 20 to 30 minutes is an effective rehydration strategy.

Target amount immediately after exercise:
20 - 24 oz for each pound lost (1.25 - 1.5 liters for each kilogram lost)

Electrolytes

Maintaining hydration status, however, is not only dependent on adequate fluid intake but also on sufficient replacement of electrolytes that are lost in sweat. The largest loss occurs from the extracellular space in the form of sodium and chloride, with smaller losses of potassium, magnesium, and calcium. Thus, adequate dietary intake of sodium and other electrolytes lost in sweat is an important strategy to maintain hydration status during and properly restore hydration status after exercise.

The ingestion of large fluid volumes in the form of water in the absence of foods or sport drinks containing sodium may lead to hyponatremia (low plasma sodium concentration). This, however, has never been reported in cross-country skiers, and the risk of hyponatremia occurring in the winter sport environment is relatively small.

Sport Drinks Versus Water
Deciding between water and a sport drink depends on the intensity and duration of exercise, dietary intake prior to exercise, environmental factors, and personal preferences. Sport drinks contain electrolytes such as sodium and potassium and are generally more palatable and stimulate fluid intake. In addition, sodium aids in the transport of water and carbohydrate across the intestinal wall, and once absorbed, helps fluid retention.

Sport drinks are recommended for prolonged, moderate intensity exercise lasting 60 minutes or longer. For high-intensity exercise, sport drinks may be beneficial even if the session is shorter than 60 minutes, however, this depends on dietary intake before exercise and personal preference.

In the heat, sport drinks should be favored over water for better fluid retention and sodium replacement during exercise. Although no recommendations are currently available for exercise in the cold and at higher altitude, sport drinks may be more effective in maintaining hydration status and decreasing the diuretic effect when exercising in these environments.

What to look for in a sport drink:
(Values correspond to 32 oz or approximately 1 liter of fluid):
Carbohydrate concentration: 4 - 8% (40 - 80 g)
Sodium: ~ 500 - 700 mg/L
Potassium: ~ (120 – 600 mg/L; variable)
Sugar sources: glucose, glucose polymers, sucrose, fructose, maltodextrin
(best to have a variety of sugars to maximize absorption due to specific transporters across the intestinal wall)
*see chapter on sport foods and supplements for more information on sport drinks, energy drinks, sport water, bars, and gels

*for conversions between ounces, milliliters, cups, and liters see Appendix G

4. MICRONUTRIENTS

General Issues

Adequate vitamin and mineral intake is essential for the working athletic body, as the rate of energy turnover in skeletal muscle during exercise increases dramatically from resting values. In addition, many micronutrients are lost through sweat, menstruation, damaged or dead cells, as well as the gastro-intestinal and urinary track.

Whereas low intakes of vitamins and minerals are not always apparent in the non-athlete, in the athlete, they may interrupt the steady substrate flow through the metabolic pathways, affect the immune system, delay recovery time, or impair formation of new cells, tissues, and structural proteins. Signs and symptoms of low micronutrient intakes in the athlete may be seen as increased fatigue and increased susceptibility to illness. Performance decrements, however, are only expected in athletes with clinical deficiencies. For the female athlete, a low intake often occurs for iron, calcium and vitamin D, zinc, magnesium, and the B-vitamins folate, vitamin B_6 and B_{12}. The following list illustrates risk factors for low micronutrient intake through dietary means in female athletes.

- Low-energy diets
- Low-protein diets
- Unbalanced vegetarian and vegan diets
- Intolerance to certain foods or components of foods (lactose, gluten)
- Avoidance of certain food groups (dairy, meat)
- High carbohydrate diets (especially with a high intake of processed carbohydrates)
- Unplanned, erratic traveling diets

In order to ensure adequate micronutrient intake, female athletes are encouraged to focus on:

1) meeting energy requirements
2) increasing the variety of foods
3) maximizing nutrient density in foods

Diets that yield around 1800 to 2000 kcal per day are thought to supply sufficient vitamins and minerals. For the female cross-country skier, higher amounts of micronutrients may be needed due to the high-energy turnover, particularly the B-vitamins. Appendix E summarizes reference intakes for various countries. In addition, specific recommendations for female athletes are given.

Environmental factors such as high altitude may also increase micronutrient needs in the cross-country skier. Thus, in addition to maximizing nutrient density through dietary means, ingesting fortified products (sport bars, cereals, juices) and/or a multi-vitamin and mineral supplement, maximally providing 2 to 3 times the respective DRI/RDA, may be considered for some cross-country skiers, but particularly for those athletes having difficulty meeting energy requirements or those on special diets. Based on individual needs and special circumstances (e.g., travel to foreign countries), supplementation, in addition to a multi-vitamin/mineral supplement, may apply for iron, calcium and vitamin D, zinc, vitamin E, and vitamin C.

The following section will focus on iron and calcium, as these nutrients are needed in adequate amounts in female cross-country skiers but often are consumed in amounts lower than the RDA. Antioxidants will also be covered in greater detail due to the high-energy turnover rates and frequent use of hypoxic (altitude-related sleep or training schemes) and/or hyperoxic strategies (supplemental oxygen) in cross-country skiers and potential greater needs for antioxidants.

Iron

Iron status has a major effect on an athlete's work capacity. The three key functions of iron are:

- transport (hemoglobin) and storage (myoglobin) of oxygen
- energy production and cell diffusion
- a functional role in the immune and central nervous systems

Iron deficiency is the most prevalent nutritional deficiency in females. It is a nutritional problem commonly reported in athletes undergoing heavy training and has been found in both male and female athletes from many different sports. Iron deficiency directly affects aerobic performance and recovery from multiple anaerobic sessions. It also affects recovery and resting overnight. Exposure to altitude may be particularly challenging for athletes with iron deficiency anemia. It has been shown that the adaptation to altitude may be impaired under such conditions.

Iron deficiency is most commonly described as occurring in three stages. Stage I refers to the depletion of iron stores, which is characterized by low serum ferritin levels. Depleted iron stores have not been found to cause any dysfunction, although new data suggest that training adaptation may be improved when iron depleted athletes increase iron intake from supplementation. However, the major concern of iron depletion is that it may progress to stage II - iron deficiency. In fact, some evidence exists that seasonal changes in training intensity and volume increases the risk for the development of stage II iron deficiency in female athletes. Abnormalities such as reduced work capacity and exertional fatigue are seen in stage II, which can be detected by low serum iron, reduced transferrin saturation and low serum ferritin. Stage III, iron deficiency anemia, is the most severe stage identified by a significant reduction in hemoglobin and hematocrit, clear signs and symptoms of reduced work capacity, delayed recovery, and greater susceptibility for illness.

Table 7 Parameters for the clinical diagnosis of iron depletion, deficiency, and anemia in females

Stage	**Change in iron measures**	**Serum ferritin (mcg/l)**	**Hemoglobin (g/dl)**	**Hematocrit (%)**	**Transf. Sat. (%)**
Normal iron storage	All iron status measures within reference range	> 30	> 12	33 - 43	20 - 40
Stage I Depletion	Low ferritin, normal to high serum transferrin saturation, normal hemoglobin and hematocrit	< 22 < 30*	Normal range of hemoglobin	Normal range of hematocrit	20 - 40
Stage II Iron Deficiency	Low ferritin, low transferrin, low serum iron, reduced transferrin saturation, free erythocyte protoporphyrin increases, normal hemoglobin	< 22 < 12	Normal range of hemoglobin	Normal range of hematocrit	< 20
Stage III Iron deficiency anemia	Low hemoglobin, hypochromic, microcytic, red blood cells, reduced MCV, low hematocrit, low serum iron, low transferrin and transferrin saturation	< 12	< 12	<33	< 20
	Factors affecting measures: dehydration, inflammation, malignancy, infection, acute exercise in trained, intense prolonged exercise				

* cut-off value for female athletes to address intervention through dietary intake and/or supplementation commonly used in practice

The prevalence of iron deficiency anemia is low in the athletic population (3%); however, iron depletion and deficiency without anemia occurs between 20 to 57% in female athletes and is higher in endurance sports and in female, adolescent, and vegetarian athletes regardless of type of sport and intensity of training. The prevalence of iron depletion (serum ferritin < 20 - 30 mg/dL) in cross-country skiers ranges from 42 to 50%. These data, however, were reported in the early and late 1980s when iron supplementation was not used as frequently as today. Iron supplementation has become a common practice among elite athletes to prevent iron depletion and deficiency and to optimize training adaptation, especially at altitude.

Maintaining iron homeostasis is a major problem for various athletes involved in regular exercise. The reported causes of iron deficiency are diverse and none of which fully explain this medical condition. Examples include excessive sweating, gastro-intestinal bleeding, mechanical trauma, and impaired iron absorption. Other most likely causes include heavy bleeding at time of menstruation, growth spurts, and insufficient dietary intake of iron.

The amount of iron potentially available from foods depends not only upon the amount of iron consumed, but the bioavailability and the composition of the meal. Iron in food exists in two

forms: heme and non-heme iron. Heme iron predominantly comes from animal products, with 30 to 40% found in pork, liver, and fish and 50 to 60% contained in beef, lamb and chicken.
The non-heme iron pool consists of iron from plant products such as vegetables, grains, fruit, legumes as well as from the non-heme iron in meats, poultry and fish, and fortified foods. They all have a somewhat limited availability. See Table 9 for dietary sources of heme and non-heme iron.

Table 8 Dietary sources of heme and non-heme iron:

Source	**Serving Size (oz/g/cups)**	**Iron Content (g)**
Animal (~40% heme and 60% non-heme)		
Liver	3 oz ~ 85g	9
Beef	3 oz ~ 85g	3
Chicken	3 oz ~ 85g	1
Fish	3 oz ~ 85g	1
Pork	3 oz ~ 85g	1
Eggs	1 whole	1
Plant (100% non-heme)		
Cereal, dry, fortified	1 oz ~ 28.4g	6
Spinach, cooked	½ cup	3
Sweet corn	½ cup	2
Pasta, cooked	1 cup	2
Rice, cooked	1 cup	2
Legumes, cooked	½ cup	2
Oats, cooked	1 cup	1.5
Raisins	¼ cup	1
Fruit	1 piece	0.5

Unique to non-heme iron is that the amount of absorbed iron can be modified markedly by components of food ingested in combination. Dietary factors, which increase the absorption of non-heme iron as much as four-fold, are vitamin C and heme iron present in meat, chicken, and fish. As the quantities of these substances in a meal increase, absorption also increases. If these enhancing products are not present in a meal, the absorption of non-heme iron is very low. However, new information emphasizes the complexity of non-heme iron in food, and the apparent stability of some non-heme iron sources such as ferritin found in food, from which sources iron seems to be well absorbed (e.g., soybeans and other legumes). Foods rich in the minerals that compete with iron for transport (e.g., zinc, calcium, and manganese) may decrease iron availability. In addition, there are a multitude of inhibitors that decrease non-heme iron availability. Table 10 provides a list of enhancers and inhibitors for iron absorption. Absorption of non-heme iron in the iron-deficient individual may be as much as 20% when enhancers are abundant. A meal lacking enhancers and/or containing high levels of inhibitors, reduces non-heme absorption to 2%.

Table 9 Factors that enhance or inhibit iron absorption

Iron Enhancers	**Examples**	**Iron Inhibitors**	**Examples**
Vitamin C rich foods	Citrus fruits and juices	Phytates	Cereal grains, legumes, soy products
Fermented Foods (low pH)	Miso, sauerkraut	Tannins	Tea, coffee, herb tea, cocoa
Heme Iron	Meat, fish or poultry foods	Calcium	Milk, cheese and yogurt
Organic acids	Citric acid and tartaric acid	Peptides from plant proteins	Soy protein*, legumes*, nuts*
Alcohol	Beer, wine, liqueurs	Oxalic acids	Rhubarb, strawberries

*relatively high ferritin content which appears to be well absorbed

Treatment of iron depletion and deficiency aims at normalizing iron stores, and it takes approximately 6 weeks but can vary greatly from athlete to athlete depending on genetics, training load, altitude, and diet. Treatment consists of increasing the dietary intake of absorbable iron, iron supplementation, and when appropriate, attempts to reduce blood loss (e.g., menstrual loss). It is important to monitor serum ferritin levels while supplementing with elemental iron. Athletes should plan to re-check their levels each 6 to 8 weeks following initiation of the supplementation schedule. Iron supplementation should be discontinued if it does not affect iron status.

Treatment of iron depletion or deficiency is managed by increasing dietary iron intake and/or supplementation. An iron supplement that consists of 45 to 60 mg of elemental iron in ferrous sulfate form (for better absorption) should be consumed. As food and other multi-vitamin and mineral tablets may impair the absorption of iron, iron supplementation should be done 30 minutes prior to or after a meal. To optimize absorption, athletes are encouraged to include a vitamin C rich source such as orange juice or a low-dose vitamin C supplement. Recent studies call for caution to not overload with iron and vitamin C cocktails in an attempt to maximize iron stores. Iron and vitamin C can be toxic in high amounts and damage the lining of the stomach and small intestine or become reactive and damage cells once absorbed. Further, excess iron stores can increase the risk for heart disease, stroke, cirrhosis of the liver, and diabetes. In addition, intramuscular injections of iron can also be dangerous because of the risk of potentially fatal anaphylactic shock. Finally, because constipation can occur due to supplementation, athletes may consider ingesting smaller amounts (1/2 dosage twice per day) or supplementing only every other day.

Legitimate and frequently used ways of increasing circulating hemoglobin and hematocrit values in cross-country skiers, although artificial, include the use of altitude houses, live-high and train-low strategies, and supplemental iron. Erythropoiesis can be stimulated by living at moderate altitude (2,300 to 3,000 m) for a 4-week period, with increases seen in red cell mass, hemoglobin, and oxygen-carrying capacity of the blood as well as aerobic power after return to sea level. Strategies of living high (>2,500 m) and training low (<1,500 m) have been shown to improve sea-level performance in events lasting 8 to 20 min. Altitude houses, developed in the 1990s with increased concentration of nitrogen and lowered concentration of oxygen, are frequently used by athletes without access to mountainous terrain, and training performed on glacier snow provides an additional exposure to a unique environment that may further stimulate erythropoiesis. However, if iron stores are not adequate, such strategies are not likely to lead to positive adaptations in blood hematology.

In contrast, illegal ways to increase circulating hemoglobin levels include red blood cell reinfusion and infusion of recombinant EPO. These methods not only impose great concerns of sportsmanship, but may also lead to adverse health effects. If the use of such strategies is detected, an athlete or team may be banned from international competition, in addition to receiving penalties and a shattered reputation within the international community. Clearly, those working with cross-country skiers must monitor iron status to ensure safe and legal practices to increase and limit hemoglobin values and stay current regarding hemoglobin and hematocrit cut-off values enforced by the FIS and the World Antidoping Association (WADA). The International Olympic Committee (IOC) and other international federations such as the FIS have adopted the World Antidoping Code designed by WADA. Hemoglobin cutoff values as well as other hematological procedures to test for artificial means used to increase red blood cell mass are expected to change, and thus, staying informed is key for those working as part of the medical team.

Calcium

Calcium is the predominant component of bone and is recognized primarily for its role in bone metabolism and long-term bone health. However, calcium is also involved in muscle contraction and nerve transmission, hormone function, enzyme activation, and membrane transport.

Bone represents the major reservoir of calcium. When dietary intake is low, calcium is withdrawn from bone in order to maintain calcium balance. Other adaptive mechanisms in times of low intake include increased calcium absorption and renal uptake of calcium. Parathyroid hormone and vitamin D are key to the control of calcium balance. However, there are a multitude of other hormones associated with bone metabolism, some of which are estrogen, insulin-like growth factor 1, and corticosteroids.

Calcium absorption from food is around 25 to 35%, although this depends on a variety of factors as illustrated in the Table 10.

Table 10 Factors that decrease calcium absorption

Vitamin D deficiency
High dietary sodium intake
High protein intake
Phytates & oxalates
Dietary fiber
Caffeine
High phosphate intake
Supplemental iron

Foods rich in calcium and daily requirements for females in a variety of countries as well as the athletic setting are shown in Appendix E. In general, athletes should consume 3 to 5 servings of low fat dairy products per day and include other calcium-rich sources from other foods throughout the day.

Table 11 Dietary sources of calcium

Foods sources	**Serving size (fl.oz/ml/g/cup)**	**Calcium (mg)**
Low fat milk	8 fl.oz ~ 240 ml	350
Low fat yogurt	6 oz ~ 170g	450
Cottage cheese	1 cup	100
Cheese	1 oz ~ 30 g	300
Spinach	1 cup	122
Soy milk (fortified)	8 fl.oz ~ 240 ml	120
Tofu (regular)	½ cup	300

Female athletes are at risk for low dietary calcium intake. In fact, average dietary intakes of calcium for female athletes are well below the recommendations. Among athletes, gymnasts and long-distance runners seem to have the lowest intake. Low calcium intake may be due to low energy intake and avoidance of dairy products in energy-restricted diets of female athletes. Under such conditions, it appears essential that female athletes use a calcium supplement to meet daily calcium requirements. This applies most of all to female athletes with one or more components of The Female Athlete Triad (see Chapter 6). Supplements should be taken outside of meals, and no more than 500 mg should be ingested at one time. Calcium requirements are set as high as 1500 mg by the United States' National Institute of Health for females age 11 to 24 years, and all female athletes with low estrogen levels with menstrual dysfunction should use calcium supplements with vitamin D (to increase absorption), in addition to eating foods high in calcium.

Because 98% of the skeleton is accrued by the age of 20 years, adequate calcium intake in combination with sufficient energy (calories) and other bone-building nutrients through the growing years and normal menstrual function after menarche are key to maximizing peak bone mass and maintaining bone mass across the life span. Whereas dietary calcium is an important factor for bone health, genetics, hormones (especially but not exclusively estrogen), and skeletal loading appear to play a more predominant role. In general, athletes have a higher bone mineral density and stronger bones than non-athletes. However, when a female athlete experiences irregular or absent menstrual cycles, bone mineral density may be 10 to 15% lower than that of an athlete with a regular cycle. Estrogen's role in bone is to help retain bone mineral during the process of bone remodeling (bone resorption or losing bone followed by bone formation or building bone). Low estrogen levels in athletes can take a toll on bone mineral and overall bone strength and increase the risk of stress fractures, low bone mass, and osteoporosis later in life. Although female athletes are advised to increase their calcium intake to 1500 mg/d if they suffer from menstrual dysfunction, a more pressing intervention goal is to help the athlete resume a regular menstrual cycle through proper nutrition, particularly sufficient calories to cover energy expenditure, in combination with the consumption of adequate calcium and other bone-building micronutrients (e.g., vitamin D, magnesium, vitamin K, vitamin C, B-vitamins, potassium).

Antioxidants

Cross-country skiers, undergoing high-volume and intensity training on a continued basis in a variety of environments, may be exposed to higher amounts of free radicals. Free radicals are highly reactive molecules with one unpaired electron in the outer orbital of their chemical structure. Free radicals can be based on carbon, nitrogen, and oxygen molecules, the latter group being the most common. Because free radicals are highly unstable, they seek and steal electrons from other molecules in body tissues. This causes a cascade of reactions in a variety of cellular locations, possibly leading to cell damage.

Sources of free radicals vary but include high rates of oxygen consumption and high-intensity exercise that may lead to increased inflammation. In addition, environmental factors such as pollution, UV exposure, and exercise at altitude may further free radical generation. Antioxidant nutrients such as vitamin C, E, β-carotene, zinc, manganese, selenium, and copper and numerous smaller molecules found in fruit, vegetables, wine, beer, whole grains, legumes, and soy (also called phytonutrients or phytochemicals) may help protect cells from damage by neutralizing free radicals. These foods deliver nutrients that scavenge existing radicals and provide essential components for enzyme systems that defend the body from the harmful effects of free radicals.

At altitude, it is speculated that the generation of free radicals is accelerated in training individuals through the process of transient tissue ischemia and reperfusion (temporary loss of blood flow to certain tissues with subsequent reperfusion), oxidative stress from increased workloads, and UV radiation. However, multiple studies in winter sport athletes, including biathletes, have not confirmed these speculations. The reason for this is probably found in the fact that training induces adaptations to antioxidant enzyme systems that can protect the body more effectively from damage. In addition, markers of oxidative stress may not be sensitive enough to trace subtle changes in free radical formation and tissue damage during and after exercise.

Research in the area of antioxidant supplementation in environmental extremes is constantly advancing, and thus, it is important to await new discoveries. Recent data have shown a significantly smaller reduction in the ventilatory threshold measured acutely at altitude in physically fit males when supplementing with an antioxidant mixture versus a placebo, 21 days prior to and during 14 days of training at altitude (4300 m). No effects were found after chronic altitude exposure. It may be that a temporary supplement scheme with antioxidants taken prior to altitude training proves beneficial, but more data are needed to substantiate these findings, particularly in women.

Antioxidant supplementation has been a common practice among athletes, partly to minimize cellular damage from intense exercise and to potentially benefit from a performance-enhancing effect. Whereas it is known that supplementation can hamper free radical damage, there is no evidence to believe that supplementation improves performance. In many cases, high-dose supplementation of vitamin C, E, and β-carotene have not been proven beneficial, with some reports demonstrating harmful side effects. For the athlete, free radicals play a key role in cell signaling, regulation of calcium release in muscle, white cell function, and regulation of blood pressure. Taking high amounts of antioxidants may override such signals important for training adaptation.

The cross-country skier should be encouraged to consume a diet high in fruit, vegetables, whole grains, legumes, nuts, soy, and plant sources of oils in order to supply antioxidants through foods rather than supplementation, with the exception of vitamin E under altitude conditions. If supplementation is used, doses should not exceed 2-3 times the RDA/RDI for individual nutrients and should be used only temporarily. Considering the high use of fortified products in athletes such as breakfast cereals, juices, and sports foods/drinks, intake of antioxidant nutrients could exceed beneficial levels if supplements are used.

Table 12 Dietary sources of antioxidants

Vitamin C	**Vitamin E**	**β- Carotene**	**Manganese**	**Zinc**	**Copper**	**Selenium**
Citrus fruit	Wheat Germ Oil	Sweet potato	Leek	Oysters	Grains	Meat
Strawberries	Vegetable Oils	Squash	Spinach	Fish	Organ meats	Fish
Lettuce	Hazelnuts	Tomatoes	Strawberries	Nuts	Fish	Eggs
Red Peppers	Soy Oil	Carrots	Oats	Legumes	Nuts	Lentils

5. FATIGUE

Fatigue has important implications for sports performance in cross-country skiing. It is commonly defined as the inability to maintain the required or expected force or power output. The site of fatigue, and consequently, the mechanism and cause vary. Peripheral (muscle) fatigue involves impairment in the contracting muscle or peripheral nerve. Central fatigue involves the failure of voluntary activation due to the impairment of the central nervous system.

There are a number of factors that can instigate the onset of fatigue amongst cross-country skiers. These include:

- Inadequate nutrition
- Imbalance in training load
- Medical conditions
- Lack of sleep (quantity or quality)
- Climate
- Psychological stress

Symptoms of fatigue should be monitored in all female in order to provide adequate rest and recovery. Nutrition plays a key role in providing the athlete's body with sufficient energy, nutrients, and fluids to maintain training stressors at the highest tolerable level.

Dietary mechanisms that can influence fatigue in cross-country skiers are:

- Dehydration, electrolyte disturbances, hypo- and hyperthermia
  During intense exercise, marked water and electrolyte shifts occur in contracting muscle. The decline in plasma volume and changes in both intra and extra-cellular fluid volume and electrolyte concentrations affect muscle metabolism, hydrogen ions, membrane potential, and fatigue.

- Acute and chronic glycogen depletion
  Inadequate carbohydrate intake and exercise-induced depletion leads to low muscle glycogen levels. When muscle glycogen, being an important substrate for contracting muscle, becomes depleted it causes a decrease in the ability to sustain the intensity of the exercise.

- Low energy intake
  Inadequate energy intake to balance energy expenditure can lead to fatigue. A low energy intake not only results in low carbohydrate intake, but also leads to low protein intake. Catabolic processes can impair recovery from training and training adaptation. Low energy availability is also linked to menstrual dysfunction, which is associated with low bone mass for age, decreased bone formation, and increased risk for injuries.

- Iron deficiency anemia
  Iron deficiency causes a decrease in work capacity. Early onset of fatigue, delayed recovery after exertion and, therefore, reduced physical capacity is commonly seen in athletes with this condition.

In summary, nutrition strategies to ensure adequate fueling for intense cross-country skiing training include:

- Consuming balanced meals and snacks
- Eating frequently
- Consuming foods and fluids before exercise
- Consuming sport drinks during exercise
- Refueling after exercise
- Avoiding dehydration
- Avoiding nutrient depletion (energy, carbohydrate, protein, micronutrients)

6. THE FEMALE ATHLETE TRIAD

The Female Athlete Triad (TRIAD) refers to causal relationships between energy availability, menstrual function, and bone mineral density. In female athletes, an eating disorder, amenorrhea (i.e., the absence of a regular menstrual cycle), and osteoporosis (i.e., brittle bones) are considered the clinical manifestation of the TRIAD. Although this form of the TRIAD (with all three components expressed) is relatively rare, it is important to recognize that active females may fall anywhere along a spectrum from a healthy young athletic woman to one that is ill and at risk for debilitating, long-term consequences. Intermediate expressions of the TRIAD occur quite frequently in athletes. For example, some athletes may present with irregular menstrual cycles but, at least in the short term, have no visibly negative signs on bone health. Likewise, an athlete may struggle with disordered eating and yet has managed to maintain a normal menstrual cycle. It is also possible for athletes to have two but not all three components of the TRIAD. What is not visible, however, does not mean it is harmless. Important is to realize that the TRIAD exists in athletes and active women and that it can be expressed in various degrees of severity along the female's spectrum from health to disease. Interestingly, it is exactly this spectrum that allows for early identification of at-risk athletes if screening is employed at the sport associations level. In fact, it should be the goal of each cross-country ski association to 1) screen all athletes for the TRIAD, 2) establish a referral system for early intervention, and 3) to organize prevention schemes beginning at the level of youth sports and carrying through the elite level. Because the demands of elite sports today are very high, specialized sports medicine and sports science services (including sport nutrition) are ever more necessary to enable optimal training adaptation in athletes and to sustain a high level of physical and mental performance throughout the year, and this should occur at no or only minimal compromise to an athlete's health.

The concept of energy availability is now recognized as the underlying factor that interferes with optimal health in female athletes. Energy availability is defined as the difference between energy intake (from diet) and exercise-related energy expenditure (energy expended from training and competition). Whether or not enough energy is available for optimal performance, training adaptation, and to maintain normal physiologic function, including normal reproductive function, depends first and foremost on the intake of energy from food and beverages wisely adjusted to total daily energy expenditure.

It appears that there are at least two types of athletes who seem to suffer from the TRIAD, and particularly menstrual dysfunction. Some athletes appear to intentionally restrict energy intake from food and beverages, most likely in an attempt to achieve or maintain a lower body weight and/or body fat level. While this approach may be timely and part of the early training goal of the athlete, especially when supervised by a professional, chronic under-eating during heavy training may point to a larger problem. Chronic energy restriction during heavy training, especially in sports that emphasize leanness such as cross-country skiing, presents a climate that may lead to compromised health or the TRIAD, even though it first may be performance-enhancing. In this scenario, the athlete initially loses weight by dieting, thereby experiencing a performance boost. However, over the long term, with a high chronic training stress, such eating patterns will eventually deter both mental and physical performance due to a chronic mismatch between energy intake and expenditure. Consequently, the athlete will lose her performance edge, which may lead to a more desperate approach (eating disorder) or an acute injury or illness, which often presents a significant stop light in the athlete's young career.

Besides the athlete who intentionally under-eats to meet weight and/or performance goals, there are athletes who unknowingly consume too little energy to cover the demand of training and normal physiologic function. This may be due to a lack of knowledge in sport nutrition, but specifically about what, how much, and how often the athlete should eat/drink to cover energy expenditure throughout the periodized training plan. Further, potential time constraints for strategic eating, a lack of planning for adequate fueling, or a temporary loss of appetite during intense training phases may also represent causes of under-eating. Regardless of the athlete's character and mind-set, early identification of such issues is key for prompt prevention/intervention schemes in order to reduce the risk for the development of the TRIAD and to maintain an athlete's full potential to achieve long-term success in her sport.

Health and Performance Consequences of the Triad

The TRIAD and its individual components can affect health and performance. Clearly, the major concern of the TRIAD centers around low estrogen levels and the negative effect on bone mineral density in young female athletes who are at their peak capacity to maximize bone mass. Menstrual irregularities, either current or in the past, have been associated with low bone mineral density, particularly at the spine, with only a small chance of reversibility. In the long-term, it is expected that these athletes are at increased risk for osteoporosis, and thus, approach fracture risk at an earlier time point in their life. Although some sports (e.g., gymnastics) may be protective against bone loss (resorption) or reduced bone growth (formation) despite established menstrual dysfunction, the general consensus is that irregular and absent menstrual cycles are detrimental to a woman's bone health. In addition, infertility and reduced endothelial function have also been mentioned as negative outcomes of irregular and absent menstrual cycles.

Athletes suffering from the TRIAD in mild or severe form are at higher susceptibility for injuries such as stress fractures. Bone turnover is an on-going process, with bone formation (building) lagging behind the phase of bone resorption (loss). This delay weakens bone temporarily. Repetitive training loads and estrogen deficiency may increase micro-damage to bone and elevate the risk of stress fractures.

Athletes do not have to experience the full expression of the TRIAD to risk consequences. In fact, it is now established that metabolic alterations, important for recovery and training adaptation as well as bone health, independent of estrogen, may be directly influenced by low energy availability. Thus, it should be the primary goal for all athletes to optimally fuel their training and prepare for competition with adequate energy and nutrient intake.

Performance-related consequences of low energy intake, regardless of its cause, include glycogen depletion, electrolyte imbalance, dehydration, micronutrient deficiencies, and compromised immunity. An athlete who eats too little will most likely eat insufficient amounts of macronutrients, but specifically carbohydrate. As the recovery from intense exercise depends greatly on carbohydrate intake and subsequent glycogen storage, these athletes run the risk of early fatigue during training and competition due to chronic glycogen depletion. Further, as athletes run out of glycogen, the body's experience of physiological stress rises. While there may be some adaptive benefit from the signals of immune markers, chronic exercise stress in muscle and blood may suppress the athlete's immunity and increase her susceptibility for illness. Repetitive training and competition schedules require athletes to eat a high carbohydrate diet (8-12 g/kg/d), and it has been shown that female cross-country skiers can do that during intensified training without having to fear weight gain.

Disordered eating and clinical eating disorders can result in severe electrolyte imbalances that may threaten safe sport participation. Thus, under the clinical manifestation of the TRIAD, athletes must be supervised by a physician to minimize risk. Along with electrolyte imbalances, athletes can become dehydrated, which takes a toll on performance and thermoregulation.

Finally, athletes who under-consume calories may run the risk of nutrient deficiencies, with iron deficiency and a performance decrement as the most common phenomenon. Low intakes of micronutrients from the B-vitamins, vitamin C, zinc, and magnesium as well as others can interfere with energy metabolism, the immune system, and an effective training adaptation.

Identification

Athletes with the TRIAD are best identified through standardized screening and assessment methods. It is recommended that all female athletes be screened during their pre-participation physical evaluation. There are a variety of options for screening which depend mostly on the staff availability within a team. Self-report questionnaires are problematic due to under-reporting, and thus, a clinical interview by a physician, psychologist, and/or sports dietitian is the best option if time and personnel are available.

Besides targeted screening, warnings signs of disordered eating and the TRIAD can be best observed by those frequently around the athlete (coach, physical therapist, athletic trainer, teammate). Common behaviors that may be observed in athletes with eating disorders include a preoccupation with food and eating, calories, and body weight, an excessive fear of becoming fat, a high dissatisfaction with body shape, participation in extra training above and beyond what is scheduled for the day, mood swings and depression, social withdrawal and isolation, frequent bathroom visits after eating, avoidance of food-related social activities, use of laxatives, diuretics, and diet pills, as well as bingeing. Physical signs include chronic fatigue, weight loss or weight fluctuations, change in performance, increased illness/injury, frequent gastrointestinal problems (constipation, bloating, gas), tooth erosion, dry skin and hair, hair loss, and menstrual dysfunction.

When and how an athlete should be approached who is struggling with disordered eating behaviors is a difficult process. It is generally recommended that the person who has the best rapport with the athlete approach her, stating the concern of recent observations regarding the athlete's eating behavior and offering professional help or simply a possibility to talk about the issue. The athlete may need some time to process and respond and should be assured that her spot on the team is not jeopardized should she disclose the problem. Even if in denial, the athlete should be encouraged to meet with a professional for a more thorough evaluation and to identify a treatment strategy.

Treatment

Screening and assessment for the TRIAD should be an integral part of each athlete's pre-participation physical evaluation before she begins training. If an athlete is identified with one component of the TRIAD she should be screened for the others.

Once an athlete has been screened and identified as having one or more components of the TRIAD, it is essential that a treatment team referral system is in place for immediate action. The extent to which the TRIAD treatment team (physician, sports dietitian, psychologist, and possibly a physiologist, physical therapist, and/or athletic trainer) will be activated depends on the severity of the disorder. The team physician may request further tests to rule out other underlying pathologies.

The first treatment goal for any component of the TRIAD is to increase energy availability by increasing energy intake and/or reducing energy expenditure. Treatment through pharmacological means is not recommended because there is insufficient evidence that such interventions restore bone loss or correct metabolic abnormalities that interfere with the athlete's health status and performance capabilities. Nutrition counseling and monitoring may be sufficient for many female athletes; however, disordered eating behaviors most likely require psychotherapy, and stress fractures require physical therapy and a reduction in training volume and intensity. In the case of cross-country skiing and the nature of skiing, a resistance training program may be of benefit to protect bone mass in an athlete with the TRIAD.

It is generally not advised to withdraw the athlete from all team training and competition, although this depends on the severity of the TRIAD in a particular athlete and the impact this condition could have on other team members. Remaining a part of the team with a modified training plan and coherent treatment activities may be best for the athlete. Return to training or competition should depend primarily on treatment compliance and success and should be determined by the treatment team. Involving other staff or the coach may be advisable not only because of the athlete-coach relationship but also because the treatment process can be a great learning process for those involved. Keeping close contact with the athlete may be a unique opportunity for the coach-athlete relationship.

Prevention

For the staff, working with the female cross-country skier, it is essential to understand trigger factors associated with disordered eating. Trigger factors of disordered eating include early dieting behavior, early start of sport-specific training, pressure to lose weight, and the emphasis on appearance and a lean body type in certain sports. In addition, the experience of a traumatic event such as an injury or a loss of a coach and an abrupt change in training intensity and/or volume have been identified as potential risk factors.

Pressure to reduce body weight or fat has frequently been used to explain the development of disordered eating in an athlete. However, it may be more the way, in which the message is communicated by coaches, peers, and scientists (e.g., the words used, the situation chosen, and whether the athlete was offered help in achieving weight loss goals). Some female athletes may also self-impose their own goals to lose weight based on comparisons to non-athletic females, such as friends outside of their sport, general societal ideals, or a teammate who is leaner and more successful. Another important factor seems that athletes are often pressured to lose weight quickly or within a certain time period. This may lead to frequent weight cycling, which represents a further trigger factor of disordered eating. If weight loss is necessary in a cross-country skier, the off-season with the transition into the main preparatory season should be chosen for this process. Weight loss strategies should not be handled by the athlete alone but should be in collaboration with the sports dietitian, especially when weight loss goals need to be achieved during high volume/intensity training.

Prevention of the TRIAD, ensuring a safe and successful training environment, should be a high priority for those working with female cross-country skiers. Education of the TRIAD is a successful tool to decrease its prevalence. Education should be directed to athletes, coaches, and parents and should center around issues such as growth and development, the relationships among body weight, composition, health, and exercise performance, fueling the body for training and competition with emphasis on strength, endurance, and fitness rather than thinness and leanness, and psychological aspects of training for the young female athlete. Messages such as “winning at all cost” should not be part of a team’s philosophy. Close monitoring of dietary patterns, menstrual regularity, injuries and illness, in addition to changes in performance and skill, mood state, resting heart rate, and biochemical markers are key. Appendix H provides a list of resources for the athlete, the coach, and parent. Most notable are the updated consensus statements through organizations such as the IOC as well as ACSM (in press), representing invaluable information on the TRIAD and its treatment and prevention schemes. These resources are available over the internet at no charge.

Table 13 Glossary of terms related to The Female Athlete Triad

The Female Athlete Triad	Syndrome of low energy availability and disordered eating, amenorrhea, and osteoporosis first identified in 1992.
Eating Disorder	Clinical eating disorder such as anorexia nervosa, bulimia nervosa, and eating disorder not otherwise specified
Disordered Eating	A wide spectrum of abnormal eating patterns that may eventually endanger an athlete’s health and performance.
Energy Availability	Energy intake minus <u>exercise</u> energy expenditure
Eumenorrhea	Regular menstrual cycle: 25-35 days in length; ~ 12 cycles per year
Oligomenorrhea	Irregular menstrual cycles: cycles longer than 35 days or less than 6 to 9 cycles per year
Amenorrhea	<u>Primary:</u> onset of menstruation after the age of 15 years despite secondary sex characteristics; <u>Secondary:</u> loss of 3 consecutive menstrual cycles or fewer than 3 cycles per year
Low Bone Mass	Low bone mineral density measured by DXA* (≥ 1 standard deviation below the mean for young, healthy adults (T-score) or below expected range for age (Z-score)
Osteoporosis	Low bone mineral density measured by DXA* (≥ 2.5 standard deviations below mean for young, healthy adults (T-score) or below expected range for age (Z-score)
Stress Fracture	A break in a bone, usually small, that develops because of repeated or prolonged forces against the bone

*DXA: Dual energy x-ray absorptiometry

7. DIETARY SUPPLEMENTS AND SPORTS FOODS

The sport world is filled with pills, potions, powders, bars, and drinks that promise the athlete the winning edge. As a consequence, athletes both elite and non-elite are avid consumers of supplements and sport foods.

Research indicates that 57 to 91% of female athletes use one or more dietary supplements on a regular or occasional basis. The most frequently used supplements are multi-vitamin and mineral, sport drinks, and sport foods.

Dietary supplements are defined as "a product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin, mineral, amino acid, herb, or other botanical or a concentration, metabolite, constituent, extract, or combination of any ingredient described above". In addition, supplements are generally categorized into groups of similar effects. For sport supplements these include: enhancers of the immune system, muscle mass, lower body fat, anaerobic power, aerobic power, recovery, sleep, and injury rehabilitation.

In most countries, manufacturers of supplements often make impressive claims about their products without adequate research to support them. In 1994 the Food and Drug Administration (FDA) in the United States established the Dietary Supplement Heath and Education Act (DSHEA). Under the DSHEA, statements and claims are not evaluated by the FDA, and manufacturers are not required to comply to good manufacturing practice, although it is expected from them. Legislation regarding supplement marketing is universally unregulated and exploited, and there is considerably less control and attention than given to prescription pharmaceuticals. Athletes and coaches are usually unaware of these lapses.

Physicians in sports medicine and sports dietitians are generally skeptical that the association between the supplements and the athletes' performance is anything more than circumstantial. Sports performance is the results of many factors including talent, training, equipment, diet and mental attitude. Often, any boost in performance that comes from taking a new product may be the result of a 'placebo effect', which is a favorable outcome arising simply from an individual's belief that she has received a beneficial treatment.

Since 1997, the IOC Medical Commission has been concerned about positive drug tests that could be linked to the use of dietary supplements. There has been speculation that the positive drug tests from high-profile athletes may have resulted from the use of dietary supplements and special sport foods rather than the deliberate use of banned substances. There is also growing evidence that many supplements or sport foods contain banned substances which often remain undeclared, or appear to be contaminants from other lines of production within one manufacturer. 'Inadvertent doping' therefore, through supplement use has emerged as a growing concern in sports governed by the anti-doping code.

A large-scale investigation, conducted by the IOC between October 2000 and November 2001, examined 634 non-hormonal nutritional supplements from 13 countries and 215 different suppliers. Ninety-one percent of them were purchased in stores or over the Internet. Out of the

634 samples tested, 94 (14.8%) contained substances that were not listed on the label and would have led to a positive doping test. Out of these 94 samples, 23 (25%) contained precursors (building blocks) of both nandrolone and testosterone, with 64 (68%) containing precursors of testosterone alone and 7 (7%) containing precursors of nandrolone alone. In addition to these 94 samples, 66 others (10.4%) returned borderline results for various unlabeled substances. The IOC hopes that these results demonstrate to governments and the supplement industry the need for greater quality control to ensure that substances not declared on the label are also not found in the product. The IOC Medical Commission recommends regulation, similar to those pertaining to the manufacture of pharmaceuticals, be applied to the production of dietary supplements. However, it may take years until such regulations will be imposed on the supplement industry.

It is important to note that not all supplements are the same. Some supplements and sport foods are valuable in helping an athlete achieve her nutritional goals to optimize performance. Sport drinks and foods are energy-containing products manufactured in a food or drink-like form (e.g., bars, drinks, gels, or modified versions of food sources). These products contain nutrients in amounts found in everyday foods and meet known nutritional needs.

Sport products and supplements of probable benefit to cross-country skiers include sport drinks, liquid meal supplements, sport gels, sport bars, and multi-vitamin and mineral supplements, calcium and vitamin D, and iron in amounts equal to or slightly higher than the DRI/RDA (<2 to 3 times) or international equivalent. When considering the use of ergogenic aids, coaches and athletes should consider the risk-to-benefit ratio and use a product only when the benefits (e.g., performance or health improvement) by far outweigh the risks (e.g., positive drug test, negative health or performance effect). Ergogenic aids that have been well studied and appear to repeatedly prove as effective performance-enhancing substances include caffeine, creatine, and sodium bicarbonate. Others that have been used for other purposes are glycerol and glucosamine. However, even these products should be evaluated on an individual basis, as products containing all of these have also been found to carry contaminants that could lead to a positive drug test.

This following section will discuss three well-researched supplements, some of which may find application in the sport of cross-country skiing.

Creatine Monohydrate

Creatine is a normal component of our daily diet. Creatine is present in all foods containing animal muscle such as red meat, fish, and poultry. The typical daily intake of creatine is approximately 1 gram per day, except for vegetarians who consume little or no meat. Creatine needs not provided by food are met by the production within the body from three amino acids. About 95% of the body's stores of creatine are found in skeletal muscle, and the daily turnover is approximately 2 g.

Creatine supplementation is one of the few dietary supplements that may be valuable for certain sports and individuals. Creatine is not banned by any sport-governing organization. Over 100 scientific studies have supported the role creatine supplementation has on increasing muscle levels of creatine and creatine phosphate in individuals. Within the muscle, creatine phosphate performs a number of important functions in exercise metabolism: the regeneration of ATP and buffering of hydrogen ions. Creatine loading is generally associated with weight gain of 1 to 2 kg in the first week of creatine loading, which is probably due to the retention of fluid when creatine is stored in the cell. A weight gain beyond that may, at least in part, be attributed to the harder training, quicker recovery, and subsequent improved lean tissue mass and strength which is typically seen after 4-6 weeks of creatine supplementation. Creatine has been found to be most effective in increasing the performance of short, high intensity, repetitive exercise. Creatine does not appear to enhance the aerobic performance in endurance sports.

Considering the fact that only 50% of individuals ‘respond’ to creatine loading and creatine’s performance-enhancing effect is mostly seen in anaerobic, high-intensity sports, cross-country ski coaches and athletes should carefully evaluate the potential drawbacks of creatine supplementation in the sport of cross-country skiing. It may be that creatine plays a role in skiers specializing in the sprint; however, no data currently exist to support this application. Creatine leads to weight gain, which may be counterproductive in skiers who participate in more than the sprint. Besides weight gain, however, creatine is associated with few side effects when used over the short term, although it has yet to be established whether creatine supplementation over the long term is a safe practice.

Caffeine

Caffeine is a drug enjoyed in social settings around the world. It is a naturally occurring stimulant found in leaves, nuts, and seeds of a number of plants. Major dietary sources include coffee, tea, cola drinks, and chocolate as well as certain energy drinks and medications. All of these sources typically provide 30 - 100 mg of caffeine per serving.

Caffeine, at relatively low levels (3-9 mg/kg body weight), has repeatedly been shown to delay the onset of fatigue during running and cycling by 20-50%. Caffeine has also been shown to increase time trial performance by ~4% and appears similarly effective in short, high intensity exercise (1 to 10 minutes) as in prolonged, endurance exercise.

Caffeine’s effect appears to occur mainly through central mechanisms. In fact, caffeine, a strong adenosine antagonist, is a central nervous system stimulant that easily crosses the blood brain barrier. Caffeine appears to counteract most of the inhibitory effects of adenosine on excitability of nerves, neurotransmitter such as serotonin, arousal, and spontaneous activity. Thus, it seems that caffeine’s early effect occurs through this central mechanism. However, another mechanism may relate to glycogen sparing and increased use of fatty acids for energy during exercise, although it seems that this only occurs at a higher dosage in certain responders, and is limited to the first 15-20 minutes of exercise. Finally, caffeine may also affect the muscle’s membrane potential through calcium ion handling, which may relate to the effect caffeine has on increasing the time to fatigue.

Caffeine is typically ingested before or during exercise in the form of coffee, gels, energy drinks, or tablets. Although blood levels of caffeine peak after 60 minutes post-caffeine ingestion, the effect of caffeine can last up to 6 hours. As may be expected, caffeine’s effect is greater in nonusers; however, this does not mean that habitual users should ingest very high amounts of caffeine. In fact, caffeine seems to work at relatively low levels (~ 3 mg/kg body weight or 50-300 mg), and high amounts are no more effective, which is also the main reason why caffeine was recently taken off the IOC-restricted substances list.

Benefits may also be seen when caffeine is ingested with carbohydrates throughout the exercise bout. Further research is needed to clarify caffeine's effect on the quantity and type of carbohydrate absorption. Caffeine is normally ingested approximately 1 hour prior to exercise, but benefits have also been identified when caffeine is consumed throughout exercise and especially late in an endurance session. A low caffeine dose does not cause dehydration if consumed shortly before or during exercise and produces no or only mild side effects. However, high doses of caffeine may have side effects such as insomnia and a rapid heartbeat and may interfere with temperature regulation during exercise in the heat.

For the female cross-country skier, caffeine may offer potential performance benefits. However, athletes are encouraged to stay within the suggested dosage and experiment with the variety of products and sources containing caffeine in order to identify the most effective supplement scheme for racing.

Sodium Bicarbonate

Anaerobic glycolysis provides the primary fuel source for high intensity exercise lasting between 30 to 90 seconds. The total capacity of this system is limited by the progressive increase in the acidity of the intracellular environment. When the intracellular buffering capacity is exceeded, hydrogen ions diffuse into the extracellular space. In theory, an increase in extracellular buffering capacity should delay the onset of muscular fatigue during prolonged anaerobic metabolism by increasing the muscle's ability to dispose of excess hydrogen ions.

The two most popular buffering agents are sodium bicarbonate (baking soda) and sodium citrate. Bicarbonate or citrate loading may be beneficial in enhancing the performance of athletic events that are conducted at near-maximal intensity for a duration of 1 to 10 minutes (sprint cross-country events) or for sports involving repeated anaerobic bursts.

The protocol for usage of sodium bicarbonate includes consuming 0.3 g/kg 30 minutes prior to exercise. One major side effect of bicarbonate loading is gastro-intestinal distress such as diarrhea and stomach cramps, and vomiting. Staying well hydrated before, during, and after ingestion of bicarbonate may help manage gastrointestinal upset, and it appears that sodium citrate may be better tolerated.

Significant variability exists for bicarbonate loading effects on performance within studies and subjects. It has been proposed that anaerobically trained athletes may show a lower response to bicarbonate or citrate loading due to better intrinsic buffering capacity. Until further research can clarify whether sprint cross-country skiers can benefit from bicarbonate or citrate loading, athletes should experiment in training and minor competitions to determine the potential for performance improvement and associated side effects. In addition, experimentation is needed with multiple loading strategies for heats and finals.

Sport Foods and Fluids

Sport products, which are portable and conveniently packaged, contain a specific dose of nutrients, which aim to meet the nutrient recommendations for a specialized situation in sport nutrition. Examples of sport products include sport bars, drinks, and gels.

The following section provides information on sport bars, drinks, and gels. Female cross-country skiers should be encouraged to consume these products, as they represent safer and more effective supplemental strategies in enhancing performance than many other dietary supplements on the market.

Sport Bars
Sports bars are purpose-built energy bars that are designed for the athlete to cover the added demands of the sport. The success of the Powerbar in the 1980s has led many other companies to make products to share the sport bar market. Sport bars can play a specific role in the athlete's sport nutrition plan but are not intended to play a general role in meeting dietary goals. They can be used as a recovery snack or a mid-day snack for athletes on the run or when traveling.

Sport bars provide a compact source of energy, carbohydrate, and protein. Although the weight and composition of bars vary, the carbohydrate content is typically 30 to 50 g per bar. Most bars are low in fat (2 to 5 g per bar) and fiber and contain moderate amounts of protein (5 to 15 g or more per bar), depending on the purpose of the bar. Most bars are fortified with vitamins and minerals. These characteristics make them ideal to eat before, during, and immediately after exercise when other solid foods are not well tolerated or not available. Table 14 outlines the range of popular sport bars and highlights their nutrient profiles.

Table 14 Sport bars

Brand	**Product**	**Weight (g)**	**Calories (kcal/serve)**	**CHO* (g)**	**PRO* (g)**	**FAT (g)**	**Fortified**
Clif	Bar	68	230-250	40-47	10-12	2.5-6	Yes
	Luna bar	48	180-190	23-28	9-10	3.5-6	Yes
	Nectar	45	160-170	26-29	2-4	6-9	Yes
	Mojo	45	200-220	21-24	8-10	8-9	Yes
	Builders	68	270	30-31	20	8	Yes
	Z-bar	36	120-140	20-24	3	3-5	Yes
PowerBar	Performance	65	230-250	45	9-10	2-3.5	Yes
	ProteinPlus	78	290-300	37-39	23	6	Yes
	ProteinPlus low sugar	78	260-270	30-32	20-22	7-11	Yes
	Harvest	65	240-250	42	10	4-5	Yes
	Nut Naturals	45	210	19-20	10	10	Yes
	Triple Threat	55	220-230	30-32	10-11	5-8	Yes
	Pria	28	110	16-17	5	3-3.5	Yes
Balance	Original bar	50	200	22-24	14-15	6	Yes
	Gold	50	210	22-23	15	6-7	Yes
	Trail Mix	50	210	22-23	14-15	7	Yes
	Gold Crunch	50	210	22-23	14-15	6-7	Yes
Isostar	High Energy	40	157	28.9	2.2	3.7	Yes
Gatorade	Energy bar	65	250	38	15	5	Yes
EAS	Myoplex Deluxe	90	340	37	30	9	Yes
	Myoplex Lite Bar	56	190	26	15	4.5	Yes
PR* bar		~ 50	180-200	19-23	13-14	6	Yes
PB Sport	Sports Bars	55	~220	41	2.8	5.1	Yes
	Energy Bars	55	~200	34.7	10.7	1.5	Yes
Maxim	Energy bar	100	361-391	69.1-72	5.1-5.7	6-10.4	Yes
	Carbo Cake	1/3 mixed	417-425	64.2-67.3	10.2-12.8	12.8-13.4	No
Promax	Energy bar	75	280-300	37-40	20	5-8	Yes
	Triple layer	75	290	34-38	20	6-8	Yes
	Oat-rageous	80	290-340	39-42	20-23	5-11	Yes
	Rampage	75	310	31	28	9	Yes
High5	Sports Bar	55	203-213	37-39	3	5	Yes
	Protein Bar	50	185-190	22-24	13	4-5	Yes
	Energy Bar	60	195	45	2	1	Yes
Science in Sport	Go Bar	65	213	47	7.9	1	Yes
Lucozade Sport	Energy bar	50	185	33.6	6.3	3.5	Yes
Honey Stinger	Energy bar	50	180-190	27-28	10	3-5	
Enervit	Energy bar	35	115-155	19.5-28.1	2-3.3	3.8-6.2	Yes
	Sport competition	40	270	40.8	14.8	5.2	Yes
	Power sport	40	226	39.3	10.6	2.9	Yes
Hammer	Food bar	~50	220	25-26	9-10	9	

*CHO: Carbohydrate; PRO: Protein

Sport Drinks
Sport drinks are sweetened, flavored beverages that contain 4 to 8% carbohydrate and electrolytes and are typically consumed before, during, and after exercise. They promote hydration, voluntary intake of fluids, and carbohydrate delivery. Gatorade was the first commercial sport drink that was invented in the early 1960s. Sport drinks have also been referred to as glucose-electrolyte drinks. The carbohydrates may be present as glucose, glucose polymers, sucrose, maltodextrins and fructose. Athletes appear to tolerate a range of compositions containing these carbohydrates; however, it appears that a mixture of sugars is best absorbed. The major electrolytes added to sport drinks include sodium and potassium. Some brands add varying amounts of minerals, vitamins, additives, artificial sweeteners, colors, and flavors. Sodium's role is to assist with the intestinal uptake of fluid and glucose into the cells and for maintaining the extracellular volume. The optimal sodium content is approximately 500 to 700 mg per liter, although this depends on factors such as sweat rate and sodium loss and is strongly associated with the environment. Table 15 provides popular sport drinks and their nutritional profile.

Table 15 Sport drinks

Brand	**Product**	**Calories (kcal/l)**	**CHO* (%)**	**CHO* (g/l)**	**PRO* (g/l)**	**Sodium (mg/l)**	**Potassium (mg/l)**
Clif shot drink	Electrolyte beverages	338	8	80		845	211
Powerbar	Beverage system	287	7	71		810	42
Gatorade	Original	211	6	59		465	127
	Endurance formula	211	6	59		846	380
PowerAde	Original	262-300	7	70		220	133
PB Sport	Fluid & electrolyte repl.	260	6.8	68		580	180
	High energy drink	880	23	230		470	500
Maxim	Energy drink	225-300	5.6-7.5	56-75		507-3800	200-1500
	Sport drink	260	1.3	13.2		60	73.6
	Energy mix	932	23	233		1520	0
Science in Sport	PSP22	371	10	99		0	0
	GO	287	15.2	152		800	240
Cytosport	Cytomax Sport Drink	211-317	4.6	46		254	127
	Cytomax Ready-Drink	220	5.4	54		236	127
AllSport	Body quencher	254	6.8	68		233	211
Hydrade	Original	233	4.2	42		385	326
Revenge	Sport energy drink	109-190	2.8-5	28-49		169-211	186-232
Isostar	Hydrate & Perform	296	7	70		700	200
Isostar	Long Energy	608	15	155		400	
Lucozade Sport	Body fuel	280	6.6	66		470	9.6
	Hydrate	160	4	40		910	0
CeraSport	Electrolyte rehydration	212/169	5.2/4	52/40		430/422	157/40
Gu	Gu2O	211	6	60		507	85
Hammer	HEED	564-634	5.3-7	53-70		105-131	27-34
	Perpetuem[a]	314-439	6.5-9	65-91	7-10	279-390	188-264
	Sustained Energy[b]	414-579	8.8-12	88-123	13-18	135-189	
PacificHealth L.	Accelerade[c]	338	6	59	14	535	110

*CHO: Carbohydrate; PRO: Protein; [a] 2.4-3.4 fat (g/l); [b] 1.2-1.7 fat (g/l); [c] 2.8 fat (g/l)

Energy Drinks
Although sport drinks effectively provide energy to the athlete before, during, and after exercise, they can be confused with the classification of beverages called 'energy drinks'. Energy drinks are fluid sources that contain a higher concentration of carbohydrate and often caffeine as one of their principle ingredients. Some energy drinks contain herbs, amino acids, creatine, or other substances that are usually added in small enough quantities to have a physiological impact. These products are marketed as a 'get up and go' drink which is appealing to teenagers and young adults.

Energy drinks can supply energy and fluid, and they may have a role in carbohydrate loading and recovery. Athletes, however, should be aware of these drinks as many may result in inefficient absorption and subsequent gastro-intestinal distress if used before and during training or competition. In addition, the doses of the ingredients are not standardized and some contain banned ingredients that may or may not be stated on the labels. Athletes need to examine energy drinks carefully and think before they buy. Being 'full of energy' requires suitable training, adequate rest, effective fueling and hydration, and an optimal mental attitude. Table 16 provides popular energy drinks and their nutritional profile.

Table 16 Energy drinks

Brand	**Product**	**Calories (kcal/l)**	**CHO* (%)**	**CHO* (g/l)**	**Sodium (mg/l)**	**Potassium (mg/l)**	**Caffeine (mg/l)**
Lucozade	Energy	700-730	18	179			121
Lipovitan		440	10.8	108	41		204
Battery	Energy drink		44	440			320
Red Bull	Energy drink	424	10.8	108			
Elements	Venom	550	14	140	42		
Rockstar	Rockstar 69	550	13	131	254	0	338
Jolt	Cola	423	11.4	114	42	0	304
SoBe	Adrenaline Rush	592	16	156	486	93	330
	No Fear	550	15	152	486	106	668
180		495	13.6	136			
Boo Koo	Energy drink	465	11.4	114	846		507
Coca cola	Coke classic	410	11.4	114	140	0	97
	Full Throttle	469	12	123	350	trace	304
	TAB energy	25	.04	.42	359	30	304

*CHO: Carbohydrate; typical serving sizes of energy drink is approximately 180 ml (6 oz)

Sport Water
Sport water is also new to the sport supplement market. Sport water is purified water, slightly flavored, with added vitamins, minerals, and/or electrolytes. This product aims to aid hydration during exercise, however, lacks the calories and strong flavor of sport drinks. The slightly flavored beverage is proposed to assist in increasing athletes' fluid intake, which aids in the maintenance of fluid balance and therefore athletic performance. Certain cross-country skiers do not consume sport drinks, as they are concerned with the added calorie contribution to their diet. Sport water typically contains no more than 2 % carbohydrate and 40 to 50 kcal per liter. This is about 20 % of the carbohydrate and calories of a typical sport drink. As 30 to 60 g of carbohydrates are recommended to be consumed per hour during endurance exercise, 375 to

1000 ml of sport drink or 1.2 to 2.4 liter of sport water is required. The sodium level of sport water and sport drinks is 0 to 12 mg/100 ml and 12 to 40 mg/100 ml, respectively. The inclusion of sodium is advantageous for athletes, as it encourages fluid intake and enhances fluid absorption and retention. Nevertheless, sport water may be ideal for cross-country skiers who dislike the taste of water and sport drink and who require hydration but not a large energy intake during training. Table 17 provides popular sport waters and their nutritional profile.

Table 17 Sport water

Brand	**Product**	**Calories (kcal/l)**	**CHO* (%)**	**CHO* (g/l)**	**Sodium (mg/l)**	**Potassium (mg/l)**
Gatorade	Propel fitness water	42	1.3	13	148	169
	Propel calcium	42	1.3	13	148	169
Aquafina	Alive	42	.08	8	270	208
Powerade	Option	42	.085	8.5	220	140
Enervit	Wellness Water	10	0	0		
Glaceau	Vitamin Water - energy	208	5.5	55	0	
	Vitamin Water - revive	208	5.5	55	0	592
	Vitamin Water - essential	208	5.5	55	0	296
	Vitamin Water - endurance	208	5.5	55	0	

*CHO: Carbohydrate

Sports Gels

In sports such as cross-country skiing where glycogen depletion is one of the mechanisms of fatigue, sport gels are beneficial, as they provide an additional source of carbohydrate, which helps to maintain blood glucose levels during and enhance glycogen synthesis after exercise. Sport gels are semi-solid forms of foods that contain approximately 25 g of carbohydrates per squeeze pack. Newer deviations of sport gels include blocks (similar to gummy bears), beans and fruit chews. It is recommended that endurance athletes consume 30 to 60 g of carbohydrate per hour of exercise, which translates into consuming 1 to 2 packs of sport gels per hour. Gels may also be useful for sprint cross-country skiers who require easily digestible carbohydrate snacks between heats.

For many athletes, the use of gels is more of a personal choice than it is a science. Some cross-country skiers opt for the gels over liquids and food because they provide a concentrated dose of carbohydrate in a very dense, easily digestible form light to carry. Others dislike gels because of the texture, sweetness, and intensity of flavor. Although gels may be an effective source of energy during exercise, combining them with sufficient fluid and sodium may be the greatest challenge. If inadequate amounts of fluids are ingested with the use of gels the rate of absorption of both carbohydrate and water may be delayed, potentially leading to gastro-intestinal disturbance, dehydration, and decreased performance. Table 18 provides an outline of sport gels and their nutritional profile.

Table 18 Sport gels

Brand	Product	Weight (g)	Calories (kcal)	CHO (g)	Fat (g)	Additional ingredients
Clif	Shot	32	100	25	0	Electrolytes; some contain caffeine
	Shot bloks	30	100	24	0	Electrolytes
Powerbar	Powergel	41	110-120	27-28	0-1.5	Electrolytes; some contain caffeine
PB	Sports gel	35	76	20	0	Electrolytes
Maxim	Energy gel	~30	100	24.8	0	B-vitamins
High5	Energy gel	38	92	23	0	Caffeine
Science in Sport	Go gel	60	86.4	21.6	0	Electrolytes
Accelerade	Accel gel	41	90	20	0	5g PRO; electrolytes
Cytosport	Cytomax Energy gel	40	110	27	0	Electrolytes
Lucozade Sport	Carbo gel	45	123	30.7	0	Electrolytes
Isostar	Power Tabs	2 tabs	87	19	0	Vitamins and minerals, electrolytes
Isostar	High Energy Actifood	90	195	50		Some vitamins, trace fat
Isostar	Energy Concentrate	100	274	69	some	Vitamins, electrolytes, cola nut/mate
Jelly Belly	Sport beans	~29	100	25	0	Electrolytes; vitamins and minerals
Hammer	Gel	36	86-93	22-23	0	Electrolytes and amino acids
Gu	Energy gel	32	100	25	0-2	Antioxidants, electrolytes, amino ac.
Carb-BOOM	Energy gel	41	110	37	0	Electrolytes
Honey Stinger	Energy gel	37	120	29	0	B-vitamins and electrolytes
Squeezy	Energy gel	30	100	25	0	Electrolytes
Fireball	Energy gel	27	100	25	0	Ginseng and glycerine
Sharkies	Energy fruit chews	45	140	36	0	Electrolytes
Enervit	Enervitene sport gel	~25	71.2	17.8	0	Branched chain amino acids

Recovery beverages

Endurance athletes often require a greater amount of total calories, and because of the duration of their sport, have an increased need for calories during recovery from a bout of training or competition. Recovery beverages contain a higher percentage of carbohydrate (10 - 23%) than sport drinks, some contain moderate to high amounts of protein (10-40%) and little, if any fat. Most often these products come in powder form and can be mixed with water or milk. Recovery beverages are aimed at rehydration including electrolyte replacement, glycogen resynthesis, and repair of muscle tissue after exercise, in an attempt to speed recovery and delay fatigue during hard training or competition. However, not every training session or competition requires the consumption of recovery beverages; they are meant for exercise bouts that are long, intense, and repetitive with limited recovery time (<24 hrs). Whereas recovery beverages are common on the market place, athletes should be cautious, read the labels, and check with companies to ensure that the product is reputable, does not contain unwanted or illegal substances, or is contaminated. Table 19 provides an outline of recovery products and their nutritional profile.

Table 19 Recovery Beverages

Brand	**Product**	**Serving size (oz/ml)**	**Calories (kcal)**	**CHO (g)**	**PRO (g)**	**Fat (g)**	**Sodium (mg)**	**Potassium (mg)**
Clif shot drink	Recovery beverage	8oz (236ml)	140-150	31	5-6	0	230-270	130
Powerbar	Recovery	20oz (592ml)	90	20	3	0	250	10
PB Sport	Sports meal shake	3.4oz (100 ml)	137	23	7	2.4	230-270	150
Maxim	Recovery drink	8.5oz (250 ml)	186	28.1	17.5	.4	100	0
High5	Energy source	25.4oz (750 ml)	368	77	20	0	800	300
	Isotonic	25.4oz (750 ml)	368	92	0	0	784	243
	Energy source	25.4oz (750 ml)	368	97	0-2	0	392	121
	High5 extreme	25.4oz (750 ml)	368	92	0	0	900	400
	Protein recovery	25.4oz (750 ml)	368-388	65-69	26-30	0-1	527	90
Science in Sport	Rego	34oz (1000ml)	314	55	27	0	578	223
Pacific Health L.	Endurox R4	12 oz (360ml)	260-270	50-52	13	1-1.5	210-220	120-270
Isostar	Recovery	50 g	184	35	10	0.7	160	
Lucozade Sport	Recovery drink	17oz (500 ml)	291	54.2	17.9	.3	n/a	n/a
Champion	Metabolol Endur.	12oz (360ml)	200	24	15	5	230	210
infinIT	Fluid energizer	16 oz (473ml)	119-418	27.2-60	0-10	0	200-650	46-150
Enervit	Enervitene	17oz (500ml)	203	40	1.5	1	65	80
Hammer	Recoverite	12-14oz (340-400)	249-498	32.5	10	0	74.4	19.2

*CHO: Carbohydrate; PRO: Protein; FAT: Fat;

8. THE TRAVELING ATHLETE

Travel is a way of life for many athletes, whether they are traveling overseas, domestically, or commuting daily to training sessions. Traveling to both training and competition sites presents a new array of eating challenges to athletes. Sporting teams need to take responsibility for their athletes' success and make sure that their winning diet goes wherever they go.

Travel whether it is by road or air can be arduous. Long trips may involve crossing time zones, which increases an athlete's risk of jet lag. In general, one day should be allowed as adjustment for each time zone crossed. Jet lag is more apparent when going east, where time is lost, than west where time is gained, and it has been shown that performance may be affected if more than 3 time zones are crossed and athletes are not able to adjust, due to time constraints and poor planning. To adjust in a timely manner, athletes should assume the sleep/wake cycle of their destination at arrival. Some medication can help ease the adjustment but should be overseen by the team physician. Long hours of travel can also upset athletes' digestive systems. To help minimize constipation during travel, athletes should drink a lot of fluids and eat high-fiber, low-fat meals. In addition, athletes should abstain from drinking alcohol and minimize caffeine consumption during travel to help prevent dehydration. Teams may order special meals on the plane; however, this needs to be done at least 1 week for a group and 24 hours prior to departure for individual athletes. Hygiene during travel, such as using frequent hand-washing and sanitizing hand wipes (liquids are no longer permitted on planes), is essential to stay healthy.

Nutrition Tips for Athletes and Staff

- Plan ahead and be organized
- Book special meals on plane trips (e.g., low fat, vegetarian)
- Investigate the availability of foods at your destination
- Identify best meal options at your country of destination
- Plan ahead for eating out and negotiate meal options
- Bring packed food to replace key items unavailable at your destination
- Take recovery foods, fluids, and supplements unavailable at your destination
- Carry a selection of snack foods
- Carry a fluid bottle at all times
- While traveling don't confuse boredom with hunger
- Adopt a meal pattern on travel days
- On arrival, shop at large shopping center located in large cities
- Be aware of safety of food and water supplies at different countries

Nutritious Snacks for on the Road (liquids can no longer be transported on planes), Plane, Luggage:

- Fresh, dried or canned fruit
- Cereal bars, fruit bars, sport bars
- Juices
- Trail mix
- Sandwiches
- Water, sport drink
- Meal replacement drinks

- Crackers

Food Safety and Travel:
While traveling, especially overseas, the risk of food-borne illness is high. Food safety issues, including food handling, storage of food, re-use of left-overs, and personal hygiene associated with food are of particular concern.

Food Handling:
There must be tight control of food handling procedures adopted within a sports team. The coaches, athletes, and sport science staff who are handling food should work with clean hands, tie their hair back, and wear clean clothing. Food handlers should not be involved with meal preparations if ill. Foods that are at high risk of contamination during handling include: eggs, meat, poultry, fish, left-overs, frozen foods, and dented or home canned foods. Order take-away foods with caution and make sure that the foods are thoroughly cooked and served hot and fresh. Feel free to return food if you suspect it may be contaminated.

Storage of Food:
Perishable foods such as yogurt, cheese, and milk need to be refrigerated. Athletes should buy and eat these foods fresh and if proper storage is not available try to stay at accommodation sites that have refrigerators in the rooms.

Re-use of Leftovers:
Left-overs should not be taken to hotels unless athletes have a refrigerator available. Athletes should always cool warm meals quickly and keep food in refrigeration until ready to eat.

Personal Hygiene:
Always make sure to wash hands with soap and warm water before eating anything. If this is not possible, carry anti-bacterial hand lotion or wipes in case of emergencies. When in doubt, throw it out – if you are uncertain about food preparation and storage do not eat it. See Appendix G for suggestions on menu planning for international and domestic travel.

APPENDIX

A. Energy Expenditure for Cross-Country Ski Training:

The table below identifies the estimated energy expenditure per minute for the different modes of training for cross-country skiers. To determine the energy expended in a training session, find the closest mode and intensity of training and the skier's body weight. Multiply this value by the minutes spent training. For example, a 130 lb (59 kg) female cross-country skier completed a 60-minute run at 12 km/hr. Her energy expenditure for this session is 12.3 x 60 = 738 kcal.

Exercise Mode	**Description**	**METS**	**Calories Expended per Minute**				
			110 lbs	120 lbs	130 lbs	140 lbs	150 lbs
			50 kg	55 kg	59 kg	64 kg	68 kg
Running	Jogging	7	5.8	6.4	6.9	7.5	7.9
	X-Country	9	7.5	8.3	8.9	9.6	10.2
	Track	10	8.3	9.2	9.8	10.7	11.3
	7 mph or 11 km/h	11.5	9.6	10.5	11.3	12.3	13.0
	7.5 mph or 12 km/h	12.5	10.4	11.5	12.3	13.2	14.2
	8 mph or 13 km/h	13.5	11.3	12.4	13.3	14.4	15.3
	8.6 mph or 14 km/h	14	11.7	12.8	13.8	14.9	15.9
Conditioning	Circuit Training	8	6.7	7.3	7.9	8.5	9.1
	Weight Training	6	5	5.5	5.9	6.4	6.8
	Stretching	2.5	2.1	2.3	2.5	2.7	2.8
	Yoga	4	3.3	3.7	3.9	4.3	4.5
X-C skiing	6-7 mph or 9.5-11 km/h	8	6.7	7.3	7.9	8.5	9.1
	8-9 mph or 13-14.5 km/h	12	10	11	11.8	12.8	13.6
	10-11 mph or 16-18 km/h	14	11.7	12.8	13.8	14.9	15.9
	12-13 mph or 19.5-21 km/h	16	13.3	14.7	15.7	17.1	18.1

B. Anthropometry *Proforma*

Name:
Test Date:
Gender:
Nationality:
Date of Birth:
Height:
Weight:
Sport:

Skinfolds:

ID	Site	Trial 1	Trial 2	Trial 3	Mean
1	Tricep				
2	Subscapular				
3	Bicep				
4	Iliac Crest				
5	Supraspinale				
6	Abdominal				
7	Front Thigh				
8	Medial Calf				
9	Mid-Axilla				

Girths:

ID	Site	Trial 1	Trial 2	Trial 3	Mean
10	Arm Relaxed				
11	Arm Flexed				
12	Waist				
13	Gluteal (hips)				
14	Mid Thigh				
15	Calf				

Breadths:

ID	Site	Trial 1	Trial 2	Trial 3	Mean
16	Humerus				
17	Femur				

C. Macronutrient Lists, Glycemic Index, Counters, and Carbohydrate Loading Example

Once an athlete's daily macronutrient requirement is identified, providing food and fluid examples to the athlete translates the numbers into practical examples. The examples below correspond to US foods and fluids. Government agencies in charge of food databases usually provide updated lists on nutrient content of most foods and fluids. Putting them into categories as shown below may facilitate the process for the athlete.

Carbohydrate content in foods

25g Carbohydrate			*50g Carbohydrate*	
AMOUNT	**FOOD**		***Amount***	***Food***
1 piece	Fruit		1 cup	Rice
1 thick slice	Bread		1 medium	Potato
1	Flour tortilla		1 ½ medium	Sweet potato
1 (8 oz/230 g)	Plain yogurt		⅓ - ½ cup	Dry couscous
2 cups	Skim milk		1 ½ cups	Cooked pasta
2 cups	Berries or watermelon		1 cup	Dry oats
1 cup	Lima beans (frozen)		2 cup	Honey Nut Cheerios
⅔ cup	Cooked black beans		⅔ cup	Granola
⅔ cup	Hummus		4 thin slices	Bread
1 ½ Tbsp	Honey		1 ½ (10")	Flour tortilla
1	Granola bar		1	Bagel
3	Ahoi chocolate chip cookies		½ cup	Raisins
2.5	Fig Newton bars		1 cup	Unsweetened apple sauce
½ cup	Frozen yogurt or ice cream		2 pieces	Fruit
¾ cup	Canned unsweetened pineapple		10 pieces	Small pretzels
12 pieces	Baked lays potato chips		2 cups	Apple juice
10	Dorito tortilla chips		2 cups	Orange juice
½	Bagel with 1 T jam		2 slices	Pizza
1 cup + 1 cup	Cheerios + milk		3 large	Carrots
10	Dorito tortilla chips		2 cups	Stir-fry vegetables
⅔ cup	Fruit yogurt		2 ¼ cups cooked	Butternut squash cooked
½ cup	Ben and Jerry's Ice Cream		1 cup cooked	Garbanzo beans

Protein content in foods

Animal-based foods				*Plant-based Foods*		
Amount	***Grams PRO***	**FOOD**		***Amount***	***Grams PRO***	***Food***
1 cup	8	Skim or 1% milk		2 Tbsp	9	Peanut butter
1 cup	8	2% chocolate milk		¼ cup	12	Soy nuts
6 oz	5	Yoplait fruit yogurt		¼ cup	8	Sunflower nuts
6 oz (170 g)	10	Plain Yoplait yogurt		¼ cup	9	Almonds
1	9	Dannon fruit yogurt		¼ cup	8	Peanuts
1	8	Dannon nonfat fruit		½ cup	6	Garbanzo beans
½ cup	12	Low-fat cottage cheese		½ cup	5	Black beans
1	8	String Cheese		½ cup	6	Hummus
1 oz (~30 g)	7	Swiss or cheddar cheese		3.5 oz (100 g)	11	Extra firm tofu
1	6	Egg		1	8	Veggie burger
1	3.5	Egg white		1 cup	14	Boca burger
3 oz (85 g)	19	Tuna, canned		1 cup	6	Pasta
3 oz (85 g)	20	Salmon		1 cup	6	Couscous
3 oz (85 g)	22	Halibut		1 cup	7	Soy milk
3 oz (85 g)	26	Chicken breast		1	4	Soy Yogurt
3 oz (85 g)	22	Steak				
3 oz (85 g)	22	Pork loin				
3 oz (85 g)	22	Hamburger				
3 oz (85 g)	23	Turkey burger				
2 oz (~60 g)	9	Deli turkey				
2 oz (~60 g)	9	Deli ham				
2 oz ~60 g)	10	Roast beef				

Combination Foods

Grams PRO	***Food***
7.5	½ cup rice & ½ cup beans
9	½ cup vanilla yogurt & ¼ cup grape nuts
7.5	½ cup vanilla yogurt & ½ cup cereal
11	2 slices bread & 2 oz (~60g) turkey sandwich
11	2 slices bread & 2 Tbsp peanut butter/jam
8	2 slices bread & ¼ cup hummus
7	1 cup couscous w/ pine nuts
11	1 tortilla & 1 oz (~30g) mozzarella cheese
15.5	½ cup cottage cheese & 1 small baked potato

Fat Content in foods

Foods Containing High Amounts of Saturated Fat

Amount	***Sat. grams***	***Total grams***	***Food***
3 oz (85 g)	7	18	Red meat, untrimmed
3 oz (85 g)	4	13	Dark meat chicken, with skin
4 pieces	3.5	10	Bacon
1	5	14	Hot dog
8 oz (230 ml)	5	8	Whole milk
1 Tbsp	7	11	Butter
1 Tbsp	3	11	Margarine
1 Tbsp	1.7	11	Mayonnaise
1 oz (~30 g)	6.5	9.5	Cheese (american, cheddar)
½ cup	9.9	18	Ice cream
1 Tbsp	1	8	Salad dressing (ranch)
1 medium	4	22	French fries (McDonalds)
10	2.5	8	Potato chips
2 oz (~60 g)	11	17	Chocolate bar

Foods Containing High Amounts of Unsaturated Fat

Amount	***PUFA grams***	***MUFA grams***	***Total grams***	***Food***
3 oz (85 g)	2.3	5	10	Salmon, herring
3 oz (85 g)	3.6	6	15	Mackerel
4 oz (115 g)	1.2	0.9	3.4	Tuna canned
1 Tbsp	1.2	10	14	Olive oil
1 Tbsp	4.4	8	14	Canola oil
1 Tbsp	8	3	14	Soybean oil
1 Tbsp	3	4	11	Margarine, non-hydrogenated
1 Tbsp	4	12	19	Almond butter
1 Tbsp	3	1	5	Flax seed
2 Tbsp	5.3	1.5	8	Sunflower seeds
2 Tbsp	3	5.5	10	Almonds, pecans, peanuts
2 Tbsp	7	1.3	10	Walnuts
1/2	1.8	9.7	15	Avocado

PUFA: Polyunsaturated Fatty Acids; MUFA: Monounsaturated Fatty Acids

Foods Containing Low Amounts of Saturated Fat

Amount	***Sat. grams***	***Total grams***	***Food***
8 oz (230 ml)	0	0	Skim milk
8 oz (230 ml)	1.5	2.5	1% milk
1 oz (~30g)	3	4.9	Mozzarella, part-skim
½ cup	1	2	Low-fat vanilla ice cream
3 oz (85g)	1	3.5	Chicken/turkey breast, no skin
1	0	1	Boca burger, soy
1	1.8	3	York peppermint patty, large
6 oz (170g)	1	1.9	Low-fat fruit yogurt

Foods Containing Trans Fats - amounts unknown

Jif and Skippy peanut butter
Cheese puffs, snack mix, gold fish
Ruffles, reduced fat/Baked lays
Mission tortilla chips/tortillas
Wheat thins, triscuits, and other crackers
French fries
Oreos, Poptarts, and other cookies
Margarine

Glycemic index (GI) of high-carbohydrate foods

Low GI Foods (<60)	***Moderate GI Foods (60-85)***	***High GI Foods (>85)***
Oatmeal and porridge	Whole wheat bread	White and instant rice
Bircher Müesli	Breakfast cereals (w/o sugar)	Potatoes
German whole grain bread	Pasta	Breakfast cereals (w/ sugar)
Most fruit (fresh, canned, dry)	Wild and Basmati rice	Honey
Dairy products	Pop corn	Syrups
Legumes	Kiwi, grapes, banana, melon	Sports foods/drinks
Lactose	Juice (100% natural)	Glucose
Fructose	Sweet potatoes	Sucrose

Carbohydrate counter

Food	Serve size	CHO (g)	Day 1		Day 2		Day 3		Day 4	
Grains										
Bread	1 slice	13		0		0		0		0
Pasta - cooked	1 cup	37		0		0		0		0
Rice - cooked	1 cup	45		0		0		0		0
Breakfast cereal	1 cup	25		0		0		0		0
English muffin	1 medium	24		0		0		0		0
Cookie / biscuit	1 medium	15		0		0		0		0
Cake / Pie	1	40		0		0		0		0
Fruit										
Apple/Pear/Orange	1 medium	18		0		0		0		0
Melon	1 cup	10		0		0		0		0
Banana	1	30		0		0		0		0
Dried fruit	1 tbsp	15		0		0		0		0
Fruit juice	1 cup	25		0		0		0		0
Tinned fruit	½ tin	17		0		0		0		0
Vegetables										
Potato	1 medium	26		0		0		0		0
Corn	½ cup	23		0		0		0		0
Pumpkin	1 cup	23		0		0		0		0
Legumes - cooked	½ cup	18		0		0		0		0
Dairy Products										
Milk / Soy Milk	1 cup	12		0		0		0		0
Yogurt	1 tub	13		0		0		0		0
Ice-cream	2 tbsp	11		0		0		0		0
Other										
Sports drink	16 oz / 1.2L	45		0		0		0		0
Candy / Lollies	2 oz / 60g	60		0		0		0		0
Soda	1 can	40		0		0		0		0
Sports bar	1	45		0		0		0		0
Jam/Honey	1 tsp	5		0		0		0		0
Weight (Kg)		**Total**		**0**		**0**		**0**		**0**

Protein counter

Food	**Serve size**	**Protein (g)**	**Day 1**		**Day 2**		**Day 3**		**Day 4**	
Meats & Alternative										
Meat	85 g / 3 oz	24		0		0		0		0
Chicken & Turkey	85 g / 3 oz	23		0		0		0		0
Fish	85 g / 3 oz	22		0		0		0		0
Luncheon meat	1 slice / 1 oz	4		0		0		0		0
Legumes	½ cup	7		0		0		0		0
Tofu	½ cup	10		0		0		0		0
Egg	1	7		0		0		0		0
Peanut butter / nuts	1 tbsp / 20	7								
Dairy Products										
Milk – whole, skim	1 cup / 8 oz	9		0		0		0		0
Soy milk	1 cup / 8 oz	7		0		0		0		0
Yogurt	8 oz /230 g	12		0		0		0		0
Cheese	1 slice / 1 oz	7		0		0		0		0
Cottage / Ricotta	½ cup	13		0		0		0		0
Ice cream	½ cup	2		0		0		0		0
Grains										
Oatmeal / Porridge	1 cup	6		0		0		0		0
Breakfast cereal	1 cup	4		0		0		0		0
Bread	1 slice	2.5		0		0		0		0
Rice	1 cup	5		0		0		0		0
Pasta	1 cup	7.5								
Other				0		0		0		0
Protein drinks	11oz/325 ml	17		0		0		0		0
Protein sports bars	1	20		0		0		0		0
Sports bar	1	10								
Weight (Kg)		**Total**		**0**		**0**		**0**		**0**

Fat counter

Food	Serve size	Fat (g)	Day 1		Day 2		Day 3		Day 4	
Meats & Alternative										
Meat – normal / lean	85 g / 3 oz	14 / 7		0		0		0		0
Chicken with/without skin	120 g / 4 oz	13 / 3		0		0		0		0
Fish – low, medium, high	120 g / 4 oz	1, 5, 15		0		0		0		0
Luncheon meat	1 slice / 1 oz	1		0		0		0		0
Legumes	½ cup	1		0		0		0		0
Tofu	85 g / 3 oz	3		0		0		0		0
Egg	1 medium	4		0		0		0		0
Peanut butter / nuts	1 tbsp / 20 g	8.5								
Dairy Products										
Milk – whole / skim	1 cup / 8 oz	8, 0.5		0		0		0		0
Soy milk – regular / low fat	1 cup / 8 oz	4, 2		0		0		0		0
Yogurt – regular / low fat	1 cup / 8 oz	6, 2.5		0		0		0		0
Cheese	1 slice, 1 oz	9		0		0		0		0
Cream – whipped / fluid	2 tbsp /1 tbsp	5		0		0		0		0
Ice cream – regular / low fat	½ cup	9, 3		0		0		0		0
Butter and Oils										
Margarine	1 tbsp	11		0		0		0		0
Oil	1 tbsp	14		0		0		0		0
Salad dressing	1 tbsp	7		0		0		0		0
Mayonnaise	1 tbsp	11								
Other		5		0		0		0		0
Potato Chips	1 oz, 17 chips	10								
Cakes	3 oz / 85 g	7		0		0		0		0
Pies	3 oz / 85 g	13		0		0		0		0
Cookie	1 regular	5		0		0		0		0
Chocolate	1 bar – 2 oz	14								
French Fries	18	15								
Weight (Kg)		**Total**		**0**		**0**		**0**		**0**

Example of 3-day carbohydrate loading for female cross-country skiers

DAY 1

Breakfast
Cereal, 1½ cups
Milk, low fat, 1 cup
Orange Juice, 1 cup
Roll/Toast, 1 roll / 2 pieces of toast
Jam & Preserves, 1 tbsp
Morning Snack
Sport Drink/Lemonade, 2 cups
Sport Bar, 1
Banana, 1 med

Lunch
2 Sandwiches:
Roll/bread, 2 roll / 4 slices of bread
Lean meat, 2 oz (60 g)
Cheese, 1 oz (30 g)
Vegetables, 2 cups
Fruit Juice, 100%, 1 cup
Afternoon Snack
Sport Drink/Lemonade, 2 cups
Apple, 1 large
Bread, 2 slices
Jam or preserves, 1 tbsp

Dinner
Vegetables, 2 cups
Olive Oil, 1 tbsp
Soy Sauce, 2 tbsp
Chicken breast, baked, 3 oz (85 g)
Rice, cooked, 1½ cups
Yogurt, fruit and low fat, 1 cup
Fruit Juice, 100%, 1 cup

Nutrition Facts

Calories	Protein	Carbs *	Fat	Calcium	Iron	Fiber
3000	116 g	554 g	47g	1395 mg	34 mg	45 g

* 10 grams per kilogram for a 56 kg cross country skier.

Day 2

Breakfast
Low fat granola, ⅔ cup
Yogurt, fruit and low fat, 1 cup
Raisins, ¼ cup
Roll/ Toast, 1 roll/ 2 pieces of toast
Jam and preserves, 1 tbsp

Morning snack
Sports drink/lemonade, 2 cups
Trail mix, ½ cup
Peach, 1 med

Lunch
Minestrone soup, 1 cup
Crackers, ½ cup
Spaghetti, cooked 2 cups
Tomato sauce, ½ cup
Parmesan cheese, 1 tbsp
Fruit Juice, 100%, 1 cup

Afternoon snack
Sport drink/lemonade, 2 cups
Banana, 1 med
Sport bar, 1

Dinner
Salmon filet, 3 oz (85g)
Potato, baked or mashed, 1 cup
Olive oil, 1 tbsp
Steamed vegetables, 2 cups
Frozen yogurt, 1 cup

Nutrition Facts:

Calories	Protein	Carbs*	Fat	Calcium	Iron	Fiber
3240	104	573	69	997	23	44

* 10 grams per kilogram for a 56 kg cross country skier.

Day 3

Breakfast
Omelet:
Egg whites, 2
Vegetables, 1 cup
Roll/ toast, 1 roll/ 2 pieces of toast
Jam and preserves, 1tbsp
Orange, 1 med

Morning snack
Sports drink/lemonade, 2 cups
Sports bar, 1
Pear, 1 large

Lunch
Grilled turkey breast sandwich:
Deli turkey, 2 oz (60g)
1 Roll/ 2 pieces of bread
Olive oil, 1 tbsp
Pesto pasta with tomatoes, 1½ cups
Fruit Juice, 100%, 1 cup

Afternoon snack
Sport drink/ lemonade, 2 cups
Pretzels, 10 small
Unsweetened applesauce, 1 cup

Dinner
Stir-fry vegetables, 1 cup
Risotto, 2 cups cooked
Shrimp, fish, or chicken 3 oz (85 g)
Olive oil, 1 tbsp
Fruit yogurt low fat, 1 cup
Berries, 1 cup

Nutrition Facts:

Calories	Protein	Carbs*	Fat	Calcium	Iron	Fiber
3360	112	573	74	1365	22	40

* 10 grams per kilogram for a 56 kg cross country skier.

D. Fluid Balance Test

FLUID BALANCE TEST							
Record your weight before & after training, the type & length of the session, the temperature & amount of fluid consumed							
Name:				Week Commencing:			
Date	Type training	Duration	Temperature	Wt b/f training	Wt a/t training	Wt lost/gained	Fluid Type & Volume

Estimate Sweat Loss:
% Dehydration = 100 x [pre-exercise wt (kg) – post-exercise wt (kg)]/pre-exercise wt (kg)

Total Sweat Loss (ml) = 1000 x [pre-exercise wt (kg) – post-exercise wt (kg)] + ml fluid consumed + solid food consumed – ml urine excreted.

E. Micronutrient Functions, Food Sources, and International Requirements

Nutrient	**Major Function in Sport**	**Good Sources**	**USA CAN (DRI)**	**AUS (RDI)**	**UK (RNI)**	**FIN**	**DACH**	**Active Female**
Vitamin A (µg)	Antioxidant function, Immune function	liver, cheese, eggs, milk, fish, orange to red vegetables	700	700	600	800	800	NA
Thiamin (Vit B_1) (mg)	Energy metabolism, Nervous function, Muscle contraction	pork, vegetables, fruit, eggs, fortified cereal	1.1	1.1	0.8	1.1	1.0	1.5-2.0
Riboflavin (Vit B_2) (mg)	Energy metabolism, Nervous function, Muscle contraction	milk, eggs, mushrooms, fortified cereal	1.1	1.1	1.1	1.3	1.2	2.4-3.0
Niacin (Vit B_3) (mg)	Energy metabolism, Nervous function, Muscle contraction	beef, chicken, liver, fish, eggs, milk	14	14	13	15	13	NA
Pyridoxine (Vit B_6) (mg)	Energy metabolism, Nervous function, Muscle contraction, Immune function	liver, pork, chicken, eggs, milk, vegetables, potatoes	1.3	1.3	1.5	1.2	1.2	1.5-3.0
Folate (µg)	Hemoglobin synthesis Nervous function, Muscle contraction	green leafy vegetables, legumes, yeast extract	400	400	200	300	400	400
Cobalamin (Vit B_{12}) (µg)	Hemoglobin synthesis Nervous function, Muscle contraction	Meats, poultry, fish, milk, eggs	2.4	2.4	1.5	2.0	3.0	2.4

DRI: Dietary Reference Intakes (USA and Canada); RDI: Recommended Daily Intake (Australia)
RNI: Recommended Nutrient Intake (UK); FIN: Finland; DACH: Deutschland-Austria-Schweiz Referenzwerte; Active Female: based on M.Manore & J. Thompson; Sports Nutrition for Health and Performance, 2000.

F. Travel Menus and Guides

Breakfast Buffet Style

A variety of breakfast options need to be provided, including juices, fruits, cereals and hot food options. Examples are:

Cereals
- Cold cereals: wholegrain cereals, bircher müesli
- Hot cereals: porridge and oatmeal (with dried fruit, brown sugar, cinnamon)

Dairy
- Milk and soymilk (whole, low fat, and skim)
- Natural, plain and fruit yogurt (whole and low fat)
- Low fat cottage cheese (plain or with fresh fruit)

Breads
- White and whole-grain toast, English muffins, bagels

Other hot items:
- Pancakes, waffles (made with white and whole grain flour, added oats, raisings, fruit)
- Eggs (poached, hard boiled or scrambled eggs)

Spreads
- Butter or margarine
- Honey, jam
- Peanut butter

Fruit
- Fresh fruit pieces or fruit salad
- Compote and stewed fruit
- Dried fruit and nuts
- Juices (orange, apple and other)

Drinks
- Coffee, tea (herbal and black), hot chocolate, milk.

Lunch – Buffet Style

Both hot and cold food options need to be available. Suggestions include:

Sandwiches
- A variety of white and whole grain rolls or breads with butter and margarine on the side
- Cold cuts (lean ham, tuna/salmon in brine, lean chicken, roast beef, cheese)
- Salads (variety of lettuce, spinach, tomatoes, cucumbers, carrots, peppers, onions etc.)
- Condiments (mustard, chutney, preserves, honey, margarine, low fat mayonnaise)

Hot dishes
- Soup (minestrone, vegetable)
- Pasta and noodles (pasta with tomato based sauces, Chinese or Japanese noodles with soy sauce; lean protein sources such as turkey, chicken, fish, lean beef)
- Rice based dishes (risotto, fried rice, pilaf, Spanish rice; lean protein sources such as turkey, chicken, fish, lean beef)
- Corn meal (polenta)
- Home made pizza
- Tortilla based dishes (chicken burrito, fish tacos, wraps)

- Baked potato (with variety of toppings)

Dessert

- Fresh fruit or fruit salad
- Low fat muffins or fruit and vegetable cakes (banana bread, carrot cake)
- Yogurt and custard
- Trail mix (nuts and dried fruit mix)
- Italian yogurt ice cream (½ plain yogurt + ½ vanilla ice cream)

Drinks

- Water, juice, tea (herbal), hot chocolate or coffee

Dinner

In the evening most skiers need to consume a large hot meal. Please ensure that minimal oil is used and lean meat and low fat dairy products are utilized. A variety of options are stated below:

Main Course

- Soup
- Vegetarian and/or meat pasta
- Stir-fry dishes with rice or couscous
- Sweet and sour chicken/beef and rice
- Grilled fish, skinless chicken breast, lean steak with potatoes
- Risotto, pilaf, or fried rice with chicken, fish, or steak
- Asian noodles with meat and vegetables
- Vegetarian or meat-based curry with rice
- Vegetarian and meat-based Mexican food
- Serve with plenty of bread rolls and salads (dressing served on the side; use olive oil)

Dessert:

- Fruit crumble, pies, cakes
- Rice pudding or milk rice
- Bread and custard pudding
- Fruit salad or fresh fruit bowl
- Serve with low fat ice cream, yogurt, or custard

Drinks:

- Water, juice, tea (herbal), coffee, hot chocolate

G. Conversions

Weight Measures

1 oz = 28.4 g
1 lb = 16 oz = 434 g
2.21 lbs = 1 kg = 1000 g
Quick conversions for practical use:
3 ½ oz = 100 grams
250 g = ½ lb = 8 oz
500 g = 1 lb = 16 oz

Volume Measures

2 T = 1/8 cup = 1 fl oz = 29.6 ml (~ 30 ml)
8 T = ½ cup = 4 fl oz = 118.3 ml (~ 120 ml)
16 T = 1 cup = 8 fl oz = 236.6 ml (~ 240 ml)
3 t (UK and USA), 4 (Australia) = 1 T

Volume of water = Weight of water
1 l water = 1 kg water ≅ 32 oz water

1 pint (USA) = 0.473 liters
1 quart (USA) = 2 pints = 0.946 liters
Quick conversions for practical use:
1 liter ≅ 32 fl oz ≅ 4 cups ≅ 2 pints ≅ 1 quart

Length Measures

1 foot = 12 inches = 30.48 cm
1 inch = 2.54 cm
1 miles = 1.609 km = 1609 m
Quick conversions for practical use:
3 ft = 0.91 m ≅ 1 m
6 ft = 72 in ≅ 1.80 m = 180 cm
6 miles = 10 km

Heat Measures

1 kilojoule (kj) = 0.239 kilocalories (kcal)
1 megajoule (Mj) = 239 kilocalories (kcal)
1 kilocalorie (kcal) = 4.184 kj

Temperature Measures

(Fahrenheit - 32)/1.8 = degrees Celsius
(degrees Celsius x 1.8) + 32 = degrees Fahrenheit
Quick conversions for practical use:
50 ^{o}F = 10 ^{o}C 20 ^{o}C = 68 ^{o}F

H. Resources

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Australian Institute of Sport: http://www.ais.org.au/nutrition/
Sport nutrition information for Australian athletes in form of fact sheets, recipe books and downloadable materials

Sports, Cardiovascular, and Wellness Nutritionists (SCAN) (American Dietetic Association: http://www.scandpg.org/
Sport nutrition organization under umbrella of American Dietetic Association; also related to Sports Dietetics-USA; mostly for professionals

UK Sport for professionals and athletes
http://www.uksport.gov.uk/
http://www.100percentme.co.uk/home.php

Gatorade Sports Science Institute: http://www.gssiweb.com
Sport nutrition information in form of fact sheets

European Anti-doping Bureau in Cologne: http://www.dopinginfo.de
World Anti-Doping Agency (WADA): http://www.wada-ama.org

International Olympic Committee: http://www.olympic.org/uk/index_uk.asp
Free booklet for download: nutrition for athletes

National Institute of Health – Office of Dietary Supplements: http://dietary-supplements.info.nih.gov/
Up-to-date information on supplements: