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

Preface

The second booklet in the series „ladies development in Cross-Country skiing" deals with facts and problems around nutrition. It was launched by the Sub-Committee for Ladies Cross-Country and Dr. Peter Jenoure from the Medical Committee. With the authors Nanna L. Meyer and Susie Parker-Simmons we found two engaged ladies with a hudge knowledge on this subject.

We hope that coaches and athletes all over the world will find some helpful information.

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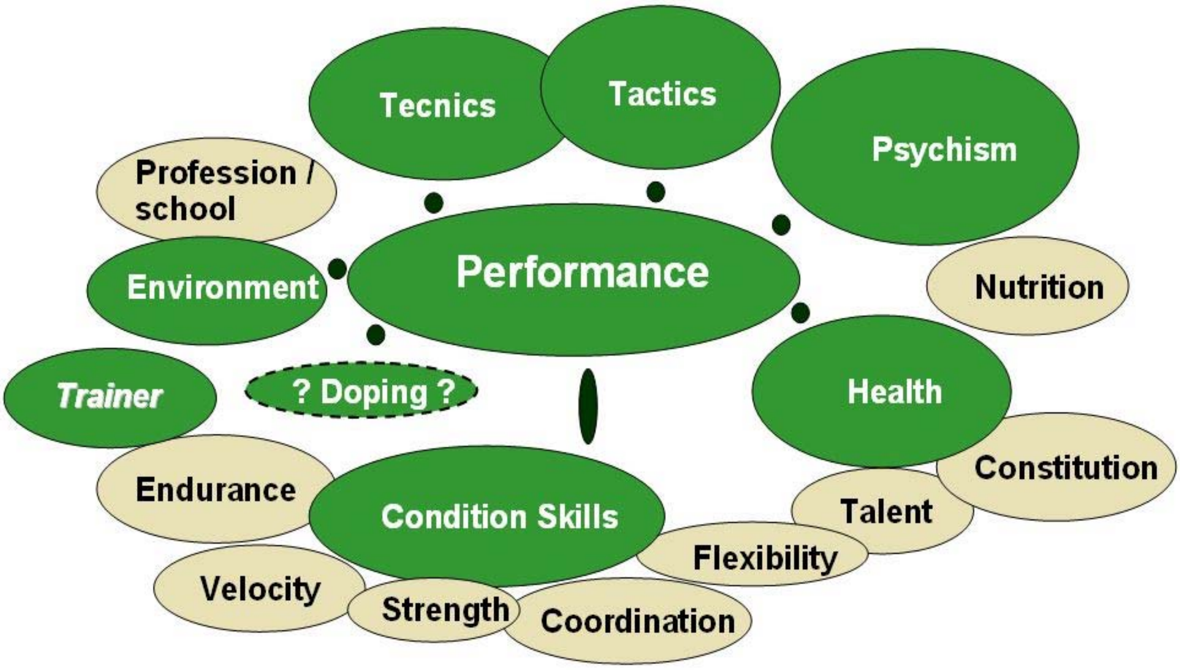
The importance of diet in the achievement of an optimal athletic performance

Considering the amount of information devoted to the problem of sport nutrition, it could be thought that this subject is of paramount importance in the quest for an optimal athletic performance.

However, in spite of the amount of research carried out, nothing, as far as we know, tries to quantifies the exact role of an adequate diet in sport.

Performance in sport, at whatever level for a given individual, can only be the result of numerous corroborating factors.
There are several ways of expressing this multi-causality. As far as we are concerned, we consider a performance as being the result of numerous corroborating elements.



The structure and the capacity for performance of the organism is determined on one hand genetically, and on the other through the quality and quantity of external biopositive stimulations. According to current knowledge, it would seem that genetics are responsible for to and extern of 60 to 70% our capacity to perform, external influences only representing 30 to 40%. However, this fairly small proportion still provides important possibilities for performance improvement, if one knows how to make use of these extrinsic factors.

To investigate these various influence, it is necessary to be acquainted with the biological basics of nutrition in relation to the effort made in sport, and as we have already said, much literature is to be found on this subject.

The relation between diet and training seems evident. The exercise essential to an optimal performance consumes a large amount of energy which is supplied by nutrition. We won't go into the quantitative or qualitative aspects here or talk about general rules concerning the best time to sustain oneself in relation to a physical effort. We will just remember that this widespread knowledge is deficient in its practical application. The principle of nutrition in sport must be practised regularly, and not just at the time of the competition.

Training sessions are more and more demanding and "consume" varius functions of the organism. The exhaustion of energy reserves, dehydration, intra and inter-cellular electrolytic transfers, but also hormonal depletion and over-consumption of central and peripheral nervous functions are the principal signs of fatigue following an intensive training session. Recuperation or regeneration, as an anti fatigue action, plays a capital role in the rapid correction of the deficiencies described above. Replacing what has been irreparably lost can only be achieved through nutrition and the quicker the replacement is made after the effort, the more efficient is the process.

It is unnecessary to underline the close relationship between diet and health. The effects of an inadequate or too rich a diet are well known as primary risk factors (obesity, anorexia etc.)

Interaction between an environment favourable to the development of a satisfactory athletic performance, and nutrition, almost certainly exists but should probably be looked at in the opposite way. It would seem that environment defines diet by fixing the practical conditions of its realization (prices, place of distribution, person responsible for preparation etc.)

When we think about diet in sport, we have only ever thought about calories, therefore energy. But food is not just a simple provider of energy in the life of a human being. An important psychological dimension can be considered, taking into account factors such as eating with the family, education, traditions etc.

Even if it is difficult to quantify precisely the role of nutrition in the quest for an optimal athletic performance, its importance does not seem overrated and we feel justified in encouraging athletes to consider this natural element very seriously.

Athletes should be conscious of the importance of, and should know all about the subtleties of nutrition in sport, making sure their diet takes into account all the information available today. Regular weight control, noted in a training notebook, and regular dietary investigations are recognized acts and easy to do.

Improved performance is achieved by paying attention to all the details which contribute to its enhancement. Nutrition is an important detail with widespread influence, and, contrary to many others, has the advantage of being fairly easily optimized.

Peter J. Jenoure, M.D.

TABLE OF CONTENTS

LIST OF TABLES

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.

In the past 2 years, The Institute for Sport Science at The Orthopedic Specialty Hospital in Salt Lake City, in collaboration with the United States Ski and Snowboard Association, the United States Speed Skating Association, United States Biathlon Association, and several other National Governing Bodies, have collected data on nutrition-related issues in winter sport athletes as part of the 2002 Salt Lake Olympic Research Grants awarded through the International Olympic Committee (IOC) Medical Commission. We are delighted to present some of the results in this brochure and will continue to focus our efforts in devoting our research interest 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 the prevalence of disordered eating, amenorrhea, and osteoporosis in cross-country skiing and provides strategies of treatment and prevention. Chapter 7 provides an overview of dietary supplements and offers details on caffeine, creatine, 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 - I) 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, and the thermic effect of activities, some of which is spontaneous with the largest part, however, coming from planned exercise. In fact, the energy expended through exercise makes up a large part of the daily energy requirement in the athlete, contributing sometimes up to 80% of 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 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 feeding account for about 1500 to 1800 kcal, 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, with energy expended through exercise alone ranging from 2000 to 3000 kcal. Injury, stress, environmental extremes, luteal phase of the menstrual cycle, and medications can increase 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). For female athletes, this is one of the highest measured energy expenditures ever reported in the literature. The researchers of this study employed the golden standard for measuring energy turnover called the doubly-labelled water technique and found that the skiers were in energy balance (energy intake = energy expenditure). 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 calories per kg body weight), whereas intakes of 50 calories per kg of body weight have been recommended as minimal levels during intense training of approximately 90-minute duration. Data from the IOC-funded study showed a large range between energy intake and expenditure in the cross-country skiers and biathletes during intense dry-land and on-snow training with an average negative energy balance during on-snow training of 10 calories per kg of body weight. However, no changes in body weight were reported. In this study, data were collected over a large time period with only a limited 6 - day representation. It is possible that athletes regain energy balance on recovery days and during training periods that are less intense.

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 in a starvation mode.

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 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 that also keep tight weight ranges aiming for fat loss and muscle gain to optimize body composition and increase the power-to-weight ratio. In most sports, the elite athletes form a select group and, in general, 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 optimum 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. Data from the IOC-funded study found height ranging from 1.59 to 1.71 m, weight from 57.0 to 67.2 kg, percent body fat from 14 to 18 %, and lean tissue mass from 46 to 53 kg. Body composition was measured by dual energy x-ray absorptiometry (DXA), viewed as the golden standard of body composition today. Unfortunately, DXA is not a feasible field method due to its high cost. Anthropometric measurements are a more practical and cost-efficient way for cross-country ski teams to assess body composition.

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 between 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 none-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, 7, 8 or 9 skinfold measure has been used 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. To estimate body fat, it is now recommended to use absolute values such as a skinfold sum, which then can be compared to the normative data for elite athletes, or an individual's value can be monitored 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 will determine fuel selection. Increased exercise duration will shift 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 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.

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 throughout the menstrual cycle. Recent data have shown that estrogen reduces carbohydrate oxidation by decreasing blood glucose uptake and muscle glycogen use, thus, sparing glycogen. The addition of progesterone reverses this effect on the level of muscle glycogen but not on the level of blood glucose uptake. In fact, progesterone may potentiate estrogen's effect on blood glucose uptake. Therefore, female athletes may present with a more optimal carbohydrate availability during prolonged exercise, particularly during certain phases of the menstrual cycle.

Environmental Factors

Environmental conditions can vary in the sport of cross-country skiing, and thus, it is 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 urine loss. Thus, 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.

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, however, women, appear to rely on fat as a fuel to a greater extent when exposed to altitude, 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). Training at altitude for cross-country skiers, however, 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 need 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. Data from the IOC-funded study showed an average energy intake for all athletes of various winter sports of approximately 2800 kcal with 61% being supplied by carbohydrates, 16 to 17% by protein, and 23 to 24% 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 recommendations should be provided in total grams or grams per kilogram of body weight. 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 carbohydrates stored in the liver help maintain blood glucose levels and provide fuel for the brain. Unfortunately, glycogen stores in both muscle (200 - 600g) and liver (80 - 120g) 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 prolonging 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 that will need to be confirmed in the training athlete in the field. Nevertheless, these results suggest that more attention needs to be given 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 also belongs to high-carbohydrate sources for the athlete. Sugar and sugary foods also provide carbohydrates and can be used to add extra fuel to a high-carbohydrate diet.

Glycemic Index
The glycemic index (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 determine which foods were best for people with diabetes. Research on GI shows that different carbohydrate foods have different effects on blood glucose levels (see Appendix C for examples). While 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 exercise, during, and after exercise. Foods and fluids consumed before exercise may 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 in certain individuals and often coincides with the onset of exercise, there is little 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, resulting in 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 - 10 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 optimize liver glycogen levels and 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
- Adequate in fluid
- Solid and/or liquid

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 ski). The aim is to maximize carbohydrate stores, which can 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: 8 - 10 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 loading as their male counterparts.

Carbohydrate Intake During Exercise
It has been long 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 candidate for 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. Thus, 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:

- Intensity of exercise: the higher the intensity the faster the glycogen reserves are depleted
- 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 gels, honey sandwich, hard candy, and sport bars (see Chapter 7).

Carbohydrate Repletion After Exercise
After prolonged exercise, glycogen stores are depleted. Adequate recovery involves quick refueling of the body immediately after exercise. The increased insulin sensitivity after exercise represents an optimal environment for accelerated glucose uptake into the muscle. 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 have an additive effect (more on this in the protein section).

To replace glycogen stores after exercise it is recommended that a snack be eaten within 1 to 2 hours after exercise if training or competition occurs once per day and within the first 30 minutes if training or competition occurs twice per day.

Target Amount after Exercise: 1 g / kg

Examples of 50 g carbohydrate recovery snacks include:
- 24 - 32 oz / 0.75 - 1 liter sports drink
- 1 banana sandwich
- 1 honey sandwich
- 1 - 2 sweet muffins
- 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 and foods for recovery with small amounts of protein, 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 per kg of body weight per day, although intakes of 2 g per kg per day may also apply in special circumstances (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 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 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. 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 8 to 12 g of protein, whereas larger amounts of protein (20 to 30 g) can be eaten at meal-time.

Examples for recovery foods to add to sports drinks or water:

- 1 low-fat yogurt + ½ cup of cereal
- 1 cup of milk + 1 cup of cereal
- ½ Sandwich (white or light wheat bread, 1.5 oz or ~ 40 g of turkey, tuna, lean ham, mustard)
- 1 sports bar containing protein (see Chapter 7)

Fat

Functions

Fat is an important contributor to total energy intake in the cross-country skier. 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 carbohydrates. Fat is an important energy source during prolonged exercise and can be supplied from both adipose and muscle tissue.

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 the trained athlete 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
Fried foods, fast foods, convenient foods
Sauces, dressings, condiments
Desserts and sweets

Vegetable fats are rich in poly- and monounsaturated fats. These fats can have a variety of chemical structures. Polyunsaturated fats contain essential fatty acids that the body can't make but need to be supplied by the diet. Some of these fats play an important role in reducing inflammatory processes but are somewhat dependent on adequate dietary intake in comparison to other sources of fat. Thus, reducing fats from Table 3 by choosing lean 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 oil	Green leafy vegetables	Canola oil
Soybean oil	Flax seeds/oil	Pecans, almonds
Corn oil	Canola oil	Peanuts

Although endurance athletes need to focus on a low-fat diet in order to achieve 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 100g) per day may help the endurance athlete replete lost fats from muscle tissue after exercise. It appears that the Mediterranean diet could be implemented to provide a greater proportion of essential fatty acids (polyunsaturated omega-6 from vegetable oils and omega-3 fatty acids from fish oils) as well as a higher proportion of monounsaturated fats from the use of olive oil. 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 high-energy requirements, it is relatively easy to achieve a higher fat intake, without compromising carbohydrate and protein adequacy.

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

In the athletic setting, however, further research certainly is 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 shown to improve exercise performance over the traditional high-carbohydrate approach. Nevertheless, a diet with a higher fat content may cater certain benefits to the athlete with regards to the up-regulation of oxidative enzymes as well as anti-inflammatory and antioxidant properties that certain fats can provide.

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 also 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, fat, and protein counters (Appendix C) provide useful strategies to determine if the female cross-country skier meets her daily requirements. Individual needs, however, depend on the following factors:

- Body mass
- Level of training
- Time of day relative to training sessions
- Environment
- Phase of the macrocycle (attention to double workouts)
- 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)	6 (1440)	1.2 - 1.6 (288 - 384)	~ 1 (540)
Moderate Day (1-2 sessions; moderate intensity)	45 - 50 (2700 - 3000)	7 - 8 (1680 - 1920)	1.2 - 1.6 (288 - 384)	~ 1.4 (756)
Hard Day (2 intense sessions)	55 - 75 (3300 - 4500)	9 - 12 (2140 - 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 10g of protein) to your recovery foods and fluids for each workout.
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. Always plan ahead.
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 and warm meals 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 get rid of 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 1 to 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 building after exercise.

Adequate fluid replacement during exercise is imperative in hot and humid environments, in which sweat rates can exceed 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 thought 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 losses through the humidifying of inspired air in the cold, low-humidity environment. Voluntary hypohydration may also occur due to increased diuresis (larger urinary volume) and a lack of restroom facilities 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.

Data from the IOC-funded study showed overall fluid intake was probably sufficient, however, hourly fluid intake of cross-country skiers, biathletes, and all other sports did not meet the minimal recommendations set by various organizations for fluid replacement during exercise. To date, it is unknown to what extent dehydration occurs in winter sport athletes and to what extent it affects both physical and mental performance.

Adequate fluid intake from both fluids and foods is key in preventing dehydration. Daily fluid needs in athletes depend on daily sweat rates. A variety of factors influence sweat rates:

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

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. 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 fluids ingested before, during, and after exercise, especially if two training sessions are scheduled in one day. Athletes should be encouraged to drink 2 to 3 cups of water per meal or 6 to 9 cups per day, with other sources such as milk, juice, herbal tea, occasional sodas, coffee, black and green tea 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 I for websites and organizations). To date, no recommendations exist for fluid replacement in the cold. The best strategy to identify individual needs in the cold is to calculate fluid loss by monitoring weight before and after exercise. It is generally recommended to replace at least 80% of fluid lost during exercise and between 150 to 200% after exercise. Weight loss from fluid loss should be minimized, as performance decrements have been reported with a body weight loss as little as 1 to 2%.

Fluid Intake Before Exercise
Athletes should attempt to begin the training session in a well-hydrated state. Most guidelines suggest 14 - 20 oz (~ 400 - 600 ml) of fluid within 120 minutes prior to exercise. In a hot environment, an additional 16 oz (~ 500 ml) are recommended.

Target Amount 120 minutes before exercise: 14 - 20 oz or ~ 400 - 600 ml

Fluid Intake During Exercise
In general, fluid ingested during prolonged exercise should be considered for training or competition lasting 60 minutes or longer. For training sessions under normal ambient conditions, athletes should carry bottles or camelbacks. 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.

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 - 12 oz (~ 150 - 360 ml) are recommended, most athletes hardly meet the lower range of this recommendation, with an hourly fluid intake of around 16 oz (~ 500 ml). More optimal intakes, especially when exercising in the heat, range from 20 - 36 oz (~ 600 - 1100 ml) per hour of exercise. 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 1 to 2 % of initial body weight.

Target amount every 15 - 20 min.: **Heat: 5 - 12 oz (~ 150 - 360 ml)** **Cold: 4 - 8 oz (120 - 240 ml)**

Fluid Intake After Exercise
Rehydration strategies are especially important if a second training session is scheduled. Recommendations are based on the amount of weight lost. Each pound or kilogram lost should be replaced by approximately 150 to 200 % (where each pound lost equals 16 oz of fluid and each kilogram lost equals 1 liter of fluid).

Target amount immediately after exercise: **24 – 32 oz for each pound lost (1.5 - 2 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 important to maintain hydration status during exercise and properly restore hydration status after exercise.

The ingestion of large fluid volumes in the form of water in the absence of foods or sports 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 potentially very small.

Sport Drinks Versus Water
Deciding between water and a carbohydrate-containing 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 8 oz or approximately 200 ml of fluid):
Carbohydrate concentration: 4 - 8% (10 - 20 g)
Sodium: ~ 110 mg (10 - 25 mmol/l)
Sugar sources: glucose, glucose polymers, sucrose, fructose
*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 H

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, low intake often occurs for iron, calcium, zinc, magnesium, and the B-vitamins folate, 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. Data from the IOC-funded study showed that average micronutrient needs were met for all vitamins, minerals, and trace elements except for folate. These analyses, however, did not include the micronutrients consumed through supplements. Thus, overall these female athletes met and exceeded the current Dietary Reference Intakes/Recommended Daily Allowance (DRI/RDA) or international equivalent. 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 also 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, providing approximately 100 to 150% of the respective DRI/RDA should 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, supplementation, in addition to a multi-vitamin/mineral supplement, may apply for iron, calcium, 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 and/or hyperoxic strategies 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 (Fe) 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 low-end recovery rates such as active recovery sessions and resting overnight. Exposure to altitude may be particularly challenging for athletes with iron deficiency anemia. It has been shown that 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 dietary iron intake through iron 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 levels and low serum ferritin. Stage III, iron deficiency anemia, is the most severe stage identified by a significant reduction in hemoglobin and hematocrit levels and clear signs and symptoms of reduced work capacity, delayed recovery, and greater susceptibility for illness.

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

Stage	**Change in iron measures**	**Serum ferritin (mcg/l)**	**Hemoglobin (g/dl)**	**Transferrin Saturation (%)**
Normal iron storage	All iron status measures within reference range	> 30	> 12	20 - 40
Stage I Depletion	Low ferritin, normal to high serum transferrin saturation, normal hemoglobin and hematocrit	< 30	Normal range of hemoglobin	20 - 40
Stage II Iron Deficiency	Low ferritin, low transferrin, low serum iron, reduced transferrin saturation, free erythocyte protoporphyrin increases, normal hemoglobin	< 12	Normal range of hemoglobin	< 16 - 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	< 10	< 12	< 16
Factors affecting measures: dehydration, inflammation, malignancy, infection, acute exercise in trained, intense prolonged exercise				

The prevalence of iron deficiency anemia is low in the athletic population (3%), however, iron depletion occurs in 37% of athletes (both males and females) and is higher in endurance sports and in female and adolescent 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. The lower prevalence of iron depletion found in the IOC-funded study was probably due to the high use of iron supplementation (74% of all study participants).

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 explains 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, insufficient dietary intake of iron, and increased blood volume.

Treatment aims to normalize 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 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.

An iron supplement that consists of 45 to 60 mg of elemental iron should be consumed with a glass of orange juice. 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. Because one of the side effects of iron supplementation is constipation, athletes need to be aware of consuming a high fiber diet with sufficient fluid intake during the supplementation period. If symptoms continue athletes should try supplementing every second day.

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% in pork, liver, and fish and 50 to 60% contained in beef, lamb and chicken. See Table 9 for dietary sources of heme iron.

The non-heme iron pool consists of iron from plant products such as vegetables, grains, fruit, as well as from the non-heme iron in meats, poultry and fish, fortified foods, and from liquid iron supplements. They all have limited availability. See Table 9 for dietary sources of 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 concomitantly. 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. 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

Athletes, coaches, and sport scientists all want to know what hemoglobin and hematocrit levels are normal and what level may enhance performance. Unfortunately, we do not know the answer to these questions. However, we do know that blood boosting and doping is risky and rampant in sports such as cross-country skiing. Athletes and their support staff need to be cautious on ingesting large doses of supplemental iron, as excess iron stores (high serum ferritin) is a risk factor for heart disease, stroke, cirrhosis of the liver, and diabetes. It is, therefore, advisable for female cross-country skiers to keep serum ferritin levels between 35 - 200 mcg/l and to not use iron supplements without monitoring iron status.

Calcium

Calcium is the predominant component of bone, and thus, 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 of calcium 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%, however, 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 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 ~ 28 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, in addition to eating foods high in calcium in order to reach a daily intake of 1500 mg.

Because 98% of the skeleton is accrued by the age of 20 years, adequate calcium intake through the growing years and normal menstrual function after menarche are key to building and maintaining bone mass across the life span. Although gymnastics and figure skating elicit sufficient stimuli for osteogenesis (bone formation), running and cross-country skiing have not proven as effective in order to override the negative effect of low estrogen levels on bone mineral density. Therefore, cross-country skiers should focus on consuming adequate calcium throughout their adolescent and young adult years.

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 that can cause cell damage and contribute to fatigue during endurance exercise. 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-oxygen consumption rates and damaging exercise with increased inflammation. In addition, environmental factors such as pollution, UV exposure, and altitude may further free radical damage. 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 may help protect cells from damage by inhibiting the formation of free radicals. These foods deliver nutrients that scavenge existing radicals, and providing 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, 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.

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 can improve 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 100% the RDA for individual nutrients, although therapeutic doses of vitamin E may be higher but should not exceed 200 - 400 IU per day. 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. Cross-country skiers with an excess intake of supplemental iron should consider decreasing their levels to around 45 - 60 mg of elemental iron and to add vitamin E as an antioxidant at a dose of 100% RDA. Iron is a pro-oxidant and may be harmful in high amounts.

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:

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

Adequate 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 intramuscular levels of glycogen. When muscle glycogen, being an important substrate for contracting muscle, becomes depleted it causes a decrease in 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, 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) consists of disordered eating, amenorrhea (absence of menstrual cycles), and osteoporosis (low bone mass) and was first recognized in the early 1990s. Today, it is well established that each component of the TRIAD exists on a continuum and that subclinical or less severe manifestations of the TRIAD also affect performance and health in the female athlete. An update of the American College of Sports Medicine's position stand published in 1997 will be available next year (see Appendix I for currently available resources).

Prevalence

The overall prevalence of the TRIAD in its initial version is not well known because it is difficult to study a large population on all three components of the TRIAD. Nevertheless, it is now known that the disorders of the TRIAD are about 30 to 60% prevalent in the athletic collegiate and elite population with the highest prevalence in aesthetic and endurance sports that require a lean body type and high power-to-weight ratio.

Early prevalence studies on eating disorders in endurance athletes showed that the TRIAD was most prevalently found in cross-country skiers. Data from the IOC-funded study revealed a high prevalence of restrained eating (characterized by moderate energy restriction) in the cross-country skiers and biathletes. These athletes were also in negative energy balance for both dry-land and on-snow training, and 57% of them had experienced oligo- and/or amenorrhea in the past (see Table 13 at the end of this chapter for terminology). Although the cross-country skiers and biathletes had the lowest bone mineral density of all athletes in the study, and 29% had experienced stress fractures in the past, none of them was classified as osteopenic or osteoporotic. No larger-scale studies have recently been conducted to assess the current prevalence of the TRIAD in cross-country skiers.

Consequences

The TRIAD and its individual components can affect both performance and health. 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 historical, 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. Although some sports can protect against bone loss (resorption) or reduced bone growth (formation), 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 exacerbate micro-damage to bone and increase the risk of stress fractures.

Performance-related consequences of the TRIAD, and particularly of disordered eating patterns and low energy availability, have recently been detailed. Restrictive eating in its initial stages usually leads to a negative energy balance and an initial weight loss with a possible improvement in performance, particularly in sports that require a high power-to-weight ratio. This scenario may give the athlete a positive feedback from the coach, teammates, or parents. The enhanced performance reinforces her behavior and the feeling of having total control. Restrictive eating behaviors may be intensified under such conditions eventually leading to a loss of control, reduced performance, and the development of a clinical eating disorder such as anorexia nervosa or bulimia nervosa. Regardless of severity, low energy availability through not eating enough to match energy expenditure in training, will eventually take its toll on both performance and health. In recent years, low energy availability has been found to be of primary importance in disrupting normal menstrual function.

Each component of the TRIAD can occur on a continuum. Energy restriction, regardless of severity, will ultimately lead to a diet that is deficient not only in calories but also in carbohydrate, protein, fat, vitamins, minerals, and trace elements. The threshold of such energy deficient diets have been identified: between 2000 to 2400 kcal are necessary for adequate carbohydrate intake and between 1800 to 2000 kcal are required to meet micronutrient needs. Although supplementation and the ingestion of fortified sports and commercial food products can assist in meeting daily recommendations for most micronutrients, this approach will not solve the issue of carbohydrate and protein deficiency.

Treatment

Screening and Assessment

Screening and assessment should be an integral part of each athlete’s physical evaluation before she begins training. If an athlete is identified with one component of the TRIAD she should be screened for the others. See Appendix F for details on screening and signs and symptoms for anorexia nervosa and bulimia nervosa.

Warnings signs of disordered eating and the TRIAD can be best observed by those frequently around the athlete (coach, physical therapist, athletic trainer, teammate). Behaviors and physical characteristics consistent with anorexia nervosa are easier to identify than those for bulimia nervosa. It may be that certain characteristics surface during vulnerable times such as an abrupt change in training intensity. On the other hand, athletes with only 1 or 2 physical symptoms or behavioral characteristics may not necessarily have an eating disorder or the TRIAD but the risk for the development certainly increases.

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, dietitian, psychologist, physiologist) will be activated depends on the severity of the disorders. The team physician may request further tests to rule out other underlying pathologies. 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 on other team members this condition could have. 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 depends primarily on treatment success and is determined by the physician. 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, particularly when trigger factors of disordered eating are abundant (see below for examples).

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

- Sudden increase in training load (volume or intensity)
- Early start of sport-specific training
- Early dieting behaviors
- Traumatic events (loss of a loved one, an injury, or a loss of coach)

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 ways, 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, or general societal ideals. 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 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 eating disorders and 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 and fitness rather than thinness, and psychological aspects of training young female athletes. 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 illnesses, in addition to changes in performance and skill, mood state, resting heart rate, and biochemical markers are key. Appendix I provides a list of resources for the athlete, the coach, and parent.

Table 13 Glossary of terms related to The Female Athlete Triad

The Female Athlete Triad	Syndrome of disordered eating, amenorrhea, and osteoporosis first identified in 1992
Eating Disorder	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 Balance	Energy intake - energy expenditure = 0
Low Energy Availability	Dietary energy intake below exercise energy expenditure
Energy Restriction	Attempt to decrease caloric intake to maintain a low weight
Eumenorrhea	Regular menstrual cycle shorter than 35 days
Amenorrhea	Primary: onset of menstruation after the age of 16 years despite secondary sex characteristics; Secondary: loss of 3 consecutive menstrual cycles or fewer than 3 cycles per year
Oligomenorrhea	Irregular menstrual cycles: cycles longer than 36 days or less than 6 to 9 cycles per year
Osteoporosis	Low bone mineral density (< 2.5 standard deviations below the mean for young, healthy adults according to World Health Organization)
Osteopenia	Low bone mineral density (1 - 2.5 standard deviations below the mean for young, healthy adults according to World Health Organization)
Stress Fracture	A break in a bone, usually small, that develops because of repeated or prolonged forces against the bone

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. Data from the IOC-funded study showed that over 90% of all athletes used dietary supplements, with 100% of all cross-country skiers and biathletes taking at least one or more supplements. The most frequently used supplements were multi-vitamin and mineral, vitamin B complex, and antioxidant supplements.

For athletes, coaches, and sports dietitians it is almost impossible to keep up-to-date on the prolific growth of the supplement industry that is promoted in sport magazines, the internet, or other points of communication.

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, producers 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). Statements and claims are not evaluated by the FDA, and manufacturers are not required to comply to good manufacturing practice. 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 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 nutritional 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 foods are energy-containing products manufactured in a food-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.

Approved sport products and supplements include sport drinks, liquid meal supplements, sport gels, sport bars, and various vitamin and mineral supplements in amounts equal to or slightly higher than the DRI/RDA 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, by far, outweigh the risks. 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.

Benefits may be:

- Increased performance
- Insurance policy
- Health
- Free samples

Risks are:

- Financial burden
- Negative health effects
- Performance decrement
- 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 is approximately 1 gram per day, except for vegetarians who consume little or no creatine. 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 are found in skeletal muscle, and the daily turnover is approximately 2 g.

Creatine supplementation is one of the few dietary supplements that is seen as valuable for certain sports. It is also not banned by any sport-governing organization. Over 100 scientific studies have supported the role creatine monohydrate has on increasing muscle levels of creatine (creatine and creatine phosphate) in trained individuals. Within the muscle, creatine phosphate performs a number of important functions in exercise metabolism; regeneration of ATP and buffering of hydrogen ions. Creatine loading is generally associated with an immediate weight gain of 1 to 2 kg, which is probably due to the retention of fluid stored with creatine in the cell. A weight gain beyond the intial 1 to 2 kg is thought to be associated with the fact that creatine may assist the athlete in training harder with improved recovery, leading to increased lean tissue mass and strength gain. Creatine, however, has been found to be most effective in increasing the performance of short, high intensity exercise, especially with repeated bouts. Creatine does not appear to enhance the performance of aerobic or endurance sports.

The muscle cell has a creatine threshold or saturation point. Typically creatine loading increases total creatine and creatine phosphate by 25% above resting levels. The quickest way to 'creatine load' is to take a large dose (~ 20 g per day) for around 5 to 7 days. This dose should be split over the day to sustain plasma creatine levels (5 g ingested 4 times per day). Carbohydrates appear to facilitate creatine uptake via a stimulatory effect of insulin. It is, thus, recommended to combine creatine ingestion with 70 - 100 g of carbohydrates.

Following the loading phase, muscle creatine stores gradually drop. Studies show it takes approximately 4 to 6 weeks for creatine stores to return to resting values. A 'maintenance' supplemental dose of 2 - 5 g per day will keep the loaded muscle at elevated levels.

Most athletes will cycle their creatine supplementation, with one week of loading, 4 to 6 week of a maintenance dose and stopping the supplement for at least 2 to 3 weeks before re-loading. Recent studies, however, have demonstrated that slow loading, ingesting smaller daily doses (3 – 5 g) over a longer period of time (5 to 6 weeks) will result in similarly high creatine retention compared to the fast loading strategy.

Considering the fact that only 50% of the population belongs to the 'responders' of creatine loading, coaches and athletes should evaluate the risk-to-benefit ratio for creatine supplementation, particularly in the cross-country skier as it is well know that creatine supplementation is ineffective for endurance-type activities.

Although negative side effects have not been reported thus far, 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.

The interest on the effect of caffeine on exercise performance dates back almost a century. Since the late 1970's, caffeine has been proposed to increase endurance work capacity via the release of stored sugars from the liver, the mobilization of free fatty acids into the bloodstream, and increased muscle force by stimulating calcium release. If glycogen sparing occurs this is generally limited to the first 15 to 20 minutes of exercise. Further, there is growing evidence that caffeine enhances performance by reducing the perception of effort via the central nervous system or sensory signals from working muscles.

There is a large individual variation in physiological response to caffeine. In general, the evidence of ergogenic benefits of caffeine intake is found at caffeine intakes of 1 - 3 mg per kg of body weight (i.e., 50 - 200 mg of caffeine). There are no reported benefits from taking larger doses. Benefits may also be seen when caffeine is ingested with carbohydrates throughout the exercise bout. Further research is needed to clarify the quantity and types of carbohydrates and their effects on caffeine absorption. Caffeine is normally ingested approximately 1 hour prior to exercise, and benefits have also been identified when caffeine is consumed throughout exercise and especially late in an endurance session. A low dose of caffeine does not cause dehydration if consumed shortly before or during exercise and produces no or only mild side effects. The International Olympic Committee (IOC) has banned doses of caffeine that produce urinary caffeine levels of ≥ 12 μg/ml.

Sodium Bicarbonate

Anaerobic glycolysis provides the primary fuel source for exercise of near maximal intensity lasting longer than approximately 20 to 30 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, lactate and 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 7 minutes (sprint cross-country events) or for sports involving repeated anaerobic bursts.

The protocol for usage of sodium bicarbonate includes consuming 300 mg per kg of body weight (approximately 4 - 5 tsp) 1 to 3 hours prior to exercise. To reduce the likelihood of suffering from gastro-intestinal distress, doses should be taken every 20 minutes beginning 3 hours prior to the event and ending one hour prior to the commencement of the event. At least 32 oz or one liter of water should be consumed. Sodium citrate is usually ingested at doses of 300 - 500 mg per kg of body weight.

One major side effect of bicarbonate loading is gastro-intestinal distress such as diarrhea and stomach cramps. Another side effect is an increase in blood pressure due to the high intake of sodium.

Significant variability within studies suggests that bicarbonate ingestion has an individual effect on different subjects. It has been proposed that anaerobically trained athletes would show a lower response to bicarbonate or citrate loading due to better intrinsic buffering capacity. Until further research can clarify if 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 potential 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.

Data from the IOC-funded study showed that total dietary energy, carbohydrate, and fluid intake were complemented up to 20% by sport foods and drinks although this varied among individuals. In fact, less than 50% of all athletes used sport drinks during on-snow training, whereas only one athlete consumed more than 20 g of carbohydrates per hour from sport foods and drinks. These intakes are below recommended hourly consumption rates for carbohydrate and may impact an athlete's capacity to maintain exercise intensity during prolonged exercise, as previously discussed in Chapter 2.

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 cater for the added demands of 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 - 50 g per bar. Most bars are low in fat (2 - 3 g per bar) and fiber. The protein content varies (5 - 15 g or more per bar) depending on the goal of the bar, and 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 tolerated or not available. Table 14 outlines the range of popular sport bars and highlights their nutrient profiles.

Table 14 Sport bars

Product	**Weight (oz ~ g)**	**Calories (kcal)**	**CHO (g)**	**FAT (g)**	**PRO (g)**	**FORTIFIED**
Clif Bar, original	2.4 ~ 68	230	48	3.5	8-10	Yes
Luna Bar	1.7 ~ 48	170	26	3	10	Yes
Clif Mojo Bar	1.6 ~ 45	200	25	7	8	Yes
PowerBar	2.2 ~ 63	230	45	2.5	9-10	Yes
PowerBar Harvest	2.3 ~ 65	240	45	4	7	Yes
PowerBar Pro Plus Sugar free	1.7 ~ 48	170	19-20	4	16	Yes
Power Bar Protein Plus	1.8 ~ 50	270-290	36.5	5	24	Yes
Layered PowerBar Protein Plus	2 ~ 56	220	26-30	5-6	14-15	Yes
PowerBar Pria	1 ~ 28	110	16	3	4-5	Yes
Balance Bar	1.8 ~ 50	200	22	6	15	Yes
Gatorade Energy Bar	2.3 ~ 65	250	38	5	15	Yes
PR* Bar	1.8 ~ 50	200	23	6	13	Yes
EAS Myoplex	3.2 ~ 90	340	44	7	24	Yes
PB Energy Bar	1.9 ~ 55	202	37	10.8	1.9	Yes
CarboPlus Energy Bar	2.5 ~ 70	255	50	8	4	Yes
Maxim Energy Bar	1.9 ~ 55	203	39	3.1	3.6	Yes
Extran Endurance Bar	2.1 ~ 60	223	50	2	1	Yes
Promax Bar	2.6 ~ 75	280	37	5	20	Yes
Isostar High Energy	1.4 ~ 40	182	27.6	1.8	7.2	Yes
High5 Energy Bar	2.3 ~ 65	211	49	0.9	2	Yes
High5 Sports Bar	1.9 ~ 55	219	41	4.5	3	Yes
High5 Protein Bar	1.8 ~ 50	189	24	4.5	13	Yes
Sis Go Bar	2.3 ~ 65	213	47	1	7.9	Yes

*CHO: Carbohydrates; FAT: Fats; PRO: Protein

Sport Drinks

Sport drinks are sweet flavored beverages that contain 4 to 8% carbohydrate and electrolytes and they are typically consumed before, during, and after activity. They promote hydration, voluntary intake of fluids, and glycogen replacement. 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 can be present as glucose, glucose polymers, sucrose, maltodextrins and fructose. Athletes appear to tolerate a range of compositions containing these carbohydrates.

The major electrolytes added to sport drinks include sodium, potassium, and phosphate. Some brands add varying amounts of minerals, vitamins, additives, artificial sweeteners, colors, and flavors. Sodium's roles are to assist with the intestinal uptake of fluid and glucose into the cells and for maintaining the extracellular volume. Optimal sodium content is proposed to be approximately 110 mg (10 - 25 mmol/l). Table 15 provides popular sport drinks and their nutritional profile.

Table 15 Sport drinks

Products	**Calories (kcal/l)**	**CHO (%)**	**CHO (g/l)**	**Sodium (mg/l)**	**Potassium (mg/l)**
Gatorade	240	6	60	400	120
Powerade	320	8	80	212	132
Accelerade	320	6.4	64	460	120
Cytomax	190	4	40	200	220
Isostar	304	7.6	76	724	211
AllSport	224	5.6	56	220-320	155
Extran	180	4	44	244	198
Hydrade	220	4	40	364	308
Revenge	315	8	80	350	385
Lucozade Sport	240	6	64	500	98
Met-Rx ORS	300	8	80	500	160
PowerBar Perform	240	7	70	440	140
Citomax	320	6	60	280	308
Cerasport	304	7	70	408	148
Metabolol Endurance	532	7	70	560	800

*CHO: Carbohydrates

Energy Drinks

Although sport drinks effectively provide energy to the athlete before, during, and after exercise, they can be confused with a new classification of beverages called 'energy drinks'. Energy drinks are fluid sources that contain a higher concentration of carbohydrates and many contain caffeine as one of their principle ingredients. Some energy drinks contain herbs, amino acids, creatine, or other substances that are usually 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 therefore 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 are not 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

Product	Calories (kcal/l)	CHO (%)	CHO (g/l)	Sodium (mg/l)	Potassium (mg/l)
Gatorade Energy	827	20	112	533	280
Extran Energy	575	14.5	145	0	0
Lucozade Energy	730	17.9	179		
Endurox	748	15	150	720	372
Lipovitan	440	10.8	108		
Battery Energy Drink	456	10.8	108		
Red Bull	424	10.8	108	771	0
Venom Energy Drink	508	11.2	112		
Sobe Adrenalin Rush	540	14.0	140		
Coca Cola	400	10.8	108	140	0

* CHO: Carbohydrates

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 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 is often a 2.5 to 3 % carbohydrate solution with 105 - 142 kcal per liter compared to a sport drink, which is a 4 to 8% carbohydrate solution with 240 - 323 kcal per liter. As 30 - 60 g of carbohydrates are recommended to be consumed per hour during endurance exercise, 375 - 1000 ml of sport drink or 1.2 - 2.4 liter of sport water is required to be consumed. The sodium levels of sport water and sport drinks are 0 - 12 mg and 12 - 40 mg/100 ml respectively. The inclusion of sodium is advantageous to athletes as it encourages fluid intake and enhances fluid absorption and retention. Research has not yet been completed on the benefits of sport water, and thus, it seems too early to provide reasonable recommendations. 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

Product	Calories (kcal/l)	CHO (%)	CHO (g/l)	Sodium (mg/l)	Potassium (mg/l)
Propel Fitness Water	40	1.2	12	140	160
Pro-Hydrator	0	0	0	10	14
Ultimate	64	2	20	32	64
Rehydralyte	100	2.5	24	1632	728
Vitamin Water	160	3.6	36	0	0

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 carbohydrates which helps maintain blood glucose levels during exercise and enhance glycogen synthesis after exercise. Sport gels are semi-solid forms of foods that contain approximately 25 g of carbohydrates per squeeze pack. It is recommended that endurance athletes consume 30 - 60 g of carbohydrate per hour of exercise, which translates into consuming 1 - 2 packs of sport gels per hour. Gels may also be useful for sprint cross-country skiers who require between-event carbohydrate snacks that are easily digestible.

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 form that is easy to digest and 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 in order to replace fluid loss 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

Product	**Weight (g)**	**Weight (oz)**	**Calories (kcal)**	**CHO (g)**	**Additional Ingredients**
Clif Shot	37	1.3	100	24	Electrolytes
Powergel	41	1.4	110 - 120	28	Antioxidants and electrolytes
Hammer Gel	35	1.2	91	23	Electrolytes and amino acids
Gu Energy Gel	32	1.1	100	25	Antioxidants, electrolytes & amino acids.
Carb-BOOM	41	1.4	107	27	Electrolytes
Honey Stinger	36	1.3	120	29	B-vitamins and electrolytes
Sis Go-Gel	70 ml	2.3 fl.oz	100	25	Electrolytes
Maxim Gel	100	3.5	310	77.4	None
Squeezy	30	1	100	25	Electrolytes
Fireball Gel	32	1.1	100	27	Ginseng and glycerine

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. Individual circadian rhythm will resynchronize by approximately 90 minutes per day after westward travel and 60 minutes a day after eastward travel. Jet lag is more apparent when going east, where time is lost, than west where time is gained. 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 to help prevent dehydration.

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:

- Fresh, dried or canned fruit
- Cereal and fruit bars
- Juices
- Trail mix
- Sandwiches
- Water
- 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. 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 you have a refrigerator available. 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, and Counters

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

Foods containing 25g of carbohydrates
1 piece of fruit
1 thick slice of bread
3/4 of 10" flour tortilla
1 plain yogurt
2 cups of skim milk
2 cups of berries or water melon
1 cup of lima beans (frozen)
2/3 cup of cooked black beans
2/3 cup of hummus
1 1/2 Tbsp of honey
1 granola bar
3 Ahoi chocolate chip cookies
2 1/2 fig Newton bars
1/2 cup of frozen yogurt or ice cream
3/4 cup of canned unsweetened pineapple
12 pieces of baked lays potato chips
10 dorito tortilla chips
1/2 bagel with 1 T strawberry jam
1 cup of cheerios + 1 cup of skim milk
3/4 of candy bar
2/3 cup of fruit yogurt
1/2 cup of Ben and Jerry's Ice Cream

Foods containing 50g of carbohydrates
1 cup of rice
1 medium potato
1 1/2 medium sweet potato
1/3 - 1/2 cup dry couscous
1 1/2 cups of cooked pasta
1 cup of dry oats
2 cups Honey Nut Cheerios
2/3 cup of granola
4 thin slices of bread
1 1/2 flour tortilla (10")
1 large bagel or 1 1/2 medium bagels
1/2 cup of raisins
1 cup of unsweetened apple sauce
2 pieces of fruit
10 pieces of small pretzels
2 cups of apple juice
2 cups of orange juice
2 slices of pizza
3 large carrots
2 cups stir-fry vegetables
2 1/4 cups butternut squash cooked
1 cup cooked garbanzo beans

Sports Foods
Bars (g)
PowerBar (45)
Harvest Bar (45)
Balance Bar (22)
Gatorbar (49)
Luna Bar (27)
Clif Bar (51)
Clif Mojo (25)
PowerBar Pria (16)
PowerBar Bites (32)
Drinks (g)
Gatorade (14/8 oz)
All Sport (19/8 oz)
PowerAde (19/8 oz)
Accelerade (26/12 oz)
Endurox (53/12 oz)
Gels (g)
Gu (20)
Clif Shot (24)

Protein Content of Foods

Plant-Based Foods	*grams*
2 Tbsp peanut butter	9
1/4 cup soy nuts	12
1/4 cup sunflower nuts	8
1/4 cup almonds	9
1/4 cup peanuts	8
1/2 cup garbanzo beans	6
1/2 cup black beans	5
1/2 cup kideny beans	6
1/2 cup hummus	6
3.5 oz extra firm tofu	11
1 Veggie burger	8
1 Boca burger	14
1 cup pasta	6
1 cup couscous	6
1 cup soy milk	7
1 soy yogurt	4

Animal-Based Foods	*grams*
1 cup skim or 1% milk	8
1 cup 2% chocolate milk	8
6 oz Yoplait fruit yogurt	5
6 oz plain Yoplait yogurt	10
1 Dannon fruit yogurt	9
1 Dannon nonfat fruit yogurt	8
1/2 cup low-fat cottage cheese	12
1 String Cheese	8
1 oz swiss or cheddar cheese	7
1 egg	3.5
1 egg wite	6
3 oz tuna, canned	19
3 oz salmon	20
3 oz halibut	22
3 oz chicken breast	26
3 oz steak	22
3 oz pork loin	22
3 oz hamburger	22
3 oz turkey burger	23
2 oz deli turkey	9
2 oz deli ham	9
2 oz roast beef	10

Combination Foods	*grams*
1/2 cup rice & 1/2 cup beans	7.5
1/2 cup vanilla yogurt & 1/4 cup grape nuts	9
1/2 cup vanilla yogurt & 1/2 cup wheaties	7.5
2 slices bread & 2 oz turkey sandwich	11
2 slices bread & 2 Tbsp peanut butter/jam	11
2 slices bread & 1/4 cup hummus	8
1 cup coucous w/ pine nuts	7
1 tortilla & 1 oz mozarella cheese	11
1/2 cup cottage cheese & 1 small baked potato	15.5

Sport Foods	*grams*
Clif Luna Bar	10
Clif Bar	12
Clif Mojo Bar	8
PowerBar	10
PowerBar Pria	5
PowerBar Bites	8
PowerBar Protein Plus	15
PR*Bar	14
Gatorbar	6
Harvest Bar	7
Balance Bar	14
Exceed	12
Accelerade (12 oz)	6.5
Endurox (12 oz)	13

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	100g / 3 oz	24		0		0		0		0
Chicken & Turkey	100 g / 3 oz	23		0		0		0		0
Fish	100 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 /200 ml	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	100g / 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	60 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 / 60 g	7		0		0		0		0
Pies	3 oz / 100 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 carbohydrate loading for female cross-country skiers

Breakfast

CEREAL, 1.5 cups
MILK, low fat, 1 cup
ORANGE JUICE, 1 cup
BAGEL / TOAST, 1 bagel / 2 pieces of toast
JAM & PRESERVES,1 tbsp

Total: 130 g carbohydrate

Morning Snack
SPORTS DRINK / LEMONADE, 2 cups
SPORTS BAR, 1
BANANA, 1 med

Total: 92 g carbohydrate

Lunch

2 SANDWICHES, 4 slices of bread with meat / cheese and vegetables
FRUIT JUICE, 100%, 1 cup

Total: 94 g carbohydrate

Afternoon Snack
SPORT DRINK / LEMONADE, 2 cups
APPLE, 1 large
BREAD, 2 slices
JAM & PRESERVES, 1 tbsp

Total: 97 g carbohydrate

Dinner

VEGETABLES, 2 cups
OLIVE OIL,1 tbsp
SOY SAUCE, 2 tbsp
CHICKEN BREAST, baked, 1
RICE, COOKED, 2 cups
YOGURT, fruit and low fat, 1 cup
FRUIT JUICE – 1 cup

Total: 153 g carbohydrate

Nutrition Facts

Calories	Protein	Carbs *	Fat	Calcium	Iron	Fiber
3100 kcal	109 g	566 g	43 g	1000 mg	25 mg	25 g

* 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	750	600	800	800	NA
Thiamin (Vit B_1) (mg)	Energy metabolism, Nervous function, Muscle contraction	pork, vegetables, fruit, eggs, fortified cereal	1.1	0.8	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	1.2	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	12-14	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	0.9-1.4	1.2	1.2	1.2	1.5-3.0
Folate (µg)	Hemoglobin synthesis Nervous function, Muscle contraction	green leafy vegetables, legumes, yeast extract	400	200	200	300	400	400
Cobalamin (Vit B_{12}) (µg)	Hemoglobin synthesis Nervous function, Muscle contraction	Meats, poultry, fish, milk, eggs	2.4	2.0	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.

Nutrient	Major Function in Sport	Good Food Options	USA CAN (DRI)	AUS (RDI)	UK (RNI)	FIN	DACH	Active Female
Vitamin C (mg)	Antioxidant function, Immune function	Citrus fruits, bell peppers, strawberries, broccoli	60	30	40	60	13	200-400
Vitamin D (µg)	Bone metabolism	Self-synthesis via sunlight, fortified milk, egg yolk, fish	5	N/A	N/A	5	5	10-20
Vitamin E (mg)	Antioxidant function, Immune function	Polyunsaturated plant oils – canola, soy, corn, wheat germ, shrimp	8	7.0	20-200 (IU)	8	12	200-400 (IU)
Calcium (mg)	Bone metabolism, Nervous function, Muscle contraction,	Dairy products, soy bean products, sardines, green leafy vegetables	1000	800	700	800	1000	1300-1500
Iron (mg)	Hemoglobin synthesis	Liver, meat, fish, dark green leafy vegetables, fortified cereals	18	12-16	14.8	12-18	15	18
Magnesium (mg)	Energy metabolism, Nervous function, Muscle contraction, Immune function	Legumes, nuts, cereals, green vegetables	310	270	270	280	300	350-400
Zinc (mg)	Energy metabolism, Immune function, Antioxidant function	Shellfish, meat, dairy products	8	12	7	7	7	12

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

F. Female Athlete Triad Screening and Assessment

Screening and assessment for the TRIAD should be conducted during pre-participation physical examinations by the team or primary care physician of the athlete. The team approach in identifying the TRIAD in the athlete with the physician, dietitian, and psychologist and possibly a physiologist may be best. The following list details the areas of screening, followed by a summary of signs and symptoms of athletes disordered eating. It has to be emphasized, however, that most athletes have some but not all characteristics consistent with eating disorders. Thus, screening should not be limited to anorexia nervosa and bulimia nervosa but should address all female athletes that may be at risk for low energy availability, menstrual irregularities, and increased risk of illness and injury.

Physician:

Complete physical assessment
Vital signs
Blood biochemistry, electrolyte imbalance, & nutritional status
Cardiovascular function
Status and history of menstrual function
Status and history of injuries including stress fractures; bone mineral density if available
Anthropometry (weight for height, age, and sex; body composition and weight range for cross-country skiing should be used rather than goal or ideal values; usual weight, weight history, ideal weight, weighing behavior, preoccupation with weight)
Medication and drug use
Previous eating disorder

Dietitian:

Energy balance
History and status of dietary patterns
Dietary rules
Presence of purging behaviors (including exercise, abuse of laxatives, enemas, diuretics, caffeine, and other stimulants)
Dietary Supplement use

Psychologist:

Body image and dissatisfaction
Preoccupation with shape and weight
Mood/depression/suicidal behavior
Symptoms of eating disorders
Underlying context of the symptoms

Physiologist:

Training status
Performance testing

Signs and symptoms of anorexia nervosa and bulimia nervosa

For anorexia, physical symptoms include hair loss, dry skin, nails, brittle hair, covering of face with fine soft hair (lanugo), dental and gum problems, delayed onset of puberty, hypothermia, significant weight loss. **For bulimia**, physical symptoms include callus or abrasion on back of hand from vomiting, swollen parotid glands, low weight despite eating large volumes of food, frequent and extreme weight fluctuations. **Common physical symptoms for both conditions** are bradycardia, hypotension, GI complaints, hypoglycemia, low estrogen levels, amenorrhea and oligomenorrhea, stress fractures, low bone mass, anemia, dehydration, electrolyte imbalances, hypokalemia, metabolic alkalosis, muscle cramps, fatigue, decreased performance, muscle weakness, hyperactivity. **Common psychological and behavioral characteristics for both conditions** are anxiety, dieting beyond that for sports performance, avoidance of social eating, self-critical, resistant to weight gain or maintenance, excessive weighing, negative reactions to being weighed, compulsive behavior especially regarding exercise and eating, excessive exercise usually added to the organized team practice, exercising while injured, restlessness, bipolar behavior, social withdrawal, depression, and insomnia. **Anorexic athletes** commonly feel fat despite of their thinness. **Bulimic athletes** are binge eaters easily agitated when binge eating episode is interrupted. Vomiting occurs not due to underlying illness but is self-induced. A common pattern for a bulimic athlete is the trip to the restroom after eating. Bulimic athletes commonly use laxatives, diuretics, other substances (whether legal or illegal), and over the counter drugs or medications (see Appendix J for further resources and classification criteria for anorexia nervosa and bulimia nervosa).

Criteria for a variety of disordered eating patterns as identified from 1994 to 2001:

Anorexia Athletica (as defined by Sundgot-Borgen, 1994)

<u>Absolute Criteria:</u>

- Weight loss
- GI complaints
- Absence of medical illness or affective disorder explaining the weight reduction
- Excessive fear of becoming obese
- Restriction of calorie intake

<u>Relative Criteria:</u>

- Menstrual dysfunction
- Purging
- Bingeing
- Compulsive exercise for weight control

Subclinical Eating Disorders [SCED] (as defined by Beals and Manore, 1999)

<u>Absolute Criteria:</u>

- Preoccupation with food and body weight
- Distorted body image/dissatisfaction with weight and/or shape
- Body weight/shape are most important in athlete’s self-evaluation
- Fear of gaining weight, becoming fat, feeling fat, always worried about weight gain
- Attempts to maintain low body weight via: severe restriction of food, limitations of food choices and food groups, excessive exercise, pathogenic weight control methods

(purging, laxatives, diet pills etc.), dietary intake strictly governed by rules and boundaries

- Avoiding specific foods and food groups (dairy, red meat, nuts)
- Eating at certain times of day (avoid late evening eating)
- Bad food avoidance (foods such as sweets, carbohydrates)
- Guilt and self-hatred if rules are broken

Relative Criteria:

- Menstrual dysfunction
- Bingeing/purging

G. Travel Menus and Guides:

Breakfast Buffetstyle

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

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 – Buffetstyle

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)
- Rice based dishes (risotto, fried rice, pilaf, Spanish rice)
- 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

H. 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 ^oF = 10 ^oC
20 ^oC = 68 ^oF

I. Resources

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