*Notes*

Sports Nutrition

(CHS 346)(Semester 2nd:3839)

Compiled by

*Dr. Iftikhar Alam*

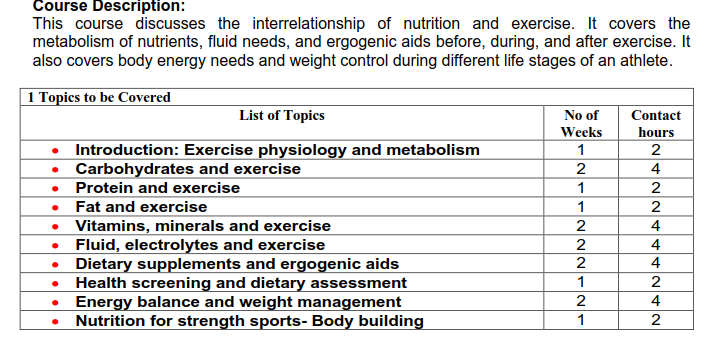
Email: [ialam@ksu.edu.sa](mailto:ialam@ksu.edu.sa)

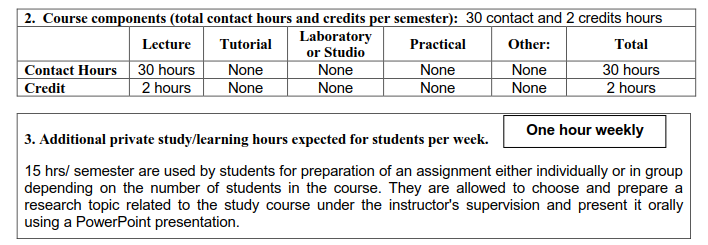
Office:2315

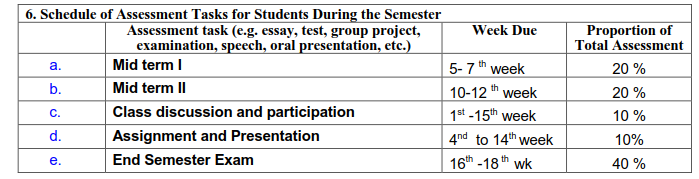
Mobile: 0590583176

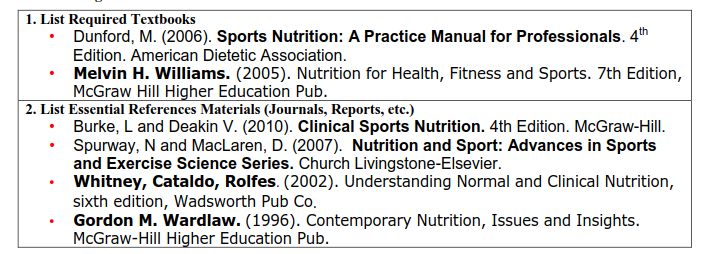
**Please visit me during my office hours for discussion related to your course**

|  |
| --- |
|  |









**UNIT-1**

**Exercise Physiology & Metabolism**

**Some Definitions**

**Sports Nutrition** is the study and practice of [nutrition](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Nutrition.html) and [diet](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Diet_(nutrition).html) with regards to a person's athletic performance. Nutrition is an important part of many sports training regimens, being most popular in strength sports (such as [weight lifting](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Olympic_weightlifting.html) and [bodybuilding](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Bodybuilding.html)) and endurance sports (e.g. [cycling](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Cycling.html), [running](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Running.html), [swimming](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Human_swimming.html), [rowing](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Rowing.html)).

Sports Nutrition focuses its studies on the type, as well as the quantity of fluid and food taken by an athlete. In addition, it deals with the consumption of nutrients such as [vitamins](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Vitamins.html), [minerals](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Minerals.html), [supplements](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Dietary_supplement.html) and [organic](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Organic_compound.html) substances that include [carbohydrates](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Carbohydrates.html), [proteins](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Proteins.html) and [fats](https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Fat.html).

Sports nutrition is a specialization within the field of nutrition that partners closely with the study of the human body and exercise science. Sports nutrition can be defined as the application of nutrition knowledge to a practical daily eating plan focused on providing the fuel for physical activity, facilitating the repair and rebuilding process following hard physical work, and optimizing athletic performance in competitive events, while also promoting overall health and well-ness.

The area of sports nutrition is often thought to be reserved only for “athletes,” which insinuates the inclusion of only those individuals who are per-forming at the elite level. In this text, the term athlete refers to any individual who is regularly active, ranging from the fitness enthusiast to the competitive amateur or professional. Differences may exist in specific nutrient needs along this designated spectrum of athletes, creating the exciting challenge of individualizing sports nutrition plans.

To fully understand and subsequently apply sports nutrition concepts, professionals instructing athletes on proper eating strategies first need to have a command of general nutrition as well as exercise science. The second step is to gain the knowledge of how nutrition and exercise science are intertwined, under-standing that physical training and dietary habits are reliant on each other to produce optimal performance. The final step can be considered one of the most critical—the practical application of sports nutrition knowledge to individual athletes participating in a sport or physical activity.

Sports nutrition professionals must be able to teach athletes by putting “book” knowledge into practice with actual food selection and meal planning, while keeping in mind the challenges presented by busy schedules of exercise, competitions, work, school, and other commitments. It is this third step that many professionals lack after graduating from an undergraduate or graduate program in sports nutrition, dietetics, exercise science, or athletic training. Our focus is to review sports nutrition concepts while also translating the information into specific meal plans, recipes, and case study scenarios. Students are encouraged to seek additional opportunities outside the classroom to work with recreational and elite athletes to gain more experience in applying sports nutrition concepts before searching for a job in the “real world.

**Why study sports nutrition?**

Sports nutrition has recently emerged as a recognized specialty area within the field of nutrition. Athletes challenge their bodies on a regular basis through physical training and competitions. To keep up with the physical demands of their activity or sport, athletes need to fuel their bodies adequately on a daily basis. This fueling process requires a specialized approach; therefore, athletes who want to make dietary changes should seek out professionals who are experts in sports nutrition and experienced in developing individualized plans.

Because of its relative infancy, sports nutrition research is providing new and exciting information on a regular basis. It is critical that sports nutrition professionals stay current so they can be evidence-based practitioners. Gone are the days of suggesting dietary practices based on anecdotal observations or experiences. Becoming an evidence-based practitioner requires use of nutrition guidelines and dietary practices that have been documented as being effective through peer-reviewed research. Professionals who have studied sports nutrition, have experience in the field, and continue to stay abreast of the latest nutrition research can prescribe individualized dietary plans that meet basic nutritional needs, enhance performance, and speed recovery in athletes of all sports. Becoming an evidence-based sports nutrition practitioner can lead to an exciting and fulfilling career.

**Nutrient Requirements for Sports**

Energy Pathways and Training Adaptations

Guidelines for the timing and amount of intake of macronutrients in the athlete’s diet should be underpinned by a fundamental understanding of how training-nutrient interactions affect energy systems, substrate availability and training adaptations. Exercise is fueled by an integrated series of energy systems which include non-oxidative (phosphagen and glycolytic) and aerobic (fat and carbohydrate oxidation) pathways, using substrates that are both endogenous and exogenous in origin.

Adenosine triphosphate (ATP) and phosphocreatine (phosphagen system) provide a rapidly available energy source for muscular contraction, but not at sufficient levels to provide a continuous supply of energy for longer than ~10 seconds. The anaerobic glycolytic pathway rapidly metabolizes glucose and muscle glycogen through the glycolytic cascade and is the primary pathway supporting high-intensity exercise lasting 10 to 180 seconds. Since neither the phosphagen nor the glycolytic pathway can sustain energy demands to allow muscles to contract at a very high rate for longer lasting events, oxidative pathways provide the primary fuels for events lasting longer than ~2 minutes. The major substrates include muscle and liver glycogen, intramuscular lipid, adipose tissue triglycerides, and amino acids from muscle, blood, liver and the gut.

As oxygen becomes more available to the working muscle, the body uses more of the aerobic (oxidative) pathways and less of the anaerobic (phosphagen and glycolytic) pathways. The greater dependence upon aerobic pathways does not occur abruptly, nor is one pathway ever relied on exclusively. The intensity, duration, frequency, type of training, sex, and training level of the individual, as well as prior nutrient intake and substrate availability, determine the relative contribution of energy pathways and when crossover between pathways occurs. For a more complete understanding of fuel systems for exercise, the reader is directed to specific texts. An athlete’s skeletal muscle has a remarkable plasticity to respond quickly to mechanical loading and nutrient availability resulting in condition- specific metabolic and functional adaptations.30 These adaptations influence performance nutrition recommendations with the overarching goals that energy systems should be trained to provide the most economical support for the fuel demands of an event while other strategies should achieve appropriate substrate availability during the event itself. Adaptations that enhance metabolic flexibility include increases in transport molecules that carry nutrients across membranes or to the site of their utilization within the muscle cell, increases in enzymes that activate or regulate metabolic pathways, enhancement of the ability to tolerate the side-products of metabolism and an increase in the size of muscle fuel stores. While some muscle substrates (e.g., body fat) are present in relatively large quantities, others may need to be manipulated according to specific needs (e.g., carbohydrate supplementation to replace muscle glycogen stores).

[**Exercise physiology**](https://en.wikipedia.org/wiki/Exercise_physiology) is "the identification of [physiological](https://en.wikipedia.org/wiki/Physiology) mechanisms underlying physical activity, the comprehensive delivery of treatment services concerned with the analysis, improvement, and maintenance of [health](https://en.wikipedia.org/wiki/Health) and [fitness](https://en.wikipedia.org/wiki/Physical_fitness), rehabilitation of [heart disease](https://en.wikipedia.org/wiki/Coronary_heart_disease) and other chronic diseases and/or disabilities, and the professional guidance and counsel of [athletes](https://en.wikipedia.org/wiki/Sportsperson) and others interested in athletics, sports training, and human adaptability to acute and chronic [exercise](https://en.wikipedia.org/wiki/Exercise)."

**Metabolism** is the set of [life](https://en.wikipedia.org/wiki/Life)-sustaining [chemical transformations](https://en.wikipedia.org/wiki/Chemical_reactions) within the [cells](https://en.wikipedia.org/wiki/Cell_(biology)) of [organisms](https://en.wikipedia.org/wiki/Organisms). The three main purposes of metabolism are the conversion of food/fuel to energy to run cellular processes, the conversion of food/fuel to building blocks for [proteins](https://en.wikipedia.org/wiki/Protein), [lipids](https://en.wikipedia.org/wiki/Lipid), [nucleic acids](https://en.wikipedia.org/wiki/Nucleic_acid), and some [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate), and the elimination of [nitrogenous wastes](https://en.wikipedia.org/wiki/Metabolic_waste#Nitrogen_wastes). These [enzyme](https://en.wikipedia.org/wiki/Enzyme)-catalyzed reactions allow organisms to grow and reproduce, maintain their structures, and respond to their environments. The word metabolism can also refer to the sum of all chemical reactions that occur in living organisms, including [digestion](https://en.wikipedia.org/wiki/Digestion) and the transport of substances into and between different cells, in which case the set of reactions within the cells is called **intermediary metabolism** or **intermediate metabolism**.

Metabolism is usually divided into two categories: [catabolism](https://en.wikipedia.org/wiki/Catabolism), the *breaking down* of organic matter for example, the breaking down of glucose to pyruvate, by [cellular respiration](https://en.wikipedia.org/wiki/Cellular_respiration), and [anabolism](https://en.wikipedia.org/wiki/Anabolism), the *building up* of components of cells such as [proteins](https://en.wikipedia.org/wiki/Protein) and [nucleic acids](https://en.wikipedia.org/wiki/Nucleic_acid). Usually, breaking down releases [energy](https://en.wikipedia.org/wiki/Energy) and building up consumes energy.

The chemical reactions of metabolism are organized into [metabolic pathways](https://en.wikipedia.org/wiki/Metabolic_pathway), in which one chemical is transformed through a series of steps into another chemical, by a sequence of [enzymes](https://en.wikipedia.org/wiki/Enzyme). Enzymes are crucial to metabolism because they allow organisms to drive desirable reactions that require [energy](https://en.wikipedia.org/wiki/Energy) that will not occur by themselves, by [coupling](https://en.wikipedia.org/wiki/Coupling_(physics)) them to [spontaneous reactions](https://en.wikipedia.org/wiki/Spontaneous_process) that release energy. Enzymes act as [catalysts](https://en.wikipedia.org/wiki/Catalysis) that allow the reactions to proceed more rapidly. Enzymes also allow the [regulation](https://en.wikipedia.org/wiki/Metabolic_pathway#Regulation) of metabolic pathways in response to changes in the [cell's](https://en.wikipedia.org/wiki/Cell_(biology)) environment or to [signals](https://en.wikipedia.org/wiki/Cell_signaling) from other cells.

The metabolic system of a particular organism determines which substances it will find [nutritious](https://en.wikipedia.org/wiki/Nutrition) and which [poisonous](https://en.wikipedia.org/wiki/Poison). For example, some [prokaryotes](https://en.wikipedia.org/wiki/Prokaryote) use [hydrogen sulfide](https://en.wikipedia.org/wiki/Hydrogen_sulfide) as a nutrient, yet this gas is poisonous to animals. The speed of metabolism, the [metabolic rate](https://en.wikipedia.org/wiki/Basal_metabolic_rate), influences how much food an organism will require, and also affects how it is able to obtain that food.

A striking feature of metabolism is the similarity of the basic metabolic pathways and components between even vastly different species. For example, the set of [carboxylic acids](https://en.wikipedia.org/wiki/Carboxylic_acid) that are best known as the intermediates in the [citric acid cycle](https://en.wikipedia.org/wiki/Citric_acid_cycle) are present in all known organisms, being found in species as diverse as the [unicellular](https://en.wikipedia.org/wiki/Unicellular_organism) bacterium [*Escherichia coli*](https://en.wikipedia.org/wiki/Escherichia_coli) and huge [multicellular organisms](https://en.wikipedia.org/wiki/Multicellular_organism) like [elephants](https://en.wikipedia.org/wiki/Elephant). These striking similarities in metabolic pathways are likely due to their early appearance in [evolutionary history](https://en.wikipedia.org/wiki/Evolutionary_history_of_life), and their retention because of their [efficacy](https://en.wikipedia.org/wiki/Efficacy).

**UNIT-2**

**CARBOHYDRATES IN SPORTS AND EXCERCISE**

**Why Carbohydrates are so important for Sports?**

Carbohydrate has rightfully received a great deal of attention in sports nutrition due to a number of special features of its role in the performance of, and adaptation to training:

1. First, the size of body **carbohydrate stores is relatively limited** and can be acutely manipulated on a daily basis by dietary intake or even a single session of exercise.
2. Second, carbohydrate provides a **key fuel for the brain and central nervous system** and a versatile substrate for muscular work where it can support exercise over a **large range of intensities due to its utilization by both anaerobic and oxidative pathways**. Even when working at the highest intensities that can be supported by oxidative phosphorylation, carbohydrate offers advantages over fat as a substrate since it provides a greater yield of ATP per volume of oxygen that can be delivered to the mitochondria, thus improving gross exercise efficiency.
3. Third, there is significant evidence that the performance of prolonged sustained or intermittent high-intensity exercise is enhanced by strategies that maintain high carbohydrate availability (i.e., match glycogen stores and blood glucose to the fuel demands of exercise), while depletion of these stores is associated with **fatigue** in the form of reduced work rates, impaired skill and concentration, and increased perception of effort. These findings underpin the various performance nutrition strategies, to be discussed subsequently, that supply carbohydrate before, during, and in the recovery between events to enhance carbohydrate availability.
4. Finally, recent work has identified that in addition to its role as a muscle substrate, glycogen plays important direct and indirect roles in regulating the muscle’s adaptation to training.

The amount and localization of glycogen within the muscle cell alters the physical, metabolic, and hormonal environment in which the signaling responses to exercise are exerted. Specifically, starting a bout of endurance exercise with low muscle glycogen content (e.g., by undertaking a second training session in the hours after the prior session has depleted glycogen stores) produces a coordinated up-regulation of the transcriptional and post-translational responses to exercise.

A number of mechanisms underpin this outcome including increasing the activity of molecules that have a glycogen binding domain, increasing free fatty acid availability, changing osmotic pressure in the muscle cell and increasing catecholamine concentrations.

Strategies that restrict exogenous carbohydrate availability (e.g., exercising in a fasted state or without carbohydrate intake during the session) also promote an extended signaling response, albeit less robustly than is the case for exercise with low endogenous carbohydrate stores. These strategies enhance the cellular outcomes of endurance training such as increased maximal mitochondrial enzyme activities and/or mitochondrial content and increased rates of lipid oxidation.

Deliberate integration of such training-dietary strategies (“train low”) within the per-iodized training program is becoming a recognized, although potentially misused, part of sports nutrition practice. Individualized recommendations for daily intakes of carbohydrate should be made in consideration of the athlete’s training/competition program and the relative importance of undertaking it with high or low carbohydrate according to the priority of promoting the performance of high quality exercise versus enhancing the training stimulus or adaptation, respectively.

Unfortunately, we lack sophisticated information on the specific substrate requirements of many of the training sessions undertaken by athletes; therefore we must rely on guesswork, supported by information on work requirements of exercise from technologies such as consumer-based activity and heart rate monitors, power meters, and global positioning systems. General guidelines for the suggested intake of carbohydrate to provide high carbohydrate availability for designated training or competition sessions can be provided according to the athlete’s body size (a proxy for the size of muscle stores) and the characteristics of the session (Table 1).

**Timing of CHO intake:**

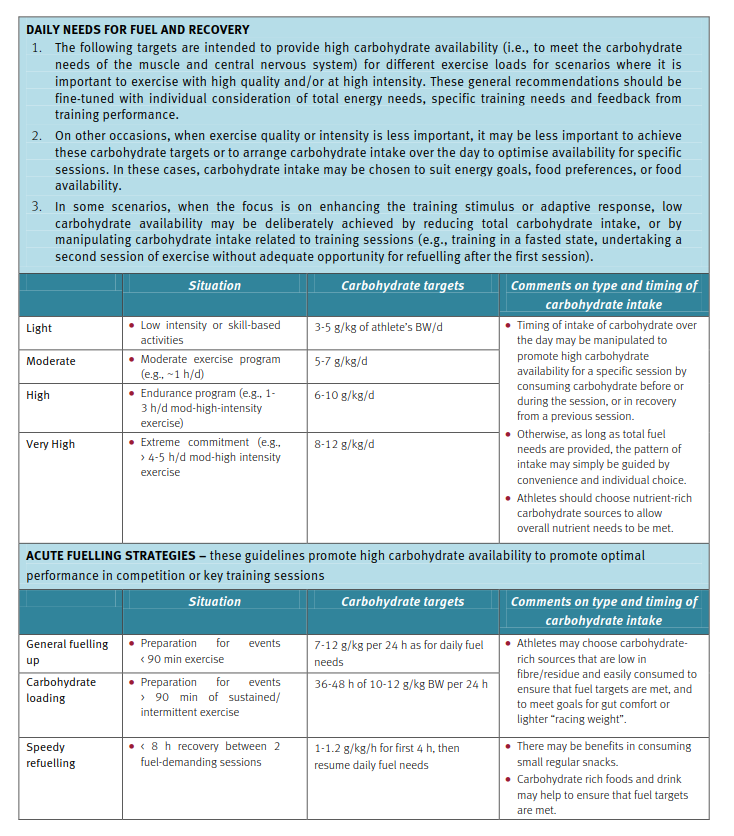
The timing of carbohydrate intake over the day and in relation to training can also be manipulated to promote or reduce carbohydrate availability. Strategies to enhance carbohydrate availability are covered in more detail in relation to competition eating strategies. Nevertheless, these fueling practices are also important for supporting the high quality workouts within the periodized training program. Furthermore, it is intuitive that they add value in fine-tuning intended event eating strategies, and for promoting adaptations such as gastrointestinal tolerance and enhanced intestinal absorption that allow competition strategies to be fully effective. During other sessions of the training program, it may be less important to achieve high carbohydrate availability, or there may be some value in deliberately exercising with low carbohydrate availability to enhance the training stimulus or adaptive response.

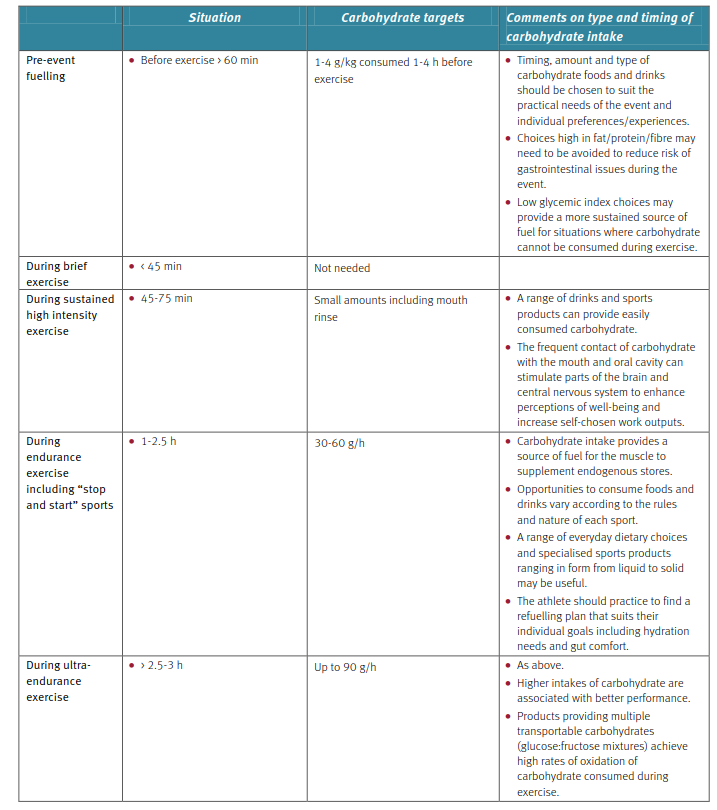
Various tactics can be used to permit or promote low carbohydrate availability including reducing total carbohydrate intake or manipulating the timing of training in relation to carbohydrate intake (e.g., training in a fasted state, undertaking two bouts of exercise in close proximity without opportunity for refueling between sessions).

Specific questions examined via the evidence analysis on carbohydrate needs for training are summarized in Table 1 and show good evidence that neither the glycemic load nor glycemic index of carbohydrate-rich meals affects the metabolic nor performance outcomes of training once carbohydrate and energy content of the diet have been taken into account. Furthermore, although there is sound theory behind the metabolic advantages of exercising with low carbohydrate availability on training adaptations, the benefits to performance outcomes are currently unclear.

This possibly relates to the limitations of the few available studies in which poor periodization of this tactic within the training program has meant that any advantages to training adaptations have been counteracted by the reduction in training intensity and quality associated with low carbohydrate variability. Therefore, a more sophisticated approach is needed to integrate this training/nutrient interaction into the larger training program. Finally, while there is support for consuming multiple forms of carbohydrate which facilitate more rapid absorption, evidence to support the choice of special blends of carbohydrate to support increased carbohydrate oxidation during training sessions is premature.

**Table 1: Carbohydrates for Athletes**





**Carbohydrate Intake Guidelines**

Because of its role as an important fuel for the muscle and central nervous system, the availability of carbohydrate stores is limiting for the performance of prolonged continuous or intermittent exercise, and is permissive for the performance of sustained high intensity sport. The depletion of muscle glycogen is associated with fatigue and a reduction in the intensity of sustained exercise, while inadequate carbohydrate for the central nervous system impairs performance influencing factors such as pacing, perceptions of fatigue, motor skill, and concentration. As such, a key strategy in promoting optimal performance in competitive events or key workouts is matching of body carbohydrate stores with the fuel demands of the session. Strategies to promote carbohydrate availability should be undertaken before, during, or in the recovery between events or high-quality training sessions.

**Achieving Adequate Muscle Glycogen Stores**

Manipulating nutrition and exercise in the hours and days prior to an important exercise bout allows an athlete to commence the session with glycogen stores that are commensurate with the estimated fuel costs of the event. In the absence of severe muscle damage, glycogen stores can be normalized with 24 h of reduced training and adequate fuel intake (Table 1).

Events >90 minutes in duration may benefit from higher glycogen stores, which can be achieved by a technique known as carbohydrate loading. This protocol of achieving super compensation of muscle glycogen evolved from the original studies of glycogen storage in the 1960s and, at least in the case of trained athletes, can be achieved by extending the period of a carbohydrate-rich diet and tapering training over 48 h36 (Table 1).

Carbohydrate consumed in meals and/or snacks during the 1 to 4 hours pre-exercise may continue to increase body glycogen stores, particularly liver glycogen levels that have been depleted by the overnight fast. It may also provide a source of gut glucose release during exercise. Carbohydrate intakes of 1 to 4 g/kg, with timing, amount, and food choices suited to the individual, have been shown to enhance endurance or performance of prolonged exercise (Table 1). Generally, foods with a low-fat, low fiber, and low–moderate protein content are the preferred choice for this pre-event menu since they are less prone to cause gastrointestinal problems and promote gastric emptying. Liquid meal supplements are useful for athletes who suffer from pre-event nerves or an uncertain pre-event timetable and thus prefer a more quickly digested option. Above all, the individual athlete should choose a strategy that suits their situation and their past experiences and can be fine-tuned with further experimentation.

The intake of carbohydrate prior to exercise is not always straightforward since the metabolic effects of the resulting insulin response include a reduction in fat mobilization and utilization and concomitant increase in carbohydrate utilization. In some individuals, this can cause premature fatigue. Strategies to circumvent this problem include ensuring at least 1.0 g/kg carbohydrate in the pre-event meal to compensate for the increased carbohydrate oxidation, including a protein source at the meal, including some high-intensity efforts in the pre-exercise warm up to stimulate hepatic gluconeogenesis, and consuming carbohydrate during the exercise.

Another approach has been suggested in the form of choosing pre-exercise meals from carbohydrate-rich foods with a low glycemic index, which might reduce the metabolic changes associated with carbohydrate ingestion as well as providing a more sustained carbohydrate release during exercise. Although occasional studies have shown that such a strategy enhances subsequent exercise capacity, as summarized by the EAL and others, pre-exercise intake of low glycemic index carbohydrate choices has not been found to provide a universal benefit to performance even when the metabolic perturbations of pre-exercise carbohydrate intake are attenuated. Furthermore, consumption of carbohydrate during exercise, as further advised in Table 1, dampens any effects of pre-exercise carbohydrate intake on metabolism and performance. Depending on characteristics including the type of exercise, the environment, and the athlete’s preparation and carbohydrate tolerance, the intake of carbohydrate during exercise provides a number of benefits to exercise capacity and performance via mechanisms including glycogen sparing, provision of an exogenous muscle substrate, prevention of hypoglycemia, and activation of reward centers in the central nervous system.

Glycogen restoration is one of the goals of post-exercise recovery, particularly between bouts of carbohydrate-dependent exercise where there is a priority on performance in the second session. Refueling requires adequate carbohydrate intake (Table 1) and time. Since the rate of glycogen re-synthesis is only ~ 5% per hour, early intake of carbohydrate in the recovery period (~1 to 1.2 g/kg/h during the first 4 to 6 hours) is useful in maximizing the effective refueling time. As long as total intake of carbohydrate and energy is adequate and overall nutritional goals are met, meals and snacks can be chosen from a variety of foods and fluids according to personal preferences of type and timing of intake. More research is needed to investigate how glycogen storage might be enhanced when energy and carbohydrate intakes are suboptimal.

|  |
| --- |
| **Points to Remember:**   1. Athletes can make informed decisions about the use of carbohydrate based on knowledge from multiple perspectives, including the types of carbohydrate that can be ingested; how this ingested carbohydrate is regulated and utilized in the body; and how carbohydrate intake influences aerobic, anaerobic, and strength training. 2. One decision has to do with the choice of food to best restore skeletal muscle glycogen that has been depleted by intense or long-duration exercise. For example, if a soccer athlete is competing in several matches in a single day (as in tournament play), it is essential that glycogen be restored as soon as possible (within several hours) so that depleted glycogen levels do not induce fatigue for later matches. In this case, it is important that the soccer athlete choose high-glycemic carbohydrate foods, as these have been shown to rapidly restore skeletal muscle glycogen. 3. For an athlete whose primary mode of training is resistance exercise, low-glycemic carbohydrate sources would be recommended for resistance training as part of everyday eating habits while higher-glycemic foods would be recommended for the immediate post-exercise period for optimal muscle glycogen repletion and insulin response. 4. The physiological processes of glycogen synthesis, glycogen breakdown, and glycolysis are all ways in which the body deals with ingested carbohydrate. These processes allow for quick ATP production (glycogen breakdown and glycolysis) during intense exercise and allow for the storing of glycogen (glycogen synthesis) in the skeletal muscle and liver for future training and conditioning. 5. An aerobic endurance athlete, say a long-distance runner, in order to prevent suboptimal carbohydrate stores, should consume approximately 55% to 65% of total caloric intake in the form of carbohydrate. While this recommendation provides a general range of carbohydrate ingestion as compared to protein and fat, the absolute amount of recommended carbohydrate (in grams) will vary tremendously depending on the total dietary caloric intake and physical activity level. 6. As a general guide, athletes training or competing on a regular basis should ingest 5 to 7 g of carbohydrate/kg body weight a day and consider increasing this amount to 8 to 10 g/kg body weight per day when the level of training sessions is extreme. 7. An anaerobic athlete, by comparison, would likely not need more than 5 to 7 g of carbohydrate/kg body weight a day. Even though an anaerobic athlete consistently trains at a high intensity, the relative duration of such intensity is lower than that of an aerobic endurance athlete. 8. An athlete engaged in a resistance training program will, on a day-to-day basis, require more total energy than a non-active, healthy counterpart of the same age. By obtaining 55% to 65% of total calories from carbohydrate, a resistance or power training athlete can ensure having near-optimal energy. Athletes on a 3,500 kcal/day diet in which 65% of caloric intake is composed of carbohydrate should aim to consume approximately 570 g of carbohydrate daily (~8 g/kg body weight for a 70-kg [154-pound] individual). In contrast, a nonactive adult consuming 2,500 kcal/day consisting of 55% carbohydrate would require considerably fewer grams of carbohydrate (i.e., 340 g) daily (~5 g/kg body weight per day for a 70 kg [154-pound] individual). The general carbohydrate prescriptions, based on an athlete’s type and extent of energy expenditure, are merely rough guidelines to illustrate the need to be mindful of the percent of carbohydrate per daily caloric intake in an athlete’s nutritional program. |

|  |
| --- |
| Key points   * Carbohydrate provides a vital source of energy production during anaerobic and aerobic exercise. * Reductions of the body’s carbohydrate sources during exercise decrease exercise performance and promote fatigue. * Consumption of adequate carbohydrate on a daily basis (e.g., 55-65% total calories) is critical for optimal athletic performance. * Dietary carbohydrate is a vital component of exercise preparation, performance, and recovery. Thus, the carbohydrate requirement for athletes is increased due to the repetitive nature of their training. * During periods of intense physical training, an athlete’s daily carbohydrate intake requirement may be as high as 10 g/kg body weight. * An athlete can take advantage of both high- and lower-glycemic food for optimal performance. Ingesting foods with a high glycemic index. * during prolonged exercise or immediately after exercise is a vital strategy that athletes are encouraged to use for peak performance and recovery. * When individuals ingest lower-GI carbohydrate, they can prevent dramatic fluctuations in blood glucose while maintaining a prolonged, lower-level exposure of the previously exercised muscle to blood glucose. Thus it is advantageous for athletes to ingest low-glycemic foods as part of their normal diet between training sessions. * By planning their carbohydrate feeding schedules, athletes can ensure optimal muscle carbohydrate stores when beginning an exercise bout or training session, carbohydrate provision during exercise, and rapid replenishment of glycogen after exercise and before a subsequent performance. * Carbohydrate (CHO) is the most important nutrient for high intensity performance. * Energy release from CHO is up to three times as fast as from fat. * However, CHO stores in the body are small, which limits the time to perform high intensity exercise. * Apart from decreasing performance, CHO depletion also induces increased utilization of amino acids (protein) for energy production. * This results in the production of ammonia, which may enhance fatigue. * CHO ingestion during exercise allows sparing of the body’s CHO stores, reduction of protein utilization=ammonia production, and a delay of fatigue=improvement of performance. * Appropriate CHO ingestion between training sessions=days or during intense endurance performance is of importance to avoid progressive fatigue development, reduction in performance capacity and possible signs of overtraining. * CHO sources to be used during high intensity exercise should preferentially be rapidly absorbable, i.e. have a high glycemic-index, and should be combined with sufficient fluid intake. * Nutritional interventions shortly before, during and after exercise may negatively affect CHO and glycogen metabolism. Basic knowledge about the timing and the type of CHO intake will be helpful to avoid this. * CHO supply to optimize performance is not only recommended for long distance runners and cyclists but has also been shown to improve performance in tennis, football and other multiple sprint sports |

**UNIT-3**

**PROTEIN IN SPORTS**

Dietary protein interacts with exercise, providing both a trigger and a substrate for the synthesis of contractile and metabolic proteins as well as enhancing structural changes in non-muscle tissues such as tendons41 and bones. Adaptations are thought to occur by stimulation of the activity of the protein synthetic machinery in response to a rise in leucine concentrations and the provision of an exogenous source of amino acids for incorporation into new proteins.

Recent recommendations have underscored the importance of well-timed protein intake for all athletes even if muscle hypertrophy is not the primary training goal, and there is now good rationale for recommending daily protein intakes that are well above the Recommended Dietary Allowance (RDA) to maximize metabolic adaptation to training.

The modern view for establishing recommendations for protein intake in athletes extends beyond the DRIs. Focus has clearly shifted to evaluating the benefits of providing enough protein at optimal times to support tissues with rapid turnover and augment metabolic adaptations initiated by training stimulus.

**Protein Needs**

Dietary protein intake necessary to support metabolic adaptation, repair, remodeling, and for protein turnover generally ranges from 1.2 to 2.0 g/kg/d. Higher intakes may be indicated for short periods during intensified training or when reducing energy intake. Daily protein intake goals should be met with a meal plan providing a regular spread of moderate amounts of high-quality protein across the day and following strenuous training sessions. These recommendations encompass most training regimens and allow for flexible adjustments with periodized training and experience.

Although general daily ranges are provided, individuals should no longer be solely categorized as strength or endurance athletes and provided with static daily protein intake targets. Rather, guidelines should be based around optimal adaptation to specific sessions of training/competition within a periodized program, underpinned by an appreciation of the larger context of athletic goals, nutrient needs, energy considerations, and food choices. Requirements can fluctuate based on “trained” status (experienced athletes requiring less), training (sessions involving higher frequency and intensity, or a new training stimulus at higher end of protein range), carbohydrate availability, and most importantly, energy availability.

The consumption of adequate energy, particularly from carbohydrates, to match energy expenditure, is important so that amino acids are spared for protein synthesis and not oxidized. In cases of energy restriction or sudden inactivity as occurs as a result of injury, elevated protein intakes as high as 2.0 g/kg/day or higher when spread over the day may be advantageous in preventing FFM loss. More detailed reviews of factors that influence changing protein needs and their relationship to changes in protein metabolism and body composition goals can be found elsewhere.

**Optimal Protein Sources**

High-quality dietary proteins are effective for the maintenance, repair, and synthesis of skeletal muscle proteins. Chronic training studies have shown that the consumption of milk-based protein after resistance exercise is effective in increasing muscle strength and favorable changes in body composition. In addition, there are reports of increased MPS and protein accretion with whole milk, lean meat, and dietary supplements, some of which provide the isolated proteins whey, casein, soy, and egg. To date, dairy proteins seem to be superior to other tested proteins, largely due to leucine content and the digestion and absorptive kinetics of branched-chain amino acids in fluid-based dairy foods. However, further studies are warranted to assess other intact high-quality protein sources (e.g., egg, beef, pork, concentrated vegetable protein) and mixed meals on mTOR stimulation and MPS following various modes of exercise. When whole food protein sources are not convenient or available, then portable, third-party tested dietary supplements with high-quality ingredients may serve as a practical alternative to help athletes meet their protein needs. It is important to conduct a thorough assessment of the athlete’s specific nutrition goals when considering protein supplements. Recommendations regarding protein supplements should be conservative and primarily directed at optimizing recovery and adaptation to training while continuing to focus on strategies to improve or maintain overall diet quality.

**Protein intake guidelines**

Protein consumption in the immediate pre- and post-exercise period is often intertwined with carbohydrate consumption as most athletes consume foods, beverages, and supplements that contain both macronutrients. Dietary protein consumed in scenarios of low-carbohydrate availability and/or restricted energy intake in the early post-exercise recovery period has been found to enhance and accelerate glycogen repletion. For example, it has been established that recovery of performance and glycogen repletion rates were similar in athletes consuming 0.8 g carbohydrate/kg BW + 0.4 g protein/kg BW compared with athletes consuming only carbohydrate (1.2g/kg BW). This may support exercise performance and benefit athletes frequently involved in multiple training or competitive sessions over the same or successive days.

Ingesting ~50 to 100 g of protein during the recovery period leads to accelerated recovery of static force and dynamic power production during delayed onset muscle soreness. Protein ingestion during exercise and during the pre-exercise period seems to have less of an impact than the post-exercise provision of protein but may still enhance muscle reconditioning depending on the type of training that takes place. Coingestion of protein and carbohydrate during 2 hours of intermittent resistance-type exercise is effective.

|  |
| --- |
| **Points to remember**   1. Unlike fat and carbohydrates, protein is not primarily a metabolic fuel that is oxidized during exercise and physical activity. Rather, protein’s main function in relation to athletic and exercise performance is to increase muscle mass and functional strength in response to the exercise and training stimulus. This understanding leads to two of the most common questions concerning protein:  * Which types are the best to ingest? * How much protein should be consumed over the course of a day?  1. Regarding the best protein type, it is quite clear that animal-based protein (beef, chicken, milk, egg) is superior to plant-based protein. Animal sources of protein contain all EAAs and are therefore considered complete sources of protein, while many sources of plant protein are missing some of the EAAs (i.e., are incomplete). Types of protein vary in their quality depending on their amino acid profile. Complete protein sources that contain greater amounts of EAAs generally have higher-quality protein. Specifically, according to the protein rating system known as the protein digestibility–corrected amino acid score (PDCAAS), egg, milk, whey, and bovine colostrum sources of protein are classified as high-quality proteins. 2. Soy protein, a plant protein, also is a high-quality protein according to this ranking system. Lean meats such as chicken breast, roast turkey, and tuna, as well as skim milk, are excellent choices of protein due to their relatively high protein content and low fat content. Protein supplements are also a good way to obtain high-quality protein. Most commercial protein supplements marketed to athletes contain whey-, casein-, egg-, and soy-based protein. Protein supplements offer high-quality protein and can be prepared relatively easily during traveling. This is the primary benefit of protein supplements—convenience—especially when one considers that whole foods containing protein need to be purchased, prepared or cooked, and then perhaps refrigerated. 3. Protein intake recommendations has been a popular topic in the sport nutrition field for many years. Ingesting 1.5 to 2 g protein per kilogram body weight is recommended for athletes and physically active individuals. For a 200-pound (91-kg) individual, this equates to approximately 135 to 180 g protein per day. For a 120-pound (54-kg) individual, it equates to approximately 80 to 110 g protein per day. 4. The protein should be ingested with each meal in approximately equal doses. Assuming a 200-pound athlete eats about five times a day, he should ingest about 30 g protein with each meal (20 g protein per meal for the 120-pound athlete). 5. Ingesting high-quality protein regularly throughout the day ensures that the skeletal muscles have the anabolic building blocks (amino acids) to support lean tissue accretion. 6. The concept of when to ingest protein in relation to exercise training and physical activity is referred to as protein timing. |

|  |
| --- |
| **Key points**   * Dietary protein is classified as complete or incomplete depending on whether or not the protein contains adequate amounts of the EAAs. * Animal sources of protein contain all EAAs and are therefore considered complete sources of protein, while many plant sources of protein are missing some of the EAAs (i.e., are incomplete). * It is generally recommended that athletes consume 1.5 to 2.0 g/kg body weight of protein to ensure adequate protein intake. * Milk (whey and casein), egg, soy, and bovine colostrum sources of protein are classified as high-quality protein. * Adequate protein ingestion is essential for maximizing training-induced adaptations, particularly in strength development. * Ingesting high-quality protein regularly throughout the day ensures that the skeletal muscles have the anabolic building blocks (amino acids) to support lean tissue accretion. Sufficient protein consumption is required for optimal muscle growth and exercise-related repair of muscle damage and enzymatic adaptations. * The protein requirement of athletes is increased and, according to present knowledge, amounts to approximately 1.21.8 g=kg body weight for endurance athletes and about 1.01.2 g=kg body weight for strength athletes. The reason for this increase is enhanced utilization of amino acids in oxidative energy production during physical exercisea process which is known to be intensified at higher endurance work levels and in a state of carbohydrate store depletion. * There is a close relationship between energy intake and protein consumption. Accordingly, endurance athletes generally ingest a protein quantity that is larger than their required amount. On the contrary, athletes who ingest low caloric diets may also have low protein intakes, which may not compensate for the net nitrogen loss from the body. This may influence protein synthesis processes and training adaptations negatively. To these categories belong body-builders, weight class athletes, gymnasts, dancers, female long distance runners and under some circumstances vegetarian athletes. * Protein intake=supplementation above levels that are normally required will not enhance muscle growth or performance. The building blocks of protein, amino acids, are also involved in numerous metabolic pathways and processes. Some of the amino acids are known to influence hormone secretion and neurotransmission. * Exercise-induced impairments in neurotransmission are speculated to influence fatigue=performance. However, data that support beneficial effects of single amino acids as present in currently available food supplements are generally lacking. * The use of single amino acids, to influence metabolic pathways involved in fatigue development and hormone production, needs further research before athletes should be informed positively about benefits |

**UNIT-4**

**FATS IN SPORTS**

Fat is a necessary component of a healthy diet, providing energy, essential elements of cell membranes and facilitation of the absorption of fat-soluble vitamins. The proportion of energy from saturated fats be limited to less than **10 percent** and include sources of essential fatty acids to meet adequate intake recommendations. Intake of fat by athletes should be in accordance with public health guidelines and should be individualized based on training level and body composition goals.

Fat, in the form of plasma free fatty acids, intramuscular triglycerides and adipose tissue provides a fuel substrate that is both relatively plentiful and increased in availability to the muscle as a result of endurance training. However, exercise-induced adaptations do not appear to maximize oxidation rates since they can be further enhanced by dietary strategies such as fasting, acute pre-exercise intake of fat and chronic exposure to high-fat, low-carbohydrate diets.

**Fat loading**

To augment and support the adaptations of physical training, athletes have increasingly sought to manipulate dietary fat. This takes the form of both food manipulation and dietary supplement administration. Eating more fat—even “fat loading”—can increase muscle concentrations of stored triacylglycerol and increase the activity of “fat-burning” enzymes. Raising the roughly 300 g of stored intra-muscular triacylglycerol would appear advantageous regarding simple fuel supply. A look inside a muscle cell reveals lipid droplets immediately adjacent to the mitochondrial furnaces that drive aerobic endurance performance, leading to interest in increasing these readily accessible depots of fuel. This is especially true given that aerobic endurance athletes have an increased capacity to store these fat droplets compared to non-exercisers (interestingly, cellular fat accumulation is part of the mechanism behind diabetes but in athletes is not deleterious). Eating more dietary fatis not intended simply to increase the content of one’s intramuscular “gas tank,” however. By adapting to a higher-fat diet, an athlete becomes better at using stored fat. One strategy, then, is to devise a pre-event dietary regimen that allows for one to two weeks of increased lipid storage and (fat oxidative) enzyme enhancement.

**How much fat is recommended in an athlete’s diet?**

Unfortunately, no firm standards exist for optimal lipid intake. The acceptable macronutrient distribution range for fat is 20% to 35% of energy intake. When fat intake is at 30% of total calories, Dietary Guidelines for Americans recommends that the proportion of energy from fatty acids be 10% saturated, 10% polyunsaturated, and 10% monounsaturated and that sources of essential fatty acids be included. In general, athletes report an average fat intake of 35% of total calories.

The area in which most athletes need to plan is fat source distribution. A fat intake with an equal balance of saturated, polyunsaturated, and monounsaturated fats is not likely to occur by chance. For this reason the following points should be remembered:

1. Saturated fats are abundant in the diet and are found in animal fat such as beef and dark meat in poultry.
2. Monounsaturated fats are found in vegetable oils, such as olive oil and canola oil, and in peanut butter.
3. Polyunsaturated fats are found in nuts, cheese, and fish.

Athletes need to make sure that they are selecting a variety of foods to obtain the recommended balance between the types of fat. While the research is limited, it appears that fat intake can vary as a percentage of total calories and not affect exercise performance. When fat intake was 20% of total calories as compared to 40% of total calories, there was no effect on exercise training or strength exercise performance in moderately trained males. In relation to aerobic exercise, researchers from Switzerland compared the effects of a diet containing 53% fat and a diet containing only 17% fat in 11 male duathletes (a duathlon consists of running and cycling). After subjects ingested the high-fat or low-fat diet for five weeks, there was no difference in the time it took to run a half marathon or in the total work output during a 20-minute all-out time trial on a cycle ergometer.

From these studies it appears that the percentage of total calories derived from fat does not have a large impact on exercise or athletic performance. But while this seems to be the case in most circumstances, athletes need to be careful not to go to extremes—eating too much or too little dietary fat. Consuming too much fat can lead to the overconsumption of total calories, which leads to weight gain in the form of body fat. Because fat tissue does not contribute to movement, it acts as “dead weight” and decreases relative force production. Athletes in sports where greater physical size is beneficial may be more prone to this problem. For example, American football linemen are more likely to consume excess calories and be classified as overweight or obese than other positions.

On the other hand, if fat intake is too low, performance can be decreased. Athletes that participate in gymnastics, figure skating, and weight class events (e.g., wrestling) are more likely to consume too little dietary fat. Horvath and coworkers assessed the aerobic endurance performance of male and female aerobic endurance athletes after they ingested isocaloric diets with varying fat contents. The athletes consumed isocaloric diets consisting of either 16% fat, 31% fat, or 44% fat for four weeks before running at 80% V.O2max until voluntary exhaustion. The authors reported that the 31% fat diet resulted in a significant improvement in aerobic endurance performance in comparison to the 16% fat diet. There were no differences in aerobic endurance performance between the 31% fat and the 44% fat diet groups, however. The recommendation is that athletes consume a habitual diet of approximately 30% fat. Of this 30%, 10% should be saturated, 10% polyunsaturated, and 10% monounsaturated. Following these fat intake suggestions avoids the extreme practices of consuming too little or too much dietary fat.

Dietary fat is frequently undervalued as a contributor to health and performance of athletes. Fat is an extremely important fuel for endurance exercise, along with carbohydrate, and some fat intake is required for optimal health. Dietary fat provides the essential fatty acids (EFA) that cannot be synthesized in the body.

The fat stores of the body are very large in comparison with carbohydrate stores. In some forms of exercise (e.g., prolonged cycling or running), carbohydrate depletion is possibly a cause of fatigue and depletion and can occur within 1 to 2 hours of strenuous exercise (see chapter 6). The total amount of energy stored as glycogen in the muscles and liver has been estimated to be 8,000 kJ (2,000 kcal). Fat stores can contain more than 50 times the amount of energy contained in carbohydrate stores. A person with a body mass of 80 kg and 15% body fat has 12 kg of fat (see table 7.1). Most of this fat is stored in subcutaneous adipose tissue, but some fat can also be found in muscle as intramuscular triacylglycerol (IMTG). In theory, fat stores could provide sufficient energy for a runner to run at least 1,300 km.

|  |  |  |
| --- | --- | --- |
| **Table Availability of Substrates in the Human Body** | | |
| **Substrate** | **Weight (kg)** | **Energy kJ (kcal)** |
| **Carbohydrates** | | |
| Plasma glucose | 0.01 | 160 (40) |
| Liver glycogen | 0.1 | 1,600 (400) |
| Muscle glycogen | 0.4 | 6,400 (1,600) |
| Total (approximately) | 0.51 | 8,000 (2,000) |
| **Fat** | | |
| Plasma fatty acid | 0.0004 | 16 (4) |
| Plasma triacylglycerols | 0.004 | 160 (40) |
| Adipose tissue | 12.0 | 430,000 (108,000) |
| Intramuscular triacylglycerols | 0.3 | 11,000 (2,700) |
| Total (approximately) | 12.3 | 442,000 (111,000) |

Ideally, athletes would like to tap into their fat stores as much as possible and save the carbohydrate for later in a competition. Researchers, coaches, and athletes have therefore tried to devise nutritional strategies to enhance fat metabolism, spare carbohydrate stores, and thereby improve endurance performance. Understanding the effects of various nutritional strategies requires an understanding of fat metabolism and the factors that regulate fat oxidation during exercise. This chapter therefore describes fat metabolism in detail and discusses various ways in which researchers and athletes have tried to enhance fat metabolism by nutritional manipulation. Finally, the effects of both low-fat and high-fat diets on metabolism, exercise performance, and health are discussed.

**Fat Metabolism During Exercise**

FAs that are oxidized in the mitochondria of skeletal muscle during exercise are derived from various sources. The main two sources are adipose tissue and muscle triacylglycerols. A third fuel, plasma triacylglycerol may also be utilized, but the importance of this fuel is subject to debate. Triacylglycerols in adipose tissue are split into FAs and glycerol. The glycerol is released into the circulation, along with some of the FAs. A small percentage of FAs is not released into the circulation but is used to form new triacylglycerols within the adipose tissue, a process called reesterification. The other FAs are transported to the other tissues and taken up by skeletal muscle during exercise. Glycerol is transported to the liver, where it serves as a gluconeogenic substrate to form new glucose.

Besides the FAs in plasma, two other sources of FAs for oxidation in skeletal muscle are available. Circulating triacylglycerols (for example in a very low-density lipoprotein [VLDL]) can temporarily bind to lipoprotein lipase (LPL), which splits off FAs that can then be taken up by the muscle. A source of fat exists inside the muscle in the form of intramuscular triacylglycerol. These triacylglycerols are split by a hormone-sensitive lipase (HSL), and FAs are transported into the mitochondria for oxidation in the same way that FAs from plasma and plasma triacylglycerol are utilized.

|  |
| --- |
| **Points to Remember**   * Classification of fat includes degrees of saturation (the number of carbon-carbon double bonds); carbon-carbon double-bond position (the placement of the double bonds counted from either end of the fatty acid chain); chain length (the length of the carbon chain that makes up the fatty acids); and fatty acid placement (differences in where the fatty acid chains are attached or omitted from the fat molecule’s glycerol backbone). * An understanding of the these differences enables athletes to choose the proper types of fat in order to optimize health and performance. * Fat is the primary fuel at rest and during low-intensity exercise. * Fat comes in a wide variety of types, some of which are essential, including linolenic acid from flax and walnuts (omega-3, polyunsaturated), EPA and DHA from fish oil (omega-3, polyunsaturated), and oleic acid from olive and canola oils (omega-9, monounsaturated). * Fat confers nutraceutical benefits, including helping to maintain sex hormones, potentially enhancing mood, reducing inflammation, and assisting in body fat control. * It is recommended that athletes consume a habitual diet of approximately 30% fat. Of this 30%, 10% should be saturated, 10% polyunsaturated, and 10% monounsaturated. * Diets that are too low in fat are associated with reduced testosterone concentrations and exercise performance. * Consuming too much fat can lead to the overconsumption of total calories, which leads to weight gain in the form of body fat. * Fat supplements (conjugated linoleic acid, medium-chain fatty acids, and structured triglycerides) have not consistently demonstrated improvements in exercise performance. |

|  |
| --- |
| **Key points**   * Fat is a slow energy source compared to CHO. * When primarily using fat as an energy source, athletes can only work at 4060% of their maximal work capacity. * Increased fat utilization, as a result of training, reduces the use of CHO from the glycogen stores in the body and will accordingly influence the duration of sufficient CHO availability during exercise. The latter will have an impact on muscle fatigue when exercise is intensive. * The daily fat intake in athletes is recommended to be relatively low, i.e. <30 en%, allowing for an increase in the proportion of CHO in the diet. Saturated fat sources should be avoided and foods rich in or prepared with oils that are rich in mono- and polyunsaturated fatty acids, such as vegetable and fish oil, should be promoted. * Some very recent data show improvements in performance during low intensity exercise after following a combined dietary intervention: CHO rich diet 2short-term high fat diet 2high CHO diet 2competition. However, the bulk of evidence points to the fact that high intensity exercise performance is best achieved after being on a diet which is relatively high in CHO and low in fat. * Statements that L-carnitine, caffeine, MCT feedings, oral TG feedings and high fat diets may improve performance of endurance athletes during high intensity events, by means of boosting fat metabolism, can at present not be supported by consistent and solid scientific evidence. |

**UNIT-5**

**MINERALS IN EXERCISE AND SPORTS**

Micronutrients do not provide energy and, therefore, they do not play any role in fattening or weight-gaining processes. Vitamins exert a large number of different functions inthe human body, such as acting as coenzymes in several metabolic reactions, hormonal function, calcium metabolism, antioxidant, coagulation, and structure of tissues, among others. Unlike vitamins, minerals are inorganic compounds. Minerals are also essential to several metabolic pathways, cell signaling, synthesis and maintenance of tissues. In theory, athletes involved with high-volume intensive training regimens could have increased requirements for daily vitamins and minerals intake. This would be due to increased rates of synthesis, maintenance and repair of muscle tissue, as well as to losses of some micronutrients in sweat. In addition, exercise stimulates metabolic pathways in which micronutrients are involved and can produce biochemical adaptations in muscle tissue that would increase the requirements of vitamins and minerals. However, studies have shown that a balanced diet that adequately supplies the needs for energy will also adequately supply the needs for micronutrients, which is true for both non-athletic and athletic populations. Hence, athletes in general do not benefit from supplementation with vitamins and minerals, unless some specific micronutrient deficiency is present. In these cases, it is important to make all necessary changes in the diet in order to ensure that all micronutrients will be eaten in adequate amounts. Also, in the event of micronutrient deficiency, supplementation with vitamins or minerals may be indicated until that specific deficiency is circumvented. The counter-measures for vitamin or mineral deficiency are especially important for athletes because physical performance is impaired by micronutrient deficiency. It is worthy to note that some specific athletic groups are at increased risk of vitamins and minerals deficiency, such as those who constantly restrict food intake, exclude specific groups of foods from the diet, or vegetarian athletes, to whom special attention in this regard must be given. Finally, it is important to emphasize that maintain-ing healthy eating habits, such as preventing severe food restriction and refraining from the exclusion of particular groups of foods, is the most appropriate way to avoid micronutrients-related problems .Supplementation would be necessary only to over come any eventual deficiency caused by unbalanced diets**.**

|  |
| --- |
| **Key Points**   * Minerals are important substances for the skeletal structures, as well as for numerous biological actions in the muscles. * Impaired mineral status may lead to a reduced bone formation (mineral density) and to muscle weakness. * Exercise is known to be associated with increased mineral losses, through sweating and also via the urine in the post-exercise phase. * As with most nutrients, mineral intake depends on the quality of the diet and the amount of energy (food) consumed. High energy consumption leads to increased mineral intake. * Athletes consuming low energetic diets may be at risk of low mineral intake, especially of magnesium, calcium and zinc. * Vegetarian athletes may be prone to iron deficiency unless their food choice is appropriate. * Impaired magnesium status has been suggested to lead to muscle cramp but hard evidence for this is still lacking. * Mineral supplementation during exercise has not been shown to enhance performance capacity. * The importance of an appropriate trace element intake and status in athletes has only received a significant interest during the last two decades. * As is the case for minerals, trace elements are increasingly lost as a result of intensive physical training. * Trace element losses with sweat (copper) and urine (chromium) may under some circumstances exceed the daily recommended intakes. * The composition of the diet may also affect these losses. For example, high CHO intakes, especially of high glycaemic index * carbohydrates, have been shown to enhance losses of chromium, whereas diets rich in dietary fibre, often consumed by endurance. * Athletes and vegetarians, are known to reduce trace element absorption. * Athletes consuming low energetic diets may be at risk of a low trace element intake. * Since it is recognized that exhaustive exercise may lead to enhanced tissue=cell damage and regeneration that is associated with an inflammatory process, the importance of selenium, as a component of the free radical defence mechanisms, has received attention. * Evidence that supplementation reduces muscle inflammation is still lacking. * There is no evidence that trace element supplementation induces the development of a larger lean body mass. * Much research is needed in this field, but it is felt that supplementation with trace element amounts that do not exceed the recommended safe daily intakes will contribute to adequate daily intake in athletes. |

**UNIT-6**

**HYDRATION, ERGOGENIC AIDS, SUPPLEMENTS**

Fatigue toward the end of a prolonged sporting event may result as much from dehydration as from fuel substrate depletion. Exercise performance is impaired when an individual is dehydrated by as little as 2% of body weight. Losses in excess of 5% of body weight can decrease the capacity for work by about 30%.

Sprint athletes are generally less concerned about the effects of dehydration than are endurance athletes. However, the capacity to perform high-intensity exercise, which results in exhaustion within a few minutes, is reduced by as much as 45% by prior dehydration corresponding to a loss of only 2.5% of body weight. Although sprint events offer little opportunity for sweat loss, athletes who travel to compete in hot climates are likely to experience acute dehydration, which persists for several days and may be serious enough to have a detrimental effect on performance in competition.

Even in cool laboratory conditions, maximal aerobic power ( .VO2max) decreases by about 5% when persons experience fluid losses equivalent to 3% of body mass or more. In hot conditions, similar water deficits can cause a larger decrease in .VO2max. The endurance capacity during incremental exercise is decreased by marginal dehydration (fluid loss of 1% to 2% of body weight), even if water deficits do not actually result in a decrease in .VO2max. Endurance capacity is impaired much more in hot environments than in cool conditions, which implies that impaired thermoregulation is an important causal factor in the reduced exercise performance associated with a body-water deficit. Dehydration also impairs endurance exercise performance. Fluid loss equivalent to 2% of body mass induced by a diuretic drug (furosemide) caused running performance at 1,500, 5,000, and 10,000 m distances to be impaired (Armstrong et al. 1985). Running performance was impaired more at the longer distances (by approximately 5% at 5,000 and 10,000 m) compared with the shortest distance (approximately 3% at 1,500 m).

A study investigated the capacity of eight subjects to perform treadmill walking (at 25% .VO2max with a target time of 140 minutes) in very hot, dry conditions (49° C [120° F], 20% relative humidity) when they were euhydrated and when they were dehydrated by a 3%, 5%, or 7% loss of body mass. All eight subjects were able to complete 140 minutes walking when euhydrated and 3% dehydrated. Seven subjects completed the walk when 5% dehydrated, but when dehydrated by 7%, six subjects stopped walking after an average of only 64 minutes. Thus, even for relatively low-intensity exercise, dehydration clearly increases the incidence of exhaustion from heat strain. Sawka et al. (1992) had subjects walk to exhaustion at 47% .VO2max in the same environmental conditions as their previous study. Subjects were euhydrated and dehydrated to a loss of 8% of each individual’s total-body water. Dehydration reduced exercise endurance time from 121 minutes to 55 minutes. Dehydration also appeared to reduce the core temperature a person could tolerate, as core temperature at exhaustion was about 0.4° C (0.7° F) lower in the dehydrated state.

The main reasons dehydration has an adverse effect on exercise performance can be summarized as follows:

* + Reduction in blood volume
  + Decreased skin blood flow
  + Decreased sweat rate
  + Decreased heat dissipation
  + Increased core temperature
  + Increased rate of muscle glycogen use

A reduced maximal cardiac output (i.e., the highest pumping capacity of the heart that can be achieved during exercise) is the most likely physiologic mechanism whereby dehydration decreases a person’s. VO2max and impairs work capacity in fatiguing exercise of an incremental nature. Dehydration causes a fall in plasma volume both at rest and during exercise, and a decreased blood volume increases blood thickness (viscosity), lowers central venous pressure, and reduces venous return of blood to the heart. During maximal exercise, these changes can decrease the filling of the heart during diastole (the phase of the cardiac cycle when the heart is relaxed and is filling with blood before the next contraction), hence, reducing stroke volume and cardiac output. Also, during exercise in the heat, the opening up of the skin blood vessels reduces the proportion of the cardiac output available to the working muscles.

Even for normally hydrated (euhydrated) individuals, climatic heat stress alone decreases .VO2max by about 7%. Thus, both environmental heat stress and dehydration can act independently to limit cardiac output and blood delivery to the active muscles during high-intensity exercise.

Dehydration also impairs the body’s ability to lose heat. Both sweat rate and skin blood flow are lower at the same core temperature for the dehydrated compared with the euhydrated state. Body temperature rises faster during exercise when the body is dehydrated. The reduced sweating response in the dehydrated state is probably mediated through the effects of both a fall in blood volume (hypovolemia) and elevated plasma osmolarity (i.e., dissolved salt concentration) on hypothalamic neurons. As explained previously, as core temperature rises towards about 39.5° C (103° F), sensations of fatigue ensue. This critical temperature is reached more quickly in the dehydrated state.

Dehydration not only elevates core temperature responses but also negates the thermoregulatory advantages conferred by high aerobic fitness and heat acclimatization. Heat acclimation lowered core temperature responses when subjects were euhydrated. However, when they were dehydrated, similar core temperature responses were observed for both unacclimated and acclimated states.

A person’s ability to tolerate heat strain appears to be impaired when dehydrated, so the critical temperature for experiencing central fatigue is likely to be nearer 39.0° C (102.2° F) when dehydrated by more than about 5% of body mass. The larger rise in core temperature during exercise in the dehydrated state is associated with a bigger catecholamine response, and these effects may lead to increased rates of glycogen breakdown in the exercising muscle, which, in turn, may contribute to earlier onset of fatigue in prolonged exercise.Hydration is not limited to the replenishment of body fluids but is also a vehicle for delivering electrolytes, sugar, and amino acids. Dehydration and hyponatremia (low blood sodium, often due to overhydration in the absence of sodium) still affect “weekend warriors” and experienced athletes alike. Further, dehydration can result in a dangerous increase in core body temperature leading to heat illness. However, even mild dehydration, which is more common, can lead to decreases in both strength and aerobic endurance and subsequently to impaired athletic performance.

The young and the elderly are the two groups at greatest risk for heat-related illness, including heat cramps, heat exhaustion, and heatstroke.

Two major factors put young athletes at risk: (1) They do not sweat as much as adults (sweat helps dissipate heat); and (2) they have a greater surface area relative to their body mass, which increases their heat gain from the environment when ambient temperatures are elevated.

In the elderly, age-related changes in thirst and thermoregulation contribute to dehydration. Elderly individuals experience a decreased thirst sensation in response to drops in blood volume, a reduction in renal water conservation capacity, and disturbances in fluid and electrolyte balance. Some prescription medicines, as well as cardiovascular disease (still the number one cause of death in the United States), can impair fluid homeostasis.

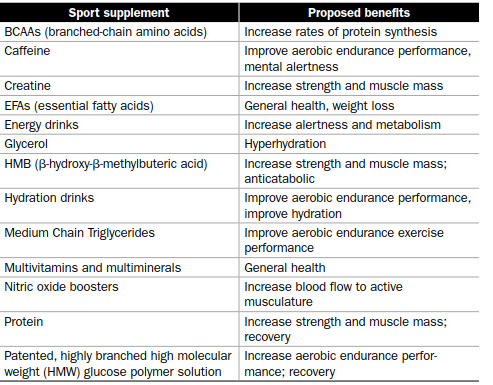
The quest for enhanced hydration has led to the examination of hyper hydrating agents such as glycerol. In addition, nutrition scientists have investigated the effects of adding amino acids to sport beverages and regular electrolyte replacement beverages to improve hydration and mitigate muscle damage. Fortunately, beverage companies are continuing to sponsor research on the effectiveness of their products, which indicates a continued focus on hydration and its effects on health and performance. Companies that conduct studies on their products should hire independent labs with no financial interest in the company itself to conduct unbiased, well-designed clinical trials.

**Ergogenic Aids**

Modern-day Olympic athletes are no different from high school athletes attempting to make their junior varsity basketball team—both groups are seeking to improve their athletic performance. Naturally, any athlete attempting to improve performance will continually manipulate his training regimen. Along with this focus on training methodology is often an equal attention on the use of ergogenic aids to improve performance. Ergogenic aids are nutritional, physical, mechanical, psychologic, or pharmacologic procedures or devices intended to improve exercise or sport performance.

Since by definition, ergogenic aids are work-enhancing substances or devices believed to increase performance (McNaughton 1986), they may range from caffeine for the aerobic endurance athlete to eyewear for a skier or snowboarder. Nutritional ergogenic aids receive a lot of attention from athletes and others in the sport performance industry. They may directly influence the physiological capacity of a particular body system and thereby improve performance, or they may increase the speed of recovery from training and competition.

➤ ergogenic aid—A work-enhancing substance or device believed to increase performance. Examples include nutritional, physical, mechanical, psychologic, or pharmacologic procedures or aids to improve exercise or sport performance.



**Macronutrients and Sport Supplements**

Nutritional ergogenic aids can be categorized into two broad categories: macronutrient intake manipulations (carbohydrate loading, increasing protein intake during a hypertrophic resistance training phase, etc.) and the ingestion of dietary supplements. Dietary supplements, products intended to make the diet more complete, contain one or more of the following ingredients: a vitamin, mineral, amino acid, herb, or other botanical; a dietary substance intended to supplement the diet by increasing the total dietary intake of certain macronutrients or total calories; a concentrate, metabolite, constituent, extract, or combination of any of the ingredients already mentioned and intended for ingestion in the form of a liquid, capsule, powder, softgel or gelcap, and not represented as a conventional food or as a sole item of a meal or the diet. Commonly used supplements such as vitamins and minerals are considered ergogenic aids only if the athlete is correcting a deficiency. Other ergogenic aids are not taken specifically to correct a deficiency but instead for a very specific benefit. For instance, a hockey player taking a time-released beta-alanine supplement for four to six weeks prior to preseason practice is doing so to zone in on one very specific component of training and recovery: buffering fatigue. Sport supplements and nutritional ergogenic aids are classified under the umbrella of dietary supplements. Often, sport supplements provide a substance that is a component of a normal physiological or biochemical process (creatine monohydrate, alpha ketoglutarate, etc.). Other nutritional ergogenic aids augment physiological or bioenergetic pathways to enhance energy production (e.g., creatine monohydrate, caffeine) or skeletal muscle mass (creatine monohydrate, leucine, etc.).

|  |
| --- |
| Points to Remember   * Sport nutritionists are an integral part of the athletic training team that also includes coaches, strength and conditioning specialists, athletic trainers, sport psychologists, team physicians, and physical therapists. * Carbohydrate and fat are the two nutrients that provide athletes with energy. * The main carbohydrate sources are muscle and liver glycogen, liver gluconeogenesis (the production of carbohydrate from noncarbohydrate sources), and ingested carbohydrate. * Aerobic endurance training leads to an increase in total fat oxidation and a decrease in total carbohydrate oxidation during exercise at a given intensity. * Due to its rate and quantity of oxidation, carbohydrate is the main source for ATP resynthesis during maximal exercise tasks lasting approximately 7 seconds to 1 minute. * Protein’s primary function is to increase and maintain lean body mass. * A protein intake of 1.5 to 2.0 g/kg per day for physically active individuals not only is safe but also may improve the adaptations to exercise training. * Dehydration can result in a dangerous increase in core body temperature leading to heat illness. Even mild dehydration, which is more common, can lead to decreases in both strength and aerobic endurance and subsequently to impaired athletic performance. * The young and the elderly are the two groups at greatest risk for heat-related illness, including heat cramps, heat exhaustion, and heatstroke. * Though the ingestion of micronutrients above and beyond the RDI has not been shown to enhance performance, population-based studies reveal that many people do not consume the RDI of certain nutrients. * In addition, many people are deficient in certain micronutrients. * And, making up for low levels of a nutrient or a true deficiency may directly or indirectly impact performance. * Creatine, protein, caffeine, amino acids, electrolyte replacement sport beverages, beta-alanine, and high molecular weight starch-based carbohydrates are among the most widely researched supplements to date. |

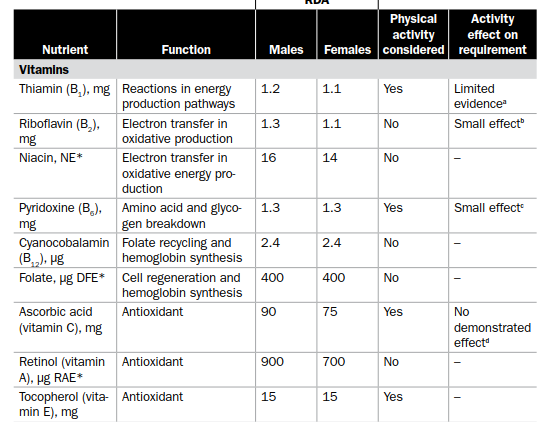
|  |
| --- |
| **Key points**   * Fluids and electrolytes are important for the maintenance of fluid balance during prolonged physical exercise, especially in the heat. * Progressive fluid loss from the body, by means of sweating and breathing, is associated with a decreased blood volume and blood flow through the extremities. Also a reduction in sweating and heat dissipation may result from this. Under circumstances of high intensity work in the heat, it may lead to heat stroke and collapse. * Dehydration of >1.5 litres is known to reduce the oxygen transport capacity of the body and to induce fatigue and gastrointestinal disturbances. * Appropriate rehydration is known to counter these effects and to delay fatigue. In contrast to plain water, the addition of CHO to rehydration drinks is known to stimulate drinking and water absorption and additionally to have a positive effect on water balance. * The carbohydrate supplied with the drink will also be of benefit for maintaining a high CHO availability, to help reduce fatigue and maintain performance capacity. * Addition of sodium to drinks will have a positive effect on postexercise rehydration by reducing urine loss and stimulating water retention. Other electrolytes may be added but should not exceed the levels of loss with whole body sweat; they have not been shown to have a beneficial effect on performance. * Sport rehydration drinks should in principle not be hypertonic. |
| * Substances such as caffeine (guarana), carnitine, aspartates, sodium bicarbonate, bee pollen, specific amino acids, creatine, ribose, choline, etc., have recently received scientific attention due to their possible influence on performance, fatigue and recovery. * Some of these substances have been shown to be useful for performance enhancement: creatine, phosphate loading, sodium bicarbonate and caffeine. * Others have clearly been disproved for functional effects at the dosages taken: L-carnitine, bee pollen, BCAAs, tryptophan, inosine, chromium picolinate. * Some lack the evidence that is required to make benefit statements for the dosage at which the supplements are advised and ingested:ribose, choline, glutamine, arginine, ornithine, CoQ10, aspartates. * Despite these aspects, supplementation use is widespread, in particular among strength athletes and bodybuilders. * Caffeine does not act as a diuretic during exercise and enhances performance even at low levels of intake. * Besides being a nutritional compound, caffeine can also be considered as a drug. It is on the doping list of the IOC and athletes are advised to test for urinary caffeine levels after intake of a standard effective dose before entering competitions. |

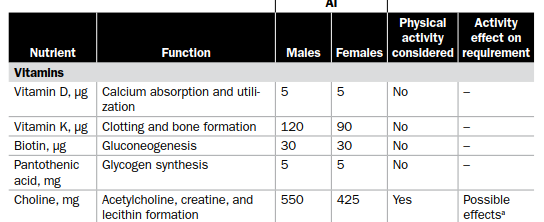
**UNIT-7**

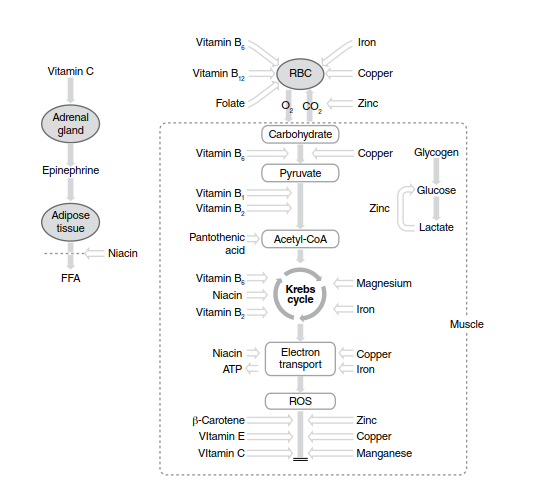
**VITAMINS IN SPORTS**

Vitamins are essential nutrients for the human body. Vitamins are involved in almost every biological function. They serve as coenzymes in many bio-reactions, biochemical reactions (including energy metabolism), are involved in protein synthesis and act as antioxidants. The most essential functions of the individual vitamins as well as their role in exercise metabolism and their influence on exercise capacity will be described briefly in the following paragraphs.

**Table 1: Importance of Vitamins**







**Figure 1: Role of Vitamins in Sports and Excercise**

**The B Vitamins**

B vitamins: – Thiamin (B1) – Riboflavin (B2) – Niacin (B3) energy metabolism – Vitamin B6 – Pantothenic acid – Biotin – Folate blood formation – Vitamin B12. Guidelines for Recommending Vitamins Supplements:

1. Is current dietary intake of the vitamin adequate?
2. Is there any indication for increased need?
3. Is the amount recommended below the toxic level?
4. Are any nutrient-nutrient or drug-nutrient interactions indicated?
5. Why does the athlete want to supplement?
6. Is the athlete willing to make dietary changes that would improve vitamin intake?
7. Can the nutrient easily be obtained from food by means of simple dietary changes that are acceptable to the athlete?

**Vitamins - Exercise-Related Functions and Dietary Requirements**

1. Thiamin: Thiamin is an essential cofactor for important enzymes involved in the metabolism of CHO, protein, and fat – Branched-chain amino acids (BCAAs)
2. Active form: thiamin disphosphate (TDP) – Coenzyme for the pyruvate dehydrogenase complex – Cofactor for α-ketoglutarate decarboxylase – Required for transketolase – Thiamin RNI: \_\_\_ mg/d (men), \_\_\_ mg/d (women).
3. Riboflavin: Riboflavin is involved with the metabolism of glucose, fatty acids, glycerol, and amino acids for energy – Necessary for the synthesis of 2 important coenzymes in the body: Flavin mononucleotide (FMN) and Flavin adenine dinucleotide (FAD) – Involved in the conversion of pyridoxine (Vitamin B6) and folate to their coenzyme forms – Hypothesized that riboflavin requirements are higher in people who exercise – Riboflavin RNI: \_\_\_ mg/d (men), \_\_\_ mg/d (women).
4. Vitamin B6: Vitamin B6 plays a major role in metabolic pathways required during exercise – Required in the metabolism of protein & amino acids and release of glucose from stored glycogen – Active form: pyridoxal-5’-phosphate (PLP) – Vitamin B6 RNI: \_\_\_ mg/d (both men & women) .
5. Niacin: Niacin (also called nicotinic acid and nicotinamide): – Precursor for 2 coenzymes: Nicotinamide adenine dinucleotide (NAD) NAD phosphate (NADP) – Niacin can come from 2 sources: • Directly from the diet • Made from the essential aa tryptophan – Niacin RNI: \_\_\_ NE/d (men), \_\_\_ NE/d (women).
6. Pantothenic Acid: Pantothenic acid is involved in many energy- producing metabolic pathways – Active forms: coenzyme A (CoA) & acyl carrier protein (ACP) – Involved in glycolysis, β-oxidation, TCA cycle, gluconeogenesis, protein degradation and aa synthesis, and the synthesis of steroid hormones, acetylcholine, fatty acids, and membrane phospholipids – Pantothenic acid AI: \_\_\_ mg/d (men & women).
7. Biotin: Biotin is involved in the metabolism of glucose, fat, and protein: – Gluconeogenesis – Fatty acid synthesis – Required for the degradation of some aa’s (isoleucine, valine, methionine, and leucine) and odd-carbon fatty acids – Biotin AI: \_\_\_mg/d (men & women).

**Pharmacological Effects & Toxic Levels B Vitamins:**

1. Thiamin – No evidence of toxicity from oral supplementation
2. Riboflavin – No evidence of toxicity from food or supplements
3. Vitamin B6 – Chronic high doses may cause neurotoxicity
4. Niacin – Can cause flushing of the skin, hyperuricemia, abnormal liver function, low BG levels – UL = 35 mg/d
5. Pantothenic Acid – No UL
6. Biotin – No UL

**Rationale for Increased Need for Active Individuals**

Exercise & the B Vitamins. Theoretically, exercise could increase the need for B vitamins:

1. Altered absorption of the nutrient due to decreased transit time – Increased turnover, metabolism, or loss of the nutrient in urine or sweat – Increased need due to the biochemical adaptations associated with training
2. Increased mitochondrial enzymes that require the nutrients are cofactors – Increased need for the nutrient for tissue maintenance and repair – Increased need due to biochemical adaptations associated with changes in the composition of the diet (higher intakes of CHO or protein or both)

**Dietary Intakes of Active Individuals**

1. Active Males and B Vitamins • Studies examining the dietary intakes of B vitamins in active males indicate: – Adequate intakes of thiamin, riboflavin, vitamin B6, and niacin – Attributed to the relatively high energy intakes in active males
2. Active Females and B Vitamins • Studies examining the dietary intakes of B vitamins in active males indicate: – Intakes are generally lower in active females as compared to active males – Most studies indicate adequate intakes for thiamin, riboflavin, and niacin – Populations at risk: amenorrheic runners, athletes at the end of their season at peak competition, those consuming < 1900 kcal/day

**Dietary Sources of B Vitamins**

1. Pantothenic acid: – Meats (esp. heart & liver), baker’s yeast, white and rice bran, mushrooms, nuts (cashews & peanuts), soybeans, broccoli, avocados, outer layer of grains
2. Biotin: – Brewer’s yeast, milk, cheese, liver, egg yolks, nuts (peanuts & walnuts), lentils, soybeans, vegetables (cauliflower, spinach, peas), grains – Small amounts are also produced in the intestinal tract of humans

**Vitamin Deficiencies & Their Symptoms**

1. Thiamin Deficiency : Beri-beri (wet or dry) – Characterized by loss of sensation in the hands and feet; muscular weakness; advancing paralysis; abnormal heart action in adults; during growth, permanent brain damage may result.
2. Wernicke-Korsakoff syndrome – Affects brain tissues; associated with alcohol abuse; characterized by apathy, irritability, mental confusion & disorientation, loss of memory, jerky eye movements, staggering gait
3. Riboflavin Deficiency. No single disease is associated with low dietary intakes of riboflavin – Low intakes are associated with lesions around the mouth, general dermatitis, and normocytic anemia – Riboflavin is essential for the conversion of vitamin B6 and niacin to their active forms
4. Vitamin B6 Deficiency. Deficiency symptoms: – weakness, psychological depression, irritability, confusion, insomnia, greasy dermatitis, anemia, convulsions; weakened immune response, increased incidence of heart disease – If high protein intakes accompany low vitamin B6 intakes, the deficiency will appear sooner
5. Niacin Deficiency : Deficiency – pellagra – 4Ds = diarrhea, dermatitis, dementia, death – Can be prevented by adequate protein because tryptophan can be converted to niacin in the body
6. Pantothenic Acid & Biotin Deficiencies: There are no deficiency diseases associated with low intakes of pantothenic acid or biotin

**Exercise and Vitamin Requirements**

1. Metabolic Diet Studies: How do metabolic diet studies assess vitamin requirements? – Determine how vitamin assessment parameters change under controlled conditions when the dietary intake of a nutrient is closely controlled – How it works: a known amount of the vitamin is fed to both sedentary and active individuals – If subsequent nutrient status is different between the two groups, vitamin requirements are different
2. B Vitamin Requirements: Exercise may increase the need for B vitamins by 1-2 times the current RDA - thiamin - riboflavin - vitamin B6 - Limited data on the effect of exercise on niacin, pantothenic acid or biotin status .

**Vitamins and Exercise Performance**

Do Vitamin and Mineral Supplements Improve Exercise Performance? – Many factors besides diet that affect performance – Many ways to measure performance – Major flaws of research studies: 1. Researchers did not determine the subject’s nutritional status before the study began 2. Neither diet nor exercise training were controlled during the study 3. Supplements often contain other nutrients besides the vitamin in question – No data to support active individuals with good nutrient status experience increased performance with additional supplementation

**Antioxidants and Free Radicals in Sports Nutrition**

Antioxidants defined: – Nutrients that act to prevent oxidative damage resulting from free radical formation – They do this by:

1. Scavenging free radicals
2. Removing the catalysts that accelerate oxidative reactions
3. Repairing damage caused by oxidation
4. Binding free metal ions to prevent them from reacting with reactive species

Free radicals defined: – Molecule with an unpaired electron in its outer orbit (valence shell) – Free radicals can arise naturally through normal metabolism (i.e. aerobic respiration, immune defence) or can be generated through other external factors (i.e. UV radiation, smog/pollution, alcohol, cigarette smoke, herbicides, stress, exercise, etc.) – Are highly reactive and can create a chain reaction that produces even more free radicals – Can cause cellular damage

**Types of Free Radicals**

1. Free radicals and reactive oxygen species: – Superoxide radical (O2-) – Hydroxyl radical (OH) – Hydrogen peroxide (H2O2) – Singlet oxygen (1O2) – Hydroperoxyl free radical (ROOH) – Nitric oxide free radical (NO)

**Enzymes Involved in Antioxidant Activities**

Numerous defence systems protect the body against excessive oxidative damage – Defences are widespread and strategically placed within and outside the cells – Enzymatic systems: e.g. Superoxide dimutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione reductase (GR), peroxidase

Require minerals as cofactors (• Cu • Fe • Mn • Zn)

Superoxide dimutase (SOD): – Accelerates the conversion of superoxide radical to hydrogen peroxide. Requires Mn, Zn, Cu.

Catalase (CAT): – Removes hydrogen peroxide. Requires Fe. • Glutathione (GSSG & GSH): – A substrate (not an enzyme) involved in the removal of hydrogen peroxide and the reduction of lipid hydroperoxides.

Enzyme Defence Systems - Glutathione peroxidase (GPX): – Removes hydrogen peroxide and reduced lipid hydroperoxides. Requires Se.

Glutathione reductase (GR): – Converts oxidized glutathione (GSSG) back to reduced glutathione (GSH) • Peroxidase: – Rids the body of excess hydrogen peroxide.

**Assumptions about Athletes & Antioxidant Requirements:**

1. Athletes generate excessive free radicals through heavy physical training as they consume more oxygen than sedentary individuals.
2. The antioxidant systems in place are not sufficient to cope with the increased free radical production that accompanies heavy training.
3. Athletes in urban (vs. rural) areas may need even more antioxidants due to high levels of air pollution that increase free radical production.

**Support for Increased Need**

***Research data suggests:***

1. Acute exercise increases free radical production. Exercise increases oxygen consumption, which increases the activity of cellular respiration.
2. Exercise also increases catecholamines (includes epinephrine), which can produce free radicals
3. Tissue damage from intense exercise can also lead to lipid peroxidation of membranes – The inflammation response can also produce free radicals.

***Effects of Acute Exercise:***

1. Evidence supports an increase in free radical production and lipid peroxidation during exercise.
2. Exercise at high altitude with poor energy intake may exacerbate this – Ultramarathoners: significant increase in DNA damage during a 50 km race.
3. Erythrocyte and blood levels of GSH decrease with acute exercise – Increases in the glutathione antioxidant enzyme system are seen with exercise.

**Effects of Chronic Exercise:**

1. Trained athletes: – Increase in mitochondrial enzymes and oxidative capacity (with endurance training adaptation), increasing the potential for oxidative damage – In animals, vitamin E decreases in muscle tissue with endurance training.
2. A significant (+) correlation exists between VO2 max and activities of antioxidant enzymes

**Antioxidants & Performance**

1. Trained athletes vs. occasional exercises and antioxidant supplementation – Who will benefit more?
2. Most studies focus on vitamins E, C, or a combination of antioxidants • Impact on performance is not significant
3. pecial circumstances: – Exposure to altitude – Conditions of extremely high ambient temperatures

**Recommendations for Antioxidant Intake:**

1. Evidence arguing for supplementation appears inadequate at this time, therefore recommendations appear premature.
2. Concerns regarding supplementations: – Toxicity risks of certain nutrients – Impact of long-term supplementation on health – Bioavailability of supplement pills – Potential interactions among other nutrients

**Nutrients Involved in Antioxidant Activities**

Vitamin E: Essential fat-soluble vitamin: – Includes 8 compounds – α-tocopherol = most biologically active.

Primary antioxidant functions of vitamin E:

1. Halts lipid peroxidation
2. Quenches singlet oxygen
3. Stabilizes the superoxide radical
4. Stabilized the hydroxyl radical
5. Spares Se and protects β-carotene from destruction – Stabilizes membrane structure

**Vitamin E Dietary sources:**

Vegetable oils, green leafy vegetables, nuts, wheat germ, and whole grains.

**Vitamin E deficiency:**

Rare in humans and occur primarily in premature infants or people with fat-malabsorption syndromes . RDA: 15 mg α-tocopherol – Equivalent to 22 IU natural vit E or 33 IU synthetic vit E.

Supplementation with vitamin E: – High doses = anticoagulant

**Vitamin C**

1. Essential water-soluble vitamin: Also called ascorbic acid or ascorbate.
2. Humans lack the enzyme gulonolactone oxidase

**Primary antioxidant functions of vitamin C:**

1. Stabilizes the hydroxyl radical
2. Quenches singlet oxygen
3. Scavenges the superoxide radical
4. Reduces the oxidized form of vitamin E
5. Reduces nitrosamines to harmless species – May help protect the lungs from ozone and cigarette smoke

**Primary antioxidant functions of vitamin C:**

May help prevent the metal ion-induced oxidation of low- density lipoproteins (LDL), reducing the risk for atherosclerosis

Dietary sources: – Fruits & vegetables • Vitamin C deficiency: – scurvy

RDA: 90 mg/day (men), 75 mg/day (women) – An additional 35 mg/day is recommended for people who smoke

**Vitamin C Supplementation with vitamin C:**

1. Supplements are easily available and inexpensive
2. Side effects (> 2000-3000 mg/day): nausea, diarrhea, abdominal cramps, erythrocyte hemolysis, iron overload toxicity
3. Prooxidant
4. increases the production of free radicals and enhances oxidative damage • Can induce DNA damage in humans (at doses of 500 mg)

Common cold: no conclusive evidence that supplementation of vitamin C prevents colds in healthy adults

**Vitamin C and exercise-related functions:**

1. Essential for collagen synthesis
2. Plays a role in the stress response
3. Required for the biosynthesis of carnitine
4. Assists with amino acid metabolism – Increases absorption of dietary non-heme iron
5. Improves symptoms of upper respiratory infections in sedentary people and ultramarathon runners

**β-Carotene& Vitamin A**

1. β-Carotene & Vitamin A or β-carotene: – Carotenoid – part of the red, orange, and yellow pigments found in F&V – Precursor to vitamin A.
2. Primary antioxidant functions of β-carotene and vitamin A: – Quenches singlet oxygen – Quenches hydroperoxyl radicals – Protects against lipid peroxidation – Vit A protects LDLs against oxidation and may reduce oxidative damage in vitamin A deficient infants
3. β-Carotene & Vitamin A • Dietary sources: – Dark green leafy vegetables, deep orange fruits (apricots, cantaloupe), and vegetables such as squash, carrots, sweet potatoes, and broccoli • β-carotene/vitamin A deficiency: – Rare in humans and occur primarily in premature infants or people with fat-malabsorption syndromes • RDA: none for β-carotene – Diet containing 5 servings of F&V/day provides approximately 5-6 mg/day of β-carotene
4. β-Carotene & Vitamin A • Supplementation with β-carotene & Vitamin A: – Vitamin A – β-carotene • hypercarotenemia.

|  |
| --- |
| **Points to Remember**   * Vitamins cannot be produced by the body and thus must be consumed in foods and beverages. * The content of vitamins in food is small (micrograms to milligrams) compared to that of protein, carbohydrate, and fat (up to hundreds of grams). * Vitamins are not direct sources of energy but facilitate energy production and utilization from carbohydrate, fat, and protein; transport oxygen and carbon dioxide; regulate fluid balance; and protect against oxidative damage. * Subclinical deficiencies of some vitamins and minerals occur in physically active individuals. * Vitamins are characterized into two main groups: water soluble and fat soluble. The water-soluble vitamins include the B vitamins and vitamin C. The fat-soluble vitamins are vitamins A, D, E, and K. * Vitamin supplements are not necessary for an athlete on a balanced diet, but health professionals may recommend them to athletes if their diet is not balanced, if they are on a very low-calorie diet, or for other special dietary needs. |

|  |
| --- |
| **Key Points**   * Vitamins are essential cofactors in many enzymatic reactions involved in energy production and in protein metabolism. * Any shortage of a vitamin may lead to suboptimal metabolism, which in the long term may result in decreased performance or even illness. * Some vitamins act as antioxidants and there is accumulating evidence that nutritional antioxidants may help optimize the protective role for the maintenance of tissue=cell integrity. * Vitamin supplementation has been shown to restore performance capacity in cases of a vitamin deficit and to reduce tissue damage due to free radical production. * Vitamin supplementation with quantities exceeding those needed for optimal=blood levels has not been shown to improve performance. * As is the case for minerals and trace elements, athletes involved in intensive training, but consuming low energetic diets, are most prone to marginal vitamin intakes. * It can be concluded that vitamin restoration of energy dense processed foods or supplementation with preparations will not enhance performance but may, in athletic populations, contribute to adequate daily intakes. * Daily intake of a low dose vitamin or combined vitamin with minerals and trace element preparation, supplying the recommended safe daily intake, may be advised in periods of intensive training or in any situation where athletes have to abstain from a normal diet. |

**UNIT-8**

**Nutrition for Strength Sports – Body Builders**

The 1996 Olympic Games included a number of very different types of sport where strength and speed are primary requirements for the participants. These include:

1. *Boxing: open to men only, including 12 weight categories ranging from 48kg to over 91 kg.*
2. *Judo: open to men (weight categories from 60kg to over 80kg) and women (from 48 to over 72kg).*
3. *Weightlifting: open to men only, with 10 weight classes from 54 to over 108 kg.*
4. *Wrestling: Greco-Roman and freestyle competition, open to men only, with 10 weight classes from 48kg to over 130kg, giving a total of 20 competitions.*

In addition, strength and speed are vital components of the sprint events on the track and of all ﬁeld events, including long jump, high jump, triple jump, pole vault, shot, discus, javelin, hammer throw. In cycling, there are sprint events on the track for men and women. In the Winter Olympic competition, speed skating and bobsleigh (two-man and four-man) also require similar characteristics: indeed many speed skaters are also top class cyclists, and bobsleigh competitors often compete at 100 m on the track in the summer. It is clear that sports in this grouping account for the majority of medals awarded at the Olympic Games.

Non-Olympic sports involving similar characteristics and demands include a variety of martial arts (karate, Tae Kwondo). Bodybuilding training follows broadly similar principles, although the training loads and numbers of repetitions performed may be somewhat different and the demands of competition are also different.

There is a large body of evidence that the protein requirement of endurance athletes ranges from 1.2 to 1.8 g=kg body weight=day (105-108). There are only limited data on athletes that are involved in strength sports and have a relatively high muscle mass and low fat mass. It is frequently stated that these athletes require more protein than endurance athletes (mainly because of their higher lean body mass) to achieve optimal training status and performance. However, this has often been suggested solely because of their observed high protein intakes, sometimes >4 g/kg body weight (BW) (108). The latter, however, does not mean that this is necessary.

Only a few well controlled nitrogen balance studies are available on strength athletes.

Protein requirements in strength athletes may be only slightly increased. However, athletes with a high energy turnover or consuming low energetic diets may be prone to a decrease in blood glucose levels and glycogen stores, both of which may induce increased AA oxidation. Independent of these nitrogen balance studies it is generally accepted that intakes of 1.5-2.5 g/kg body weight contribute to optimal well-being and performance in strength athletes.

Supplementation is particularly high among athletes involved in strength sports that are also weight class limited, or are characterized by the athletes. Desire to have a high muscle mass=low fat mass, as is the case in bodybuilders. Several studies have highlighted a very high use of supplements among bodybuilders in the range of 100% among females and 90% among males. Some bodybuilders seem to cycle the use of specific supplements or their combinations depending on their stage of training. In the building phase a special focus is on supplements that are believed to be helpful in improving muscle mass and muscle strength, whereas during the cutting off phase the focus is more on supplements that may help reduce fat mass.

The majority of the bodybuilders (70.3%) reported using supplements in order to meet the extra demands of heavy training and more than 50% to improve training performance and energy levels. The author concludes that many bodybuilders have attached false hopes to these products. Clearly, such false hopes are based on erroneous opinions and information as well as claims that are communicated by the marketing media of supplements companies.

|  |
| --- |
| **Key points**   * Sufficient protein consumption is required for optimal muscle growth and exercise-related repair of muscle damage and enzymatic adaptations. * The protein requirement of athletes is increased and, according to present knowledge, amounts to approximately 1.2-1.8 g/kg body weight for endurance athletes and about 1.0-1.2 g/kg body weight for strength athletes. The reason for this increase is enhanced utilization of amino acids in oxidative energy production during physical exercise - a process which is known to be intensified at higher endurance work levels and in a state of carbohydrate store depletion. * There is a close relationship between energy intake and protein consumption. Accordingly, endurance athletes generally ingest a protein quantity that is larger than their required amount. On the contrary, athletes who ingest low caloric diets may also have low protein intakes, which may not compensate for the net nitrogen loss from the body. This may influence protein synthesis processes and training adaptations negatively. To these categories belong body-builders, weight class athletes, gymnasts, dancers, female long distance runners and under some circumstances vegetarian athletes. * Protein intake=supplementation above levels that are normally required will not enhance muscle growth or performance. The building blocks of protein, amino acids, are also involved in numerous metabolic pathways and processes. Some of the amino acids are known to influence hormone secretion and neurotransmission. * Exercise-induced impairments in neurotransmission are speculated to influence fatigue/performance. However, data that support beneficial effects of single amino acids as present in currently available food supplements are generally lacking. * The use of single amino acids, to influence metabolic pathways involved in fatigue development and hormone production, needs further research before athletes should be informed positively about * benefits |