As we have discussed many times this term, our health is enhanced by more than just making good food choices. Physical fitness plays an important role in maintaining health and good nutrition helps to obtain better fitness.

People who are physically fit are more likely to have:

- Better resistance to infectious diseases
- Lower risk of diabetes
- Lower risk of some cancers
- Lower risk of cardiovascular disease
- Greater bone density
- A more optimal body composition with more muscle (lean body mass) and less fat tissues
- Nutritional flexibility – they can consume more calories
- Cardiovascular fitness – better respiratory and cardiac function with lower risk of cardiovascular disease
- Better sleep patterns
- Higher basal metabolic rate
- Reduced stress levels
- Physical and psychological well-being
- Better quality of life as one ages
- Improved fitness - can sustain physical activity for longer periods

Physical fitness refers to the characteristics that allow one to do physical activity and meet the demands of physical activity with reserve energy. Fitness is comprised of:

- Strength
- Flexibility
- Endurance
    - Cardiovascular
    - Muscle

And, for athletes - skill, coordination, balance and speed

Fitness is achieved and maintained by **exercise**, and **nutrition's role** in fitness is to **assist** the efforts of exercise to help realize one's potential. A physically active life promotes fitness, and fitness allows one to have a physically active and satisfying life, even if our fitness is only tested by the commute from the parking lot to our classrooms while carrying without effort the 50-pound expensive textbook-laden back pack.

No one really agrees about how much is too little or too much exercise, or exactly how any one individual will benefit from physical activity, but all agree that the sedentary lives led by too many are counter to fitness.

To benefit from physical activity one must **condition** his/her body. This requires training the body's muscles slowly and routinely to a specific group of physical motions. Conditioning involves performing physical activities designed to cause progressive overload on muscle tissues. The variables of progressive overload include:

- Frequency of activity
- Duration of activity
- Intensity of activity

Frequency, duration and intensity complement each other. Longer duration with less intensity can achieve the same level of fitness for health purposes as shorter duration with less intensity. An exception is frequency. Doing 6 hours of intense activity one day a week does not confer the same fitness benefit as 1 hour a day of moderate activity. In addition, infrequent, intense activity for a person who is not at optimal fitness for health puts him or her at health risks, particularly cardiovascular health risk.

Fitness guidelines include:

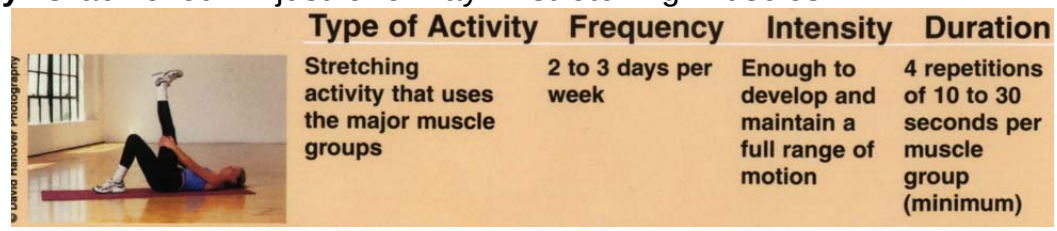
- Perform a sustained exercise of at least 20 - 30 minutes, preferably daily but a minimum of 3 - 4 times/week. Burn 3500 calories a week on some form of exercise.
- For health benefits, get an **hour** of physical activity daily. This can be a combination of 30 minutes of sustained activity and an additional 30 minutes comprised of 3 10-minute brisk walks, pulling weeds, chasing children or pets, etc.
- Do the activity "correctly", especially strength training and flexibility activities to prevent injury and maximize training benefit. Listen to your body and avoid over-activity that can lead to injury and health problems.
- Dress appropriately for the activity.
- Make physical activity a priority. Avoid putting off physical activity to infrequent, but longer sessions that do not confer the same health benefits.

For those with overweight issues, one can lose 15-20 pounds a year with 30 minutes of daily exercise.

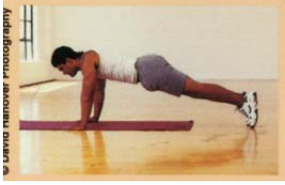
For those of appropriate weight, one can consume additional calories with more frequent exercise.

Each type of exercise chosen should address one or more of the components of fitness.

Flexibility is achieved in just one way – stretching muscles



Strength training requires activity known as resistance activity. Weight training is needed for develop muscle bulk. Weight training also helps maintain muscle tone.



Type of Activity	Frequency	Intensity	Duration
Resistance activity that is performed at a controlled speed and through a full range of motion	2 to 3 days per week	Enough to enhance muscle strength and improve body composition	8 to 12 repetitions of 8 to 10 different exercises (minimum)

Endurance is achieved by repetitious activity for longer periods of time for both muscle endurance and cardiovascular endurance. Weight training is beneficial for muscle endurance, although for endurance one uses lighter weights with more repetitions than when building muscle strength.

Cardiovascular fitness requires aerobic activities.

Type of Activity	Frequency	Intensity	Duration
Aerobic activity that uses large-muscle groups and can be maintained continuously	3 to 5 days per week	55 to 90% of maximum heart rate	20 to 60 minutes

No one exercise can fulfill all fitness requirements. It's best to combine exercises, which can also reduce the tedium and boredom risk. If, however, there is just one exercise you like and will do consistently, it's better to do just that exercise than to not exercise at all.

Benefits of Strength Training

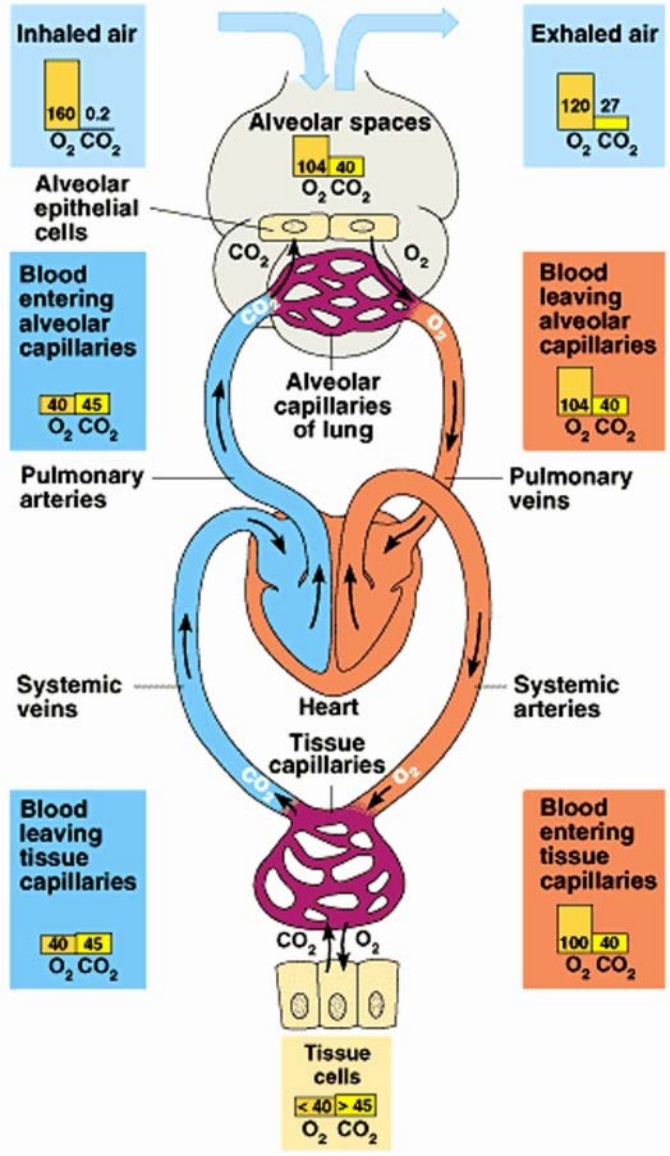
- More fit muscles put less pressure on the respiratory and cardiovascular systems to deliver oxygen and nutrients. More fit muscles can use a higher proportion of fats in cell respiration, preserving glycogen stores.

- Retaining mobility as we age is critical for quality of life. Studies on aging and fitness show that strength training is essential for retaining mobility. Elderly people in assisted care facilities after doing supervised strength training (weight-training) for several weeks, were able to improve mobility, had better eating habits and had better psychological well-being with the improved mobility. Balance also improved and they had fewer falls and injuries than before the strength training.

Benefits of Cardiovascular Fitness

Being able to circulate oxygen and nutrients to cells and tissues is essential whether one is fit or not. Cardiovascular fitness improves delivery of oxygen and nutrients to all tissues and removal of CO_2 from tissues, including muscle tissues. People with cardiovascular fitness have

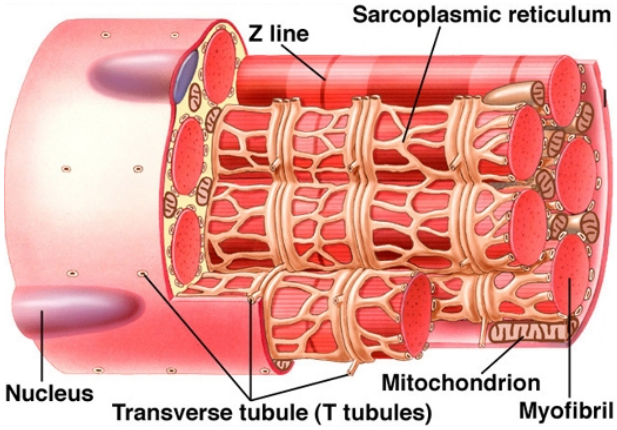
- Stronger hearts
- Lower resting pulse lower
- Increased breathing efficiency
- Lower blood pressure
- Better overall circulation

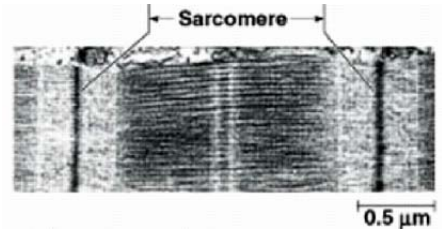


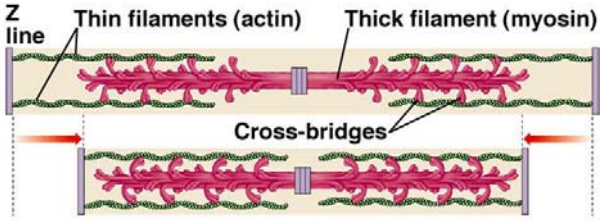
Muscle Structure and Muscle Activity

The amount and kind of muscle fibers an individual has is genetic. How fit one's muscles are depends on how we use them and maintain them. Although we have three different muscle types: skeletal, smooth and cardiac, skeletal muscle is the one used in physical activity.

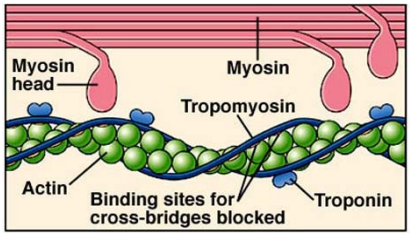
Skeletal muscles are banded and composed of units called sarcomeres. Each sarcomere has alternating thick (myosin) and thin (actin) filaments. The banding is caused by overlapping filaments. Each sarcomere is surrounded by membrane tubules, the transverse tubules (T-tubules) of the sarcoplasmic reticulum that store Ca^{++} ions, needed for muscle contraction.



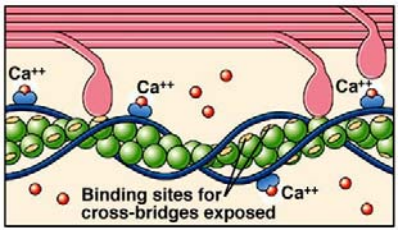




- Muscle contraction is initiated by nerve messages to the neuromuscular junction that activate Ca^{++} release from the T-tubules.
- Ca^{++} activates the actin thin filament. Actin binding sites are blocked when muscle is at rest. Ca^{++} binds to the blocking protein, freeing the actin binding sites.



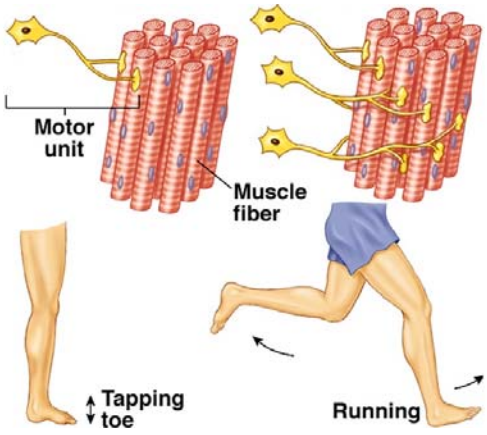
Resting Muscle Filament



Ca^{++} activation of binding sites

- ATP binds to myosin head forming a "charged" myosin - ATP complex.
- The charged myosin binds to the activated actin.
- ATP breaks into ADP and P, providing energy to slide the actin and myosin filaments past each other contracting the muscle. The myosin heads act like little ratchets that pull actin filaments past myosin filaments.
- Attachment of a new ATP to myosin detaches myosin from actin and the muscle relaxes.
- Removal of Ca^{++} are removed to the T-tubules freeing actin to have a new contraction.

A set of muscle fibers that is activated by a nerve is called a motor unit. More intense muscle action requires a greater number of motor units. Each sarcomere contracts fully or not-at-all.



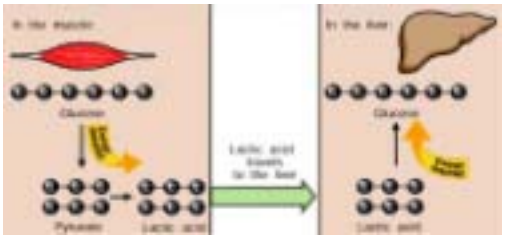
Muscle contraction can be aerobic or anaerobic. Anaerobic exercises build strength, bulk, and agility and promote fast-twitch muscle fibers. Other muscle fibers are aerobic (slow-twitch) and are used for endurance.

Activities that improve the cardiovascular system and muscle endurance are **aerobic**, or oxygen demanding. In contrast, strength and muscle bulk building activities are **anaerobic** activities, which require a burst of activity rather than sustained moderate action of the muscles. Such action may not use oxygen. Fit muscles are prepared for both anaerobic and aerobic activities.

Use of Nutrients to Support Muscle Activity

It's important that we understand the use of aerobic and anaerobic respiration and the fuel molecules used in muscle activity to better understand the role of nutrition in maintaining fitness.

- Only glucose or molecules that can be converted to glucose are used in anaerobic muscle activity.
- Sustained muscle activity must be aerobic in order to have the required amount of ATP produced to sustain the activity.
- Moderate muscle activity will burn proportionally more fatty acids in aerobic respiration for greater efficiency.
- Anaerobic respiration, if prolonged, results in the accumulation of lactic acid, which must be returned to the liver for conversion to pyruvate, and energy consuming process. Accumulation of lactate in muscles is indicative of placing demands on muscle above the muscle's level of fitness.



Although we addressed how our variety of energy-yielding nutrients is used in cell respiration, it helps to review nutrient fuels as specifically used in muscle activity. Any given muscle contraction is a rapid response and activity. In order to meet the demand for contraction muscle tissue has to have energy available to for the initial contractions, and then, a ready supply to sustain muscle activity.

Muscles that are fit have reserves of **myoglobin** (oxygen reserve), **glycogen stores** and **creatine phosphate** (phosphate reserve for ATP synthesis) for sustained response to muscle activity demand. Creatine phosphate can transfer its phosphate to ADP for rapid re-supply of ATP during muscle activity giving cell respiration time to "kick in". Very rapid intense muscle activity relies more on glycolysis than aerobic respiration for ATP simply because of the time needed to complete the Krebs cycle and electron transport activities in the mitochondria. Having stores of glycogen and creatine phosphate permit rapid intense muscle activity.

Diet and Endurance

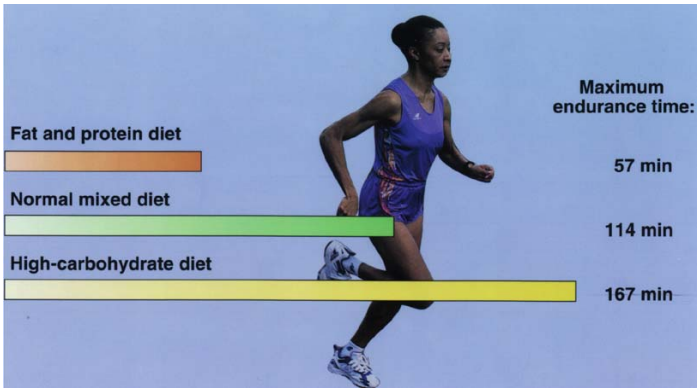
Most muscle activity using our skeletal muscles uses glycogen stores, if available, for the first 20 minutes or so of activity. After about 20 minutes, fats are mobilized and continued activity uses a mix of fatty acids and glycogen until the glycogen reserves and/or oxygen is depleted. When one is hypoglycemic and deprived of oxygen no respiration occurs and the body quits. In the absence of oxygen, fatty acid fuels are not processed. In the absence of glucose, anaerobic respiration cannot occur.

If fit muscles use mixes of fatty acids and glucose to sustain activity, what is the best diet? Some studies show that building glycogen reserves is important. As we have learned, glycogen is produced from excess glucose and stored in both the liver and muscle tissues up to about a 24-hour supply. As muscles use their glycogen, the liver responds by shipping its reserve into circulation.

- The amount of glycogen reserve depends on carbohydrate intake. If insufficient carbohydrate is consumed, glycogen reserves can not be maintained
- More fit muscles have more glycogen stores and can sustain activity longer. They have more water too, since glycogen attracts water.
- The amount and rate of glycogen use in muscle activity depends on muscle demand and conditioning.
- When muscle demand exceeds the ability to supply oxygen, glycogen is the only fuel that can provide ATP. Endurance activities that are intense rely on glycogen and anaerobic assistance for ATP production, along with aerobic respiration.

The Glycogen Loading Plan

Maximizing muscle glycogen is often a training goal for endurance activities, often referred to as glycogen loading. The benefits of glycogen reserves over other nutrient "stockpiles" have been shown with endurance activities. A diet high in fat and protein, but low in carbohydrate sustained running activity for 57 minutes. A "normal diet" for 114 minutes and a high carbohydrate diet with glycogen loading for 167 minutes. Marathoners have improved second-half performance with better glycogen reserves.



For non-endurance activities, glycogen loading may be negative, since muscles become heavier and less flexible.

For "competitive" bodybuilding (as distinguished from competitive weight lifting), muscle will look "bulkier" with better glycogen reserves (because of the water mostly). Weight lifters may find that glycogen loading inhibits activity, because the water adds no strength.

Maintaining Adequate Glycogen Reserves for Endurance Competition

- Eat a diet that has 8 grams of carbohydrate per kgm body weight or about 70% of total calories.
- Consume dilute juices, such as orange or tomato juice, or dilute sports drinks throughout the endurance activity.
- Eat carbohydrate-rich foods following the activity to regain stores. The sooner after muscle use one eats carbohydrates, the better the muscle is able to accumulate glycogen. Delays of more than two hours do not restore muscle glycogen effectively.
- Condition muscles to maximize glycogen storage.

Optimizing Fat Use for Physical Activity

As stated, after 20 minutes of moderate exercise, the body starts conserving glycogen and glucose and uses fats. With the exception of some endurance activities, for people who have good cardiovascular fitness increased use of fat reserves readily sustains muscle activity. Moderate muscle activity for long duration is one of the best ways to reduce the amount of one's fat reserves and lose weight so long as one is also not increasing total calories consumed

As intensity of activity increases, use of fat declines, as stated. However, more fit muscles can sustain a higher rate of fat use with increasing intensity, since demand on muscle is related to the fitness of the muscle. Someone who has poor muscle strength cannot do the same intensity of activity as someone who has more fit muscles. High intensity activity raises metabolic rate more, too, so overall energy requirements stay higher, longer, including those that routinely use fat mixtures for cell respiration.

Clearly, restricting fat intake below recommended levels is not beneficial.

Using Protein

Protein synthesis activities are suppressed during skeletal muscle activity and during the body's recovery time following activity. Protein synthesis is most active during resting periods. When we use muscles, and condition muscles, the body responds by building and repairing our muscle tissues, after the conditioning activity. However, the more fit our muscles are, the less protein is actually used for this routine maintenance.

We need adequate dietary protein to meet the muscle building and maintenance needs. As a general rule, muscle use does not require more **proportional protein** in the diet, although active people do use more protein than sedentary people require. Active people need more total calories and more total calories will contain proportionally more total grams of protein needed. For example, if one eats 3000 calories and 12% protein, he/she would have consumed 360 calories (90 grams) of protein. The same person who ate 200 calories and 12% protein would be consuming 240 calories of protein (60 grams). The additional 30 grams of protein consumed with the increased calories needed to sustain more activity can be used for added muscle needs.

Only minimal amounts of protein are used for fueling muscles, even under strenuous conditions. Endurance activity that depletes glycogen puts the most demand on protein for fuel, but endurance athletes tend to consume more calories, too, and if taken in proportion, those extra calories will provide additional energy nutrients.

When conditioning for added muscle bulk, one can easily double the **grams** of protein eaten. However, it is equally important to provide sufficient calories to support the activity needed to build that muscle, and if calories are taken in proportion to overall nutrient needs, you will get more grams of protein. Doubling the proportion of protein calories is not the same thing as increasing total grams of protein eaten. Recall that most of us already consume more protein than our bodies require. For most people, eating more protein is not really needed. And diets rich in carbohydrates and adequate in fat ensure that one's body protein is not degraded for fuel purposes, and that protein ingested can be used for protein needs not fuel.

Vitamin/Mineral Supplementations

There is no need to do supplementation for one who is more physically active assuming one's diet meets one's nutritional needs. Those who are active enjoy the opportunity to consume more total calories to sustain levels of physical activity and consequently can make more food choices that provide adequate total nutrients.

Additional **iron** may be needed for physical activity for some because of iron losses in sweating and more rapid degradation of red blood cells associated with some forms of exercise, particularly aerobic exercises that are high-impact. In addition, myoglobin requires iron, and the cytochromes of the electron transport system in the mitochondria require iron. Because of individual variations of iron intake, recycling and degradation, no recommendations are made to increase iron intake when more physically active, assuming one's diet is nutritionally adequate. Iron deficiency is more common in young women than in men, but there is not good evidence to show a relationship between performance and iron intakes.

Special "Supplements"

Hormones

Non-legal **anabolic steroids** are still used in the sports world. These have well-known negative effects. Your text describes these very well. One should never use these chemicals, even for short-term gains!

Two testosterone hormone precursors, **DHEA** and **androstenedione**, are also used in sports, again with the notion that better muscle development will occur faster with their use. It doesn't help when sports "heroes" admit to using these substances.

Some also use **growth hormones** to stimulate muscle growth. Excess growth hormone causes abnormal growth patterns and interferes with normal hormone regulation of kidneys, ovaries, thyroid, etc.

There is nothing known that improves muscles over the long term without negative side effects **except** sustained training and a balanced diet!

Other Ergogenic Supplements

Other purported physical activity enhancing supplements are discussed with our section on supplementation.

Fluid Needs in Exercise

Dehydration reduces the ability of the body to function. Dehydration leads to fatigue and diminished muscle work. Water losses during exercise include sweating to maintain thermoregulation and breathing. An endurance athlete may lose 1.5 liters of fluid in an hour. It is **critical** to maintain fluids during exercise! It is also critical to maintain appropriate body temperature. Health risks are associated with both over-heating and loss of too much body heat when exercising during cold temperatures. Fluids help maintain proper body temperature, although do not help if one is not appropriately dressed for cold weather activities.

Recommended fluid replacement for most is plain water, and plenty of it. Dilute juices or electrolyte beverages are also acceptable, but the more diluted, the better. Water readily moves across the intestinal lining to restore body tissues; solutes in the water interfere with its passage.

- **Electrolyte drinks**, carbonated beverages, **milk**, and full strength **juices** may have too many have solutes which compete for the water in the digestive tract, especially if you are seriously dehydrated
- **Salt** tablets are counter to fluid uptake
- **Caffeine** is a stimulant, and mobilizes fat use, conserving glycogen, but caffeine is also a serious dehydrator.
- **Alcohol** slows reaction time, causes water excretion by the kidney and is very dangerous to consume during or immediately after exercise!

Special considerations for those whose exercise and conditioning is not maintained at a consistent level – the off season

Muscles atrophy when not used and the "contents: of the muscle mass being degraded become available to the body either for fuel purposes or for conversion to stored fuel.

Too often, one sees a "body turned to fat". This is especially true for those who had very high muscle bulk. It takes constant work to maintain muscle bulk, and those muscles, when not worked, readily become fat bulk.

When one is losing muscle mass it's best to use the amino acids for fuel. In order to do so, one must decrease calories just as if one was on a weight loss plan. The body needs fewer calories to begin with when not in training or at a reduced level of conditioning. Failure to decrease calories taken in may result in an increase in body fat mass.

Special Problems Associated with Some Competitive Fitness Activities
Gastrointestinal disorders
Distance runners, in particular, are prone to increased intestinal motility. No one really knows why, and there is no cure. Adequate fluid intake to restore fluid losses from increased motility is important.

Pulmonary embolism
Sports (wrestling, gymnastics and jockeys) where weight is critical for performance involves some risk for blood clot formation that lodge in the lungs causing pulmonary embolisms. Individuals in these sports often practice severe food and fluid restrictions, and use diuretics to make the mandatory weight. As a result, individuals can:

- Lose muscle strength
- Have a lower blood volume
- Have higher blood viscosity

All of which can add up to the formation of blood clots.