Herbalife Fitness Manual

Please Note

This manual is not intended for the purpose of diagnosing or treating any illness or disease. It is intended solely as a source of information about Herbalife's nutrition and fitness programs. The products and programs mentioned in this manual are not being represented by Herbalife International or its nutritional and scientific advisors as being medical treatments or cures, nor are they considered to be substitutes for proper medical diagnosis or treatments.

This manual is intended as a guide to the science of nutrition and fitness behind Herbalife's products and programs. The information contained in this manual does not cover all possible uses, actions, precautions, side effects, and interactions. It is not intended as medical advice for individual problems. Liability for individual actions or omissions based upon the contents of this manual is expressly disclaimed.

1st Edition, 2006, Herbalife International, Inc.

Chairman, Herbalife Scientific and Nutritional Advisory Boards

A Letter to Herbalife Distributors and Your Customers

Dear Herbalife Disrtibutor/Customer ,

All humans are genetically programmed to be active and our modern society with its conveniences has reduced the amount of daily physical activity we all experience. Here in America, we are spending twice as much time in our cars and the average person spends seven hours per day watching television. These habits of inactivity are spreading around the world. One of the results of these changes is that obesity is the number one nutritional problem in the world today. Increasing physical activity and fitness are clearly a key part of the solution. Staying fit has a number of benefits including maintaining muscle mass and bone health as well as maintaining your metabolism.

The lack of physical activity leads to a gradual loss of muscle with aging which is considered to be a "normal" part of aging. However, being inactive is not a necessary part of aging and sitting around can lead to negative health consequences. There are simple, quick, and easy things you can do to slow down, stop or even reverse the decline in muscle mass and fitness with aging that will make you feel better and stronger every day. This manual will help you get started no matter where you are in your fitness level. The weekend athlete will benefit from this manual, but you will also benefit if you are sitting on your couch now thinking about getting fit.

This manual is designed to give you a basic understanding of nutrition and fitness. We have included scientific references so that if you wish you can investigate further the science behind this manual. However, this is not necessary and you will find all the information you need right here. If there is too much information for you, just skip to the part that interests you.

Herbalife International, is a publicly traded company listed on the New York Stock Exchange, a leader in nutrition and weight loss for 25 years, with $2 billion in revenues yearly invites you to become a "product of the product" and to embrace our fitness philosophy. Don't go to quickly. As our founder Mark Hughes said " Just get a little better every day." Certainly, our CEO Michael O. Johnson is a model of healthy fitness and nutrition that exemplifies Herbalife's "mission for nutrition."

With athletes all over the world setting the pace, you can join the Herbalife nutrition and fitness program now at any level. This Fitness Manual is based on concepts developed by David Heber, MD, PhD, Professor of Medicine and Public Health at UCLA* and Director of The Center for Human Nutrition at The David Geffen School of Medicine at UCLA*. Dr. Heber is Chairman of both The

Nutrition and The Scientific Advisory Board at Herbalife International and directs an international group of medical and scientific advisors.

The Vice President of Medical Affairs and Vice Chairman of the Nutrition Advisory Board Dr. Luigi Gratton MD, MPH will be working with a number of members of our Nutrition Advisory Board expert in nutrition and fitness. As an athlete and teacher, Dr. Gratton has a deep understanding of the concepts in this manual both from a theoretical and practical perspective. He will be taking the information in this manual around the world as an invaluable resource for all Herbalife distributors and their customers. .

This innovative state-of-the-art program offered to you by an industry leader with a 26 year history in nutrition and based on the best science available in nutrition and fitness will help you to provide a comprehensive program to support your fitness plans. Please feel free to contact us with any further questions at the phone number given above or via email at medaffneauto@herbalife.com. You can find more information about fitness products and programs from Herbalife at www.Herbalife.com .

Sincerely,

Luigi Gratton, MD, MPH
Vice President,
Medical Affairs and Education
Vice Chair, Medical Advisory Board

David Heber, MD, PhD,FACP, FACN
Chairman,
Nutrition and Medical Advisory Boards

*Dr. Heber's name and title are for identification purposes only, the University does not endorse specific products or services as a matter of policy.

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Section I. Introduction

A. Philosophy and History of Herbalife International

Herbalife International is a unique company that has a worldwide mission of changing people's lives through improved lifestyles, nutritional health, and weight management This company, now traded on the New York Stock Exchange (symbol HLF) is the largest manufacturer of meal replacements in the world with over 1 million independent distributors in over 60 countries.

How did Herbalife grow to this position as an international leader in nutrition? Herbalife was founded in 1980 by Mr. Mark Hughes. At the time this remarkable individual was only in his 20's but he had the passion to bring healthy weight loss solutions to the world since his mother died of complications from taking diet pills.

In his first year of business, he was able to sell one million dollars of meal replacements from the trunk of his car by offering people the opportunity to lose weight and at the same time make money by helping others. However, the company did more than give people a chance to make money. Mark Hughes inspired people to change for the better in many ways. He taught them to speak in front of groups as they received recognition. He taught them to train others to do the same job and then learn business and leadership skills in the process.

The critical issue in weight management is adherence to diet and lifestyle change. In our best universities, the average weight loss achieved in any trials is on the order of five percent of initial body weight on average with dropout rates from clinical trials of between 20 and 40 percent after one year. However, in these trials there are always individuals who do much better than the average and some who gain weight despite being given all of the nutritional and lifestyle tools to be successful. The key difference between those who succeed and those who fail is found in their personal motivation and ability to change themselves.

Through hard work and person-to-person contact, independent Herbalife distributors from every walk of life move up through the ranks at first helping their family and friends and then developing the skills to run a small business. Through training they can reach leadership positions in the company as President's Team and Chairman's Club members. These individuals with innate business skills often have little or no formal education or have failed in other businesses before coming to Herbalife. However, by combining product results, recognition, and a sense of community. Herbalife has helped countless individuals change their health status through long-lasting weight loss and maintenance. In the process, Herbalife has developed an army of over 1 million agents of change throughout the world, and one of the most powerful weapons in the war against the international epidemic of obesity.

Herbalife International was acquired from the estate of Mark Hughes in 2003 by the investment banking firms of Whitney and Golden Gate and is led by

CEO Michael O. Johnson, former head of Disney International and President Gregory Probert. The Chief Scientific Officer Steven Henig, Ph.D. has a twenty year history in the food business including positions with Con-Agra, Ocean Spray, and POM Wonderful and was a member of the Board of Directors of ILSI, the International Life Sciences Insititute. A prestigious 12 member Scientific Advisory Board is led by David Heber, MD, PhD, FACP, FACN Professor of Medicine and Public Health and Director of the prestigious UCLA Center for Human Nutrition. Dr. Louis Ignarro, winner of the 1998 Nobel Prize in Medicine and Physiology is a member of the board. Under the leadership of Dr. Heber, Dr. Luigi Gratton, MD, MPH, a Clinical Instructor in Medicine at UCLA administers a worldwide Medical Advisory Board made up of highly qualified physicians often with current or former prestigious university affiliations who work in the training of Herbalife distributors in science-based approaches to nutrition and weight management.

B. Cellular Nutrition

Good nutrition begins at the cellular level. Not only must the nutrients be delivered but they must get to the appropriate cells of the body. These principles are the basis for cellular nutrition. Cellular Nutrition is the overriding nutritional philosophy of Herbalife International . A fully referenced section on Cellular Nutritoin and the Fundamentals of Human Nutrition is included in Section 2 below.

Today, throughout the world, people are facing undernutrition of vital nutrients that their cells need for good health. This occurs even in countries where overweight and obesity are common. In the past 100 years, the human diet has changed drastically in ways that do not fit well with our genes. Our cells are adapted to a calorie-poor environment, rich in bioactive substances from colorful fruits and vegetables, and high in dietary fiber and healthy plant-based proteins. Our genes cannot change rapidly enough through evolution to enable us to adjust in just the past few hundred years to a diet missing key cellular nutrients.

For example, humans and fruit-eating bats have given up the cellular machinery to make vitamin C, since both our diets and those of fruit-eating bats were originally rich in vitamin C from plant foods. Unfortunately many individuals in the US don’t eat a single piece of fruit all day and so do not get enough vitamin C for optimum health. They often can get the tiny amount (20 milligrams) needed to prevent scurvy from fortified foods, but not enough to get the antioxidant benefits of this essential vitamin.

Similarly, many different pathways promote retaining calories when excess food is eaten. The key element in reaching a successful body composition is not simply eating less but eating more of the right foods. Significant scientific evidence supports a high protein/low fat diet including meal replacements such as Herbalife’s ShapeWorks Formula 1 fortified when necessary with Performance Protein Powder to provide additional protein to help control hunger and support increasing muscle mass with exercise. ShapeWorks meal replacements taken twice a day lead to weight loss while one meal replacement per day helps keep weight off for life. Meal replacements work by structuring the diet so that the healthy shake is providing better control of hunger and more protein to support the lean body mass than the foods normally eaten at meal time. However, these shakes are taken with at least one healthy meal per day, and Herbalife includes a healthy colorful meal plan recommending seven servings of fruits and vegetables per day.

While it was generally taught in medical schools some twenty years that you got all you need from the so-called four basic food groups, this is not true. Significant research reviewed in this manual demonstrates that most Americans are not getting what they need from the diet and nutritional supplements are a useful prevention strategy for the general population.

Of course, nutritional supplements work best when used together with a healthy diet and lifestyle. Nutritional supplements help you obtain vitamins, minerals, proteins, and other nutrients frequently missing from modern diets. Supplementation including multivitamin supplements, protein supplements, individual mineral and vitamin supplements provided alone or in combination as well as botanicals, amino acids, and other supplements are being used by millons of consumers around the world.

Herbalife International has been providing nutritional supplements to over one million distributors in 64 countries and is making a positive contribution to the lives of millions around the world. With over 27 years of experience in providing the finest nutritional supplements available, Herbalife is changing the health of the world one person at a time.

C. How Does Fitness Relate to Herbalife's ShapeWorks Program

Over the past 27 years, Herbalife International has become the leading global manufacturer of meal replacements for healthy nutrition and weight management. The goal of weight management is to achieve and maintain not only a healthy weight but also a healthy shape. Shape is critical to achieving the health goals of weight management, since shape includes the concept of body fat distribution, optimizing lean body mass and getting into proper level of fitness. Shape means both body shape and "getting into shape" and so provides a valuable tool for communicating the benefits of a healthy diet and lifestyle regardless of body weight.

It is not simply the weight of the body that determines health but the quality of the body tissues in terms of lean versus fat. Simply because someone is overweight, normal weight, or underweight, does not tell you that they are in nutritional balance. Weight loss can lead to loss of lean body mass which occurs during unsupplemented starvation and with hypocaloric diets that are deficient in protein.

A body of scientific research is demonstrating that increased protein provided at about 1 gram per pound of lean body mass (29 percent of resting metabolic rate) provides better control of hunger and maintains lean body mass better than the usually recommended amount of protein which is about 15 percent of total calorie intake. In addition to research at UCLA which forms the basis for the ShapeWorks program, recent studies in Australia and in Colorado demonstrate that increased protein may be especially useful for promoting weight loss in the pre-diabetic insulin resistant obese individual. Herbalife is currently doing studies in Brazil, Germany, and Korea.

Fitness is part of Herbalife, because exercise helps to maintain healthy body weight. During weight loss, exercise has a minimal effect on speeding up weight loss. However, it is one of the most important habits to help you keep your weight off for the long term.

Here are the pillars of our nutrition program including fitness:

Pillars of our Program

I. ***Lose Fat/Retain Muscle*** while you ***Increase Energy*** and ***Control Hunger*** – ***ShapeWorks, PPP, Green Tea, Herbal Tea, Multivitamins***

II. ***Increase Your Energy*** – ***Liftoff, Niteworks***

III. ***Protect Your Cells*** by ***Balancing Nutrition*** – ***Herbalifeline, Green Tea, Aloe Concentrate***

IV. ***Get and Stay Fit***

Many Americans take in too little protein and have a sedentary lifestyle. resulting in loss of muscle and increase in fat or sarcopenic obesity. Attempts at rapid weight loss by eating less of their favorite foods results in deficiencies of multiple nutrients usually including protein. When In this common condition, lean tissue is deficient and the percent body fat is high (>30 percent) despite a normal Body Mass Index (BMI). Similarly, weight lifters can be overweight with a high BMI, but have a normal percent body fat. Their increased weight is due to increased muscle tissue, and they require increased protein based on their lean mass both to control hunger and maintain muscle.

The rate at which weight is lost is a function of how much of a calorie deficit you create from those required to maintain current weight. For every 500 Cal/day deficit created through calorie restriction, increased physical activity or some combination of the two, there will be a one pound weight loss per week. Increased protein intake does not make weight loss more rapid, but it does result in better maintenance of lean body mass at the same rate of weight loss when compared to a lower protein intake. Starvation is the extreme in which about 1 pound of body protein is lost for every 4 pounds of weight lost. With exercise and increased protein intake during weight loss, it is possible to minimize the loss of lean body mass.

Some thin women will gain weight when given adequate protein due to an increase in muscle mass. They may not be happy with this and it is their choice to remain at a lower muscle mass. However, in order to keep their body fat percentage in a healthy range these women will need to burn calories daily with aerobic exercise and carefully watch their food intake to minimize total calorie intake. Their lower muscle mass means that they will need fewer calories to maintain their tiny shape.

Consistency in maintaining a simple program is the key to steady weight loss. Herbalife Tea Mix – Lemon & Hibiscus taken hot or cold is an important adjunct to weight loss using ShapeWorks. It provides energy during the late afternoon or whenever this is needed during the day. When individuals are overweight or obese, sympathetic nervous system activity is increased. Low energy and fatigue are common complaints during dieting and Herbalife Tea Mix – Lemon & Hibiscus can help to boost energy during the day.

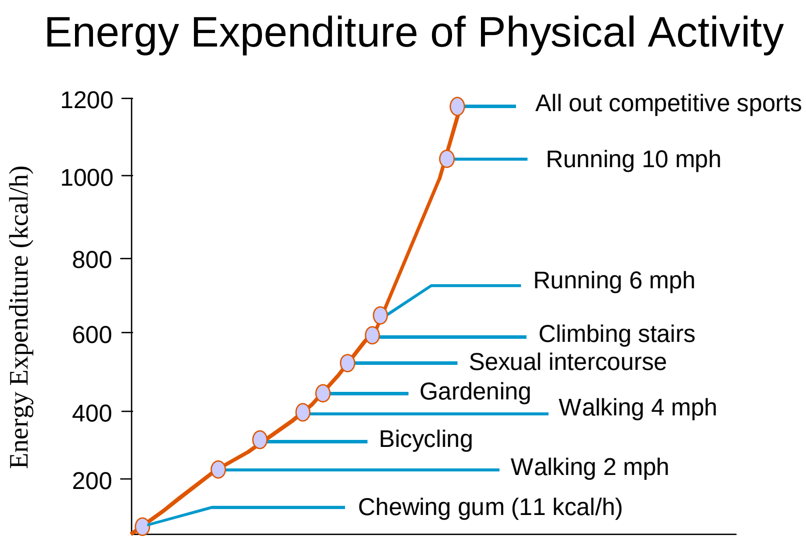
The ultimate secret ingredient in this program is the care that each Herbalife distributor provides to their customers. Herbalife International provides many resources in the form of pamphlets and educational materials as well as downloadable web-based information to help distributors provide the best care for their customers. In addition to these resources, the Medical Affairs Department maintains an e-mail for inquiries and inquiries can be made by phone through the Herbalife Call Center.

Section 2: Background Material

1. Fundamentals of Fitness

There are many benefits to having a healthy active lifestyle including regular exercise including the following:

Benefits of Physical Activity and Exercise
•Decreases loss of fat-free mass associated with weight loss
•Improves maintenance of weight loss
•Improves cardiovascular and metabolic health, independent of weight loss

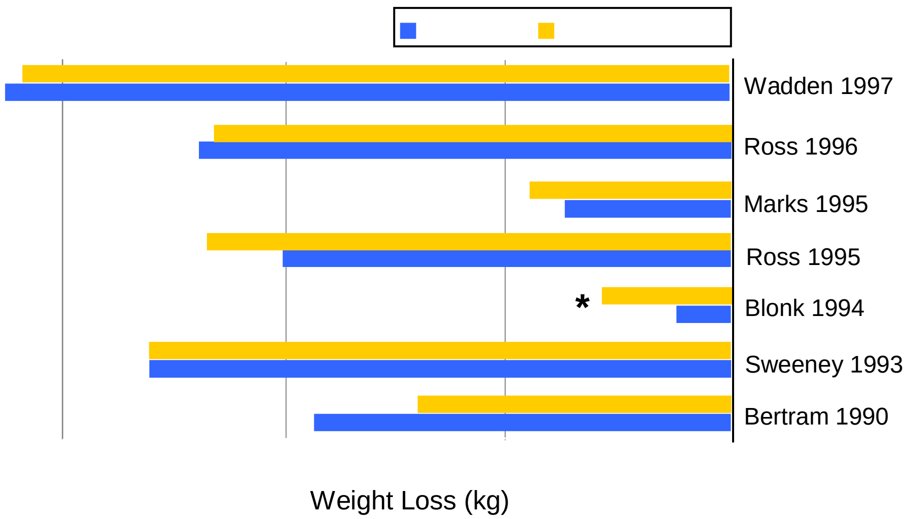


Adapted from: Alpers. Undergraduate Teaching Project. Nutrition: energy and protein.
American Gastroenterological Association, 1978.

Many activities of daily living burn calories and these calories can be beneficial in maintaining a healthy body weight. The energy used in various forms of exercise and physical activity is shown above.

It takes a lot of physical activity to burn enough calories to make a difference in weight loss. Physical activity as shown below does not increase the rate of weight loss, but it is an important strategy for maintaining weight loss in the long-term.

Physical Activity Usually Does Not Increase Short-term Diet-Induced Weight Loss

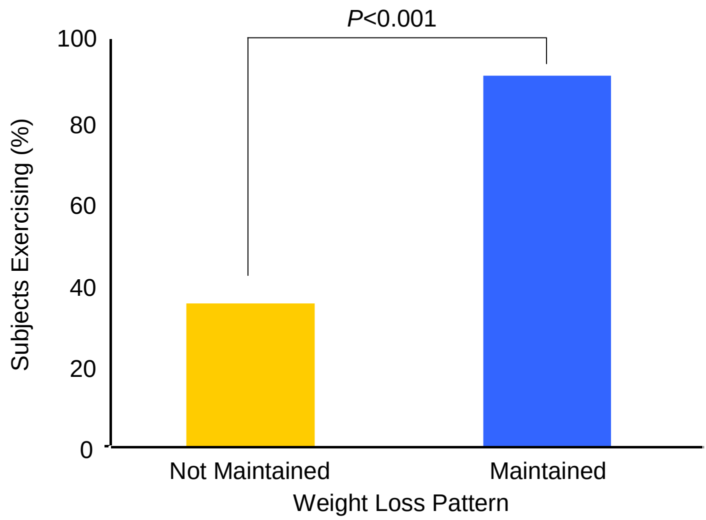


Duration of each study ranged from 4 to 6 months.

***P*<0.05 vs diet-only group.

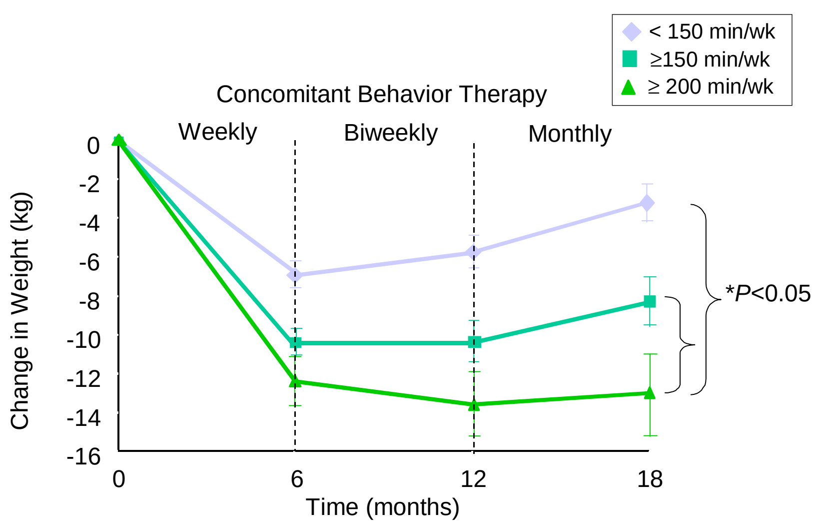
Wing. *Med Sci Sports Exerc* 1999;31(suppl):S547

Relationship Between Physical Activity and Maintenance of Weight Loss



Kayman et al. *Am J Clin Nutr* 1990;52:800.

Considerable Physical Activity is Necessary for Weight Loss Maintenance

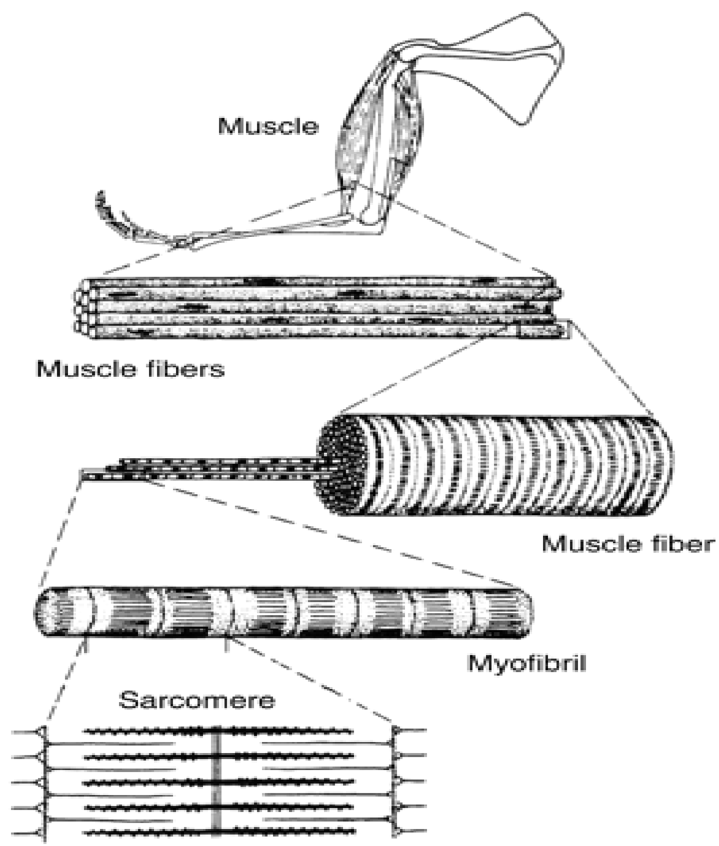


Jakicic et al. *JAMA* 1999;282:1554.

As shown above, you need to do over 200 minutes per week (which is only 30 minutes per day) to maintain weight loss. Why does it take so much exercise to maintain weight and why doesn't exercise help with short-term weight loss induced by diet? Below we discuss the energetics and metabolism of anaerobic and aerobic exercise which provides the answer.

II. Fuel Utilization During Exercise

Skeletal muscle requires energy to relax. Contraction is an automatic process once calcium channels are opened resulting in the binding of calcium to troponin. The troponin protein inhibits the movement of actin and myosin fibers. Therefore, once troponin is inactivated by calcium, muscle contracts. The fact that energy is needed to relax muscle is best illustrated by rigor mortis where the eyelids remain open. You may remember in the old Western movies where the villain eyes are closed by the sheriff after he is shot dead.



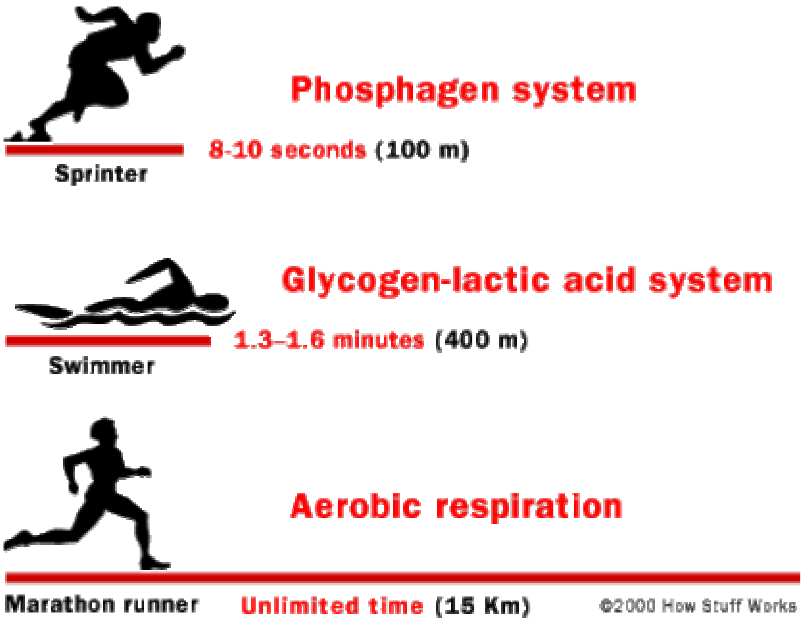
Under most circumstances, fat and carbohydrate are the fuels utilized during exercise. The degree to which each fuel acts as the primary or secondary source of energy and the efficiency with which energy is utilized depends on the prior nutrition of the athlete and the intensity and duration of the exercise. At low levels of prolonged exercise most energy needs come from fat and lesser energy needs come from carbohydrate. At higher intensity carbohydrate plays a greater role but is limited in its duration of action. Protein plays only a minor role at very high levels of energy utilization, but adequate protein intake is critical for maintenance of lean body mass to enable exercise performance.

Energy is extracted from foods in the body by converting the chemical energy stored in chemical bonds to high energy phosphate bonds in **ATP (**Adenosine Triphosphate). This high energy bond can be used in a number of biochemical reactions as a fuel with the conversion of ATP to ADP (adenosine diphosphate). If ADP begins to accumulate in muscle then an enzyme is activated in muscle to break down phosphocreatine (**PCr**) in order to restore ATP levels (PCr + ADP $\rightarrow$ ATP + Cr). The creatine released from this reaction is converted to creatinine and excreted in the urine. The stores of PCr are extremely limited and could only support muscle ATP levels for about 10 seconds if there were no other sources of ATP. Since ATP is provided from other sources, PCr ends up being a major energy source in the first minute of strenuous exercise. PCr has the major advantage of being localized in the muscle so that it can rapidly restore and maintain ATP levels for intense exercises such as sprinting, jumping, lifting, and throwing.

II. Aerobic and Anaerobic Metabolism

With moderate exertion, carbohydrate undergoes **aerobic metabolism**. Under these conditions, oxygen is used and the carbohydrate goes through both the Embden-Meyerhoff pathway of **anaerobic metabolism** in which glucose is converted to lactate, but, prior to the conversion of pyruvate to lactate, pyruvate enters the **Krebs Cycle** in mitochondria where oxidative phosphorylation results in a maximum extraction of energy from each molecule of glucose. If there is plenty of oxygen available and the exercise is of low to moderate intensity, then the pyruvate from glucose is converted to carbon dioxide and water in the mitochondria. Approximately 42 ATP equivalents can be produced from a single glucose molecule compared to only 4 ATP with anaerobic metabolism.

A muscle cell has some amount of ATP floating around that it can use immediately, but not very much -- only enough to last for about three seconds (see figure below). To replenish the ATP levels quickly, muscle cells contain a high-energy phosphate compound called creatine phosphate. The phosphate group is removed from creatine phosphate by an enzyme called creatine kinase, and is transferred to ADP to form ATP. The cell turns ATP into ADP, and the phosphagen rapidly turns the ADP back into ATP. As the muscle continues to work, the creatine phosphate levels begin to decrease. Together, the ATP levels and creatine phosphate levels are called the phosphagen system. The phosphagen system can supply the energy needs of working muscle at a high rate, but only for 8 to 10 seconds.



Aerobic metabolism supplies energy more slowly than anaerobic metabolism, but can be sustained for long periods of time up to 5 hours. The major advantage of the less efficient anaerobic pathway is that it more rapidly provides ATP in muscle by utilizing local muscle glycogen. Other than PCr, it is the fastest way to resupply muscle ATP levels. Anaerobic glycolysis supplies most energy for short term intense exercise ranging from 30 seconds to 2 minutes. The disadvantages of anaerobic metabolism are that it cannot be sustained for long periods, since the accumulation of lactic acid in muscle decreases the pH and inactivates key enzymes in the glycolysis pathway leading to fatigue. The lactic acid released from muscle can be taken up by the liver and converted to glucose again (**Cori Cycle**), or it can be used as a fuel by the cardiac muscle directly or by less active skeletal muscles away from the actively contracting muscle.

Muscle glycogen is the preferred carbohydrate fuel for events lasting less than 2 hours for both aerobic and anaerobic metabolism. Depletion of muscle glycogen causes fatigue and is associated with a build-up of muscle lactate. Lactate production increases continuously but physiologists have defined a point at which breathing changes as a result of acid-base imbalance called the **anaerobic threshold**. Both the nutrition and conditioning of the athlete will determine how much work can be performed in a specific exercise before fatigue sets in. This can be measured directly or indirectly. An indirect measurement uses an exercise treadmill or stairway according to standard protocols and pulse is measured. The more conditioned athlete can produce the same amount of work at a lower pulse rate. This indirect determination assumes that pulse rate is proportional to oxygen consumption. On the other hand, oxygen consumption can be measured directly during exercise. A motorized treadmill is usually used to increase the intensity of exercise until fatigue occurs. The amount of oxygen consumed just before exhaustion is the maximal oxygen uptake or VO_2max.

Exercise intensity can be expressed as a percentage of VO_2max. Low intensity such as fast walking would be 30 to 50% of VO_2max. Jogging can demand 50 to 80 % of VO_2max depending on the intensity, and sprints can require from 85% to 150% of VO_2max (with the added 50% coming from short term anaerobic energy production).

It is possible to build up glycogen stores prior to exercise to improve performance. With exercises lasting for more than 20 to 30 minutes, blood glucose becomes important as a fuel to spare muscle glycogen breakdown. Both aerobic and endurance training lead to increases in glycogen stores, triglycerides, oxidative enzymes, and increased number and size of mitochondria. Both the oxidative enzymes involved in the Krebs cycle oxidation of glucose and the lipoprotein lipase needed to convert triglycerides to fatty acids are increased through training. This is not a general effect, but is specific to the muscle and muscle fiber type being used for the exercise. Slow twitch muscle fibers provide for prolonged aerobic activity, while the fast-twitch muscle fibers are used for short intense activities.

The fatigue that develops with intense exercise can be related to specific fiber types. In prolonged exercise at 60 to 75 percent of VO_2max Type I fibers (red, slow twitch) and Type IIa (red, fast twitch) are recruited during the early stages of exercise, but as the intensity increases Type IIb fibers (white, fast twitch) must be recruited to maintain the same intensity. It requires more mental effort to recruit Type IIb fibers and they produce lactic acid. As the glycogen levels drop in the red muscle fibers, they will rely more on fat. Since fat is less efficient than carbohydrate, intensity will decrease (pace will slow).

At the other end of the spectrum, during mild exercise such as a brisk walk, muscles burn fat for fuel because the supply of ATP provided from fat is adequate to maintain intensity. As mentioned earlier in this course, fatty acids are readily available from stored fat and the rate of lipolysis is three times the rate of fatty acid release at rest so that fatty acids can be supplied at an increased rate rapidly during the onset of low levels of exercise. So while fat is not very useful for short term, intense exercise, it is a great advantage for increasingly prolonged exercise especially when it is maintained at a low or moderate level of intensity.

The advantage of fat as a fuel is that it provides extensive stores of calories in a easily portable form. Since fat is not hydrated it weighs much less per unit calorie than protein or carbohydrate (9 Cal/gm of fat vs. 4 Cal/gm of carbohydrate or protein). When you compare the number of ATP produced per carbon atom, fat is also more efficient. A 6-carbon glucose molecule produces 36 to 38 ATP on average providing a ratio of 6 ATP/Carbon, while an 18 carbon fatty acid produces 147 ATP providing a ratio of 8.2 ATP/Carbon. However, carbohydrate is more efficient than fat when the amount of ATP produced per unit of oxygen consumed is considered. Six oxygen molecules are required to metabolize six-carbon glucose producing 36 ATP (ratio = 6 ATP/oxygen molecule), while 26 oxygen molecules are required to produce 147 ATP from an 18 carbon fatty acid (5.7 ATP/oxygen molecule). Therefore, for a performance athlete it is important to maintain the efficiency edge provided by carbohydrate as long as glycogen is available in the muscles. Under usual exercise conditions, protein only provides about 6% of energy needs. With high intensity endurance exercise, the production of glucose from amino acids can be significant up to about 10 or 15% of total energy needs. The only food that provides energy for short-term fast-paced exercise is carbohydrate, while slow steady aerobic exercise uses all three primary fuels but primarily fat and carbohydrate.

Assessment and Prescription of Exercise and Physical Activity

1) Medical and psychological readiness
2) Physical limitations

3) Current activities

4) Barriers to activity

•Develop physical activity plan

•Start activity slowly and gradually increase planned aerobic activity to 200 min/wk

•Enhance compliance

–Programmed vs lifestyle activity

–At-home vs onsite activity

–Multiple short bouts vs single long bout of activity

The Exercise Prescription: How Much Exercise Is Enough?

The practical application of the above knowledge falls into two categories: first, the prescription of adequate amounts of exercise to optimize performance, and second, the use of dietary, hormonal and pharmacological ergogenic aids to improve performance. The second topic will be covered later in the course, but this brief introduction to exercise prescription is provided as a background to your upcoming self-assessment exercise.

Cardiovascular Training

A gradual incremental exercise program emphasizing cardiovascular fitness is the basis of all exercise programs. Vigorous exercise involves minimal risks for healthy individuals but can be risky for couch potatoes or the dedicated sedentary. These individuals should check with their physician first as should all those over 35, or with medical conditions such as arthritis, hypertension, shortness of breath, diabetes, obesity, or a family history of heart disease.

A basic prescription involves a stretching session and a ten minute low intensity warm-up, to increase blood flow and minimize risk of injury. Then exercises to increase muscular strength, endurance, and flexibility are done. These should be performed at an intensity adequate to increase heart rate into a training zone which is 60 to 90 % of maximum age-adjusted heart rate (**MHR** = 220 - age). I usually start individuals at 50 to 60% of MHR, and then keep them in the training zone. For weight loss, prolonged sessions at 70% of MHR are effective at burning fat, while increased levels of exercise induce muscle to hypertrophy. A ten minute cool-down is important to minimize cramping and muscle injury at the end of each session.

Components of Fitness

Flexibility - ability to bend without injury which is dependent on the elasticity of muscles, tendons, ligaments, and joints. Stretching for at least 10 seconds with gradual tension will improve flexibility.

Strength - the ability to work against resistance. Strength of particular muscle groups can be increased by careful heavy resistance training at 60 to 80 % of single repetition maximum with three sets of 8 to 12 reps.

Endurance - the ability to sustain effort over a period of time. high repetition exercises such as push-ups, pull-ups, and sit-ups increase endurance.

Cardiovascular Endurance - the ability of the cardiovascular system to sustain effort over a period of time. This should involve larger muscle groups and be at 60 to 90 % of MHR.

THE EXERCISE PRESCRIPTION

•A basic prescription involves a stretching session and a ten minute low intensity warm-up, to increase blood flow and minimize risk of injury.

•Exercises should be performed at an intensity adequate to increase heart rate into a training zone which is 60 to 90 % of maximum age-adjusted heart rate (MHR = 220 - age).

•For weight loss, prolonged sessions at 70% of MHR are effective at burning fat, while increased levels of exercise induce muscle to hypertrophy.

Note: A ten minute cool-down is important to minimize cramping and muscle injury at the end of each session.

How Many Calories are Burned?

Exercise output can be quantified as METs which are a ratio of the energy being burned to that burned at rest. An individual at rest burns about 1 Cal/per kg/per hour (depending on lean body mass content) and this rate is one MET. Therefore a 50 kg woman would be expending about 10 mets if she was in a heavy aerobics exercise class expending 500 Cal/hour.

$$\frac{500 \text{ Calories/hour}}{1 \text{ Cal/kg} \times 50 \text{ kg}} = 10 \text{ METs}$$

Typical MET levels (for comparison only, since they differ by individual):

For a 150 pound male:

Activity	MET level	Calories/Hr
Writing	1.7	118
Walking	4	299
Basketball	10	544
Bicycling	3	204
Eating	1.4	93
Jogging	7	476
Weightlifting	9	612

Strength Training Basics

In the last 15 years, better strength training programs have been developed as scientists learned more about how to maximize muscle building over the long term. Studies have shown that over the first twelve weeks the general advice of doing three sets of 8 to 10 repetitions of weight lifting exercises at 60 to 80 percent of the maximum weight you can lift has as good a result as more scientific programs. The difference shows up when you look at results over 6 months to a year between standard training advice and periodized resistance training – where different workouts with different intensities and different numbers of repetitions are used together with different rest and recovery periods.

Individualization is a principle of training just as it is of judging metabolism and protein requirements. Baseline testing of your muscle strength is needed to determine which muscle groups need strengthening. The next step is the development of realistic, specific, and individual goals. So, your expectations for improvement can be framed in terms of time and ultimate muscle bulk or strength desired.

Specific movements and tasks train groups of muscles involved in those complex movements. The type of muscle fiber recruited to the movement also depends on how much external weight is being lifted. Endurance exercises at low weights and high repetitions recruit the Type I slow-twitch fibers while heavier exercises recruit the type 2 fast-twitch fibers as well.

You should not experience pain in your workouts, but you need to stimulate your muscles to grow by constantly increasing the demands you make on your muscles at every session. The muscle fibers are stretched on the down cycle of a biceps curl. So the sequence of timing should be two seconds on the upswing and a slower controlled four seconds on the downswing. For other exercises up may be down or sideways and you need to decide which is the eccentric movement for the muscle you are trying to train. On the last few repetitions you should feel a slight burning on the eccentric move.

The term for this is progressive overload and simply means if you were comfortable doing ten repetitions of an exercise - now go to eleven. The way to measure this scientifically is to use the one-repetition maximum or 1RM. The external weights at which you can do five repetitions is called the 5RM, and the weight at ten repetitions 10RM and so forth. The RM system has been used for more than 50 years to describe resistance exercise intensities. Using this system DeLorme and Watkins in a famous paper documented the importance of progressive resistance exercise to build the quadriceps muscles for the purpose of rehabilitating military personnel with knee injuries.

An RM training zone of 8 to 10RM is the general level used by most trainers, but in order to continue to improve variation is needed and that is where periodized training is used. The various intensities for different types of training days are listed below:

Very Heavy: Maximal development of 1RM strength by doing 3 to 5 sets of 2 to 4 repetitions and resting 4 minutes or more between sets.

Moderate: Strength development, increase muscle size, and some endurance by doing three sets of 8 to 10 repetitions with 2 to 3 minutes rest between sets

Power Training: Development of maximal mechanical power in a multiple joint exercise such as throwing a medicine ball by doing 3 to 6 sets of 3 repetitions at 30 to 50% of the 1RM with 3 to 4 minutes rest between sets.

Very Light: For developing local muscle endurance by doing two sets of 15 to 17 repetitions with less than one minute rest between sets.

High Lactic Acid: To develop tolerance lactic acid accumulation in muscles which normally cause fatigue and soreness by doing three sets of 8 to 10 repetitions with only 1 to 2 minutes of rest.

Periodized training on a four day per week workout schedule could consist of varying from heavy (3 to 5RM) to moderate (8 to 10 RM) to light (12 – 15 RM) on successive Mondays and Thursdays. While on Tuesday and Fridays you would train with moderate loads of 8 to 10 repetitions. If more repetitions than the target can be achieved the resistance can be increased for the next session. When this type of regimen was tested in college-age women against simply working out three alternate days per week at 8 to 10 repetitions, there was a clear advantage for the periodized method, but this advantage was not realized until 6 months. At 12 weeks, both methods worked.

For most exercisers, varying the routine by doing using different strategies on different days reduces boredom and tends to keep them involved in the training program. This model has been proven to be superior to using the same repetition maximum in every workout. Your workouts should be individually supervised to be sure you are doing each exercise in the above sequence correctly. The American College of Sports Medicine (ACSM) certifies health and fitness instructors and this should be a minimum requirement for the trainer you choose. I would also get personal recommendations as you would with any professional you consult.

Control of Muscle Protein Metabolism/Anabolism

The area of sports nutrition and anabolic strategies draws its rationale from the physiology of starvation reviewed earlier and on the interrelationships of fuels during aerobic and anaerobic exercise already discussed. There are two broad areas which will be discussed: 1) Ergogenics which are substances touted to enhance performance; and 2) Anabolics which are substances touted to build muscle. The rationales for the various approaches will be reviewed, but it should be emphasized that there is much room for future research and contributions in this field.

1. Ergogenics

The background to increasing energy and performance is eating a balanced diet meeting the same dietary recommendations given for the general public. Because of the importance of loading carbohydrate as emphasized below, and because there are adequate fat stores for exercise, many athletes prefer to shift from eating a general diet of 25% fat, 50% carbohydrate and 25% protein to one with 60% carbohydrate, 15% fat, and 25% protein on training and performance days. This diet recommendation provides adequate protein at about the level of 1 gm/lb of lean body mass. A number of studies have demonstrated that this is an adequate amount of protein which can be kept constant with increased energy demands as long as adequate carbohydrate is provided. This makes sense, since protein is rarely used as a fuel in exercise. Furthermore, most amino acid tablets provide too little protein to be a significant source of high quality protein which is more easily derived from egg white, soy, or milk protein.

As already reviewed, in moderate intensity exercise lasting 4 to 6 hours, 60 to 70% of the fuel burned is fat. Exercising for 10 to 15 minutes does not burn significant amounts of fat. Short bursts of high intensity exercise burn primarily carbohydrates and require large stores of glycogen in the muscle. Training causes an increase in the mitochondrial capacity for fat oxidation which spares glycogen utilization. Therefore, the trained athlete will burn fat with long term moderate intensity exercise, but will also want to be sure that the glycogen stores are repleted.

Everything that follows in regard to ergogenics does not apply to the weekend athlete, but to the trained high performance athlete where differences in mood, energy, and minor differences in metabolism can be the 0.3 seconds difference between a gold and silver medal in the Olympics. Since many of these effects are minor, they are difficult to demonstrate in standard scientific experiments using normal subjects who are not highly trained athletes.

A. Water and Bicarbonate

It is recommended that 0.4 to 0.6 liters (14 to 20 oz.) of cool water be ingested 15 to 20 minutes before exercising (1). Typical insensible losses of water in an athlete total about 2.4 liters per day. It is also recommended that 0.5 to 2.0 liters/hour be ingested in most forms of exercise activity. In heavy endurance performance, it is recommended that 3.0 liters/hour be ingested. Dehydration leads to decreased aerobic capacity (2). Bicarbonate is an important buffer which can neutralize organic acids accumulated from protein breakdown, and also help to neutralize lactic acid released from muscle during anaerobic glycolysis. When lactic acid combines with bicarbonate, carbon dioxide gas and water are formed. The carbon dioxide is excreted through the lungs. By increasing the concentration of bicarbonate in blood, the buffering capacity is increased for lactic acid.

B. Carbohydrate Loading

It was previously recommended that a 3 day regimen be used to load glycogen stores (3-5) but during rest days prior to an event it is now recommended that a 65-70% carbohydrate diet be ingested as discussed above. Many athletes also load carbohydrates just before an event. This pre-exercise loading depends on the period remaining until exercise and will vary from 1 to 4 gm carbohydrate/kg as follows (6):

Example: for a 64 kg athlete -	1 hr. before exercise:	64 g.	of carbohydrate
	2 hr. before exercise:	128 g.	"
	3 hr. before exercise:	192 g.	"
	4 hr. before exercise:	256 g.	"

During exercise it is recommended that 15 to 30 gm/ half hour be ingested (7,8). The most rapid glycogen depletion occurs immediately after exercise. Waiting 2 to 3 hours after exercise to ingest carbohydrates reduces the rate of glycogen repletion, while taking 50 to 75 grams of carbohydrate within 30 minutes followed by 50 to 75 gm every 2 hr can help speed glycogen repletion (9).

C. Branched Chain Amino Acids

The branched chain amino acids (isoleucine, leucine, and valine) have a special role in metabolism. Alanine is one of the most important amino acids used for glucose synthesis between meals or in the fasting state via the Alanine Cycle (see below).

Alanine → liver to form glucose
NH_2 removed to form pyruvate in the process
then pyruvate to glucose by gluconeogenesis

Glucose formed from Alanine is then utilized, releasing pyruvate

Pyruvate → muscle where it gains an NH_2 to form Alanine again

The Branched Chain AA's donate this NH_2 through the action of a specific enzyme branched chain amino acid oxidase which utilizes only these three amino acids.

During intense exercise with increased glucose utilization, the levels of the BCAA drop. This drop can be prevented by feeding or infusing the BCAA, but the effects on performance are minor. A second effect reported by athletes is in preventing the depression or drop in mood that occurs when blood glucose levels fall. The mechanism for this effect has to do with the transport of tryptophan into the brain by a neutral amino acid transport system that transports both valine and tryptophan into the cerebrospinal fluid. With carbohydrate ingestion there is a rise in insulin levels which leads to increased tryptophan transport and increased serotonin synthesis. This theory is the basis of the so-called Carbohydrate Craver's Diet by Judith Wurtman, based on research in animals done by her husband Richard Wurtman at M.I.T. Tryptophan's effects on sleep, and the effects of a warm glass of milk in promoting sleep are based on the same concept.

Tryptophan→ **Tryptophan → Serotonin**

Common Transport Protein→ CNS

Valine→ **Valine → Other Metabolites**

D. Phosphate

When glucose is utilized in cells, the first biochemical step is phosphorylation. In diabetic patients who are out of control and given insulin, low phosphate levels can result as the high glucose levels in the blood are driven into cells. Unless phosphate is provided these diabetics will have low phosphate levels leading to bursting of their red blood cells. Phosphate salts in the athlete are also meant to enhance glucose utilization for glycogen synthesis which requires phosphorylation.

E. Carnitine

Carnitine is synthesized from two amino acids (lysine and methionine) by two hydroxylase enzymes containing ferrous iron and L-ascorbic acid. It is found in heart, skeletal muscle, and other tissues where fatty acid oxidation occurs. Carnitine is needed to transport any fatty acids of greater than 8-10 carbon chain length into the mitochondria for oxidation to carbon dioxide and water with the production of energy. Since during heavy exercise fat is a primary fuel, this is taken to enhance fat utilization and sparing of glycogen stores.

F. Glutamine

Glutamine is the most abundant amino acid in the body, and constitutes more than 60% of the free intracellular amino acids in skeletal muscle. Glutamine plays an essential role in a number of metabolic processes including interorgan transfer of nitrogen, renal ammonia synthesis, hepatic gluconeogenesis, and hepatic glycogen synthesis. Circulating levels of glutamine may also regulate muscle protein synthesis and breakdown. Glutamine is an important substrate for cells growing in culture, for proliferating lymphocytes, and for the cells of the gastrointestinal tract.

Combinations of glutamine, branched chain amino acids and carnitine are ingested by some athletes based on the above rationale. Results are poorly documented.

2. Anabolics

Anabolic agents are designed to cause muscle hypertrophy (increase in the size but not the number of muscle cells) with an increase in muscle strength.

A. Insulin - leads to amino acid uptake and protein synthesis, but this is not a practical strategy since administered insulin reduces the amounts of insulin released by the pancreas into the blood stream.

B. Growth Hormone - increases muscle protein synthesis by increasing insulin-like growth factor I (IGF-1) levels. IGF-1 is also called somatomedin.
Arginine and Insulin release growth hormone, but only in very high doses.
Therefore, while supplementation with arginine can increase fitness by increasing nitric oxide production, arginine will not increase muscle mass.

C. Anabolic Androgens - synthetic forms of testosterone which are more potent. These are illegal for athletes to use and their use is controlled by physicians since they can have serious side effects. They are most effective in adolescents, children or in women who need them to build muscles. In adult males high dose testosterone has been shown to build muscle. This may be an important and effective strategy for the elderly, but not a good idea for competitive athletes.

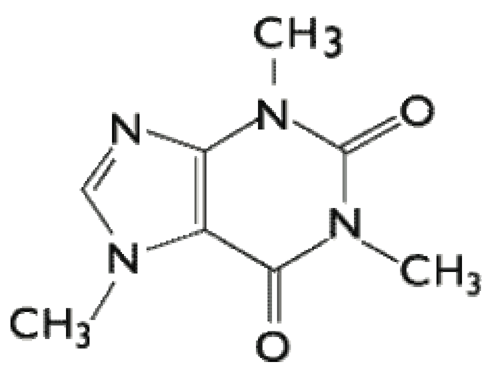
Coffee and Caffeine-Containing Products for Athletes

Caffeine causes fat cells to release more fatty acids into the blood stream at rest and so are efficient energy boosters for exercising athletes. Most regulatory bodies in the world have recognized the safety of caffeine discussed. In addition to its metabolic effects, caffeine increases mental alertness and this can clearly have a positive effect on athletic performance.

What Is Caffeine?

Caffeine is a naturally occurring substance found in the leaves, seeds or fruits of at least 63 plant species worldwide. Caffeine, also known as trimethylxanthine, coffeine, theine, mateine, guaranine, methyltheobromine and 1,3,7-trimethylxanthine, is a xanthine alkaloid found naturally in such foods as coffee beans, tea, kola nuts, Yerba mate, guarana berries, and (in small amounts) cacao beans. For the plant, caffeine acts as a natural pesticide since it paralyzes and kills insects that attempt to feed on the plant.

Caffeine's main pharmacological properties are: a stimulant action on the central nervous system with psychotropic effects and stimulation of respiration, a stimulation of the heart rate, and a mild diuretic effect.



Chemical Structure of Caffeine

The most commonly known sources of caffeine are coffee, tea, some soft drinks and chocolate. The amount of caffeine in food products varies depending on the serving size, the type of product and preparation method. With teas and coffees, the plant variety also affects caffeine content.

Coffee is the chief source of caffeine in the U.S. An eight-ounce cup of drip-brewed coffee typically has 85 milligrams (mg) of caffeine; an eight-ounce serving of brewed tea has 40 mg; soft drinks that contain caffeine have an average of 24 mg per eight-ounce serving; and an ounce of milk chocolate has just six mg.

Coffee Consumption

Published data shows the per capita consumption level of caffeine for the average adult is approximately 200 mg. daily. The average child consumes much less caffeine—only one-quarter of the caffeine consumed by adults.

For children and young adults, the primary sources of caffeine are tea and soft drinks, while for adults, caffeine intake is mostly from coffee.

Foods and beverages derived from cocoa beans, kola nuts and tea leaves often contain some caffeine. Caffeine is also added to some foods and beverages for flavor. It contributes to the overall flavour profile of those foods in which it is added.

F.3 Caffeine Safety

In 1958, the U.S. Food and Drug Administration (FDA) classified caffeine as Generally Recognized As Safe (GRAS). In 1987, the FDA reaffirmed its position that normal caffeine intake produced no increased risk to health. In addition, both the American Medical Association and the American Cancer Society have statements confirming the safety of moderate caffeine consumption.

What constitutes a normal amount of caffeine depends on the individual. Caffeine sensitivity depends on many factors, including the frequency and amount of regular intake, body weight and physical condition.

Numerous studies have shown that moderate amounts of caffeine - about 300 milligrams per day—are safe for most adults. Children consume about 35-40 milligrams daily.

Depending on the amount of caffeine ingested, it can be a mild stimulant to the central nervous system. Although caffeine is sometimes characterized as "addictive," moderate caffeine consumption is safe and should not be classified with addictive drugs of abuse. Often, people who say they are "addicted" to caffeine tend to use the term loosely, like saying they are "addicted" to running, working or television.

When regular caffeine consumption is stopped abruptly, some individuals may experience mild symptoms such as headache, fatigue or drowsiness. These effects are usually only temporary and will end in a day or so.

Moderate amounts of caffeine are safe for most people. Some individuals may be sensitive to caffeine and will feel effects at smaller doses than do individuals who are less sensitive. Pregnancy and aging all may affect an individual's sensitivity to caffeine.

There is no evidence that the caffeine in beverages is dehydrating. Any diuretic effect is more than likely compensated for by the total amount of fluid provided by the beverage.

Research has found no evidence to suggest the use of caffeine at the levels in foods and beverages is harmful. As with all foods and beverages, parents should use common sense in giving their children normal servings of caffeinated foods and beverages.

There is no evidence to show that caffeine is associated with hyperactive behaviour. In fact, most well-conducted scientific studies show no effects of caffeine-containing foods—or any food or beverage, in general—on hyperactivity or attention deficit disorder in children.

Scientific evidence suggests that children are no more sensitive to the effects of caffeine than adults.

Most physicians and researchers today agree that it's perfectly safe for pregnant women to consume caffeine.

Daily consumption of up to 300 mg/day (approximately two to three 8 oz. cups of brewed coffee) has been shown to have no adverse consequences during pregnancy. However, it is wise for pregnant women to practice moderation in consumption of all foods and beverages.

The weight of scientific research indicates that moderate caffeine consumption does not affect fertility, or cause adverse health effects in the mother or the child.

Caffeine-containing foods and beverages, in moderation, can be enjoyed while breastfeeding. Studies have shown that although caffeine is passed to the infant through breast milk, the amount is minute and has no effect on the infant.

Both the American Academy of Pediatrics and researchers of a review published in the American Journal of Clinical Nutrition confirm that caffeine consumption at usual amounts has no effect on the infant.

2. General Dietary Guidelines for Training

Exercise requires different diets depending on the goal of the athlete.

A diet moderate to high in carbohydrates is used by aerobic exercisers and endurance runners. In this type of diet, carbohydrate should be about 55 to 70% of total calories, with the endurance athlete meeting the higher figure. Fat intake will then be reduced from typical 36% of total calories to between 15% and 30 %. Protein will then make up the rest with about 10 to 15% of total calories. Multiple servings of fruits, vegetables, cereals, and grains rather than simple sugars will help maintain glycogen stores, avoid hypoglycemia, and maintain overall energy levels. This will result in a thin look typical of the long distance runner with relatively low muscle and fat mass. However, this athlete will have a lower energy expenditure than the muscular athlete and so will have a harder time maintaining weight if they deviate to a high fat/high calorie diet. Many women seek this “never too thin, never too rich” look characteristic of models. It is a luxury of our modern era of nutrition, antibiotics, dietary supplements and sanitation that such individuals can survive without dying of an infectious disease. They often eat salad with no chicken on top, skip breakfast, and eat tiny dinners. This behaviour is related to binge-eating behaviours when they lose control, and it is interesting that those societies that have a high incidence of obesity also have a high incidence of eating disorders, including bulimia and anorexia.

For muscle-building regimens, athletes should consume 1.0 to 1.5 grams of protein per kg per day (0.5 to 0.7 grams per pound body weight). This is slightly above to about double the RDA for protein of 0.8 gm/kg/day. This can easily be achieved by eating normal foods without taking protein supplements. For example, 80 grams of protein could be obtained from 4 ounces of chicken, 3 ounces of tuna, and 3 glasses of non-fat milk per day. This does not include the protein found in grains and vegetables. If you are a vegetarian, it is possible to obtain the protein you need from soy and other high quality vegetable proteins through combining of legumes (beans) and rice or corn. The amino acids in these foods are complementary increasing the biological value of the proteins. Alternatively, you can eat soybean protein, which is the only complete protein in the plant world. Soybean protein isolates are available which provide the protein without the natural soybean fat. Tofu is about 40% fat, and lite Tofu is about 30% fat.

What about the “Zone” diet ? This plan is based on concepts borrowed from several sources including a misreading of the diabetes literature. It is basically a 30% protein, 30% fat, 40% carbohydrate diet. It “works” to cause weight loss for those individuals with an increased muscle mass, since it organizes the eating plan. It does not work for individuals with a low muscle mass, since the 30% fat is associated with too many calories to permit weight loss. In humans, it is difficult to separate fat and calories (with the exception of the artificial non-metabolizable fat, olestra). This diet and Met-Rx plan before it, increased the importance of increased protein in the diet. Many individuals attempting to lose weight made the mistake of reducing dietary protein intake which led to weight and muscle loss and a decrease in metabolism (sarcopenic obesity). By increasing protein intake and raising consciousness about heavy resistance (muscle-building) as well as aerobic exercises, these diets influence the public's dieting behaviours.

To maximize performance, athletes generally want to achieve an optimum sport-specific body size, body composition and mix of energy stores. Always in search of the 'perfect diet', many athletes experiment, often by trial and error, with the best dietary pattern for their own needs, or which will afford them the winning edge. While there may be some variation by sport, generally speaking athletes require at about 15% of calories from protein, fats at about 25% or calories, with the remaining calories supplied by carbohydrates. For those athletes with extraordinary energy demands, the relative contribution can change, such that carbohydrate would supply up to 70% of total calories.

The total number of calories consumed also needs to be considered, and is highly variable depending on the body size, sex and sport of the athlete. Calorie expenditure through exercise has been reported to be as high as 12,000 kcal per day, and individuals with high expenditures from sports such as swimming or distance running may have difficulty in maintaining their desired weight and experience gradual weight losses over the course of a season.

Athletes should aim to achieve carbohydrate intakes to meet the fuel requirements of their training program and to optimize restoration of muscle glycogen stores between workouts. However, just as not every day of training should be intense or prolonged, not every day of training requires a high intake of carbohydrate. The most important objective of periodization of daily carbohydrate intake would be to ensure high muscle glycogen levels at the start of the hard training sessions. Athletes typically perform 2-4 'hard' training sessions per week. To raise muscle glycogen to high levels, athletes should eat a total of 7-12 grams of carbohydrate/kg body weight during recovery from the last training session. The recovery period should be not be less than 24 hours. However, during the 24 hours prior to a moderate or easy day of training, it may be satisfactory for athletes to eat 5-7 grams of carbohydrate/kg. If muscle glycogen is not fully recovered and the athletes sense this as a feeling of slight residual fatigue, they may refrain from exercising too intensely.

An athlete's daily energy intake should generally match energy expenditure to minimize hunger and stress. Fluctuations in carbohydrate intake can be matched by inverse fluctuations in calories from fat and or protein. Thus, on the day before an easy day of training, if athletes choose to eat a moderate amount of carbohydrate (5 grams/kg), they can appropriately increase their intake of healthy fat and lean protein. In addition to providing them with a varied diet to satisfy taste, the extra dietary fat may help to raise the concentration of intramuscular triglyceride (Coyle et al., 2001), a source of muscle fuel; extra protein may also be beneficial on a periodic basis.

There are as many approaches to varying dietary carbohydrate as there are to weekly and monthly periodization of training intensity. However, the most important aspect is that endurance athletes should not exercise for 20-24 hours prior to a hard training session, and during that time they should consume 7-12 grams of carbohydrate/kg of body weight.

Many athletes attempt to reduce body fat as much as is appropriate for their particular sport. Therefore, the simple advice to eat a high-carbohydrate diet may cause concern that it may lead to a positive energy balance and a gain in body fat. In a 65-kg (143 lb) athlete, a daily intake of 7-12 grams of carbohydrate/kg of body weight would be 455-780 grams, amounting to 1820-3120 kcal. This is the amount of carbohydrate needed to fully recover muscle glycogen. However, this amount of carbohydrate can represent either a relatively large or small portion of an athlete's daily energy needs depending on the sport. For example, for athletes who have depleted their muscle glycogen stores with brief, high-intensity interval training, a positive energy balance during recovery may be elicited with 7-12 grams of carbohydrate/kg of body weight. On the other hand, in cyclists training for 4-6 hours per day, this amount of carbohydrate, while sufficient to replenish glycogen stores, may represent only one-half of the total energy intake needed for energy balance. For these reasons, it may be better to express an individual's carbohydrate requirements in grams/day as opposed to a percentage of calories.

In all but a few exceptional cases, the contribution of protein as an energy source during exercise ranges from 2-10% of total energy expenditure. This will vary, depending on the type of exercise, its duration and intensity, and the individual’s previous diet. Active endurance exercise results in the oxidation of several amino acids, and a low energy or low carbohydrate intake could increase total protein requirements. However, with adequate calories and carbohydrates, low to moderate intensity endurance activity has little impact on dietary protein requirements. In strength-trained athletes, an increased protein requirement may arise due to catabolic loss of amino acids associated with resistance training. At the same time, studies have also shown that strength training can increase the efficiency of use of dietary protein. Given the relatively high energy needs of the athlete, however, those who consume even 15% of total calories from protein will consume absolute amounts in excess of 100 grams per day to support muscle growth and recovery.

Nutrition Before and During Events

The pre-event meal serves two purposes. First, it keeps the athlete from feeling hungry before and during the event, and second, it maintains optimal blood glucose levels for working muscles. Carbohydrate feedings just prior to exercise can help restore suboptimal liver glycogen stores, which could result, for example, after an overnight fast. Allowing for personal preferences and habits, the pre-event meal should be high in carbohydrate, low in fat and fiber and easily digested.

Before exercise, athletes should consume 1-4 grams of carbohydrate per kilogram (.5-2 grams of carbohydrate per pound) one to four hours before exercise. To avoid gastrointestinal distress, the carbohydrate content of the meal should be reduced, the closer the meal is consumed to the event. For example, 1 gm carbohydrate/kg would be appropriate immediately before exercise, while 4 gm/kg could safely be consumed 4 hours before exercise. Liquid meals have a shorter gastric emptying time and are recommended over solid meals if they are to be consumed close to competition.

Formula 1 with added fruits such as one cup of berries and one banana will provide 300 calories or 75 grams of carbohydrate in addition to what is found in Formula 1 which is approximately 20 grams of carbohydrate. This provides more than 1 gm/kg for most athletes and can be safely consumed 2 hours before exercise for maximum nutrition of your muscle. This will prepare them with both healthy carbohydrate stores and the amino acids to avoid excess muscle breakdown.

During exercise, athletes should consume 30-60 grams of carbohydrate each hour (120 to 240 calories from carbohydrate per hour). Since both carbohydrates and fluids are necessary during events, sports drinks can go a long way in providing adequate carbohydrate and fluid. Typical foods that are used during long events include sports drinks, carbohydrate gels, energy bars, bagels, gingersnaps and bananas.

An excellent hydration product is Herbal Tea Concentrate which will enhance the breakdown of fat cells providing energy as you exercise. Be careful to use as directed on the label as too much Herbal Tea can cause rapid pulse and anxiety. This is simply a natural result of the stimulation of the brain and nervous system by the natural caffeine in Herbal Tea Concentrate.

Recovery Nutrition

Recovery from intense activity requires nutrients which will replenish muscle glycogen stores, body water, electrolytes and triglyceride stores in skeletal muscle. Proper nutrition during the recovery period is essential for rapid and effective recovery and for optimal performance at the next event or workout. During a heavy workout or competition, an individual weighing 130 – 160 pounds could lose the following:

- Water: 2,000 ml (1,000 – 3,500 ml) – depending on exertion. Active athletes will need more while the average person may need an additional 4 glasses of water per day.
- Sodium Chloride: 5 gm
- Muscle glycogen: (200 gm (150 – 250 gm)
- Liver glycogen: 50 gm
- Intramuscular triglyceride: 75 gm (50 – 100 gm)
- Adipose tissue triglyceride: 50 gm

For muscle glycogen recovery, the average consumer who has performed aerobic activity for 30 minutes, needs simply water for hydration and one Formula 1 shake. However, the following intense regimen is recommended for very active athletes in competition who exercise at least one hour per day:

- Within 15 minutes after stopping exercise, eat 50-100 gm rapidly absorbed carbohydrate along with 10-20 grams of protein. An excellent recovery meal is

Formula 1 made with Yogurt, milk, or soy milk with an added scoop of Performance Protein Powder (PPP) and a fruit.

- Continue eating 50-100 gm carbohydrate plus 10-20 grams of protein every 2 hours until the next complete meal. So you can take another shake as needed until your next meal.
- For the day, eat 400-800 gm carbohydrate. The exact amount will vary depending upon the intensity and duration of the training

It is valuable to choose nutrient-rich carbohydrate foods and to add other foods to recovery meals and snacks to provide a good source of protein and other nutrients. These nutrients may assist in other recovery processes and, in the case of protein, may promote additional glycogen recovery when carbohydrate intake is suboptimal or when frequent snacking is not possible. Muscle glycogen synthesis is twice as rapid if carbohydrate is consumed immediately after exercise, as opposed to waiting several hours, and a rapid rate of synthesis can be maintained if carbohydrate is consumed on a regular basis. Glycogen synthesis is enhanced with by the combination of carbohydrate and protein, and this combination also stimulates amino acid transport, protein synthesis and muscle tissue repair. Research also suggests that aerobic performance following recovery is related to the degree of muscle glycogen replenishment.

When the period between exercise sessions is < 8 h, the athlete should begin carbohydrate intake as soon as practical after the first workout to maximize the effective recovery time between sessions. There may be some advantages in meeting carbohydrate intake targets as a series of snacks during the early recovery phase, but during longer recovery periods (24 h) the athlete should organize the pattern and timing of carbohydrate-rich meals and snacks according to what is practical and comfortable for their individual situation. Carbohydrate-rich foods with a moderate to high glycemic index provide a readily available source of carbohydrate for muscle glycogen synthesis, and should be the major carbohydrate choices in recovery meals.

Although there is new interest in the recovery of intramuscular triglyceride (IMTG) stores between training sessions, there is no evidence that diets which are high in fat and restricted in carbohydrate enhance training. It has been assumed that given the amount of triglyceride stored in adipose tissue, dietary fat is probably not essential for recovery from exercise. However, the increase in body fat oxidation characteristic of endurance-trained athletes is derived almost exclusively from IMTG. In order to fully restore IMTG, athletes should not follow an extremely low fat diet, but are advised to consume about 20% of their calories from the healthier fats and oils such as olive oil, nuts and avocado.

Fluids and Electrolytes

During vigorous activity, heat that is produced is dissipated through the process of sweating. However, long-term, extensive sweating can pose significant challenges for athletes with regard to fluid balance. Without effective management, athletes will fatigue prematurely, and as dehydration progresses, heat exhaustion, heat cramps and heat stroke can result.

In addition to the air temperature, other environmental factors such as relative humidity, air motion and choice of clothing can modify the amount of sweat loss. The magnitude of loss incurred during exercise in a warm environment is dependent primarily on exercise intensity and duration. In warm to hot conditions, adult athletes lose between 1 and 2.5 liters of sweat per hour of intense competition or training, and can increase to over 3.5 liters per hour in world-class athletes competing in very hot and humid conditions. Losses in these ranges cannot be sustained for long, and although gastric emptying rates tend to approximate sweat losses to allow for fluid replacement, only about half of sweat losses are voluntarily replaced during exercise.

Athletes who are used to training in hot climates and are acclimatized may sweat more than those who are not, which gives the athlete a thermoregulatory advantage, but greater sweating also presents greater challenges with regard to fluid intake. However, sweating rates range widely between sports and within sports (positions played), and even in relatively homogeneous populations of athletes, such that inter-subject sweating variability can be significant.

Dehydration by 2% of body mass during exercise in a hot environment clearly impairs endurance performance (continuous aerobic exercise of more than 60 minutes in duration), while similar losses in a temperate environment will have a lesser effect; in cold environments, dehydration by more than 2% may in fact be tolerable. Nevertheless, athletes exercising in any climate need to pay attention to fluid losses and replace them adequately, even if they do not feel their performance is impaired.

When body water content is decreased, an increased heart rate and decreased stroke volume is observed, indicating an increased cardiovascular strain. If exercise in taking place in a warm environment, then cardiac output may not be able to be maintained at a level that allows exercise to continue. In addition to effects of performance, signs of dehydration include loss of appetite, decrease in urinary frequency, increase in urine concentration, an increase in perceived exertion during activity.

In addition to water, sodium and chloride are the primary ions lost during sweating. The concentrations of lost electrolytes are variable, with some well-conditioned and well-acclimatized athletes able to conserve more sodium. Sodium and chloride concentrations also vary with the rate of sweating; as the rate goes up, the concentrations of sodium and chloride usually increases. Potassium and magnesium are also lost through sweating, but the losses are typically much lower, with athletes losing 3-10 times more sodium than potassium during exercise.

Without adequate replacement, electrolyte losses can lead to incomplete rehydration, poorer performance and heat-related muscle cramps, and can put the athlete at higher risk for developing heat exhaustion. Heat-related muscle cramps can occur during prolonged exercise, especially if there has been previous extensive and repeated fluid and sodium losses. Water will restore fluids, but dietary salt should be increased to replenish lost electrolytes. Athletes should not restrict salt in their foods, and good sources of sodium, chloride and potassium would include tomato juice, mixed vegetable juices and soups, which would also provide fluid.

While for the average person thirst may provide appropriate cues for maintaining hydration needs, it may be advisable for physically active people to drink on a schedule, and to keep track of their weight pre- and post-event to replace losses adequately. However, many athletes begin competition or training dehydrated to some degree, so that a post-exercise body water deficit may be worse than that indicated by pre- and post-event body weight difference. In addition, thirst is not a rapidly responding indicator of body water loss, and there could be a fluid deficit of more than 1 liter before thirst is distinctly perceived.

At the same time, athletes need to be aware that overdrinking can dilute body sodium, leading to hyponatremia. When rehydration guidelines are followed, risks are slight, but some athletes or their coaches take the approach with fluid replacement that ‘if some is good, more is better’. Hyponatremia occurs when blood sodium concentration falls to abnormally low levels, causing swelling in the brain that can lead to seizures, coma, and even death. Drinking more fluid than the amount lost in sweat is a key risk factor for hyponatremia, but it can also occur in dehydrated athletes during prolonged exercise as a result of large sodium losses in sweat. Also, standard fluid replacement recommendations may not be adequate for those who engage in vigorous physical activity, especially in warm temperatures, or those who tend to sweat heavily even in moderate temperatures, or so-called "salty sweaters" with higher than typical sodium loss through sweat. Symptoms of hyponatremia can be subtle, and can mimic those of other exercise-related illnesses, which complicates the diagnosis and treatment.

The American College of Sports Medicine Recommendations:

Before Activity or Competition

- Drink adequate fluids during the 24 hours before the event, especially during the meal before exercise
- Drink about 500 mL (about 17 ounces) of water or a sports drink in the final two to three hours prior to exercise
- Ten to twenty minutes before starting exercise, another 10 ounces of water or sports drink is advised.

During Activity or Competition

- 6-12 ounces every twenty minutes during activity to facilitate optimal hydration
- Fluids should be cooler than ambient temperature and flavoured to enhance palatability and promote fluid replacement

During Activity that Lasts More than One Hour

- Fluid replacement should contain 4-8 % carbohydrate concentration
- Electrolytes should be in the solution for flavour and to reduce the risk of hyponatremia

Following Exercise

- For each pound of weight loss, consume two cups (16 ounces) of water or a sports drink. Caffeinated beverages should be avoided, as they accelerate fluid loss.
- Drinking fluid that is 125 to 150% of fluid loss is usually enough to promote complete hydration

Sports Drinks

Sports drinks are formulated to provide carbohydrates for energy, electrolytes and fluids to promote hydration. Generally speaking, they are recommended when the duration of exercise is going to exceed one hour. These drinks have a light flavour and slightly sweet taste to encourage athletes to take in more fluid, and the carbohydrate concentration is formulated to maximize fluid absorption (less than 10% carbohydrate concentration) while minimizing gastric upset which can occur with liquids with higher carbohydrate concentrations. Fruit juices and soft drinks are concentrated sources of carbohydrates and can slow gastric emptying. Additionally, fructose in fruit juices and in some soft drinks is associated with slower gastric emptying. Sports drinks are sweetened with glucose, maltodextrin, sucrose or high frucrose corn syrup.

Vegetarian Athletes

There is growing interest in the potential health benefits of a plant-based diet. Depending upon how strict the diet is, nutrient imbalances could occur which could affect performance. Generally speaking, vegetarian diets which are well planned and appropriately supplemented should effectively support performance in most sports provided that protein intakes are adequate. Meeting protein requirements for strength training could pose a challenge for the vegetarian athlete, with greater challenges for the vegan. Female vegetarians are at risk for iron deficiency, which could limit endurance performance, and vegetarians, as a group, have lower muscle creatine concentrations compared to omnivores, which may affect supramaximal exercise performance. Some athletes adopt vegetarian diets as a weight control strategy, and coaches and trainers should be aware that an athlete following a vegetarian diet, particularly if it is accompanied by unwarranted weight loss, may signal a disordered eating pattern.

Physical activity increases protein requirements to different extents depending on the type and amount of activity. Typical recommendations are 1.2 to 1.4 g/kg/d for endurance athletes, and up to 1/7 g/kg/d for resistance and strength-trained athletes. Vegetarians who consume dairy products, eggs or egg whites, and complementary mixtures of high biological value plant proteins should be able to meet needs. However, those following a vegan plan will have a limited intake of essential sulfur-containing amino acids. Protein intake among vegetarians is lower than that of omnivores, although they are generally above the RDA. Because of relatively high energy requirements in athletes, however, it is possible for a diet with a relatively low percentage of calories from protein to provide adequate absolute amounts of protein when energy intake is high.

Several micronutrients have the potential to influence athletic performance, particularly iron and vitamin B12. Vegetarian diets contain no heme iron, which occurs in animal products and is more efficiently absorbed than the non-heme form in plant foods. Absorption of the non-heme form is enhanced by factors in animal products, and inhibited by phytic acid in whole grains, legumes, lentils and nuts which may form the basis for the vegetarian diet. These factors could result in reduced hemoglobin levels, still within normal range, which could negatively affect performance due to reduced oxygen transport. Vegetarians who exclude all animal proteins do not have a reliable source of vitamin B12 if they do not use fortified foods or supplements. Over time, inadequate intakes could lead to macrocytic anemia which is associated with reduced oxygen transport. Supplements or fortified foods are advised under these circumstances.

The Female Athlete Triad and Anorexia Athletica

In some sports, athletes with a low body weight have an advantage over their opponents. These sports include ski jumping, road cycling, climbing, gymnastics and long-distance running. However, this advantage can turn to a disadvantage as low body weight can be associated with health risks. Athletes may be too restrictive with their calorie intake and/or over exercise to achieve or maintain low body body weight and fat mass.

In female athletes, disordered eating coupled with delayed onset of menarche or menstrual irregularities and decreased bone density with a high frequency of injuries are hallmarks of the Female Athlete Triad. Female athletes are more at risk for disordered eating and associated health problems because they participate in sports in which a low body weight is favoured, such as ballet, gymnastics and figure skating. Over controlling parents and coaches coupled with social isolation resulting from over-training can increase the risk of the Triad.

The true incidence of the Triad is difficult to ascertain, as it often goes undetected. Disordered eating among female college athletes has been reported to range from 15-62%, an amenorrhea has been reported in up to 66% of female athletes, compared to only about 5% or less in the general population. Common characteristics of individuals who develop the Triad include a perfectionist personality, self-critical behaviour, poor self-esteem and depressive symptoms, and individuals may have stress fractures without any significant changes in their training, or multiple or recurring fractures. Patients with the triad present with symptoms such as cold intolerance, fatigue, depression, anaemia, dry skin, constipation, decreased ability to concentrate and light-headedness.

Food restriction, intense training and significant loss of body fat upset the body's natural hormonal balance, leading to amenorrhea. With the low estrogen levels and often poor intakes of dietary calcium, individuals are then at risk for stress fractures and osteoporosis. This issue is particularly important since individuals with the Triad are generally at an age when they should be achieving peak bone mass.

Obstacles that need to be overcome include the beliefs that 1) the loss of regular menstrual cycles mean that the athlete is training at the proper intensity; 2) very low body fat is the key to excellent performance; and 3) the optimal weight for appearance is the same as the optimal weight for performance. The treatment team often consists of the primary care physician as well as a psychologist and dietitian, and family, coaches and trainers need to be involved in the treatment plan.

Anorexia Athletica (AA) is differentiated from an eating disorder in that the reduction in body mass and/or the loss in body fat mass are based on *performance* and not on *appearance* or *excessive concern about body shape*. This is not to say that excessive concern about body shape will not develop. In fact, it often does when athletes compare their degree of body fatness with other athletes who may be more successful. Individuals with AA generally initiate dieting and/or overtraining on a voluntary basis or in response to recommendations from coaches or trainers. Loss of body mass and frequent weight cycling are also characteristic of AA. Another distinction from other eating disorders is that eating behaviours associated with AA should no longer be detectable at the end of the athlete's career. Nevertheless, symptoms of AA can certainly overlap those of anorexia nervosa.

3. Body Composition Measurement and Interpretation

Body Composition

E 1. Classification of Obese Subjects According to Lean Body Mass

Obesity = Excess Body Fat

(Body Fat > 20% in men, > 30% in women)

Sarcopenic Obesity (reduced lean mass)	Normal Obesity (proportionate)	Hypermuscular Obesity (increased lean mass)

Increased lean mass as well as fat mass is seen in obese individuals. In 1964 Forbes reported that lean tissue in obese children was increased compared to non-obese peers (2). Drenick (3), using total body potassium, found increased lean tissue in obese adults (3). Webster et al. measured the body composition of 104 obese and normal weight women by densitometry (4). They reported that the excess body weight of the obese over non-obese women consisted of 22 to 30% lean and 70 to 78% fat tissue. Forbes and Welle (5) examined data on lean body mass in obese subjects collected in their laboratory or published in the literature. Their own data demonstrated that 75% of the obese population had a lean-to-height ratio that exceeded 1 standard deviation (SD) and that more than half exceeded 2 SD. A review of the literature supported these observations and determined that the lean body mass could account for approximately 29% of excess weight in obese patients. A proportionate increase of lean body mass of approximately 25% is considered normal. Deviations both above and below this amount of lean mass are observed on clinical grounds based on various etiologies listed below (see Table Two below). An example of data collected in the UCLA High Risk Breast Cancer Clinic is shown in Table Three below.

TABLE TWO

Etiologies of Sarcopenic and Hypermuscular Obesity

Sarcopenic Obesity

- Chronic Use of Corticosteroids
- Prolonged Inactivity or Bed Rest
- Hypogonadism
- Hypopituitarism
- Neuromuscular Diseases
- Menopause and Age-Related Hypogonadism
- Genetic

Hypermuscular Obesity

- Childhood Onset Severe Obesity
- Use of Anabolic Androgens
- Hyperandrogenism in Females
- Athletics (e.g. football, wrestling, weightlifting)

- Genetic

TABLE THREE

Body Mass and Percent Body Fat in Women at Increased Risk of Breast Cancer

(From Heber et. al. American Journal of Clinical Nutrition, 1996).

n=28	Age (yr)	Wt. (lbs)	Ht. (in)	BMI (wt/ht^2)	Body Fat (%)
Mean ± SD	36.8±6.4	137.8±1.9	65.3±2.7	22.9±3.1 (nl < 27)	34.6±4.8 (nl 22-28%)

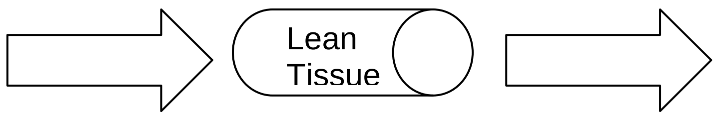
E.2 RMR and Predicted Weight Loss from Lean Body Mass

Lean body mass is clinically important for two reasons. First, lean body mass predicts energy expenditure and, thereby, the predicted rate of weight loss on a given calorically-restricted diet (10). Secondly, lean body mass can be used to diagnose increased or decreased lean body mass. In the first instance, the increased lean body mass can be used to calculate a more appropriate target weight than would be predicted from ideal body weight tables. In those subjects with reduced lean body mass, a program of aerobic and heavy resistance training can be initiated to provide for an increase in lean body mass and energy expenditure. In both markedly obese individuals and individuals with decreased lean body mass, there is linear relationship (Sterling-Pasmore Equation) of lean body mass to energy expenditure (ca. 13.8 Kcal/day/lb lean body mass). This represents approximately 90% of total energy expenditure in a sedentary obese individual, and provides a good clinical estimate of maintenance calories in my clinical experience.

E. 3 Basic Science behind Bioimpedance

The principle behind bioelectrical impedance analysis is that the fat tissues of the body do not conduct electrical impulses as well as lean tissues, such as muscle, which are 70% water. While there are many ways to measure bioimpedance, the most widely accepted method involves the placement of four skin paste electrodes similar to those used to obtain electrocardiograms. These are placed at set points on one arm and one leg. By separating the electrodes a known distance based on the height of the individual which is provided to the computer in the analyzer, it is possible for the bioimpedance analyzer to quantitatively measure the electrical characteristics of the body. This can then be used to calculate lean body mass and fat mass as described below:

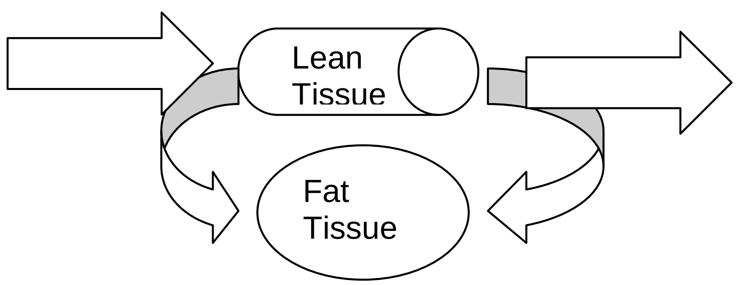
The impedance meter is a simple electrical circuit with the following characteristics:



→ Resistor (at low and high frequencies) →

Input → → Output

→ Resistor and Capacitor →
(at mid-range frequency)



This type of circuit has a frequency-dependent impedance based on the resistance and capacitance (reactance) of the circuit elements, which are fat and lean tissue in this case. As the frequency is increased the circuit acts more like a simple resistor, and electricity travels through the circuit easily. At low frequencies it acts more like a capacitor until at 0 Hz (cycles/sec) there is no circuit flow and the impedance approaches infinity. All bioimpedance analyzers use an equation such as the one shown below. The Biodynamics impedance analyzer in particular uses four sets of equations to be able to predict lean body mass with different constants for different body types.

$$LBM = (A \times Ht^2) + (B \times Wt) + (C \times Age) + (D \times R) + E$$

Where: LBM= lean body mass

Ht^2 = the height squared in units the machine reads either cm. or inches

Wt = weight in pounds or kilograms

Age = age in years since lean body mass tends to decrease with age
R = bioimpedance in ohms.

The reactance is not used but by convention the bioimpedance is read at 50 Hz. Some variable frequency machines are available which claim to represent extracellular and intracellular water by measuring impedance at different frequencies.

Data Provided By a Manufacturer on Correlation with Underwater Weighing
(Bioanalogics, Inc.)

Clinical Results	Men	Women
Percent Body Fat	4.3-37.1	12.0-45.5
R correlation	0.98	0.96
SEE (% body fat)	1.50%	1.62%
Sample Size	198	226

E. 4 Challenges in the Clinical Use of Bioelectrical Impedance

During the first week of caloric restriction, there is a loss of body weight in excess of the loss of lean and fat tissue due to a diuresis. If patients are measured at their first visit and then weekly thereafter, it is possible to find that patients are apparently gaining fat as they lose weight using bioelectrical impedance. Since lean body mass is assessed based on both body water and muscle, the loss of water leads to an apparent decrease in lean body mass which in most cases exceeds the loss of fat in the first week of dieting leading to an increase in percent body fat (11). I have found the bioelectrical impedance measurement most useful at the first visit for assessing type of obesity (usual, decreased lean mass, increased lean mass, or fat maldistribution), and not useful for multiple serial determinations. In fact, I explain to patients that the machine is not accurate enough to pick up small changes, and delay repeating the measurement until the patient has reached a weight close to target weight.

A second potential problem is overemphasis on the quantitative accuracy of body fat estimation. Small changes cannot be measured using this device. It is important to stress this fact to patients. The changes observed in percent fat often don't impress patients as much as the ratio of the absolute change in fat mass in pounds compared to changes in lean mass.

E.5 Future Research and Other Methods

There should be standards set for calibrating machines from different manufacturers. There are a number of laboratories that have multiple methods for measuring body composition including total body potassium, underwater weighing, TOBEC, DEXA, and deuterium dilution. Each of these has drawbacks and strong points, but none is the gold standard. The only perfect method is carcass analysis and that can only be done once. The table below shows the methods and the principles underlying their determination. They correlate with one another but do not give the exact same measurements of body composition.

Total Body Potassium	Detects natural K^{39} decay in body from potassium assumed to be in muscle. Assumes potassium concentration of muscle is constant – not always true in malnutrition. Body fat attenuates signal so poor in obesity
DEXA Scan	X-ray absorptiometry of body on scan table Assumes density of muscle and fat different
TOBEC	Body passes through magnetic field weakening it proportional to conductivity of the body. Uses magnetic field for bioimpedance- Similar problems to bioimpedance
Underwater Weighing	Weight underwater compared to land is a function of body density. Air trapped in lungs affects density
Deuterium Dilution	Exact volume of deuterium diluted into the body water. Water volume not exactly equivalent to lean tissues similar problems to bioimpedance.
BOD POD	Air displacement in a closed chamber with scale in the seat. Similar problems to underwater weighing.

4. Fundamentals o f Cellular Nutrition

Diets are made up of numerous foods in varied proportions that are prepared in many different ways, but ultimately the purpose of foods is to contribute energy to the body to support basic cellular energy needs. How that energy is provided as foods which are made up of the basic macronutrients – protein, carbohydrate, and fat – plays a major role in determining the impact of dietary patterns on health and disease. Within each category of macronutrient, there are marked differences in how different food sources are digested, absorbed, and metabolized. It is critical to understand the impact of the specific food sources of these macronutrients.

Foods can be grouped according to their content of macronutrients combined with their traditional use in an ethnic or societal geographic cuisine. Food groupings such as the basic four food groups [1) Fruits and Vegetables 2) Grains and Cereals, 3) Dairy, and 4) Meat, Beans, Nuts, and Cheese] classify foods of very different composition together such as red meat and ocean-caught fish or muffins and whole-grain bread. However, considerations of chemical structure, digestibility, metabolism and functionality contribute to what is called the quality of the diet overall as well as for individual macronutrients.

B2. The Quality of the Diet: Good vs. Bad

The quality of dietary macronutrients, such as the ratio of n-3 fatty acids to n-6 fatty acids or of whole grains to refined grains complicates the basic considerations of the effects of diet on the incidence of chronic diseases and efforts to organize dietary interventions designed to reduce risk. An additional and important consideration is the presence of phytochemicals in fruits, vegetables and whole grains leading to their designation in some cases as functional foods. The term “functional food” indicates the presence of bioactive substances that affect physiology or cellular and molecular biology.

The term “quality” implies that a value judgment is being leveled against a particular food. While there is a hierarchical ranking of fats, carbohydrates, and proteins common to the disease prevention literature, the mechanisms underlying the differences among foods which provide protein, fat, and carbohydrate to the diet are simply analyzed in light of fundamental principles of nutrition. Taken together these aspects of foods contribute to the assessment of the quality of the diet. The lowest quality foods are called junk foods, since they are high in energy density but low in nutrient density (e.g. French fries). It has been said that there are no junk foods but simply junk diets. Obviously, if one combines enough junk foods, it results in a junk diet.

B.3 Energetics and obesity

Among species, smaller surface area animals such as mice burn more energy at rest per unit body mass than large mammals such as elephants. Children have higher metabolic rates than adults per unit body mass. Within the same species there can be significant variations in metabolic rates. For example, the sedentary and overfed laboratory rat has a higher metabolic rate than the desert rat that is better-adapted to starvation (Kalman *et al.,* 1993). Energy efficiency may vary as well among humans. There is evidence that the post-obese adult may have a lower metabolism than a never-obese individual of the same size. However, the impact of excess energy is modulated by the location of excess body fat and its effects on hormones and inflammatory cytokines. Therefore, while energy balance is critical, it is not sufficient for an understanding of the effects of nutrition on disease risk.

Since obesity results from an imbalance of energy intake and expenditure, certain dietary factors have been identified as contributing to obesity. These include hidden processed fats in foods, added refined sugars in foods, and a high glycemic load diet rich in refined carbohydrates. Therefore, the quality of the diet in terms of nutrient density can contribute to the tendency of a dietary pattern to promote the development of obesity in genetically susceptible individuals. Low energy density foods include all fruits and vegetables, generally due to their high water content. High energy density foods include red meats, fats, cheeses, pastries, cookies, cakes, ice cream, snack chips, some fruit juices, and refined grains.

B.4 Protein and Its Role in Cellular Nutrition

Proteins are involved in the growth, repair and replacement of tissue, and serve numerous functions in the body as enzymes, antibodies, hormones, regulators of fluid and acid-base balance, and as integral parts of most body structures including skin, muscle and bone. Within each cell, there is a continuous process of synthesis and breakdown of proteins in the body, referred to as protein turnover.

The rate of protein turnover affects organ protein mass, body size, and ultimately the body's protein and amino acid requirements (Matthews, 1999; Fuller, 2000). The amino acids are the basic units in protein metabolism, and all have the same basic structure with a central carbon atom with a hydrogen, an amino group, and an acid group attached to it. Attached to the fourth site on the carbon atom is a distinct side chain, which defines the amino acid. Cells link these amino acids in an infinite variety to create proteins which become metabolically essential compounds.

B.4.1 Protein Quality

There are 21 amino acids in human proteins, and 12 of these are synthesized by the body and are therefore known as nonessential amino acids. The nine remaining amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) are either not made by the body or are not made in sufficient quantities to meet needs, and are thus termed essential amino acids.

The proper balance and sufficient intake of essential amino acids, along with an adequate amount of nitrogen for the production of nonessential amino acids, is required for proper protein nutriture. (Berdanier, 2000)

In order to manufacture proteins, cells require all the needed amino acids simultaneously with adequate nitrogen-containing amino groups for the manufacture of the non-essential amino acids. The amino acid composition of a food can vary widely, and determines the nutritional quality of the dietary protein. Foods that contain essential amino acids at levels that facilitate tissue growth and repair are known as complete proteins and are supplied in the diet from animal sources and soy protein.

There are several ways of measuring protein quality. Most commonly, the term biological value is used, which is a measure of the efficiency of a given protein in supporting the body's needs. Complete proteins have a high biological value, which is an expression of the amount of nitrogen absorbed relative to the amount of nitrogen retained by the body. All protein sources are compared with egg white, which provides the most complete protein and has the highest biological value of 100, indicating that 100 percent of the nitrogen absorbed is retained.

A low concentration of one or more essential amino acids in a food lowers its biological value. With the exception of soy, most plant proteins are deficient in one or more essential amino acids and are therefore regarded as incomplete. However, the biological value of incomplete proteins can be improved by combining two proteins that are complementary so that those essential amino acids lacking or deficient in one protein are provided by the other when they are combined. In this way the two complementary proteins together provide all the essential amino acids in ratios ideal for human protein utilization. (Kreutler and Czajka-Narins, 1987; Lappe, 1971; Matthews, 1999). For example, the combination of corn (limited in lysine) with beans (limited in methionine) results in a high-quality protein food combination. Thus, the requirement for adequate essential amino acids can be met in a vegetarian diet by mixing foods of complementary amino acid composition. (Berdanier, 2000; Committee on Diet and Health, 1989; Lappe, 1971)

A Few Facts on Amino Acids

There are twenty-one common (non-essential) amino acids and nine essential amino acids. Essential amino acids are those that cannot be synthesized from other amino acids, but must be consumed in the diet. The usual way that non-essential amino acids are formed is by metabolism of other amino acids. All amino acids have a basic structure of an alpha-amino nitrogen and carboxylic acid. What defines their identity is the side chain denoted as R in the diagram below:

R - C – C – O – O – H

NH_2

Some amino acids are called conditionally essential, because they must be consumed in the diet during growth to provide adequate growth rates, but become non-essential in adults who are not growing. One such amino acid is histidine which is essential for growing rats but not adult rats. Much of the data on essentiality of amino acids is obtained in rats, where single amino acid elimination is a way of determining whether a given amino acid is essential. For example lysine and threonine cannot be made from other amino acids by transamination and must be included in the diet.

Essential Amino Acids	Non-Essential Amino Acids
Histidine	Alanine
Isoleucine	Arginine
Leucine	Asparagine
Lysine	Aspartic Acid
Methionine	Cysteine
Phenylalanine	Glutamic Acid
Threonine	Glutamine
Tryptophan	Glycine
Valine	Proline
	Serine
	Taurine
	Tyrosine

B.4.2 Protein Requirements.

The US food supply can provide an average of 102 g of protein per person per day (Nationwide Food Consumption Survey, 1984). Actual daily protein consumption ranges from 88 to 92 g for men and from 63 to 66 g for women (McDowell *et al*., 1994). Animal products provide 75% of the essential amino acids in the food supply, followed by dairy products, cereal products, eggs, legumes, fruits, and vegetables (McDowell *et al*., 1994). The recommended daily allowance (RDA) for protein of high biological value for adults, based on body weight, is 0.8 g/kg (National Research Council, 1989) or 0.36 g/lb. However, the RDA is set to meet the needs of a defined population group as a whole rather than indicating individual requirements. In a recent report concerning Dietary Reference Intakes, the Acceptable Macronutrient Distribution Range (AMDR) was set at 10-35% of total calories from protein. The AMDR is defined as the acceptable range of intakes for protein associated with reduced risk of chronic disease while providing intakes of essential nutrients (Barr *et al.,* 2003). This range was largely set so that the intake of other macronutrients in the diet would be in an acceptable range.

There are many conditions in which extra protein is needed, including periods of growth, pregnancy, lactation, intense strength and endurance training and other forms of physical activity, and possibly in the elderly (Campbell *et al*., 1994). Additionally, there is recent research into the role of protein in the regulation of long-term energy balance, maintenance of body weight and satiety (see Role in Satiety, below).

B.4.3 Optimum Protein Intake

Given the variation in the needs for protein throughout the life cycle, there is an individual optimum intake that exists based on lean body mass and activity levels. However, optimal intakes are difficult to determine based on the existing science base in nutrition. In 1977, Garza *et al*. studied a small number of healthy volunteers and found that 0.8 g/kg/day resulted in positive nitrogen balance. Subsequent studies in endurance athletes found that more than 1 gm/kg/day was required for positive nitrogen balance (Tarnopolsky, 2004) and studies in weightlifters indicated that more than 2 gm/kg/day were needed to achieve positive nitrogen balance (Tarnopolsky *et al.,* 1992). Therefore, while the DRI, which is the same as the RDA, is set at 56 gm/day for men consistent with the 1977 study, the allowable range of macronutrient intake is broad (10 to 35 percent of total calories) enabling some individual adjustment for optimal intakes both to control hunger and to provide support to lean tissues.

B.4.4 Protein's Role in Satiety.

In comparison with carbohydrate or fat, protein provides a stronger signal to the brain to satisfy hunger. While the mechanism of action is unknown, it has been suggested that either single amino acids or small peptides enter the brain to elicit their effects and several amino acids, including tryptophan, phenylalanine, and tyrosine, have been theorized to affect the hunger control mechanisms once they cross the blood-brain barrier. Small differences in the rates at which proteins release their amino acids into the blood stream may also affect satiety. In subjects consuming high protein meals compared with high carbohydrate meals fed ad libitum, a voluntary reduction in energy consumption has been observed.

Researchers in the Netherlands (Westerterp-Plantenga *et al*., 1999) have studied the effects of protein on hunger perceptions by studying two groups of subjects in a whole body energy chamber under controlled conditions for over 24 hours. Subjects were fed isocaloric diets which were either high-protein/high-carbohydrate (protein/carbohydrate/fat, percentage of calories 30/60/10) or high-fat (protein/carbohydrate/fat, percentage of calories 10/30/60). Significantly more satiety was reported by subjects on the high-protein/high-carbohydrate diet. At the same time, hunger, appetite, desire to eat, and estimated quantity of food eaten were significantly lower in this group, with less hunger both during and after the high-protein meals. The level of protein in the diet may also impact maintenance of body weight after weight loss. After following a very low energy diet for four weeks, subjects who consumed a 20% higher intake of protein than controls (15 % vs 18% of energy) showed a 50% lower body weight regain, only consisting of fat-free mass, with increased satiety and decreased energy efficiency during a three-month maintenance period. (Westerterp-Plantenga *et al.,* 2004).

Similar studies have reported improved weight loss and fat loss in subjects consuming a high protein diet vs a control diet (25% vs 12% energy from protein) ad libitum, due to a reduction in daily calorie intake of approximately 16% (Skov *et al.,* 1999) and improved utilization of body fat with maintenance of lean body mass in subjects consuming 32% of energy from protein compared with controls who consumed 15% of calories as protein (Layman *et al.*, 2003). A similar study comparing diets with 15 percent vs. 30% of calories from protein found that while weight loss in the two groups was similar over the 6-week trial, diet satisfaction was significantly greater in those consuming the higher protein diet (Johnston *et al.,* 2004).

A meta-analysis of studies (Eisenstein *et al.,* 2002) concluded that, on average, high-protein diets were associated with a nine percent decrease in total calorie intake. While the role of protein in affecting overall calorie intake and in body weight regulation in comparison to fat and carbohydrate needs further investigation, the evidence is strong that protein affects hunger signaling mechanisms in the brain, induces thermogenesis and contributes to the building and maintenance of lean body mass.

B.5 Fats in Cellular Nutrition

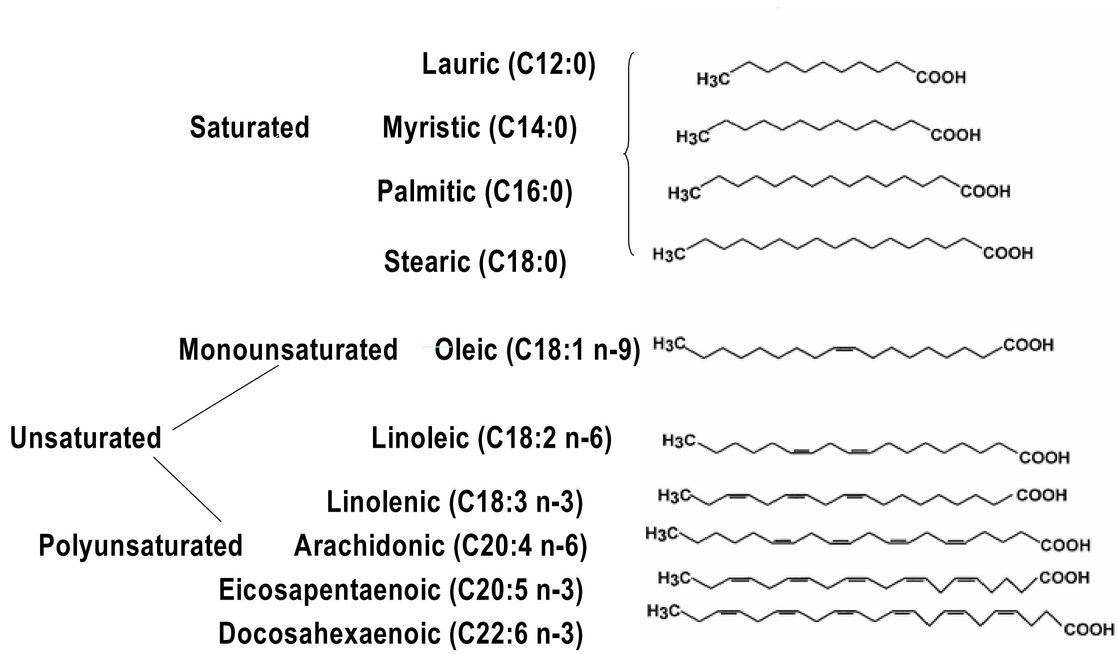
Fats are a subset of the lipid family, which includes triglycerides (fats and oils), phospholipids and sterols. Fats play an extremely important role in energy balance by enabling efficient the storage of calories in adipose tissue. It is possible for the mythical 70 kg man to carry 130,000 Calories in 13.5 kg of fat tissue compared to only 54,000 Calories stored as protein in an equivalent weight of lean tissue. This efficient storage is accomplished both by largely excluding water from adipose tissues and by storing energy in the chemical bonds of very long chain fatty acids. The typical fatty acids found in digested and stored fat range between 16 and 22 carbons in length.

Triglycerides are the chief form of fat in the diet and the major storage form of fat in the body and are composed of a molecule of glycerol with three fatty acids attached. The principal dietary sources of fat are meats, dairy products, poultry, fish, nuts, and vegetable oils and fats used in processed foods. Vegetables and fruits contain only small amounts of fat, so that vegetable oils are only sources of fat due to processing of vegetables. The most commonly used oils and fats for salad oil, cooking oils, shortenings and margarines in the U.S. include soybean, corn, cottonseed, palm, peanut, olive, canola (low erucic acid rapeseed oil), safflower, sunflower, coconut, palm kernel, tallow and lard. These oils contain varying compositions of fatty acids which have particular physiological properties. The fats stored in tissues reflect to a certain extent the fats in the diet. Humans synthesize saturated fats (e.g. palmitic acid) from carbohydrates, but the polyunsaturated essential fats (linoleic and linolenic acids) must be taken in from the diet and the balance of these fats and the metabolic products of these fats reflect short-term and long-term dietary intake. There is a statistically significant but poor correlation between adipose tissue fatty acid profiles and dietary fatty acid intake as measured on a food frequency questionnaire (London *et al.,* 1991). Red blood cell membranes change their composition in about three weeks. However, it is clearly possible to change the amount of fatty acids in tissues (Bagga *et al.,* 1997) and total quantitative fatty acids can be altered by dietary intervention. The quality of fats in the diet is defined as that ratio of fatty acids that can be measured in plasma and tissues.

B.5.1 Fatty Acid Structure and Classification

Fatty acids are organic compounds composed of a carbon chain with hydrogens attached at one end and an acid group at the other. Most naturally

Fatty Acids in Dietary Fats



Saturated fatty acids are completely saturated with hydrogens. Those fatty acids lacking two hydrogen atoms and containing one double bond are monounsaturated fatty acids, and polyunsaturated fatty acids contain two or more double bonds in the carbon chain. The degree of saturation influences the texture of fats so that, in general, polyunsaturated vegetable oils are liquid at room temperature and the more saturated fats, most of which are animal fats, are solid. Some vegetable oils such as palm and coconut oils are highly saturated, and liquid oils can by hydrogenated in the presence of a nickel catalyst to produce a firmer fat.

The nomenclature of fatty acids is based on location of the double bonds: an omega-3 fatty acid has its first double bond three carbons from the methyl end of the carbon chain. Similarly, an omega-6 fatty acid has its double bond six carbons from the methyl end. Fatty acids are also denoted by the length of the carbon chain and the number of double bonds they contain, such that linoleic acid is an 18:2 fatty acid which contains 18 carbons and two double bonds. The human body requires fatty acids and can manufacture all but two essential fatty acids: linoleic acid and linolenic acid (18:3). (See Figure 1, below)

Omega-3 fatty acids possess anti-inflammatory, antiarrhythmic and antithrombotic properties and have been shown to reduce the risk for sudden death caused by cardiac arrhythmias and decrease mortality from all causes in patients with coronary heart disease. Conversely, the omega-6 fatty acids, obtained in the diet primarily from vegetable oils such as corn, safflower, sunflower and cottonseed, are proinflammatory and prothrombotic. Fish and fish oils are the richest sources of the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosshexaenoic acid (DHA) and are also present in algae. Green leafy vegetables, nuts, seeds and soybeans contain the omega-3 fatty acid alpha-linolenic acid (AHA).   The increased consumption in the US of omega-6 fats from vegetable oils and grain-fed animals has led to a drastic increase in the ratio of omega-6 to omega-3 fatty acids in the diet from an estimated 1:1 in early human diets to a ratio exceeding 10:1 today (Simopoulos, 2001).

A great way to help reduce inflammation in the joints is to lower your total dietary fat while supplementing with about 3 grams per day of a fish oil supplement such as Herbalifeline.

B.5.2 Fatty Acids as Cellular Signals

Increasing evidence from animal and in vitro studies indicates that omega–3 fatty acids, especially the long-chain polyunsaturated fatty acids EPA and DHA, present in fatty fish and fish oils inhibit carcinogenesis (Karmali *et al.,* 1984; Lindner, 1991; Rose *et al.,* 1991; Tsai *et al.,* 1998; Boudreau *et al.,* 2001;

Narayanan *et al.,* 2001). Several molecular mechanisms have been proposed for the influences on the process, including suppression of arachidonic acid-derived eicosanoid biosynthesis (Rose, 1999; Okuyama, 1996) and influences on transcription factor activity, gene expression, and signal transduction pathways (Bartsch *et al.,* 1999).

The peroxisome proliferator-activated nuclear receptors (PPAR α, δ, γ) are activated by polyunsaturated fatty acids, eicosanoids, and various synthetic ligands (Willson *et al.,* 2000). Consistent with their distinct expression patterns, gene-knockout experiments have revealed that each PPAR subtype performs a specific function in fatty acid balance including breaking down fatty acids or stimulation of metabolism of the fatty acids within the cells of the body.

B.6 Carbohydrates in Cellular Nutrition

As with proteins and fats, one can consider the quality of carbohydrates based on the source of the carbohydrates (fruits, vegetables or whole grains vs. refined grains and simple sugars) and their digestibility (soluble vs. insoluble fiber). A quantitative approach to the analysis of dietary carbohydrate has been developed based on glycemic index and glycemic load as discussed below.

B.6.1 Sugars and Starches.

Simple carbohydrates are present in foods as mono- or di-saccharides, and are naturally present such foods as fruit and milk. Glucose, fructose and galactose are the most common monosaccharides in the human diet and combine to form the disaccharides sucrose (glucose + fructose), lactose (glucose + galactose) and maltose (glucsose + glucose). Oligosaccharides are short chains of 3-10 sugar molecules, and the most common ones, raffinose and stachyose, are found in beans, peas and lentils. Polysaccharides are starches which contain more than 10 sugar molecules, found in wheat, rice, corn, oats, legumes and tubers. Starches form long chains that are either straight (amylose) or branched (amylopectin). Amylose and amylopectin occur in a ratio of about 1:4 in plant foods.

While there are several dietary factors that contribute to obesity, a dietary pattern that is rich in sugars and starches is considered a risk factor for obesity, whereas a high intake of nonstarch polysaccharides in the form of dietary fiber is considered protective (Swinburn *et al.,* 2004). The typical Western diet is high in refined starches and sugars which are digested and absorbed rapidly, resulting in a high glycemic load and increased demand for insulin secretion. This in turn promotes postprandial carbohydrate oxidation at the expense of fat oxidation. Both acute (Ludwig *et al.,* 1999; Febbraio *et al.,* 2000) and short-term studies (Agus *et al.,* 2000; Howe *et al.,* 1996) indicate that a dietary pattern that produces a high glycemic response affects appetite and promotes body fat storage.

However, diets based on high-fiber foods that produce a low glycemic response can enhance weight control because they promote satiety, minimize postprandial insulin secretion, and maintain insulin sensitivity. (Brand-Miller *et al.,* 2002). This is supported by several intervention studies in humans in which energy-restricted diets based on low glycemic index foods produced greater weight loss than did equivalent diets based on high glycemic index foods. Long-term studies in animal models have also shown that diets based on high glycemic index starches promote weight gain, visceral adiposity, and higher concentrations of lipogenic enzymes than do isoenergetic diets with a low glycemic index which are macronutrient-controlled. (See below for a full explanation of glycemic index and glycemic load).

B.6.2 Soluble and Insoluble Fiber

Insoluble dietary fibers such as cellulose and lignins are not digested in the intestine and pass in the stool intact. These fibers trap water and increase fecal weight, and accelerate transit time in the gastrointestinal tract, thus promoting regularity. Soluble carbohydrates such as pectin, gums and β-glucans are digested by bacteria in the colon. These fibers delay glucose absorption, and are able to bind bile acids in the gastrointestinal tract, thus reducing serum cholesterol levels. Ancient humans ate a great deal of fiber, estimated at over 50 grams per day, whereas modern humans consume on average 10 to 15 grams per day.

Eating fruits and vegetables, whole grains and adding fiber to a goal of 25 grams per day will help to control absorption of glucose and provide the overall diet with a healthy glycemic load. Fiber supplements such as those from Herbalife can help you reach this goal.

B.6.3 Glycemic Index and Glycemic Load.

Conventional approaches to weight loss have focused on decreasing dietary fat, due to its high calorie density. However, the relationship between dietary fat and obesity has been brought into question for several reasons. Low fat diets have been shown to produce only modest weight loss, and prospective epidemiological studies have not been able to consistently correlate dietary fat intake with weight. Despite a decrease in fat consumption as a percentage of total calories and widespread availability of low-fat and fat-free foods, obesity prevalence in the United States has risen dramatically since the 1970s (Putnam and Allshouse, 1999). At the same time, carbohydrate consumption has increased, and most of this increase has been in the form of refined starches and concentrated sweets with a high glycemic index (GI) and/or glycemic load (GL).

In 1981, Jenkins et al introduced the glycemic index as a system for classifying carbohydrate-containing foods based upon their effect on post-prandial glycemia (Jenkins *et al.,* 1981). The glycemic response to the ingestion of 50 grams of available carbohydrate from the test food is compared to the response from the ingestion of 50 grams of the reference food (glucose or white bread), and the glycemic index is expressed as the area under the glucose response curve for the test food divided by the area under the curve for the standard, multiplied by 100. However, the amount of carbohydrate in 50 grams of a given food will vary depending upon the food, and this observation led to the introduction of the concept of glycemic load. This is an expression of the glycemic index of the food multiplied by the carbohydrate content of the food, and takes into account the differences in carbohydrate content among foods (Liu, 1998). Foods with a high index but with relatively low total carbohydrate content, such as carrots, have a low glycemic load. In general, fruits, non-starchy vegetables, nuts and legumes have a low GI. (See Table 1, below)

One problem with the GI is that it only detects carbohydrate quality not quantity. A GI value tells you only how rapidly a particular carbohydrate turns into sugar. It doesn't tell you how much of that carbohydrate is in a serving of a particular food. You need to know both things to understand a food's effect on blood sugar. The most famous example of this is the carrot. The form of sugar in the carrot has a high glycemic index, but the total carbohydrated content of the carrot is low so it doesn't add a lot of calories.

A low Glucose Load (GL) is less than 16, and this has been found to be the most important variable in studies of populations and their risk of chronic disease. You are not going to be able to eat all low GL foods, but it is important to know both the GL and the Calories that the food provides.

The problem with GL is that fatty foods which carry lots of calories have a lower glycemic index. Fatty foods can still add calories to the diet even though they have a low glycemic index.

GLYCEMIC INDEX, GLYCEMIC LOAD AND CALORIES

The GI, GL, and total calories of foods are listed here. The GI is of foods based on the glucose index—where glucose is set to equal 100. The other is the glycemic load, which is the glycemic index divided by 100 multiplied by its available carbohydrate content (i.e. carbohydrates minus fiber) in grams. (The "Serve size (g)" column is the serving size in grams for calculating the glycemic load.) Except as noted, each of the G.I. values shown below are based on the 120 studies in the professional literature referenced in the *American Journal of Clinical Nutrition,* July 2002.

LOW GI (<55) and LOW GL (< 16) FOODS

Lowest Calorie
(110 calories per serving or less)

	GI	**GL**	**CALORIES**
APPLE	40	6	75
BANANA	52	12	90
CHERRIES*	22	3	85
GRAPEFRUIT	25	5	75
KIWI	53	6	45
MANGO	51	14	110
ORANGE	48	5	65
PEACH	42	7	70
PLUMS	39	5	70
STRAWBERRIES	40	1	50
TOMATO JUICE	38	4	40

Most Other Vegetables	<20	<5	40
NON-FAT MILK	32	4	90

Moderate Calorie (110 to 135 calories per serving or less)

	GI	GL	CALORIES
APPLE JUICE	40	12	135
GRAPEFRUIT JUICE	48	9	115
PEAR	33	10	125
PEAS	48	3	135
PINEAPPLE JUICE	46	15	130
WHOLE GRAINBREAD	51	14	120
SOY MILK	44	8	130

Higher Calorie (160 to 300 calories per serving)

	GI	GL	CALORIES
BARLEY	25	11	190
BLACK BEANS	20	8	235
GARBANZO BEANS	28	13	285
GRAPES*	46	13	160
KIDNEY BEANS	23	10	210
LENTILS	29	7	230
SOYBEANS	18	1	300
YAM	37	13	160

HIGH GI (>55) BUT LOW GL (< 16) FOODS
All Low Calorie 110 or less

	GI	GL	CALORIES
APRICOTS	57	6	70
ORANGE JUICE*	57	15	110
PAPAYA	60	9	55
PINEAPPLE	59	7	75
PUMPKIN	75	3	85
SHREDDED WHEAT	75	15	110
TOASTED OATS	74	15	110
WATERMELON	72	7	50

Low GI and Low Gl - But High Fat and High Calorie

	GI	**GL**	**CALORIES**
CASHEWS*	22	4	395
PREMIUM ICE CREAM	38	10	360
LOW FAT ICE CREAM	37-50	13	220
PEANUTS*	14	1	330
POPCORN FULL FAT	72	16	110
POTATO CHIPS	54	15	345
WHOLE MILK	27	3	150
VANILLA PUDDING	44	16	250
FRUIT YOGURT*	31	9	200+
SOY YOGURT	50	13	200+

HIGH GI $\geq$ 55
HIGH GL $\geq$ 16
Includes Typical Trigger Foods, Many Higher Calorie

	GI	GL	CALORIES
BAKED POTATO	85	34	220
BROWN RICE	50	16	215
COLA*	63	33	200
CORN	60	20	130
CORN CHIPS*	63	21	350
CORN FLAKES	92	24	100
CRANBERRY JUICE	68	24	145
CREAM OF WHEAT	74	22	130
CROISSANT	67	17	275
FRENCH FRIES*	75	25	515
MAC ‘N’ CHEESE*	64	46	285
OATMEAL	75	17	140
PIZZA*	60	20	300
PRETZELS*	83	33	115
RAISIN BRAN	61	29	185
RAISINS	66	42	250
SODA CRACKERS*	74	18	155
WAFFLES	76	18	150
WHITE BREAD*	73	20	160
WHITE RICE	64	23	210

The intake of high GI/GL meals induces a sequence of hormonal changes, including an increased ratio of insulin to glucagon, that limit the availability of metabolic fuels in the post-prandial period and promote nutrient storage (Ludwig, 2002) and would be expected to stimulate hunger and promote food intake. Short-term feeding studies have demonstrated less satiety and greater voluntary food intake after consumption of high GI meals as compared to low GI meals (Ludwig *et al.,* 1999), for example, the demonstration of prolonged satiety after consumption of a low GI bean puree vs a high GI potato puree (Leathwood and Pollett, 1998).

Weight loss on a low calorie, reduced fat diet may be enhanced if the diet also has a low GI (Slabber *et al.,* 1994) and even when energy intake is not restricted, low GI and/or low GL diets have been shown to produce greater weight loss than conventional low fat diets (Ebbeling *et al.,* 2003). Additionally, subjects consuming a low GI diet ad libitum have been reported to experience a spontaneous 25% reduction in energy intake, with significant reductions in body weight and waist and hip circumference when compared with controls (Dumesnil *et al.,* 2001).

B. 7 Functional Foods

Functional foods contain bioactive substances and have effects on health and physiological function beyond simply providing calories. While many of the foods reviewed above fit this definition (e.g. n-3 fatty acids), the foods reviewed in this section have received attention as foods and food ingredients for health. They are contained in Herbalife products. For example, soy protein is a major ingredient of the Formula 1 Protein Drink Mix used in ShapeWorks and the Performance Protein Powder is made of soy protein and whey protein.

B.7.1 Soy Protein.

Soy protein is the highest quality protein found in the plant kingdom, and it is eaten by 2/3 of the world's population. Interest in soy proteins and cancer prevention arose from the observation that naturally occurring chemicals within soy protein called soy isoflavones were able to inhibit the growth of both estrogen-receptor positive and negative breast cancer cells in vitro (Peterson and Barnes 1996). In addition, the studies of populations eating soy protein indicated that they had a lower incidence of breast cancer and other common cancers compared to populations such as the U.S. population where soy foods were rarely eaten. These studies provided only supportive evidence for a positive role of soy foods, since the diets of the populations eating more soy protein were also richer in fruits, vegetables and whole cereals and grains by comparison to the U.S. diet.

Soy protein naturally contains isoflavones, primarily genistein and daidzein, which are called phytoestrogens. They are usually found in foods linked to sugars called glycosides and these phytoestrogens act like very weak estrogens or anti-estrogens similar to raloxifene. When primates have a surgical menopause induced and are given estradiol alone or estradiol in combination with soy isoflavones, the isoflavones antagonize the actions of estradiol in the breast and the uterus but demonstrate estrogen-like beneficial activities in the bone, on serum lipids and in the brain. These observations are explained by the existence of two estrogen receptors called alpha and beta. Soy isoflavones bind with very low affinity (1/50,000 to 1/100,000 the affinity of estradiol) to the alpha-estradiol receptor, but bind equally well to the beta-estradiol receptor (Clarkson et.al 2001).

Soy protein isoflavones have been shown to influence not only sex hormone metabolism and biological activity but also intracellular enzymes, protein synthesis, growth factor action, malignant cell proliferation, differentiation and angiogenesis, providing strong evidence that these substances may have a protective role in cancer (Kim *et al.,* 2002).

Soy food intake has also been shown to have beneficial effects on cardiovascular disease, although data directly linking soy food intake to clinical outcomes of cardiovascular disease have been sparse. A recent study among the participants of the Shanghai Women's Health Study, a population-based prospective cohort study of approximately 75,000 Chinese women, documented a dose-response relationship between soy food intake and risk of coronary heart disease, providing direct evidence that soy food consumption may reduce the risk of coronary heart disease in women. (Zhang *et al.,* 2003)

B.7.2 Phytochemical-rich Fruits, Vegetables and Grains.

Because fruits and vegetables are high in water and fiber, incorporating them into the diet can reduce energy density, promote satiety and decrease energy intake while at the same time providing phytonutrients. Few interventions have specifically addressed fruit and vegetable consumption and weight loss, but evidence suggests that the recommendation to increase these foods while decreasing total energy intake is an effective strategy for weight management. Obesity, while often considered synonymous with overnutrition, is more accurately depicted as overnutrition of calories but undernutrition of many essential vitamins, minerals and phytonutrients.

This increased incidence of obesity has been associated with an increased incidence of heart disease, breast cancer, prostate cancer, and colon cancer by comparison with populations eating a dietary pattern consisting of less meat and more fruits, vegetables, cereals and whole grains. The intake of 400-600 grams/day of fruits and vegetables is associated with a reduced incidence of many common forms of cancer, heart disease and many chronic diseases of aging (Temple, 2000; Willett, 1994; Willett, 1995)

The common forms of cancer, including breast, colon, and prostate cancer, are the result of genetic-environmental interactions. Most cancers have genetic changes at the somatic cell level which lead to unregulated growth through activation of oncogenes or inactivation of tumor suppressor genes. Reactive oxygen radicals are thought to damage biologic structures and molecules including lipids, protein, and DNA, and there is evidence that antioxidants can prevent this damage.

Fruits and vegetables provide thousands of phytochemicals to the human diet and many of these are absorbed into the body. While these are commonly antioxidants, based on their ability to trap singlet oxygen, they have been demonstrated scientifically to have many functions beyond antioxidation. These phytochemicals can interact with the host to confer a preventive benefit by regulating enzymes important in metabolizing xenobiotics and carcinogens, by modulating nuclear receptors and cellular signaling of proliferation and apoptosis, and by acting indirectly through antioxidant actions that reduce proliferation and protect DNA from damage (Blot *et al.,* 1993).

Phytochemicals found in fruits and vegetables demonstrate synergistic and additive interactions through their effects on gene expression, antioxidation, and cytokine action. Fruits and vegetables are 10 to 20 fold less calorie dense than grains, provide increased amounts of dietary fiber compared to refined grains and provide a balance of omega-3 and omega-6 fatty acids and a rich supply of micronutrients. Together with Herbalifeline, Herbalife's Garden 7 provides many of these phytochemicals which can work together with multivitamins for optimum cellular nutrition.

Several studies have sought to characterize dietary patterns and relate these patterns to body weight and other nutritional parameters. A prospective study of 737 non-overweight women in the Framingham Offspring/Spouse cohort explored the relationship between dietary patterns and the development of overweight over a 12 year period. Participants were grouped into one of five dietary patterns at baseline, which included a heart healthy pattern (low fat, nutritionally varied), light eating (lower calories, but proportionately more fat and fewer micronutrients), as well as a wine and moderate eating pattern, a high fat pattern and an empty calorie pattern (rich in sweets and fat, and low in fruits and vegetables). Women in the heart healthy cluster consumed more servings of vegetables and fruits than women in each of the other four clusters. Over the 12-year period, 214 cases of overweight developed in this cohort. Compared with women in the heart healthy group, women in the empty calorie group were at a significantly higher risk for developing overweight (RR1.4, 95% CI) (Quatromoni *et al.,* 2002).

In another analysis of dietary patterns among 179 older rural adults, those in the high-nutrient-dense cluster (higher intake of dark green/yellow vegetables, citrus/melons/berries, and other fruits and vegetables) had lower energy intakes and lower waist circumferences than those in the low-nutrient-dense cluster (higher intake of breads, sweets, desserts, processed meats, eggs, fats and oil). Those with a low-nutrient-dense pattern were twice as likely to be obese (Ledikewe *et al.,* 2004). Similar observations were reported utilizing data from the Canadian Community Health Survey from 2000-2001. The frequency of eating fruits and vegetables was positively related to being physically active and not being overweight (Perez, 2002).

In a controlled clinical trial, families with obese parents and non-obese children were randomized into either a comprehensive behavioral weight management program which featured encouragement to increase fruit and vegetable consumption or to decrease intake of high-fat, high-sugar foods. Over a one year period, parents in the increased fruit and vegetable group showed significantly greater decreases in percentage of overweight than in the group attempting to reduce fat and sugar (Epstein *et al.,* 2001).

Current NCI dietary recommendations emphasize increasing the daily consumption of fruits and vegetables from diverse sources such as citrus fruits, cruciferous vegetables, and green and yellow vegetables (Steinmetz and Potter, 1991). The concept of selecting foods by colour was extended in a book for the public to seven different groups based on their content of a primary photochemical family for which there is evidence of cancer prevention potential (Heber and Bower man, 2001).

Why worry about the composition of the diet? The premise is simple: diet is a major etiologic factor in chronic disease. Dietary chemicals change the expression of one's genes and even the genome itself. Genetic variation may explain why two people can eat exactly the same diet and respond very differently. Nutritional genomics emphasizes the interactions at a cellular and molecular level studied through systems biology. Herbalife products provide not only a balance of macronutrients but also vitamins and minerals critical to health as reviewed in the next section.

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Lecture 8

Nutritional Concerns of the Athlete

Optimal nutrition is an essential part of every athlete's training program. The primary areas of concern are 1) consuming enough calories to support performance; 2) consuming the correct balance of macronutrients before, during and after exercise and 3) proper hydration. There are other concerns for certain population groups as well, such as vegetarian or vegan athletes, or female athletes – particularly those who compete in sports which focus on weight or build, such as figure skating and gymnastics.

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