PROPER NUTRITION FOR PEAK ATHLETIC PERFORMANCE IN FEMALES

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PROPER NUTRITION FOR PEAK ATHLETIC PERFORMANCE IN FEMALES

Athletics in training and competition are always searching for that ultimate ingredient which just might give them that extra edge to win. Unfortunately, that magic ingredient has not yet been found. As stated by several nutritionists and exercise physiologists, "In general no type of diet supplementation will improve any type of performance in a normal person, on a normal diet...No specific diet will change a moderately endowed athlete into a champion, but a sound dietary regimen is necessary to produce maximum fitness."

This paper will present a very broad spectrum of the nutritional aspects of a female athlete in competition and training. The first section of this paper will include the proper diet for the average female. It will then present modifications of this diet for the female athlete, and finally a short summary of the best way to lose weight, to enhance performance. The second part of this paper will deal with the ways proteins, fats, and carbohydrates are used in the production of energy. It will also deal with the functions of the major vitamins, minerals, and electrolytes in the production of energy. The last section of this paper will deal with some food fads, some legitimate diet modifications, such as carbohydrate loading, and some special areas where research is still needed.

A PROPER DIET FOR MOST FEMALES

The basic functions of all of the foods that an individual consumes are to provide energy, build and repair tissues, and regulate
metabolic functions in the body. The functions of these foods are as important in the sedentary woman as in the athlete. The athlete's metabolic rate will substantially increase while exercising, and will continue at this elevated level for more than an hour. Even with this increased rate, there is really no substantial difference between feeding an athlete and a non-athlete. Both require the same basic nutrients, but the athlete will just need more of certain foods that will be discussed later. This is true, however, only if the athlete is receiving the proper diet and the proper nutrition. If she is not, then certain steps need to be taken to facilitate this need for a proper diet.

An adequate diet for any woman is a diet which contains the recommended number of calories and nutrients for that individual (see Table 1). The problem with this is that much of the time most females do not receive this adequate intake of food. Thus, their diets are many times lacking in some areas. For example, twelve females between the ages of fifteen and twenty-two, on an AAU swim team, participated in a food and nutrient intake study. These females consumed an adequate number of calories for their ages and activity level, yet were deficient in vitamin D and iron. In another study on women who were not athletes, the minimal number of calories recommended for their height, weight, and age were not consumed, plus there were deficiencies seen in iron, vitamin D, and in some, calcium. In a third study these women consumed too many calories on the average, and there was still a deficiency in iron. Most of the extra calories tended to be from fat sources.

Because of these facts, the athlete as well as the non-athlete needs to understand the basic minimal requirements. The modified
basic four diet, by Janet King, explains these requirements simply, yet efficiently. The basic four groups were divided into two groups; the basic group and the supplemental group. The basic four included the minimal number of daily servings. The supplemental foods included the remaining foods such as fats, sugars, sweets, and additions to the basic four. 6

The Basic Four Minimal Daily Servings

Basic Four Minimal Number of Daily Servings Recommended by the USDA

1) 2; 2-3 ounce servings meat or meat substitutes
2) 2 servings of dairy products
3) 4 servings (3/4 each cup) of fruits and vegetables
4) 4 servings of enriched breads and cereals

Modified Basic Four

1) 2 servings milk and milk products
2) 4 servings protein (3 ounces)
   2 of animal protein
   2 of legumes and nuts
3) 4 servings fruits and vegetables (3/4 each cup)
   1 serving of vitamin C rich foods
   1 serving of dark green
   2 servings of other
4) 4 servings whole grain cereal products
5) 1 serving fat or oil 7, such as peanut oil, crisco, or margarine

Good Sources for the Basic Four

Some interesting facts to note, when trying to use these recommendations are that whole grain foods and cereals contain richer sources if vitamin E, B-6, folacin, magnesium, and zinc, more so than enriched, refined foods. 8 Some good sources of food for the
modified basic four for proteins are meat, fish, poultry, eggs, cheese, beans, and nuts. Some sources for dairy products are milk, cheese, and ice milk. Some sources for fruits and vegetables are greens such as spinach, broccoli, and citrus fruits such as oranges, lemons, and grapefruit. Finally some examples of breads and cereals are whole grain breads, crackers, spaghetti, and rice. There are also some differences in the amount of servings, according to the age of the female (see table 1). One example of this is with milk products, which supply a large amount of calcium. Children nine years and under should have two to three glasses (8 oz.) daily. Children nine to twelve require three or more glasses (8 oz.), and teenagers should consume four or more glasses (8 oz.). Adults only require two or more cups daily. Modifications for the Female Athlete

This modified diet can be used as a basis for the competitive female athlete, but a few modifications need to be made for her increased energy output. According to Dr. Robie, Professor of Nutrition at Ball State University, the additions should especially include added carbohydrates, since they are the main source of energy for the competitive athlete. This athlete's diet should contain 50-60 percent carbohydrates. Research has found some other nutrient deficiencies in female athletes as well. As mentioned before, deficiencies in vitamin D and iron were found to be common in female swimmers.

Iron in the Diet

The problem of the low iron content in females is not a new phenomenon. Athletes, however, can have their performances adversely affected by this low iron content. In one study, for example,
the total calorie intake for the women was 2,026 per day, but their iron intake was well below the RDA for women. This low iron intake many times will not show up in iron hemoglobin levels, but is obvious in serum ferratin levels. Many times there is also a fall in blood pH and a resultant increased blood lactate level. These conditions were found to precipitate limited aerobic carbohydrate metabolism, and an early reliance on anaerobic energy production, resulting in lactate accumulation and fatigue. From this result, it is obvious that a low iron intake can severely deter the chance for a female athlete to reach peak performance.

There are three peculiarities included in the iron content of female athletes. One peculiarity involves her increase in blood volume. Since there is more blood volume in the female athlete, the red blood cells are going to be dispersed into a larger amount of blood. This is a very important fact to remember when trying to determine the iron consumption of the female athlete. Since there is this larger volume of blood, there will be a fewer number of red blood cells per milliliter of blood. This could make the individual appear iron deficient.

The second peculiarity involves the female's compensation for her suboptimal iron intake. When the female's body is low in iron, it takes the iron from the bone marrow to use in the blood. Because of this compensation, lower serum ferratin, and serum iron levels were found in the female distance runner. Thus, if the runner's body had to continually make up for a low iron intake, there would be a deficiency in the bone marrow.

The third peculiarity involved a disturbance in iron absorption, which resulted in a faster loss of iron than in normal subjects.
Thus, the combination of a disturbance in iron absorption and an increased iron loss would explain the latent iron deficiency in 80 percent of female runners. This also explains why the endurance runner's adaptation mechanism is not as problem free as it first sounds. Besides vitamin D and iron, salt and water replacement should be adequate. This will be discussed later.

As Dr. Roepke stated, an athlete's diet should consist of 50-60 percent carbohydrates. If a competitive athlete were to consume 5,000 calories per day, she would need 180 grams of protein, 135 grams of fat, and 730 grams of carbohydrates. One should remember, however, that there are varying needs of calories, according to age, type of activity, and intensity of activity (see table 2).

Weight Gain after the Season Ends

The consumption of additional calories is sometimes detrimental to the competing athlete, after her training season is over. She becomes accustomed to her increased calorie intake, and continues this high consumption. The resultant body weight may be detrimental to the athlete's future performances. If the athlete wants to lose weight, while in training, she should lose no more than one to three pounds per week. If too much weight is lost, water, and possibly muscle mass will be lost, instead of fat. The best and the safest approach for the athlete to take, would be for the athlete to start losing the excess weight three to four months before the competitive season begins. This should be done so that when the practices and competition start, the athlete will not have to worry about losing the weight.

PROTEIN IN THE DIET

Throughout the years, many coaches and athletes have probably
advocated a steak dinner for the meal before the athletic event. For example, in *Super Food for Super Athletes* (Flemming 1968), protein was proclaimed as the magic pill, which would do wonders for athletes. Protein, however, is actually more important for structural material, rather than energy material. Protein is important mainly as a source of amino acids, from which an organism can build its own structural and functional proteins. The protein molecule provides the lattice work around which calcium and phosphorus are deposited, to form bones. Collagen, a protein substance, gives strength to connective tissues. It also creates the fibers that form the tendons, and that make up the sheets that cover the muscles and hold them in place. Besides providing the basic structure for most of the bodies tissues, amino acids are required for the structure of enzymes, hormones, and oxygen carriers. These include hemoglobin, cytochromes, genes, and antibodies. The secondary function of protein is to serve as an energy source, but this happens only when the body is depleted of the stored carbohydrates and fats.

Understanding Protein Metabolism

In order to understand protein metabolism, one should understand the chains which make up these proteins, referred to as amino acids. Stated very simply, each protein molecule is a chain with links of small nitrogen containing molecules called amino acids. The chains are called polypeptides. The amounts of the various amino acids in the protein chains will determine the food's nutritional value. One very important fact in the metabolism of amino acids is that they depend on the nitrogen from the air, thus proteins would never be used in any anaerobic work. The amino acids, which are used for
energy, are not clean burning fuels since nitrogen cannot be oxidized by the body. It requires a large amount of energy to convert amino acids into a usable form of energy, and they also leave residue. The remaining residue is the nitrogen fragment, and the remains of other protein substances, which result in urea and uric acid.32

Protein breakdown and synthesis is constant as a process in the human body. During the growing years, there is also a positive nitrogen balance in training which indicates the buildup of the muscles.33 A basic explanation of how the amino acids are metabolized, is that after the amino acids have been digested and absorbed, they are transported into the liver, which breaks down the amino acids. The liver will then synthesize an amino acid mixture for the tissues and plasma proteins, that will channel them into pathways of carbohydrate and fat metabolism. Surplus protein cannot be stored as amino acids, so the amino acid's carbon is transformed into carbohydrate or fat. As mentioned before, the nitrogen is oxidized and converted to ammonia, then finally into urea, which is excreted.34

The Need for Protein while Training

Physical activity significantly increases the need for dietary protein.35 While this is true in most cases, there are a few exceptions and some controversy about this statement. The normal requirement for the athlete undergoing serious training is 1g/kg body weight per day.36 Some authorities feel, however, that this should be increased during training. There are many different reasons for this line of thinking. Training and competition demand greater amino acid retention and protein under anabolic circumstances.37
Increases in lean body mass, enzymatic protein myoglobin, and hemoglobin are typical effects of training. Also the development of protein urea, and myoglobin urea also would require higher than normal protein levels. Many researchers use these reasons as supporting evidence of the need for increased amounts of dietary protein. There has been very little objective experimental evidence, however, to support these contentions.

It is felt that protein supplementation during training is met by increased calorie consumption in the normal diet. The only time a protein supplement is needed, is when the athlete is not receiving the adequate amount of protein from her diet. This, however, is highly unlikely.

THE ROLE OF DIETARY FAT

Just as proteins are used predominantly for building blocks, fats and carbohydrates are used for energy. Fats are also used to protect various organs, as main constituents of some body structures, and also as carriers for the fat soluble vitamins A, D, E, and K. There are also many different types of fats. For clarification, they will be divided into three main groups: simple, compound, and derived.

The Basic Structure of Fat

The simple fats are primarily triglycerides. These represent the main stores of fat in the body, since 99 percent of the body fat is in this form. The triglyceride molecule contains glycerol, which is not a fat, and three clusters of fatty acids. The two types of fatty acid molecules are saturated and unsaturated. The saturated fats bond with as many hydrogen atoms as chemically possible, and do not melt at room temperature. Saturated fats are
found in beef, pork, egg yolks, and dairy products. Unsaturated fatty acids contain at least one double bond, along the carbon chain, and do not contain the optimum potential for hydrogens to bind. If there is only one double bond, the fatty acid is monounsaturated, but if there are two bonds or more, the fatty acid is polyunsaturated. These are the fats which melt at room temperature, such as vegetable oil.

The compound fats are the phospholipids, glucolipids, and lipoproteins. The lipoproteins are the most important of these three, because they transport the fat in the blood. Finally, the derived fats are types derived from simple and compound fats, such as cholesterol. Cholesterol is present in all cells, and is either consumed in foods or synthesized within the cell.

Fat as an Energy Source

One would think that fat is the ideal cellular food because each molecule carries large quantities of energy per unit weight, is easily transported and stored, and is readily converted into energy. During sedentary periods, most of the lipid from the fatty acid digestion, produces chylomicrons. These are released into the lymph, then carried away into the blood stream. After a meal, there is usually an elevated blood lipid level. Both the liver and adipose tissue play an important role in the processing of these chylomicrons. The fat is a fairly good energy source, because it contains more than twice the energy storage capability than carbohydrates or protein. However, the slow rate of metabolizing the fat makes it a less efficient source of quick energy.

During prolonged exercise, there is a gradual increase in the amount of fat used for energy (see graph 2). When this happens, the
fatty acids are derived from three sources: 1. Fat stores in adipose tissues, which are mobilized in response to exercise induced elevation of adrenalin; 2. Circulating triglycerides rich lipoproteins which use fatty acids in hydrolysis. The lipoproteins have been shown to increase in muscles with prolonged exercise; 3. The fat stored within the tissue itself (this fat has been shown to be greater in physically trained subjects, than in untrained subjects). During these extensive periods of exercise, fat mobilization is initiated by a hormone sensitive lipase, that hydrolyzes triglyceride to free fatty acids and glycerol. "These, then diffuse into the blood for transportation throughout the body...Using fatty acids for energy involves the breakdown of fatty acids to substances that can be broken down into CO$_2$ and H$_2$O." This is the process used to produce acetyl-Co-A units which enters into the Krebs cycle to eventually produce energy (see illustration 4).

Exercise also increases mobilization of fat from the adipose tissues. In trained athletes there are higher levels of use of the free fatty acids during a muscular contraction. In fact, if work is at a low enough intensity, over a long period of time, fatty acids will contribute from 80-90 percent of the energy. With the athlete's intensive training, her efficiency of utilizing fat can be improved. This is extremely important in endurance events where glycogen could be spared as fat is burned. However, in maintaining performance at intensities of 60 percent to 75 percent VO$_2$ max, (percentage of oxygen consumed), even the highly trained athlete will have to depend on her glycogen store. The reason for this is because the fatty acid breakdown process cannot be utilized at a rate high enough to benefit the athlete.
In summary, fat is an energy source in a very concentrated form. It can be utilized during prolonged low intensity work. Carbohydrates are the preferred fuel during sustained high level activity. Thus, a high fat diet is not recommended. In fact, as Dr. Costill suggested in my interview, "A high fat diet could severely deter peak performance for an athlete."

CARBOHYDRATES IN ENERGY PRODUCTION

Types of Carbohydrates

Carbohydrates, as mentioned before, are the main energy fuel for the body. The energy derives from the breakdown of carbohydrates is used to power muscular contractions to serve as a "primer" for fat metabolism, and is essential for the proper functioning of the nervous system. There are three main forms of carbohydrates, these are: polysaccharides, disaccharides, and monosaccharides. Most of the natural foods such as wheat, peas, and beans are polysaccharides. These polysaccharides are converted into starch in our bodies. The disaccharides include maltose, lactose, and sucrose. These disaccharides are hydrolyzed to produce monosaccharides. The monosaccharides are glucose, fructose, and galactose.

Carbohydrate Breakdown

The primary end product of the carbohydrate breakdown is the monosaccharide, which is represented by glucose. Once digested and absorbed, these monosaccharides are transported by the blood to the liver and other tissues, where they are metabolized. Glucose can be derived from many other sources as well. Galactose and fructose can be converted into glucose-6-phosphate. Amino acids, such as alanine, can be converted into glucose-6-phosphate. Lactic acid can even be converted into glucose. This process is accomplished
by transportation of the lactic acid, by the blood, to the liver, where it is reconverted into glucose. This is, however an energy consuming process, and is not just a simple reversal of glycolysis (see graph 3).61 There is one result of this blood glucose, it is a phosphorilation of glucose-6-phosphate. After this, it is converted into stored muscle glycogen, or it goes into the glycolytic pathway to be released as energy. Excessive carbohydrates can be converted into triglycerides and stored as adipose tissue.62

Carbohydrates as Energy Production

Carbohydrates, when used for energy, are the most efficient sources available to our bodies. Stored muscle glycogen, and blood glucose are the main contributors during high intensity exercise. Blood glucose may supply as much as 30-40 percent of the total energy used for the exercising muscle.63 The exact amount of glucose utilized will depend, however, on such things as temperature, physical conditioning, pre-exercise diet, and the types of exercise. There is also a greater demand for carbohydrates, when the flow of oxygen in the working muscle does not meet the demand for oxidative metabolism.64 During the early minutes of exercise, before the oxygen transport system (circulation) has fully compensated for the sudden increase in exercise metabolism, carbohydrate serves as the primary energy source.65 This carbohydrate is metabolized in the muscle, to form Adenosine Triphosphate (ATP). Adenosine Triphosphate is the main source of energy for our bodies. In these early minutes of exercise, ATP is metabolized without oxygen, so it is anaerobic. If energy is needed for continued exercise, a high energy compound called phosphocreatine is used (see graph 4).66 After this, glycogen,
which is derived mainly from carbohydrates, is used as an energy source for muscles. It is stored in the muscles and can be metabolized within the muscle, to produce ATP. This process is also, mainly anaerobic. The final, long term source of energy is from the aerobic metabolism of glucose (carbohydrates) and some fats (see graph 4).  

**Glycolysis**

This energy transfer system in our bodies is a very intricate and marvelous achievement, which takes place whenever needed, in most people. There are actually two stages for this breakdown of glucose for energy. The first stage involves the breakdown of the glucose molecule into two molecules of pyruvic acid. These are the anaerobic stages. The second stage is of glucose metabolism. In this stage, pyruvic acid is degraded into carbon dioxide and water. Energy transfers resulting from these involve carbon electron transport, and oxidative phosphorilation, so they are aerobic.  

When glucose enters a cell to be used for energy, it undergoes a series of chemical reactions called glycolysis (see graph 5). Glycolysis is a complex series of steps. Stated very simply, phosphates activate the carbohydrate molecule. This is accomplished by ATP being broken down into ADP, with energy as a result. Glycolysis generates 4 ATP's during substrate reactions. There is, however, only a net gain of 2 ATP's. Each pair of electrons produced, going through electron transport permits 3 molecules ATP. There are 2 pairs of electrons generated by each glucose unit, so there is a total of 6 ATP's added to the previous 2 ATP's.  

After glycolysis, the pyruvate is transferred into the Krebs cycle.
The Krebs cycle is a series of 8 steps which eventually produce 36 ATP's (see graph 6). These ATP's are used as fuel for muscular work. 70

The Reasons for Fatigue

It seems, with this energy producing system, that one should be able to perform physical work forever. This, however, is obviously not the case. There are many different theories regarding the exact cause of fatigue. Some of the theories are very obvious, such as the build up of lactic acid in the muscles, exhaustion of fuel, and a fluid electrolyte imbalance, which leads to a reduced metabolism. 71 One theory with two parts to it which works together to help produce fatigue is, a drop in blood sugar, which affects the central nervous system. 72 Many scientists feel that the theory of fuel exhaustion is not a primary contributor, unless the exercise is at a maximum level, for a long period of time. 73 Many theorists agree that instead of first being affected by a depletion of fuel, that the drop caused in blood sugar would affect the central nervous system. 74 It seems that in prolonged exercise, physical exhaustion may not be due to changed biochemical state of the muscle, but possibly due to lowered blood glucose levels, which affect the neural state of the muscle (see graph 7). 75 Dr. Roepke, in my interview with her, also agreed that this could be a large contributing factor in causing exhaustion. She stated that when a muscle was biopsied, that there was still an amount of fuel left, which could have been utilized. 76 The aspect of fatigue is caused by a combination of the many variables mentioned.

As it can be seen, carbohydrates serve as the major source of energy, as well as fuel for the central nervous system. Muscle
glycogen and blood glucose are the major fuels during intense exercise. Our bodies need all three types of food stuff: proteins, fats, and carbohydrates. If deficiencies result in one area, the body will try to compensate for the deficiency, but if the deficiency is prolonged for any of the three (especially carbohydrates) a resultant detrimental affect on performance will be seen.

THE ROLE OF VITAMINS

Carbohydrates, proteins, and fats are all essential to our bodies. There are, however, other important nutrients as well. These include the vitamins, minerals, and water. Vitamins represent a number of organic food sources found in many foods. They are essential for the optimum functioning of many bodily functions. They are also important in increased levels of activity. There is much controversy as to whether athletes need to supplement their diets with increased intakes of vitamins. Advertisements abound about the need for increased vitamin intakes. However, except for persons with special medical needs, the Food and Nutrition Board of the National Research Council, has indicated that there is no available scientific justification for recommending the routine use of vitamin supplements. Vitamins are in almost everything one eats or drinks. The athlete who consumes a well-balanced diet, with the proper number of calories, will receive the Recommended Daily Requirement for the various vitamins. This statement is the key. The diet of the female athlete has to be well balanced, and provide the proper number of calories. If it is not well balanced, the potential for having a deficiency which would affect performance significantly.

There are actually fourteen different vitamins, each having its own function within our bodies. These vitamins are classified as
water soluble and fat soluble. Vitamins received in excess amounts that can be excreted from the body are the water soluble vitamins. These vitamins include the B vitamins (thiamin, riboflavin, niacin, B₆, B₁₂) pantothenic acid, biotin, choline, folacin, and vitamin C. The fat soluble vitamins are vitamins A, D, E, and K.⁷⁹ All of these vitamins are essential to an athlete's growth and functioning, but for the purposes of this paper, I will only discuss the ones which are most important in the athlete's performance (for a chart of the functions of all the vitamins listed, see graph 8).

The B Vitamins

The vitamins which seem to affect performance the most, also have tended to raise the most controversy. They have been used in many schemes, for profit. These are the B complex vitamins, and vitamin C, D, and E. The B vitamins are water soluble, so they are not stored in the human body. The B vitamins which seem to raise the most controversy are thiamine, riboflavin, niacin, and pyridoxine.⁸⁰

Thiamin

Thiamin (B₁) plays an important role in energy metabolism and the nervous system. It also plays an important role in the oxidative decarboxilation of pyruvate to acetyl-CoA, where it enters into the Krebs cycle, to ultimately produce ATP.⁸¹ If the thiamin were not available, lactic acid would be produced in increased amounts, and fatigue would be a possible result. Because of the obvious relationship of this vitamin with energy utilization, many people jump to the conclusion that the more ingested, the more ATP would be produced. However, there is not conclusive evidence that thiamine
intake above the normal RDA will enhance physical performance.\textsuperscript{82} Foods which contain thiamin include meat, fish, poultry, cheese, vegetables, enriched cereals, and milk.

Riboflavin

Riboflavin ($B_2$) functions as a coenzyme. Its main role seems to be involved with the oxidative reactions occurring in the mitochondria. Good sources for riboflavin include liver, yeast, milk, meats, green leafy vegetables, and whole grain breads. There has not been very much research as to the effects of riboflavin and athletic performance.\textsuperscript{83} Since it is involved, however, with the mitochondria, which is the energy producer of the cell, false claims of its energy producing abilities have been made.\textsuperscript{84}

Niacine

A third $B$ complex vitamin is niacin ($B_3$). Its major function is to act as a component to two coenzymes concerned with glycolysis, fat synthesis, and tissue respiration. It used to be felt that increased niacin levels would lead to increased anaerobic capacity, since it served in conjunction to NAD and NADP (these two act as hydrogen acceptors in energy production).\textsuperscript{85} Niacine is widely distributed in such things as peanuts, meat, fish, and grain products. More research needs to be conducted on this vitamin, because conflicting studies have resulted. Thus far there seems to be no substantial evidence that even a dietary deficiency would result in a detrimental affect on energy metabolism.\textsuperscript{86}

Pyridoxine ($B_6$)

The last $B$ vitamin to be mentioned, is pyridoxine ($B_6$). This is not just one substance, but a term for three functionally related
pyridines: pyridoxine, pyridoxal, and pyridoxamine. These pyridines play an important role in the reactions of the cell, converting amino acids into the particular amino acids necessary for the cell's own activity.\(^8^7\) It is also important in oxygen transportation and utilization, because it aids in forming hemoglobin, myoglobin, and cytochromes. This would lead one to believe that it would aid in aerobic endurance activities, but no research has been conducted to back this up.\(^8^8\) It has also been found that when an athlete eats a high protein diet, the need for pyridoxine increases. Some of the foods which contain this vitamin are meats, fish, poultry, and potatoes. More research needs to be done on this vitamin.\(^8^9\)

Research has shown that inadequate amounts of the B vitamins have resulted in a decreased capacity to perform endurance activities. It may be concluded that a deficiency of the B complex vitamins will lead to a decreased ability to perform endurance work. However, an athlete on a proper diet should not encounter this chance for deficiency. There are many references which recommend that a supplement be taken, but unless the athlete's diet is very poor, she will not need this supplement.\(^9^0\)

**Vitamin C**

Besides the B vitamins, vitamin C (ascorbic acid) has provoked misconceptions. The total role of vitamin C is still not known. It is known, however, to aid in synthesis of collagen, in the metabolic reactions of amino acids, in the synthesis of epinephrine, and in the anti-inflammatory corticoids of the adrenal gland.\(^9^1\) Some good sources of vitamin C are citrus fruits, tomatoes, white potatoes, broccoli, and greens. One should be careful in preparing these, since vitamin C can be destroyed by cooking. Massive amounts of
this vitamin, besides not helping performance, could actually be detrimental to an athlete's performance. Large amounts can cause bowel problems, diarrhea, and in some studies have been shown to destroy vitamin $B_{12}$, which is essential for prevention of anemia. If a deficiency results, over a long period of time, muscle weakness, along with a decreased trainability of the muscles results. Once again there is wide controversy surrounding the question of an increased need for vitamin C, during strenuous athletic training. While it is believed that some increase in the intake of ascorbic acid could be needed by the training athlete, the amount which is needed is still subject to question. 92

Another area dealing with vitamin C, which should be explored involves wound healing, and its affect on muscle soreness. Although no data is yet conclusive, there has been a relationship established between healing tissue, and increased intakes of vitamin C. 93 It would be very beneficial to the injuries athlete if it were found that vitamin C aids in the healing of wounds.

Vitamin D

Vitamin D is a sterol which aids in the absorptive capacity of calcium and phosphorus. It also promotes calcification of the bones. 94 Vitamin D aids in calcium transport, by acting in the nucleus of intestinal cells. This induces the production of mRNA for proteins, which will in turn increase calcium absorption. 95 Vitamin D occurs in two forms; $D_2$ which results for irradiation of ergosterol, and $D_3$ which is a compound in the skin activated by the sun. 96 It is also a fat soluble vitamin, which means that excesses will just build up in the body. If this build up becomes too large, a toxic effect
will result. Obviously this toxic state would be very detrimental to any type of activity, especially any athletic pursuit. Results of this toxic affect would be such symptoms as weight loss, vomiting, nausea, and loss of muscle tone. There may also be a release of calcium from the bones to be deposited in the soft tissues. Because of these ill affects of vitamin D, supplementation for the athlete is not needed, and could possibly be harmful. If an athlete feels that she needs more of this vitamin, she should increase her intake of such foods as breads, fish, and fortified milk.

Vitamin E

The last vitamin which will be discussed is vitamin E. This is also a fat soluble vitamin. Good sources of vitamin E include wheat germ oil, margarine, green leafy vegetables, legumes, and nuts. Research, once again is needed on this vitamin. One of its primary functions is to act as an antioxidant to prevent damage to the cell membrane. It is also speculated that it is involved in certain activities in the body, such as the formation of red blood cells. There are various falacies which have been recorded about this vitamin, about it being needed in building energy and endurance. There have also been reports that it aids in the reduction of the accumulated lactic acid in the blood. These reports are highly subjective to false interpretation, since many of the experiments did not contain proper control. Therefore, as of yet there is no real evidence that vitamin E supplementation has any effect on improving performance. Since it is a fat soluble vitamin, excesses are stored, and there can result in detrimental effects.

In conclusion, vitamin supplements can reverse the symptoms of vitamin deficiency. If an athlete consumes her RDA for caloric intake,
she should not spend her money foolishly because vitamin myths she will encounter. If, however, her diet is very haphazard and indiscriminate, a multivitamin supplement would be recommended to assure her that she will receive her adequate needs. While the supplement will not allow her to do better than her physical capabilities, it could be an aid if she were deficient. Many of the facts have been clouded, on this subject, because of testimonials by coaches and athletes. More research needs to be done on such vitamins as the B complex, C, E, and D. When more research is done and documented, the facts will be able to be separated from the myths.

MINERALS IN THE DIET

Often spoken of, when vitamins are mentioned, are minerals. Just like vitamins, there is little need for supplementation of these elements if the female athlete ingests the proper diet. Most minerals are found in the living cells. They are classified into two types; major minerals which are present in large quantities, and trace minerals, those present in minute quantities.

The Role of Minerals

Minerals serve various functions in the human body. Some are utilized as building blocks, such as calcium and phosphorus, in the bones and teeth. Iron in hemoglobin, cobalt in B₁₂, zinc in insulin, and iodine in thyroxine all represent the roles of minerals in enzymes and hormones. Minerals are also important in such regulatory functions as pH buffering, regulation of muscular contractions, nerve impulse conductions, and regulation of normal heart rhythm. Of the seventeen major and minor minerals, (for complete listing, see chart 9) only six have RDA's. These six are: calcium, phosphorus, iodine,
magnesium, zinc, and iron. Since I have discussed the importance of iron earlier in this paper, I will now briefly discuss the remaining five, plus briefly mention the importance of sodium.

**Calcium**

Calcium is the most abundant mineral in the body. Ninety-nine percent of the body's calcium is contained in the bones and teeth. The calcium combines with phosphorus to produce the bones and teeth. While it is obvious that most of the calcium is in use, the remainder is used in several functions, not related to bone structure. It is needed in many enzyme systems, in heart and skeletal muscle contraction, nerve impulse transmission, and blood clotting. If there are decreased amounts of circulating calcium, the parathyroid, which regulates calcium metabolism, could be affected. A sudden increase in calcium, in its ionized form, can cause respiratory or cardiac failure, whereas a sharp decrease of calcium can cause muscle tetany. One should remember, however, that the chances of an imbalance, either way, to cause such erratic behavior, are not large. The fact that calcium benefits the functioning nerves and muscles, does not mean that by increasing the intake of calcium, one will improve his nervous or athletic performance. Thus, if one receives the RDA for calcium, this will be sufficient for the individual to function at her optimum level without fear of a deficiency occurring.

**Phosphorus**

Along with calcium, phosphorus, as mentioned, combines with calcium to provide the rigidity to bones and teeth. Phosphorus is also essential to the effectiveness of the B vitamins, plus it is an essential ingredient in high energy adenosine triphosphate
and creatine phosphate compounds. These two compounds are essential in supplying energy for any type of activity. Phosphorus also buffers certain acid end products of muscular work. It is for this reason that there are so many claims by advertisers, coaches, and athletes for the high consumption of special phosphate containing drinks to improve performance. As of yet there is no evidence to prove this assumption.

Iodine

In the subject of athletic performance, iodine does not have much influence, however, it is still an essential mineral. Iodine's main involvement is with the thyroid gland, and some enzymes. If there were a severe deficiency, a thyroid malfunction would be likely to occur.

Magnesium

Unlike iodine, magnesium is vital to man, because it is important in regulating body heat, muscle contraction, and protein synthesis. It is also important in the formation of muscle and liver glycogen from exogenous glucose. During energy metabolism, glucose, fatty acids, and amino acids are acted on by magnesium. Magnesium also helps in muscle contractions, by stabilizing the contractions.

In 1974, the National Research Council reported that magnesium deficiency was rare, because it is widely distributed in foods. "Russian investigators, however, reported a need for a 30 percent increase of magnesium of athletes in training. In a recent report (Rose and others) the magnesium content, after a marathon race had been significantly reduced." Since this, not much research has been done to study magnesium deficiencies or supplementation for the athlete.
Zinc

Since zinc is a trace element, not much research has been done on it, as far as its effect on athletic performance. Zinc is important for many enzymes which function in carbon dioxide disposition, and the energy metabolism of the muscle. It is also involved with insulin now.\textsuperscript{119} There has also been some interest in the powers of zinc in healing wounded skin, however, most research tends to indicate that it is only effective if the person is already low on zinc.\textsuperscript{120}

Sodium

Although sodium is not one of the minerals which has an RDA, it receives enough controversy and misinterpretation, that some facts on this substance should be brought out. Sodium, along with potassium and chloride are electrolytes. This means that when ingested, they act as electrically charged particles within the body. These particles maintain the body's fluid balance. This balance includes exchanging nutrients and wastes within the body. Electrolytes sodium and potassium also maintain proper electrical gradients across cell membranes. This differentiation is required for the proper transmission of nerve impulses, for the stimulation and contraction of the muscles, and for proper functioning of the glands.\textsuperscript{121}

Salt (sodium) is contained in almost all foods people eat. The body, however, contains mechanisms to allow for a wide range of sodium intake. Aldosterone is the key mechanism in this regulation. Sometimes, however, the body's regulatory system cannot make up for excessive losses. These losses would take place in hot weather, with excessive sweating. These excessive water and electrolyte losses cause impaired performance, heat cramps, heat exhaustion, or heat
stroke. This obviously would severely impair performance. Many athletes can lose up to 5 Kg of water in practices or games, because of sweating. The immediate treatment for this loss, is to replace the water lost through sweating. Although, in most cases, people unconsciously ingest more salt when it is needed, sometimes a slight amount of salt should be added to the fluid ingested. The suggested amount is 1/3 teaspoon of table salt per liter of water. Although this does not seem like much, it is quite efficient to replace the fluid and electrolytes which have been lost. From this description one should realize that the ingestion of salt tablets is totally unneeded and could be very harmful, if done over a long period of time. It should also be obvious that water is the essential ingredient that needs to be replaced because it is the loss of this, along with the electrolytes, which causes the deficiency symptoms.

Minerals serve a vast array of functions in the human body. While it is not hard to receive the minimum daily requirements for these minerals (except possibly iron), a deficiency will result in substandard performances. While supplementation for most of these minerals is not usually needed, one should try to consume the proper diet to receive these minerals.

HELPFUL HINTS FOR THE DIET OF THE FEMALE ATHLETE

The last sections of this paper will not be dealing with, what would be considered, ordinary nutritional information. This section will contain special information, that the female athlete should appreciate. This last section will deal with such topics as; ergonic acids, carbohydrate loading, pre-game meals, the best time for consumption of other meals, some nutritional myths, and ideas for future study.
Ergonic Aids

The idea of ergonic aids has persisted for a long time. Athletes are willing to try anything and everything to gain that extra edge. Manufacturers and salesmen know this, and have tried every conceivable scheme to convince the athlete to buy their product. This paper will discuss the ones most commonly known to athletes, and their benefits or hazards.

At one time or another, everyone has heard that glucose, dextrose, or honey act as quick energy sources during competition. The reasoning behind this assumption is that the ingested sugar causes insulin to be released from the pancreas. The insulin then causes the blood sugar to be stored in the muscles. The problem with this, is that this causes a low blood sugar (hypoglycemia) which will give the athlete a feeling of weakness. It is obvious then, that these substances would not aid in performance. If anything, ingesting any of these substances approximately an hour before an athletic event could elevate the insulin, consequently lowering the blood sugar, and severely deterring performance.

Gelatin, has also been reported as possessing an ergonic affect. The rationale most commonly used in recommending gelatin is its relationship to creatine formation. Since glycine, which is gelatin, is considered essential for the formation of creatine, some have speculated that gelatin may help form phosphocreatine in the muscle. This, however, has not been proven. As far as researchers can speculate, neither gelatin, nor glycine contain any ergonic effects for the athlete.

The most popularly advertised ergonic aid is wheat germ oil.
Coaches as well as national and internation athletes swear by it. Wheat germ oil has been promoted by the Biobin Oil Company as improving endurance, stamina, and vigor. This oil company does not have any studies to back up its claims, but it even has a brochure with comments from coaches and athletes.\textsuperscript{128} There is also a researcher (Cureton 1949) who claims that wheat germ oil is a "wonder aid" for athletes.\textsuperscript{129} With all of these claims of the magic of wheat germ oil, it is not hard to realize the reasons for its controversy.

The reasons for the imagined success of the wheat germ oil are varied. The Shute Foundation for Medical Research claimed that it was the vitamin E in the oil which reduced the oxygen requirements for the tissues. Others, such as Cureton, reported the ergonic effect was because of an alcohol extracted from the germ or embryo of the kernel.\textsuperscript{130} The problem with most of these statements, once again, is that there had been no real scientific research to verify them. There have been other studies done, which contrast with these statements and findings for the effects of wheat germ oil. Because of these conflicting reports, and the need for further research, it is felt that wheat germ oil can be used as an ergonic aid, but its effects may be more psychological, than physiological.\textsuperscript{131}

Another ergonic aid, which has recently been brought up, is caffeine. Unlike the other ergonic aids mentioned, there seems to be a possible benefit from its ingestion. It has been shown that consuming the amount of caffeine found in two cups of coffee, sixty minutes before exercising, significantly extends endurance in moderately strenuous exercise. Caffeine does this by stimulating epinephrine to release fatty acids. The fatty acids are then used for energy, instead of carbohydrates.\textsuperscript{132}
This sounds great, unfortunately there are some complications in using caffeine. One problem is that athletes who are accustomed to drinking normal doses of coffee, will not be affected by ingesting caffeine before their athletic events. Also, if too much caffeine is ingested, the athlete will become too kinetic and may ultimately destroy her carbohydrate stores, at a faster rate than normal. In older studies, caffeine was found to increase work performance, but in more recent studies (Bugyi, 1941) the caffeine in various doses, had no effect on initial strength, final strength, or the rate of fatigue. Once again, there are conflicting reports resulting from research. More research obviously needs to be done, to determine caffeine's actual value, if any. If, however, it is found to be of value in enhancing athletic performance, an ethical issue will arise involving the morality and legality of using caffeine since it is known to be a stimulant.

The last ergonic aid which will be presented is the high sugar variety of replacement fluids. These fluids contain a variety of minerals, carbohydrates, salts, and water that the body loses while sweating. Ergonic aids of this type, can sometimes be used to maximize performance. The key to using one of these solutions, is the time of ingestion. If one wishes to facilitate her best performance, she should ingest the ergonic mixture during the course of the long distance event. This will stimulate one's body to burn the glycogen more efficiently. It also causes the hormone response to be different, thus not as much insulin is needed. The ergonic aid should not be ingested, however, before competition begins. This is because the high sugar content of the drink will cause the glucose
in the blood to transfer into the muscle. This induces a low blood sugar, and a resulting feeling of weakness. This does not happen, however, while exercising, because as mentioned before, the insulin response is different, and the ergonic aid facilitates glycogen utilization. If in the long distance run, however, the body reaches the point that the muscle fibers are emptied of glycogen, even an ergonic aid will not help. The fibers are still producing glycogen, but not at a fast enough rate for the amount of energy required. In conclusion, it is felt at this time, that the benefit of ergonic aids is more psychological than physiological. The use of mixtures, such as Gatorade, however, do have some significance if used during a long distance event. An athlete must realize that her loss of water should be her main concern. She should also remember that any ergonic aid will not cause her to perform better than her present capabilities.

**Carbohydrate Loading**

Besides ergonic aids, carbohydrate loading has filled magazines and advertisements as a new wonder formula, for producing optimal performance. Carbohydrate loading has changed from when the theory was first introduced. Bergstrom and Holtman (1972) stated, "that in order for glycogen depletion techniques to be most effective, it is important that the glycogen stores be maximally depleted through exhaustive exercise." This depletion of muscle glycogen consisted of a depletion stage 4-7 days before the athletic event. This depletion included a maximal energy output workout, plus a diet consisting of high fat, high protein, and low carbohydrate consumption. In the second phase of this, the following 3 days included increasing the
carbohydrate intake, and maintaining the protein and fat intake. This was to supersaturate the muscles with glycogen. In the third phase, four to six hours before the event, the athlete would eat any meal desirable.  

These three phases of diet have recently been changed through extensive research in this area. The research was done because one or two bouts of exhaustive exercise are not beneficial for the athlete during his "tapering" phase. There is also the fact that these exhaustive bouts could increase the chance for injury. Because of these disadvantages of the carbohydrate loading technique, a study was undertaken to determine to what significance the depletion phase had on muscle glycogen supercompensation. The study took six well trained runners and put them on diets with 15 percent, 50 percent, and 70 percent carbohydrates. Each diet was consumed during six day intervals. There were also standardized training runs, and competitive time trials. During the research, adequate amounts of time were given between each of the three six day diets, to assure that any physiological change was due to the present diet, and not to the previous one. The results of this study clearly indicated that 3 days on a mixed diet along with a tapering-depletion type schedule elevated the muscle glycogen stores to levels similar to severe exercise, depletion diet regimens. This research also backed up another previously known fact. This is, that carbohydrate loading is of little benefit to shorter endurance events, such as a 12 mile run. In events of shorter endurance the question of, "does my diet contain enough carbohydrate to maintain adequate stores of muscle glycogen for training and performance?" In longer distance events,
however, (20 miles or more) carbohydrate loading does seem to produce some benefit.142

As it can be seen, the technique of carbohydrate loading has changed in the last few years. Now there is no longer a recommended severe depletion or exercise phase. This is a step in the right direction considering this phase could end up deterring the performance, more than the carbohydrate loading would aid the performance. (see chart 10 for suggested meals). Females participating in distances less than this should worry more about getting the right nutrition and carbohydrates in their normal diets, than worrying about the techniques of carbohydrate loading. She should remember that any technique like this cannot make up for any deficiency that she already has.143

The Pre-game Meal

One of the most over-rated aspects of nutrition, is the significance put on the pre-game meal. Ingestion of food is not followed by an increased physical efficiency, yet this subject has been one of discussion and controversy.144 Two major points of the pre-game meal are timing and size. If a meal is too close to a competitive event, nausea or cramps could result. If meals are too far apart, hunger could arise, also causing uncomfortable feelings. The types of pre-game meal most often recommended is one which is minimal in fat and protein. Carbohydrates such as grains, fruits, and vegetables are good supplements for a meal. The meal should contain approximately 500 calories (this is according to preference) and should be eaten three to four hours before the athletic event.145 The high carbohydrate meal results in a rapid rise of blood glucose, which is followed by a below normal glucose level. However, if liver glycogen is high
enough, the secretion of epinephrine before the competition should restore the blood glucose level to normal by performance time.\textsuperscript{146} The reason for limiting high fat intake before an event, is that fats have a slow absorption and emptying rate. High protein meals are discouraged, because they may affect the amount of acetic acid in the body, and may also produce acid residues which will result in acidosis.\textsuperscript{147} Besides these two effects, the protein to carbohydrate breakdown is an energy consuming process, which may be detrimental to peak performance.\textsuperscript{148}

A substitute which may be used for a solid pre-game meal, is the liquid supplement. There are some advantages to this type of meal. It is economical, well balanced in nutrient, and easily digested.\textsuperscript{149}

Aside from the liquid meal's value as a pre-game meal, it would also be of value to the athlete trying to consume four meals a day. One suggestion for athletes, since they expend such high amounts of energy daily, is to eat four smaller meals throughout the day, instead of two or three bigger meals. This concept may be especially healthy for those athletes who have morning practices, to consume a light meal in the later evening before sleeping.\textsuperscript{150} There are many different types of liquid meals which can be purchased, or they can be prepared very economically. For approximately one quart of liquid meal, mix together one half cup of water, one half cup of nonfat dry milk, one fourth cup of sugar, three cups skim milk, and a teaspoon of flavoring, such as cherry, vanilla, or chocolate extract.\textsuperscript{151}

The most important aspect that the athlete needs to remember about her meals, is that they are adequate for nutritional purposes.
She needs to remember that her pre-game meal, as well as her number of meals a day, will not provide maximum benefits, if she is lacking in essential nutrients.

Some Common Falacies in Nutrition for the Athlete

Many of the myths and misinformation which athletes receive, have hopefully already been settled in this paper. There are, however, hundreds more which probably have not been touched upon. These are some of the questions and answers I have come across, while doing my research:

1. Does meat build energy? No, protein is not the main energy food. Proteins are used mostly for structural processes. Carbohydrates are the best foods to consume to produce energy.  
2. Does drinking water during an athletic event cause cramps and slow the individual down? No, there is no evidence to support these claims. In fact, water is the most important resource for physical activity.  
3. Do athletes need salt tablets when they sweat? No, this is entirely false. Extra salt intake does more harm than good, because it irritates the lining of the stomach. Also sweat contains relatively small amounts of salt, and nutritionally balanced diets will usually contain enough salt.  
4. Will eating steak and eggs the night before a game enhance performance? No, this is also untrue. The meal ingested the night before the game has little affect on the event the next day. A nutritionally balanced diet is the best safeguard to insure optimal affects from one's diet.  
5. Does milk before an athletic event cause cotton mouth, cut speed, and cause stomach upset due to curdling? No, cotton mouth is caused by emotional stress and fluid loss. Also milk "curdling" is a natural part of digestion, and does not cause the stomach to become upset. If a meal is eaten too soon, prior to the competition, the blood which
has traveled to the stomach may cause a nauseous feeling.

Food Interactions

Because of myths such as these, there needs to be continuous research in the field of nutrition, and nutrition in athletic performance. It could be seen throughout this paper, that there are topics such as caffeine, the B vitamins, gelatin, and wheat germ oil which need to have more information for definite conclusions to be made. Another aspect which should be explored is the nutrient vitamin and mineral interactions. For example, we know about some of these interactions already. Vitamin D, is known by almost everyone to help the absorption of calcium. There are other reactions such as this. The simultaneous ingestion of vitamin C, with sources of iron, helps in the absorption of iron. High levels of zinc adversely affect copper metabolism, and ingestion of high levels of phosphorus interfere with calcium absorption. Some studies have shown that high fiber intake affects the absorption of some essential nutrients. Plus, essential minerals such as iron and chromium need to be in special chemical and physical form for effective absorption.

Besides these nutrient and vitamin interactions, more research needs to be conducted on food and drug interactions, and the effects of all of the synthetic substances in our food. For example, Gorgonzola cheese and antihistamine cause acute allergic reactions in some people, when they are combined. Oral contraceptive use lowers blood levels of folic acid, vitamin $B_12$, and $B_6$. Alcohol also affects the interactions of many nutrients. Besides these, the many synthetic substances routinely added to foods also creates many reactions. Included in these interactions are that excessive levels
of EDTA, other chelating agents, highly purified foods, soy protein isolates, and modified starches and lipids affect the absorption and utilization of essential nutrients.\textsuperscript{161} Processing and fabricating foods destroys many of their nutrients, and finally the extensive replacement of conventional food, with highly processed or fabricated foods, may result in an unbalanced intake of some nutrients.\textsuperscript{162} This processing could also convert some components into compounds which are highly toxic.\textsuperscript{163}

These examples are just the tip of the iceberg, as far as drug, mineral, vitamin, and synthetic interactions in our bodies. These interactions must be explored, so that the general public as well as the competitive athlete will know the effects of the substances put into their bodies. Along with this, thorough research, there may be some way of uncovering other synergistic affects of vitamins and minerals, with carbohydrates, fats, or proteins. An end result of this could help the athlete utilize these substances to aid in peak performance.

A very broad spectrum of nutrition for the female athlete has been presented. The topic of basic nutrition, has been presented, along with the affects of proteins, fats, carbohydrates, vitamins and minerals on the athlete's body. The subjects of nutritional misconceptions, ergonic aids, and needs for future research were also explored.

Total nutrition for female athletes differs little from that of male athletes. The only exceptions would be vitamin D, B\textsubscript{6}, iron, and caloric consumption. This caloric consumption varies little until puberty, because body weights and structure are very similar. In early adulthood, the difference between calories/pound body weight
is also strikingly similar. The female athlete needs to understand her body in order to achieve her desired performance. She should realize that by monitoring her dietary intake, she will not be able to perform better than her capabilities, but she will give herself every chance to perform at her optimal best level.
Tables and Graphs
Table 1

Suggested Allowances of Vitamins, Minerals, and Calories Recommended by the Food and Nutrition Board.

**Fat Soluble Vitamins**

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight</th>
<th>Height</th>
<th>Energy</th>
<th>Protein</th>
<th>Vit. A (I.V.)</th>
<th>Vit. D</th>
<th>Vit. E</th>
</tr>
</thead>
<tbody>
<tr>
<td>years</td>
<td>kg</td>
<td>lbs.</td>
<td>cm</td>
<td>g</td>
<td>(RE)</td>
<td></td>
<td>(I.V.) (I.V.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females A) 11-14</td>
<td>44</td>
<td>97</td>
<td>155</td>
<td>2400</td>
<td>44</td>
<td>800</td>
<td>4000</td>
</tr>
<tr>
<td>B) 15-18</td>
<td>54</td>
<td>119</td>
<td>162</td>
<td>2100</td>
<td>48</td>
<td>800</td>
<td>4000</td>
</tr>
<tr>
<td>C) 19-22</td>
<td>58</td>
<td>128</td>
<td>162</td>
<td>2100</td>
<td>46</td>
<td>800</td>
<td>4000</td>
</tr>
<tr>
<td>D) 23-50</td>
<td>58</td>
<td>128</td>
<td>162</td>
<td>2000</td>
<td>46</td>
<td>800</td>
<td>4000</td>
</tr>
</tbody>
</table>

**Water Soluble Vitamins**

<table>
<thead>
<tr>
<th>Ascor-</th>
<th>Folacin</th>
<th>Nia-</th>
<th>Ribo-</th>
<th>Thia-</th>
<th>Vita-</th>
<th>Vita-</th>
<th>Cal-</th>
<th>Phos-</th>
<th>Io-</th>
<th>Iron</th>
<th>Mag-</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>bic</td>
<td>cin</td>
<td>flavin</td>
<td>min</td>
<td>min</td>
<td>B₆</td>
<td>min B₁₂</td>
<td>cium</td>
<td>phorus</td>
<td>dine</td>
<td>nesium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mg</td>
<td>ug</td>
<td>mg</td>
<td>mg</td>
<td>mg</td>
<td>mg</td>
<td>ug</td>
<td>mg</td>
<td>mg</td>
<td>ug</td>
<td>mg</td>
<td>ug</td>
<td>mg</td>
</tr>
<tr>
<td>A) 45</td>
<td>400</td>
<td>16</td>
<td>1.3</td>
<td>1.2</td>
<td>2.0</td>
<td>3.0</td>
<td>1200</td>
<td>1200</td>
<td>115</td>
<td>18</td>
<td>300</td>
<td>15</td>
</tr>
<tr>
<td>B) 45</td>
<td>400</td>
<td>14</td>
<td>1.4</td>
<td>1.1</td>
<td>2.0</td>
<td>3.0</td>
<td>1200</td>
<td>1200</td>
<td>115</td>
<td>18</td>
<td>300</td>
<td>15</td>
</tr>
<tr>
<td>C) 45</td>
<td>400</td>
<td>14</td>
<td>1.4</td>
<td>1.1</td>
<td>2.0</td>
<td>3.0</td>
<td>800</td>
<td>800</td>
<td>100</td>
<td>18</td>
<td>300</td>
<td>15</td>
</tr>
<tr>
<td>D) 45</td>
<td>400</td>
<td>13</td>
<td>1.2</td>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
<td>800</td>
<td>800</td>
<td>100</td>
<td>18</td>
<td>300</td>
<td>15</td>
</tr>
</tbody>
</table>


A Suggested Food Guide

Fruits and Vegetables

- Leafy vegetables
- other fruits and vegetables

Proteins

- Legumes
- whole grains
- refined grains

Grains

- liberal consumption
- moderate consumption
- very moderate consumption
- sparse consumption

Taken from:
Considerations for A New Food Guide, p. 53.
Table 2
Feeding the Female

<table>
<thead>
<tr>
<th>food</th>
<th>later 10-12 elementary</th>
<th>early 13-15</th>
<th>18-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>milk</td>
<td>3 cups or more</td>
<td>3-4 cups or more</td>
<td>4 cups</td>
</tr>
<tr>
<td>eggs</td>
<td>1 whole egg</td>
<td>1 or more whole eggs</td>
<td>1 or more whole eggs</td>
</tr>
<tr>
<td>meat, poultry, fish</td>
<td>3-4 ounces (1 serving)</td>
<td>4 ounces or more (1 serving)</td>
<td>7 ounces</td>
</tr>
<tr>
<td>dried beans, (poultry, fish, eggs)</td>
<td>½ cup or more</td>
<td>½ cup or more (1 serving)</td>
<td></td>
</tr>
<tr>
<td>potatoes (replaced by macaroni, spaghetti, rice)</td>
<td>1/3 cup or more</td>
<td>3/4 cup or more</td>
<td>3/4 cup or more</td>
</tr>
<tr>
<td>other cooked vegetables</td>
<td>1/3 cup or more at 1 or more servings</td>
<td>½ cup or more at 1 or more servings</td>
<td>½ cup or more</td>
</tr>
<tr>
<td>raw vegetables</td>
<td>1/3 cup or more</td>
<td>½ cup or more</td>
<td>1 cup or more</td>
</tr>
<tr>
<td>Vitamin C food</td>
<td>1 med. size orange or equiv.</td>
<td>1 large orange or equivalent</td>
<td>1 large orange or equivalent</td>
</tr>
<tr>
<td>Other fruits</td>
<td>½ cup or more at 1 or more meals</td>
<td>2 servings</td>
<td>1½ or more servings 1½ cup</td>
</tr>
<tr>
<td>Cereals whole grain restored or enriched</td>
<td>1 cup or more</td>
<td>1 cup or more</td>
<td>1 cup</td>
</tr>
<tr>
<td>bread whole grain or enriched</td>
<td>2 or more slices</td>
<td>2 or more slices</td>
<td>2 or more slices</td>
</tr>
<tr>
<td>butter or fortified margarine</td>
<td>1 tablespoon or more</td>
<td>1 tablespoon or more</td>
<td>1 tablespoon</td>
</tr>
<tr>
<td>sweets</td>
<td>1/3 cup or more ½ cup or more simple dessert</td>
<td>2 small servings at the most</td>
<td></td>
</tr>
<tr>
<td>Vitamin D source</td>
<td>U.S.P. of Vitamin D daily</td>
<td>U.S.P. of Vitamin D daily</td>
<td>U.S.P. of Vitamin D daily</td>
</tr>
</tbody>
</table>

2200 calories 3000 calories 2500-3000 calories

Taken from: Considerations for a New Food Guide, p. 55.
<table>
<thead>
<tr>
<th>Event:</th>
<th>Short Burst Maximum Effort</th>
<th>Less than 1 Minute-Strenuous Effort</th>
<th>1-10 Minutes Sustained Effort</th>
<th>10 minutes or more Intensive Repeated Effort</th>
<th>Endurance High Intensity Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event:</td>
<td>Dashes including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event:</td>
<td>440 yd.</td>
<td>880 yd. run</td>
<td></td>
<td>Basketball</td>
<td>Cross Country Running</td>
</tr>
<tr>
<td>Event:</td>
<td>Hurdles</td>
<td>1 &amp; 2 mile runs</td>
<td></td>
<td>Lacrosse</td>
<td>6 mile Run</td>
</tr>
<tr>
<td>Event:</td>
<td>Long Jump</td>
<td>Swimming events</td>
<td></td>
<td>Tennis</td>
<td>Soccer</td>
</tr>
<tr>
<td>Event:</td>
<td>50 &amp; 100 yd. Swimming events</td>
<td>over 100 yd. Fencing</td>
<td></td>
<td>Gymnastics-all around</td>
<td>Cross Country Skiing</td>
</tr>
<tr>
<td>Event:</td>
<td></td>
<td></td>
<td></td>
<td>Most gymnastic events</td>
<td></td>
</tr>
<tr>
<td>Event:</td>
<td></td>
<td></td>
<td></td>
<td>Downhill skiing</td>
<td></td>
</tr>
<tr>
<td>Event:</td>
<td></td>
<td></td>
<td></td>
<td>Slalom</td>
<td></td>
</tr>
<tr>
<td>Event:</td>
<td></td>
<td></td>
<td></td>
<td>Skiing</td>
<td></td>
</tr>
<tr>
<td>Table</td>
<td>K/cal day</td>
<td>Table</td>
<td></td>
<td>Training Increase in Daily Caloric Requirement over that Required during day of competition:</td>
<td></td>
</tr>
<tr>
<td>Table</td>
<td>3000-4000</td>
<td>3000-4000</td>
<td>3000-5000</td>
<td>3000-6000</td>
<td>4000-5000</td>
</tr>
<tr>
<td>Table</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>13</td>
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<tr>
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<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Table</td>
<td>15</td>
<td>15</td>
<td>25</td>
<td>30</td>
<td>38</td>
</tr>
</tbody>
</table>

Taken from: Nutritional Aspects of Human Physical and Athletic Performance, pp. 298-299
Graph 2

Relative Proportion of Fatty Acids Used

Time 120 minutes

60 90 120

Exercise Recovery

20 40

Fatty Acids

Exercise Recovery

0 6 12 18 3 15

Time (minute)

Taken from:
Exercise Physiology Energy, Nutrition, and Human Performance, p. 298
Graph 3

Sources and Fates of Blood Glucose

Liver glycogen ————————> Blood Dietary glucose ————————> Extra Hepatic Tissues Glycogen

Other Dietary Sugars ————————> Glucose-b-Phosphate ————————> Blood Glucose ————————> Glucose-b-Phosphate

Glucose-b-Phosphate ————————> pyruvate ————————> pyruvate

pyruvate ————————> CO₂ ————————> CO₂

CO₂ ————————> acetyl coA ————————> Acetyl coA

acetyl coA ————————> glycol Genic Amino Acids, etc. ————————> glycol Genic Amino Acids, etc.

glycol Genic Amino Acids, etc. ————————> Fatty Acids, Steroids, etc.

Fatty Acids, Steroids, etc. ————————> Urine glucose ————————> Urine glucose

Urine glucose ————————> Acetyl coA ————————> Acetyl coA

Taken from:
Nutritional Aspects of Human Physical and Athletic Performance, p. 46.
Graph 4

Predominant Energy Pathways

Time

0's 4's 10's 1½ min. 3 min.

Are
- Strength-Power
  - Power lift-high Jump
  - Shotput-golf swing-tennis serve

ATP-CP
- Sustained Power
  - Sprints, fast breaks
  - football line play

ATP=CP-Lactic Acid
- An Aerobic Power Endurance
  - 200-400 m. dash
  - 100 yd. swim

Aerobic Endurance
Beyond a ½ mile run

Immediate/Short term Non-Oxidative Systems

Aerobic-Oxidative System

Taken from:
Glycolysis and the Krebs Cycle
Combined - Simplified for a Basic Understanding

Source                      Reaction               Net ATP
Substrate Phosphorilation   glycolysis             2

$2 \text{H}_2 (4 \text{H})$                     glycolysis           4

$2 \text{H}_2 (4 \text{H})$                     Pyruvate—Acetyl CO-A  6

Substrate Phosphorilation   Krebs Cycle           2

$8 \text{H}_2 (16 \text{H})$                    Krebs Cycle          22

Total $36 \text{ ATP}$

Taken from: Exercise Physiology Energy, Nutrition & Human Performance, p. 75.
Graph 7
Blood Glucose Cycle in
Muscle During Exercise

Taken from:
Exercise Physiology
### Graph 8

Water and Fat Soluble Vitamins, their RDA's, Dietary Sources, Major Functions, and Effects of Deficiencies and Excesses

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>RDA for Healthy Adult (mg)</th>
<th>Dietary Sources</th>
<th>Major Body Functions</th>
<th>Deficiency</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WATER</strong></td>
<td>Soluble</td>
<td>Pork, Organs, meats, white meats, legumes</td>
<td>Coenzyme in reactions involving the removal of carbon dioxide</td>
<td>Beriberi (peripheral nerve damage, heart failure)</td>
<td>None Reported</td>
</tr>
<tr>
<td>Thiamine</td>
<td>1.5</td>
<td>Widely Distributed</td>
<td>Constituent of two flavin nucleotide coenzymes involved in energy metabolism (FAD and FmN)</td>
<td>Reddened lips, cracks at corners of mouth, lesions of eyes</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>B-2</strong></td>
<td>.03</td>
<td>Liver, lean meats, grains, legumes</td>
<td>Coenzyme involved in amino acid metabolism</td>
<td>Pellagra (skin and gastrointestinal lesions, nerve disorders)</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>B-6</strong></td>
<td>.5-10</td>
<td>Meats, vegetables, whole grain cereals</td>
<td>Constituent of coenzyme A, which plays a central role in energy metabolism</td>
<td>Fatigue, sleep disturbances, impaired coordination</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>Pantothenic Acid</strong></td>
<td>.4</td>
<td>Legumes, green vegetables, whole wheat products</td>
<td>Coenzyme involved in transfer of single carbon units in nucleic acid metabolism</td>
<td>Pernicious anaemia, neurological disorders</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>Choline</strong></td>
<td>.003</td>
<td>Muscle meats, eggs, dairy products, not present in plant foods</td>
<td>Fatigue, depression, nervous system disorders</td>
<td>None Reported</td>
<td></td>
</tr>
<tr>
<td><strong>Biotin</strong></td>
<td>Not Established</td>
<td>Legumes, vegetables, meats</td>
<td>Coenzyme required for fatty acid metabolism and glycogen formation</td>
<td>Fatigue, depression, nervous system disorders</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>Choline</strong></td>
<td>Not Established</td>
<td>All foods containing phospholipids (egg yolk, liver, green)</td>
<td>Constituent of phospholipids, precursor of putative neurotransmitter acetylcholine</td>
<td>None Reported</td>
<td>None Reported</td>
</tr>
<tr>
<td><strong>Vitamin C</strong></td>
<td>Soluble</td>
<td>Citrus fruits, tomatoes, green peppers, salad greens</td>
<td>Maintains intracellular matrix of cartilage, bone, and dentine. Important in collagen synthesis.</td>
<td>Scurvy (degeneration of skin, teeth, blood vessels)</td>
<td>Relatively toxic, possibility of kidney stones</td>
</tr>
<tr>
<td><strong>Vitamin A</strong></td>
<td>.45</td>
<td>Green vegetables, butter, milk, cheese</td>
<td>Constituent of rhodopsin (visual pigment) maintenance of epithelial tissues. Role in muco polysaccharide synthesis</td>
<td>Night blindness, permanent blindness</td>
<td>Headache, vision problems, skin, nose, loss of long bone</td>
</tr>
<tr>
<td><strong>Vitamin D</strong></td>
<td>.15</td>
<td>Cod liver oil, eggs, dairy products fortified milk, margarine</td>
<td>Promote growth and mineralization of bones, increases absorption of calcium</td>
<td>Rickets (bone deformities) in children, osteomalacia in adults</td>
<td>Vomiting, diarrhea, loss of weight</td>
</tr>
<tr>
<td><strong>Vitamin E</strong></td>
<td>Seeds, green leafy vegetables, margarines, shortening</td>
<td>Functions as an antioxidant to prevent cell membrane damage</td>
<td></td>
<td>Possibly Anemia</td>
<td>Relatively Non-toxic</td>
</tr>
<tr>
<td><strong>Vitamin K</strong></td>
<td>Green leafy vegetables, small amount in cereals, fruit &amp; meats</td>
<td>Important to blood clotting (active formation of prothrombin)</td>
<td></td>
<td>Conditioned deficiencies, associated with severe bleeding.</td>
<td>Relatively Non-toxic</td>
</tr>
</tbody>
</table>

Taken from: Exercise Physiology
### Important minerals in the Body, Their Recommended Daily Intake, Dietary Sources, Major Bodily Functions, and Effects and Deficiencies and Excesses

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Amount in Adult Body (g)</th>
<th>RDA for Adult Healthy (mg)</th>
<th>Dietary Sources</th>
<th>Major Body Functions</th>
<th>Deficiency</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>1,500</td>
<td>800</td>
<td>milk, cheese vegetables, dried legumes</td>
<td>Bone &amp; Tooth Formation, Blood clotting, nerve transmission</td>
<td>Stunted</td>
<td>Not reported</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>860</td>
<td>800</td>
<td>milk, cheese, meat, poultry, grains</td>
<td>Bone &amp; Tooth Formation, Acid-base bal.</td>
<td>Weakness</td>
<td>Erosion</td>
</tr>
<tr>
<td>Sulfur</td>
<td>300, Provided by Sulfur</td>
<td>800</td>
<td>sulfur, amino acids</td>
<td>Constituent of Active tissue compounds, cartilage &amp; tendon</td>
<td>Related to Excess intake &amp; take lead deficiency to poor growth &amp; mineral metabolism</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>180</td>
<td>2500</td>
<td>milk, many fruits</td>
<td>Acid-base bal.</td>
<td>Weakness</td>
<td>Weakness</td>
</tr>
<tr>
<td>Chlorine</td>
<td>74</td>
<td>2000</td>
<td>common salt</td>
<td>Formation of gastric juice, Acid-base bal.</td>
<td>Muscle cramps, vomiting, mental intapted reduced appetite high BP growth failure diarreha distub. Diarrheal and vomiting weak, spasm ing</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>64</td>
<td>2500</td>
<td>common salt</td>
<td>Acid-base bal.</td>
<td></td>
<td></td>
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<td>Magnesium</td>
<td>25</td>
<td>350</td>
<td>green leafy vegetables</td>
<td>Activates enzymes involved in protein synthesis</td>
<td></td>
<td></td>
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<tr>
<td>Iron</td>
<td>4.5</td>
<td>15-18</td>
<td>eggs, lean meat, whole grains, green leafy vegetables</td>
<td>Constituent of Iron def. siderosis anemia cirrhosis of liver</td>
<td></td>
<td></td>
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<tr>
<td>Fluorine</td>
<td>2.6</td>
<td>2</td>
<td>drinking water, seaweed</td>
<td>May be important in maintenance of bone tooth structure</td>
<td></td>
<td></td>
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<tr>
<td>Zinc</td>
<td>2</td>
<td>15</td>
<td>widely distributed in foods</td>
<td>Constituent of Growth enzyme involved in digestion</td>
<td></td>
<td></td>
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<tr>
<td>Copper</td>
<td>1</td>
<td>2</td>
<td>meats drinking water</td>
<td>Constituent of enzymes associated with iron metabolism</td>
<td>Anemia, rare metabolic condition (Wilson's Disease)</td>
<td></td>
</tr>
<tr>
<td>Element</td>
<td>Concentration</td>
<td>Distribution</td>
<td>Function</td>
<td>Toxicity</td>
<td></td>
<td></td>
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<td>-----------</td>
<td>---------------</td>
<td>--------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
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<tr>
<td>Silicon</td>
<td>.024</td>
<td>Not established</td>
<td>Widely distributed in foods</td>
<td>Function not reported</td>
<td></td>
<td></td>
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<tr>
<td>Vanadium</td>
<td>.018</td>
<td>Estab-</td>
<td>Silicones, var-</td>
<td>Silicones, var-</td>
<td></td>
<td></td>
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<tr>
<td>Tin Nickel</td>
<td>.017</td>
<td>lished</td>
<td>dium-lung irritation, tin-vomiting</td>
<td>tin-vomiting</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>.013</td>
<td>Not established</td>
<td>Seafood meat, grains</td>
<td>Seabfood meat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>.012</td>
<td>Not established</td>
<td>Widely distributed in foods</td>
<td>Constituents in close assoc. w/Vit. E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine</td>
<td>.011</td>
<td>.14</td>
<td>Marine fish, dairy products, vegetables</td>
<td>Constituents of thyroid hormone</td>
<td></td>
<td></td>
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<tr>
<td>Moly Bdenum</td>
<td>.009</td>
<td>Not estab-</td>
<td>legumes, cereals, organ meats</td>
<td>Constituents Not inhibition of enzymes by man</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>lished</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chromium</td>
<td>.006</td>
<td>Not established</td>
<td>fats, vegetables, oils, meats</td>
<td>Involved in metabolism glucose</td>
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<td></td>
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<tr>
<td>Cobalt</td>
<td>.0015</td>
<td>Required as Vitamin</td>
<td>organ &amp; muscle meats, milk</td>
<td>Muscle metabolism glucose</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Constituents Not Industrial exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>40,000</td>
<td>1-5 liters per day</td>
<td>solid foods, liquids, drinking water</td>
<td>Transport, Thirst, Headaches, nausea</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(60% of body weight)</td>
<td></td>
<td></td>
<td>High blood pressure, regular participation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Taken from:
Exercise Physiology
Energy, Nutrition, and Human Performance, pp.30-5
Chart 10

Carbohydrate Loading, Sample One
Day Meal Plan

Breakfast: 1 cup fruit juice
            Hot or Cold Cereal
            1 to 2 muffins
            1 tbsp. butter
            coffee (cream/sugar)

Lunch: 2-3 oz. Hamburger with bun
        1 cup juice
        1 orange
        1 tbsp. mayonnaise
        pie or cake

Snack: 1 cup yogurt

Dinner: 1-1½ pieces baked chicken
        1 baked potatoe, with margarine
        1 cup vegetable
        1 cup sweetened pineapple
        iced tea (sugar)
        1 tbsp. sour cream (optional)

Snack: 1 glass chocolate milk with
        4 cookies

*entire days menu approximately 2,500 calories.

Taken from:
Diet and Nutrition
p. 300.
Footnotes
Footnotes


2 Ibid., p. 17.


4 Ibid., p. 125.

5 Porcello, p. 126.


7 Corruccini, p. 30.

8 Corruccini, p. 31.

9 Williams, p. 21.

10 Porcello, p. 125.

11 Judy Roepke, Dr., Interview at Ball State, Muncie, Indiana, July 25, 1983.

12 Asmundson C., BSc, MSc, Clement BSc, MSC, "Nutritional Intake and Hematological Parameters In Endurance Runners," The Physician and Sports Medicine, March, 1982, p. 40.


14 Asmundson, p. 40.

15 Roepke.

16 Asmundson, p. 36.

17 Roepke.

18 Asmundson, p. 40.

19 Asmundson, p. 41.

20 Asmundson, p. 41.

21 Williams, p. 247.

22 Ibid., p. 298.
23 Ibid., p. 298.
24 Ibid., p. 299.
25 Roepke.
26 Williams, p. 96.
29 Ibid., p. 110.
30 Williams, p. 98.
31 Ibid., p. 104.
32 Ibid., p. 104.
33 Ballentine, pp. 113-114.
34 Williams, p. 102.
37 Williams, p. 101.
38 Worthington-Roberts, p. 568.
39 Ibid., p. 568.
40 Williams, p. 105.
41 Ibid., p. 112.
42 Ibid., p. 76.
44 Ibid., p. 12.
46 Ibid., p. 13
49 Cramp-ton, p. 97.
50 Worthington-Roberts, p. 566.
52 Cramp-ton, p. 97.
53 Ibid., p. 97.
54 Dave L. Costill, Dr., Interview at Ball State University, Muncie, Indiana, July 23, 1983.
55 Worthington, p. 567.
56 Williams, p. 83.
57 Dr. Costill-Interview.
58 Katch, p. 8.
59 Williams, p. 45.
60 Ibid., p. 45.
61 Cramp-ton, p. 63.
62 Williams, p. 47.
63 Ibid., p. 47.
64 Katch, p. 8.
65 Dr. Costill-Interview.
67 Katch, p. 8.
68 Dr. Costill-Interview.
70 Worthington, p. 565.
71 Ibid., p. 566-567.
72 Katch, p. 86.
Dr. Carl Warnes, Microbiology class notes, July 15, 1983.

Dr. Larry Stewart, Exercise Physiology class notes, May 1, 1983.


Ibid., p. 355.


Williams, p. 50.

Dr. Roepke.

Ibid., p. 114.

Ibid., p. 116.

Katch, p. 25.

Williams, p. 120.

Ibid., p. 123.

Ibid., p. 123.

Ibid., p. 125.

Dr. Roepke.

Williams, p. 125.

Ibid., p. 127.

Ibid., p. 127.

Dr. Costill-Interview.

Worthington, p. 571.

Williams, p. 133.

Ibid., p. 135.

Ibid., p. 144.

Stewart, May 12, 1983.

99 Ibid., p. 39.
100 Williams, p. 145.
101 Stewart, April 26, 1983.
102 Katch, p. 27.
103 Stewart, April 20, 1983.
104 Dr. Costill-Interview
105 Frasier, p. 38.
106 Dr. Costill-Interview.
107 Katch, p. 28.
108 Ibid., p. 29.
109 Williams, p. 153.
110 Ibid., p. 154.
111 Katch, p. 32.
112 Williams, p. 133.
113 Ibid., p. 133.
114 Katch, p. 32.
115 Williams, p. 134.
117 Ibid., p. 273.
118 Dr. Roepke.
119 Williams, p. 154.
120 King, p. 28.
121 Williams, p. 155.
122 Ibid., p. 157.
123 Ballentine, p. 244.
124 Ibid., p. 247.
125 Dr. Roepke.
126 Ballentine, p. 250.
127 Ibid., p. 252.
128 Ibid., p. 244.
129 Ibid., p. 244.
130 Williams, p. 212.
131 Ibid., p. 212.
132 Dr. Roepke.
133 Williams, p. 219.
134 Ibid., p. 219.
135 Dr. Costill-Interview.
136 Ibid.
137 Katch, p. 308.
138 Williams, p. 67.
141 Ibid., p. 116.
142 Williams, p. 74.
145 "Nutrition and Athletics" (Data from Food and Nutrition Board, National Research Council) 1980.
146 Williams, p. 306.
147 Ibid., p. 307.
148 Ibid., p. 307.
149 "Nutrition and Athletics"
150 Smith, p. 253.
151 Williams, p. 311.
152 Ibid., p. 314.
153 "Nutrition and Athletics"
154 Ibid.
155 Ibid.
156 Ibid.
158 Ibid., p. 112.
159 Ibid., p. 112.
160 Ibid., p. 113.
161 Ibid., p. 113.
162 Ibid., p. 114.
163 Ibid., p. 114.
164 Williams, p. 301.
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