AN ABSTRACT OF THE THESIS OF

Susan M. Burky for the degree of Master of Science in Foods and Nutrition presented on August 16, 1985

Title: Effectiveness of a Nutrition Education Workshop for High School Coaches

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The purpose of this study was to evaluate the effectiveness of a one-hour in-service nutrition education workshop for high school coaches in Corvallis, Eugene and Salem, Oregon. The objectives were to determine: 1. if the workshop can make positive changes in nutrition knowledge; 2. which type of participant benefits most from the workshop in terms of an increase in knowledge; and 3. how high school coaches feel about the usefulness of this type of workshop.

Eighty-one coaches participating in the study completed a pre-questionnaire immediately prior to and then a post-questionnaire immediately following the workshop. The questionnaire was designed to measure the nutrition for fitness and sport knowledge of coaches. A 17 minute slide/tape program (Nutrition in the Fast Lane) was the major educational component of the workshop.

Statistically significant differences were found between pre- and post-questionnaire scores indicating that

coaches increased their nutrition knowledge as a result of attending the workshop. Similar results were found for a group of student athletic trainers, teachers and parents of young athletes. It was also found that the age of the coach, academic degree, number of years of coaching, completion of a college level nutrition course or attendance at a nutrition education workshop within the past two years did not have a significant effect on the overall knowledge score. However, female coaches had significantly greater overall knowledge scores than male coaches.

Nearly all coaches (95%) found this workshop either very or somewhat useful and 97.5% would recommend it to their colleagues. The conclusions are that within the framework of a one-hour in-service nutrition education workshop coaches are able to achieve significant increases in nutrition knowledge and that with the exception of female coaches, no one type of participant benefited most in terms of an increase in knowledge.

Effectiveness of a Nutrition Education Workshop for High School Coaches

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I. INTRODUCTION

It is generally accepted that good nutrition can make a positive contribution to the health of any individual. In athletics, it is axiomatic that the athlete is given a nutritious diet not only to maintain health, but to provide for the increased energy needs required for his or her physical exertions.

The role of nutrition in physical performance has been recognized for a very long time. Early Greek athletes were apparently concerned with diet (Harris, 1966; Gardiner, 1930; Gardiner, 1910). Charmis of Sparta, a victorious sprinter in the Olympic games of 668 B.C., is said to have trained on diet of dried figs (Harris, 1966). The first athlete to train on a predominantly meat diet was Dromeus of Stymphalus, who twice won the long race at Olympia (460, 456 B.C.) (Gardiner, 1930). The dietary habits of athletes have continued to change over the years. G. O. Nickalls wrote about the training practices for the Oxford and Cambridge Boat Race during the late 1800's. Crew members were advised to avoid cheese, pastry, puddings, bread and potatoes. Fruit and green salads were encouraged and meat and poultry were to be plainly cooked. Liquid refreshment included milk before the morning run, tea or coffee for breakfast, beer (probably limited to one glass), lemonade or water for luncheon and a pint of beer and one or two glasses of port for dinner. "Fizz nights" (a bottle of champagne per person) were given two or three times before the day of the race as an "invaluable restorative." On the following day, the crew reportedly rowed like giants.

Most early dietary recommendations for athletes were based on fads or the experience of coaches and trainers. With the development of nutrition as a science, it has become possible to investigate much more accurately how diet affects physical performance. Such information has been invaluable in identifying and clarifying sports nutrition misinformation. The review of literature of this thesis will concentrate on the scientific studies which have been done in the field of sports nutrition and what such research implies. It was intended that this literature review be written so that the general public might understand and utilize the information presented.

"The responsibility for controlling the nutritional practices of athletes is assumed largely by coaches" (Wolf et al., 1979). Most coaches, however, do not have the time or expertise needed to keep abreast of developments in nutrition research (Wolf et al., 1979). In a national study of the current practices of secondary coaches in recommending diets for athletes, it was found that a major portion of coaches based their dietary recommendations on their own athletic experience. Very few made use of medical or nutritional advice (Horwood, 1964).

In the quest for maximal athletic performance, the importance of proper dietary habits is often overlooked. Many coaches, trainers and athletes prescribe high protein diets, megavitamin supplementation, individualized fad diets, and starvation and semi-starvation diets which supposedly improve performance (Bentivegna et al., 1979). In reality, these are potentially dangerous in addition to being nutritionally inadequate.

Several studies have been done to assess the nutrition knowledge of groups such as physical education majors (Cho and Fryer, 1974), athletes (Parr et al., 1984; Grandjean et al., 1981; Werblow et al., 1978), coaches (Parr et al., 1984; Bedgood and Tuck, 1983; Bentivegna et al., 1979; Woff et al., 1979) and athletic trainers (Parr et al., 1984; Bentivegna et al., 1979). Results of such research indicate that these populations both want and need, more and better information about nutrition. Nutrition education for primary and secondary school coaches is especially important because it is these coaches who have a responsibility to teach good dietary patterns to young athletes before detrimental habits become established (Porcello, 1983).

At the White House Conference on Food, Nutrition and Health, it was recommended that

> because of continuous expansion of knowledge in nutrition and food science, advancements in food technology, and developments in educational techniques, a strong continuing education program must be provided for teacher-educators and school personnel.
> (White House Conference on Food, Nutrition, and Health, 1970, p. 151).

Workshops, extension courses, in-service programs, individualized instruction and educational television programs were suggested methods to accomplish the educational goals.

In response to this need, an in-service nutrition education workshop was planned and subsequently given in the cities of Corvallis, Salem, and Eugene, Oregon. A one-hour program with voluntary attendance was chosen for the following reasons: 1) funding was not available for a more extensive workshop such as the type where graduate credit is given; and 2) a short workshop kept teachers' time to a minimum thereby allowing more teachers to attend.

While an in-service workshop appeared to be the most practical way to deliver information to coaches, its effectiveness was questioned. In the discussion chapter of this thesis, this subject will be addressed. Previous research has found a three-hour nutrition education workshop for home economics teachers to be an effective way to communicate information (Stark and Johnson, 1981).

The purpose of this study was to evaluate the effectiveness of a one-hour nutrition education workshop for high school coaches in Corvallis, Salem, and Eugene, Oregon. The objectives were to determine: 1. if a one-hour workshop can make positive changes in nutrition knowledge; 2. which type of participant benefits most from this type of workshop in terms of an increase in knowledge; and 3. how high school coaches feel about the usefulness of this type of workshop.

The hypothesis was that a one-hour workshop is a useful and convenient way to conduct in-service education and positive changes in knowledge are possible. It was also hypothesized that educational background and work experience influence these changes.

II. REVIEW OF LITERATURE

The Role of Carbohydrates in Exercise

The body needs energy in order to perform muscular work. Sources of food energy may be derived from carbohydrate, fat and protein. Alcohol contributes energy to a limited extent. Carbohydrates, however, are the most important energy source and supply about 4 Kcal per gram.

While carbohydrates are not considered essential in the same way essential amino and fatty acids are, there is a metabolic need for carbohydrate. Red blood cells depend on glycolysis for energy and the brain uses glucose and in rare cases ketone bodies. Carbohydrates also provide oxaloacetate which reacts with acetyl-CoA to initiate the tricarboxylic acid cycle.

Food sources of carbohydrate include monosaccharides (glucose, fructose, mannose), disaccharides and oligosaccharides (sucrose, lactose, maltose), and -glucan polysaccharides (starches, dextrins, glycogen). Unavailable carbohydrates are those which cannot be hydrolyzed by enzymes of the intestinal tract and are therefore not absorbed. Dietary fiber is considered unavailable carbohydrate and has certain physiological properties which will not be discussed here. The National Research Council (1980) has not made a specific recommendation for carbohydrate intake but suggests that intake of refined sugar be reduced and complex carbohydrates maintained or even increased.

A. Carbohydrate Metabolism in Exercise

1. Body Fuel Stores

Compared to the body reserves of fat (some 60,000 Kcal), carbohydrate stores in the average person are very small--only about 2,000 Kcal. Of this amount, about 350 g (1600 Kcal) is stored as muscle glycogen and about 80 to 90 grams (300-400 Kcal) as liver glycogen. Approximately 20 g of glucose is contained in the extracellular water (Durnin, 1982; Essen, 1977; Felig and Wahren, 1975). While muscle glycogen is the primary storage form of carbohydrate, muscle tissue lacks the enzyme glucose-6-phosphatase which is needed to convert glucose-6-phosphate to glucose. As a result, muscle glycogen cannot be directly involved in regulating the blood glucose, but it is of use in meeting the energy requirements of the muscle fibers in which it is contained. The contribution muscle glycogen may make to glucose homeostasis is limited to that produced via the Cori cycle and the glucose alanine cycle (Wahren and Björkman, 1981). Liver glycogen, on the other hand, can be converted to glucose and then serve as a blood-borne fuel for exercise.

Several factors will influence how carbohydrates are utilized in exercise. Discussion here will include the duration and intensity of exercise, participation of skeletal muscle fiber types, level of training of the muscles, diet, type of exercise, temperature of the environment, and circulating substrate levels.

2. Duration and Intensity of Exercise

During the earliest phase of exercise, muscle glycogen is the major fuel consumed (Felig and Wahren, 1975). The initial rapid rate of muscle glycogen utilization seen during the first 20 minutes of exercise is thought to be related to the muscle reaching a steady state of oxygen uptake-aerobic adenosine triphosphate (ATP) production (Hickson, 1983). The next phase of carbohydrate utilization is marked by a slower and steady decline of muscle glycogen until low levels are reached. Finally, glycogen becomes depleted in most of the working fibers. At this point, additional energy is provided by increased fat oxidation, increased gluconeogenesis by the liver, or recruitment of additional fibers from the same or other muscle groups (Hickson, 1983).

Wahren et al. (1971) found that during short-term exercise, splanchnic glucose uptake increased 2-5 times, and kept pace with increased glucose utilization by muscle. This phenomenon was dependent on work intensity.

The increased glucose production was derived almost entirely from glycogenolysis. When exercise continued beyond 40 minutes, hepatic production and peripheral utilization of glucose became imbalanced. At this point, increased hepatic gluconeogenesis was observed (Wahren, 1977). During prolonged exercise, leg glucose uptake increased 16-fold and exceeded splanchnic glucose output throughout the exercise period (Ahlborg and Felig, 1982). Splanchnic glucose output peaked at 90 minutes and fell by 60% during the third hour. Circulating glucose levels eventually fell, producing hypoglycemia (Ahlborg and Felig, 1982). Hypoglycemia (blood glucose < 45 mg/deciliter) has been observed in Boston marathon runners (Levine, 1924) and in later studies (Felig et al., 1982; Pruett, 1970; Bergstrom et al., 1967; Christensen and Hansen, 1939). Hypoglycemia appears to stimulate catecholamine secretion (Christensen et al., 1975). In support of this, Felig et al. (1982) observed that hypoglycemia results in an exaggerated rise in plasma epinephrine. Also, hypoglycemia fails to affect endurance, and its prevention does not consistently delay exhaustion. Glycogen is the most important fuel substrate at work intensities greater than 90% of the maximal oxygen uptake (VO2 max) (Essen, 1977). At moderate work intensities (55%-85% VO2 max) glycogen concentration decreases rapidly at the start of exercise and continues to decrease curvilinearly to very low levels at exhaustion (Hermansen et al., 1967). At low work intensities (55% or less of VO2 max), muscle glycogen concentration decreases slowly and is not necessarily low at exhaustion (Hickson, 1983, Essen, 1977).

3. Participation of Skeletal Muscle Fiber Types

The human skeletal muscle contains fiber types with different metabolic potentials. The type I fibers (slow-twitch red) have low glycogenolytic capacity, high respiratory capacity, and low myosin ATPase activity; type IIa fibers (fast-twitch red) have high glycogenolytic capacity, high respiratory capacity, and high myosin ATPase activity; type IIb fibers (fast-twitch white) have high glycogenolytic capacity, low respiratory capacity, and high myosin ATPase activity (Hickson, 1983).

At work intensities of 30%-85% VO2 max the first fiber type to lose glycogen is the type I (Gollnick et al., 1974; Costill et al., 1973). Type IIa fibers are recruited as the red fibers become glycogen depleted (Gollnick et al., 1973). Following 60 minutes of intense intermittent exercise, similar and significant glycogen depletion occurred in both type I and type II (a and b) fibers (Essen, 1978). In the same study, continuous intense exercise to exhaustion (4-6 minutes) resulted in a more marked glycogen depletion in the type II (a and b) than type I fibers. Intermittent high intensity ice-hockey (120% VO2 max) resulted in preferential loss in type II fibers, most notably the type IIb fibers (Green, 1978). The metabolic potential of these fibers may be influenced by the amount of carbohydrate in the diet. With increased glycogen storage, the energy requirements of the fibers may be met more fully.

4. Level of Training of the Muscles

At the same relative workload, trained and untrained subjects show a similar glycogen utilization in relation to the total combusted carbohydrate (Hermansen et al., 1967). However, physical training results in decreased glycogen utilization during exercise and lower respiratory quotient (RQ) values which would indicate an enhanced oxidation of fat (Karlsson et al., 1974).

Hormonal responses to exercise change as a result of training. Plasma glucagon and catecholamines increase during prolonged submaximal exercise, but the magnitude of the increase is less in endurance trained individuals than in untrained subjects. This adaptation has been shown to appear after only 3 weeks of training (Winder et al., 1979). A smaller decrease in plasma insulin has been observed following endurance training (Gyntelberg et al., 1977; Hartley et al., 1972). Such adaptations may account for the sparing of glycogen noted by Karlsson et al. (1974).

Muscle glycogen resynthesis is also affected by training state. Piehl et al. (1974) found trained muscle to have a higher activity for total glycogen synthetase and hexokinase than untrained muscle. Synthetase I-form activity increased in both trained and untrained muscle following activity. Both type I and type II fibers have similar glycogen synthetase activities and muscle glycogen content (Piehl and Karlsson, 1977).

5. Diet

Early in this century, Zuntz (1911) demonstrated that the diet could influence the metabolism of the muscles. He found that fat combustion was essentially the only source of energy for mild exercise following an extremely high fat diet. Krogh and Lindhard (1920) studied the respiratory quotient (RQ) during work and their results confirmed the importance of fat as an energy source during exercise. They noted an 11% increase in the muscular efficiency when subjects were consuming a high carbohydrate diet. Christensen and Hansen (1939) found that a subject could continue strenuous work three times as long when a high carbohydrate diet was consumed as compared to a high fat diet. RQ measurements indicated that at rest and moderate levels of work both fat and carbohydrates were utilized. The percentage of fuel derived from carbohydrate increased when performing heavy work, if such fuel was available. Bergstrom et al. (1967) utilized the muscle biopsy technique to determine the content of glycogen in the quadriceps femoris muscle. The glycogen content after a fat, protein and a carbohydrate-rich diet varied from 0.6 g/100 g muscle to 4.7 g. They concluded that the initial glycogen content of the working muscle was a critical factor in the ability to perform prolonged heavy exercise. Karlsson and Saltin (1971) confirmed the benefit of a carbohydrate enriched diet as an aid to enhanced performance. Muscle glycogen content in the lateral portion of the quadriceps muscle was 35 g/kg after the special diet versus 17 g/kg wet muscle on a mixed diet. The best performance (shortest work time) was attained by all subjects following the carbohydrate enriched diet.

Studies such as these have indicated that the capacity to perform work for prolonged periods of time is dependent on the glycogen content of the muscle. The glycogen content of the muscle, in turn, is influenced by the composition of the diet. As a result, dietary manipulations of carbohydrate have been suggested as a means to increase the performance of athletes involved in such activities as distance running and swimming, long duration cycling, cross-country skiing, crew, soccer, ice hockey and tournament tennis.

Forgac (1979) outlined the classic carbohydrate loading method. Phase I, the depletion phase, which occurs 7 to 4 days before the event, involves depleting the muscles of their glycogen stores. This is accomplished by exercising those muscles used in the event to exhaustion and then consuming a high-fat, high-protein diet for approximately three days. Phase II, the supersaturation phase, occurs on days 3 to 1 before the event. The diet remains adequate in protein and fat, but carbohydrate intake increases so that about 250 to 525 g CHO/day is consumed. Exercise is not recommended at this time. Phase III is the day of the event, and the athlete may consume foods as desired. However, foods should be consumed so that the stomach and upper bowel are empty at the time of competition.

Carbohydrate loading is not accomplished without some negative effects. The three days of low carbohydrate diet lead to hypoglycemia and associated nausea, fatigue, dizziness and irritability. Electrocardiogram abnormalities have been reported during both the depletion (Goulard, 1981) and loading (Mirkin, 1973) phases of the diet.

There may be benefits other than increased muscle glycogen storage involved with carbohydrate loading.

Three to four grams of water are associated with each gram of glycogen stored (Olsson and Saltin, 1970). It has been proposed that this water may, upon liberation, serve to regulate body temperature and offset dehydration. Plyley et al. (1980) explored this possibility and found that while the water may help to maintain plasma volume, it does not directly affect temperature regulation. Astrand (1977) noted a drawback of high glycogen storage. With a glycogen storage of 700 g, there is an increase in body water which may amount to around 2 kg. This extra weight may inhibit the most efficient movement of the body. Forgac (1979) feels that in endurance exercise, the benefits of the extra energy from the glycogen stores outweigh the additional weight. As a final note on this, Sherman et al. (1982) recently observed that muscle water content showed no consistent relationship to the glycogen content, and the commonly accepted muscle glycogen-to-water ratio of 1.0:3.0-4.0 (g:g) may be incorrect.

In order to determine if a less stringent version of the classical carbohydrate loading pattern would bring about similar high levels of muscle glycogen, Sherman et al. (1981) evaluated three types of muscle glycogen supercompensation regimens in six well-trained runners. Results indicated that muscle glycogen stores could be elevated to high levels using a "modified" regimen of diet and exercise. This included depletion-tapering exercise from days 7 to 3 and a diet consisting of 50% carbohydrate on days 7 to 5 and 70% carbohydrate days 4 to competition. Muscle glycogen rose from 130, 130, and 80 mmol/kg to 160, 205, 207 mmol/kg for the control, modified and modified-classical treatments, respectively (Sherman and Costill, 1984).

The rate limiting enzyme for glycogen synthesis is glycogen synthetase which exists in the I-form (nonphosphorylated) or the D-form (phosphorylated). The D-form is dependent on G-6-P for activation and the I-form is independent of G-6-P (Sherman, 1983). Daily exercise appears to be required to keep certain intermediate forms of glycogen synthetase in a state of enhanced sensitivity to activation. A low level of muscle glycogen may not be the prerequisite to supercompensation (Sherman, 1983).

6. Type of Exercise

Different muscle groups are involved in various types of exercise and it has been noted that glycogen utilization may be different in the same muscle area depending on the type of endurance exercise. Bicycle exercise results in glycogen depletion in the quadriceps femoris (Pernow and Saltin, 1971). Running on a level treadmill at 75% VO2 max for 2 hours resulted in greater glycogen depletion of the gastrocnemius and soleus muscles, while running uphill involves a significant glycogen depletion of the vastus lateralis (Costill et al., 1974). Bergstrom et al. observed a glycogen depletion of 50% to 60% in the vastus lateralis and 80% to 90% in the deltoideus muscle following the 86 km Vasa Ski race (Essen, 1977). Hickson (1983) has postulated that differences in carbohydrate utilization by specific muscle groups during cycling, running and skiing might be due to the distribution of fiber recruitment over a greater muscle mass with running or skiing than with cycling.

7. Temperature of the Environment

Exercise in warm environments places greater demands on carbohydrate stores. Fink et al. (1975) found accelerated muscle glycogen depletion (+76%) during exercise in the heat (Tdb = 41°C, R.H. = 15%) as compared to exercise in the cold (Tdb=9°C, R.H. = 55%).

8. Free Fatty Acids

A reduced availability of free fatty acids and muscle glycogen will seriously affect the ability to perform prolonged exercise (Pernow and Saltin, 1971). On the other hand, elevated levels of plasma free fatty acids have been shown to spare carbohydrate utilization (Hickson et al., 1977; Costill et al., 1977) and increase endurance in exercising rats (Hickson et al., 1977). The mechanism by which raising plasma FFA slows carbohydrate utilization is probably due to the inhibitory effect of citrate on phosphofructokinase which, in turn, results in the accumulation of glucose-6-phosphate, a powerful inhibitor of hexokinase. Glycolysis and glucose uptake in muscle are compromised. The influence of elevating plasma FFA is more obvious in the type I muscle fibers because of their high oxidative capacity. Hickson et al. (1977) noted an accumulation of citrate, glucose-6-phosphate and free glucose in the red but not white muscle types.

Hickson et al. (1977) also found a decrease in liver glycogen depletion in animals with raised free fatty acids. The animals could continue exercising one hour after liver glycogen depletion. Mechanisms responsible for postponing the development of hypoglycemia following liver glycogen depletion in these animals were thought to be a) inhibition of glucose uptake by increased oxidation of fatty acids in the muscles; b) gluconeogenesis in liver from glycerol produced in lipolysis, and from lactate and alanine produced by working muscles; or c) ketones providing an alternate substrate for the central nervous system.

9. Glycerol

Rat studies have indicated that glycerol ingested before exercise can slow depletion of muscle and liver glycogen stores, enhance endurance and protect against development of hypoglycemia during exercise (Terblanche et al., 1981). In man, it appears that glycerol cannot be utilized as a gluconeogenic substrate rapidly enough to serve as a major energy source during strenuous exercise. Miller et al. (1983) found that while glycerol feeding postponed the decline in blood glucose by about 30 minutes during pro-longed cycling exercise in man, glycerol ingestion did not spare muscle glycogen during 90 minutes of treadmill exercise at 71% VO2 max.

10. Caffeine

Ingestion of caffeine containing substances has been found to increase levels of plasma free fatty acids (Ivy et al., 1979) and increase the rate of lipolysis (Costill et al., 1978). The increased availability of fatty acids has a carbohydrate-sparing effect (Hickson et al., 1977) which may prolong endurance. Competitive cyclists who ingested 330 mg of caffeine 60 minutes prior to exercise were able to perform an average of 90.2 minutes of cycling as compared to the 75.5 minutes of cycling performed by subjects who had not consumed caffeine (Costill et al., 1978). Essig et al. (1980) observed that ingestion of caffeine (5 ml/kg body weight) 1 hour prior to cycling decreased muscle glycogen use by 42% in 7 subjects as compared to a decaffeinated control trial. During exercise, the respiratory exchange reflected a shift from carbohydrate to lipid utilization.

Gollnick (1985) stated that the studies of Ivy et al. (1979) and Costill et al. (1978) assume that caffeine will block the degradation of cyclic AMP by phosphodiesterase and that the experimental data which demonstrate this effect are equivocal and the levels of plasma free fatty acids after such protocols do not appear to be significantly different from those produced by light warm-up exercise. A recent study (Casal and Leon, 1985) has shown that in well-trained marathon runners, ingestion of 400 mg of caffeine failed to affect substrate utilization during 45 minutes of treadmill running at 75% VO2 max.

Thus it appears that caffeine may not be an effective aid. Other dietary attempts to increase mobilization of fatty acids have not been successful. Ivy et al. (1980) found ingestion of medium- and long-chain triglycerides had little effect on endurance during 90 minutes of treadmill running at 70% VO2 max.

B. Carbohydrate Ingestion Prior to Exercise

Athletes have long been intrigued with the idea of consuming sugar prior to exercise as a means to increase energy and performance. As a result, several studies have been done to observe the physiological effects of carbohyhydrate feedings prior to exercise and determine if such feedings will enhance performance.

Ahlborg and Felig (1977) fed subjects 200 g of glucose 50 minutes before a 4 hour cycle exercise session at 30% VO2 max. Such feeding results in: a) augmented glucose uptake by the exercising leg; b) a diminution in lipolysis; and c) increased splanchnic glucose escape in association with decreased hepatic gluconeogenesis. They theorized that these responses may be mediated in part by the hyperinsulinemia and relative hypoglucagonemia induced by glucose feeding. Other studies have been done using different carbohydrate doses, forms of exercise, intensities and exercise times. For example, Costill et al. (1977) fed 75 g of glucose 45 minutes before a 30 minute treadmill exercise session at approximately 70% VO2 max. The carbohydrate produced a 3.3 fold increase in plasma insulin and a 38% rise in plasma glucose at 0 minutes of exercise. Subsequent exercise increased muscle glycogen utilization and total carbohydrate oxidation 17% and 13%, respectively when compared to the control trial. The elevation of plasma insulin produced hypoglycemia (3.5 mmol/l) in most subjects throughout the exercise. A similar study was conducted by the same laboratory (Foster et al., 1979) with a few exceptions--bicycle ergometer exercise was undertaken to exhaustion at 80% and 100% VO2 max. Endurance time was decreased by 19% as a result of the pre-exercise glucose feeding at 80% VO2 max. At 100% VO2 max, the pre-exercise feedings had no effect on exercise time to exhaustion. Serum free fatty acids were depressed throughout the glucose trial. It becomes apparent that glucose feedings 30-50 minutes before endurance exercise increase the rate of carbohydrate oxidation and impede the mobilization of free fatty acids with the ultimate result being a decreased exercise time to exhaustion.

Keller and Schwarzkopf (1984) did an interesting study which may be of more practical significance. Many popular sports are characterized by intermittent high-intensity activity (racquetball and basketball, for example). The authors set up the study to duplicate such exercise by having subjects bicycle for 2 minutes at 85% VO2 max, then rest 1 minute, until a 70-rpm rate could no longer be maintained. Subjects consumed a 12 ounce drink containing 100 g of glucose 60 minutes pre-exercise. The researchers found a 25% decrement in work time which agreed with results obtained by Foster et al. (1979).

In addition to glucose, researchers have studied the use of fructose as a pre-exercise carbohydrate feeding. Seventy-five grams of fructose consumed 45 minutes prior to exercise at 75% VO2 max spares muscle glycogen (Levine et al., 1983) and helps to maintain stable blood glucose and insulin concentrations (Koivisto et al., 1981).

Bonen et al. (1981) have proposed that differences in the pre-exercise insulin environment can have significant physiological effects during exercise. When glucose was ingested 15 minutes before exercise, approximately three-fold greater quantities of insulin were available at the onset of exercise. Therefore, more insulin was available to bind to its receptors in muscles and it appears that when about 20% of the receptors are occupied, continued glucose uptake during exercise may be promoted. Such enhanced carbohydrate metabolism with decreased fat metabolism will certainly have negative consequences for the endurance athlete.

C. Carbohydrate Ingestion During Exercise

The effects of carbohydrate taken during exercise appear to be quite variable. In looking at the research one must take into account the duration and intensity of the exercise, type of exercise, amount and type of carbohydrate fed and time of carbohydrate feeding. Even in doing this, there is still no concensus.

Most studies have been carried out using prolonged exercise. At low intensity cycling (30% VO2 max), 200 g of glucose ingested at 90 minutes into exercise resulted in an augmented uptake and oxidation of glucose by exercising legs, diminished lipolysis, augmented splanchnic glucose escape in association with ingested glucose within the splanchnic bed and reversal of exercise-induced stimulation of glucagon secretion (Ahlborg and Felig, 1976). During treadmill exercise of moderate intensity (50% VO2 max), Pirnay et al. (1977) found that 100 g of (^{13}C) glucose fed 15 minutes following the start of exercise represented 55% of the carbohydrate metabolized and 24% of the total energy expenditure. Krzentowski et al. (1984) did a similar study and found that when 100 g of glucose are ingested during exercise at 45% VO2 max, approximately half of the ingested amount is oxidized during the 2 hour period following ingestion, irrespective of whether the load was given 15 minutes or 120 minutes after initiation of exercise.

In contrast to these studies, Costill et al. (1973) found that during the final 20 minutes of a 90 minute exercise session, glucose from a glucose load (31.8 g (^{14}C) glucose in 300 ml) which was administered at 30 minutes following start of exercise comprised only about 5% of the total carbohydrate oxidized. Van Handel et al. (1980) gave cyclists working at 50% VO2 max either 139 mM or 589 mM of glucose in 400 ml 120 minutes into the exercise session.

At 180 minutes, less than 12% of the glucose was recovered. They postulated that "most of the ingested glucose seemed to remain in compartments within an unoxidized glucose pool."

Recently, Hargreaves et al. (1984) have produced results contrary to earlier research studies. They found that solid carbohydrate feedings administered hourly during 4 hours of cycle ergometer exercise helped maintain blood glucose levels, reduced muscle glycogen depletion during prolonged exercise and enhanced sprint performance at the end of such activity.

Use of glucose polymers have been examined as a means to delay fatigue during prolonged exercise. Coyle et al. (1983) studied cyclists working at 70-79% VO2 max to see if a glucose polymer solution fed at 20 minutes following initiation of exercise would delay fatigue. They found that blood glucose concentration was 20-40% higher during the exercise after carbohydrate ingestion. The exercise induced decrease in plasma insulin was prevented by carbohydrate feeding. Fatigue was postponed in seven of ten subjects and this effect appeared to be mediated by prevention of hypoglycemia in only two subjects. The exercise time to fatigue averaged 134 ± 6 minutes without and 157 ± 5 minutes with carbohydrate feeding ($p < .01$). Ivy et al. (1983) fed doses of 30 g of glucose polymers at 60, 90, 120 and 150 minutes following the start of walking exercise at 45% VO2 max. This treatment increased exercise time to exhaustion by 11.5% as compared to controls. Plasma glucose did not fall below pre-exercise levels and was significantly higher than that of the control group plasma glucose concentration at exhaustion.

As a final note, Felig et al. (1982) bring forth even more confusion as to the value of carbohydrate ingestion during prolonged exercise. Normal subjects exercised at 60-65% VO2 max on a cycle ergometer until exhaustion. It was found that hypoglycemia occurred in seven of nineteen subjects, and yet, this did not affect endurance. When hypoglycemia was corrected for by ingestion of either 40 or 80 g of glucose per hour, there was no consistent delay in exhaustion or alteration in the subjective sensation of exertion. These findings do not support a beneficial role for glucose ingestion in improving prolonged exercise performance.

D. Carbohydrate Ingestion Following Exercise

Exercise induced glycogen depletion followed by a high carbohydrate diet appears to enhance the resynthesis of muscle glycogen (Bergstrom and Hultman, 1966). The rate of muscle glycogen resynthesis is related not only to the carbohydrate content of the diet, but to the activity of glycogen synthetase (Piehl, 1974). As mentioned previously, regular exercise appears necessary to maintain enhanced sensitivity of glycogen synthetase to activation.

Successive days of prolonged severe exercise result in marked depletion of muscle glycogen concentration (Costill et al., 1971). When glycogen depletion is greater than 70-80 mmol/kg muscle, glycogen resynthesis is generally incomplete following 24 hours on a high carbohydrate diet (Costill, 1985; Piehl, 1974). Such evidence indicates that athletes who perform prolonged, severe exercise over successive days should consume a diet high in carbohydrates to help prevent cumulative glycogen depletion and chronic fatigue.

The type of carbohydrate fed makes only a small difference in glycogen resynthesis. A complex or simple carbohydrate diet (approximately 3,000 Kcal) fed to athletes after strenuous running resulted in similar muscle glycogen levels after 24 hours of exercise (Costill et al., 1981). However, in the same study, the complex carbohydrate diet resulted in significantly higher muscle glycogen levels 48 hours after exercise. Rats fed either glucose or fructose following exercise to exhaustion had similar levels of glycogen storage in both muscle and liver (Costill et al., 1984). It was noted that fructose was converted to liver glycogen to a greater extent than glucose and that glucose was converted to muscle glycogen to a greater extent than was fructose. According to the findings presented here, a diet high in carbohydrates, and specifically complex carbohydrates, appears to be most beneficial in optimizing glycogen resynthesis. Regular exercise, however, is equally critical to ensure increased glycogen synthetase activity.

The Role of Fats in Exercise

Dietary fats are of value for several reasons: they make our food more palatable, delay gastric emptying, have satiety value, are a carrier for fat soluble vitamins, provide the essential fatty acid linoleic acid and are a concentrated source of energy. Endogenous fat cushions and insulates internal organs and is a potential storehouse of energy. Obviously the degree to which fat is stored in the body is important, excess fat deposits have more negative implications than positive.

While there is no specified Recommended Dietary Allowance for fat, the National Research Council (1980) suggests that fats supply no more than 35% of the total daily caloric intake. Polyunsaturated oils should compose a maximum of 10% of the total daily caloric intake and the remaining 20-25% may be derived from saturated and monounsaturated fat.

A. Fat as a Fuel for Exercise

Studies done at the turn of the century made it apparent that both fats and carbohydrate serve as fuels for exercise (Zuntz and Loeb, 1894; Zuntz, 1901). Later studies, also measuring the respiratory exchange ratio (RER) (CO_2/O_2) confirmed this hypothesis (Marsh and Murlin, 1928; Krogh and Lindhard, 1920). It took a great deal of work and time to eventually establish that the free fatty acids (FFA) in plasma represented a major energy source (Gollnick, 1977). Havel et al. (1963) demonstrated that plasma FFA are elevated during exercise, and today it is accepted that fatty acids are oxidized by working muscles in relation to their concentration in the blood perfusing the muscle (Costill, 1984).

In a review, Carlson (1967) noted that long chain fatty acids are delivered from the plasma to muscle in the form of the three major lipid transport classes (chylomicrons, lipoproteins and free fatty acids). In addition, fatty acids may be taken from intracellular triglycerides and phospholipids, or the extracellular adipose tissue between muscle fibers. Triglycerides from adipose tissue make the greatest contribution of fatty acids for oxidation during exercise (Askew, 1983).

When fat is metabolized, ketone bodies are formed and may create a condition of acidosis. Ketone bodies increase slightly during exercise and sharply following exercise (Winder et al., 1979). Following exercise training, this effect is lessened (Holloszy and Coyle, 1984; Winder et al., 1979). Physical training is associated with increased activities of enzymes that metabolize ketones (Askew et al., 1975; Winder et al., 1974). Adequate carbohydrate in the diet prior to exercise may help prevent post-exercise ketonemia (Koeslag et al., 1980).

B. Fat Metabolism in Exercise

1. Duration and Intensity of Exercise

The duration and intensity of exercise affect the utilization of fat as a fuel. Using the muscle biopsy technique, studies have been done where, following 1-2 hours of exercise at 50-60% VO2 max or after 3 hours at 30% VO2 max, a decline in glycogen concentration of only 50%-60% was observed (Essen, 1977). During 4 hours of exercise at approximately 30% VO2 max, uptake of free fatty acids by leg muscle increased progressively until by beyond 40 minutes, the contribution of FFA to total oxygen metabolism reached 62% (Ahlborg et al., 1974). These data, plus other studies where a low respiratory exchange ratio was observed, indicate that in low to moderate intensity work fat is a major fuel source. High-intensity (60%-70% VO2 max) work of short duration inhibits the mobilization, delivery and adequate oxygenation of the tissue for oxidation of fatty acids (Askew, 1983).

2. Training

Prior training also affects fat metabolism. Enzymes which oxidize fatty acids increase in activity following exercise training (Molé et al., 1971). Winder et al. (1979) found that trained persons had lower levels of plasma catecholamines, plasma FFA, and blood glycerol at the end of prolonged exercise than in the untrained state. They hypothesized that the trained individual obtains a greater proportion of their energy requirement during long-term submaximal exercise from intramuscular lipid stores than from carbohydrate utilization. The acute increase in glucagon secretion in response to exercise is decreased following training (Gyntelberg et al., 1977). This is believed to be related to the blunted catecholamine response following exercise training since epinephrine and norepinephrine stimulate the A cells of the pancreas to secrete glucagon (Winder et al., 1979; Gyntelberg et al., 1977). Martin et al. (1984) showed that following cessation of endurance training, blood FFA and glycerol responses to epinephrine infusion are decreased. The loss of this training effect was complete 4 days following onset of inactivity. Holloszy and Coyle (1984) wrote a review paper on adaptations of skeletal muscle and their metabolic consequences. Among these adaptations are increased mitochondrial content and respiratory capacity of muscle fibers which are beneficial for increased fat oxidation.

3. Diet

Dietary intake prior to exercise is known to influence substrate oxidation. The previous section on carbohydrates discussed the effects of high carbohydrate diets on fuel metabolism. Phinney et al. (1983) explored the effect of a ketotic diet on exercise performance in endurance trained humans. They found that aerobic exercise endurance was not compromised following four weeks of a eucaloric ketogenic diet providing less than 20 g of carbohydrate daily. Fat became the predominant energy source when cycling at 62%-64% VO2 max until exhaustion. Sherman and Costill (1984) point out that exercise at this relatively low power output and intensity level is not limited by depletion of glycogen levels. Perhaps at higher intensities performance would be affected.

Miller et al. (1984) found that rats exposed to a high-fat diet are capable of prolonged intense exercise in spite of limited glycogen stores. They also looked at the adaptations which may be responsible for their findings. The most prominent adaptation they found was that muscular 3-Hydroxyacyl CoA dehydrogenase and citrate synthase activity increased after 1 and 5 weeks of the low carbohydrate diet. While the above findings are of interest, no recommendations can be made at this point. In addition, the atherogenic effects of high fat diets are not to be dismissed.

C. Benefits of Fat as a Fuel

Burning fat as a fuel for exercise has positive benefits. Elevation of plasma FFA can markedly increase endurance by slowing glycogen depletion (Costill et al., 1977; Hickson et al., 1977). Also, regularly performed aerobic exercise helps promote fat oxidation. This in turn exerts an effect on blood lipids. It is generally accepted that relatively low plasma concentrations of high-density lipoprotein (HDL) cholesterol are associated with increased risk of coronary heart disease. In a cross-sectional comparison of the distribution of plasma lipids and lipoproteins in groups of 41 male and 43 female long distance runners versus larger control groups matched for age and sex, Wood et al. (1977) showed that runners had a mean triglyceride level 50% below that of the controls. The mean HDL-cholesterol level was higher in runners vs. controls (75 $\pm$ 14 vs. 56 $\pm$ 14 mg/100 ml for women; 64 $\pm$ 13 vs. 43 $\pm$ 10 for men) and a mean low-density lipoprotein cholesterol level that was lower in runners vs. controls (113 $\pm$ 33 vs. 124 $\pm$ 34 for women; 125 $\pm$ 21 vs. 139 $\pm$ 32 for men). The running "lifestyle" appears to be a positive one with respect to risk of the development of cardiovascular disease. It is important to note here, however, that runners often choose diets which are higher in carbohydrates and lower in fat and that this may also contribute to the values observed in the preceding study. Runners in that study were predominantly normotensive, relatively lean and exclusively nonsmokers. Alcohol intake for runners was higher than for controls. This was thought to be related to the generally higher socio-economic status of the runners. Wood et al. (1977) states that it may be that moderate to generous drinking can occur in runners without the increase in plasma triglyceride levels that would be anticipated for relatively sedentary groups.

Blair et al. (1981) examined the nutrient intake of runners and sedentary controls to determine if the different plasma lipoprotein values could be explained by dietary differences. Middle-aged (35-59 years) men and women runners averaging 55-65 km per week, were leaner, had higher caloric intakes, ate more fat and carbohydrate, and were more likely to consume alcoholic beverages than sedentary controls. The differences noted between the two groups were not thought to account for the observed differences in plasma lipids and lipoproteins.

A recent review by Wood et al. (1985) considered the interaction of exercise level, caloric intake, adiposity, and serum lipoprotein concentrations. Citing their own research, it appears that middle-aged, sedentary men who become more fit by undertaking a program of moderate jogging, exhibit plasma lipoprotein concentrations that are generally considered as anti-atherogenic (increased HDL-C and decreased LDL-C). In addition, body fat is decreased, but total caloric intake increased. The percentage of calories derived from carbohydrate increased significantly.

D. Effects of Other Nutrients

The question has arisen as to whether certain nutrients may affect fat utilization. Carnitine is an example. It is a carrier molecule which translocates long-chain fatty acids across the inner mitochondrial membrane to the matrix where they are accessible to oxidative enzymes. Since regular exercise has been shown to enhance the turnover of long-chain fatty acids (Havel et al., 1963), it has been hypothesized that supplemental carnitine may enhance the oxidation of lipds in exercise. Using a rat model, Askew et al. (1980) found that fatty acid oxidation in vitro or in vivo was unaffected by carnitine feeding and concluded that increased demands for fatty acid oxidation resulting from exercise or fat feeding are met by endogenous carnitine stores.

To conclude, are there any beneficial reasons for the active individual to increase dietary fat consumption? According to the evidence presented here, no. The National Research Council (1980) recommended upper limit of 35% of total calories derived from fat is more than adequate.

The Role of Protein in Exercise

Protein in the diet is needed to provide the essential amino acids as well as sufficient amino groups to synthesize the non-essential ones. Major uses of amino acids in the body are for building and maintaining tissue, synthesis of blood proteins, enzymes and some hormones, milk formation and energy. Amino acids are continuously required in our diet to replace the nitrogen lost via urinary excretion, feces, sweat, sloughed skin, hair and nails, and various other bodily secretions and excretions.

Surplus dietary protein in excess of the amounts needed for the synthesis of nitrogen containing tissue cannot be stored as amino acids. Rather, this excess protein is converted to amino acids and then further metabolized; the nitrogen is excreted as urea, and the carbon skeletons are oxidized directly for energy or are transformed to carbohydrate or fat.

The current Recommended Dietary Allowance (RDA) for protein is 0.8 g/kg of body weight per day For the reference 70 kg man this would amount to 56 g of protein per day and for the reference 55 kg woman, 44 g (National Research Council, 1980).

A. Protein Metabolism in Exercise

The theory that protein is an essential nutrient for exercise has been disputed for over 100 years. Von Liebig (1851) indicated that protein was being utilized during heavy physical activity. Contrary to this, von Pettenkofer and Voit (1866) demonstrated that protein did not contribute to energy because urinary nitrogen excretion was not affected by prolonged exercise. Cathcart (1925) reviewed the literature up until 1925 and concluded that "the accumulated evidence seems to me to point in no unmistakable fashion to the opposite conclusion, that muscle activity does increase, if only in small degree, the metabolism of protein." More recent studies, which will be discussed here, support this conclusion.

1. Protein Synthesis

It is generally believed that a decrease in protein synthesis occurs during exercise (Dohm et al., 1980; Rennie et al., 1981; Hagg et al., 1982). Using a skeletal muscle perfusion system (rat hemicorpus), Dohm et al. (1980) demonstrated that rats swimming for one hour experienced a 17% decrease in protein synthesis. Other groups have used the primed constant infusion technique to measure whole body protein synthesis in human subjects and have found that exercise decreases protein synthesis (Rennie et al., 1981; Hagg et al., 1982). The intensity and duration of exercise appears to affect the rate at which protein synthesis is decreased. One hour of treadmill running resulted in a 30% decline in protein synthesis, while running to exhaustion produced a 70% decline (Dohm et al., 1985).

While most research confirms decreased protein synthesis during exercise, Swartman et al. (1981) observed increased synthesis of myosin in the myosin protein fraction of rat heart during swimming to exhaustion. Also, Lemon et al. (1984) maintained that when exercise is very long (4-12 hours), the body's protein production increases. This observation comes from studies utilizing techniques that result in muscle hypertrophy. Goldberg (1975) has reviewed in detail protein metabolism in strength training. Rogozkin (1976) investigated the effect of multiple daily training sessions on skeletal muscle protein synthesis in rats. Results indicated that three training sessions per day increased protein synthesis when compared to one session per day.

2. Protein Degradation

The picture with regard to protein degradation during exercise is confusing. Different laboratories have produced conflicting results and further research is required to elucidate how different factors such as exercise duration and intensity, training state and previous diet affect protein breakdown. Dohm et al. (1980) measured protein degradation in perfused hindquarters of rats and found increased tyrosine release from rats made to swim one hour versus control rested rats. Dohm et al. (1982) also found increased urinary excretion of 3-methylhistidine in both rats and human subjects following a strenous bout of exercise. Urinary 3-methylhistidine is thought to be an index of myofibrillar protein degradation (Lemon et al., 1984; Dohm, 1983). Rennie et al. (1981) found that moderate long-term treadmill exercise decreased the rate of myofibrillar protein breakdown. Décomabaz et al. (1979) did not find an increase in 3-methylhistidine excretion in human subjects following a 100-km run.

Historically, urinary urea nitrogen excretion has been the classic indicator of protein catabolism. Strenuous exercise seems to increase urinary urea excretion (Décombaz et al., 1979; Refsum and Strömme, 1974). However, it is important to consider sweat urea nitrogen loss as well as urinary urea nitrogen excretion if accurate conclusions are to be drawn regarding nitrogen metabolism. Sweat content of urea constitutes an important mode of nitrogen loss (Consolazio et al., 1975).

Lemon and Mullin (1980) altered muscle glycogen levels by either carbohydrate loading or carbohydrate depletion to study the effect on protein catabolism. They calculated from sweat urea nitrogen excretion that protein breakdown could account for 10.4% of the energy expenditure during cycling for 1 hour at 61% VO2 max. This information suggests that previous diet may influence protein degradation during exercise.

3. Participation of Amino Acids in Gluconeogenesis

The rate of gluconeogenesis is increased during exercise (Ahlborg and Felig, 1982; Ahlborg et al., 1974). This in turn contributes to the glucose supply, thereby helping to prevent hypoglycemia. Certain amino acids can serve as precursors for glucose synthesis. Felig and Wahren (1971) observed that while a variety of amino acids are released by exercising muscle, a net output is observed only for alanine. Alanine output increases in proportion to the severity of exercise performed, and the major factor determining alanine output is the availability of pyruvate (Felig and Wahren, 1971). While it would seem that alanine is formed by the transamination of glucose derived pyruvate, it appears that alanine may be produced from other amino acids (Goldstein and Newsholme, 1976). The alanine synthesized in muscle is then transported to the liver and its carbon skeleton is converted to glucose, thus creating the glucose-alanine cycle (Felig and Wahren, 1971).

Some of the other amino acids are metabolized to provide metabolites of the citric acid cycle which in turn help to increase the capacity of the citric acid cycle to oxidize the acetyl-CoA units arising from pyruvate and free fatty acids (Dohm, 1985).

Certain enzymes have been suggested as playing a role in increasing the hepatic gluconeogenic flux during exercise. These include increased activity of pyruvate carboxylase, fructose-1, 6-bisphosphatase and glucose-6-phosphatase and diminished activities of phosphofructokinase and pyruvate kinase (Dohm and Newsholme, 1983).

4. Amino Acid Oxidation

The liver was once thought to be the primary site for amino acid degradation in animals. However, recent research indicates a significant metabolism of branched chain amino acids (BCAA) in both resting and working muscle (Hagg et al., 1982; Lemon et al., 1982; White and Brooks, 1981). Using the techniques of constant infusion of labeled leucine oxidation in humans (Hagg et al., 1982) and labeled leucine oxidation in rats (Lemon et al., 1982; White and Brooks, 1981), these investigators have demonstrated that exercise increases the rate of leucine oxidation. Lemon and Nagle (1981) cite studies providing further evidence for BCAA metabolism. The enzymes necessary for BCAA catabolism (BC α-keto acid dehydrogenases) are found predominantly in muscle, a situation apparently not observed with other amino acids (Khatra et al., 1977). This finding also supports the hypothesis for BCAA oxidation.

It is important to note here, however, that leucine is the amino acid which has been studied most thoroughly with reference to amino acid oxidation as an energy source for exercise. Further research is required to determine what role, if any, other amino acids may play.

B. Protein Supplements

Clever advertising capitalizing on the word protein, has led to the sale of a variety of products which promise that the athlete will gain weight in the form of muscle, have abundant energy, and most important, become a winner. A recent trip to the local nutrition center in Corvallis, Oregon found these supposed benefits are not available inexpensively; a weeks supply of protein powder supplement costs about $10.00.

The typical American diet supplies sufficient protein so that supplements are unnecessary. The athlete in training receives more protein in the diet naturally when he/she increases caloric consumption due to the increased demand of exercise. Lean meats, fish, poultry, dairy products and eggs will provide the athlete with necessary amino acids.

Rasch and Pierson (1962) investigated the effect of a 25-g protein supplement (0.34 g/kg) during 6 weeks of progressive resistance training on achievement of strength and muscular hypertrophy. While the amount of weight lifted increased for both supplement and placebo groups, there were no significant differences between the two groups regarding changes in body weight, arm volume, upper arm girth or strength. In a later study, Rasch et al., (1969) tested the effect of a 0.69 g/kg protein supplement over 4 weeks of physical training. There were significant increases noted in tests of strength, power, and muscular endurance at the conclusion of training, but there were no differences between control and experimental groups. Therefore, the protein supplement was concluded to have no effect on physical performance. Neither of the above studies mentioned the dietary protein intake.

C. Protein Requirements for Athletes

Do athletes require more protein in their diet than the Recommended Dietary Allowance permits? While evidence has been presented indicating that significant amounts of protein are catabolized during long duration, high intensity exercise there is little information showing that such changes will necessitate an increase in nitrogen requirements as brought about by a negative influence in the long-term nitrogen economy of the body.

Despite this, different investigators have proposed increased protein requirements for athletes. Lemon et al. (1984) suggests 1.8 g/kg per day for exercising adults and 2.0 g/kg per day for those exercising individuals with special increased demand (growing children or adolescents, pregnant and lactating women). Brotherhood (1984) recommends 1.0-1.2 g/kg per day for the endurance athlete who is training hard for one hour each day and 1.3-1.6 g/kg per day for the power athlete increasing muscle bulk. Based on nitrogen balance study data, Consolazio et al. (1975) concluded that 1.4 g/kg per day was adequate for men performing fairly heavy work and improving in strength and fitness versus a diet containing 2.8 g protein/kg body weight per day. Yoshimura (1970) coined the term "sports anemia" to describe the transient drop in hemoglobin observed at the beginning of heavy physical training. Yoshimura (1970) reviewed studies done by his Japanese colleagues and concluded that the hemoglobin in red cells is utilized (degraded) to produce muscle protein and new red cells. A dietary protein level of 2 g/kg body weight was suggested to prevent the training athlete from developing sports anemia.

It appears that the body may adapt to lower protein intakes after about a week of training, provided calorie intake is adequate (Gontzea et al., 1975). In fact, Butterfield and Calloway (1984) have suggested that the protein requirement needed to maintain lean body mass in chronically active individuals may be somewhat less than that of the inactive individual. This may be attributed to the increased energy intake brought about by the activity, or the effect of the activity itself.

Because most athletes typically increase their caloric intake with training, protein content of the diet usually increases too. Haymes (1983) gives the example of a 70-kg athlete increasing calories from 3,000 to 4,000 kcal/day at the start of training. If 12% of the caloric intake was protein, the intake relative to body weight would increase from 1.3 g/kg to 1.7 g/kg per day which is certainly sufficient.

The Role of Vitamins and Minerals in Exercise

Vitamin and mineral supplements have been and continue to be used frequently in the athletic community. Athletes use these products in hope of achieving a competitive edge. This is based on the theory that if a vitamin or mineral has a specific function in the body, such as thiamin has in energy release, then taking more thiamin will somehow provide more energy.

According to Bentivegna et al. (1979), 68% of coaches surveyed recommend the use of vitamin supplements at one time or another. Another study (Wolf et al., 1979), reported that approximately 35% of Big Ten conference coaches instruct their athletes to take vitamin or mineral supplements. Recently, one well-known university track coach went into business selling athletic mineral supplements (KEZI, 1985). Situations such as these help perpetuate the myth that expensive food supplements are necessary for success in sport.

Young athletes are particularly vulnerable to sports nutrition misinformation. In a survey of 568 high school males, over 50% of those participating in organized sports reported using food supplements (Fleischer and Read, 1982). In the same study, 11.9% of the sample perceived a positive influence by coaches/teachers toward the use of food supplements. Fleischer and Read (1982) also found that 32.5% of the multiple vitamin users believed "they help me in sports," and 38.7% of the mineral supplement users believed "they give me energy." College athletes are not much better informed. Of those surveyed, 75% believed that athletes need more vitamins than non-athletes and 27% reported using dietary supplements (Gradjean et al., 1981). Taking vitamin supplements is also not inexpensive. The average adult vitamin user spent $28.00 on vitamin supplement products in 1981 (Stanton, 1982).

The aim of this particular section is to examine the rationale behind using vitamins and minerals in quantities exceeding the RDA and compare this to scientific findings to determine what benefits on physical performance, if any, may be obtained from vitamin and mineral supplementation.

A. Fat Soluble Vitamins

1. Vitamin A

Vitamin A is supplied in the diet as preformed retinol and from provitamin A carotenoid pigments. β -carotene is the most plentiful of the carotenoids and has the greatest vitamin A activity (National Research Council, 1980). It is found in a variety of dark yellow fruits and vegetables and dark green vegetables. Carotene is readily converted by the human body to the active retinol form.

Vitamin A is a fat soluble vitamin which may be stored in the body for prolonged periods of time. Some incidents of toxicity have been reported in individuals taking large daily doses. One adolescent soccer player was reported to consume a minimum of 100,000 international units (IU) of vitamin A daily in hopes of increasing his performance (Fumich and Essig, 1983). This led to hypervitaminosis A, a condition which is characterized by loss of appetite, fatigue, weakness, pain in the long bones and joints, loss of body hair and/or brittle nails. The National Research Council (1980) recommends 1000 μg retinol equivalents (RE) (5,000 IU) daily for adult males and 800 μg RE (4,000 IU) daily for adult females.

One function of retinol is in the maintenance of normal mucous membranes; in the eye this affects the visual process, specifically dark adaptation. This may be a theoretical reason for supplementary use in athletics (Williams, 1976).

There is little research on vitamin A and performance. Wald et al. (1942) studied the effect of vitamin A deficiency on the ability to perform muscular exercise. Five subjects consumed a high vitamin A diet for 30 days followed by an extremely low vitamin A diet for 6 months. The diet did not appear to affect physical performance or visual thresholds. Plasma vitamin A remained at its maximal levels throughout the study suggesting body reserves were sufficient to supply tissues. It seems that vitamin A supplementation is unnecessary for healthy athletes eating a varied diet.

2. Vitamin D

Vitamin D plays an important role in regulating calcium and phosphorus metabolism. The active metabolite of vitamin D is 1,25-dihydroxycholecalciferol. It is this hormone-like factor which is responsible for enhancing the intestinal absorption of calcium when there is a dietary calcium deficiency or increased calcium requirement (Fraser, 1984).

Vitamin D should be provided in the diet or may be produced in the body by the action of sunlight on 7-dehydrocholesterol in the skin. The daily allowance of vitamin D for infants, children and adolescents is 10 μg (400 IU); for adults 19-22 years it is 7.5 μg (300 IU); and for adults 22 years and older, it is 5 μg (200 IU) (National Research Council, 1980). Because it is another potentially toxic fat soluble vitamin, vitamin D supplementation should not be practiced without the advice of a physician.

DeLuca (1980) states there is evidence that vitamin D functions to improve muscle strength but the nature of this function is unknown. While the author did not elaborate on this statement, it is surmised that he was referring to the role of ionized plasma calcium in muscle contractility. This ionized calcium is generally assumed to be under hormonal control (Schuette and Linkswiler, 1984). As mentioned previously, vitamin D hormone is intricately involved in calcium metabolism.

3. Vitamin E

Vitamin E is a fat soluble vitamin derived from the tocopherols and tocotrienols. The α-tocopherol form has the highest biological activity. The recommended daily dietary allowance for vitamin E is 8 mg α-tocopherol equivalents (TE) for adult women and 10 mg α-TE for adult males (National Research Council, 1980).

The function of vitamin E has not been fully elucidated, but it appears to serve as an antioxidant of the polyunsaturated fatty acids in the tissues (Horwitt, 1980). In many animal species vitamin E deficiency is linked with a muscular dystrophy (Horwitt, 1980). By extrapolating these findings, one might hypothesize that athletes need additional quantities of vitamin E to avoid susceptibility to hypoxia and to increase muscular performance.

Cureton (1954) claimed that vitamin E can improve physical performance, but other more recent and well-controlled studies have reported no improvement (Sharman et al., 1976; Lawrence et al., 1975; Sharman et al., 1971). In particular, Sharman et al. (1976) studied two experimental groups each of eight young male and seven young female trained swimmers who were given either 400 mg α-tocopheryl acetate or placebos to their ordinary daily diet during a six week period of swimming training. No significant differences in cardiorespiratory efficiency and motor fitness and performance were observed between the two groups as a result of the vitamin E treatment.

Wheat germ and wheat germ oil are good sources of vitamin E and for this reason are often promoted as ergogenic foods. In addition, octacosanol, a solid white alcohol extracted from wheat germ is purported to provide energy and increase endurance. Cureton (1972) again is a major promoter of these ergogenic aids. Williams (1976) provides a thorough review and critique of Cureton's work in this area. He concludes that further research is needed to investigate the supposed merits of wheat germ, wheat germ oil, and octacosanol.

One vitamin E study does deserve special note. Kobayashi (1974) reported increased maximal oxygen uptake at altitudes of 5,000 and 15,000 feet following 6 weeks of supplementation with 1,200 IU of alpha tocopherol (1.2 g α-TE). While there appears to be no advantage from vitamin E supplementation at normal barometric pressure, vitamin E may be of use at reduced barometric pressure. Further work is indicated in this area.

4. Vitamin K

Vitamin K acts to catalyze the post-translateral carboxylation of peptide- bound glutamate in various coagulation proenzymes and other vitamin K dependent proteins (Suttie and Olson, 1984). The requirement for vitamin K may be met through foods consumed in the diet or through synthesis by intestinal bacteria. In the normal individual, vitamin K deficiency is rare. The suggested vitamin K intake for adults is 70-140 g/day. Athletes consuming a typical diet should receive sufficient vitamin K. There is no theoretical basis for vitamin K supplementation in the diet of athletes.

B. Water Soluble Vitamins

1. Vitamin C

Vitamin C occurs in two forms, ascorbic acid and dehydroascorbic acid. Ascorbic acid is the predominant form. Scurvy is the vitamin C deficiency disease which is characterized by bruising, petechiae and spongy gums. Fortunately, today in the United States scurvy is rare.

Megadoses of vitamin C are associated with diarrhea (known as "runner's trots" when occurring in runners taking generous doses of vitamin C) (Fogoros, 1980) and rebound scurvy (Rhead and Schranzer, 1971). Rebound scurvy occurs in people who have taken high levels of vitamin C over long periods of time and then suddenly stop taking supplements. The body tries to readjust to new lower levels of vitamin C, and a deficiency may result if dietary intake is low. The recommended adult daily dietary allowance for vitamin C is 60 mg (National Research Council, 1980).

The biochemical functions of vitamin C are not entirely clear, but one role is in the formation of collagen. In a review, Sauberlich (1984) cites research indicating vitamin C may also be involved in the metabolic reactions of amino acids, the synthesis of epinephrine and anti-inflammatory steroids, wound healing, the immune system and in leucoctye functions. Vitamin C also aids in increasing the absorption of iron (Monsen et al., 1978).

Vitamin C supplementation has been recommended for athletes to help replace losses resulting from exercise stress, to facilitate tissue oxygen release, and to lower the oxygen debt (Williams, 1983). Williams (1983) noted that 5 of 17 studies investigating the effects of vitamin C supplementation on physical performance reported improvements in either endurance capacity or mechanical efficiency; however, he states that all of these studies are invalid due to some methodologic problems such as poor experimental design, not accounting for a training effect or variations in work intensity. Henschel et al. (1944) observed no changes in strength or in the ability to perform muscular work in dry heat following a diet supplemented by 500 mg of ascorbic acid daily. Keren and Epstein (1980) found 21 days of 1,000 mg vitamin C supplementation had no effect on VO2 max. The increase in VO2 max was almost identical for both control and experimental groups. Also, no improvement in anaerobic capacity was noted. Howald et al. (1975) found a daily intake of 1 g of ascorbic acid had no effect on exercise performance in athletes. Despite some conflicting results in the literature, it appears that the most well-controlled studies indicate that vitamin C supplementation will not improve physical performance.

2. Thiamin

Thiamin is part of thiamin pyrophosphate, a coenzyme for pyruvate dehydrogenase, α-ketoglutarate dehydrogenase and transketolase. Thus, thiamin is very important in key reactions of energy metabolism. The requirement for thiamin increases with greater caloric intake. A deficiency of thiamin leads to the disease beriberi. The recommended thiamin allowance for adults is 0.5 mg/1000 kcal (National Resaerch Council, 1980).

Keys et al. (1943) found no reduction in the physical performance of young men when thiamin levels were reduced to 0.23 mg/1000 kcal over a period of 12 weeks. Archdeacon and Murlin (1944) found decreased muscular endurance in persons consuming a diet containing 0.27 mg thiamin daily. Adding thiamin back to the diet increased muscular endurance. They noted that inclusion of B vitamins to an already adequate diet will not improve muscular endurance.

Thiamin intake is easily met by consuming a varied diet including such foods as pork, whole grains and enriched grain products. There is no conclusive evidence indicating that athletes should supplement their diet with thiamin beyond the RDA.

3. Riboflavin

Riboflavin is converted to the flavoprotein coenzymes flavin mononucleotide (FMN) and flavin dinucleotide (FAD). These flavoproteins are involved in oxidation reduction reactions. The allowances for riboflavin have been related to protein intake, energy intake and metabolic body size (National Research Council, 1980). Horwitt (1980) suggests that the daily riboflavin allowances be computed from the daily protein allowances because the level of dietary protein influences riboflavin status (Turkki and Holtzapple, 1982). Riboflavin allowances have been computed as 0.6 mg/1000 kcal for people of all ages (National Research Council, 1980). Riboflavin deficiency results in skin and mucous membrane disorders.

With respect to exercise, riboflavin is one of the least investigated vitamins. Belko et al. (1983) determined the riboflavin requirement of young women during periods of sedentary living and exercise during a 12 week metabolic study. Riboflavin requirements increased from 0.63 to 1.4 mg/1000 kcal during the 6 week exercise period, and this could not be related to the energy intake or lean body mass of the subjects in the study. The authors concluded the 1980 Recommended Dietary Allowances for riboflavin are incorrect for healthy young women and that exercise increases riboflavin requirements. Based on their findings, young women who are exercising regularly require a level of 1.1 mg/1000 kcal.

Haralambie (1976) theorizes that riboflavin may affect the activity of glycolytic enzymes and would therefore be of importance in sports whose performance is dependent on a high glycolytic rate. Further studies seem warranted to more fully elucidate the effect of exercise on riboflavin metabolism.

4. Niacin

Niacin is the term used to describe nicotinamide and nicotinic acid. The coenzyme forms of nicotinamide are nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). Deficiency of niacin in the diet results in pellagra which is characterized by dermatitis, diarrhea and dementia. Niacin comes from the diet and from the conversion of tryptophan to niacin. Sixty mg of tryptophan is considered equal to 1 mg of niacin, and either of these values is equal to 1 niacin equivalent (NE). The niacin allowance recommended for adults is 6.6 niacin equivalents per 1000 kcal (National Research Council, 1980). Good dietary sources of niacin are liver, meat, fish, poultry, peanuts and enriched grain products.

NAD and NADP are involved in the intracellular respiratory process of all cells. Reduced NAD usually donates hydrogens to FAD in the schema of energy release, while NADP is involved in fat synthesis. Williams (1981) suggests that with the role NAD plays in glycolysis, it might be theorized that increased niacin levels might lead to increased anaerobic capacity.

Large doses of nicotinic acid have been shown to decrease mobilization of fatty acids (Carlson et al., 1963). Bergstrom et al. (1969) suggested that reduced free fatty acid delivery to muscles following nicotinic acid administration is compensated for by an increased use of muscle glycogen. Subjects with low muscle glycogen stores who were given nicotinic acid were shown to have a seriously impaired ability to perform prolonged exercise (Pernow and Saltin, 1971). To summarize, megavitamin doses of niacin are contraindicated for optimizing athletic performance.

5. Vitamin B-6

Vitamin B-6 is a class name for pyridoxine, pyridoxal and pyridoxamine. Vitamin B-6 has numerous biological functions including involvement in carbohydrate metabolism, immune function, nucleic acid metabolism, lipid metabolism and hormone function. Perhaps the most well-recognized role is its involvement in nearly all reactions of amino acid metabolism. One example is the conversion of tryptophan to niacin. Pyridoxal 5'-phosphate (PLP) is a cofactor for glycogen phosphorylase (Krebs and Fischer, 1964). The release of energy stored as glycogen depends on the cleavage of glucose units from glycogen by phosphorylase. Each phosphorylase monomer contains a mole of PLP. PLP is also the coenzyme for muscle and liver aminotransferases which maintain blood glucose during prolonged exercise via the glucose-alanine cycle. Vitamin B-6 is indirectly involved in fat metabolism as well (Mueller, 1964).

Deficiency of vitamin B-6 has been associated with mental depression and confusion (Hawkins and Barsky, 1948) and electroencephalographic abnormalities ultimately resulting in consulvions (Canham et al., 1964). Large doses of vitamin B-6 may be more toxic than once believed. Recent studies (Schaumburg et al., 1983) have shown that individuals taking vitamin B-6 megadoses are at risk for sensory neuropathies.

The allowance for vitamin B-6 is related to protein intake (Canham et al., 1969; Miller and Linkswiler, 1967). Considering protein intake as well as the uncertain bioavailability of vitamin B-6 (Kabir et al., 1983; Gregory and Kirk, 1981; Leklem et al., 1980; Gregory and Kirk, 1978), a daily dietary allowance of 2.2 mg of vitamin B-6 for adult males and 2.0 mg for females is recommended

(National Research Council, 1980). Good food sources of vitamin B-6 are meat, fish, poultry, legumes, nuts and bananas.

Leklem and Schultz (1983) observed increased levels of pyridoxal 5'-phosphate and plasma total vitamin B-6 in male adolescents following a 4500 meter run. Walter (1985) found that trained women have lower levels of plasma vitamin B-6 and a greater excretion of 4-pyridoxic acid as a result of a regular exercise program. Supplementation with vitamin B-6 could not be recommended because the status of the subjects was adequate with a diet containing 2.3 mg of B-6 daily. Several investigators have examined the effect of vitamin B-6 supplementation on exercise. Seventeen mg of pyridoxine hydrochloride supplemented daily over a period of 6 months had no effect on the swimming endurance of trained swimmers (Lawrence et al., 1975). Hatcher (1983) and deVos (1983) together conducted a 3 week diet study to determine the effects of diet-altered glycogen stores and B-6 supplements on B-6 and fuel metabolism during controlled strenuous exercise. For week 1 a normal (40%) carbohydrate diet was fed. Week 2 was a carbohydrate loading diet (Sunday through Tuesday, 11% carbohydrate; Wednesday through Saturday, 71% carbohydrate). Week 3 was identical to week 2, but with 8 mg supplementary pyridoxine. A total of six exercise tests per subject were administered. These were given each Wednesday and Saturday over the 3 week period. Hatcher (1983) found increased plasma pyridoxal 5'-phosphate (PLP) and plasma vitamin B-6 (PB6) levels (pre versus post) for all exercise tests. Exercise following the low carbohydrate diet resulted in smaller pre to post increases in PLP and PB6. It appeared that tissue redistribution of vitamin B-6 occurred with exercise. With the low carbohydrate diet more vitamin B-6 was thought to be needed for gluconeogenesis. The greater increases in PLP with exercise following supplementation suggest increased storage may have occurred. deVos (1983) suggested that B-6 supplementation, because of its role in glycogen phosphorylase, may contribute to a more rapid emptying of muscle glycogen stores and thus a reduction in endurance capacity. It would seem that vitamin B-6 supplementation is unnecessary for and possibly detrimental to athletic performance.

6. Folacin

Folacin is the term used to describe compounds having nutritional properties and chemical structures similar to those of folic acid (Wagner, 1984). The function of folates is to transport one-carbon units. These one-carbon units are produced mainly during amino acid metabolism and are used in the normal metabolism of amino acids and in the synthesis of nucleic acids which are needed for cell division (Wagner, 1984). Thus, deficiency of folacin leads to impaired cell division and altered protein synthesis (National Research Council, 1980). The RDA for folacin is set at 400 μg for normal adults and adolescents (National Research Council, 1980). Good sources of folacin are liver, fruits and leafy vegetables. A folacin deficiency could theoretically cause anemia and reduce aerobic endurance capacity. Brotherhood et al. (1975) looked at the hematological status of British athletes and found normal blood folate values.

7. Vitamin B-12

Folacin and vitamin B-12 interrelate in that a vitamin B-12 containing enzyme removes the methyl group from methylfolate. This causes a regeneration of tetrahydrofolate (THF), a precursor to 5, 10-methylene THF which is required for thymidylate synthesis (Herbert, 1984). Thus, vitamin B-12 is required in the synthesis of nucleic acids and red blood cells. A deficiency of vitamin B-12 leads to pernicious anemia which is characterized by anemia and eventual spinal cord degeneration. The RDA for vitamin B-12 is set at 3.0 μg daily for adults (National Research Council, 1980). The vitamin is found only in animal products thus strict vegetarians must find alternative ways of obtaining it. Some seaweeds provide vitamin

B-12 from microbial synthesis, but spirulina may not (Herbert and Drivas, 1982).

It has been theorized that giving vitamin B-12 injections will help increase oxygen delivery and improve aerobic endurance (Williams, 1981). Research has shown vitamin B-12 supplementation does not result in improved VO2 max or physical performance (Tin-May-Than et al., 1978; Montoye et al., 1955).

8. Biotin

Biotin is a sulfur containing water soluble vitamin. It is a component of several carboxylating enzymes and plays an important role in carbohydrate and fat metabolism. While biotin is widely distributed in foods, some especially good sources of biotin are liver, kidney, egg yolk and most fresh vegetables. Avidin, present in raw egg whites, makes biotin unavailable. 100-300 g of biotin per day should meet requirements for adults (National Research Council, 1980). Theoretically, biotin could be important for aerobic endurance. No experimental evidence was found to indicate that biotin directly influences physical performance.

9. Pantothenic Acid

Panthotenic acid is part of acetyl CoA. It is a very important cofactor for acyl-group activation reactions which are involved in the release of energy from carbohydrates, gluconeogenesis, and in the synthesis and degradation of fatty acids. Panthothenic acid is widely distributed in foods and is particularly abundant in meats, whole grains and legumes. As a result, deficiencies are unlikely. Four to seven mg/day are considered adequate for adults (National Research Council, 1980). While panthothenic acid supplementation may be theorized to be important for optimizing energy metabolism in exercise, support in the form of concrete research evidence is lacking except for one study which will be discussed in the B-complex supplementation section following this.

10. B-complex Supplementation

The marginal intake of the B-group and of vitamin C has been shown to decrease aerobic capacity (van der Beek et al., 1984). Earlier studies have also demonstrated a negative influence of vitamin B deficiency on physical performance (Berryman et al., 1947; Archdeacon and Murlin, 1944). On the other hand, supplementation of B vitamins to athletes already consuming balanced diets will not change performance (Read and McGuffin, 1983; Keys and Henschel, 1942). However, one study is available suggesting that fatigue was reduced during hard exercise in a warm environment which resulted in excessive sweating when a B vitamin supplement was given for 6 days (Early and

Carlson, 1969). The authors suggested that thiamin and pantothenic acid may have been responsible for the reduced fatigue (because of their roles in oxidative decarboxylation and as a component of acetyl-CoA, respectively). If a deficiency of either of these were present, there might be a shift in energy production from the TCA cycle to glycolysis alone, which is less efficient.

C. Minerals

1. Calcium

Calcium is a mineral necessary for the formation and maintenance of bone as well as a number of other essential processes. A 70 kg adult body contains about 1200 g of calcium. Approximately 99% of this calcium is present in the skeleton. The remaining amount, which does not exceed 10 g in the adult, is located in extracellular fluids and soft tissues. This calcium is involved in muscle contractility, myocardial function, neuromuscular irritability, blood coagulation and cellular adhesiveness (Schuette and Linkswiler, 1984). Calcium is also involved in the activation of certain enzymes (Kretsinger, 1980) including muscle phosphorylase b kinase and sarcoplasmic Ca ATPase.

Major food sources of calcium are the dairy products. Some components of foods will affect the absorption of calcium. Foods high in oxalic acid and phytic acid as well as various forms of food fiber and saturated fats have been shown to decrease calcium absorption (Nicolaysen et al., 1953). The calcium allowance for growing males and females aged 11-18 years is set at 1200 mg daily; the allowance for adult males and females is 800 mg daily (National Research Council, 1980). A calcium-to-phosphorus ratio of 1:1 (unity) appears to be sufficient for maintaining calcium homeostasis (National Research Council, 1980).

A high protein intake may increase calcium excretion, but this effect has only been observed in studies where purified amino acids were fed (Walker and Linkswiler, 1972). Spencer et al. (1978) found a high protein diet fed as meat had little effect on calcium excretion. The high phosphorus content of meat was hypothesized to influence calcium excretion. More recent studies (Hegsted et al., 1981) have shown that when protein and phosphorus intakes are high, urinary calcium excretion is not affected.

There is limited research on calcium and exercise. Two controlled studies (Shore and Consolazio, 1959; Konishi, 1957) found decreased urinary calcium excretion during exercise. Calcium absorption and serum calcium levels were unaffected, but calcium retention increased significantly during exercise (Konishi, 1957). Shore and Consolazio (1959) found that neither serum calcium nor urinary calcium excretion were immediately affected by exercise, but high intensity exercise for longer periods led to an eventual decrease in calcium excretion. Rapid changes in serum phosphorus and citrate levels suggested there is probably a relationship between calcium and some of the metabolites produced during exercise. It was not indicated if this relationship would affect calcium requirements during exercise. Contrary to these findings, Gontzea et al. (1966) found that young men consuming approximately 800 mg of calcium daily were in positive calcium balance when sedentary but were in negative balance when subjected to controlled exercise programs. During exercise, calcium excretion increased and absorption decreased. When intakes were raised to 1.2 or 2.0 g calcium, the balance became positive. Consolazio (1983) reported that during conditions of heavy sweating, up to 20 mg calcium/hour may be lost. For the athlete exercising daily in the heat, it would be prudent to be aware of dietary calcium intake.

Prolonged bed rest has been shown to cause a loss of calcium from the bone (Donaldson et al., 1970). However, it has not been shown conclusively that increased physical activity will increase bone mineral content.

One form of calcium supplementation which may be used by some athletes is the so-called vitamin B-15. This compound is also known as pangamic acid or calcium pangamate. The composition of such preparations is variable because the term is chemically meaningless. One component, diisopropylamine dichloroacetate, has been shown to be mutagenic using the Ames test (Herbert, 1979). Calcium pangamate supplementation does not improve aerobic endurance (Black and Sucec, 1981) or result in any metabolic or circulatory advantages during short-term submaximal exercise (Girandola et al. 1980).

2. Phosphorus

Phosphorus is the second most abundant mineral element in the body (calcium being the first). About 85 percent of body phosphorus is present in the inorganic phase of the skeleton. The remainder is found in the cells and extracellular fluids as organic phosphoric esters, phosphoproteins, phospholipids and the inorganic phosphate ions, H_2PO_4 and HPO_4^{2-}. Phosphate is important because it is a constituent of nucleic acids, cell membranes, bone and is an essential factor in all of the energy-producing reactions of the cell. The importance of phosphorus is often overlooked because it is so abundantly available in the food supply. The recommended allowance for phosphorus is the same as that for calcium (National Research Council, 1980).

Embden (1921) hypothesized that phosphates could delay fatigue caused by acidosis. He reported an increase in the work capacity of soldiers after supplementation. The purpose of phosphates was to neutralize the excess acid formed during hard physical exercise, and as a result, enhance work performance. Those who have reviewed the literature on phosphate loading (Consolazio, 1983, Williams, 1976) have tended to dismiss the practice as an ineffective means of improving work capacity. However, recently Cade et al. (1984) studied the effect of phosphate loading on red blood cell (RBC) 2,3-diphosphoglycerate (DPG) concentration in normal humans to determine if an elevated RBC 2,3-DPG could increase aerobic exercise capacity. 2,3-DPG interacts with hemoglobin to promote oxygen release from oxyhemoglobin. After oral phosphate loading there was a significant increase in serum phosphate and RBC 2,3-DPG. Maximal oxygen uptake was significantly increased and the increase in blood lactate after exercise on the 10% grade was attenuated during sessions which followed phsophate loading.

3. Magnesium

Magnesium is an essential ion in many important enzymatic reactions. Some of these reactions include those which transfer phosphate groups, acylate coenzyme A, hydrolyze phosphate and pyrophosphate groups and activate amino acids. Other roles for magnesium are in protein synthesis, the formation of cyclic AMP and in neuromuscular transmission and activity. Documentation for these functions may be found elsewhere (Wacker and Parisi, 1968). About 55 percent of magnesium is present in bone and about 27 percent is found in muscle. Magnesium is also in the erythrocytes, plasma and cerebrospinal fluid. Magnesium is widely distributed in foods so a deficiency is unlikely. The magnesium allowance for adult males is 350 mg/day and for adult females, 300 mg/day (National Research Council, 1980).

Exercise has been shown to affect serum magnesium. Rose et al. (1970) found a significant decrease in serum magnesium in eight subjects immediately following the Boston marathon. It was noted that some of the participants complained of nausea and muscle cramps following the race. They hypothesized that these symptoms may be related to the observed changes in magnesium. From this study, they concluded that magnesium should perhaps be incorporated in the various commercial glucose electrolyte solutions. Beller et al. (1972) also found decreased serum magnesium in association with exercise under thermoneutral and hot conditions. Sweat losses of magnesium were implicated in this study. Magnesium in sweat averages about 0.6 mEq/l in humans (Consolazio et al., 1963).

Reiter (1984) hypothesized that the decreased concentrations of magnesium in serum and red blood cells following exercise may play a role in hemolysis through impairment of magnesium-dependent adenosine triphosphatase (ATPase) in the red blood cell. Impairment of ATPase would in turn possibly cause an imbalance in the sodium and potassium concentrations of the serum and red blood cell resulting in spherocytosis and hemolysis. Such a sequence of events could lead to the development of what is termed sports anemia. This refers to the transient decrease in hemoglobin observed at the beginning of physical training (Yoshimura, 1970). Reiter (1984) studied eight adolescent males before and after 50 minutes of cycle ergometer exercise at 60% VO2 max. Her resarch did support her theory in that the exercise resulted in a transient spherocytosis and increased erythrocyte fragility. Significant reduced serum and red blood cell magnesium concentrations, decreased serum sodium concentrations and total serum sodium content, and increased serum potassium concentration add further support.

D. Trace Elements

1. Iron

Iron is a part of hemoglobin, myoglobin and various intracellular hem enzymes including cytochromes a, a_3, b, c_1, c, b_5, and P450 as well as others. Iron is also present in some nonheme enzymes. Approximately three-fourths of body iron is in hemoglobin and myoglobin.

About 26 percent of total body iron is stored in liver, spleen and bone cells in the form of ferritin and hemosiderin. The most important role of iron is in oxygen transport. Iron deficiency results in decreased hemoglobin in the blood which in turn causes a lowered capacity to provide oxygen to the tissues. Such a change would certainly affect physical performance.

The iron allowance for women of childbearing age is set at 18 mg/day in order to compensate for menstrual blood losses (National Research Council, 1980). For males 11-18 years the allowance is 18 mg/day and for males 19 and older the allowance is 10 mg/day (National Research Council, 1980). Dietary iron may be heme and nonheme. Foods which contain heme iron are liver, lean red meat, poultry and fish. Heme iron is the most readily absorbed form of iron. The availability of nonheme iron (found in foods such as dried peas and beans, whole grain breads and cereals, leafy vegetables, eggs, dried fruits and dark molasses) is enhanced by dietary ascorbic acid and a "meat factor" (Monsen et al., 1978).

There has been a great deal of interest regarding iron status of athletes. DeWign et al. (1971) found that among athletes training for the 1968 Olympic games, 9% of the men and 22.5% of the women appeared to be iron deficient. Twenty-five percent of a group of women field hockey players and 32 percent of a group of moderately active women had lower than normal plasma iron levels while only 8% of a group of sedentary women were classified as such (Haymes, 1973). Ehn et al. (1980) studied iron status in eight long distance runners. They found that despite normal hemoglobin values, bone marrow iron was either absent or present in traces. This was thought to be indicative of latent iron deficiency. Depressed or absent bone marrow iron was found in another study of competitive distance runners (Wishnitzer et al., 1983). Runners in particular tend to have a higher incidence of anemia in comparison to rowers and cyclists (Dufaux et al., 1981).

Thus it appears that women and long distance runners of either sex are prone to negative iron status. Clement and Sawchuk (1984) reviewed iron status and sports performance. They stated that factors influencing iron deficiency include inadequate nutrition, increased hemolysis, decreased iron absorption and increased iron loss via sweat, fecal loss, hemoglobinuria/myoglobinuria, hematuria, or menstruation. Paulev et al. (1983) found that daily sweat losses of more than 1 mg are possible in athletes training 125-350 km/week year round. It is possible to be iron deficient with or without anemia. Evidence is presented in a review by Clement and Sawchuk (1984) indicating that iron deficiency without anemia may result in decreased work capacity. This was thought to be due to decreased tissue concentrations of myoglobin and iron-containing enzymes important in energy production.

Sports anemia is the name given to the transient drop in hemoglobin observed in response to heavy training (Yoshimura, 1970). Possible causes for sports anemia are plasma volume expansion, reduced hemoglobin synthesis and/or erythropoiesis, and increased destruction of red blood cells (Pate, 1983). It is important to note that various investigators define the term sports anemia differently (Clement and Sawchuk, 1984; Pate, 1983; Yoshimura, 1970). Pate (1983) chooses to make sports anemia a more all-encompassing term designating a subnormal hemoglobin concentration in an athlete or physically active person.

Is iron supplementation appropriate for women athletes and long distance runners of either sex? Pate (1979) states that there is no reason for all women athletes to prophylactically ingest oral iron supplements. However, tests of hemoglobin and iron storage should be included in the medical screening of women athletes and such tests should be repeated whenever an athlete experiences an unexplained decline in endurance performance. Dickson et al. (1982) observed that serum ferritin levels of long distance runners were falsely elevated (35% above normal) following heavy training. This in turn may be masking a true iron deficiency. Care must be taken in monitoring the serum ferritin of ultra-marathon runners as the changes noted took up to six days to normalize. Recommendations for prevention of anemia related to sport include: 1. ensure athletes consume the RDA for iron, protein, vitamin C, vitamin B-12 and folic acid; 2. screen athletes routinely for iron deficiency and hemoglobin concentration; and 3. prescribe iron and/or other dietary supplements for athletes who manifest low hemoglobin levels or iron deficiency (Pate, 1983).

2. Zinc

Zinc is essential for the function of numerous enzymes from different species including alkaline phosphatase, carbonic anhydrase and thymidine kinase. A deficiency in zinc results in growth depression, sexual immaturity, skin lesions, impaired wound healing and changes in taste acuity. Marginal zinc deficiency may exist in some areas of the United States (National Research Council, 1980). An intake of 15 mg/day is recommended for adults (National Research Council, 1980).

Dressendorfer and Sockolov (1980) conducted a cross-sectional study of serum zinc in experienced runners to see if the high carbohydrate, relatively low animal protein diets popular among endurance athletes provide enough zinc. Serum zinc levels were found to be significantly higher among the nonrunner controls. Eighteen runners had serum zinc levels below 65 µg/100 ml, and were considered hypozincemic. There were no signs or symptoms of zinc deficiency, but serum zinc is not conclusive evidence of abnormal zinc status. Possible reasons for these observations were increased sweat losses of zinc, redistribution of zinc stores within the body and dietary deficiency of zinc. Haralambie (1982) found that in 160 training athletes (57 females), 23.3% of the male and 43% of the female athletes had serum zince values lower than normal (75 µg/dl) when measured in the morning at rest. Consolazio (1983) found that zinc losses ranged from 2.2 to 2.4 mg during a 7.5 hour heat exposure period, or about 18% of the total daily intake. The evidence presented here suggests that athletes should closely monitor dietary zinc intake in order to meet the RDA.

3. Iodine

Iodine is a constituent of the thyroid hormones triiodothyronine and thyroxine. Iodine deficiency leads to goiter, depression of thyroid function and cretinism. Iodine deficiency may still be found in many parts of the world, but has rarely occurred in the United States since the introduction of iodized salt. Goitrogens inhibit iodination of tyrosines and are implicated in the development of goiter. Progoitrin foods include members of the Brassicae family (cabbage, Brussels sprouts, turnips and rutabaga). Seafoods are excellent sources of iodine. An iodine allowance of 150 μg is recommended for adolescents and adults of both sexes (National Research Council, 1980).

Irvine (1968) found that muscular exercise causes an increase in thyroxine secretion and degradation rate resulting from increased fractional turnover with little change in pool size. Athletes had a faster thyroxine turnover than non-athletes undertaking the same exercise and at the end of a three day rest period have a faster turnover than resting non-athletes.

4. Copper

Copper is a part of a number of oxidative enzymes, interacts with iron, and is involved in the cross-linking of elastin. Copper deficiency results in anemia, changes of ossification, and possibly elevated serum cholesterol. A daily copper intake of 2-3 mg is recommended for adults (National Research Council, 1980).

Megadoses of vitamin C can interfere with copper metabolism and as a result lead to a secondary problem of iron-deficiency anemia (Finley and Cerklewski, 1983). Athletes should be aware that taking excesses of a vitamin or mineral may not only be harmful in itself, but vitamins and minerals have interrelationships which can be upset.

Rusin et al. (1980) found decreased blood copper content in athletes following a 50 km ski race. Dressendorfer et al. (1982) found marginally low copper levels on days 1 and 2, and elevated but normal levels thereafter in men participating in a 20-day 500 km road run. The rise in plasma copper was thought to reflect the liver's increased production of ceruloplasmin in response to minor skeletal muscle injury. Consolazio (1983) found copper losses in sweat ranged from 1.0 to 1.9 mg during a 7.5 hr heat exposure period, or about 40% of the daily intake.

5. Manganese

Manganese is a part of several enzyme systems involved in protein and energy metabolism and in the metabolism of mucopolysaccharides. Good sources of manganese are nuts and grains. The recommended manganese intake for adults is in the range of 2.5-5 mg/day (National Research Council, 1980). In studies by Russian investigators (Rusin et al., 1979), it was found that trained women have greater losses of manganese in urine, sweat and feces than untrained women in response to muscular training. In addition, Rusin et al. (1980) found athletes had increased manganese excretion following a 50 km ski race. Few details were provided in these English abstract translations.

6. Chromium

Chromium is necessary for glucose tolerance (Schwarz and Mertz, 1959). It is likely that the chromium containing glucose tolerance factor forms a complex with insulin (Evans et al., 1973). Brewer's yeast, meat, cheese and whole grains are good sources of chromium. An intake of 50-200 μg/day is tentatively recommended for adults (National Research Council, 1980).

Anderson et al. (1982) studied 9 male runners before and after a strenuous 6-mile run. Mean urinary chromium concentration was increased nearly five-fold 2 hours after running even when expressed per mg creatinine. Total daily urinary chromium excretion was approximately two times higher the day of running compared with the following nonrun day. The authors state this data suggests an increased requirement of Cr for individuals who exercise routinely. Vallerand et al. (1984) studied the influence of exercise training on tissue chromium concentrations in the rat. Exercise training appeared to increase tissue chromium levels. The authors suggested that the male Sprague-Dawley rate adapts to exercise training by enhancing tissue levels of chromium or by simply maintaining the high levels of the element found at a younger age.

7. Other trace elements

Other trace elements including fluoride, selenium and molybdenum will not be discussed here because of a lack of available research on exercise as related to these nutrients. The evidence presented here suggests that while supplementation is probably unnecessary, athletes should pay close attention to their dietary intake of calcium, magnesium, iron, zinc, copper and chromium.

The Role of Water and Electrolytes in Exercise

Water is the often forgotten essential nutrient. In the average healthy individual, water comprises between 50% to 70% of the body weight. Athletes usually have a greater percentage of body water than nonathletes due to their greater lean body mass and reduced body fat (Randall, 1980). Adipose tissue contains less water than muscle. Body water is located intracellularly, and extracellularly (in the interstitial and plasma fluids).

Water has numerous functions in the body. Chiefly, water is a transporter of nutrients, waste products, and secretions such as hormones. Water also provides a medium where various chemical reactions of the body may take place. In this particular section, the role of water in body temperature regulation will be discussed. Under normal circumstances, the average individual may consume approximately 1 ml/kg of water daily (National Research Council, 1980).

Sodium is the principle cation of the extracellular fluid and is intricately involved in regulating osmotic equilibrium and extracellular fluid volume. Davis and Freeman (1976) review this topic more thoroughly. Briefly, the kidney is the site of sodium regulation which is mediated by the renin-angiotensin-aldosterone system. Low sodium intake increases renin output and activates aldosterone via angiotensin, thus resulting in decreased sodium excretion. High sodium intake has the opposite effect. Renal blood flow is increased and renin output is decreased, thus resulting in increased sodium excretion. Under normal conditions, the recommended safe and adequate daily intake of sodium is 1100-3300 mg sodium for adults and 900-2700 mg for adolescents 11 years and older (National Research Council, 1980).

Potassium is the principle cation of the intracellular fluid (ICF). Approximately 98% of total body potassium is contained in the ICF space. Some functions of potassium include involvement in membrane excitation, transport of glucose across cell membranes, storage of glycogen in muscle and liver, protein synthesis, and enzymatic regulation of many important cellular reactions (Lehninger, 1982). Athletes often have greater total body potassium due to their larger muscle mass. Potassium homeostasis is dependent on the elements responsible for regulating sodium balance. An estimated safe and adequate daily range of intake for potassium is 1875-5625 mg for adults and 1525-4575 mg for adolescents 11 years and older (National Research Council, 1980).

Chloride is an extracellular fluid anion important in maintaining fluid and electrolyte balance. It is also present in gastric juice. An adequate and safe chloride intake range for adults is approximately 1700-5100 mg daily, and for adolescents 11 years and older, 1400-4200 mg daily (National Research Council, 1980).

A. Fluid Loss and Gain in the Body

In the normal individual, body water is continually being lost and replaced. Routes of loss include water vapor exhaled from lungs; evaporation from the skin (both insensible and sweat); urine; and feces. Average total loss is about 2.0-2.5 liters daily. Routes of gain include fluid intake in the form of water, beverages, and soups; water in solid foods; and the water produced from metabolic reactions.

B. Thermoregulation

Man has a relatively large potential capacity for heat dissipation by evaporation of sweat which allows him to perform high intensity physical exercise for prolonged periods of time (Greenleaf, 1981). During exercise, the internal body temperature rises independent of ambient temperature (Gisolfi, 1983; Roberts and Wenger, 1979). The increase in body temperature is proportional to the relative, not absolute workload and is what provides the stimulus for sweating and cutaneous vasodilation (Gisolfi, 1983). Hydration level will affect sweat rate and skin blood flow. Greenleaf and Castle (1971) found significant elevations in rectal and mean body temperatures in the hypohydrated (loss of 5.1% of body weight) versus a hyperhydrated state. This response was attributed to inadequate sweating. Physical training and heat acclimation will help alleviate cardiovascular strain produced by exercise in the heat. Changes include increased sweating during thermal stress and decreased level of skin blood flow needed to maintain body temperature (Roberts and Wenger, 1979). Women tend to have lower sweating rates than men (Haymes, 1984; Nunneley, 1978). The most important adaptation to heat is the expansion of plasma volume (Senay et al., 1976). Endurance training increases plasma volume (Senay, 1979).

An acute exercise session or thermal dehydration decreases plasma volume (Gisolfi, 1983; Rotstein et al., 1982; Costill and Sparks, 1973). Thermal dehydration to -0.4% of body weight was found to induce a 12% decrement in plasma volume (Costill and Sparks, 1973). This effect is primarily due to transcapillary filtration of intravascular fluid into working skeletal muscle (Gisolfi, 1983). Mechanisms include decreased hydrostatic pressure within inactive vascular beds and arterial hyperosmolality (Gisolfi, 1983).

C. Heat Illness

With impaired thermoregulation, heat illness may result. Heat injury has proven fatal to a number of American football players who suffered heat stroke (Murphy, 1973). The American College of Sports Medicine (1984) recently published a position paper on prevention of thermal injuries during distance running. Recommendations were made to the organizers of distance and community fun runs. Such educational efforts are commendable, yet it is the athletes themselves who would benefit most from such information. Only a few short months ago in the 1984 Olympic Games the world was witness to one marathon runners agonizing experience with heat injury.

Fainting is a mild form of heat illness which may occur in the person unfamiliar to heat or in the acclimatized individual upon a sudden increase in environmental temperature or humidity during exercise. Treatment involves rest in a cool area and drinking cold fluids.

Heat cramps result from excessive loss of salt in sweat. Cramps usually appear in the calf muscle or the abdomen. Treatment involves rest and salt ingestion from foods or by taking small quantities of salt with sufficient water.

Salt depletion heat exhaustion occurs most frequently in individuals unfamiliar to working in hot temperatures who are not replacing salt lost in sweat. Symptoms are fatigue, nausea, giddiness, vomiting and exhaustion. Body temperature is generally normal. Treatment is similar to that for heat cramps.

Water depletion heat exhaustion occurs from inadequate water intake with prolonged sweating. It is characterized by strong thirst, fatigue, giddiness, oliguria and fever. Skin is usually pale, cool, clammy and the individual is sweating profusely. Treatment involves cooling the individual in a reclining position and providing cool drinks.

Heat stroke is the most dangerous form of heat illness. The individual who exercises beyond the early warning stages may proceed to the point where thermoregulation seriously malfunctions. Sweating may cease and core temperature may elevate to dangerous levels. A loss of consciousness may lead to heat stroke. The condition is characterized by hot dry skin, high body temperature, and signs of cerebral dysfunction. Treatment involves cooling the patient as quickly as possible by immersion in a tub of ice water and seeking immediate medical attention. The preceding information was summarized from the National Research Council (1980) and Williams (1976).

D. Sweat and Electrolyte Losses

Sweat losses may be considerable during exercise and this situation is aggravated during exercise in the heat. Sweat rates of 1.5 l/hour are common in endurance exercise (Brotherhood, 1984). During competition in a warm environment, a marathoner may lose approximately 2.8 l/hour (Costill, 1977). Performance is negatively affected when water losses in sweat are not replaced (Pitts et al., 1944). When man is sweating rapidly, he tends not to consume enough water to replace sweat losses; i.e. his thirst sensation is not strong enough to demand a sufficient water intake to replace water loss. This condition is termed voluntary dehydration (Adolph, 1947) and necessitates consuming enough water to maintain pre-exercise body weight.

Various micronutrients are lost in sweat (Brotherhood, 1984; Costill, 1977; Consolazio et al., 1963). According to Brotherhood (1984), loss of iron in sweat of some athletes in heavy training (sweat losses greater than 3 l may approach 1 to 2 mg/day. This may be of particular concern to female athletes. Electrolyte losses in sweat have received much attention. Subjects who reduced their weight 5.8% by exercising in a warm environment lost an average of 4.11 l of sweat composed of 155 mmol Na^+, 16 mmol K^+, 137 mmol Cl^-, and 13 mmol Mg^{++}. This amounted to a loss of 5% to 7% of body Na^+ and Cl^- and a less than 1.2% loss of K^+ and Mg^{++} (Costill, Cote and Fink, 1976). It would seem that during prolonged exercise, replacement of salt losses are most important.

Use of salt tablets to replace sweat losses is still common among many athletes according to Christine Wells, PhD, a professor at Arizona State University. While salt replacement in conditions of frequent profuse sweating is undeniably important, the practice has been abused (Williams, 1976). Taking salt without adequate water simply aggravates an already upset equilibrium. When one considers that the typical American diet contains from 8-10 g NaCl per day, and often more in the case of athletes with high caloric intakes, there is no sound reason to also take salt tablets (Fink, 1981). Costill et al. (1976) showed that repeated days of exercise dehydration induced a renal conservation of sodium. The mechanism responsible for this observation appears to be the elevated renin and aldosterone levels noted during and immediately after exercise (Costill et al., 1976). Salt deficiency is unlikely to occur in well-trained athletes consuming typical diets.

Some research has indicated that heavy sweat losses may produce a potassium deficiency that may ultimately lead to rhabdomyolysis (muscle tissue necrosis) (Lane and Cerda, 1978; Knochel, Dotin and Hamburger, 1972; Knochel and Vertel, 1967). Costill, Cote and Fink (1982) challenged these findings, and despite efforts to create a body K^+ deficiency by providing a low K^+ diet and having subjects undergo heavy exercise-sweating, potassium remained in balance. If sodium intake is too high, potassium may possibly be depleted (Costill, Cote and Fink, 1982).

E. Fluid Intake for Exercise

Dehydration exceeding 2% of body weight is generally believed to decrease plasma volume and impair exercise performance. For this reason, fluid intake associated with exercise, and especially exercise in the heat, is of considerable importance to athletes wishing to achieve optimal performance.

1. Hyperhydration

Hyperhydration (also known as superhydration, prehydration or overhydration), appears to help maintain blood volume, stroke volume and lower heart rates. These in turn help to regulate body temperature. The hyperhydration technique involves drinking a large volume of water

(2 to 3 l) prior to and during exercise. Unfortunately, it is often impractical to consume this much fluid in a competitive setting. Hyperhydrating confers little advantage for athletes competing in short events, but may be critical for endurance athletic performance. Williams (1976) recommends taking large quantities of water one hour prior to exercise, and if taken immediately prior to exercise, 0.5 l should present no problems. Herbert (1983) reviewed the literature, and concluded that "preliminary drinking prior to distance running in the heat may not forestall hyperthermic fatigue at maximal performance levels as well as if water is drunk during the race."

2. Gastric Emptying

Gastric emptying properties of a fluid replacement drink are important because the more volume delivered to the intestine for absorption into the circulation, the more useful the drink is in maintaining hydration. The greater the volume ingested (up to 600 ml) the more rapidly it is emptied (Costill and Saltin, 1974). Exercise intensity of 65%-70% VO2 max and above will slow the rate of gastric emptying (Costill and Saltin, 1974).

3. Glucose Electrolyte Solutions (GES) vs. Water

Water, in comparison to commercial hydration solutions is most effectively emptied from the gut. The reason for this is that the sugar in some commercial solutions delays emptying in proportion to its concentration (Coyle et al., 1983). Producers of sport drinks have taken advantage of the fact that prolonged exercise precipitates loss of electrolytes and low blood sugar. The best known drink is Gatorade, and it contains the following ingredients per liter: sodium (21.0 mEq), potassium (2.5 mEq), chloride (17.0 mEq), phosphorus (6.8 mEq), and 5% glucose. Research has shown that a drink with a composition similar to this emptied from the stomach at a 35% slower rate than water (Coyle et al., 1983). This latter study indicates that drinks over 2.5% sugar are too concentrated to drink as is, and if any beneficial absorption of nutrients is to occur, they must be diluted. Replacing electrolytes is unnecessary because the normal diet supplies enough to cover any losses. Despite this, it's a wise idea for all athletes to be aware of their diet.

F. Recommendations for Athletes

To conclude, athletes and coaches should consider the following suggestions for maintaining fluid balance and achieving optimal physical performance:

1. Proper training.
2. Heat acclimation as part of the training program.

3. Avoid heavy exercise during the hottest part of the day.
4. Consume cold fluids in volumes equal to sweat losses.
5. Drink small volumes often (approximately 400 ml every 15 to 20 minutes).
6. Have fluids present at all exercise sessions and readily accessible.
7. Salt replacement is important during prolonged exercise or heat exposure over several days. Choosing a balanced diet should provide enough salt. If unsure, contact a registered dietitian (R.D.) to plan a salt adequate diet.
8. Avoid high protein diets because they lead to increased urine water excretion.

III. METHODS

A. Nutrition in the Fast Lane, Development of Research

This project began with the assistance of the Oregon State University Extension Service. Margaret Lewis, an extension foods and nutrition specialist, had funds budgeted for a project in the area of nutrition and physical fitness. She had asked Dr. James Leklem to collaborate on this project by helping to create a slide/ tape program which would address some of the myths and misconceptions associated with nutrition and exercise. This graduate student whose research goals were to plan and conduct a nutrition education study involving a media product was fortunate in becoming a part of the project team.

By May of 1983, the initial production of Nutrition in the Fast Lane (NFL), a 17 minute slide/tape show was complete. Several resources were used to help plan and produce this product (Kemp, 1975; Kodak, 1975), including a course at Oregon State University taught by Dr. Ruth Stiehl (Ed 437, Multi-Media Production). In mid-May 1983, NFL was presented to a group of extension home economists for comments and critique. This information was then used to improve the finished product. The content was determined very good. Major suggested revisions included retaping the script with both male and female speakers and using real foods in sample meals instead of food models. By mid-October of 1983, all revisions were completed and NFL assumed it's final form. Further evaluation of the effectiveness of NFL as a teaching tool included: 1. a Readings and Conference course in the Department of Education on evaluating instructional materials; 2. the author's thesis proposal where members of the faculty and graduate students in the Department of Foods and Nutrition were able to view NFL and to provide input; 3. comments of Foods and Nutrition graduate students (several were involved in nutrition and exercise studies); and 4. the course ED 437, Multi-Media Production. The NFL script is found in Appendix A.

B. Preliminary Research Organization

In reviewing the literature, it became apparent that groups responsible for instructing young athletes about nutrition (coaches, trainers, physical education majors) were lacking in adequate nutrition knowledge (Parr et al., 1984; Bedgood and Tuck, 1983; Bentivegna et al., 1979; Wolf et al., 1979; Cho and Fryer, 1974). While these studies indicated a need for nutrition education for these groups, none of these included a workshop which was conducted with the goal of increasing nutrition knowledge and awareness.

In response to this need, a one-hour in-service workshop for coaching and physical education staff was planned. NFL, because of its specialized content on nutrition for fitness and sport, formed the core of the workshop. The author coordinated the project by contacting high school athletic directors located within a one-hour driving radius of Corvallis, Oregon. It became clear that to successfully gather data from the particular audience desired it would be necessary to structure the workshop in a formal fashion. This ultimately led to contacting school district athletic directors and/or superintendents and requesting space and time for a presentation during regularly scheduled fall in-service sessions. Even with the aid of the school district there was no guarantee that the audience would contain any or all coaches. Part of the problem stems from school district funding of athletics and to some extent the nature of coaching the various sports. Some coaches are not school teachers. Dates and times of workshops varied according to each school district's in-service schedule. Each district publicized the workshop through in-service announcements. A final schedule of workshops held for purposes of data collection is shown in Table 1.

C. Workshop Design

To identify the specific nutrition and athletics

Table 1

Workshops Given for Purposes of Data Collection

Workshop: Corvallis High School Coaches
Location: Corvallis High School
City: Corvallis
Date: May 10, 1984
Time: 7:30 PM

Workshop: Athletic Training Workshop
City: Training Room, Gill Coliseum
Date: July 10, 1984
Time: 10:30 AM

Workshop: Corvallis School District 509J
City: Crescent Valley High School
Date: Aug. 28, 1984
Time: 10:30 AM

Workshop: Corvallis School District 509J
City: Crescent Valley High School
Date: Aug. 28, 1984
Time: 1:00 PM

Workshop: Eugene School District 4J
City: South Eugene High School
Date: Sep. 5, 1984
Time: 10:00 AM

Workshop: Crescent Valley Boosters Club
City: Crescent Valley High School
Date: Oct. 9, 1984
Time: 7:00 PM

Workshop: Salem School District
City: North Salem High School
Date: Oct. 12, 1984
Time: 10:00 AM

target areas in which coaches were misinformed, popular sports nutrition books and articles were reviewed. Suggestions from the faculty and graduate students at Oregon State University were also considered. Most key topics were included in the slide show NFL. However, certain areas were further brought out in a brief discussion following the slide show, or in a handout (Appendix B). This handout was developed especially for coaches and was distributed following the slide program. The handout included an annotated bibliography of reference materials available to coaches. Some resources were present for inspection following the workshop.

The objectives of the workshop were to: 1. provide accurate nutrition and athletics information; and 2. make participants aware of the variety of instructional materials available to them for use in instructing students/ athletes. An approximate time schedule for the workshop is illustrated in Table 2.

D. Evaluation Instruments

A questionnaire was designed to measure the nutrition knowledge of coaches. In order to determine the type of nutrition for fitness and sport information reaching the general public, sources of information such as current popular books, pamphlets produced by food companies, magazines for coaches, and various magazine and television

Table 2

General Plan of the One Hour Workshop

	Approximate time (minutes)
I. Introduction	
A. Introductions	
B. Outline of Program	5
C. Completion of Pre-test	12
II. Nutrition for the Athlete	
A. Nutrition in the Fast Lane	17
1. Specifications: 83 slides, 17 minute narration with music, cassette tape, cassette recording with synchronization	
2. Equipment needed: One carousel slide projector; Wollensak tape player; screen	
3. Program goals: This program deals with the role of nutrition in physical performance. The six essential nutrients-carbohydrate, fat, protein, vitamins, minerals and water are the main focus. Common myths and misconceptions are identified and clarified.	
B. Distribute coaches' guide	
C. General Discussion Review, some aspects of interest mentioned, questions, comments.	5-15
III. Closing	
A. Completion of Post-test	12
B. Examination resource materials (optional)	

advertisements promoting vitamin and mineral supplements were reviewed. Commonly held myths and misconceptions were particularly noted. In addition, scientific literature was also reviewed for further information on current nutrition knowledge and attitudes. The above information was used to write items for the questionnaire.

With the assistance of the Survey Research Center at Oregon State University, the initial questionnaire was completed. Four major sections composed the knowledge portion of the questionnaire. These included nutrient composition of foods; vitamins and minerals in athletic performance; general nutrition and athletics; and pre-game/completion nutritional practices. The format for questions 1 through 6 was modified from the Eat to Compete workbook (Block and Ikeda, 1982). A Likert-type scale was used for the general nutrition and athletics questions. This was used so that respondents were able to indicate how strongly they agreed or disagreed with the factual statements about nutrition. Other researchers have made use of such a scale (Bedgood and Tuck, 1983; Werblow et al., 1978; Cho and Fryer, 1974). Another scale, agree/disagree/don't know, was used for the remaining nutrition fact questions (questions 7 and 9).

Initial validation of the questionnaire items was made during the author's thesis proposal. Following this, several graduate students involved in nutrition and exercise studies were asked to critique the instruments. Further and final changes were made following the pilot test.

The pretest questionnaire included questions on the background of the respondent; the post-test questionnaire requested workshop evaluation information. Participants were asked to record the last four digits of their home phone number on the cover page of the questionnaires for purposes of coding. An example of both the pretest and post-test questionnaire appears in Appendix C.

E. Pilot Test

The initial pre- and post-questionnaires were tested in several ways. As mentioned previously, copies of both questionnaires were available for critique at the author's thesis proposal. Also, several graduate students examined the questionnaires and made comments regarding content, ambiguity, wording, definition of terms and misleading statements. Third, students in a running class on campus were asked to take the test twice; initially, and then one week later. This was to observe any changes due to repeated measurement. Nine persons in the class completed both the pre- and post-questionnaires. Of these nine, six decreased in score from pre to post. Fourth, a pilot workshop was held in March 1984 in Yuba City, California.

Participants included coaching and physical education staff. These participants were given the pre-questionnaire, presented the same information that was to be included in all the future workshops, and then given the post-questionnaire. These questionnaires were then evaluated to determine if questions were too simple (items yielded a near 100% correct response), too difficult (items yielded a near total negative response), or if participants indicated the question was unclear. From this information, and all previous tests, items were either omitted or revised. In question 1, serving sizes were listed for the food sources of iron. In questions 1 through 5, some food items were replaced with others with the goal of having a list of foods that were fairly obviously correct or incorrect. Based on pilot test results and comments, this area was perceived as being potentially difficult for respondents. The knowledge statements were not changed with the exception of three items. One carbohydrate loading item was deleted because it was ambiguous. Another carbohydrate loading item was revised slightly. Another statement dealing with protein needs was reworded. These changes yielded a total of 34 knowledge statements in addition to questions 1 through 6. It should be noted here that certain statements were deliberately left in the questionnaire which were not addressed in either the slide program NFL or the brief discussion following NFL. The reason for this was to determine if there was some change in response despite not having learned any specific information on which to base a new decision. The final test instrument was then deemed ready for use.

F. Selection of Sample

The participants in the study included any person attending the workshops given. Although the presentations were aimed at coaching and physical education staff, a number of individuals participated because of personal interest. Since the focus of the study was coaches, the final sample was broken down into four populations and analyzed separately as well as a whole. The populations were designated coaches, student athletic trainers, teachers and parents of young athletes.

G. Data Collection

The pre-questionnaire was given at the beginning of the workshop before any presentation was made. The fact that it was a "pre"-questionnaire was not mentioned nor was any reference made to a "post"-questionnaire. At the conclusion of the presentation, participants were asked to complete a post-questionnaire.

H. Scoring of Questions

The questionnaires were scored following procedures recommended by the Survey Research Center at Oregon State University. One point was given for each correct answer when the scale was agree/disagree/don't know. No points were given for an incorrect or don't know response. For items with a Likert-type response scale, a direction was assigned so that correct responses were given a higher score. For example, if the statement was written in a positive manner, four points were given for "agree strongly", three points for "agree", two points for "disagree", and one point for "disagree strongly". If the statement was written in a negative manner, scoring was reversed. No credit was given for a don't know response.

Items regarding the nutrient composition of foods were scored so that a correct food choice yielded one point. Five points each were given for correct responses to question 6 and 6b which dealt with the composition and timing of pre-competition meals, respectively. For all of the scored questions, a total of 142 points was possible.

I. Data Analysis

The data was analyzed by computer at the Milne Computer Center, Oregon State University. A statistical consultant from the Computer Center assisted with the analysis. The computer program SPSS (Statistical Package for the Social Sciences) (Nie et al., 1975) was used to analyze all questionnaire items except for the open-ended questions. The BMDP Statistical Software program was used to do the repeated measures analysis (Dixon, 1983).

Multiple response frequency tables were set up for questions 1 through 5 to determine whether coaches and/or parents had problems recognizing specific food sources of various nutrients and to observe changes between pre- and post-test scores. Breakdowns were given for questions 1 through 5 to determine the total score for each question by category (coach, student trainer, parent and teacher).

Breakdowns were also given for questions 6, 6b, 7, 8 and 9 to determine the total score for each question and category. Two-way contingency tables were set up for questions 6, 6b, 7a-g, 8a-u, and 9a-f, to determine how many participants in each category chose a particular response.

Post-questionnaire demographic data was analyzed by setting up multiple response frequency tables. Pre-questionnaire demographic data was obtained for coaches only. Depending on the question, data was generated either by a two-way contingency table (question 3a, for example), frequency table (question 7, for example), or from the repeated measures analyses.

Repeated measures analysis was done to determine change in total knowledge for each category from pre to post. Repeated measures analysis was also made to see whether or not sex of the participant, a previous nutrition course, academic degree, attendance at a nutrition workshop within the past two years, or years of coaching experience had an effect on knowledge from pre to post. In addition, a Pearson product moment correlation was done to determine if a correlation existed between age and total knowledge (Nie et al., 1975).

IV. RESULTS AND DISCUSSION

A. Workshop Participants

A total of 143 people attending the seven workshops completed both pre- and post-questionnaires. Of these, 81 (56.6%) were coaches, 13 (9.1%) were student athletic trainers, 28 (19.6%) were parents of young athletes, and 21 (14.7%) were teachers (Table 3). The potential sample size was larger (160 individuals attended altogether), but certain participants were eliminated from the study because they did not fully complete one or both questionnaires or they did not provide enough demographic data to allow the researcher to categorize them.

Coaches ranged in age from 16 to 59 years, with a mean age of 37.6 years. Sixty-three (77.8%) of the coaches were male and 18 (22.2%) were female. Coaches involved in this study coached a variety of different sports (Table 4). Football, basketball and track and field were the sports coaches most often. Some coaches coached more than one sport. The coaches had been involved in coaching for varying numbers of years.

Results may be found in Table 5 indicating what coaches chose as their one main source of recent nutrition information. Twenty-six (32.1%) chose newspapers, popular magazines, and paperbacks as their one main source. Professional journals were selected by 22 (27.2%). Bedgood

Table 3

Number of Participants Completing Questionnaires by Workshop and Category

Workshops Used for Evaluation	Coach	Student Athletic Trainer	Parent	Teacher	
OSU Athletic Training Workshop	7	13			
Corvallis Coaches	5				
Corvallis School District (combined)	26		2	12	
Eugene School District	19				
Crescent Valley Booster's Club			26		
Salem School District	24			9	
Total	81	13	28	21	143
% of Total	56.6	9.1	19.6	14.7	

Table 4

Number of Persons Coaching Mens and Womens Teams and the Years Coached

Sport	No. Yrs. Coached	Team Coached/Number Coaching	
		Mens Team	Womens Team
Football	0-5	5	
	6-10	8	
	11-15	3	
	16-20	4	
	>21	3	
Basketball	0-5	6	3
	6-10	6	5
	11-15	1	
	16-20	2	
	>21		
Track & Field	0-5	4	7
	6-10	3	2
	11-15	1	1
	16-20	2	2
	>21	2	2
Baseball	0-5	1	
	6-10	4	
	11-15	2	
	16-20	1	
Wrestling	0-5	3	
	6-10	1	
	16-20	3	
Cross-Country	0-5	3	2
	6-10	1	1
	16-20	1	1
Soccer	0-5	1	
	6-10	3	2
Softball	0-5		5
Swimming	0-5	2	1
	6-10	2	2
Volleyball	0-5	1	1
	6-10		2
	16-20		1
Tennis	0-5	1	3
	6-10	1	1
	11-15		1
	16-20		1
Golf	6-10	2	
Badminton	11-15	1	1
Gymnastics	0-5	1	1
Strength/ Conditioning	16-20	1	1

Table 5

Demographic Data and Nutrition Background of Coaches

Highest Earned Degree	Number	Percent
Associate	4	5
Bachelor	22	27
Masters	46	57
Doctoral	2	2
No response	7	9
One Main Source of Recent Nutrition Information		
Newspapers	26	32.1
Radio, T.V.	7	4.9
Professional journals	22	27.2
Colleagues	12	14.8
Other	13	16.0
No response	1	0.7
Completed a College Level Nutrition Course		
Yes	27	33.3
No	50	61.7
No response	4	5.0
Attendance at a Nutrition Education Workshop Within the Last Two Years		
Yes	21	25.9
No	56	69.1
No response	4	5.0

and Tuck (1983) found that 66% of high school coaches surveyed in their study read professional journals and 52% read popular literature. Wolf et al. (1979) reported that 69% of Big Ten coaches surveyed rarely read about nutritional aspects of coaching and 78% felt a need for more knowledge of diet and nutrition.

Fifty-seven percent of the coaches held master's degrees, but only one-third of the coaches had completed a college level nutrition course. Approximately one-fourth of the respondents had attended a nutrition workshop, seminar or conference other than this one in the past two years.

Approximately three-fourths of the coaches indicated that during the coaching season they teach their athletes about nutrition and/or make nutritional recommendations for them to follow. Of these 60, 35% spend 30 minutes or less on the subject of nutrition, 33.3% spend 30 minutes to 1 hour, and 20% spend 1 to 2 hours (Table 6). Nineteen (70%) of the 27 coaches who indicated they had taken a college level nutrition course teach their athletes about nutrition and/or make nutritional recommendations for them to follow during the coaching season.

B. Workshop's Effect on Knowledge

As hypothesized, the workshop had a positive effect on changing knowledge. A comparison between the mean

Table 6

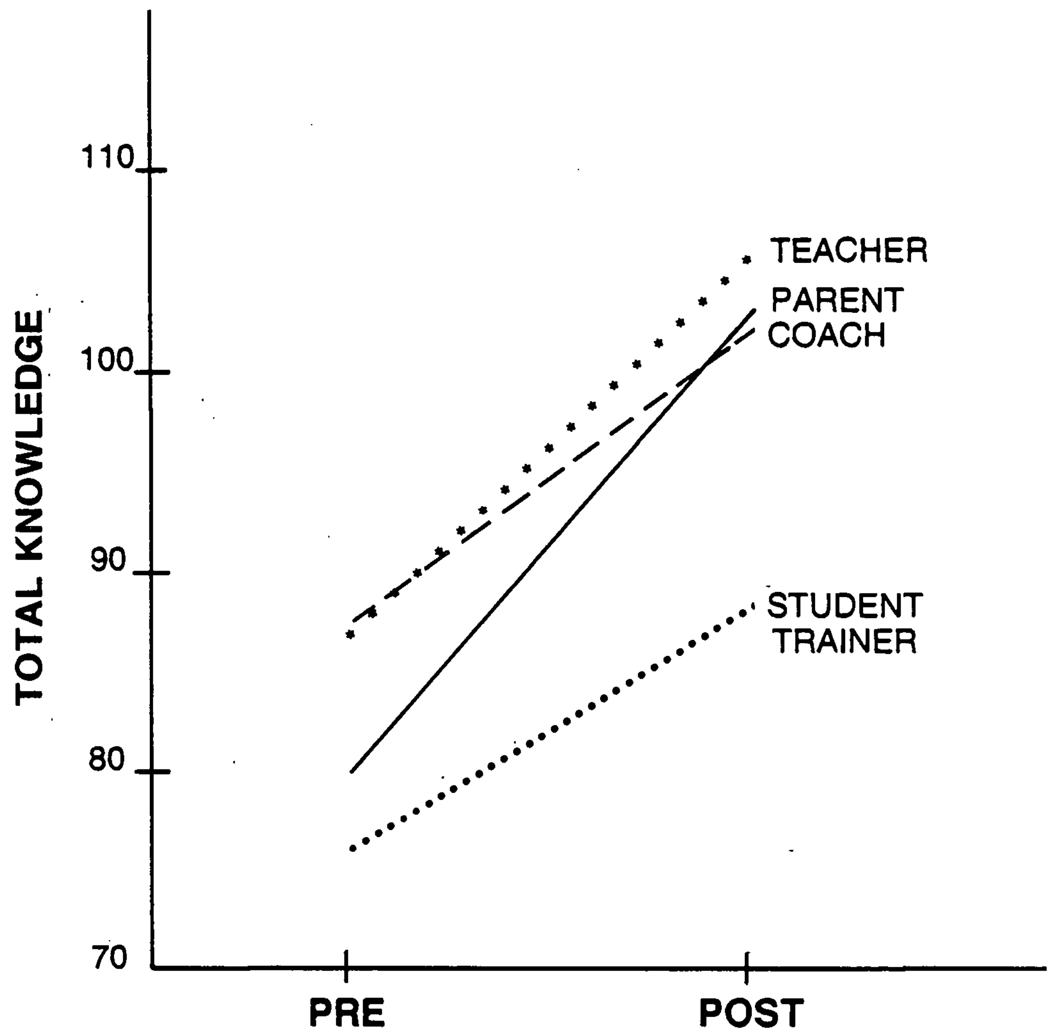
Do Coaches Teach Athletes About Nutrition? How Much Time is Spent on the Subject Throughout a Sport Season?

Question	Number	Percent
During the coaching season do you teach your athletes about nutrition and/or make nutritional recommendations for them to follow?		
No	16	19.8
Yes	60	74.1
No response	5	6.2
How much time is devoted to the subject of nutrition throughout the sport season?		
30 minutes or less	21	35.0
30 minutes to 1 hour	20	33.3
1 to 2 hours	12	20.0
2 to 4 hours	0	0
4 hours plus	4	6.7
No response	3	5.0

scores for each category (coaches, student trainers, parents and teachers) showed differences between pre- and post-questionnaire values (Figure 1). The pre- and post-questionnaire mean knowledge scores and their standard deviations are shown for each category in Table 7.

It is of interest to note that teachers as a category obtained the highest mean post-questionnaire score. One might also note that a score of 105 points is about 75% correct. Parents showed the greatest improvement from pre to post of all four categories. Coaches, while having the

FIGURE 1.
(Change in mean knowledge score from pre to post for each category.)



highest pre-questionnaire score, failed to improve to the same degree as either parents or teachers. Student athletic trainers fared the worst of all categories on both the pre- and post-questionnaire. This is probably due to the fact that some of these student trainers had not yet graduated from high school or were still attending college. One might argue that perhaps not all of the parents had graduated from high school or college and yet their scores were higher than those of the student athletic trainers. While demographic data was not obtained for parents, it was suspected that the parents surveyed here were of a higher socioeconomic status and probably had a better than average educational background.

A repeated measures analysis was made to determine if there was a significant difference in total knowledge between the four categories, if there was a significant difference between pre and post, and if there was a significant difference between pre and post within each category. All three tests proved significant at the $p < .01$ level indicating that the workshop did have a significant effect on increasing knowledge for all participants.

C. Factors Affecting Change in Knowledge

With the exception of the sex of the coach, the significant changes in the overall knowledge of coaches were not dependent on any of the following factors: the number

Table 7

Means and Standard Deviations for Total Knowledge Score by Participant Category

	Category			
	Coach	Student Trainer	Parent	Teacher
Mean score PRE ±S.D.*	87 ±15	76 ±20	80 ±13	87 ±13
Mean Score POST ± S.D.	102 ±11	88 ±16	103 ±9	106 ±10
Difference between scores	15	12	23	19

*S.D. = standard deviation

of years involved in coaching, the academic degree, whether or not the coach had taken a college level nutrition course, or attendance at a nutrition workshop within the last two years (Table 8). There was a significant difference between the two sexes in overall knowledge score with females doing better than males. The reasons for this are not known, but one might hypothesize that female coaches obtained more food and nutrition knowledge by having taken home economics courses in school and possibly through having had more experience in shopping for food and in food preparation.

A Pearson product moment correlation test was done to determine if there was a correlation between age and change in overall knowledge. The R value obtained was not significant at $p < .05$. Therefore, there was no correlation between age and change in overall knowledge.

Table 8

Factors Affecting Change in Overall Knowledge Score of Coaches (pre to post)

Factor	Changes in Overall Knowledge Score (pre to post)
Number of years coaching	N.S.*
Academic degree	N.S.
Completed college level nutrition course	N.S.
Previous nutrition workshop attendance	N.S.
Sex of coach	p = .0108

*N.S. = not significant

D. Item Analysis

Frequency distributions were run for each question in both the pre- and post-questionnaires. This was done: 1. to point out responses in the pre-questionnaire data that were consistently incorrect; 2. to observe if the workshop helped change these incorrect responses to correct ones by comparing pre-questionnaire and post-questionnaire data; and 3. to point out responses in the post-questionnaire data that were consistenly incorrect, and to discuss why this may have occurred.

The data examined first included questions 1 through 5. These questions asked respondents to identify which foods they believed were good sources of iron, were complex carbohydrate foods, were high in salt or were sources of low-fat protein. In addition, one question asked respondents to identify beverages they would recommend for athletes during either practice or competition. Results are included for both coaches and parents. It was hypothesized that parents may do better on this portion of the data. The reason for this, while not intending to be sexist, is that 23 (82%) of the parents were female (mothers of the young athletes). It was assumed, and this point is certainly arguable, that the women may be more familiar with the nutrient composition of foods through experience with shopping and meal preparation. Also, being a parent, some may have different interests in their child's health and well-being. Parents had greater pre and post scores than coaches for all five questions except for the pre-questionnaire score on question 3 (Table 11). This latter question referred to those foods believed to be complex carbohydrate foods.

Question 1 asked respondents to check foods they believed were a good source of iron. Liver was the food both coaches and parents were most certain of being a good source of iron (Table 9). Two food sources of iron men-

Table 9

Percent of Coaches and Parents Choosing Foods Believed to be a Good Source of Iron

Food	Coaches Pre	Coaches Post	Parents Pre	Parents Post
*Liver	95.0	91.2	96.3	100.0
Oranges	2.5	10.0	3.7	10.7
*Raisins	51.3	57.5	**81.5	32.1
French Fries			3.7	
Cottage Cheese	11.2	17.5	3.7	10.7
*Dried apricots	**20.0	48.7	**37.0	89.3
*Prune juice	27.5	28.8	**33.3	64.3
Milk	21.2	16.2	**25.9	7.1
*Molasses	18.8	18.8	**25.9	7.1
*Oysters	**31.3	18.8	**25.9	7.1
*Baked Beans	**16.2	66.2	**14.8	85.7
Bananas	17.5	10.0	14.8	7.1
Total possible = 7				
Mean ± SD	2.6±1.2	3.3±1.5	3.1±1.3	4.7±1.0

*a correct response

**indicates a change of at least 10% from pre to post

tioned in NFL (dried fruits and baked beans) seemed to have an effect on post-questionnaire scores for at least the baked beans and dried apricots items. The percentage of parents selecting raisins in the pre-questionnaire decreased from 81.5% to 32.1% in the post-questionnaire. This change may be due in part to the fact that while raisins are indeed a dried fruit, some people may not consider them in that way. For example, dried apricots are labelled as such, but one does not call a raisin a dried grape or typically think of it as a dried grape.

Question 2 asked which beverages respondents would recommend for athletes during either practice or competition. It is noteworthy that 53.1% of the coaches and 67.9% of the parents checked Gatorade on their pre-questionnaire (Table 10). The scientific literature reveals that commercial sport drinks are too concentrated to drink as is and can inhibit gastric emptying (Coyle et al., 1978). Such drinks should be diluted if used. Following the workshop, 20% of the coaches and 11.1% of the parents still recommended Gatorade. One-hundred percent of coaches and parents recommended water on their post-questionnaire. Bentivegna et al. (1979) found that during practice sessions and athletic contests 70% of coaches surveyed provided ad lib hydration, 19% provided one water break, and 7% provided water only in hot weather.

Table 10

Percent of Coaches and Parents Selecting Beverages They Would Recommend to Athletes During Either Practice or Competition

	Coaches		Parents	
Beverage	Pre	Post	Pre	Post
Soda Pop	4.9		3.6	
*Orange juice, diluted	**38.3	53.7	**35.7	74.1
Coffee				
*Water	97.5	100.0	**82.1	100.0
Gatorade	**53.1	20.0	**67.9	11.1
Beer				
*Mineral water	18.5	15.0	10.7	7.4
Tang	**21.0	10.0	**17.9	
Tea	3.7	1.2		
Milk, whole	2.5	10.0	3.6	
Total possible = 3				
Mean ± SD	1.5±.7	1.7±.7	1.3±.8	1.8±.6

*a correct response

**indicates a change of at least 10% from pre to post

Question 3 asked which foods respondents considered to be complex carbohydrate foods (Table 11). Both coaches and parents seemed familiar with certain of these food items including pancakes, potatoes, whole wheat bread and spaghetti. They were less certain of food items such as apples, lima beans, and raisin bran cereal. Approximately one-fourth of both coaches and parents initially thought peanut butter was a complex carbohydrate food. Bedgood and Tuck (1983) found that over 70% of coaches surveyed were knowledgeable about the inclusion of bread and potatoes in the training diet.

Question 4 asked respondents to check foods they believed were high in salt (Table 12). Both coaches and parents did well on this question despite certain items being inadequately presented. Two questionnaire items in particular could have been written in a more specific way. Dry cereals contain variable amounts of sodium and certain types of peanut butter are lower in sodium. Neither of these points were made clear on the questionnaire. Also, serving sizes should have been indicated for each item. The degree to which certain condiments are used often increases the sodium content of the diet excessively.

Question 5 asked which foods were sources of low-fat protein (Table 13). Both coaches and parents easily recognized the more familiar protein sources such as baked chicken, low-fat cottage cheese, tuna in water pack, non-

Table 11

Percent of Coaches and Parents Selecting Foods Believed to be Complex Carbohydrate Foods

Food	Coaches Pre	Coaches Post	Parents Pre	Parents Post
*Apples	**16.0	32.5	** 7.7	39.3
Fish	2.5	6.3		3.6
*Lima beans	**37.0	47.5	**38.5	78.6
*Pancakes	64.2	66.2	61.5	53.6
*Potatoes	69.1	72.5	**73.1	89.3
Sausage	2.5	3.7		
*Bread, whole wheat	**77.8	91.2	**73.1	89.3
Honey	11.1	8.8	** 3.8	17.9
Low-fat yogurt	7.4	8.8	7.7	10.7
Peanut butter	**25.9	13.7	**23.1	10.7
*Raisin bran	21.0	28.8	**34.6	57.1
*Spaghetti	79.0	81.3	76.9	82.1
Total possible = 7				
Mean ± SD	3.6±1.5	4.1±1.6	3.4±1.6	4.9±1.4

*a correct response

**indicates a change of at least 10% from pre to post

Table 12

Percent of Coaches and Parents Choosing Foods Believed to be High in Salt

	Coaches		Parents	
Food	Pre	Post	Pre	Post
*Canned vegetables	69.1	71.2	78.6	78.6
*Cheese	**43.2	66.2	**39.3	64.3
Fresh fruit				
*Ham	**91.4	81.3	89.3	92.9
Lemonade	2.5	3.7	3.6	3.6
Milk	1.2	2.5		
*Olives	**49.4	80.0	**60.7	78.6
*Pickles	**74.1	86.2	75.0	82.1
*Catsup	70.4	71.2	64.3	71.4
*Dry cereal	16.0	11.2	14.3	7.1
Fresh vegetables				
Jelly	3.7	1.2	3.6	
*Luncheon meat	77.8	85.0	**85.7	96.4
*Mustard	23.5	23.8	25.0	21.4
Peanut butter	25.9	35.0	17.9	17.9
*Soups (canned)	77.8	73.7	85.7	85.7
Total possible = 10				
Mean ± SD	5.9±2.2	6.4±2.2	6.2±2.2	6.8±1.6

*a correct response

**indicates a change of at least 10% from pre to post

Table 13

Percent of Coaches and Parents Selecting Foods
Believed to be Sources of Low-fat Protein

	Coaches		Parents	
Food	Pre	Post	Pre	Post
Potato chips	4.9	2.5		
*Baked chicken	60.5	69.6	**67.9	85.7
*Low-fat cottage cheese	63.0	64.6	71.4	75.0
*Kidney beans	43.2	49.4	**35.7	64.3
Ham	2.5	1.3		3.6
*Tuna, water pack	71.6	70.9	78.6	82.1
*Macaroni	13.6	16.5	10.7	14.3
*Non-fat milk	76.5	77.2	82.1	82.1
Bacon	2.5	1.3		
Sausage	2.5	2.5		
*Baked halibut	77.8	68.4	89.3	85.7
Steak	7.4	5.1		7.1
*Green peas	21.0	25.3	*10.7	21.4
Swiss cheese	18.5	17.7	25.0	14.3
Total possible = 8				
Mean ± SD	4.3±1.4	4.3±1.8	4.5±1.5	5.1±1.4

*a correct response

**indicates a change of at least 10% from pre to post

fat milk and baked halibut. They had some difficulty recognizing kidney beans, macaroni and green peas as potential food sources of low-fat protein. Admittedly, these foods provide less protein than the other items. However, in counseling a vegetarian athlete it is important to be aware of a variety of protein sources.

For question 6, coaches were presented with three sample pre-competition meals and then asked to select the one they would recommend. Coaches did well on this question with 82.5% choosing the correct meal on the pre-questionnaire and 93.8% on the post-questionnaire (Table 14). Only 13.7% initially thought the classic steak and eggs breakfast was the best choice. In a study by Wolf et al. (1979), 13% of the coaches still regarded steak and other high protein food as an essential component of pre-competition meals.

When coaches were asked why they chose a particular meal, responses for meal C were almost always appropriate.

Table 14

Percent of Coaches Selecting Sample
Pre-competition Meals

Meal	Pre	Post
A - "high fat"	3.7	3.7
B - "steak and eggs"	13.7	2.5
C - "lower fat/protein"	82.5	93.8

Some representative comments included, "lower in fats and protein", "easily digested", "higher carbohydrate content." Coaches in this study were knowledgeable about the timing of a pre-game meal as well (Table 15). Seventy-nine percent of the respondents on the pre-questionnaire felt the meal should be completed either 2 or 2 1/2-3 hours prior to competition. On the post-questionnaire 87.7% chose 2 1/2-3 hours. These results correlate well with those of Bedgood and Tuck (1983) who found that 89% of coaches surveyed were knowledgeable about the timing of the pre-event meal. In a study by Bentivegna et al. (1979) coaches were asked about the timing of the pre-event meal. Forty-nine percent said they recommended three hours before game time and 37% said they recommended four hours.

Question 7 was a group of 7 individual items concerning vitamins, minerals and athletic performance. Overall, scores increased from pre to post for coaches. Coaches were knowledgeable enough to answer most questions in this section correctly (Table 16). However, there was some confusion regarding the statement, "magnesium supplements are recommended for athletes to help avoid muscle cramping." About half of the respondents did not know the answer to the question initially. The correct response was never presented in the slide show or discussion during the program which may explain why in the post-question-

Table 15

Percent of Coaches Indicating How Soon Before Competition They Believe That Athletes Should Finish the Meal

Time	Pre	Post
1/2 hour	0	0
1 hour	7.4	0
2 hours	24.7	7.4
2 1/2-3 hours	54.3	87.7
6 hours	4.9	3.7
other	8.6	1.2

naire data, only 54.3% answered correctly. About one-fourth of the coaches still believed that "vitamins contribute significantly to body structure" following the workshop. Another statement which initially caused some confusion was "vitamin E supplementation has not proven helpful in increasing physical performance." In the pre-questionnaire data 43.8% agreed with this statement and 41.3% did not know the answer. Post-questionnaire data revealed that 67.9% agreed and only 13.6% did not know.

In a study by Wolf et al. (1979) it was noted that 35% of Big Ten coaches surveyed prescribed vitamin supplements to all or some of their players. About half of these coaches actually dispense the supplements. Fourteen

Table 16

Coach Response to Question 7

7a. Vitamins supply energy for the body.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree	17	21.2	12	14.8
Disagree	57	72.2	68	85.2
Don't Know	5	6.3	0	0

7b. Vitamin megadoses may be harmful.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree	72	88.9	69	85.2
Disagree	4	4.9	9	11.1
Don't Know	5	6.2	3	3.7

7c. Magnesium supplements are recommended for athletes to help avoid muscle cramping.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree	17	21.0	15	18.5
Disagree	24	29.6	24	29.6
Don't Know	40	49.4	22	27.2

7d. Female athletes should pay special attention to consuming foods high in iron.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree	62	77.5	77	95.1
Disagree	7	8.8	2	2.5
Don't Know	11	13.7	2	2.5

Table 16 (Cont.)

7e. Vitamins contribute significantly to body structure (increases in muscle size, for example.)

	Pre		Post	
	Number	Percent	Number	Percent
Agree	18	22.2	20	24.7
Disagree	51	63.0	59	72.8
Don't Know	12	14.8	2	2.5

7f. Vitamin E supplementation has not proven helpful in increasing physical performance.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	35	43.8	55	67.9
Disagree	12	15.0	15	18.5
Don't Know	33	41.3	11	13.6

7g. Most athletes need extra vitamins and minerals beyond what they receive in a balanced daily diet.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	18	22.2	10	12.5
Disagree	58	71.6	70	87.5
Don't Know	5	6.2	0	0

percent of the coaches recommended mineral supplements and 8% actually dispensed them. Forty-six percent of the coaches in one study recommended vitamin supplementation depending on the situation (Bentivegna et al., 1979). Some reasons given by these persons included use of vitamin C to prevent colds, vitamin C for energy, B vitamins for energy and vitamin E for muscle building. None of these reasons have sound scientific basis.

Question 8 was a series of 21 statements concerning nutrition and athletics (Table 17). For purposes of discussing the results here, these statements will be further grouped into smaller sections. These sections include carbohydrates (8a, e, g, r, s), general nutrition information (8b, c, f, k, p, q), water and electrolytes (8d, m, u), protein (8h, j, n), special dietary considerations (8i, o, t), and fats (8l).

Nearly 40% of the coaches initially thought that eating a candy bar right before exercise will provide quick energy. It is believed that the attention given to this concept in NFL was what brought about the post-questionnaire result of 88.9% of coaches disagreeing with the statement. Fifty-four percent of coaches surveyed in the Bentivegna et al. (1979) study said they recommended the use of Gatorade for quick energy during practice sessions and regular athletic contests.

Coaches appeared knowledgeable about which athletes may benefit from carbohydrate loading which conflicts with results of Bedgood and Tuck (1983) and Wolf et al. (1979). However, only one question was asked in this area. Coaches were knowledgeable about the importance of including carbohydrates in the training diet, but they were not very certain of the statements "fructose is a better source of carbohydrate energy than glucose because it is metabolized

Table 17

Coach Response to Question 8

8a. Eating a candy bar right before exercise will give you quick energy.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	0	0	0	0
Agree	32	39.5	9	11.1
Disagree	18	22.2	31	38.3
Disagree Strongly	28	34.6	41	50.6
Don't Know	3	3.7	0	0

8b. Athletes need more calories than non-athletes.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	27	33.7	22	27.2
Agree	45	56.3	50	61.7
Disagree	6	7.5	7	8.6
Disagree Strongly	1	1.2	2	2.5
Don't Know	1	1.2	0	0

8c. Exercise is not useful in weight reduction because it uses so few calories.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	0	0	1	1.2
Agree	2	2.5	3	3.7
Disagree	28	34.6	33	40.7
Disagree Strongly	51	63.0	44	54.3
Don't Know	0	0	0	0

Table 17 (Cont.)

8d. Water is the best fluid replacement for athletes before, during and after practice or competition.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	40	49.4	69	85.2
Agree	39	48.1	12	14.8
Disagree	2	2.5	0	0
Disagree Strongly	0	0	0	0
Don't Know	0	0	0	0

8e. Carbohydrate loading may be of benefit to a select group of athletes.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	18	22.2	23	28.4
Agree	50	61.7	50	61.7
Disagree	6	7.4	7	8.6
Disagree Strongly	2	2.5	1	1.2
Don't Know	5	6.2	0	0

8f. All athletes should eat the same amount of food.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	1	1.2	0	0
Agree	0	0	1	1.2
Disagree	45	55.6	53	65.4
Disagree Strongly	32	39.5	25	30.9
Don't Know	3	3.7	2	2.5

8g. Complex carbohydrates are the preferred fuel for the active individual.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	22	27.5	34	42.5
Agree	32	40.0	39	48.7
Disagree	9	11.2	4	5.0
Disagree Strongly	2	2.5	1	1.2
Don't Know	15	18.8	2	2.5

Table 17 (Cont.)

8h. Athletes and others who exercise regularly need extra protein.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	5	6.2	4	4.9
Agree	38	46.9	14	17.3
Disagree	30	37.0	53	65.4
Disagree Strongly	3	3.7	9	11.1
Don't Know	5	6.2	1	.7

8i. Alcohol has been shown to be ineffective as a means of increasing performance capacity.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	38	47.5	41	50.5
Agree	26	32.5	26	32.1
Disagree	5	6.3	6	7.4
Disagree Strongly	5	6.3	8	9.9
Don't Know	6	7.5	0	0

8j. Protein supplements are especially useful for weight lifters.

	Pre Number	Pre Percent	Post Number	Post Percent
Agree Strongly	8	10.0	3	3.7
Agree	33	41.3	13	16.0
Disagree	13	16.2	45	19.8
Disagree Strongly	5	6.3	16	19.8
Don't Know	21	26.2	4	4.9

Table 17 (Cont.)

8k. A healthy diet should have 30% of its total calories coming from fat, 55-60% from carbohydrates and 12% from protein.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	8	10.0	15	18.5
Agree	21	26.2	45	55.6
Disagree	15	18.8	14	17.3
Disagree Strongly	8	10.0	1	1.2
Don't Know	28	35.0	6	7.4

8l. Fats are an important energy source during mild to moderate levels of exercise.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	4	5.0	8	9.9
Agree	24	30.0	53	65.4
Disagree	25	31.3	14	17.3
Disagree Strongly	15	18.8	3	3.7
Don't Know	12	15.0	3	3.7

8m. Salt tablets are not necessary even during strenuous exercise and excessive sweating.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	27	33.7	42	51.9
Agree	43	53.7	30	37.0
Disagree	6	7.5	4	4.9
Disagree Strongly	2	2.5	5	6.2
Don't Know	2	2.5	0	0

8n. Most vegetarian athletes can't get enough protein.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	3	3.7	2	2.5
Agree	12	14.8	13	16.0
Disagree	34	42.0	44	54.3
Disagree Strongly	22	27.2	18	22.2
Don't Know	10	12.3	4	4.9

Table 17 (Cont.)

8o. Bee pollen helps runners' performance.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	4	4.9	4	4.9
Agree	7	8.6	4	4.9
Disagree	15	18.5	33	40.7
Disagree Strongly	9	11.1	18	22.2
Don't Know	46	56.8	22	27.2

8p. A balanced diet consisting of a variety of foods from the Basic Four Food groups is the key for good health and optimal athletic performance.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	39	48.1	40	50.0
Agree	39	48.1	38	47.5
Disagree	0	0	2	2.5
Disagree Strongly	1	1.2	0	0
Don't Know	2	2.5	0	0

8q. The amount of calories an athlete needs depends on how active he/she is.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	31	38.3	58	71.6
Agree	45	55.6	22	27.2
Disagree	5	6.2	0	0
Disagree Strongly	0	0	1	1.2
Don't Know	0	0	0	0

Table 17 (Cont.)

8r. Fructose is a better source of carbohydrate energy than glucose because it is metabolized more efficiently.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	7	8.8	11	13.6
Agree	19	23.8	25	30.9
Disagree	14	17.5	20	24.7
Disagree Strongly	4	5.0	6	7.4
Don't Know	36	45.0	19	23.5

8s. Honey is not nutritionally superior to sugar.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	10	12.3	13	16.0
Agree	31	38.3	41	50.6
Disagree	23	28.4	17	21.0
Disagree Strongly	3	3.7	3	3.7
Don't Know	14	17.3	7	8.6

8t. Fast foods (McDonalds, etc.) are not nutritious and should be avoided by athletes.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	9	11.1	12	14.8
Agree	18	22.2	25	30.9
Disagree	44	54.3	38	46.9
Disagree Strongly	7	8.5	2	2.5
Don't Know	3	3.7	4	4.9

8u. Gatorade and other commercial thirst quenchers are not good beverages for athletes because they contain excess sugar and salt.

	Pre		Post	
	Number	Percent	Number	Percent
Agree Strongly	9	11.2	17	21.0
Agree	25	31.3	41	50.6
Disagree	36	45.0	21	25.9
Disagree Strongly	2	2.5	1	1.2
Don't Know	8	10.0	1	1.2

more efficiently" and "honey is not nutritionally superior to sugar." Neither of these items were clarified in the presentation which may explain the uncertainty.

As Bedgood and Tuck (1983) found, coaches are knowledgeable about general nutrition information. They responded appropriately to questions about the caloric needs of athletes, the value of exercise in weight reduction and the composition of a healthy diet. Thirty-five percent of coaches were initially unsure about the percentage of total calories which should be derived from carbohydrate, protein and fat. Bentivegna et al. (1979) found that only 22% of coaches surveyed could identify correct percentages in a similar statement. For future workshops it may be of value to provide an activity where it is possible to calculate this information for a meal or a 24 hour recall.

Some statements addressed various issues of water and electrolytes in exercise. The data for item 8d correlated well with that of question 2. Coaches are well aware of the importance of water as a fluid replacement. Coaches also did surprisingly well with the statement "salt tablets are not necessary even during strenuous exercise and excessive sweating." Nearly 90% responded correctly both pre and post. This conflicts with results of Bedgood and Tuck (1983) who found that 68% of coaches believed that supplementation with salt tablets is necessary to combat excessive sweating. Statement 8u was phrased "Gatorade and other commercial thirst quenchers are not good beverages for athletes because they contain excess sugar and salt." The results here supported responses obtained in question 2. While 45% of the coaches disagreed initially, 71.6% agreed following the presentation.

Over 50% of coaches initially believed that athletes and others who exercise regularly need extra protein. While the scientific literature does reflect the fact that protein is utilized during exercise, the quantities required are not such that protein supplementation of the diet is necessary. This concept seemed to be clear to the coaches following the presentation as evidenced by 76.5% disagreement with the statement 8h. To further illustrate the confusion surrounding the protein requirements of athletes, one can look at the response to "protein supplements are especially useful for weight lifters." Prior to the presentation, 51.3% of the coaches agreed with this statement and 26.2% did not know. Following the presentation, 75.4% disagreed. Most coaches were fairly certain that vegetarian athletes could receive enough protein in their diet. Of Big Ten coaches surveyed, 15% recommended that their team members take protein supplements (Wolf et al., 1979). Fifty-one percent of coaches surveyed believed that protein is the most important factor needed in increasing muscle mass (Bentivegna et al., 1979).

With respect to special dietary considerations, most coaches were aware that alcohol is ineffective as a means of increasing performance capacity. They were not sure if bee pollen will help the performance of a runner or not. On the pre-test, 56.8% of coaches circled don't know. Following the workshop 62.9% disagreed with the use of bee pollen as an ergogenic aid. It becomes increasingly apparent that any successful nutrition education program for coaches will need to present very effective arguments against the use of popular but ineffective ergogenic aids.

There was no concensus as to whether fast foods were acceptable for occasional consumption by athletes or not. Fast foods should be limited in the diet of athletes, and non-athletes, but depending on one's food choices, fast foods can be nutritious. This message was not made very clear in the presentation.

Finally, prior to seeing NFL, coaches did not have a good idea of the role of fats as a fuel for exercise. With the emphasis of carbohydrates, glycogen loading and blood glucose concentrations in the popular and scientific literature it is little wonder that most people don't understand where and when fat is burned as a fuel for exercise. Perhaps this is a mixed blessing in that information could be misconstrued so that athletes felt they needed to increase their consumption of dietary fat for performance in some events.

Question 9 was composed of 6 statements about pre-competition nutritional practices (Table 18). Respondents were asked whether they agreed or disagreed with each statement or did not know. About 56% of the coaches initially agreed with statement 9a ("milk consumed before an athletic event causes cotton mouth, cuts speed and wind, and causes stomach upset.") Following the workshop, only 7.4% agreed and 92.6% disagreed. This change was thought due to the fact that one slide in NFL directly addressed this statement.

Statement 9b - ("steak and eggs for breakfast makes a good pre-game meal") may be related to question 6. In 9b, 61.7% initially disagreed with the statement. Following the workshop, 93.8% disagreed. Looking at the data again for question 6, 13.7% of the coaches chose a typical steak and eggs breakfast on the pre-questionnaire and only 2.5% chose it on the post-questionnaire.

There was some confusion associated with statement 9c ("whole milk is not recommended before competition.") On the pre-questionnaire 66.7% of the coaches agreed with the statement. However, on the post-questionnaire, 63% of the coaches disagreed with the statement. This was thought attributable to the slide previously mentioned in association with statement 9a. This slide promoted milk as an

Table 18

Coach Response to Question 9

9a. Milk consumed before an athletic event causes cotton mouth, cuts speed and wind, and causes stomach upset.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	45	55.6	6	7.4
Disagree	24	29.6	75	92.6
Don't Know	12	14.8	0	0

9b. Steak and eggs for breakfast makes a good pre game meal.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	22	27.2	4	4.9
Disagree	50	61.7	76	93.8
Don't Know	9	11.1	1	1.2

9c. Whole milk is not recommended before competition.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	54	66.7	29	35.8
Disagree	8	9.9	51	63.0
Don't Know	19	23.5	1	1.2

9d. Caffeine-containing beverages are beneficial as pre-competition fluids.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	14	17.3	11	13.6
Disagree	57	70.4	61	75.3
Don't Know	10	12.3	9	11.1

9e. A pre-game or pre-event meal should be small (500-900 calories) and should be eaten two to three hours before competition.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	62	76.5	78	96.3
Disagree	15	18.5	1	1.2
Don't Know	4	4.9	2	2.5

Table 18 (Cont.)

9f. Liquid pre-game meals are preferable to solid meals.

	Pre		Post	
	Number	Percent	Number	Percent
Agree	12	14.8	20	24.7
Disagree	48	59.3	52	64.2
Don't Know	21	25.9	9	11.1

important food in the training diet which does not negatively affect performance. The concept that whole milk is high in fat, and may in turn delay gastric emptying if included in a pre-competition meal was not addressed.

Statement 9d ("caffeine containing beverages are beneficial as pre-competition fluids") was appropriately responded to by most coaches. While there is some evidence that caffeine taken prior to endurance exercise enhances performance (Essig et al., 1980; Costill et al., 1978), this has been recently disputed (Casal and Leon, 1985). It is unwise to encourage young athletes to consume caffeine for this purpose. Many are not familiar with the effects of caffeine and may find that it is overstimulating to a nervous system already excited by the prospect of the impending competition.

Coaches did well in responding to statement 9e regarding the timing and size of pre-competition meals. There was some confusion however, with statement 9d ("liquid pre-game meals are preferable to solid meals.")

Initially, 26% did not know the answer to this statement and about 60% disagreed with it. During the discussion associated with the workshop advantages and disadvantages of liquid meals were brought out. On the post-questionnaire, about one-fourth of the respondents agreed with the statement as compared with about 15% on the pre-questionnaire. There was obviously some misunderstanding due to the presentation. Despite this, about 65% correctly disagreed with the statement on the post-questionnaire. It is important to note here that this statement could have been worded better. In some instances a liquid pre-competition meal could be desirable over a solid meal (these products leave the stomach quickly, enabling small amounts to be taken closer to the time of competition).

E. Coach Reaction to the Workshop

The coaches reaction to the workshop was almost entirely positive (Table 19). Ninety-five percent of the coaches found the workshop either very useful or somewhat useful. Only three persons (3.7%) found the workshop not too useful, and no one responded that it was not at all useful. When asked to indicate in what ways the workshop was useful to them, some representative comments included, "(the workshop provided) new information and facts plus review and refresher," "the handout materials will be

Table 19

Coach Reaction to the Workshop

	Number	Percent
How Useful Was the Workshop?		
very useful	34	42.0
somewhat useful	43	53.1
not too useful	3	3.7
not at all useful	0	0
no response	1	1.2
Was This Workshop Held at a Convenient Hour?		
yes	76	95.0
no	2	2.5
no response	2	2.5
Was the Workshop the Right Length?		
not long enough	16	19.8
too long	0	0
just right	62	76.5
no response	3	3.7
If Not Long Enough, Which Type Would You Attend?		
half day in-service day	18	22.2
half day Saturday	2	2.5
1 hour/week/4 weeks	0	0
one day during the summer	1	1.2
other	1	1.2
no response	59	72.8
Would You Recommend This Workshop to Your Colleagues?		
yes	78	97.5
no	0	0
no response	2	2.5

beneficial," "(I have) a better understanding of commercial drinks and pre-game meals," "rejuvenated my feelings on continuing to stress nutrition with my team," and "I feel more comfortable about discussing diet with my athletes." Some comments on how the workshop was not useful included, "too simple," "too general," "more on weight loss," "would like to see a panel of 2-3 individuals."

The time the workshop was held was convenient for 95% of the respondents. Approximately three-fourths of the coaches thought the workshop was the right length and about 20% thought it was not long enough. Eighteen coaches (22.2%) were interested in a half day in-service day.

Coaches were asked to describe in what ways, if any, they might use the information from the workshop in their work. Some typical comments included, "advising my team about their nutritional habits," to instruct my assistant coaches and players," give information to the parents of athletes in my wrestling program."

At each workshop given, several individuals requested information on ordering Nutrition in the Fast Lane for classroom use. This provided indirect evidence that the audiovisual used for the presentation was well-received. When coaches were asked if they would recommend this workshop to their colleagues, 97.5% said yes.

F. Effective In-service Education

Four of the seven workshops given in this study were within the framework of school district in-service education. It becomes important then to examine the various factors which have been linked with an effective in-service program. Several authors have attempted to define these factors (Wade, 1985; Lytle, 1983; Hull, 1982; Patton and Anglin, 1982; Farnsworth, 1981; Hutson, 1981; Meeth, 1978; Wilen and Kindsvatter, 1978; Zigarmi et al., 1977; Brimm and Tollett, 1974; Ernst, 1974; Callahan, 1973).

Based on the work of these authors, certain recurrent themes have evolved regarding what makes a workshop or in-service training that includes both elementary and secondary teachers is often more effective than in-service for either group separately, 2. a good workshop must be offered at a time and for the length of time convenient for the participants, 3. all efforts and goals of the workshop should have an application to everyday tasks and activities, 4. the workshop should provide the participants with a range of resources, 5. useful in-service education programs are planned in response to assessed needs of teachers and build on the interests and strengths of the teaches for whom they are designated, 6. teachers need to be directly involved in planning the goals, content, and instructional approach of in-service education programs, 7. in-service education programs should be held during the regular school day when possible and when not, teachers should be financially compensated for their participation, and 8. in-service education program evaluation must be assessed immediately upon completion based on objectives and again later to determine the extent to which objectives have been translated into teacher behaviors in the classroom.

The workshop planned and used in this study could have been further strengthened by implementing some of these guidelines. For example, none of the coaches were able to participate in planning the information that was included in the workshop. If they were involved perhaps the coach response to the workshop would have been predominantly "very useful" instead of "somewhat useful." It was probably not enough to assess the nutrition information needs of coaches based on previous surveys of coaches. Further support for the direct involvement of coaches in planning the workshop comes from the response of some coaches that the workshop was "too general" or "too simple." However, the scores from the knowledge test reveal that the information was probably not "too simple" for most coaches.

Another way to improve the effectiveness of this in-service program would have been to involve the coaches more in the actual presentation. They were not given the opportunity to take an active role. Perhaps if they had been able to do an activity such as planning a pre-game meal, or evaluating a sample training diet for nutritional adequacy, they would have found the workshop of greater practical use.

Finally, a follow-up evaluation of this workshop at a later date was not made. It is unknown if any of the information presented was ever translated into actual teaching and coaching. The amount of knowledge retained at a later date is also unknown. Other researchers did do a follow-up evaluation of a three hour nutrition education workshop (Stark and Johnson, 1981). They mailed the same questionnaire used for the workshop pre- and post-test evaluation to participants one month following the workshop. There was a significant loss in knowledge ($p<.01$) from the time of taking the post-questionnaire to completing the delayed questionnaire. However, the mean score one month later was significantly higher ($p < .01$) than the pre-questionnaire score.

Another example of an effective in-service nutrition education program was reported by Grogan (1978). Thirty-five teachers participated in an in-service program where courses were held two nights a week for three hours each night over a three month period. The teachers were pre- and post-tested with 50 multiple choice and true and false questions. The difference between the means of the pre- and post-tests were significant at .01 level. In addition, 300 students of the teachers who had attended the in-service were pre- and post-tested using the same instrument that assessed the teachers. This was done to ascertain the effectiveness of the curriculum which had been implemented following the in-service. Significant gain at the .05 level was shown for the post-test mean score using the t-test.

V. SUMMARY AND CONCLUSIONS

A one-hour nutrition education workshop was conducted for high school coaches in Corvallis, Eugene and Salem, Oregon. The purpose of this study was to evaluate the effectiveness of the workshop in terms of a change in knowledge as a result of being a participant in the workshop presentation. The workshop included the slide/tape show Nutrition in the Fast Lane (NFL) and a brief discussion following the slide show. Topics covered in NFL included the role of the six essential nutrients (carbohydrate, fat, protein, vitamins, minerals and water) in physical performance; clarification of common myths and misconceptions associated with nutrition and exercise; and a practical guideline for choosing a healthy diet (the Fitness Food Plan). Participants were also given a sports nutrition guide which was designed to summarize the information in NFL, as well as to provide additional practical nutrition information. In addition, the guide included an annotated bibliography of sports nutrition references. This guide was written by the author.

Possible factors affecting change in knowledge such as years coaching, academic degree, nutrition background, age and sex were examined. Coach reaction to the usefulness of the workshop was also evaluated. A total of 81 coaches participated in the study.

It was found that a one-hour nutrition education workshop can make statistically significant changes in knowledge. The mean scores for knowledge measured in this study were significantly higher following the nutrition education program. Unfortunately, follow-up evaluation for this workshop was not made so it is unknown how much knowledge was retained at a later date or if the information gained from the workshop was ever put into coaching practice.

Women coaches did significantly better than male coaches in terms of an increase in knowledge from the workshop. Other than this factor, years of coaching, academic degree, completion of a college level nutrition course, attendance at a nutrition education workshop within the past two years and age had no effect on change in knowledge.

Coach reaction to the workshop was very positive. Ninety-five percent of the coaches found the workshop either very useful or somewhat useful and 97.5% would recommend it to their colleagues. The workshop was also held at a convenient hour for 95% of the coaches. Judging from this reaction, it would appear that the school district in-service format used for this workshop was a practical one.

The positive changes that occurred in knowledge show that this type of workshop can be an effective means of nutrition education. However, one cannot conclude that all types of coaches may benefit from this workshop. While the workshop was conducted during scheduled school district in-service meeting time, coaches still attended voluntarily. One might assume that these coaches were those most interested in improving their nutrition knowledge. Therefore, the increase in knowledge of this group of coaches, who may have been more motivated to learn, could have been higher than if a true random sample of coaches had attended the workshop.

There are other considerations which may have allowed for an even more effective workshop. The nutrition education needs of the coaches involved in the study should have been assessed prior to the workshop. A larger sample size obtained by doing more workshops in other locations would have provided more data with which to confirm results. Assessment of the attitudes of coaches toward sports nutrition information would have been valuable for determining if negative or positive attitudes would affect the knowledge score negatively or positively. This information also would indicate if attitudes toward the topic changed as a result of the presentation. Finally, coaches should have been able to participate more actively in the program. An example would be providing an activity such as evaluating a sample meal for nutritional adequacy or evaluating popular advertisements for food supplements.

This study implies that coaches need and respond to nutrition education. If left to their own devices, coaches will not always recognize valid nutrition information. While completion of a college level nutrition course did not have a positive effect on nutrition knowledge in this study, it is still recommended that those physical education majors and those teachers or individuals desiring coaching endorsement take a basic nutrition course. This could provide a solid foundation for further nutrition education. For those coaches who have left school and are actively teaching physical education courses and coaching organized sports, in-service nutrition education must be provided. Coaches would then have the opportunity to keep abreast of current nutrition findings. Another option would be to have an appropriately trained registered dietitian or nutritionist speak to athletes and coaches at the beginning of the training season.

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APPENDICES

APPENDIX A

SCRIPT - NUTRITION IN THE FAST LANE

SP 12-232
1/84

Oregon State University Extension Service

NUTRITION IN THE FAST LANE

Slides	Script (17 minutes)
	Introduction
#1 Swimmer #2 Volleyball #3 Runners #4 Bicyclers #5 Skier	People of all ages are exercising to become more fit. From the competitive athlete to the individual pursuing his or her own fitness program, more and more Americans are working on achieving a healthier and happier way of life.
#6 Title Slide #7 Dancers #8 Football #9 Bicyclers	Physical fitness and health are not the result of exercise alone however. Nutrition, and the right kind of nutrition, plays a major role.
#10 Nutrient needs #11 Meal	You may wonder what your nutritional needs are. Do they change if you are more active? How do you know if the foods you are presently eating will provide you with all the nutrients you need? The purpose of this program is to help you answer these questions.
	Good nutrition and exercise together can have a positive influence on both physical and mental health.
#12 Heart #13 Stretch #14 Pulse	Some of the physical benefits are: an increased efficiency of the heart, the development of muscular strength and cardiovascular endurance, better muscle tone and greater flexibility, and possible modifications in blood pressure, pulse rate and percentage body fat.
#15 Results	Some of the psychological benefits include: improved self-esteem, greater self-reliance, decreased anxiety, and relief from mild depression.
#16 Fitness Books #17 Nutrition Books	Many individuals misinterpret the role of nutrition in physical performance. Newspapers, magazines, and advertisements bombard us every day with a new wonder food or drug which promises we will run faster, jump higher, and swim farther. While good nutrition will allow us to have a competitive edge, it is not cure-all. Let's take a closer look at what nutrition can do for you.
#18 Puzzle pieces	There are six classes of nutrients which are essential for good performance. We need to choose foods so that we obtain all of these nutrients each day. Let's see how the nutrition puzzle fits together.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Extension Service, Oregon State University, O. E. Smith, director. Produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

Slides	Script
#19 CHO #20 Foods	The most efficient and usually least expensive sources of food energy are the sugars and starches which make up the group known as carbohydrates. Food sources of complex carbohydrates are whole-grain breads, cereals, vegetables, rice and beans. Fresh fruits are another important source of carbohydrate. In addition to energy, all of these foods contain vitamins and minerals.
#21 Is CHO fattening #22 Energy	Some people think that carbohydrate foods are fattening and should be avoided. This is an oversimplification. Energy is measured in units called calories, and ounce for ounce carbohydrate has the same amount of food energy as protein. Fat is a more concentrated source of energy. It contains twice as much energy as the same amount of carbohydrate or protein.
#23 Potato and Bread	The problem with carbohydrate foods usually results from the extras people put on them. For example, the butter or margarine on toast, or the sour cream on a baked potato add significant calories. The bread and potato alone are not terribly high in calories.
#24 Candy	Simple sugars are another type of carbohydrate. They are found in candy bars, soft drinks, cakes, cookies and pies. They should be limited because they contain little but calories.
#25 Eating Candy #26 Runners	Many people believe sugar is a quick source of energy. While it may feel good, it's not a wise idea to eat concentrated sweets immediately before exercise. The body's response to sugar is to secrete insulin and this results in early fatigue.
#27 CHO Loading	Some athletes manipulate their consumption of carbohydrate to increase muscle glycogen stores for optimal energy. This is known as carbohydrate loading. It is used primarily in endurance events such as marathons and cross-country skiing.
#28 1st → 3rd day #29 3rd Day → competition #30 X on Slide 28	The classic carbohydrate loading diet pattern has 3 stages: depletion, carbohydrate deprivation, and carbohydrate loading. Assuming the competition is on a Saturday, one would start preparing the Sunday or Monday before. The first 2-1/2 days the diet is primarily protein and fat with a limited carbohydrate intake. On the third day the diet switches to high carbohydrate, but with adequate protein and fat.
	Some studies have shown the 2nd step, the limited carbohydrate step, to be unnecessary. In fact, it may even be harmful. Not only does the athlete experience a great deal of discomfort, but exercise during this phase may adversely affect heart function. Carbohydrate loading is not intended for routine exercise.

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Slides	Script
#31 Fat--puzzle	Along with carbohydrate, fat is another essential part of the diet. It serves to build fat stores in the body, adds flavor to our foods, and is a carrier of fat soluble vitamins.
#32 Butter vs. jelly	Because fat is the most concentrated source of energy, it may be important to limit its intake. For example, look at how many calories are in one tablespoon of butter or margarine versus one tablespoon of jelly.
#33 Foods with Fat	Food sources of fat may be visible or invisible. Some examples of visible fat are butter and margarine, the oil in salad dressing, and the fat on a cut of meat. Some less obvious sources of fat are avocados, olives, the marbling in steak and the shortening in baked products.
#34 Tennis	During mild to moderate levels of exercise fat may be an important energy source. Since fat intake for most of us is already high, there is no reason to increase dietary fat for greater physical activity.
#35 Protein Puzzle	Protein is another part of the nutrition puzzle. The basic functions of protein are growth and repair of body tissue, and manufacture of functional and regulatory substances such as hormones and enzymes.
#36 Meat Meal #37 Dietary Protein #38 Weight Lifter	We have a preoccupation with protein in our diet. Most Americans already get 2-3 times the Recommended Dietary Allowance for protein. Such excess is unnecessary, expensive and possibly harmful. When protein is metabolized by the body, urea is produced which must be excreted in the urine and this requires water which may lead to dehydration and places additional stress on the liver and kidneys.
#39 Weight user	Many athletes or people engaged in vigorous physical activity feel they need more protein. They think because they have more muscle that they need to consume more protein for optimal muscle building. You can't force additional protein into muscles to make them grow, and excess protein in the diet is wasted because it's not used to build body protein but is used for energy instead. Carbohydrate or fat could serve just as well and less expensively. Even for the competitive athlete, there is <u>no</u> increased protein need!
#40 Protein Supplements	You often read or hear about protein supplements and how they help to increase body size and strength. This <u>isn't</u> true! Once again, the average diet provides more than enough protein. These supplements are an inefficient source of energy and are expensive and

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Slides	Script
	dehydrating. High-protein diet also increases the body's excretion of calcium, a mineral important for building and repairing bones.
#41 Steak and Eggs	One final misconception associated with protein is the benefit of the "steak and eggs breakfast" on the day of the game or event. A high-protein meal would make dehydration a greater possibility. In addition, the high fat content would lead to a feeling of fullness. Carbohydrate, which is the primary source of energy needed for the event is greatly lacking. This is probably not a winner's meal!
#42 Energy Puzzle	Let's talk about energy now. Our nutrition puzzle is half complete. Carbohydrate, fat and protein contribute calories to provide us with the energy we need. As we have discussed, carbohydrate is the most efficient energy source.
#43 Calorie Requirement #44 Very light exercise #45 Light Exercise #46 Moderate exercise #47 Heavy exercise	What about calories? It's true that the more active you are, the more fuel you burn. Some examples of activities in the very light exercise category are driving, reading, and watching T.V. Light exercise includes shopping, housework, walking slowly and fishing. Moderate exercise activities are walking fast, playing tennis, baseball, downhill skiing, leisurely swimming, bicycling slowly and gardening. Heavy exercise, which burns the most fuel, includes playing basketball, weightlifting, running, and cross-country skiing. Unless you increase your food intake, a regular exercise program may result in a weight loss.
#48 Vitamin Puzzle	The next part of the puzzle is the vitamins. How do they fit in? Vitamins are organic substances which work as regulators of body processes. They're <u>not</u> a direct source of energy for the body but are necessary for the use of the energy sources previously mentioned.
#49 Vitamin Collage	Consuming an excess of a single nutrient can be dangerous as well as expensive. For example, fat soluble vitamins A, D, E, and K are stored in the body and can reach toxic amounts. Excess water soluble vitamins are excreted. This can stress the kidneys. If the physically active individual is consuming enough calories from a wide variety of foods, that person's vitamin needs should be met without taking vitamin supplements.
#50 Mineral Puzzle	Minerals, unlike vitamins, are inorganic elements. They have several functions in the body such as in body structures, working with vitamins, maintaing fluid balance, or in controlling the action of nerves and muscles.
#51 Mineral Collage	Some minerals such as calcium, magnesium,sodium and

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Slides	Script
	potassium are present in the body in rather large amounts. Others, equally important, are known as the trace minerals. They are present in small amounts.
#52 Female Runners	Iron is the mineral often in low supply in the diet. Women, growing children and adolescents should make a conscious effort to consume foods high in iron. Lean meats, liver, dried fruits, and baked beans are good sources of iron.
#53 Water Puzzle #54 Splash	Water is a very important nutrient for the physically active person. It serves many vital functions. Transportation of nutrients and elimination of waste products as well as important chemical reactions take place in the presence of water. During exercise, water is especially important in controlling body temperature. When excessive heat is generated, it must be given off. The most effective way for the heat to be dissipated is through the evaporation of sweat, and adequate water is necessary for this to occur.
#55 Drinking Water	Thirst alone is not enough to indicate the need for additional water. Plan to have water available so that plenty can be consumed during exercise. Experts recommend drinking cool or cold drinks during activity in hot environments.
#56 Weighing	One way to get an indication of how much water is needed during exercise is to weigh in before and after an exercise session. This is especially useful when the weather is very warm.
#57 Drinking	What about some of the commercial liquids available on the market? These are generally too concentrated to drink as is, but if they're used, be sure to dilute these one part water to one part drink. But remember, the best and least expensive way to replace lost fluid is by drinking water. Diluted fruit juices are a good alternative.
#58 Salt	Salt tablets, or sodium chloride, are unnecessary even for the athlete in intensive training. The American diet supplies more than enough salt to replace any losses which might occur during exercise. While exexercising in very warm climates it may be a good idea to eat saltier foods though. Some examples are olives, pickles, crackers, cheese, and processed meats.
#59 Beer Caps	What about drinking beer as a fluid replacement? It sounds nice but not a good idea. Because of its concentration, it's slow to leave the stomach, and the alcohol in it acts as a diuretic and can have a dehydrating influence.

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Slides	Script
	There are still some parts of the nutrition fitness puzzle which need to be discussed before the puzzles complete.
#60 Magician	The first of these involves magic foods. There are many promoters of "magic foods." These are supposed to help one increase the capacity for bodily or mental labor, mainly by eliminating fatigue. Don't let them trick you! Honey, gelatin, wheat germ oil, and alcohol among others will do nothing to increase your performance.
#61 Caffeine drinks	The use of caffeine is a subject of much debate. As a magic food, it probably has little affect on work or aerobic capacity.
#62 Mice	A recent study in rats showed that fat loss with aerobic exercise can be increased when caffeine is ingested prior to the training sessions. More research is needed in this area though before any application to humans may be made.
#63 Milk	Milk, an excellent source of calcium, is often avoided in the diet of athletes. Milk doesn't hinder performance. Some believe it may cause cotton mouth. Cotton mouth is more likely the result of stress, fluid loss, or both. Finally, the milk curdling which occurs naturally upon digestion does not lead to stomach upset. Unless you're lactose intolerant, there is no sound reason to eliminate milk from the diet.
#64 Runner Puzzle	Now that you know the essentials of a nutritionally adequate diet, how can you be sure what you are eating will provide all of the six classes of nutrients necessary for good health and fitness?
#65 Fitness Food Plan	The Fitness Food Plan is the answer! By following this guideline, you will be able to choose the minimum amount of a variety of foods that can supply your body with what it needs.
#66 Fruits and Vegetables	There are six groups in the Fitness Food Plan. The first is composed of fruits and vegetables. 4 servings per day from this group are recommended for adults. Make sure to include Vitamin C sources--like citrus fruits, berries, tomatoes, and potatoes. Also include a Vitamin A source like dark green and deep yellow fruits and vegetables.
#67 Bread and Cereals	The second group includes all products made with whole grains, or enriched flour or meal. Again, 4 servings per day. Whole grains are best!

Slides	Script
#68 Milk and Cheese	Next is the milk and cheese group which provides protein and calcium. 2-4 servings per day are recommended. To reduce fat, choose skim and low-fat products.
#69 Meat, Fish, Poultry	The fourth group contains meat, poultry, fish and beans. 2 servings per day are enough. Lean cuts of meat should be emphasized to reduce consumption of fat and reduce calorie intake.
#70 Fats, Sweets, Alcohol	The next group is made up of sweets, fat and alcohol. Foods from this group contribute little but calories and should not replace foods from other groups.
#71 Water	The final group is water. While water is not usually included as a food group, it ought to be. The warmer the weather, the more active we are, the more water we require.
#72 Sample Meal #73 Sample Menu	Here is a sample dinner illustrating appropriate food choices. It includes lean meat as a protein source. The vegetables and bread provide complex carbohydrate. The margarine or butter, fat. What is nice about these foods is that they contain other nutrients such as vitamins and minerals.
#74 Sample Menu	Special consideration is necessary in planning a pre-game or pre-event meal. Dr. Nathan Smith in <u>Food for Sport</u> makes the following suggestions. There should be adequate energy intake to avoid feelings of weakness and hunger during the period of activity. The stomach and upper bowel should be empty at the time of competition. Adequate fluid should be provided by food and drink. Foods chosen should not upset the gastro-intestinal tract, and familiar foods are best to help psyche the athlete into a winning attitude. The overall recommendation is to take modest amounts of high carbohydrate foods up to 2-1/2 hours before competition.
#75 Exercisers #76 Basketball #77 Elderly #78 Kids #79 End of the Race	Nutritional advice commonly given to phsyically active people today is a combination of tradition, superstition, and scientific fact. The goal of this program was to help you sort fact from fantasy and piece the nutrition puzzle together. Remember, the better you eat, the closer you come to achieving physical fitness and a healthy and happy life.
#80 Extension Service Logo Slide	

Slide tape developed by
Susan Burkey, Jim Leklem
and Margaret Lewis,
Oregon State University

APPENDIX B

NUTRITION IN THE FAST LANE - A GUIDE FOR COACHES

NUTRITION

IN THE FAST LANE

A Guide to Nutrition for the High School Coach

Presented by:

Susan M. Burky

Graduate Student in Foods and Nutrition

and

Dr. James E. Leklem

Associate Professor in Foods and Nutrition

Oregon State University

CALORIES AND WEIGHT CONTROL

Calories are a measure of the energy food provides. How many calories an individual needs depends on how much energy he or she "burns" up. Carbohydrate and fat are the primary energy sources for exercise, with protein contributing only about 1-2% of the energy needed during normal exercise. Fats are the most concentrated source of energy. They contain about twice as many calories as the same amount of carbohydrate or protein. Fatty foods should be limited in weight loss programs.

How to lose weight. One pound of fat equals approximately 3500 calories. To lose about a pound of fat weight per week, decrease caloric consumption by 500 calories a day. For athletes in weight control sports such as wrestling and gymnastics, start a diet before the season begins. Increase activity level. Cut back on high calorie foods or substitute low calorie foods. For example:

TRY	INSTEAD OF
skim or 2% milk	whole milk
poultry or fish	pork and ham
fresh fruits	sweetened canned fruits
steamed vegetables	creamed or sauced vegetables
bran flakes	sugar-coated cereals
whole wheat bread	doughnuts and muffins
angel food cake	chocolate cake

Choose foods from the Fitness Food Plan outlined in the handout Nutrition in the Fast Lane. Avoid fatty and sugary foods.

Calorie counter books are available in most book stores. These provide an accurate and easy way to keep track of your daily intake.

How to gain weight. Increase caloric intake by 500 calories each day. To gain muscle, not fat, vigorous training must accompany increased food intake. Snacking is a good way to add extra calories. Try nutritious high-energy snacks like juices, milkshakes sandwiches, yogurt, dried fruits, and nuts.

How not to lose weight. Saunas, cathartics, diuretics, and crash diets are not the way to lose weight. Following is the American College of Sports Medicine Position Statement on Weight Loss in Wrestlers which points out some of the negative health aspects of such weight loss methods.

AMERICAN COLLEGE OF SPORTS MEDICINE POSITION STAND ON WEIGHT LOSS IN WRESTLERS

(Reprinted from Medicine and Science in Sports and Exercise, Vol. 8, No. 2, 1976.)

Since the "making of weight" occurs by combinations of food restriction, fluid deprivation, and dehydration, responsible officials should realize that the single or combined effects of these practices are generally associated with:

1) a reduction in muscular strength;
2) a decrease in work performance times;
3) lower plasma and blood volumes;
4) a reduction in cardiac functioning during sub-maximal work conditions which are associated with higher heart rates, smaller stroke volumes, and reduced cardiac outputs;
5) a lower oxygen consumption, especially with food restriction;
6) an impairment of thermoregulatory processes;
7) a decrease in renal blood flow and in the volume of fluid being filtered by the kidney;
8) a depletion of liver glycogen stores;
9) an increase in the amount of electrolytes being lost from the body.

Since it is possible for these changes to impede normal growth and development, there is little physiological or medical justification for the use of the weight reduction methods currently followed by many wrestlers. These sentiments have been expressed in part within Rule 1, Wrestling Rule Book published by the National Federation of State High School Associations.

CAFFEINE AND PHYSICAL PERFORMANCE

Caffeine is an alkaloid substance found in coffee beans, tea leaves, cocoa beans, kola nuts and other plants.

Caffeine is classified as a stimulant and has a bitter taste. There are several physiological effects associated with caffeine use:

- *Caffeine is a central nervous system stimulant.* In lower quantities(50-200 mg) it may contribute to alertness. In higher quantities(300-500 mg) it may produce nervousness and muscular tremor.

- *Caffeine is a diuretic.* It stimulates urine production and the corresponding loss of water from the body which may contribute to dehydration, especially when exercising in the heat.

- *Caffeine stimulates the release of adrenalin.* Associated with increased levels of adrenalin are increased levels of free fatty acids. Free fatty acids may be used by the muscle as an energy source.

- *Caffeine consumption may lead to upset stomach in some people.* Caffeine causes an increased secretion of stomach acids.

Will caffeine improve physical performance?

Most research has shown that caffeine will not improve performance in events involving strength, power, or endurance events lasting less than an hour.

Some research has indicated that caffeine may be useful in long distance events such as marathons. Caffeine helps to elevate levels of free fatty acids in the blood. These fatty acids may in turn be used more by muscle as an energy source than glycogen would be. In essence, caffeine has a "glycogen sparing" effect.

Moderate caffeine consumption(150-250 mg/day) does not appear to be harmful to the average healthy adult. More than 250 mg/day is considered excessive.

Tables from Zeman, F.J., Clinical Nutrition and Dietetics. Lexington, MA: D.C. Heath and Co., 1983, p. 636.

Food or Beverage	Caffeine (mg/6-oz cup)
Roasted and ground coffee, brewed to varying strengths	60-150
Instant coffee	60
Nescafé	7
Decaffeinated coffee	3
Decaf	0.10
Sanka	3.3
Tea, brewed to varying strengths	18-107
Instant tea	33
Cocoa (mean, all types)	13
African	
South American	
Cola beverages	
Coca-Cola	64.7
Diet Pepsi-Cola	36
Diet-Rite Cola	31.7
Dr. Pepper	60.9
Diet Dr. Pepper	54.2
Pepsi-Cola	43.1
Royal Crown Cola	33.7
Diet RC Cola	30.0
Tab	49.4
Mountain Dew	54.7

DRUG SOURCES OF CAFFEINE

Drug	Usual Purpose for Use	Caffeine Content (mg/tablet)
Anacin	Headache relief	32
A.P.C.	Analgesic	32
Bromoquinine	Cold tablet	15
Cope	Headache relief	32
Darvon	Prescription drug	32
Dristan	Allergy relief	30
Excedrin	Headache relief	32
Fiorinal	Prescription drug	40
Migral	Prescription drug	50
No Doz	Keep awake	100-200
Sinarest	Allergy relief	31
Vivarin	Keep awake	100-200

PRE-EVENT NUTRITION

Food consumed prior to competition will not benefit physical performance. Nutritious food choices must be made throughout the training season as well as during the days prior to competition. The overall purpose of the pre-event meal is to prevent feelings of hunger during the event.

TIMING. The meal should be eaten 2-3 hours prior to activity. This allows time for food to leave the stomach thereby reducing competition between the stomach and muscles for blood supply.

TYPE OF MEAL. The meal should contain foods high in carbohydrate and low in protein and fat. Fatty foods delay stomach emptying and excess protein may compromise hydration. Carbohydrate foods are easily digested and readily absorbed.

Avoid sugary foods, especially during the hour prior to exercise. Eating sugar stimulates insulin secretion which results in a hypoglycemic(low blood sugar) effect. Sugary foods also cause water to be drawn into the stomach possibly producing cramps and nausea. Finally, the insulin released in response to sugar consumption blocks the utilization of free fatty acids by muscle. This could effect performance in that muscle glycogen stores would be used at a faster rate.

SIZE OF MEAL. Smaller meals of 500-1,000 Calories are recommended. The larger the meal, the longer it will take to leave the stomach.

FOODS TO AVOID. These recommendations must be considered on an individual basis. Bulky, high fiber foods such as bran should be reduced in pre-event nutrition because of their contribution to fecal bulk. Spicy foods may be irritating to some individuals. Some to avoid may be peppers, clove, and mustard seed. Gas formers such as beans, cabbage, onions may be eliminated by those athletes who experience discomfort following consumption of these foods.

FLUIDS. Adequate fluid consumption is critical! Athletes may take fluids up to 15 minutes before competition. Avoid coffee, tea and alcohol because they are diuretics(cause loss of body water). A high protein diet will produce increased fluid loss from the body.

FOOD PREFERENCE. This may be the most important consideration. Athletes must learn which foods agree and disagree with them. Special food preferences should be recognized.

SAMPLE MEALS

8 oz. orange juice	8 oz. skim milk
½ cup dry cereal with sliced banana	sliced turkey sandwich
1 slice whole wheat toast with jelly	1 tsp. mayonnaise
4 oz. skim milk	1 small orange

SPORTS NUTRITION GLOSSARY

aerobic- in the presence of oxygen

amino acids- simple nitrogen containing compounds which are the building blocks of protein

anabolic steroids- hormone preparations designed to duplicate the hormones of puberty

anaerobic- in the absence of oxygen

anemia- a condition of lack of blood characterized by a decreased number of red blood cells, decreased hemoglobin, ineffective hemoglobin, or all of these

caffeine- a central nervous system stimulant with a diuretic effect

complex carbohydrates- these are made from chains of simple sugars and they include pasta, bread, cereal, beans, and other starchy foods

dehydration- loss of body water below normal levels

diuretic- an agent which increases urine excretion

electrolytes- in water, the molecules of electrolytes separate into two or more electrically charged particles called ions. The chief electrolytes in the body fluids are sodium, potassium, and chloride

ergogenic- thought to increase the capacity for bodily or mental labor, mainly by eliminating fatigue

fat soluble- dissolves in fat

glucose electrolyte solution(GES)- a solution containing varying proportions of water, glucose, sodium, potassium, chloride, and other electrolytes designed to replace sweat losses

glycogen- the storage form of carbohydrate in animal tissue

hemoglobin- the protein-iron containing molecule in the red blood cells that transports oxygen

hormone- a product that is secreted into the bloodstream and acts to modify physiological responses of target cells

hyperhydration- the practice of increasing body water stores by increasing fluid consumption above normal

hypoglycemia- low blood sugar

insulin- a hormone which regulates the blood sugar(glucose) level

megadose- an excessively large dose of a substance compared to a normal dose

RDA-Recommended Dietary Allowances. Based on current research, these are the levels of intake of essential nutrients thought to meet the known needs of practically all healthy persons

simple carbohydrates- also known as simple sugars. They include glucose(dextrose), fructose, and sucrose(table sugar) sports anemia- decreased hemoglobin levels associated with early stages of training

urea- a compound produced by protein degradation that is excreted in the urine

vegetarian- a person who 1) excludes all foods of animal origin (a vegan); or 2) includes dairy products, but excludes meat, poultry, fish and eggs(lacto vegetarian); or 3) includes eggs and dairy products, but excludes meat, poultry and fish(lacto-ovo vegetarian)

water soluble- dissolves in water

SUMMARY

Experts agree that the best diet for the athlete is the one in which foods are chosen in sufficient amounts from each of the four main food groups. This diet will supply the healthy individual with all necessary nutrients without the need to use supplements(vitamin, mineral or protein). The benefit to you as the coach in stressing basic good nutrition is that you are more likely to have a well conditioned team, and a healthier, better performing athlete.

QUESTIONS ABOUT SPORTS NUTRITION?

Where to find answers to your nutrition questions:

There is a great deal of information available on nutrition and often people find it difficult to keep up to date, or to sort out which information is valid. Help is available, however. Extension agents who are nutrition specialists have a wealth of resources available on food and nutrition. You may contact a registered dietitian(R.D.) in your area, they are knowledgeable in all areas of applied nutrition. Physicians who specialize in sports medicine are good sources of information as well as faculty members from a college or university nutrition department.

NUTRITION AND ATHLETICS • RESOURCE LIST

TECHNICAL REFERENCE BOOKS

Textbook of Work Physiology, Chapter 14:Nutrition and Physical Performance. Astrand, P.O. and K. Rodahl, 1977. From McGraw-Hill Book Company, New York, 681 pp., $35.00.
A textbook addressing the various factors which affect human physical performance. This book is technical and some background in physiology and biochemistry is helpful.

Nutrition and Athletic Performance: Proceedings of the Conference on Nutritional Determinants in Athletic Performance, San Francisco, California, September 24-25, 1981. Haskell, W., J. Scala, and J. Whittam, eds., 1982. From Bull Publishing Company, Box 208, Palo Alto, CA 94302, 284 pp., softcover, $18.
This book presents the latest research findings concerning the roles of nutrition, fluid intake, and body composition on athletic performance. Special problem topics such as anemia, diabetes, and the elderly are included.

Nutritional Aspects of Human Physical and Athletic Performance. Williams, M.H., 1976 From Charles C. Thomas, Publishing Co., Springfield, IL, 456 pp., $22.50.
This valuable reference book is basically a review of the current literature on nutrition and athletic performance.

BOOKS TO RECOMMEND TO STUDENTS/COACHES

Fit or Fat. Bailey, C., 1978. From Houghton Mifflin Company, Boston, 107 pp., softcover, $4.75.
This enjoyable and easy-to-read book proposes that the way to achieve fitness is by reducing body fat. The exercise prescription of 12 minutes of aerobics per day is questionable, but there is much valuable information in this book.

The Athlete's Kitchen. Clark, N. From CBI Publishing Company, Inc., Boston, MA, 322 pp., softcover, $9.95.
The Athlete's Kitchen is both a cookbook and a nutrition guide. Areas of special interest to athletes are covered and recipes are included.

Nutrition, Weight Control and Exercise. Katch, F.I., and W.D. McArdle, 1983. From Houghton Mifflin Company, Boston, 332 pp., softcover, $18.50.
A textbook combining theoretical and practical information on nutrition and exercise physiology. Good reference for evaluating body composition and a source of information on cardio-respiratory fitness.

Nutrition for Athletes: A Handbook for Coaches. American Alliance for Health, Physical Education, and Recreation Publication, Washington, D.C., 1980. 56 pp., softcover, $7.
A must for every coach and athletic director. Practical nutrition information is presented and common myths evaluated.

Food for Sport. Smith, N.J. From Bull Publishing Company, Palo Alto, CA, 188pp., softcover, $6.95. (2nd edition now available)
For athletes of all capabilities, this book is written in a clear and readable way. The relationship between food and fitness and performance is the central focus.

Nutrition for Fitness and Sport. Williams, M.H., 1983. From Wm. C. Brown Co., Dubuque, Iowa, 296 pp., softcover, $17.10.
This book is designed to provide nutritional information to the individual who is physically active or to those who desire to initiate or are just initiating a personalized exercise program. The book uses a question-answer format; is clear, easy-to-read and understand.

PAMPHLETS

Note: Pamphlets are often prepared by food companies which use the literature to promote their products. This list is not an endorsement of these products.

Food Power: A Coach's Guide to Improving Performance

National Dairy Council
Rosemont, IL 60018
1984 ($10)
Coach's guide has chapters on nutritional needs, fluid intake, fuels, body composition, meal plans, weight control, and sports misinformation. 12 handouts are included which may be reproduced and given to athletes.

Nutrition and Physical Fitness

Nutrition Department
General Mills, Inc.
P.O. Box 1113
Minneapolis, MN 55440

©General Mills, Inc., 1983

A well organized 12 pg. pamphlet discussing key dietary factors, food groups, menu plans, pre-game meals, and supplements.

ARTICLES

1. Hanley, D.F. Athletic training and how diet effects it. Nutrition Today 14(6), Nov./Dec. 1979, pp. 5-9.
2. Hanley, D.F. Basic diet guidance for athletes. Nutrition Today 14(6), Nov./Dec. 1979, pp. 22-23.
3. Hursh, L.M. Practical hints about feeding athletes. Nutrition Today 14(6), Nov./Dec. 1979, pp. 18-20.
4. Forgac, M.T. Carbohydrate loading--a review. J.A.D.A. 75:42-45, 1979.
5. Nutrition and Athletic Performance. Dairy Council Digest 46(2) March/April 1975.
6. Nutrition and Human Performance. Dairy Council Digest 51(3) May-June, 1980.
7. Nutrition and Physical Fitness. J.A.D.A. 76:437-443, 1980.
8. Vitousek, S.H. Is more better? Nutrition Today 14(6), Nov./Dec. 1979, pp. 10-17.

JOURNALS/MAGAZINES(for professionals)

Note: While these journals are not devoted specifically to nutrition, they often include excellent articles.

1. Medicine and Science in Sports and Exercise

American College of Sports Medicine
1400 Monroe St.
Madison, WI 53706

5/year ($23.00)

2. Physician and Sports Medicine

McGraw-Hill Publishers
4530 West 77th St.
Minneapolis, MN 55435

12/year ($32.00).

EC 1167
March 1984

Nutrition in the Fast Lane

Good nutrition is vital for top performance. Both the competitive athlete and the individual involved in a fitness program benefit from a nutritious diet—there's no magic involved!

A diet which supplies enough, but not too much, carbohydrate, fat, protein, vitamins, minerals and water is important to all athletes.

Exercise and Energy Use

- Glucose is the primary fuel source for high-intensity, short-duration exercise.
- When exercise continues for five minutes or longer, both glucose and fat are used for fuel.
- If exercise continues, fat becomes the major fuel for muscles.
- Endurance events use the glycogen (a form of glucose) stored in muscles and the liver.
- Carbohydrate loading is a dietary manipulation used to increase muscle and liver glycogen stores. The larger these stores are, the longer fatigue may be avoided.

Caution: Carbohydrate loading causes unpleasant side effects—fatigue, nausea, irritability, water retention, and weight gain. Exercise during depletion may cause heart irregularities.

Carbohydrate loading should be used **only** by endurance athletes under the supervision of an expert.

- High-protein and fat foods don't compose the best pregame meal; they take longer to digest than carbohydrates and may cause stomach upsets.

Carbohydrate

- provides energy for body processes
- is the preferred fuel for muscles.
- is the most economical source of energy.

Fat

- supplies the essential fatty acid.
- provides fat soluble vitamins.
- is a concentrated source of energy. It has twice the calories of carbohydrate or protein.

Protein

- is necessary for growth, repair, and maintenance of body tissues.
- is necessary for the production of hormones, enzymes and antibodies.
- overconsumption may cause stress on the liver and kidneys.
- overconsumption does not build extra muscle nor give a competitive edge.

Vitamins and Minerals

- Rely on a variety of foods to supply the necessary vitamins and minerals.
- Mega-doses may interfere with the use of other nutrients.
- Iron deficiency may affect performance because insufficient oxygen reaches muscles to allow them to work efficiently.
- Women and growing children may lack enough iron in their diets.

Water

- is necessary for all body processes.
- prevents dehydration during strenuous exercise and warm weather.
- can be provided by diluted fruit juice. Athletic beverages are not needed.

Activity and Energy Needs

Activity Level	Calories used per minute
Sleeping	1
Very light exercise. Office work, drinking, reading, watching TV, studying, telephoning, typing	2
Light exercise. Housework, shopping, golf, volleyball, walking slowly, fishing, riding horseback at a walk	2—5
Moderate exercise. Walking fast, playing tennis, gardening, skiing downhill, bicycling slowly, hiking, dancing slowly, swimming leisurely, playing baseball	5—7
Heavy exercise. Playing basketball, weight lifting, playing football, running, cross-country skiing, bicycle racing, horseback riding at a gallop	7—12

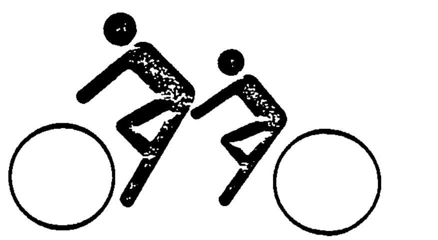
Supplements

- Protein supplements don't enhance performance and may cause dehydration or create stress on the liver and kidneys.
- Supplements of vitamins or minerals in the form of pills, liquids, powders or highly fortified foods are unnecessary, don't aid performance, and may be dangerous to your health.

No one food or dietary product will enhance performance.

Use this information as a foundation for good nutrition—and better performance. Follow these guidelines in designing your food plan.

After selecting minimum amounts from these basic foods, choose additional food and beverages to meet your energy needs. If you exercise regularly you may need to eat 500 to 1,000 calories a day more than a person who doesn't exercise—just to maintain your ideal weight.



Oregon State University Extension Service

The secret of good physical performance is hard training, natural talent, motivation and good nutrition.

Fitness Food Plan

Vegetable Fruit Group

At least 4 servings daily

A serving is ½ cup or a medium-size fruit or vegetable. Be sure to include vitamin C sources—citrus fruits, berries, tomatoes, and potatoes, as well as vitamin A sources—dark green and deep yellow vegetables and fruits.

Milk Cheese Group

Two servings for adults a day

A serving is 1 cup of milk, yogurt, a 2-inch cube of cheese, or 1½ cups ice cream. These foods supply protein and calcium.

Fats Sweets Group

These foods provide little other than calories. Don't let them replace foods from the other groups. For successful performance, don't consume alcohol before or during exercise.

Bread Cereal Group

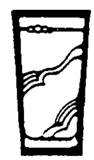
At least 4 servings daily

A serving is one slice of bread; a tortilla or pancake; ½ cup cooked cereal, rice, or pasta; or 1 ounce of ready-to-eat cereal. These products are made with grain or flour or meals. Whole grains are best.

Meat Poultry Fish and Beans Group

Two servings daily

A serving is 3 oz. cooked lean meat, poultry or fish; 2 eggs; 1 cup cooked dried peas or beans, or ¼ cup peanut butter. These foods provide protein and iron. Choose lean cuts of meat.



Water

Drink plenty everyday

The hotter the weather and the more active you are, the more water or fluids you need to dissipate heat, transport nutrients, and eliminate wastes. Drink water before, during, and after exercise.

Prepared by Margaret J. Lewis, R.D., Extension nutrition specialist, Oregon State University.

Extension Service, Oregon State University, O. E. Smith, director. Produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

APPENDIX C

QUESTIONNAIRES

Correct knowledge responses have been underlined for this appendix. The pre- and post-questionnaires were identical with the exception of page 6a included here.

NUTRITION AND ATHLETIC PERFORMANCE

The following questionnaire will be used to evaluate this workshop. Please help me with this evaluation by reading each statement and answering it to the best of your ability. All answers will be strictly confidential and no names will be used with the data. My request that you write the last four digits of your home phone number is for the purpose of coding this questionnaire.

Please write the last four digits of your home phone number in the space provided. ____ ____ ____ ____.

Thank you for your assistance!

Susan Burky
Graduate Student
Dept. Foods & Nutrition
College of Home Economics
Oregon State University
April, 1984

1. Please check the foods you believe are a good source of iron.

_x_ LIVER (3 ounces)	_x_ PRUNE JUICE (1/2 cup)
___ ORANGES (1 medium)	___ MILK (1 cup)
_x_ RAISINS (2 Tbsp.)	_x_ MOLASSES (1 Tbsp.)
___ FRENCH FRIES (10 avg.)	_x_ OYSTERS (6)
___ COTTAGE CHEESE (1/2 cup)	_x_ BAKED BEANS (1/2 cup)
_x_ DRIED APRICOTS (4 halves)	___ BANANAS (1 medium)

2. Please check which of the following beverages you would recommend for athletes during either practice or competition.

___ SODA POP	___ BEER
_x_ ORANGE JUICE, DILUTED	_x_ MINERAL WATER
___ COFFEE	___ TANG
_x_ WATER	___ TEA
___ GATORADE	___ MILK, WHOLE

3. Which of these foods do you consider to be complex carbohydrate foods?

_x_ APPLES	_x_ BREAD, WHOLE WHEAT
___ FISH	___ HONEY
_x_ LIMA BEANS	___ LOW-FAT YOGURT
_x_ PANCAKES	___ PEANUT BUTTER
_x_ POTATOES	_x_ RAISIN BRAN
___ SAUSAGE	_x_ SPAGHETTI

4. Please check the foods that you believe are high in salt.

_x_ CANNED VEGETABLES	_x_ CATSUP
_x_ CHEESE	_x_ DRY CEREAL
___ FRESH FRUIT	___ FRESH VEGETABLES
_x_ HAM	___ JELLY
___ LEMONADE	_x_ LUNCHEON MEAT
___ MILK	_x_ MUSTARD
_x_ OLIVES	___ PEANUT BUTTER
_x_ PICKLES	_x_ SOUPS (CANNED)

5. Which of these foods are sources of low-fat protein?

___ POTATO CHIPS	_x_ NON-FAT MILK
_x_ BAKED CHICKEN	___ BACON
_x_ LOW-FAT COTTAGE CHEESE	___ SAUSAGE
_x_ KIDNEY BANS	_x_ BAKED HALIBUT
___ HAM	___ STEAK
_x_ TUNA, WATER PACK	_x_ GREEN PEAS
_x_ MACARONI	___ SWISS CHEESE

6. The three sample meals below have been used as pre-competition meals. Please indicate by a check which meal you would recommend eating as the best pre-competition meal.

MEAL A ___	MEAL B ___	MEAL C _X_
Bacon-2 slices	T-bone steak-8 oz	Orange juice-8 oz
Fried eggs-1	Scrambled eggs-2	Whole wheat toast-2
Cheddar cheese-2 oz	Whole wheat toast-1 slice	Poached eggs-2
Whole wheat toast-1 slice	Butter-1 tsp	Sliced peaches/skim milk
Butter-1 tsp	Whole milk-8 oz	
Coffee-8 oz		

6a. Please discuss briefly the reason for your meal choice in No. 6 above.

6b. How soon before competition should athletes finish the meal?

_____1/2 hour
_____1 hour
_____2 hours
__X__2 1/2 - 3 hours
_____6 hours
_____other

7. Listed below are some statements concerning vitamins, minerals, and athletic performance. Please indicate whether you agree with each statement, disagree, or don't know. (circle one number for each statement)

STATEMENT	AGREE	DISAGREE	DON'T KNOW
a. Vitamins supply energy for the body.......	1	2	3
b. Vitamin megadoses may be harmful	1	2	3
c. Magnesium supplements are recommended for athletes to help avoid muscle cramping	1	2	3
d. Female athletes should pay special attention to consuming foods high in iron	1	2	3
e. Vitamins contribute significantly to body structure (increases in muscle size, for example)......................	1	2	3
f. Vitamin E supplementation has not proven helpful in increasing physical performance	1	2	3
g. Most athletes need extra vitamins and minerals beyond what they receive in a balanced daily diet......................	1	2	3

8. Some statements often made concerning nutrition and athletics are listed below. Please indicate, by circling a number, how strongly you agree or disagree with each one.

STATEMENT	AGREE STRONGLY	AGREE	DISAGREE	DISAGREE STRONGLY	DON'T KNOW
a. Eating a candy bar right before exercise will give you quick energy.............	1	2	3	4	5
b. Athletes need more calories than non-athletes....................	1	2	3	4	5
c. Exercise is not useful in weight reduction because it uses so few calories..........	1	2	3	4	5

STATEMENT	AGREE STRONGLY	AGREE	DISAGREE	DISAGREE STRONGLY	DON'T KNOW
d. Water is the best fluid replacement for athletes before, during and after practice or competition..........................	1	2	3	4	5
e. Carbohydrate loading may be of benefit to a select group of athletes................	1	2	3	4	5
f. All athletes should eat the same amount of food.................................	1	2	3	4	5
g. Complex carbohydrates are the preferred fuel for the active individual...........	1	2	3	4	5
h. Athletes and others who exercise regularly need extra protein	1	2	3	4	5
i. Alcohol has been shown to be ineffective as a means of increasing performance capacity	1	2	3	4	5
j. Protein supplements are especially useful for weight lifters...................	1	2	3	4	5
k. A healthy diet should have 30% of its total calories coming from fat, 55-60% from carbohydrates and 12% from protein..........	1	2	3	4	5
l. Fats are an important energy source during mild to moderate levels of exercise	1	2	3	4	5
m. Salt tablets are not necessary even during strenuous exercise and excessive sweating..	1	2	3	4	5
n. Most vegetarian athletes can't get enough protein.................................	1	2	3	4	5
o. Bee pollen helps runner's performance....	1	2	3	4	5
p. A balanced diet consisting of a variety of foods from the Basic Four Food groups is the key for good health and optimal athletic performance....................	1	2	3	4	5
q. The amount of calories an athlete needs depends on how active he/she is.....	1	2	3	4	5
r. Fructose is a better source of carbohydrate energy than glucose because it is metabolized more efficiently........................	1	2	3	4	5

	STATEMENT	AGREE STRONGLY	AGREE	DISAGREE	DISAGREE STRONGLY	DON'T KNOW
s.	Honey is not nutritionally superior to sugar..............................	1	2	3	4	5
t.	Fast foods (McDonalds, etc.) are not nutritious and should be avoided by athletes..............................	1	2	3	4	5
u.	Gatorade and other commercial thirst quenchers are not good beverages for athletes because they contain excess sugar and salt.........................	1	2	3	4	5

9. Following are some statements regarding pre-game/competition nutritional practices. Please indicate whether you agree, disagree, or don't know. Please circle one number for each statement.

	STATEMENT	AGREE	DISAGREE	DON'T KNOW
a.	Milk consumed before an athletic event causes cotton mouth, cuts speed and wind, and causes stomach upset...............	1	2	3
b.	Steak and eggs for breakfast makes a good pre-game meal....................	1	2	3
c.	Whole milk is not recommended before competition...........................	1	2	3
d.	Caffeine containing beverages are beneficial as pre-competition fluids....	1	2	3
e.	A pre-game or pre-event meal should be small (500-900 calories) and should be eaten two to three hours before competition......................	1	2	3
f.	Liquid pre-game meals are preferable to solid meals.........................	1	2	3

**** **** **** **** **** **** **** **** **** ****

The last series of questions are designed to help me interpret the results more accurately. I would very much appreciate your answers to these important questions about you and your coaching experience.

1. Age (in years) ____________________

2. Sex (circle one) M F

3. Listed below are several sources of information on nutrition. Please rank their usefulness to you on a scale of one to five, where "1" is most useful and "5" is least useful.

____ A. Newspapers, popular magazines, and paperbacks
____ B. Radio, television
____ C. Professional journal(s), please specify which one(s) ________________________________

____ D. Colleagues
____ E. Other (please specify)________________________________

3a. Of the sources listed above in question 3, which is your one main source of recent nutrition information?

_______(Place appropriate letter, A-E, in the blank)

4. Are you coaching any organized sports at your school?

____YES ____NO (skip the next part of the question)

Please check the sport(s) you coach during the school year, and give the total number of years (seasons) that you have coached each. Please indicate if the team coached was male or female.

SPORT COACHED	YEARS	M/F TEAM	
_____Football..........................	_____	M	F
_____Basketball........................	_____	M	F
_____Wrestling.........................	_____	M	F
_____Volleyball........................	_____	M	F
_____Badminton	_____	M	F
_____Soccer............................	_____	M	F
_____Tennis............................	_____	M	F
_____Swimming..........................	_____	M	F
_____Field Hockey......................	_____	M	F
_____Baseball..........................	_____	M	F
_____Track and Field...................	_____	M	F
_____Cross-country.....................	_____	M	F
_____Softball..........................	_____	M	F
_____Golf..............................	_____	M	F
_____Gymnastics........................	_____	M	F
_____Other(specify)______________	_____	M	F

5. Which of the following best describes your present position. (Check one)

_____Physical education teacher in a middle or junior high school
_____Physical education teacher in a senior high school
_____Physical education teacher in a community college
_____Other (please specify)________________________________

6. How many years have you been employed in this or a similar position? (check one)

_____0-3 years
_____4-6 years
_____7-10 years
_____11-15 years
_____over 15 years

7. During the coaching season, do you teach your athletes about nutrition and/or make nutritional recommendations for them to follow?

_____NO _____YES (If yes, please answer the following)

7a. Approximately how much time is devoted to the subject of nutrition throughout a sport season?

_____ 30 MINUTES OR LESS
_____ 30 MINUTES - ONE HOUR
_____ 1 - 2 HOURS
_____ 2 - 4 HOURS
_____ 4 HOURS PLUS

8a. FOR HIGH SCHOOL COACHES: What classification for athletic competition is your high school in?

_____ AAA (Average Daily Membership is 601 students and over)
_____ AA (201-600 students)
_____ A (200 students and under)

9. What is your highest earned degree? (Check one)

_____ ASSOCIATE DEGREE
_____ BACHELOR DEGREE
_____ MASTERS DEGREE
_____ DOCTORAL DEGREE
_____ OTHER (please specify ____________________)

10. What year did you receive this degree? _____

11. Have you completed a college level nutrition course? (check one)

_____ NO _____YES (If yes, please answer the following.)

11a. How many years ago was your last college level nutrition course?

_____ 0-3 YEARS
_____ 4-6 YEARS
_____ 7-10 YEARS
_____ 11-15 YEARS
_____ OVER 15 YEARS

12. In the last two years have you attended any workshops, seminars, or conferences on nutrition other than this one?

_____ YES _____ NO

**** **** **** **** **** **** **** **** **** ****

The last series of questions are designed to help me interpret the results more accurately. I would very much appreciate your answers to these important questions about this workshop.

1. How useful would you say this workshop has been for you personally?

_____ very useful (go on to question 1a._
_____ somewhat useful (go on to question 1a.)
_____ not too useful (go on to question 1b.)
_____ not at all useful (go on to question 1b.)

1a. Please indicate how or in what ways the workshop was useful to you.

1b. Please indicate how or in what ways the workshop was not useful to you.

2. Was this workshop held at a convenient hour of the day for you?

_____ YES (skip to question 3)
_____ NO (skip to question 2a.)

2a. If it was not a convenient hour of the day for you, what time would you have preferred?

_______________________ time

3. Did you feel this workshop was not long enough, too long, or just right?

_____ not long enough (go on to question 3a.)
_____ too long (skip to question 4)
_____ just right (skip to question 4)

3a. If you felt this workshop was not long enough, which type of workshop would you attend?

_____ half day in-service day
_____ half day Saturday
_____ 1 hour once a week for 4 weeks
_____ one day during the summer
_____ other (please specify____________________________________)

4. Would you recommend this particular workshop to your colleagues?
_____YES _____ NO

5. Please describe how or in what ways, if any, you might use the information from this workshop in your work.