Chapter - I

Introduction
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INTRODUCTION

1.1 Nutrition

Nutrition science seeks to explain metabolic and physiological responses of the body to diet. With advance molecular biology, biochemistry and genetics, nutrition science is additionally developing into the study of integrative metabolism, which seeks to connect diet and health through the lens of biochemical processes.

The human body is made up of chemical compounds such as water, amino acids (proteins), fatty acids (lipids), nucleic acids (DNA/RNA) and carbohydrates (e.g. sugars and fiber). These compounds in turn consist of elements such as carbon, hydrogen, oxygen, nitrogen and phosphorous, and may or may not contain minerals such as calcium, iron or zinc. Minerals ubiquitously occur in the form of salts and electrolytes. All these chemical compounds and elements occur in various forms and combinations (e.g. hormones / vitamins, phospholipids, hydroxyapatite), both in human body and in organisms (e.g. plants, animals) that humans eat.
The human body necessarily comprises the elements that it eats and absorbs into the bloodstream. The digestive system, except in the uniborn fetus, participates in the first step which makes the different chemical compounds and elements in food available for the trillions of cells of the body. In the digestive process of an average adult, about seven litres of liquid known as digestive juices, exit the internal body and enter the lumen of the digestive tract. The digestive juices help break chemical bonds between ingested compounds as well as modulate the conformation and/or energetic state of the compounds/elements. However, many compounds/elements are absorbed into the bloodstream unchanged, through the digestive process helps to release them from the juice is eliminated by this process; the intestines reabsorb most of it; otherwise, the body would rapidly dehydrate; (hence the devastating effects of persistent diarrhea).

Study in the field must take carefully into account the state of the body before ingestion and after digestion as well as the chemical composition of the food and the waste. Comparing the waste to the food can determine the specific types of compounds and elements absorbed by the body. The effect that the absorbed matter has on the body can be determined by finding the difference between the pre-ingestion state. The effect may only be discernible after an extended period of time in which
all food and ingestion must be exactly regulate and all waste must be analyzed. The number of variables (e.g. confounding factor) involved in this type of experimentation is very high. This makes scientifically valid nutritional study very time-consuming and expensive, and explains why a proper science of human nutrition is rather new.

In general, eating a variety of fresh, whole (unprocessed) plant food has proven hormonally and metabolically favourable compared to eating a monotonous diet based on processed food. In particular, consumption of whole plant foods slows digestion and provides higher amounts and a more favourable balance of essential and vital nutrients per unit of energy, resulting in better management of cell growth, maintenance, and mitosis (cell division) as well as regulation of blood glucose and appetite. A generally more regular eating pattern (e.g. Eating medium-sized meals every 3 to 4 hours) has also proven more hormonally and metabolically favourable than infrequent, haphazard food intake.

The contribution that nutrition can make to the general health of any individual which has been generally accepted, has not been given the attention it deserves. As the saying “A sound mind in a sound body”, it is needless to say that one can never think or act promptly if that person is in ill health or malnourished. Good nutrition is therefore vital to optimal
event performance. Physical activity is essential for normal development in early adolescence. It is because of this, physical training is generally accepted and recommended as an essential part of school (Driskell, and Wolinsky 2002). Exercise alone cannot be beneficial to the body. Proper exercise and balanced diet are the true basic necessities for a healthy man. Fitness is a combination of heart and muscle capacity to use oxygen for energy production. Nutrition and well being hence assumes a vital role in the field of sports (Rosates, 1994).

Regular involvement in sports and exercise programmes offer positive cognitive experiences, which include feeling healthy and relaxed, detached consciousness, improved quality of life, euphoria, sense of accomplishment, self-worth and confidence (Dube, 1995). Regular aerobic physical activity for a total 30 minutes is a vital part of a healthy life style, as it leads to proper functioning of heart, less injury, better sleep and improvement in body composition (Wardlaw, 2003). Physical activities also reduce stress and positively affect blood pressure, blood cholesterol and blood glucose regulation. In addition, it aids in weight control both by raising energy expenditure for a short period of time after exercise and by increasing overall energy (Gordon, 2003).

Organized athletics is said to have first appeared in history with the Olympic games, which existed in Greece in 776 B.C. Thereafter every
four years, the Olympic games were held periodically. Development of sports in India came into light as a profession only in the recent past. The endurance games like volleyball; basketball were introduced in India by the Y.M.C.A. organization in 1955. Athletics, Volleyball and basketball are all endurance games where the muscle wastage and degradation of essential amino acid like leucine, isoleucine and valine is more, which may result in increased fatigue and decreased performance. These games are played both for recreational and competitive purpose. Sports as such classified based on various factors like demand of oxygen, intensity, endurance, type of activity, season, etc.

As a saying goes “Eat to win”, proper nutrition plays a major role maximizing everyone’s ability to maintain higher levels of physical activity. Behind each spectacular performance there is a systematic and careful management of eating habits. Many factors affect nutrient needs and its availability, including the sportsmen physical condition, nutritional status, age and genetic background. Diets do not create strong bodies or increase speed. Strength, power and endurance come only through training. The diet mostly provides the necessary raw materials that allow the training that build and run the human machine (Chandrasekar, 1989). Therefore good, well-balanced nutrition plays a vital role to optimal performance of a sportsman.
The dietary requirements of a sportsman vary depending upon the intensity of the event. Sportsmen involved in endurance games require more of energy than other group of sportsmen. Since they are in stress for a long time, their caloric requirement must be met through rich carbohydrate, protein and fat sources. Vitamins and minerals have to be supplemented to avoid various deficiency disorders. Fluids are must for a sportsman in large amount in order to prevent dehydration during training (Lemon et. al., 1992).

Optimal nutrition along with supplementation are often used to enhance performance. Nutrients obtained from ingested carbohydrate rich foods provide fuel elements for initiation and maintenance of high-level performance (Crowder, 1997).

Body fat stores are of tremendous importance in sportsmen. Unlike glycogen stores, which are limited, body fat stores can fuel hours of exercise without running out. Fat is virtually unlimited source of energy. In general, the contribution of fat to the total fuel required diminishes as the intensity of exercise increases. Fat can be breakdown for energy in one way by aerobic metabolism (Whitney and Hamilton, 1990).

Protein plays an important role in the diet of sportsman. Nature of protein taken is also important and current emphasis is to include foods
rich in leucine, isoleucine, and valine. Athletes who are protein deficient may complain about having fingernails that grows slowly and break easily. Female athlete who eat a protein-poor diet may also have irregular menstrual cycle (Goyal, 2004). The protein needs vary, depending on whether an athlete is growing, rapidly building new muscle doing endurance exercise or dieting in which case protein requirements of sportsmen are higher than the current RDA of 0.4g of protein per pound of body weight which is based on the needs of non-exercise (Zawadzki, 1992).

Various studies show that athletes who refueled with carbohydrate and protein had hundred percent glycogen stores than those who only had carbohydrate. The insulin was also highest in those who consumed the carbohydrate and protein drink. After exercise, consuming a sports drink enriched with protein results is much faster sports drink (Masa & Lige, 2003). According to Niles et. al 2001, sports supplements that provide the amino acids necessary to restore muscle glycogen and rebuild muscle tissue that is damaged during intense, prolonged exercise would be beneficial. It also increases and improves the absorption of water from the intestines and improves muscle hydration. The amino acids in protein can also stimulate the immune system making the individual more resistant to colds and other infections. Branched chain amino acids L-leucine and L-
valine help to increase the Bio-availability of high complex carbohydrate intake and are absorbed by muscle cell for anabolic muscle building activity (Goyal, 2004).

The current theory states that during prolonged exercise, the branched chain amino acids are released from skeletal muscle, the carbon part is used as fuel and the nitrogen part is used to make the amino acid alanine which then goes to the liver where it is turned into glucose for energy. So for the sportsmen who want to protect their existing mass, the advice is to take a branched chain amino acid source before the year. Available research supported the fact milk protein; whey protein in particular is an ideal protein supplement for sportsmen (Goyal, 2003).

Branched chain amino acid in whey protein promote protein synthesis and increases the availability of complex carbohydrates and help to prevent the breakdown of lean muscle mass. Whey protein are also rich sources of cysteine and methionine and these play an important role in maintaining the level of natural anti oxidants which enhance immune response and quench free radicals. Casein also contains higher amounts of essential amino acids and usually is the standard against which the qualities of other protein are compared.
The nutritional requirements are much higher than that of normal individuals and hence utmost attention should be given to the diet. To meet the demands of nutrients, foods with high nutrient density can be included. Milk proteins namely casein and whey have been enriched naturally with essential amino acids and hence would form ideal foods for supplementation.

India being a global giant in milk production and since low cost membrane technologies is available now to recover these proteins from milk and they can be utilized for the preparation of health supplements for sportsmen. Research findings support the evidence that carbohydrates in combination with good quality protein food sources can help to suffice the additional demands of the body during training and meets. The supplements should be easy to consume, economical, digestible easily and must also provide psychological satisfaction.

1.2 Sports Performance

Sports is a world wide phenomenon today. In no period of the world history sport was so popular, organised and important as today. There are numerous federations which organize sports competitions every year at various levels and also encourage participation in sports by providing technical and material facilities.
In performance sports, competitions provide the means by which one can show one's worth by competing successfully. Consequently sports competitions have triggered off a vigorous competition in research on sports physiology, sports psychology, sports training, sports nutrition and sports medicine. Competitive sports have brought into sharp focus a number of means for improvement and achieving high level performance. Everywhere new efforts are on to set up research laboratories so that ways and means could be found out to access and accelerate human performance in sports.

Arthur Jones (1977) has defined sports performance as a unity of execution and result of sports action or a complex sequence of sports action measured or evaluated according to agreed and socially determined norms. It's further exploration and determination need an integrated effort of various science disciplines and theory and methods of specific sports.

Sports performance not only denotes the psychomotor capacity of an individual sportsman but also gives expression of the overall efficiency of a nation and society. The countries which win greater number of medals in Olympics have better political, social and cultural conditions which are indispensable for producing world champions.
1.2.1 Prerequisites of High Level Sports Performance

A number of factors are responsible for high level sports performance and many authors have attempted to identify the factors in different ways. In modern days highly competitive sports essentially require a very effective and specific selection of participants, improved training procedures, advanced techniques, modern equipments, congenial environment and suitable diet.

Sports technology has so advanced into the sports area for enhancing performance. Science and technology has brought wonders and its application in the field of sports has been miraculous. To bring success, scientific methods are used to coax every centimeter, every fraction of a second and every ounce of energy out of an athlete who is considered to be almost a machine.

There are a number of important performance prerequisites for good performance in a sport. Some of the factors are aerobic capacity, the ability to use anaerobic reserves, mobility, agility, balance, speed, strength, power, endurance, skills, tactics, intelligence, coordination, good eye sight, peripheral vision, reaction time, perceptual ability, motivation, concentration, dedication, adequate rest, food, sleep, coaching facilities, specific physical preparation and countless physiological and psychological factors.
Hardayal Singh (1982) describes that the sports performance is the result and expression of the total personality of the sportsman. Certain personality traits, beliefs and values, motives and interests are indispensable for successful performance in a sport. The role of technique and co-ordinative abilities is self evident. Tactical knowledge, tactical abilities are of high importance in team and combative sports. The physical fitness abilities form the sound base for achievement and execution of high level sports performance. Also the constitutional factors like body weight, height, physique, body proportions, stability of the musculo-skeletal system play a vital role in performing better way.

Kregher (1983) adds that a sportsman’s performance depends to a great extent on nothing more than his state of mind. There may be other factors to consider as well his strength of body, his level of skill, the play arises between him and his opponents. These all have their effect on the final outcome. But they are secondary in importance to the sportsman’s will to win, which is the heart of all competition and the impetus for all athletic genius. The way an athlete finds to deal with the tension, anxiety and depression involve in the performance in the competition.

According to Gurdial Singh (1986) to win in international sports, a superb physical fitness and best training of the individual are important factors. Philosophers, psychologists and teachers all testify to the three
areas of human development that are critical to growth; the physical, the mental and the emotional. Kriese (1989) describes that a player must also develop his whole person in order to develop his game. He must be physically capable of skill, mentally recognize and have confidence in that capability.

1.3 Importance of Proper Nutrition in Sportsmen

Success can largely be attributed to talented athletes working within flexible well concerned progressive long term programs with good nutrition as the strength, speed and endurance vary with nutritional status.

There is a general agreement on the relative nutrient demands of the athletes concerning the percentage of energy to be derived from protein, fats and carbohydrates. But there is no conclusive, evidence related to nutrition and physical performance. For Indian athletes definite conclusion on their diets and nutritional requirements is needed for optimum performance.

Sports nutrition represent the application of nutritional principles to sport, which enhance the performance of the sportsman. Grandjean et. al. (1993) stated that optimal nutrition can reduce fatigue allowing an athlete to train and compete longer or recover faster between training sessions and also reduce susceptibility to disease and injury. It helps in achieving
and maintaining health. Optimal nutrition is not the consumption of excessive calories that would result in obesity but the nutrient intake necessary to maintain man in maximal physical condition for athletic or other performance (Worthington 1981).

There are six major nutrients in our body. They are water, carbohydrates, proteins, lipids, vitamins and minerals. The human body requires 17 vitamins and 24 mineral elements for various day-to-day activities. The composition of human body is 60-62 percent water, 17 percent proteins, 14 percent fat, 6 percent minerals and 1 percent carbohydrates. In infants the percentage of water is more as compared to an adult. In women water content is slightly lower whereas fat content is more than in men. Fat deposition in the body increase with age.

Percentage Composition of Human Body

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Man</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>60-62</td>
<td>54</td>
</tr>
<tr>
<td>Protein</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Fat</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>Minerals</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Vitamins are present in negligible amounts.
Relationships of food to health have been made from the research conducted by chemists, microbiologists, pathologists and nutritionists from the past two centuries.

Human nutrition is governed by many factors like food habits and behaviour, food beliefs, ethnic influences, geographic influences, religious and sociological factors, psychological factors, food and production, income, national and international food policies, food technology, processing, fisheries, transportation, marketing, educational status and other mass media facilities.

The benefits of food nutrition are health, happiness, efficiency and longevity.

1.3.1 Optimum or Adequate Nutrition

When all the essential nutrients are present in a correct proportion as required by our body, it is called optimum nutrition or adequate nutrition. Optimum nutrition is required to maintain good health.

There are certain signs of good nutrition. They are height and weight for the age, clear complexion, fresh and lively skin and hair, healthy pink nails, correct posture and gait inquisitive and alert eyes.
good appetite and bowel evacuation, emotional maturity and confident
deeds and pleasing personality and optimum in life and overall health.

The provision of good nutrition in combination with proper
training encourages an athlete to give high performance where as poor
nutrition leads to the dark side of failure and dejection.

Adolescent athletes are elite part of society. Particularly young
girls who are in pubertal stage need an extra energy, protein, increased
amount of iron and calcium etc.

Sports activity involves expenditure of a high level of energy and
greater loss of protein and other nutrients. The energy in take and
proposition of energy obtained from the macronutrient determine the
ability to perform the various athletic activities.

The right diet for sports person is a balanced diet. The athletes need
a balanced diet to keep in good health to grow, to exploit his / her
potential to the full and to obtain the best result.

Iron deficiency anemia sometimes appears in girls after they starts
menstruating, especially if they are involved in athletic activity, which
produce fatigue often.
William, M.H. (1988) said that proper nutrition is an important component in total training program of an event. Certain nutrient deficiencies can seriously impair performance, while supplementation of other nutrient may be helpful in delaying fatigue and improving performance.

Basically, the nutritional needs of sportsman are similar to non-sportsman with the exception of calories and fluids. A diet that provides a variety of foods supplying 55 to 65% of calories as protein and 20% to 30% calories as fat is recommended for health as performance.

In 1980, U.S. Department of Agriculture, Health and Human services (HHS), jointly established the dietary guidelines for sportsman. This guidelines was modified in 1995, which emphasize balance, variety and moderation in the diet and serve as the nutrition guide for athletes.

The 1995 guidelines are:

- Eat a variety of foods.
- Balance the food you eat with physical activity. Maintain or improve your weight.
- Choose a diet with plenty of grain products, vegetables and fruits.
❖ Choose a diet low in fat, saturated fat, and cholesterol.

❖ Choose a diet moderate in sugar.

❖ Choose a diet moderate in salt and sodium.

❖ If you drink alcoholic beverages, do so in moderation.

Research conducted over the past twenty years has provided us with many of the answers relative to the role of nutrition in athletic performance, but some of the research findings have been misinterpreted or exaggerated so that a number of misconceptions still exists (Simon, N.J., 1982).

Nutritional needs for sportsman was classified by Bower et. al., (1997) into 3 fundamental classes.

1) Energy nutrients, 2) Vitamins and minerals and 3) Water

1.3.2 Energy Nutrients

Carbohydrate, protein and fat are the major foodstuffs, which are capable of serving as a fuel for generating ATP energy during performance. The energy cost of any activity is determined by type of exercise. During training daily requirement vary from 3000 Kcal to 5000 Kcal. No one nutrition could supply 100 percent of the calorie intake. The calories taken in as food should be approximately equal to the caloric
expenditure resulting from body maintenance and physical activities of the total calories taken in a certain proportion should be derived from each of the three food nutrients given below

<table>
<thead>
<tr>
<th>Food Nutrient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>10-15%</td>
</tr>
<tr>
<td>Fat</td>
<td>25-30%</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>55-100%</td>
</tr>
</tbody>
</table>

**Carbohydrate**

The caloric requirements of athletes are frequently doubled during periods of intense physical activity and it is recommended that under these circumstances athletes eat five to six meals per day (Rose Marry et. al., 1997). According to Rudd, (1996) carbohydrate requirement vary depending on age and size. A sportsman with more muscle mass will require more carbohydrates. The amount of carbohydrates needed also depends on the intensity and level of training. Consuming carbohydrates during exercise can delay fatigue and improve performance by preventing blood glucose levels from declining in the latter stage of prolonged exercise.

Sherman et. al., (1991) studied that cycling performance was improved by 15% when athletes consumed 312g of liquid carbohydrate 4 hours before moderately intensive exercise. In 1993 Sherman suggests that endurance athletes who train aerobically for more than 90
minutes, daily need approximately 8 to 10 grams of carbohydrate / 1 kg body weight / day to adequately restore glycogen levels (560 to 700 total grams of carbohydrate of 60 to 70% of total calories intake).

Sherman et. al (1991) has reported that athletes who consume carbohydrates before exercise have the potential to significantly increase their carbohydrate stores and enhance training and performance capacity.

Wright et. al., (1991) stated that consuming 0.2g carbohydrate / kg body weight every 20 minutes resulted in a 32% improvement in endurance time and 34% improvement in total work output.

Ivy et. al., (1999), said that endurance athletes should consume at least 1.5g of carbohydrate / kg / body weight immediately and again 2 hours after exercise to maximize glycogen resynthesis.

**Protein**

Athletes often choose a high protein diet because muscles are built of protein. Actually a well balanced diet should give athletes enough protein (Y.H. Hur 1985) Rudd J.S. (1996) state that both endurance and strength training increase the need of protein in the diet. This increased need may occur directly, as a result of changes in amino acids metabolisms or indirectly, as a result of insufficient energy in take.
Lemon, and Nagal (2001) showed that exercise causes an increased utilization of several amino acids particularly the branched chain amino acids and that under certain conditions such as decreased muscle glycogen, total oxidation may become significant. Endurance athletes require between 1.2 and 1.4g/Kg body weight / day of protein. This additional protein is needed to cover for the increased loss of amino acid during exercise to help repair exercise induced muscle damage (Lemon P.W.R., 1995). In the case of younger athletes it is still growing to i.e., 1-2g kg body weight YH Hur (1985).

**Fats**

The major advantage attributed to the use of fats as a source of energy during exercise is the role of fatty acid oxidation in sparing muscle glycogen. During endurance exercise, carbohydrate reserves are depleted and the body relies on the breakdown of fat energy production. When carbohydrate stores are low, the breakdown of fat for ensures that the muscles energy needs can be met. The ability to obtain a substantial proportion of energy from fat is imported for athletes such as cyclists, runners and triathletes who exercise for prolonged periods of time and need to conserve muscle glycogen stores for the later stages of training or competition (Rudd 1996).
Vitamins and Minerals

Richard et. al., (1994) stated that, most health experts suggest that athletes consume around 30% of total calories from fat. Fat should be consumed 3 to 4 hours prior to competition because fats are digested slowly. A sportsman who is on a balanced diet has no need for vitamin and mineral supplementation. Van Eric Baart et. al. (1989) suggested that thiamin requirements might be higher in athletes consuming high-calories, high carbohydrate diets. The need for Vitamin E may be increased in athletes exercising at high altitudes. Vitamin and minerals are required for the production of energy, tissue maintenance and repair. Calcium is important in maintaining bone mass and muscle contraction. Iron is required not only for blood formatting elements but also for enzymes in muscles required for oxygen transport (Davis Errol Cajamus 1996).

According to Barrow et. al., the level of iron in the blood of sportswomen have been found to be significantly decreased after heavy physical training. Thus, female athletes especially those who have heavy blood losses, can take supplementation of extra iron in their diets.

Water and Electrolytes

Water is an important nutrient for the athlete. It must be consumed regularly and in sufficient amounts to ensure normal functioning of the
body and thermal regulation. Failure in the replace water loss results in dehydration which can lower the performance.

All athletes need to be aware of the effect of heat, humidity and dehydration. During strenuous prolonged exercise, some athletes can lose up to 3 liters of sweat per hour. Athletes should consume 500 ml every 15 to 20 minutes before exercise and 118 to 177 ml of fluid every 10 to 15 minutes during exercise. Sodium is the electrolyte most affected by physical exercise. The athlete’s typical diet provides enough sodium; potassium and other electrolytes to replace sweat (Rudd, 1996).

Electrolyte Concentrations and Osmalarity Sweat, Muscle and Plasma (mmOL/I)

<table>
<thead>
<tr>
<th></th>
<th>Na</th>
<th>A</th>
<th>K</th>
<th>Mg</th>
<th>Osmalarity (MOs mol/I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweat</td>
<td>40-60</td>
<td>300-50</td>
<td>4-5</td>
<td>1.5-5</td>
<td>80-185</td>
</tr>
<tr>
<td>Plasma</td>
<td>140</td>
<td>101</td>
<td>4</td>
<td>1.5</td>
<td>302</td>
</tr>
<tr>
<td>Muscle</td>
<td>9</td>
<td>9</td>
<td>162</td>
<td>31</td>
<td>302</td>
</tr>
</tbody>
</table>

Source: Costill and Miller, 1990.
Energy and Nutrient needs of Sportsman

<table>
<thead>
<tr>
<th></th>
<th>Energy (Keal)</th>
<th>Pro (g)</th>
<th>Fat (g)</th>
<th>Ca (g)</th>
<th>Fe (mg)</th>
<th>Vitamin A (IU)</th>
<th>Vitamin B1 (mg)</th>
<th>Vitamin B2 (mg)</th>
<th>Vitamin B3 (mg)</th>
<th>Vitamin C (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6000</td>
<td>225</td>
<td>200</td>
<td>3.0</td>
<td>85</td>
<td>2500</td>
<td>6</td>
<td>6</td>
<td>60</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>5200</td>
<td>195</td>
<td>144</td>
<td>2.5</td>
<td>75</td>
<td>2000</td>
<td>5</td>
<td>5</td>
<td>80</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>4500</td>
<td>160</td>
<td>120</td>
<td>2.0</td>
<td>60</td>
<td>1500</td>
<td>4</td>
<td>4</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>3600</td>
<td>135</td>
<td>120</td>
<td>1.5</td>
<td>50</td>
<td>1000</td>
<td>3</td>
<td>3</td>
<td>35</td>
<td>80</td>
</tr>
</tbody>
</table>

* Group

I. Power event of higher weight category

(80-10 Kg and 70 Kcal / kg weight)

II. Endurance events with daily energy expenditure

(60-70 Kg and 80 Kcal / kg weight)

III. Team events and power events of middleweight category

(65Kg, 10 Kcal / kg Body weight)

IV. Events of lightweight category

(60Kg, and 60 Kcal / kg Body weight)

Sources: Satayanarayana et. al., 1985
1.4 Importance of Protein

Protein plays an important role in the diet of sportsman. Nature of protein taken is also important and current emphasis is to include food rich in leucine, isoleucine, and valine. Athletes who are protein deficient may complain about having fingernails that grow slowly and break easily. Female athletes who eat a protein-poor diet may also have irregular menstrual cycle (Goyal, 2004). The protein needs vary, depending on whether an athlete is growing, rapidly building new muscle doing endurance exercise or dieting in which case protein requirements of sportsmen are higher than the current RDA of 0.4kg of protein per pound of body weight which is based on the needs or non-exercise (Zawadzkl 1992).

Proteins are very complicated molecules. They are truly the physical basis of life, because every function in the living cell of our organism depends on them.

Some scientists call this nutrient VIP – very important protein.

Its main function is to build up, keep up, and replace the tissues in your body. Our organs, muscles, and even some of our hormones are made up mostly of protein.
Take care of your organism and never miss your chance to give it some more protein.

Cribb (2005) More than any other area of sports nutrition, the topic of protein intake for athletes has been a point of much confusion and debate. Much of the controversy surrounding protein recommendations can be contributed to the realization that requirements for various amino acids in adults may be much more complicated than previously assumed. There are many gaps in our understanding of protein requirements for healthy, active people; this lack of biological understanding has exacerbated the difficulties of resolving the controversies. When bodybuilders and other athletes determine their daily protein requirements they should consider the following pertinent facts.

• The current laboratory measures used to assess protein requirements are not concerned with optimizing health or enhancing physical performance.

• Protein recommendations for healthy populations have been based almost entirely upon nitrogen balance studies. Yet protein metabolism scientists now acknowledge that this method is flawed. The nitrogen balance technique overestimates nitrogen (protein) intake and underestimates nitrogen losses.
• Exactly how much protein an athlete needs to optimize results from training is not easy to determine. Individual goals, calorie intake and exercise intensity, duration and type, as well as training history, gender and age all shape a person’s protein requirements.

• Until the various functions of amino acids are understood at both the mechanistic and quantitative levels, the current dietary recommendations for both healthy and sick humans are intellectually unsatisfactory empirical values. (Some scientists are smart enough to admit that previous recommendations were way off; protein requirements to optimize results from intense exercise training may be higher than previously suspected.

• While it has been established that athletic individuals require a higher protein intake than sedentary people (at least double the recommended dietary allowance), an ever-increasing amount of research shows that some types of protein improve health and enhance athletic performance better than others.

Finally, there is no evidence in the scientific literature that suggests a high protein intake (up to 3 times the RDA) harms a healthy body. In fact, increasing the ratio of protein in the diet is now considered a safe, effective strategy that provides a number of health benefits such as lower
blood lipid concentrations, improved insulin/glucose metabolism and reduction of unwanted body fat.

**Casein and Protein**

The protein fraction of milk is composed of casein, lactalbumins and lacto globulins (when protein), Casein called a phosphoprotein is a complicated chemical mixture. Several components, including alpha, beta and kappa – caseins, are combined in an orderly fashion to form approximately spherical micelles that are colloidally dispersed as micelles in the aqueour medium (Rose et. al., 1970, Web et. al., 1970).

Casein is the principal protein of cow’s milk produced by controlled acidification of pure pasteurized skim milk resulting in the precipitation of casein curd. The curd is washed to remove other milk solids prior to grinding. It contains 21 amino acids (Paris diary, 2000). Casein is normally yellowish white in color for cow and chalky white for buffalo milk has a faint pleasant cooler, a slightly acid taste, a total acidity is high because of acidifications. Acid casein agranular milk protein, is available in 2 types edible and technical (Hemandoz 2002). Technical and caseins have good binding properties and are used for the manufacture of paper coatings, paints, fabrics and cosmetics.
Edible acid casein is highly nutritional, low in fat and cholesterol and flavorful, making it ideal for medical and nutritional applications. It is used in coffee whiteners, infant formulas, and cheese and for use in pharmaceutical products. Hydrolyzed casein is casein that has been broken down partially or completely to its constituent’s amino acids and is often used in canned fish as hydrolyzed.

Caseinates are the salts of casein made by dissolving acid casein in a suitable hydroxide and drying it to make a water-soluble product. Calcium caseinate is used in nutritional beverages processed cheese and frozen desserts because it has a milky appearance and smooth feel in mouth.

Edible Casein is Used

1) For nutraeuticals, health foods, dietetic and infant food applications.

2) For medicinal nutrition and geriatric foods.

3) For lactose free food formulation.

4) For sports food and weight management formulae.

5) For conversion of caseinates, hydrolysates.

6) For meat products, baked goods, applications etc.
Casein provides protein - $N \times 6.25 - 94.7\%$

True protein digestibility - 99\%

Amino acid score - 1.19\%

Protein digestibility corrected score - 1.00

Casein with wheat flour blend provides

True protein digestibility - 95\%

Amino acid score - 0.96\%

Protein digestibility corrected score - 0.91

Source: Sarwar. G (1990)

**Whey Protein**

Whey is the serum of watering part of the milk that remain after separation of curd that results from the acid and proteolytic enzyme mediated coagulation of milk. It is a major by-product of dairy industry, obtained during manufacture of product like channa, paneer, cheese and casein (Sharma et. al., 1999). Parekh et. al., (1997) stated that Whey is a source of carbohydrate, minerals, proteins and water soluble vitamins. It is estimated that 30\% of the milk production is utilized for cheese production which generates nearly 83,030 million Kg of whey (Regester et. al. 1996). Shilpa Viji and Gandhi in 1993 reported that the total...
amount of whey produced in India is more than 16,000 metric tones annually. The world wide production of whey is reported to 1.5 million metric tonnes / annum.

Whey proteins are a combination of various protein fractions, as per details given below:

<table>
<thead>
<tr>
<th>Protein Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total whey protein in milk</td>
<td>0.62%</td>
</tr>
<tr>
<td>α-Lactoglobulin</td>
<td>0.30%</td>
</tr>
<tr>
<td>β-Lactalbumin</td>
<td>0.12%</td>
</tr>
<tr>
<td>Serum Albumin</td>
<td>0.04%</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>0.07%</td>
</tr>
<tr>
<td>Protease peptones</td>
<td>0.06%</td>
</tr>
<tr>
<td>Minor proteins</td>
<td>0.03%</td>
</tr>
</tbody>
</table>

Whey proteins are recovered by passing pasteurized whey through ultrafiltration membranes to concentrate protein to various level between 20% to 80% as per requirement (Goyal, 2003).
The standard composition of whey proteins is given below:

### Standard Composition of Whey Protein

<table>
<thead>
<tr>
<th>Product</th>
<th>Moisture</th>
<th>Protein</th>
<th>Lactose</th>
<th>Fat</th>
<th>Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whey Protein 80</td>
<td>5</td>
<td>80</td>
<td>04</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Whey Protein 70</td>
<td>5</td>
<td>70</td>
<td>14</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Whey Protein 60</td>
<td>5</td>
<td>60</td>
<td>24</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Whey Protein 45</td>
<td>5</td>
<td>45</td>
<td>40</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Whey Protein 35</td>
<td>5</td>
<td>35</td>
<td>50</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

The properties and nutritional characteristics of whey proteins:

1) Physical and Chemical properties of whey proteins:

   a) Both hydrophobic and hydrophilic regions are present.

   b) Easily heat denatured.

   c) Stable in milk and acidic environment (Ramesh Chandan, 1996)

2) Biological Value

   It is the amount of protein nitrogen that is retained by the body from the given amount of protein nitrogen that has been consumed (European Dairy Association, 2000).
European Dairy Association gave the biological values for different sources of proteins which is listed below:

- Whey proteins : 104
- Whole egg : 100
- Egg white (albumin) : 88
- Casein : 77
- Rice : 74
- Soya : 59
- Wheat : 54

3) Protein Efficiency Ratio

It is used as a measure of growth expressed in terms of weight gain of an adult by consuming 1 gm of food protein.

<table>
<thead>
<tr>
<th>Protein Source</th>
<th>Protein Efficiency Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.00</td>
</tr>
<tr>
<td>Rice</td>
<td>1.25</td>
</tr>
<tr>
<td>Soya</td>
<td>2.12</td>
</tr>
<tr>
<td>Casein</td>
<td>2.50</td>
</tr>
<tr>
<td>Lactalbumin</td>
<td>2.86</td>
</tr>
<tr>
<td>Whey proteins</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Source : New Zealand Dairy Board (1991)
4) Essential Amino Acids Profile

Essential amino acid profile for whey protein, casein and other protein foods are given below:

**Protein Sources per gm of Protein**

<table>
<thead>
<tr>
<th>EAA</th>
<th>Wheat</th>
<th>Rice</th>
<th>Soya</th>
<th>Egg</th>
<th>Casein</th>
<th>Whey protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iso-leucine</td>
<td>14</td>
<td>15</td>
<td>21</td>
<td>28</td>
<td>46</td>
<td>55</td>
</tr>
<tr>
<td>Leucine</td>
<td>27</td>
<td>32</td>
<td>31</td>
<td>34</td>
<td>91</td>
<td>11</td>
</tr>
<tr>
<td>Lysine</td>
<td>11</td>
<td>15</td>
<td>26</td>
<td>29</td>
<td>77</td>
<td>88</td>
</tr>
<tr>
<td>Methionine</td>
<td>6</td>
<td>10</td>
<td>5</td>
<td>14</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Phenylanine</td>
<td>18</td>
<td>18</td>
<td>19</td>
<td>23</td>
<td>51</td>
<td>34</td>
</tr>
<tr>
<td>Theronine</td>
<td>12</td>
<td>15</td>
<td>16</td>
<td>21</td>
<td>43</td>
<td>70</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Valine</td>
<td>18</td>
<td>25</td>
<td>24</td>
<td>29</td>
<td>57</td>
<td>52</td>
</tr>
<tr>
<td>Histidine</td>
<td>21</td>
<td>21</td>
<td>24</td>
<td>21</td>
<td>30</td>
<td>22</td>
</tr>
</tbody>
</table>

Source: Nutritive value of Indian Foods by C. Gopalan and New Zealand Dairy Board (1991)

Whey protein provides excellent nutritional values hence suitable in nutritional foods formulated for kids, adults and old aged people for body health and maintenance.
Nutritional experts suggest that only 14.5 g of whey proteins in native form will satisfy the daily requirements of Essential Amino Acid as compared to 17.4 gm of Egg proteins (Tadeusc Sienkiewiez, 2002).

Whey protein are rich in calcium and phosphorous and provide good bio-availability of these minerals essential for bone formation and better bone strength.

**Clinical Application of Casein and Whey Protein**

Edible casein are used in neutraceuticals and healthy foods formulation. Because of high quality protein and easy digestability of casein it is used in sports food and weight management formulae. Whey proteins have been enriched by nature with branched chain amino acid. These branched chain amino acid must be present in the muscle cell to promote protein synthesis of the Branched chain amino acid.

Leucine plays a central role in promoting muscle protein synthesis. This Branched chain amino acid helps to increase the bio-availability of high complex carbohydrate intake and are absorbed by muscle cells for anabolic muscle building activity.

During prolonged exercise, the branched chain amino acid are released from skeletal muscle, the carbon part is used as fuel and nitrogen
part is used to make the aminoacid alanine which then goes to the liver where it is turned into glucose for energy. So for athletes who want to protect their existing muscle mass, the idea is to take a Branched chain amino acid source before and after exercise. The use of Branched chain amino acid in sports nutrition especially in making exercise feel easier. These amino acids improve the turnover of muscle protein which is very important in athletes and also helps in speedy repairing of injured and torn muscles during practice and performance (Goyal, 2004).

1.5 Diets during Physical Training

According to Steel (1970), Nutrition is an important feature of any training program. Education of coaches and athletes is needed in regard to both nutritional needs and the role of different foods in the diet. A study of Australian Olympic athletes showed great variability in their diets and in their nutrition knowledge. Intakes of some nutrients were much higher than is required, particularly protein, calcium and Vitamin C and although these are usually harmless, the diets would be economical. Some diets were below recommended levels of thiamin if the large energy need of the athletes is taken into account. Records in the competition showed that those whose thiamine intake was adequate
placed better, some winning medals, in comparison with the ones whose diets were suboptimal in thiamine content.

Yoshimura (1970) stated during training there is an increased need for protein, in the order of 2 gm per kilogram of body weight. Muscle tissue must be built, and there is an increase of plasma protein and of iron containing muscle and blood proteins. During very strenuous, stressful physical work, the red blood cells become fragile and there is a transient anemia that is corrected after about 2 weeks of training. If the diet is adequate in protein and iron reserves are normal.

Meyar and Bullen (1980) stated, diet must be adequate in all essential nutrients, but there is no evidence that supernormal intakes of nutrients will do anything to improve work capacity. A good diet-one based on meat, milk, fish, poultry and eggs, whole-grain cereals, legumes and nuts, leafy, green vegetables and other vegetables and fruits will meet all the nutritional requirement of athletes and persons engaged in hard physical labor.

1.6 Supplementation

For competitive athletes, the diet must provide the optimal mix of nutrient to fuel their special needs. The idea that specific nutrients might enhance athletic performance and confer athletic process is now new.
Many nutritional supplements are marked as ergogenic aids, or performance-enhancing aids.

Good nutrition must be a key part of your training program. If you succeed there is not one “miracle food” or supplement that can supply all of your nutritional needs. Certain foods supply mainly proteins, other foods contain vitamins and minerals, and so on.

Eating the right food helps you maintain desirable body weight, stay physically fit and establish optimum nerve–muscle reflexes. Without right foods, even physical conditioning and expert coaching aren’t enough to push you to your best.

Nutritional and medical support is essential for the relation of the athlete’s natural capacity for optimal performance.

Athletes especially female adolescent should focus special attention on iron intake. So that sports anemia can be prevented.

A pregame meal should be a light meal and eaten 2 to 4 hours before an endurance event to top off muscle and liver glycogen stores.

Burke, and Read (1993), from their studies of the dietary practices of athletes report that nutritional supplements are commonly used. Supplementation practices vary between sports and individual
athletes; however, there is evidence that at least some athletes use a large number of supplements concurrently, often in doses that are very high in comparison with normal dietary intakes. In exploring supplementation practices we propose a classification system separating the supplements into dietary supplements and nutritional ergogenic aids. The dietary supplement is characterised as a product which can be used to address physiological or nutritional issues arising in sport. It may provide a convenient or practical means of consuming special nutrient requirements for exercise, or it may be used to prevent/reverse nutritional deficiencies that commonly occur among athletes.

The basis of the dietary supplement is an understanding of nutritional requirements and physiological effects of exercise. When the supplement is used to successfully meet a physiological/nutritional goal arising in sport it may be demonstrated to improve sports performance. While there is some interest in refining the composition or formulation of some dietary supplements, the real interest belongs to the use or application of the supplement; i.e., educating athletes to understand and achieve their nutritional needs in a specific sports situation.

The sports drink (carbohydrate-electrolyte replacement drink) is a well known example of a dietary supplement. Scientific attitudes towards the sports drink have changed over the past 20 years. Initial caution that
carbohydrate-electrolyte fluids comprise gastric emptying during exercise has now been shown to be unjustified. Numerous studies have shown that 5 to 10% solutions of glucose, glucose polymers (maltodextrins) and other simple sugars all have suitable gastric emptying characteristics for the delivery of fluid and moderate amounts of carbohydrate substrate. The optimal concentration of electrolytes, particularly sodium, remains unknown. Most currently available sports drinks provide a low level of sodium (10 to 25 mmol/L) in recognition that sodium intake may promote intestinal absorption of fluid as well as assist in rehydration. The sodium level of commercial oral rehydration fluids (used in the clinical treatment of diarrhea and dehydration) is higher than that of the present range of sports drinks. However, even if research indicates that intestinal glucose transport is optimally stimulated at higher sodium concentrations, concern for the palatability of sports drinks may impose a lower ceiling for sodium levels. Commercial viability of a sports drink requires that it provide a refreshing and palatable fluid replacement across a wide variety of sports and exercise situations.

Importance of Supplements

Buike and Read (1993) stated / reported on studies of the dietary practices of athletes report that nutritional supplements are commonly used. Supplementation practices vary between sports and individual
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Although supplementation and sports food receive most of the glamour and attention in sports nutrition, they really should be thought of as “icing on the cake” rather than substantial fare. The following figure shows that the process of eating well to achieve the nutritional goals of training achieves the most important benefits.

Desbrow and Minehan (2000) reported the sports world is filled with special foods, potions, pills and powders that promise to provide the athlete with the performance edge. Advertisement and testimonials for these products claim prolonged endurance, faster recovery, increases in muscle mass and strength, losses of body fat, and resistance to fatigue, illness or infection. Such promises are attractive to athletes and coaches,
especially in elite competition where very small difference separate the fame and fortune of winning from the anonymity of the rest of the field. Yet external rewards provide only part of the drive to find a “magic bullet”, because even non-elite and recreational athletes show considerable interest in using sports supplements.

**Effect of Supplementation in Sportsmen**

Burke and Reed (1993) stated that dietary supplementation is characterised as a product, which can be used to address physiological and nutritional requirements for sportsmen. The basis of dietary supplementation is an understanding of nutritional requirements and physiological effect of exercise. They also concluded that there is a need for nutrition education of sports person to explain the appropriate use of dietary supplements.

Flakoll, et. al., (2004) in his study stated that supplements of a supplement containing higher proportion of protein than carbohydrate and fat immediately after exercise enhanced muscle protein deposition, thus having a positive impact on health, muscle soreness and tissue hydration during prolonged intense exercise training. Blomstand et. al., (2001) supplemented Branched chain amino acid for seven healthy male cyclists during an hour of ergometer cycle exercise and a 2 hour recovery period.
The results of the study proved the Branched chain amino acid have a protein sparing effect during the recovery after exercise.

Tanfuchun and Lee Chihwen Hgieh Yu (1998) selected 19 male athletes randomly and divided into groups. The groups were given either placebo or Branched chain amino acid (2.2g) in addition to a high carbohydrate (approx. 84%) formula diet one hour before an exhaustion program and after exercise. It was found that Branched chain amino acid tend to increase exercise endurance.

Ivy et. al., (2002) found the effect of supplementation of 7 male cyclist. They were given either carbohydrate or carbohydrate – protein supplements within 10 minutes and two hours post exercise. The results showed that carbohydrate – protein supplementation of muscle glycogen after exercise is better than the supplements based only on carbohydrate.

Panton et. al., (2001) in his study found that nutritional supplementation of the leucine metabolite – hydroxy β-methyl butyrate (HMB) during the resistance training increased upper body strength and minimize muscle damage.

Maisey, et. al., (2004) formulated a beverage containing 112g of carbohydrate with protein 0.3g. He found that this beverage provided 1.5g
of carbohydrate per kg body weight following glycogen depletion during exercise.

A study by Pakora et. al., (1999) revealed that acceleration of sweating without noticeable differences in body temperature. Colombani, et. al., (1999) in his study investigated the influence of a milk protein hydrosylate supplemented drink on metabolism during and after a marathon run and was compared to the drink without protein. It was concluded that the supplemented protein was absorbed and probably atleast partially oxidized during the run and that no obvious negative metabolic effects occurred.

Yoshiharu, et. al., (2004) stated that branched chain amino acids supplementation before and after exercise would decrease exercise induced muscle damage and promote muscle protein synthesis.

A supplementation with beverage containing essential amino acids and sucrose was carried out by Ras Mussen et. al., (2000). The results showed that this beverage stimulate muscle protein anabolism by increasing muscle protein synthensis when ingested one hour or three after renaissance exercise.

The market is flooded with a varied number of commercial drinks, which claim to exert beneficial effects on the fitness and performance.
The intense competition in the market coupled with preference for functional foods exert pressure on processing industries to look out for functional ingredients food. Ingredients, which have high nutritional value and possess therapeutic properties, are going to play a predominant role. Since casein and whey proteins have the dual advantage of being nutritionally superior and also therapeutical benefits, are much suitable for formulated of health supplements for sportsmen. As studies related to its suitability in formulating the supplements in Sports are much limited, the present study was undertaken.

1.7 Nutrition Research in India

Nutrition Research began in India as the “Beri Beri Enquiry” unit in 1918 under Sir Robert McCarrison at Coonor Pasteur Institute. Then later it was called a “Deficiency Disease Enquiry” unit and expanded to full fledged Nutrition Research Laboratories. Under the leadership of Dr. W. R. Aykroyd, studies were conducted on the nutritive value of various Indian food stuffs.

Field studies on the diet and nutrition~1 status of people in different parts of the country were also done Dr. V.N. Patwardhan. The First Indian Director of Nutrition Research Laboratories expanded the scope of nutrition research programme to clinical, biochemical and public
health aspects. Later Dr. Gopalan established food toxicology, endocrinology and genetics departments. Field studies gained more importance. Dr. S. G. Srikantia did community based studies, particularly research on the problems related to the vulnerable groups. New lines of research such as functional consequences of growth retardation, nutritional assessment, drug-nutrient interaction were studied. Later research focus was on iron fortified salt, double fortified salt and iodised salt. In 1970, in recognition of the work being done, the institute was renamed as National Institute of Nutrition.

Lately studies have been initiated on the interaction of nutrition with degenerative diseases and cancer both from experimental and epidemiological angels.

Computerisation of data processing by National Nutrition Monitoring Bureau (NNMB) and a moden infrastructure facility for breeding and supply of pathogen free laboratory animals are recent endeavours.

Nutrition research is conducted not only at National Institute of Nutrition, Hyderabad but also at Central Food Technologies Research Institute, Mysore, units of Indian Council of Medical Research and Indian Council of Agricultural Research.
The Nutrition department of various Home Science Colleges also contribute to nutrition research.

1.8 Recent Findings

The frontiers of Nutrition Science would now seem to extend far beyond the earlier confines of “growth, development maintenance and repair” to include such other aspects of health as immunocompetence, ageing, mental well being and prevention and retardation of degenerative diseases and cancer.

There is urgent need for intensive research in sports nutrition to generate data on

- Nutrient requirement of our sports person and athletes.
- Need and justification for extra supplement of nutrient.
- To study the possible effects of early childhood malnutrition which many of our sports person and athletes might have suffered on their current performance.
- To correct any such individual during their training period.

The three basic conditions that must be observed to maintain the top physical efficiency and performance as stated y margin are
1. The general unimpaired physical and mental health.

2. Adaptation to control environment.

3. Good nutrition with adequate quantities of calories, protein, fat, carbohydrate, vitamins and fluid.

1.9 Statement of the Problem

The purpose of the study was to find out the effect of protein supplementation along with the regular physical fitness training given to experimental groups on selected physical, physiological and biochemical variables.

1.10 Hypothesis

1. It was hypothesized that physical fitness training and supplementation process may improve the selected physical fitness variables, physiological and biochemical variables.

2. It was also hypothesized that there may be significant difference among the control and experimental groups.

3. It was also hypothesized that there may be significant difference among volleyball players, basketball players and athletes who took whey protein supplementation.
4. It was also hypothesized that there may be significant difference among volleyball players, basketball players and athletes who took casein protein supplementation.

1.11 Delimitation

The study was delimited to the following aspects.

1. 15 volleyball players, 15 basketball players and 15 athletes were randomly selected from Swami Sivanandha Sports School.

2. Their age group is ranged from 13 to 15 years.

3. The nutrient rich foods stuffs were selected and formulated and it was given as supplementation in the training period.

4. Regular physical fitness training followed by sport school students was followed.

5. The study was conducted only on sports school students.

6. The supplementation was given for a period of three months.

1.12 Limitations

The study was limited to the following aspects and these limitations were taken into consideration in the interpretation of data and results.
1. The level of motivation of the students was not taken into consideration which may influence their performance.

2. The day to day activities which might have affected the performance during the test administration were considered as limitations.

3. Certain factors like habits, life style, routine work and diet which might have an effect on the results of this investigation were considered as limitation in the study.

1.13 Significance of the Study

1. To improve the performance in sports and games the results of the investigation may help to formulate supplementation process and physical fitness training schedule.

2. The results of this study may be used to measure the status and process in fitness.

3. The findings of the study may bring to light the effectives and the importance of physical fitness training and supplementation process in improving the physical fitness, hemoglobin, serum protein and physiological variables.
4. The study may be of great significance for those who are involved in research in the areas of physical education.

5. The study might be of great use in developing programmes to improve the physical fitness variables, physiological variables and bio-chemical variables of the sportsman.

1.14 Definition of Terminologies

**SPEED**

Speed is the ability to make rapid movements of the same type in the shortest possible time.

**PROTEIN**

A compound containing amino acids and one of the basic food stuffs.

**MUSCULAR ENDURANCE**

The ability of a muscle or muscle group to perform repeated contractions against a high load for an extended period of time.

or

This is the quality that enables a person to sustain localized muscle group activities for extended periods of time.
VITAL CAPACITY

Maximal volume of air forcefully expired after maximal inspiration.

CARDIO VASCULAR ENDURANCE

This is the quality that enables one to continue in reasonably vigorous physical activities for extended periods of time and where the required cardio-respiratory adjustments to the activity is built up.

STRENGTH

Strength is the amount of muscular force one is capable of exerting in a single muscular contraction.

BLOOD PRESSURE

The driving force that moves blood through the circulatory system. Systolic pressure is obtained when blood is ejected into the arteries diastolic pressure is obtained when the blood drains from the arteries.

BODY COMPOSITION

Assessment of the ratio of lean body weight (composed of muscle, bone, and other tissues) to internal and subcutaneous fat weight.

HEMOGLOBIN (Hb):

A complex molecule found in red cells, which contains iron and protein and is capable of combining with oxygen.