Chapter – I

INTRODUCTION

Today, sports have become inseparable phenomenon of our social life. It has made its own place at the apex of human civilization because of its trial, competitive event and improving nature. The acquisition of new knowledge for betterment of performance of human organism in relation to physical, motor and physiological qualities is in process of saturation. The million dollar question is one such area that plays a critical role in process of continuous sports performance improvement. Physiology as a main science has made its contributions for improving sports performance. It has helped coaches to coach more effectively and athletes to perform more proficiently. Thus, physiological aspects of exercise in sports are gaining much attention among sports administrators.

Education in its broadest sense means preparation for life and Physical Education as an integral part of education is recognized to enhance this process. Physical education provides the individual with opportunities to develop his physical, mental, social and personal skills through the medium of physical activities. In fact, physical education seems to be the most natural way of exposing the individual to situations in order to enable him to develop great
variety of skill and prepare him for acquiring rich learning experiences.

Man is a social animal and is primarily distinct from other animals in his ability to learn. He has been endowed with intelligence, which enables him to modify his animal tendencies in accordance with the demands of the environment and the society. It is, however, the education, which enhances his intelligence and capabilities, so as to ensure proper progress in life. Education is a process, which enables man to acquire knowledge through attitude, which is essential for being a human being.

Aristotle believed that play, physical training, music, debate and the study of science and philosophy were all have their place in the forming of body, mind and soul.

In 1949 Voltmer and Esslinger suggested that Physical Education is the process by which changes in the individual are brought about through his movement experiences. Physical Education is that part of education which proceeds by means of predominantly physical activity. Physical Training is perhaps the oldest and the most widely used term. The term training denotes "practical education in any profession" or "a course of diet and exercise for developing physical strengths, endurance or dexterity".

Physical education is as old as the history of mankind, because the very basis of human existence is physical activity, whether in an
unorganized form or organized life right from the pre-historic times. In his uncivilized state it was absolutely necessary for man to hunt for his food and protect himself from the wild animals. This involved vigorous running, jumping over the hills, gorges and streams, and throwing crude weapons at the animals. Sophisticated weapons which appeared with the passage of time were not available to him in early days. That is why he had to depend upon his physical prowess and skills.

The simple proposition is that, during his “struggle for existence”, man interacted with forces in such a manner that physical activity itself became a way of his life. Not only does this system lay emphasis on maintaining a sound health and fitness but also on purifying the mind, leading to the ultimate goal of life. Physical education gained much more importance in the human society and in the total education system.

Over the decades, the society in general has realized the need for keeping fit and healthy through organized physical activity programmes. Scientific evidence from biological sciences has made it clear that unless man engages in organized vigorous physical activity programmes the real benefits would not come. All round development of man must begin with the development of physique, which is the basis of his existence. The mental, the intellectual and the social developments then follow.
Charles Bucher (1960), while considering physical education essentially a process of educating the child in its totally, proposed. Physical education, an integral part of the total education process, is a field of endeavor that has as its aim the development of physically, mentally, emotionally and socially fit citizens through the medium of physical activates that have been selected with a view to realizing these outcomes.

Physical Education is an integral part of education. It is the education through physical activities for the development of total personality of the child to its fullness and perfection in body, mind and spirit. J. P. Thomas, one of the stalwarts of physical education in India remarks, “Physical education is education through physical activated for the development of total personality of child and its fulfillment and perfection in body, mind and spirit”.

Physical education is the interdisciplinary study of all area of science relating to the transmission of physical knowledge and skills to an individual or a group, the application of these skills, and their results. The complete physical education should have five principle aspects :-

- The Physical and Sports
- The Vital
- The Mental
- The Physic and
The Spiritual

The aim of Physical Education is the wholesome development of human personality or complete living. Although physical education is considered as a profession and a discipline, it must have an aim and certain objectives. J. F. Williams, a leading physical educationalist has put forward the following aim of physical education, “Physical education should aim to provide skilled leadership, adequate facilities and ample time for the individuals and the groups to participate in activities that are physically wholesome, mentally stimulating and socially sound.

The aim of Physical Education depends to a great extent for the political and social changes that take place in our society.

Only education can imbue people with the knowledge, the sense of purpose and the confidence essential for building a dynamic, vibrant and cohesive nation capable of providing its with where withal for creating better, fuller and more purposeful life. It has definitely taken us squirted sometime to realize the effectiveness of physical education and games. The aims of physical education can be expressed as:

1. To help children move in a skilled and effective manner in all selective activities in which they engage in the programme of physical education.
2. To develop an understanding and appreciation movements in children and youth so that their life becomes meaningful.

3. To develop an understanding and appreciation of certain scientific principles concerned with movements.

4. To develop through games and sports better inter-personal relationships.

5. To develop the various organic systems of the body so that they respond in healthful way to increased demand placed on them.

Through the physical activities and physiological experience, Physical Education can develop the Physiological, mental, emotional and social all-round development through the objectives for socially fit citizen and to make human resource called nature of Physical Education. Natures are –

1) To learn any type of game and sports.

2) To learn the procedure the game, duration of the game, rule of the game etc.

3) To make a good citizen.

4) To make a person who can be physically fit and mentally sound.

5) To make international good relationship.
Radhakrishnan Commission 1948-49 recommended a strong programme of physical education and sports in universities and colleges. After observing that “a sound mind dwells in a sound body” it recommended that “we may say there is lack of interest both on the part of the students and the authorities, insufficient trained personnel, death of playgrounds and equipment, poverty of students, absence of organization, poor types of program, small variety of games, conflict with academic work and inconvenience of time. There must be provision of adequate gymnasium, playgrounds and physical facilities in universities. Two years of physical education should be required of all university students except the physically unfit and those in the cadet corps.

The Mudaliar Commission (1952-53) recommended that “Physical education, group games and individual physical exercises should be given, no doubt, in the school under the supervision of Director of Physical Education. We recommend that all teachers or at least those below the age of 40 should actively participate in many of the activities of physical education and thus make it a living part of the total school programme instead of being a side issue entrusted to an isolated member of the staff we placed special value on group games as they help to mould character of students in addition to affording recreational facilities and contributing to their physical well being.
The Kothari Commission (1964 – 66) recommended that “it must be emphasized that such education contributes not only to physical fitness but also to physical efficiency, mental alertness, development of certain qualities like perseverance, team spirit, leadership, obedience to rules, moderation in victory and balance in defeat physical education should include developmental exercises, rhythmic activity, sports and games, outing activities and group handling activities simpler activities should be introduced in the early classes, more advanced ones should be gradually provided as boys and girls become more and more mature”.

Sports Psychologists are now concerned with a multitude of subjects such as violence and aggression, arousal, incentive motivation, social reinforcement, anxiety, frustration.

In today’s world there is keen sense of competitiveness in every walk of life. The urge for competition for assumed such proportion that each one of us using his or her might to outclass and excel others in achieving the specified goals or even to excel in the process of investigation, experiment and research.

The field of games and sports is a no exception to this Phenomenon of rapid development and progress. After the start of modern Olympic games a tremendous development has taken place in this discipline.
At present, competitive sports leads to a new era where the competitive sports performance has made scientist of different fields to come to a common platform and work together harmoniously to achieve excellence in a particular discipline. The quest for excellence in Olympic or World Cup events no longer makes allowances for haphazardly constructed coaching or training scheduled but the scientists in this area are working day and night discover new means a methods.

For the physiological system of the body, to be fit, the systems must function well enough to supports the specific activity that the individual is performing. Moreover different activities make different demands upon the organism with respect to circulatory, respiratory, metabolic, neurological and temperature regulating functions. Physiological fitness is specific to activity. Physiological systems are highly adoptable to exercise. Each task requires different functioning of the appropriate systems (Lawrence E. Morehouse and Augustus T. Miller).

The primary work of exercise physiologists is to describe the changes that occur in organ and organisimic is to describe the changes that occur in organism function as a result of single (acute) or repeated (chronic) doses of exercise and top explain how those functional changes occur. The first part of this task i.e. describing changes brought on by exercise, is much nearer
completion than the second explaining. The mechanism that produce changes. As one example of this lag between description and explanation, it has been known for many years that regular exercise such as running, swimming is eventually cause but there is still not experimentally verified explanation of precisely how this training effect is brought about (Robert N. Singer et al.). All human activity centers around the capability to provide energy on a continuous basis. Without continuous source of energy cells, including muscles, cease to function and they die.

Participation in Physical activities under expert leadership result in certain constructive out comes for the participants. These out comes are called objectives. Physical Education must have in mind the objectives to be achieved through participation, objectives had also classified into four categories I) Physical development objectives II) Motor development objectives III) Mental development objectives IV) Social development objectives.

The following come under the scope of Physical Education Exercise i) Corrective Exercise ii) Games and Sports and Swimming iii) Self Defence Activities, iv) Fundamental Gymnastics v) Rhythmus, vi) Recreation, vii) Yoga viii) Health Education.

The scope of physical education, at best, can be discussed from three important aspects i.e. from the view-point of subject matter, from the view-point of its beneficiaries and from the
view-point of activity programmes which are the means to the achievement of desired ends.

Physical education, like education is a life-long process and everybody—rich or poor, old or young, man or woman, intellectual or manual—benefits from participation in physical education programme. Physical education as play in infancy, as sport in childhood through adolescence and recreation in adult and old age, is omnipresent. All the nations of the world have now realized the efficacy of physical education. Physical education, as a discipline and as a profession, has touched new zenith today and its horizons are extending beyond the boundaries of the Globe. Verily, physical education is a blend of the old and the new the traditional and the progressive and the passive and the active. Hence the scope of physical education is unlimited.

Endurance like strength, speed, flexibility, coordinative abilities are the conditional ability. It is primarily determined by energy liberation process. The ability of the human body to maintain a certain level of energy production forms the physiological basis of endurance. Due its high importance for health and training and competition and also due to its physiological determinations, which can be relatively easily studied, it is an ability which has been studied in great detail and depth by the physiologist.
Endurance is directly or indirectly of high importance in all sports. It is however not easy to define endurance.

It relates to doing work for long time or period, working under fatigue conditions. It involves a large number of muscle and work efficiency.

**IMPORTANCE OF ENDURANCE FOR SPORTS:**

Endurance is a very important ability in sports. But at the same time it is an ability the importance of which is often overlooked in several sports. Endurance is the product of all physic and physical organs and systems. No other motor ability depends so much on the working capacity of complete psycho – physical apparatus of humans as endurance. All other performance factors depend on one or more parts of this psycho–physical apparatus and a result are directly or indirectly affected by endurance.

In sports, endurance ensures optimum speed of motor actions. The ability to maintain pace or tempo of an exercise or during competitions is impossible without the requisite level of endurance. Good endurance also ensures high quality or skill of movement execution which finds expression in accuracy precision, rhythm, consistency etc. under conditions the fatigue the sportsman tends to loose motor co-ordination, concentration, mental alertness etc. This clearly points out the importance of endurance for tactical efficiency.
Endurance training results in the improvement of functioning of various organs and systems of the human body. This in turn improved the ability to recover quickly from training and competition load. At the same time endurance activities enable the sportsmen to better resist the fatigue i.e. to delay the fatigue. The ability to withstand fatigue to recover faster from fatigue enable the sportsmen to tackle higher training volumes with higher intensity in a training session, week, month or year. Higher training load leads improvement in performance. From this point of view therefore, endurance is of high importance of endurance for recovery assumes much more relevance during competition i.e. in between heats rounds matches or successive days etc.

Endurance activities have been found to be of high value for maintenance of good organic health, for increasing the general resistance against infection and for cure and treatment of various disease and metabolic disorders.

Koinzer (1981) pointed out the stabilization effect of endurance activities on health of adult and children. He further argued that endurance activities in childhood have a stabilizing effect on health in later stages of life also.

Cooper (1978) points out that positive effect of endurance activity on various physiological system e.g. cardio respiratory, digestion, metabolism etc. He also stats that this activities have a
preventive and curative effect on a number of health problems e.g. blood pressure, cardiac disorder, diabetes etc.

Israil (1983) found that children who do regular sports, fall sick less frequently, they have better resistance to infections, can tolerate extreme temperatures better and their wounds heal faster. Neumann (1984) discovered that endurance loads 70-80% of best performance intensity. Over 60 min. duration have the best effect for prevention and therapy of heart – circulatory and metabolic disorder.

Performance sports aim at high sports performances and for that the physical and psychic capacities of sportsmen are developed to limits. This normally does not happen in other areas of human activity. As a result, performance sports yield valuable knowledge about the limits to which human performance and various performance factors can be developed. It also leads to discovery of means and methods for improving various physical and psychic capacities to exceptionally high level.

Sports performance is indeed an aspect of complex human performance which has several aspects of dimensions. Hence several disciplines of sports science are required to work a coordinated manner to explore the nature of sports performance and the process of improving sports performance. In the last few decades several disciplines of sports science have been established
e.g. sports medicine, sports physiology, sports training weight training, circuit training isometric and isotonic exercises, training scheduled, training load and recovery, strength training, speed training, Bio-mechanics, sports physiology etc.

All the disciplines of sports science have their own areas of study which in all cases is a certain aspect of sports performance and sports training.

Each discipline has its own qualified cadre of workers as well as means and methods of investigation.

Sports training (Hardayal Singh, 1995) scientifically based and pedagogically organized process which through planned and systematic effect on performance ability and performance readiness aims at sports perfection and performance improvement as well as at the contest in sports competition (Theies and Schnabl, 1986).

Sports training is a pedagogical process based on scientific principles, aiming at preparing sportsmen for higher performances in sports competitions. It improves the Endurance Performance Through Training, Nutrients And Health Drinks.

ENDURANCE, It is the ability to overcome resistance or to act against resistance under conditions of fatigue. Strength endurance can be a form of static or dynamic strength depending on a fact
whether the movement is static (iso-metric) or (iso-tonic) depending on the nature of combination of strength and endurance.

Sports in which heavy resistances have to be tackled under conditions of fatigue the strength endurance depends considerably on maximum strength. Most of the methods for improvement of strength endurance are variations of interval method or continuous method. For better effect of strength endurance training either special or competition exercise are used with minor adjustments regarding resistance and duration / volume of training.

Speed endurance can be improved significantly through training. For its improvement both indirect and direct methods be used both are effective methods. In indirect method effort should be made to improve anaerobic capacity (especially alactacid tolerance), explosive strength and technique.

Harre (1986) stresses the importance of basic endurance training for speed endurance. The amount of basic endurance training in speed endurance sports should be quite high up to 90% of the total training volume in the preparatory period.

The methods for the improvement of speed endurance is followed by repetition method, intensive interval method.
SHORT TIME ENDURANCE TRAINING:

This endurance ability is needed for cyclic activities lasting from about 45 seconds to two minutes. The 800 m run in track and field is a typical example of short time endurance activity. In short time endurance activities the energy is produced by a combination of glycolysis and oxidation. The contribution of alactacid mechanism is insignificant. The contribution of glycolytic process to energy production is significantly more than that of oxidation.

Short time endurance activities result in high amount of lactic acid and concentration in the muscles and blood pressure of comparatively long duration of activity the lactate values can exceed those found in speed endurance activities. Short time endurance depends to a significant extent on speed endurance and strength endurance heart rate 185-200, 100% VO$_2$ max (22% aerobic, 55% glycolysis, 23% alactacid) Production (250kj/min, 380-460 kj total energy consumption, 10% muscle glycogen depletion, 18m/m01/1 lactate of glycolysis).

MEDIUM TIME ENDURANCE TRAINING:

This ability is required for cyclic activities lasting from 2-11 minutes. Typical examples of cyclic activities requiring medium time endurance are 1500m and 3000m in track and field and 1000m in rowing. The energy production for activities of this duration is achieved by a combination of glycolysis and oxidation. The activities
lasting for about 3 min. 40 sec are the activities in which contribution of glycolysis and oxidation is nearly equal. But for long duration activities the contribution of glycolysis steadily decreases. The contribution of lactic acid metabolism is practically nil. For oxidation of source of energy is muscle glycogen which due to limited duration of activity can not be depleted to a significant extent and as a result is not a limiting factor for performance. Due to involvement of glycolysis in medium time endurance activities lasting upto eleven minutes, high concentrations of lactic acid are produced.

**LONG TERM ENDURANCE TRAINING:**

The long time endurance is needed for cyclic activities lasting more than eleven minutes. The energy production is achieved mainly from oxidation of glycogen. For activities lasting up to 30 minutes significant amount of energy production is achieved through glycolysis. But for longer duration activities the contribution of glycolysis is very less. For marathon run nearly the total amount of energy required is released by oxidation. There is however one significant change in energy production. For activities lasting more than the 30 minutes the energy production by oxidation of fatty acids increases steadily with the increase in the duration of activity. Depending on the nature of energy production as a result of duration of activity long time endurance can be divided into three types.
For good performance in long time endurance activities especially of (30 – 90 min and above) the glycogen stores in the muscles and liver assume great importance. These often act as limiting factors, as low level of muscle glycogen and blood glucose significantly plays important role on several psychical factors like will power, motivation, ability to tolerate and agony. The long time endurance particularly (30 – 90 min above) is dependent to a great extent on basic endurance. The changes are Heart circulation. 120 – 170, \( \text{O}_2 \) uptake 50 – 60% \( \text{VO}_2 \) max, energy production – 99%, aerobic, % glycolysis, energy consumption 75KJ/min, total consumption 27000 above. Glycogen depletion 95% muscle glycogen Lipolysis 2.5 m/mol/1, glycolysis 2 lactate m/mol 1.

Circuit training has proved to be a very effective method for improving strength endurance. It offers rich variation of exercises and load structure. Circuit training is conducted in a circular formation where various stations are used. It is just like the electric circuit where current starts from one end and ends in the same end.

Essentially it aims at developing general; or basic fitness which is a prerequisite to every sport. It is designed to assist the development of the muscular as well as the circulatory and respiratory systems of the body. A circuit may consist of a number of different exercises with or without apparatus.
The arrangement of a circuit stations and the exercises to be contained at each station requires careful thought and vast experience. Specific time also mentioned at each station. After signal they (athletes) should change their stations and so on for whole circuit program.

Further one must aim to improve the time per circuit first. Then as fitness improves, then repetitions may be increased and later the load per stations increased exercises may include in the circuit training like free hand exercises, stretching exercises, skipping, Dand and Baithaks, spot run, Dip, Barbell and Dum-bell exercises, hopping, jumping, squat, sit-ups etc.

The aerobic capacity is measured by the maximum amount of oxygen which can be consumed by the working muscles in one minute \((\text{VO}_2 \text{ max})\). when \(\text{VO}_2 \text{ max}\) is divided by the body weight of the sportsmen then we get the relative \(\text{VO}_2 \text{ max}\) i.e. the amount of oxygen consumed per kilogram of body weight per minute.

For endurance activity, a continuous flow of oxygen has to be ensured to the muscle cells for the liberation of energy. In case of higher speeds the energy can be partly or completely in the absence of oxygen, but after the cessation of activity the required (called oxygen debt) oxygen has to be supplied to the muscles. The human body gets oxygen from the atmosphere and is then transported to the muscles where it is consumed. The ultimate amount of oxygen
therefore depends primarily on three factors there are i) Oxygen intake, ii) Oxygen transport, iii) Oxygen uptake, iv) Energy reserves.

The amount of muscle glycogen has a decisive effect on activities lasting longer than 30 minutes. The muscles store glucose in the form of glycogen. When the activity is to be done at moderate speed, the energy is largely derived from the oxidation of muscle glycogen. The depletion of muscle glycogen beyond a certain level results in the onset of fatigue. The activities which last for very long periods (e.g. marathon race) lead to extreme depletion of muscle glycogen. It also leads to consumption of liver glycogen and blood sugar which further adds to the degree of fatigue. The discovery of the role of muscle glycogen in endurance performance has led to introduction of diet manipulation before and during long duration activities.

For extremely long duration activities fatty acids are also used as energy fuel. But the total amount of stored fat in the human body is so much that it is practically inexhaustible during a single but extremely long duration activity. Hence it is no a long limiting factor for endurance performance.

During sports activities muscle can use three substances as fuel for energy production. These substances are phosphogens, carbohydrates and fat. These however are used differently for activities depending on the speed or pace of activity. For extremely
slow activity like normal walking, standing etc. When the activities are faster, oxidation of fat and carbohydrate takes place; and when the speed is still faster, it is oxidation of carbohydrate alone. In case of still faster activities glycolysis replaces oxidation. When the activity is done at maximum or near maximum speeds the energy is derived from the phosphogens. The normal contents of these energy fuels in terms of phosphate equivalency is used protein in seldom used as energy fuel during sports activities.

The aerobic capacity is determined to a great extent by genetic factors. Astrand and Rodahl (1986) and Hollman et al (1988) are of the view that aerobic capacity is genetically determined by up to 70-80%. This means that through training VO$_2$ max. Values cannot be improved considerably especially in case of well trained sportsmen.

The VO$_2$ max. values are not reliable measures for judging the potential for performance in endurance events. The lower level of VO$_2$ max, can be effectively compensated by good technique motivation and good training state. Astrand and Rodiahl (1986) found that some marathon runners of world elite class have quite modest VO$_2$ max. values i.e. below 70ml../kg/min. Neumann (1988) also state that typical VO$_2$ max value for elite athletes have changed very little during the last thirty years. This means that the improvement in endurance performances in the past 30 years cannot be a result of an increase in VO$_2$ max.
Much more important is that the VO$_2$ max. value is the ability of the sportsman to work for longer times at speeds of 100% VO$_2$ max. or close to it (i.e. percent utilization of VO$_2$ max). This ability is highly trainable and perhaps partly explains the improvement in endurance performance inspite of stable or unchanged values of VO$_2$ max. Astrand and Rodahl (1986) found that well trained athletes including marathon runners can exercise for hours with O$_2$ uptake around 70-80% of their maximum with their little or no increase in blood lactate concentrations. All this signifies that for assessment of endurance improvement the changes taking place at sub-maximal level should be given more weightage.

This is reflected by the founding that well-trained endurance sportsmen have significantly higher threshold level in terms of VO$_2$ max. For example Neumann (1984) reports that untrained persons start using glycolytic metabolism (i.e. Anaerobic metabolism) in exercises surpassing 60% of VO$_2$ max. whereas trained and well trained at 80% and 90-95% of VO$_2$ max. respectively.

The inadequate explanations and answers offered by sports physiology regarding the nature and extent of aerobic capacity contribution towards endurance performance slowly giving rise to the trend to look for answers in other factors of endurance namely technique physic factors and aerobic capacity.
IMPROVEMENT OF ENDURANCE PERFORMANCE:

A vast amount of literature is available on means and methods of endurance improvement. But most of it is devoted to the development of aerobic and anaerobic capacity or their components. Very less literature is available on means and method of improving endurance techniques and this is mostly covered under the aspect of technique. Literature on means and methods for improving the physical factor of endurance performance and training is practically non-existent. As training volumes in endurance training are reaching their saturation point, therefore in the future stress is shift to this aspect of endurance which however has not been explored and studies so far.

An endurance training becomes effective only when the sportsman gets tired to a significant extent. The longer and frequently a sportsman trains under extreme condition under fatigue the more improvement of endurance takes place. Slow continuous, Fast continuous, Variable Pace, Fartlek, competition method, Interval, Repetition methods are very helpful for improving the endurance performance.

In this variation the sportsman exercises at a certain speed without any pause for very long durations. Long cross country runs are typical examples of slow continuous method. In this method the speed or pace of exercise is determined according to heart rate. For
trained sports persons the heart rate during the exercise should be from 140-160 beats per minute. The volume in terms of total durations should not be less than 30 minutes. The total duration in case of endurance athletes can go up to 2 hours or even more. Cyclic activities like running, cycling, walking etc are used for this method.

Effects of slow continuous method because of relatively low intensity and very high training volume, are mainly limited to the muscles. For reaching changes or adaptations take place in the muscle. Some of the most important changes are increase in muscle glycogen and liver glycogen, increase in capilarization, increase in the quantity of oxidative enzymes, increase in the number and size of mitochondria, better thermo regulation, improvement in movement economy. In addition it also positively effects fat metabolism for exercise control and regulation of endurance activity, general resistance and so on. It also has positive effect on heart and lung. Slow continuous method, however, results in decrease in muscle site and strength. The changes caused by this method, in the muscles on the whole aim at adapting in the muscles for slow long durations effects.

The physic effects of this method are also important. It improves will-power and ability to work under progressively
increasing fatigue for long duration. It leads to self discipline and self conquest.

Fast Continuous Method is done at fast but unchanging pace for long durations without any break. Heart rate is normally between 160-180 beats/minute. The total volume or duration should be not less than 20 minutes for trained sports persons. Because of higher intensity the fast continuous method is more strenuous and exhaustive. For best result the exercise should be done with a heart rate of about 175-180 i.e. about 90-100% of VO₂ max. This speed is called critical speed as it approximates the speed at which lies the anaerobic threshold in trained sportmen. Training at such an intensity pushes the aerobic threshold level still up in terms of speed. In other words it improves the percent utilization of VO₂ max.

Fast pace method is very effective for improving the VO₂ max. It significantly improves the capacity of the muscles to consume maximal amount of oxygen for long duration. There is highly significant increase in number and size of mitochondria and quantity of oxidative enzymes. Fast method, however, has less effect on capilarization, muscle glycogen movement economy etc. But due to higher intensity and involvement of glycolytic mechanism to some extent (especially towards the end) this method has positive affect on anaerobic capacity. It also does not lead to much decrease in
muscle size and strength. It is strong stimulus for structural changes in the heat and lungs.

Variable Pace Method is done continuously but with changing pace or speed. The heart rate normally ranges between 140-180 beats/minute. The total duration or volume ranges from about 15 minutes to 1 hour. Because of change of speed, which is pre-planned. This method is very strenuous and can be used by trained sportsmen only. Depending on the dynamics of speed this method can be used to improve aerobic or anaerobic capacity or both at the same time.

Another method of increasing endurance is Fartlek Method. Fartlek is Swedish word meaning “speed play”. In stricter sense it is a variation of variable pace method. In Fartlek the change of pace or speed is not pre-planned. The sportsman changes the speed on his own during the activity according to the terrain, surrounding and his feelings. Therefore, this method requires more self discipline in order to be effective. Like variable pace method in fartlek also the heart rate fluctuates between 140-180 beats/minute. The total volume and duration are also similar to variable pace method. The physiological and training are also, therefore the same.

Certain components of anaerobic capacity like phosphogen stores, non oxidative enzymes and lactic acid tolerance can be effectively improve by repetition method. For the improvement of
phosphogen stores and lactic acid metabolism, short sprints lasting for about 6 – 8 seconds are effective. These sprints should be done in series of 3-4 repetitions with complete recovery in between the series.

The lactic acid tolerance can be improved by exercising at maximal or near maximal intensity for about 40-45 seconds or even little longer. This should be repeated 3-5 times with complete recovery in between the repetitions.

Endurance training without participation in sufficient number of competitions is incomplete. Competitions are not only essential for the improvement of specific endurance but are also important for various psychic quantity essential for good endurance performance. These are also effective for the development of endurance tactics. The competition method is used in endurance. The competition method in its three forms should be used quite frequently (also in preparatory period) for the improvement of endurance and its components. For example, cross country competitions in the preparatory period to be very effective for endurance sports like middle and long distance running, long distance swimming, walking etc. This helps in improving the basic endurance along with the required psychic qualities.

The interval method has been used most frequently, and with good results, in cyclic sports like tract events, swimming rowing,
cycling etc. In this sports; due to the nature of interval method, it cannot be very effective for the improvement of specific endurance which is of continuous nature. The continuous and repetition method are more suitable for the improvement of specific endurance in these sports. The interval method, however, can be very effectively used for the improvement of specific endurance in team games. Combat sports and racket sports. The activities in these sports are of interval nature. Therefore the specific endurance the interval method should be used with special or competition exercises. It is not obligatory to use only an exercise of cyclic nature (e.g. running or swimming) for using interval method. Any exercise can be done general or specific, according to interval method, some typical examples are (A) Boxing, (B) Hockey or Football (C) Volleyball.

Interval method is perhaps the most versatile method for improving endurance of various types. In interval method, the exercises is done at relatively higher intensity with intervals of complete recovery. Interval method is based on the following principles. Work should be done with sufficient speed and duration so that the heart rate goes up to 180 beats/min. After this there should be a recovery period and when the heart rate comes down to 120 – 130 beats/min the work should be started again. The training load is interval method therefore, can be controlled by repeatedly checking the heart rate.
The effect of interval method is determined by the variables of interval method which are the following speed of work, duration of work, duration of recovery, number of repetitions, nature of recovery.

By proper manipulation of the above mentioned variable the interval method can be used in several ways each having a different physiological and training effect. However, from general point of view interval method is of two types (A) Intensive interval method and (B) Extensive interval method. In intensive interval method the intensity is from 80-90%. Whereas, in external interval method the intensity is from 60-80%. These physiological and training effects of intensive and extensive interval method have already been given in the chapter on training means and methods.

Interval method, by proper manipulation of the five variables, can be used for the improvement of any type of endurance or any Pre-requisite of endurance. Some typical examples of internal method for different purposes such as – (A) For heart and circulatory system, (B) For aerobic capacity, (C) For lactic acid tolerance, (D) For improving VO₂ max.

The repetition method is characterized by high intensity (90-100%) of work with intervals of complete recovery. It is the best method for the improvement for speed abilities for including speed endurance. In endurance training the repetition method is used to
improve components or factors or specific endurance of anaerobic capacity.

For the improvement of specific endurance the repetition method is used in the form of repetitions of the complete distance or past distance with the purpose of improving pace judgment of competition tactics.

**Nutrients and Sports:**

Optimal physical performance requires careful dietary balance of the essential nutrients. The U.S. government (Jack H. Wilmore and David L. Costill) has established standards for optimal nutrient intake that are termed Recommended (Daily) Dietary Allowances, or RDA. The RDA of a substance is an estimate of the intake adequate to maintain good health. RDA values are guidelines to help people of average activity levels gauge their diets.

However, the nutritional needs of very active athletes can exceed the RADs considerably. Individual caloric needs are quite variable, depending on the athletes size, sex and sports choice. Some athletes have been reported to need as many as 12,000 K cal per day. Also some competitive sports require adherence to rigid weight standards. Athletes who participate in these sports must closely monitor their weight and thus their caloric intake. Too often this leads to nutritional abuses, dehydration and serious health risks.
In addition the dietary tactics uses by some athletes to achieve successive weight loss are of increasing concern because of the potential association with eating disorder, such as anorexia nervosa and bulimia nervosa.

A person's diet should contain a relative balance of carbohydrate, fat and protein. Of the total calories consumed the recommended balance for most people is carbohydrate: 55% to 60%, fat no more than 30% (less than 10% saturated) and protein: 10% to 15%.

Although all foods can ultimately be broken down to carbohydrate, fat or protein, these nutrients are not all that the body needs. The energy form the foods we eat essential to our ability to sustain physical activity, but we rely on foods for much more than energy. Food can be categorized into six classes of nutrients. Each with specific functions in the body: carbohydrate, fat (lipid), protein, vitamins, minerals, water.

In the following discussion, we examine the physiological importance to the athlete of each the classes of nutrients.

Recent studies have indicated that endurance performance can be significantly improved by dietary manipulation a few days or immediately before the competition. Glucose intake before and during long duration competitions is well known as it helps in
maintaining the blood sugar level thereby delaying the onset of fatigue. In sports dietary manipulation for endurance performance is of two types which are explained below.

A carbohydrate (CHO) is classified as either monosaccharide, disaccharide or polysaccharide. Monosaccharides are the simple one-unit sugars (such as glucose, fructose, and galactose) that cannot be reduced to a simpler form. Disaccharides (such as sucrose, maltose, and lactose) are composed of two monosaccharides for example, sucrose (table sugar) consists of glucose and fructose, polysaccharides contain more than two monosaccharides. Common polysaccharides include starch and glycogen, both composed completely of glucose units. Larger polysaccharide for example; starches are commonly referred to as complex carbohydrates. All carbohydrates must be broken down to monosaccharides before the body can use them.

Muscle glycogen provides a major resource for energy during exercise (Jack H. Wilmore and David L. Costill). Because muscle glycogen depletion has been shown to be a major cause of fatigue and ultimate exhaustion in events lasting more than an hour, efforts to load the muscle with extra glycogen before starting the exercise has been considered ergogenic for performance.
Blood glucose levels become (hypoglycemia) during exhaustive long distance running and cycling, and this might contribute to fatigue.

Several studies have shown that subjects' performance improve when they are given carbohydrate feedings during exercise lasting 1 to 4h: comparisons of subject when they received carbohydrate feeding and when they received placebos revealed no performance difference during the early phase of the exercise, but during the final stage of the experiments, performance was greatly improved with carbohydrate feedings.

Although we don’t fully understand how carbohydrate feedings\(^5\) improve performance, most scientists believe that maintaining blood glucose near normal levels allow the muscles to obtain more energy from blood glucose. Carbohydrate feeding during exercise do not spare muscle glycogen use. Instead they may preserve liver glycogen enabling the exercising muscles to rely more on blood glucose for energy late in the exercise. Endurance performance (more than 1 hour) can be enhanced when carbohydrate is consumed with in 5 min. before the exercise begins, more than 2 hour before exercise (such as during the pre-competition meal), and at frequent intervals during the activity.

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An athlete should not ingest carbohydrate food during the period 15 to 45 min before exercise because it could cause hypoglycemia shortly after the exercise begins, which could lead to early exhaustion by depriving the muscle of one of its energy sources. Carbohydrate ingested during that period stimulates insulin secretion, causing an elevation of insulin when the activity begins. In response glucose uptake by the muscles reaches an abnormally high rate, leading to hypoglycemia. Not everyone experiences this reaction but sufficient evidence indicates that simple carbohydrates (those that cause a large increase in blood insulin) should be avoided in the period 15 to 45 min before exercise.

Carbohydrate load is based on the fact that initial level of muscle glycogen has a direct relationship with endurance performance especially in events which last longer than 30 minutes. Astrand and Rodahl (1986) state that “at work rates exceeding 75% of individuals ability VO$_2$ max, the initial glycogen content in the skeletal muscles is decisive for the individuals ability to sustain such exercise for more than an hour.

It has been found that if the muscle glycogen content is improved then the endurance performance also improves (Fox 1979, Fox and Mathews 1981, Astrand and Rodahl 1986, Costill 1988). The following methods of carbohydrate loading can be used in sports training.
Three to four days before the competition the sportsman is given high carbohydrate diet. By this method the muscle glycogen content can be significantly increased. According to Bergstrom et al (1967) the glycogen content can be improved by this method up to 25gm/kg of muscle weight. This is the simplest and the safest method of carbohydrate loading. The other two methods are more complicated and risky.

Our body stores excess carbohydrate, primarily in our muscles and liver as glycogen. Because of this our carbohydrate consumption directly influences our muscle glycogen storage and our ability to train and compete in endurance events. Athletes who trained intensely and ate a low carbohydrate diet (40% of total calories) experienced a day-to-day decrease in muscle glycogen.

When these athletes consumed a high-carbohydrate diet (70% of total calories) their muscle glycogen levels recovered almost completely with in the 22nd hour between training bouts. In addition athletes, perceive training as easier when their muscle glycogen is maintained throughout a workout.

Muscle glycogen is first depleted by doing training for 3-4 days and having carbohydrate low diet. Muscled glycogen depletion is best possible by adapting slow continuous method. After this the sportsman consumes high carbohydrate diet for the next 3-4 days before the competition. During these days the sportsman does not
do any hard training. By this method the muscle glycogen content can be nearly doubled.

This method is much more complex and risky and should not be used without expert guidance. Glycogen is first depleted through hard training over 3-4 days. After this the muscle glycogen is further reduced by going on carbohydrate poor diet for about three days. This is followed by 3-4 days of high carbohydrate diet. By this method maximal increase in muscle glycogen contents can be achieved. During high carbohydrate diet no hard training should be done. However, hard training can continue during low carbohydrate diet.

Carbohydrate loading through proved to be effective for endurance performance, should be done carefully. It can have unfavourable side effects. Following suggestions are given in this regard --

a) Carbohydrate loading is effective for endurance performance which last for more than 30 minutes.

b) High carbohydrate intake into 3-4 hours period before the competition is not advisable as it can lead to lowering of blood sugar due to reflexively increased secretion of insulin hormone.

c) Increased muscle glycogen is always accompanied by increased storage of water in the muscles. One gram of muscle
glycogen is stored along with 3-4 gm of water. A total of 1-2 kg extra water can be stored as a result of carbohydrate loading. This may generate uncomfortable feeling in a sportsman.

d) The process of carbohydrate loading should be done at the correct time because increased muscle glycogen can be retained by the body for a maximum period of 2-4 days.

e) Carbohydrate loading should be attempted in stages. If there are no complications then the whole process should be attempted.

f) Carbohydrate loading should not be attempted too often. In a year it should be done at the maximum 2-4 times.

g) Expert help from a nutritionist, dietitian physiologist and a physician is essential to avoid possible harmful side effects of carbohydrate loading.

Considering this limitation many propose that the depletion exercise and the low carbohydrate aspects of Astrand’s regimen should be eliminated. Instead, according to Sherman and colleagues, the athlete should simply reduce training intensity a week before competition and eat a normal, mixed diet containing 55% of the calories from carbohydrate until 3 days before the competition. For three days training should be reduced to a daily
worm-up of 10 to 15 min of activity, accompanied by a carbohydrate rich diet.

Diet is also important in preparing the liver for the demands of endurance exercise. Liver glycogen stores decrease rapidly when a person is deprived of carbohydrates for only 24 hour even when at rest. With only 1 hour of strenuous exercise, liver glycogen decreases by 55%. Thus hard training combined with a low carbohydrate diet can empty the liver glycogen stores. A single carbohydrate meal, however, quickly restores liver glycogen to normal. Clearly, a carbohydrate-rich diet in the days preceding competition will maximize the liver glycogen reserves and minimize the risk of hypoglycemia during the event.

Water is stored in the body at a rate of about 2.6 g of water for each gram of glycogen. Consequently an increase or decrease in muscle and liver glycogen generally produces a change in body weight of from 0.45 to 1.36 Kg. Some workers (Jack H. Wilmore and David L. Costill) have proposed that muscle and liver glycogen stores can be monitored by recording the athletes early morning weight immediately after rising : after emptying the bladder, but before eating breakfast. A sudden drop in weight might reflect a failure to replace glycogen, a deficit in body water, or both.

Athletes who must train or complete in exhaustive events on successive days should replace muscle and liver glycogen stores as
rapidly as possible. Although liver glycogen can be totally depleted after 2 hours of exercise of 70% VO₂ max, it is replenished with in a few hours when a carbohydrate-rich meal is consumed. Muscle glycogen re-synthesis, On the other hand is slower process, taking several days to return to normal after an exhaustive exercise bout such as the marathon. Studies in the late 1980s revealed that muscle glycogen re-synthesis was most rapid when individual were fed at least 50g of glucose every 2 hours after the exercise. Feeding subjects more than this amount did not appear to accelerate the replacement of muscle glycogen. During the first 2 hours after exercise the rate of muscle glycogen re-synthesis is 7% to 8% per hour which is some what faster than the normal rate of 5% to 6% per hour. Thus an athlete recovering from an exhaustive endurance event should ingest sufficient carbohydrate as soon after exercise as is practical.

For the athlete fat is especially important as an energy source. Muscle and liver glycogen stores in the body are limited so the use of fat (free fatty acids or FFA) for energy production can delay exhaustion. Clearly, any change that allows the body to use more fat would be an advantage, particularly for endurance performance. In fact, one adaptation that occurs in response to endurance training is an increased ability to use fat as an energy source. Unfortunately merely eating fat does not stimulate the muscles to burn fat. Instead,
eating fatty foods tends only to elevate plasma triglycerides, which must then be broken down before the FFA can be used for energy production. To increase the use of fat, the FFA levels in the blood not the triglyceride levels, must be increased.

Dietary attempts to elevate plasma FFA have been relatively unsuccessful. Some foods that contain the stimulate caffeine promote fat use and improve performance in prolonged, exhaustive exercise when they are consumed an hour before exercise. But many people have negative reactions to caffeine and show no performance improvements.

Should athletes who are training for strength and endurance increase their protein intake? Amino acids are the body’s building blocks. So, protein is essential for the growth and development of body tissues. For many years, protein supplementation was believed essential for athletes. In fact, muscle was once through to consume itself as fuel for its own actions, so protein supplementation was considered necessary to prevent muscle wasting. Over the year nutritionists and physiologists have argued the necessity of supplementing protein for optimal sports performance. It was generally argued that the RDA of 0.8g of protein per kilogram of body weight each day would adequately meet the demands of hard training.
Considering the importance of endurance in athletics and everyday life, it was thought desirable to conduct a study regarding the improvement of work efficiency during prolonged performance by supplementation of glucose in different times of the work.

I.a. Statement of Problem:

The purpose of the study was to determine the effect of intermittent glucose supplementation on blood glucose, blood lactic acid, and blood uric acid during endurance performance.

I.b. Delimitation:

1. The study was delimited to the twenty long distance cross country male Runners aged between 23 to 26 years who have already participated in West Bengal state level cross country championship.

2. The study was further delimited to the following variables :-

   -- Blood glucose
   -- Blood lactic acid
   -- Blood Uric acid.

I.c. Limitation:

1. Regular routine, food and social background of the cross-country runners also were taken as a limitation of this study and individual differences on life style.
2. No special motivational devices were used to enable the subjects to give better performance while collecting data.

3. Non availability of sophisticated equipment and facilities were considered another limitation of this study.

4. Individual difference on food habit and life style were one of the limitation of the study.

I.d. Hypothesis:

It was hypothesized that there will be significant differences in blood glucose, blood lactic acid, and blood uric acid among the varying schedules of glucose supplementation while endurance running.

I.e. Definition and Explanation of terms:

❖ GLUCOSE

A monosaccharides also known as dextrose, found in certain foodstuff, especially fruits. It is the end of the carbohydrate metabolism and is the chief source of energy for living organism. Glucose stored in muscle as glycogen.

❖ BLOOD GLUCOSE

Amount of glucose present in blood. Normal human blood contains about 80-100 mg of glucose per 100 ml. of blood. Blood glucose may supply 30 to 40% of the total energy exercising muscle.
**LACTIC ACID**

The glucose formed from glycogen in the liver enters into circulating blood and forms blood glucose by glycogenesis which in turn enters into the muscle and forms muscle glycogen which according to G.T. Corti 1931, produces lactic acid after a sequence of reaction done by anaerobic oxidation.

The one fifth part of lactic acid produces carbon dioxide and water through kerb's carboxylic acid cycle and the rest $\frac{4}{5}$th part enters into blood to form blood lactate which enters into liver and forms liver glycogen again.

The process of glycosis in tissues consists in the breakdown of glycogen, glucose or other sugar to pyruvic and lactic acid. The EMP pathway theory offers a credible explanation by which glycogen molecules are converted into Lactic Acid.

The accumulation of waste product like lactic acid mainly may reach up to 0.3% or more in the muscle, which causes fatigue.

**URIC ACID**

Uric acid is the final end product of purine metabolism in man and is excreted in urine of about 0.5 gm to 1.0 gm per 24 hours. But the amount is subject to wide variation, particularly under certain dietary and pathological conditions. It is a transparent crystalline powder particularly insoluble in cold water, sparingly soluble in hot
water easily soluble in alkalies. It is found in normal human urine, blood.

Uric acid content of urine is very important in formation of uric acid calculi. The administration alkali carbonates and citrates and by decreasing the acidity of urine, decrease the liability of formation of this calculi.

The purine nitrogenous base which is one of the end product of nucleoprotein digestion contains adenine and guanine. These in turn forms uric acid in man from their own breakdown.

**ENDURANCE**

1. Ability to do the work for a longer period. According to Schnable (1987) Endurance is ability to resist fatigue and continue the activity for a longer time.

2. It is characterized by the maintenance of working capacity and by the degree of resistance of the organism against fatigue or against the influence of unfavorable environmental conditions.

3. Martin (1979) and Matweyes (1981) have also used the concept of ‘ability to resist fatigue’, for defining endurance.

4. Hardayal Singh (1995) presents the following definition of endurance: “Endurance is the ability to do spots movements, with the desired quality and speed, under conditions of fatigue”.
I.f. Significance of the study:

1. The finding of the study will add knowledge to the already existing literature of this field.

2. The findings also will be helpful to make the athlete convinced regarding consumption of glucose mixed fluid to enhances endurance performance.

3. The research work will further help to the coaches for preparing the strategy regarding supplying of glucose water for enhancement of performance during endurance activities.

4. The present study will be significant for the teachers of Physical Education to make understand the students and general citizens that one should takes part in aerobic running activities for promoting total health especially lowering the blood glucose.

5. This study provides a comparison between intermittent glucose supplementation and without supplementation of glucose during endurance type of activity is evaluated.