Chapter I

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All life on earth evolved under both a light and dark cycle. As the sun rises and reaches its peak at noon, the spectrum it emits is smooth throughout the visible spectrum with a high intensity in the blue region [400 - 500 nm]. As the sun sets, blue visible light is preferentially scattered (removed) from sunlight, leaving an emission appearing orange-red [600 - 700 nm]. At night, there is darkness with limited visible light emitted from the stars, with the exception of when there is a full moon. During the full moon, there is five times the amount of visible light emitted from the sky, and significant light emitted in the blue visible range **(Czeisler and Gooley, 2007)**.

Humans evolved being exposed to different spectra of light in the morning, the late afternoon and evening. So it should not be surprising that human physiology is profoundly affected by the daily and seasonal changes in the visible light spectrum. Exposure to the appropriate spectrum of light during the day and evening enhances human health and well being, immune response and productivity. However, exposure to light sources that do not match the natural solar spectrum to the time of day or evening, is hazardous to human health **(Stevens et al., 2007; Rea et al., 2008; Erren and Reiter, 2008; Arendt, 2010)**. The reason visible light has such a powerful effect on human health is that light exposure through the eye modifies circadian rhythm **(Gaddy et al., 1993; Roberts, 1995; Czeisler et al., 1995)**.

1.1 CIRCADIAN RHYTHM

Circadian Rhythm is derived from the Latin words *circa dies* meaning "approximately a day". It may be defined as the changes in human behavior and physiology that occur within a 24 hour period. The mammalian circadian system is regulated by endogenous clock genes **(Reppert and Weaver, 2001; Richter et al., 2004; Berger, 2004; Ueda et al., 2004; Walker and Hogenesch, 2005; Siepka et al., 2007; Belle et al., 2009)**. There is a master clock found in the brain in an anterior section of the hypothalamus known as the suprachiasmatic nucleus (SCN) **(Reppert and Weaver, 2002)**. The SCN synchronizes clock cells in peripheral tissues located in the eye, brain, heart, lung, gastrointestinal tract, liver, kidney and fibroblasts **(Roberts et al., 2000; Scher et al., 2002; Dubocovich et al., 2003; Richter et al., 2004; Takahashi et al., 2008)**. Clock genes found in lower species of mammals have recently been detected in humans **(Su et al., 2002; Ciarleglio et al., 2008)**. Without external stimuli, human circadian rhythm has an average period of 24.2 hours **(Czeisler et al., 1999)**. Although there may be some modification of the circadian cycle with food **(Mendoza et al., 2010; Mendoza, 2007)** and temperature **(Van Someren, 2000)**, the most powerful external stimulus for synchronizing (entraining) circadian rhythm to a 24 hour cyclic is exposure to the light of day and darkness at night.

Most individuals consider that their athletic prowess is best in the late afternoon and early evening, and this is the time period when best performances and even world records are most often likely to be set in competitions. External factors may be in part responsible, the world records set in track and field events in the evening reflecting the times at which grand prix events and major championships are held in front of large crowds and the media. However, recent reviews have considered the evidence that sports performance shows a diurnal rhythm that is, in part at least, due to the activities of a "body clock" **(Reilly and Waterhouse, 2009)**.

1.2 RHYTHMS IN SPORTS PERFORMANCE

If body temperature was a determining factor, then peak performance should occur in the evening when the temperature of the body at rest is at its highest point. Most athletic world records are set at this time of day: indeed all middle-distance world records set by British runners ***(Seb Coe, Steve Cram, Steve Ovett and Dave Moorcroft)*** were set between 19:00 and 23:00 hours. The only exceptions in track and field events over the last half century have been the two set pre-noon in men's shot and women's javelin. Both of the events entail dynamic explosive rather than sustained effort: for activities that depend more on central nervous system arousal than on the curve in body temperature, the period for high performance levels may be closer to mid-day. Indicants of arousal, such as circulating levels of catecholamines, reach a peak about 4 hours earlier in the day than does body temperature. Nevertheless, achievement of peak performances before noon is highly unusual.

The competitive data indicating high points for evening performances are supported by time trials for a variety of sports. A time of day effect is evident in the performance in all-out swimming over both 100 m and 400 m. A turning point in the performance curve is noted at about 20:00 hours. These trends in better performances in the evening than in the morning are evident also in throwers and rowers. The results for swimmers correspond to performance in power output on a swim-bench, peak power in this instance being produced at about l8:00 hours. Amplitude in performance of 14% has been reported for power output in the first 5 s of a 30 s test, and 11% for mean power production over the whole test.

Many components of sports performance show cycles closely in phase with the circadian curve in body temperature. Variables following this pattern include broad jump and grip strength, both of which can be used as markers of circadian rhythmicity. The rhythm in muscular strength is noticeable also in back and in leg strength, data for which closely conform to a cosine function. This extends not just too isometric measures but also to dynamic movements such as peak torque achieved on isokinetic equipment. The amplitude of muscle performance in these contexts is about 7% of the mean value. In general, the more complex the task the greater is the amplitude in the circadian rhythm.

Rhythms have been identified in many components of athletic performance including sensory motor (simple reaction time), psychomotor (hand-eye co-ordination), sensory perceptual, cognitive and neuromuscular performance. It is incorrect to refer to a single performance rhythm as different types of task can display different circadian characteristics. These depend largely on whether they are influenced by the body temperature or the sleep wake oscillator. Despite this caveat, it seems there is a window around the peak time of body temperature when the state of the body favors maximal performance. This at least applies to single or multiple effort bouts. Exercises that tax thermoregulatory mechanisms or that are distributed throughout the day merit a separate consideration.

When measures are made repeatedly throughout the waking day, speed of movement in a reciprocal tapping task demonstrates a bimodal pattern: it has an early turning point round mid-day and a so-called post-lunch dip prior to a peak later in the day. This transient down-turn in performance persists even when lunch is missed. Similarly after-effects of alcohol ingestion are much more detrimental to motor performance at about lunch-time compared to later on in the day. The early peak reflects changes in arousal and the same sub-harmonic is noted in perception of exertion when set exercise loads are performed serially over the course of the solar day. This has implications for the motivation levels of athletes to perform strenuous exercise and complete arduous training regimens.

1.3 DESYNCHRONISATION AND ATHLETIC PERFORMANCE

A poor competitive performance may result when an athlete does not take into consideration his or her circadian performance profile, since an athletic task undertaken several hours before or after the circadian peak "window" will potentially be performed with less than optimal efficiency. Taking circadian rhythms into consideration can produce major benefits in tasks involving endurance, mental function, physical strength, and others. Selecting the best circadian time can result in as much as a 10% increase in athletic performance. A 10% decrement in peak performance can be compared with a performance after less than three hours of sleep, after drinking the legal limit of alcohol **(Folkard and Monk, 1983)** or after taking barbiturates **(Klein, Bruner, Wegmann, *et al.* 1967).**

1.4 ENERGY METABOLISM RHYTHM

The biochemical parameters of total cholesterol, total protein and blood glucose showed significant change with time of day. In mammals, the circadian patterns in the levels of a number of biochemical variables, hormones, oxidative and antioxidative status were reported **(Bonacho, *et al.*, 2000; Baydas, *et al.*, 2002)**. Blood glucose and insulin responses to oral glucose **(Jarrett, 1979)** or to mixed meals **(Service, *et al.*, 1983)** found higher in the evening rather than in the morning further support the existence of a circadian influence on glucose metabolism. Similarly total protein also shows diurnal rhythms in humans and mice **(Touitou, *et al.*, 1986)**. Cholesterol in the humans show diurnal variation and found peaking during early morning, indicative of maximal efflux of free cholesterol to the ester pool during this period. These findings offer direct evidence for diurnal patterns in human cholesterol synthesis **(Jones and Schoeller, 1990)**.

1.5 ELECTROLYTES RHYTHM

Electrolytes are positively or negatively charged particles that readily dissolve in water. The predominant positively charged electrolytes in the body are sodium, potassium, calcium, and magnesium, while negatively charged electrolytes include chloride, phosphates, and bicarbonate. Electrolytes have many functions and roles in the body. The concentration of electrolytes must be maintained within a narrow range within the blood, otherwise deleterious physiological effects may occur. Sodium in the blood peaks around late evening in humans **(Baghdassarian, *et al.*, 1990)**. However, Calcium concentrations followed a W-shaped curve with maxima at 11 and 1 AM and troughs at 5 AM and 6 PM **(Markowitz, *et al.*, 1984)**. This shows that electrolytes sodium and calcium elicit circadian rhythm.

1.6 ANTIOXIDANTS RHYTHM

Free radicals induced oxidative stress has been implicated in the pathogenesis of several diseases **(Ray and Hussain, 2002)**. Free radicals can damage proteins, lipids, carbohydrates, and nucleic acids. The most important function of free radicals in vivo or in vitro is lipid peroxidation resulting in deleterious effects on membrane system and death of affected cells. However, the body has developed several endogenous antioxidants defence systems (non enzymatic and enzymatic) to deal with the production of reactive oxygen intermediates **(Noguchi, Watanabe and Shi, 2000)**. The antioxidant enzymes include superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) and the small molecule non enzymatic antioxidants include vitamin E, C and reduced glutathione (GSH) **(Noguchi, Watanabe and Shi, 2000)**.

Chronobiology is the study of temporal relationships of biological phenomena. Temporal coordination of biological processes with an approximately 24 hour's cycle (circadian) is common throughout the animal and plant kingdom **(Murphy and Campbell, 1996)**. Since overproduction of lipid peroxidation products and depleted antioxidants have an important role in the development of diseases, researchers have focused their interest on circadian fluctuations of the above-said biochemical variables.

Lipid peroxidation and antioxidant defense mechanisms may relate to preventive and curative chronochemotherapeutic efficacy and management. The concentrations of thiobarbituric acid reactive substances and conjugated dienes in human plasma are often used as indices of lipid peroxidation.

Circadian rhythms of antioxidants have been the subject of considerable interest in recent years **(Valencia, Marin and Hardy, 2001)** and significant 24-hour fluctuations of oxidants and antioxidants have been reported in healthy subjects **(Valencia, Marin and Hardy, 2001)** as well as in diseased patients **(Valencia, Marin and Hardy, 2001)**.

Time of day effect was noticed among the athletes. It is well known that these athletes differ in their responses to the time of day. Since athletic training held at various times during the day and studies in time of day effect on athlete's performances are restricted. Hence, the purpose of this study was to investigate diurnal variation of selected physical and biochemical variables among sprinters, jumpers and throwers.

1.7 OBJECTIVES OF THE STUDY

The purpose of the study were divided by two aspects,

1. To determine the existence of diurnal pattern and locating peak on selected motor fitness components and biochemical parameters separately for sprinters, jumpers and throwers.
2. To determine the differences between sprinters, jumpers and throwers at different times of day on selected motor fitness components and biochemical parameters.

1.8 STATEMENT OF THE PROBLEM

The present study was intended to examine the influence of diurnal patterns on selected physical fitness and biochemical variables among college athletes.

1.9 HYPOTHESIS

Based on the purposes of the study it was hypothesised that, there would be a significant changes on selected physical fitness and biochemical variables among sprinters, jumpers and throwers at different times of the day.

1.10 SIGNIFICANCE OF THE STUDY

The research in physical education is providing new insights and innovation to the physical educationist as well as educationist. The ultimate goal of research in physical education is to help coaches and physical educators to train their athletes and players based on new concepts to improve their performance. The findings of this study will be of significance in the following ways.

1. Athletic competitions are organized at various times in the day, ranging from morning to night. Competitive performance of football players depend on a certain factors, including physiological and psychomotor variables. The work-rate of athletes which correlates with maximal aerobic power **(Reilly & Thomas, 1976)**, and sprint performance is influenced by anaerobic power, explosive power, flexibility and strength endurance. Because these performance measures are affected by diurnal variation in association with changes in body temperature **(Reilly & Down, 1992)**, it is likely that some components of physical performance of athletes are affected by the time (with reference to circadian rhythms) they take place. Moreover, competition times are often out of synchrony with the typical time for training, and this separation might affect performance in competition and also apply to

training at a typical times. An awareness of the existence of circadian variation in athletics performance would have practical relevance for coaches, both in preparing athletes for competition at different times of day and in optimizing training programs. Furthermore, a coach or trainer might make allowances for below par execution of performance at times of day demonstrated to be outside of the period at which performance was demonstrated to be at its diurnal peak.

2. The findings of this study may add to the existing fund of knowledge with regard to the circadian rhythm on the selected factors related to athletic performance.
3. The results of the study may provide guidelines, which will help the Physical Educators and Coaches in preparing the training schedules for men athletes in their respective sports.
4. The results of the study may help the Physical Educators and Coaches to find out the zone of peak performance i.e. time in which the peak value of circadian rhythm of factors determine sports performance.
5. The findings of this study will add to the quantum of knowledge in the area of Sports Physiology and Training Methods.
6. The study may help the players and the athletes to engender the awareness on circadian variation on the selected factors related to athletic performance.

1.11 DELIMITATIONS

The study was confined to

1. Thirty male athletes in the age group of 19 to 23 years from Department of Physical Education and Sports Sciences, Annamalai University during the academic year 2010-2011.

2. These subjects were classified into three groups as Sprinters (10), Jumpers (10) and Throwers (10).

3. The criterion variables as mentioned in Table 1.

Table I

Physical fitness components and biochemical parameters

I	Physical Fitness Components	II	Biochemical Parameters
1.	Speed	1.	Glucose
2.	Strength Endurance	2.	Total Cholesterol
3.	Explosive Power	3.	Total Protein
4.	Flexibility	4.	Sodium (Na)
5.	Agility	5.	Calcium (Ca)
6.	Anaerobic Power	6.	Superoxidase Dismutase (SOD)
		7.	Thiobarbituric Acid Reactive Substance (TBARS)

4. The criterion variables were tested at five different times of the day (06:00, 09:00, 12:00, 15:00 and 18:00 hours).

5. All the subjects were non smokers and also they were free from injuries for two months before the commencement of the study.

6. The subjects did not use any form of oral ergogenic aids or supplementations.

1.12 LIMITATIONS

1. The subject's quantity and quality of nutrition and diet consumption was not quantified. As the nutrition is the only source for replenishing the blood volume, the amount of diet intake was consider as a limitation in this study.
2. The time of food consumption may have some sort of influence on both the blood profiles and fitness parameters, which is considered as a limitation of this study.
3. The collection of data was performed once in three hours. The summation of blood collected may have some impact on the profiles of the blood to be collected, and it is considered as limitation.
4. As part of data collection, the physical fitness components were also measured once in three hours, which may have some impact on blood profiles and fitness components to be next measured.
5. The duration of warm up was quantified, and it is considered as a limitation of this study.
6. The quality of sleep was not quantified, and it is considered as a limitation of this study.
7. The environmental factors such as ambient temperature, humidity etc. during the period of testing was considered.

1.13 MEANING AND DEFINITION OF THE TERMS

1.13.1 TEMPORAL PATTERNS

Temporal Patterns is regular rhythms of growth or activity occurs on an approximately 24 hour's cycle.

1.13.2 DIURNAL

Daytime variations are known as diurnal.

1.13.3 ACROPHASE OR PEAK

The acrophase is the measure of the peak time of the variable studied.

1.13.4 SPRINTERS

In the present study, the Annamalai University students who were practicing sprinter training for the purpose of participating in the short distance athletic events, in the inter collegiate athletic championship were treated as sprinters.

1.13.5 JUMPERS

In the present study, the Annamalai University students who were undergoing jump training for the purpose of participating in the high jump, long jump and triple jump events, in the inter collegiate athletic championship were treated as jumpers.

1.13.6 THROWERS

In the present study, the Annamalai University students who practiced and were trained for throwing events, such as shot put, discus throw, hammer throw and javelin throw, in the inter collegiate athletic championship were treated as throwers.

1.13.7 PERFORMANCE VARIABLES

In the present investigation, the variables that help to improve the performance of sports and games have been designated as performance variables.

1.13.8 SPEED

A skill related component of physical fitness that relates to the ability to perform a movements with a short period of time **(Corbin & Lindsey, 1994).**

1.13.9 STRENGTH ENDURANCE

The abilities of the muscle to overcome resistance under the conditions of fatigue **(Wilmore & Costill, 1994).**

1.13.10 EXPLOSIVE POWER

A skill related components of physical fitness to the rate at one can perform work.

1.13.11 FLEXIBILITY

A health related component of physical fitness that relates to the range of motion available at a joint **(Wilmore & Costill, 1994).**

1.13.12 AGILITY

Agility is the physical ability that enables a person rapidly to change body position and direction in a precise manner.

1.13.13 ANAEROBIC POWER

Anaerobic power refers to the absence of oxygen. It is equated with intensity activity, yet initiates all activities. It functions in a deficit of oxygen, is the immediate precursor for all aerobic metabolisms, and occurs simultaneously with it in most strenuous that require more than 10 seconds to complete.

1.13.14 BLOOD

Blood is a connective tissue composed of a liquid portion called plasma and cellular portion consisting of various cells and cells fragments. Blood is the vehicle of transportation that makes possible the specialization of structure and function characteristic of all but the lowest organisms.

1.13.15 SERUM

Serum is the fluid separated from the clotted blood **(Lamb, 1984).**

1.13.16 GLUCOSE

Glucose refers to the blood sugar circulating in the blood at on constant level and which the muscle uses during muscular activity **(Perrott, 1985).**

1.13.17 TOTAL PROTEIN

A chain of amino acids joined by peptide bonds; a protein typically contains over 100 amino acids and may be composed of more than one polypeptide **(Raven, 1995).**

1.13.18 TOTAL CHOLESTEROL

Cholesterol is a white, waxy, solid found associated with fats but chemically different from them **(Deb, 1996).** Like any other fatty substances, cholesterol is insoluble in plasma unless combined with carrier molecules called lipoproteins.

Fat like chemical is found in all animal tissues **(Shaver 1982).**

1.13.19 ELECTROLYTES

Chemically, electrolytes are substances that become ions in solution and acquire the capacity to conduct electricity. Electrolytes are present in the human body, and the balance of the electrolytes is essential for normal function of our cells and our organs. Common electrolytes that are measured include sodium, potassium, chloride, and bicarbonate.

1.13.20 SODIUM

Sodium is the major positive ion (*cation*) in fluid outside of cells. The chemical notation for sodium is Na+. When combined with chloride, the resulting substance is table salt. Excess sodium (*such as that obtained from dietary sources*) is excreted in the urine. Sodium regulates the total amount of water in the body and the transmission of sodium into and out of individual cells also plays a role in critical body functions. Many processes in the body, especially in the brain, nervous system, and muscles, require electrical signals for communication. The movement of sodium is critical in generation of these electrical signals.

1.13.21 CALCIUM

A mineral found mainly in the hard part of bones, where it is stored. Calcium is added to bones by cells called osteoblasts and is removed from bones by cells called osteoclasts. Calcium is essential for healthy bones. It is also important for muscle contraction, heart action, nervous system maintenance, and normal blood clotting.

1.13.22 SUPEROXIDE DISMUTASE (SOD)

SOD are group of metalloenzymes that catalyze the dismutation of the superoxide anion and hence diminish toxic effects due to this radical or to prevent the other free radicals derived from superoxide anion **(Kakkar *et al.*, 1984).**

$$2O_2^{\,-} + 2H^+ \xrightarrow{\text{SOD}} H_2O_2 + O_2$$

1.13.23 THIOBARBITURIC ACID REACTIVE SUBSTANCES (TBARS)

Lipid peroxidation is a process which is determined by the extent of peroxide-forming free radical mechanisms and the peroxide removing antioxidant system **(Yagi K, 1987).**