Chapter I

INTRODUCTION

'Time of Day may Influence Athletic Performance', recent headlines in major newspapers around the world had a major impact on sports persons. Athletically minded readers, skimming the stories to discover their optimal time to play volleyball, squash, cricket, or soccer, found a summary of a report from the 83rd Annual Meeting of the American Endocrine Society in Denver, Colorado, which indicated that exercising in the evening might be best since it seemed to boost levels of key hormones involved in energy metabolism (Adam, 2008).

Human physical performance is determined by a combination of several anatomical, physiological, and psychological factors. The relative importance of each of these depends on the nature of the exercise. Various physical, psychological and physiological functions have been shown to undergo changes related to the time of the solar day. These variations are known as circadian or diurnal rhythms. These functions exhibit peaks and troughs of maximum and minimum function at specific times of the day. Many components related to athletic or games performance has been shown to possess these circadian rhythms.
CIRCADIAN RHYTHMS

In the 17th century, De Mairan, Jean-Jacques discovered the circadian rhythm. He placed a heliotrope (a herb that turns towards the direction of sun) in his closet, away from sunlight, in order to investigate the heliotrope’s inclination to respond to the sun. De Mairan noticed that twenty-four hour patterns (Circadian Rhythms) continued to exist in the movement of the heliotrope’s leaves even when the heliotrope was isolated from external stimulus, which in this case was the sun. The word Circadian Rhythm comes from the Latin circa, “around”, and dies, “day” which means “around a day”. Circadian Rhythm can be defined as the daily biological rhythm. This biological rhythm or the internal clock is sometimes referred to as the biological clock, which exists in mammals, plants, fungi, insects and so on, and it runs on a 24-hour cycle (Maryam Muhammed Amin, 2006).

Circadian rhythms are self-sustained variations in biological and behavioral functions with a period of 24 hours. Circadian rhythms are internally driven by the brain’s suprachiasmatic nucleus (SCN), the “circadian clock”. These endogenously produced circadian rhythms can be modified by bright light (or darkness), melatonin, and exercise because the SCN (1) receives neural input from cells in the retina that detect light, (2) has melatonin receptors, and (3) receives input from brain areas integrating information about the level of physical activity and
central nervous system arousal. These inputs to the SCN allow for an individual's circadian rhythms to be synchronized to a given environment. Healthy people are usually synchronized to the environment in which they live, and the dominant synchronizer is the light-dark cycle. The potential for circadian rhythms to influence sport performance is related to the neural outputs of the SCN. Neurons from the SCN project most densely to the hypothalamus, but there are also projections to the forebrain. The hypothalamus plays an important role in regulating a host of body and brain functions with potential relevance to athletic performance (Patrick O'Connor, Shawn Youngstedt, Orfeu Buxton and Michael, 2004).

**PHYSIOLOGY OF CIRCADIAN RHYTHM**

Within the circadian (24-hour) cycle, a person usually sleeps approximately 8 hours and is awake 16 hours. During the wakeful hours, mental and physical functions are most active and tissue cell growth increases. During sleep, voluntary muscle activities nearly disappear and there is a decrease in metabolic rate, respiration, heart rate, body temperature, and blood pressure. The activity of the digestive system increases during the resting period, but that of the urinary system decreases. Hormones secreted by the body, such as the stimulant epinephrine (adrenaline), are released in maximal amounts about two hours before awakening so that the body is prepared for activity. The circadian cycle is controlled by a region of the brain known as the hypothalamus, which is the master
centre for integrating rhythmic information and establishing sleep patterns. A part of the hypothalamus called the suprachiasmatic nucleus (SCN) receives signals about light and dark from the retina of the eye (Encyclopedia Britannica, 2009).

A clock entrained to the natural environment has a 24 hour period, while to a free running (non 24 hour) circadian clock (in constant dark or dim–light conditions) has a slightly different period, with marked variability among species and individuals. In humans, for example, the period is slightly longer than 24 hour, while in most rodents it is slightly less. The components of a circadian system include the clock itself, which generates the biological rhythms; input pathways that transmit environmental cues to the clock; and output pathways that transmit the clock’s rhythms to the rest of the organism, influencing a large number of endocrinology, biochemical, and electrophysiological processes (Frederick Goodwin and Kay Redfield Jamison, 2007).

By applying cosinor rhythometry method, a circadian rhythm can be characterized by estimating three parameters such as Mesor, Amplitude and Acrophase. Mesor is the acronym for Midline Estimating Statistic Of Rhythm i.e., the mean level of oscillation. Amplitude means the extent of oscillation from the Mesor or half of the total oscillation. Acrophase means timing of the crest of the wave form.
GENDER DIFFERENCES ON CIRCADIAN RHYTHMS

Sex differences in sleep-wake periods are more pronounced when the rhythms are desynchronized than when they are internally synchronized. These differences may be the result of differences in the length of intrinsic period between temperature and sleep-wake rhythms. The intrinsic periods of sleep-wake rhythms are indeed shorter in women than in men, whereas the intrinsic periods of temperature rhythms are found identical in both sexes. The consequences of internal desynchronization may be therefore greater in women than in men.

Sex hormones receptors are present in the human suprachiasmatic nucleus. Estrogen and progesterone may therefore act directly on neurons of the main human circadian clock. These biochemical mechanisms may probably explain the chronobiological gender differences which have been observed.

COMPONENTS OF VOLLEYBALL PERFORMANCE INFLUENCED BY CIRCADIAN RHYTHM

Volleyball is a sport in which the effort of the players during the game is not constant but includes a variety of interrupted explosive movements. The flexibility, anaerobic power, aerobic power, body temperature, resting heart rate, blood variables and total mood disturbance (TMD) plays a significant role on volleyball performance.

There is a circadian variation in trunk flexibility and hip flexibility. Circadian variation has also been found in lumbar flexion
and extension, passive straight leg raising and the distance from finger tip to floor in forward flexion. The timing of the peaks tends to follow the phase of the body temperature curve; although this does not imply that they are caused by the changes in temperature.

Most physiological functions exhibit circadian rhythmicity; maximum and minimum functions occur at specific times of day. In humans, circadian rhythms are expressed by oscillations in various physiological systems including blood pressure, body temperature, heart rate, hormone levels, and tremors (Michael J. Alter, 2004).

The metabolic functions showing cyclical changes include oxygen consumption $\text{VO}_{2\text{max}}$, carbon dioxide production $\text{VCO}_2$ and minute ventilation $\text{VE}$. In leg exercise the anaerobic capacity (as measured by the Wingate test) is reduced by eight per cent at 06:00 hours compared with 14:00 hours whereas the peak power value is maintained well, a decline in performance during the 30-s test suggests a motivational component in the circadian variation in anaerobic capacity.

Heart rate at rest tends to be recorded in assessments of athletes, notably in endurance specialist whose training regimens lead to low resting values. The rhythm in heart rate tends to occur earlier in the afternoon than does that of $\text{VO}_2$ or $\text{VCO}_2$, this phase leads being attributed in part to changes in catecholamine whose peaks occur around 13.00 hours (Edward M. Winter, 2006).
Robust variations in glucose regulations across the 24 hour cycle are now well demonstrated in both normal conditions and states of impaired glucose tolerance. Plasma glucose responses to oral glucose, intravenous glucose, or meals are markedly higher in the evening than in the morning. Diminished insulin sensitivity and decreased insulin secretion in relation to elevated glucose levels are both involved in causing reduced glucose tolerance later in the day. It has been shown that glucose tolerance further deteriorates as the evening progresses, reaching a minimum around the middle of the night (*Amita Sehgal 2004*).

The normal physiologic levels of several substances are affected by the time of day. Several tests such as corticotrophin, cortisol, lymphocyte count, and total WBC count peak in the morning hours. Several tests such as serum creatinine, triglycerides, blood urea nitrogen, and transferring peak in the late afternoon hours (*Steven Jones, 2000*). Ingestion of a protein rich meal in the evening leads to increases in the blood urea nitrogen, phosphorus, and uric acid that can persist for as long as 12 hours (*Kenneth McClatchey, 2002*).

The alertness and positive mood states peak in the walking hours, usually the afternoon, conversely, mood disturbance is lowest in the afternoon and early evening. Mood and subjective alertness are important, since such states can alter an individual’s motivation for strenuous physical exercise, circadian variations in mood states may
also affect the team “cohesion” of a sports squad (Michelle Warren and Naama Constantini, 2000).

**SCOPE OF THIS STUDY**

The scope of this study is to analyse the circadian rhythm on selected factors which have the main contributions of volleyball performance. Each factor of the variables has its own peak time and trough time. This will also vary between men and women. But if the peak times of all these selected factors of the variables would be predicted and if their peak times are closer together then that time would be the better time for peak performance of that particular individual or group.

Circadian rhythmicity of many variables has been established in previous research works. Not much works have been carried out to find to what extent these rhythmicity varies between men and women. There is no notable research works in this area conducted to analyse the circadian rhythmicity on flexibility, anaerobic power, aerobic power, body temperature, resting heart rate, blood variables and total mood disturbance (TMD) in a combined way and among group of both gender. Moreover, studies on circadian rhythm of mood states of athletes are also done to a lesser extent and the results are equivocal.

If any one has the knowledge of peak time for performance of an individual then one can go accordingly to plan training
methods and strategies to improve further and exhibit on highest performance in the competition.

On the basis of this knowledge and as a continuation of this research, selected factors of the variables were determined under normal schedules conditions in an attempt to gain an insight into the mechanisms of the circadian rhythms of flexibility, anaerobic power, aerobic power, body temperature, resting heart rate, blood variables and total mood disturbance (TMD) of this specie.

**Statement of the Problem**

The purpose of the study was to analyse the effect of circadian rhythm on selected factors related to volleyball performance of men and women volleyball players.

**Delimitations**

The study was delimitated in the following factors.

1. To achieve the purpose of the study, a total of thirty volleyball players [men (n = 15) and women (n = 15)] age between 19 years and 22 years from Einstein College of Engineering, Tirunelveli District, Tamil Nadu, India were selected as subjects for this study.

2. The study was confined to the men and women volleyball players.
3. It was confined to selected factors of the variables such as; flexibility, anaerobic power, aerobic power, body temperature, resting heart rate, blood sugar, blood urea, diastolic blood pressure, systolic blood pressure and total mood disturbance (TMD) which are the primary sub domains of Volleyball performance as dependent variables.

4. The various time points selected for collection of data were 02:00, 06:00, 10:00, 14:00, 18:00 and 22:00 hours.

Limitations

The following limitations were considered while interpreting the results of the study.

1. The weather conditions such as atmospheric temperature, humidity, exposure of light and dark and meteorological factors during testing period were not considered.

2. Though the subjects were motivated verbally, no attempt was made to differentiate the motivation level during the period of testing.

3. Since the manual operation was made in stop watch, the time was recorded in one tenth of a second.

4. Since the subjects were made to stay in the Human Performance Laboratory of Lotus Paramedical College, Ambasamudram, TamilNadu, and were asked to do the
tests even during night times, the psychological factors involved in their process could not be ascertained.

5. No effort was made to control the food habits, rest period, life style, sleep–walk cycle and other factors that affect metabolic function.

6. The investigator made an attempt to avoid, practice effort, familiarity with the tests and serial fatigue while conducting the tests; however no attempt was made to find out whether the above said factors influenced the performance of the subjects.

7. The investigator made an attempt to avoid the women subjects who are in menstrual cycle phase.

8. Only the total mood disturbance (TMD) was obtained from the Profile of mood state questionnaire.

9. Only selected physical, physiological and bio-chemicals variables were analyzed for the study and performance variables were not taken in to consideration.

**Hypotheses**

1. There may be a significant difference on selected factors related to volleyball performance between men and women volleyball players irrespective of different times of the day.

2. There may be a significant difference on selected factors related to volleyball performance between different times of the day irrespective of gender status.
3. There may be a significant difference on selected factors related to volleyball performance for men and women volleyball players on different times of the day.

4. There may be a significant circadian rhythmicity in selected factors related to volleyball performance of men and women volleyball players.

**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. 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 volleyball performance.

2. The findings of this study may add to the existing fund of knowledge with regard to the gender difference on the selected factors related to volleyball 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 and women 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, Sports Psychology 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 volleyball performance.

**Definition of Operational Terms**

**Circadian Rhythm**

The natural pattern of physiological and behavioral processes that are timed to a near 24-hour period. These processes include sleep-wake cycles, body temperature, blood pressure, and the release of hormones. This activity is controlled by the biological clock, which is located in the suprachiasmatic nuclei of the hypothalamus in human brains. It is highly influenced by natural dark-light cycles, but will persist under constant environmental conditions *(Brandon Peters, 2009)*.
Gender Difference

A gender difference is a distinction of biological and/or physiological characteristics typically associated with either males or females of a species in general (*Eric Loveday, (2009)*).

Flexibility

Flexibility is the ability of an individual to move the body and its parts through a wide range of motion as possible without strain to the articulations and muscle attachments (*Johnson and Nelson, 1984)*.

Anaerobic Power

Anaerobic power is the power produced without the requirement for oxygen to be present. Sprinting, at the end of a race, is predominantly an anaerobic activity. The power at these intensities can only be sustained for a short period of time (*Thomas, 1994)*.

Aerobic Power

The maximum amount of energy that can be produced from the aerobic energy system per unit time. Aerobic power depends on the ability of tissues to use oxygen to breakdown metabolic fuels and the combined abilities of various systems (pulmonary, cardiac, vascular, and cellular) to transport oxygen from the air to
mitochondria. Aerobic power is usually measured in terms of oxygen consumption ("The Maximum", 2007).

**Body Temperature**

Body temperature is typically expressed in terms of the core temperature and it is usually measured orally. It reflects the metabolic rate and the balance between heat production and heat loss. Normal adult body temperature, as measured orally, is 98.6° F (37° C). Oral temperatures ranging from 96.5° F to 99° F are consistent with good health, depending on the person's physical activity, the environmental temperature, and that person's usual body temperature ("The level", 2008).

**Blood Sugar**

Blood sugar is the simple sugar released from the liver into the blood stream, which nourishes all the cells of the body (Ardy Fred Berg, 1984).

**Blood Urea**

The nitrogen in the form of urea in whole blood or serum is blood urea. Its concentration is a gross measure of renal function. The upper limit of the normal range is 25 mg/100 ml ("The nitrogen", 2008).
Systolic Blood Pressure

Systolic blood pressure (SBP) is defined as the maximum pressure produced during the cardiac cycle. It is recorded during systole. Therefore, it is called systolic blood pressure (Pal, 2005).

Diastolic Blood Pressure

Diastolic blood pressure is defined as the minimum pressure recorded during the cardiac cycle. It is recorded during diastole. Therefore, it is called diastolic blood pressure (Pal, 2005).

Resting Heart Rate

“The number of times of heart beats per minute while at complete rest” (“The number”, 2007).

Mood States

An emotional condition that persists for some time, such as irritable, cheerful, or aggressive mood (“An emotional”, 2007).

Profile of Mood States (POMS)

A psychological test designed to measure a person’s affective states. These include tension, depression, anger, vigour, fatigue, and confusion. Unlike personality traits, mood states are thought to be transitory and specific to a given situation, although moods can also be measured for recent prolonged periods such as the past several months. POMS are a popular research tool among sport psychologists (“A psychological”, 2008).