EFFECT OF CIRCADIAN RHYTHM ON SELECTED MOTOR FITNESS AND PHYSIOLOGICAL PARAMETERS IN TRACK AND FIELD ATHLETES

A SYNOPSIS OF THESIS SUBMITTED TO THE JADAVPUR UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ARTS

By

SUMANTA DAS

DEPARTMENT OF PHYSICAL EDUCATION

JADAVPUR UNIVERSITY

KOLKATA-700032

WEST BENGAL

INDIA

MARCH, 2022

INTRODUCTION

The concept of circadian rhythm and its effects on sports training and performance was studied by several researchers, sports physiologists as well as sports scientists. The diurnal variation of circadian rhythm taxes on sports performance in terms of motor fitness as well as the physiological and psychological orientation of an athlete. Sincere efforts have also been made by the researcher to explore various dimensions of circadian rhythm in the sports arena. Nowadays, technological advancement and scientific orientation directly involve exploring sports performance and a tremendous comparative atmosphere has been observed in the field of sports. Now sports are not only limited to amateur settings, it is a profession as well as bread and butter. A large number of sports physiologists, sports scientists, and sports performance analyzers try to identify the specific internal and external orientation of optimum performance. However, it is well known that different types of sports demand different types of physical, physiological as well as psychological characteristics. Generally, physical training or activity indirectly alters the physiological and psychological dimensions of human beings, and family culture, food habits, lifestyle, local climate, and genetic factors play a leading role to build the physical structure. From this point of view, it is clear that specific physical orientation is required to execute any task effectively, that may be fieldwork or daily life activity. Now researchers, coaches, physical trainers as well as sports physiologists try to explore specific times of the day for specific physical training or activity according to their psycho-physiological condition. However, the motor performance of an individual depends on the functioning efficiency of neuro-physiological coordination and psychological readiness and diurnal effects of circadian rhythm taxes on neuro-physiological coordination and psychological readiness. Several studies discover the relationship between circadian rhythm and various physiological factors and conclude most of the physiological parameters (heart rate, blood pressure, body temperature, etc.) are affected by specific time intervals of the day.

There are several kinds of research that have been carried out to study the effect of circadian rhythm of physiological parameters of human beings such as body temperature, heart rate, blood pressure. The physiological functions were closely related to the changes in body temperature. Body temperature depends on the balance between heat production and heat loss. **Kleitman et al, (1938**) reported that the cause of the rhythm of body temperature probably was in variation in functioning of the heat loss mechanism or temperature-regulating mechanism and also suggested that the accepted distinction between morning and evening types might be related to early and late peaking in body temperature.

According to **Conroy and Mills, (1970)** temperature thresholds for vasodilation and sweating are greater by day than at night, although this appears to be a secondary manifestation of altered hypothalamic activity rather than the primary cause of the variation in core temperatures. According to **Folkard et al, (1985)** that individuals could differ from one another in the phase of their circadian rhythms in various measures including body temperature and performance efficiency for various tasks. It was also concluded that the circadian rhythms in temperature, alertness, and some types of performance could vary from person to person.

According to **Kleitman and Kleitman (1953) and Lewis and Lobban (1957)**, the heart rate shows a substantial circadian variation at rest. They reported that the circadian rhythmicity in resting pulse rate showed its lowest level between 4 to 6 a.m., rising rapidly until noon, increasing slightly until 5 to 6 p.m., and finally decreasing gradually until again reaching its lowest level. There is a substantial circadian variation in heart rate both at rest and during sub maximal exercise **(Voigt et al, 1967; Klein et al, 1968 and Crockford and Davies, 1969).**

The circadian rhythm in oral temperature and heart rate were parallel to each other in both phase and magnitude. They also observed individual variation in the circadian rhythms in these parameters **Sen and Kar, (1979).Reilly et al, (1984)** observed that the heart rate peaked in the afternoon. They also studied the effect of exercise on circadian rhythm and found that the normal rhythm became weakened at maximum heart rate.

Many investigations have been reported that blood pressure also exhibits circadian rhythm. The blood pressure, blood flow, blood component, oxygen consumption show circadian variation **(Cohen, 1980).** Similar results were obtained by **Reilly et al, (1984).**But according to **Cabri et al, (1988)**, there is no significant effect of circadian rhythm in pre-exercise blood pressure. They also observed there was no change in systolic blood pressure after exercise. They could observe circadian rhythm only in post-exercise diastolic pressure.

There is general agreement that athletic performance improves over the course of the day. One major factor in this variation is plainly the level of arousal of the competitions. The soccer players during 45 minutes, and found that movement on the field reached a minimum at about 05.00 hours, with a peak at 17.00 hours **(Reilly and Walsh, 1981).**According to **Reilly and Brooks, (1982)** the metabolic responses to exercise under steady-state conditions varied with the time of day. The maximal efficiency has been noted in the late afternoon **(Ferrario et al, 1982).** According to **Hill and Zauner, (1984)** the adaptation to exercise training might be specific to the time of the day of training. They found after regular weight training at a particular time of day, human subjects were stronger at that time of day than at another. **Hill, Cureton, and Collins, (1989)** studied the effect of

circadian rhythm on exercise performance. They found that the subjects who were trained in the morning had a higher value in the morning and subjects who were trained in the afternoon had higher values in the afternoon.

The present study has been designed to investigate the changes in motor fitness and physiological parameter that have been closely linked to the circadian rhythm. The supple change of motor fitness and physiological parameters maybe not be evident in the university student-athlete and sometimes evoked these changes of physiological and motor fitness parameters indicate the alteration of the circadian variation. From the above discussion, it appears that there are several investigations have been made regarding the circadian variation of physiological and motor fitness performance on humans. But less importance has been given to the changes of motor fitness and physiological parameter of the university student-athlete in different time intervals of the day as well as seasonal variation. The purpose of the study was to enrich the field of physical education with the knowledge of circadian rhythm that might be helpful in planning and programming training and competition for a higher level of motor performance. So the problem was stated as **EFFECT OF CIRCADIAN RHYTHM ON SELECTED MOTOR FITNESS AND PHYSIOLOGICAL PARAMETERS IN TRACK AND FIELD ATHLETES.**

STATEMENT OF THE PROBLEM

The purpose of the study was to investigate the effect of circadian rhythm on selected motor fitness and physiological parameters of the sprinter and jumper. Accordingly, the problem was stated as, **"EFFECT OF CIRCADIAN RHYTHM ON SELECTED MOTOR FITNESS AND PHYSIOLOGICAL PARAMETERS IN TRACK AND FIELD ATHLETES."**

PURPOSE OF THE STUDY

The purpose of the study were as follows

(i) To observe the effect of circadian rhythm on selected physiological and motor fitness parameters.

(ii) To find out the relationship between both physiological and motor fitness parameters at different times of the day.

(iii) To find out the zone peak performance i.e. peak value of circadian rhythm of both physiological and motor fitness parameters.

(iv) To observe seasonal influence such as summer and winter season on different physiological and motor fitness performance.

(v) To find out the appropriate time of competition for better performance of athletes.

DELIMITATIONS OF THE STUDY

To conduct the present study successfully the researcher had delimited the study in the following aspects

i) The age of the subject was delimited to 22-25year

ii) The study was confined to AAHPER Youth Physical fitness tests such as 50-yard speed, sit up, pull up, standing broad jump, shuttle run, 6oo yard run.

iii) The study was confined to resting pulse rate, body temperature, blood pressure (BP) only at physiological parameters.

iv) The study was delimited to only three-time of a day such as 8.00 am, 12.00 pm, and 4.00 pm.

v) The study was confined to environmental temperature and humidity.

vi) The study was confined to the summer and winter seasons only

LIMITATIONOF THE STUDY

The present study was carried out with limiting conditions such as:

i) The study would be better in its way if the scholar could also assess certain factors like lifestyle and socio-economic status among the population. But unfortunately, it was not done.

ii) It should be better if the motivational level would be measured. However, the participants were motivated verbally.

iii) The researcher was unable to control other variables such as the willingness of the participants which might serve as the limitation of the study.

HYPOTHESIS

The hypothesis for the present study were

i) H_1: There may be a positive relationship between both physiological and motor fitness parameters at different times of the day.
ii) H_1: There may be a significant difference among the different time periods of the day on the selected motor fitness and physiological parameters of the athletes.
iii) H_0: There may be no effect of seasonal circadian variation in selected motor fitness and physiological parameters among the athletes

REVIEW OF RELATED LITARATURE

According to related review literature, **Cohen and Muchl (1977)** were the first to investigate circadian variation in human physiology. They conducted a study to analyze the human circadian rhythms in resting and exercise pulse rates and founds lowest resting pulse rates for all subjects occurred between early morning to morning session (04:00 am - 08:00 am) and the highest resting pulse rates occurred between evening and night session (6:00 pm to 12:00 am). Furthermore, they concluded that exercise pulse rates also followed this same general pattern, and tended to amplify the circadian rhythmicity.

Diurnal effects of the circadian rhythm also tax on sports performance. **Rajagopal (2010)** conducted a study to explore the effect of circadian rhythm on volleyball performance. Selected performance-related parameters such as flexibility, anaerobic power, aerobic power along with some physiological and psychological determine (body temperature, resting heart rate, blood sugar, blood urea, diastolic blood pressure, systolic blood pressure, and mood disturbance were measured from thirty 19-22 years volleyball players. The research reveals significant differences in flexibility, anaerobic power, aerobic power, body temperature, systolic blood pressure, and mood disturbance at different times of the day. Numerous studies were conducted to discover invasive effects of circadian rhythm on sports performance and they observed many performance-related indicators directly related to diurnal variation **(Atkinson et al., 2005; Reilly and Waterhouse, 2009; Waterhouse, 2010; Teo et al., 2011; Atkinson et al. 2014).** According to scientific literature survey, early evening (3:00 pm – 6:00 pm) is considered as prime performance time of the day, in consequence, core body temperature has also been observed optimum in the human body at that time **(Reilly and Garrett, 1998; Starkie et al., 2005; Atkinson et al., 2005).** Ideal core body temperature signifies physiological arousal which generally improves human performance. In the year 2005, Racinaiset. al. introduced a study design to evaluate fluctuation of maximal sprint power and repeated sprint ability

with a different training time of the day. The study concludes that blood lactate concentration and heart rate were higher in the evening than morning in repeated sprint ability which indicates afternoon session training useful for improving blood lactate tolerance. The peak power developed during the first sprint was higher in the evening than morning, but this difference was not apparent in subsequent sprints. The study suggests that the beneficial effect of time of day may be limited to a single expression of muscular power and fails to advantage performance during repeated sprints. A similar study was also investigated by **Giacommicet. al., (2006)** investigated the diurnal effect on repeated all-out cycle performance and short-term recovery. Short-term recovery patterns were investigated after ten 6-seconds maximal sprints inter-spaced by 30 seconds rest in the different times (morning, afternoon) of separate days. During the experiment, peak power output, total mechanical work, peak pedaling rate, and peak efficient torque were recorded. To evaluate neuromuscular fatigue and short-term recovery patterns from all-out intermittent effort maximal voluntary contraction of knee extensors muscles were also measured before and immediately after the cycle bouts. The activity of the vastuslateralis muscle was also tracked by electromyography. The study revealed different time of day was not significant for any biomechanical indices of neuromuscular performance. However, the results suggested that short-term recovery patterns of neuromuscular function are faster in the morning session compared to the afternoon sessions. **Reilly et. al. (2007)** conducted a study to analyze the diurnal variation in mental and physical performance and simulated football-specific skills. Strength, reaction times, flexibility, juggling and dribbling, and wall-volley tests were directed on different days at morning, noon, afternoon, and night in a counterbalanced manner. Significant diurnal variations were found for reaction time, flexibility. Juggling performance showed significant diurnal variation and was highest in the afternoon session, whereas performance on the wall-volley test tended to peak at night session and dribbling showed no time-of-day effect. The study concluded that football playing performance may be affected by circadian rhythm and afternoon to night session is most appropriate for optimum performance.Body temperature also peaked at a similar time, but positive mood states seemed to peak slightly earlier.Another group of sports physiologists **Martin et al (2001)** studied physiological responses to incremental running at different times of the day. Several noninvasive physiological variables such as core body temperature, heart rate, minute ventilation, oxygen uptake, respiratory exchange ratio, and capillary blood lactate were measured at rest, after a warm-up, and at 10, 20, and 30 minutes during the run. A significant diurnal variation was observed in core body temperature and respiratory exchange ratio. Diurnal variation continued for body temperature throughout the warm-up and during exercise. However, morning trials significantly elevated the rate of perceived exertion compared to afternoon running trials. These findings suggested core body temperature is broadly

affected by diurnal variation. Whereas other physiological responses during running at lactate threshold levels were rarely affected by circadian variation.

METHODOLOGY

In these section the subjects, criterion measure, design of study, procedure followed to collect data and analytical procedures had been described here

THE SUBJECT

In the present study, 30 male athletes in each group of sprinters and jumpers were selected having the age range 22-25 years from different training institutions of west Bengal. The subjects were studying in college and universities and have represented in Athletic Championship. Data were collected at two seasons (winter and summer) of the year at three time periods of a day (8.00 am, 12.00 pm, and 4.00 pm).

CRITERION MEASURE

The criterion measure adopted for the studies measuring the Motor fitness parameters and physiological parameters are given below.

Tests and criterion measure for the selected parameters

Table A: Physiological Parameters.

Sl No	Parameters	Tests and instruments	Unit of measurement
1	Resting pulse Rate	pulse oximeter	Beats/minute
2	Resting systolic blood pressure (SBP)	Digital sphygmomanometer	mm of Hg
3	Resting diastolic blood pressure (DBP)	Digital sphygmomanometer	mm of Hg
4	Body temperature	Digital thermometer	Fahrenheit

Table B: Motor fitness parameters

Sl. No	Component	Test items	Unit of measurement
1	Speed	50 - yard dash	In seconds
2	Agility	Shuttle run	In seconds
3	Explosive leg power	Standing broad jump	In meter
4	Basic endurance	600-yard run	In seconds
5	Muscular strength endurance of arm and shoulder	Pull up	In number
6	Muscular strength endurance of abdominal muscle	Sit up	In number

DESIGN OF THE STUDY:

The experiments of the study were divided into the following phases:

Phase-I: Comparison and correlation of motor fitness and physiological parameters among the sprinter in summer and winter season at the different time periods of the day – In this phase the evaluation of different selected motor fitness and selected physiological parameters of the sprinter at the different time periods of a day in summer and winter season on a comparative basis and also determine the correlation between motor fitness and physiological parameters in the different time periods of the day in both season.

Phase- II: Comparison and correlation of motor fitness and physiological parameter among the jumper in summer and winter season at the different time periods of the day – In this phase the evaluation of different selected motor fitness and selected physiological parameters of the jumper at the different time periods of the day in summer and winter season on a comparative basis and also determine the co-rrelation between motor fitness and physiological parameter in the different time periods of the day in both season.

PROCEDURE FOR COLLECTING DATA:

In order to acquaint the participants with the specific purpose of the research being conducted, all the participants were assembled in their Fitness Centre. All the necessary information pertaining to the requirement of the testing procedure was imparted to them. To make the research findings more authentic, a positive attitude towards investigation was emphasized.

During the test measurements, the subjects were informed that they should maintain their normal eating habits and avoid excessive fatty food intake. Before 24 hours of each test session. Athletes were warned that they should sleep for at least 8 hours, not use any caffeine or stimulants, and not perform high-intensity activity. They were also informed that they should receive light food before each test session. To see the circadian variation of the selected motor fitness and physiological variables (pulse Rate, Blood Pressure, body temperature) the data on the same day were collected from the selected participants in resting conditions at selected times of the day i.e. 08.00 hours, 12.00 hours, 16.00 hours. During the day athletes came to the sports hall thirty minutes before each test session. Firstly, a digital sphygmomanometer was attached to athletes in order to determine resting

blood pressure, and then body temperature and resting pulse rate were measured. The athletes were warmed with the trainer for 15 minutes. After warming up,the motor fitness of the subjects was measured by the six-item AAHPER Youth Fitness Test Battery.

ANALYTICAL PEOCEDURE

For the purpose of analysis of data, the following statistic was applied. The obtained data in form of digital scores were treated statically to get the result and to draw a conclusion. Mean and SD was used as descriptive statistic. The degree of relationship was measured with the help of the correlation coefficient. The significance of statistical difference at different time periods was measured with the help of F test and to find out the exact difference between time periods of the day post hoc test was applied.

RESULT AND DISCUSSION

RESULTS OF THE STUDY

On the basis of analysis of data the following result s have been obtained in the present study-

The present study indicated that different time periods of the day had a effect on the different parameters of motor fitness (Speed, agility, explosive leg power, basic endurance, muscular strength endurance of arm and shoulder, and muscular strength endurance of abdominal muscles), the performance of the athletes as well as some physiological variables. It was seen that the nature of the circadian rhythm of motor fitness showed a lower/ moderate value in the morning at 08.00 am and noon at 12.00 pm, and peak value in the evening at 04.00 pm in winter season. Some components of motor fitness such as agility, explosive leg power, and basic endurance showed significant circadian variation. On the other hand, no significant circadian variation was noted in the speed, muscular strength endurance of the arm and shoulder, and muscular strength endurance of abdominal muscles values among the athletes. Regarding the effect of circadian rhythm in physiological parameter suggests that the physiological variables in resting condition increases from morning to afternoon and then starts declining slowly among the athletes. A significant circadian variation was seen in the blood pressure and body temperature having a peak value at 04.00 hours and lowest at 08.00 hours

among the selected athletes. There was no significant circadian variation was noted in the pulse rate values at different time periods of the day in both seasons among the selected athletes. Almost all the physiological parameters showed a significant positive correlation with motor fitness components at different time periods of the day for both seasons. Regarding the effect of seasonal variation on circadian rhythm in motor fitness, it was noted that the nature of circadian rhythm became moderate value at 08.00 am and 12.00 pm and peak value during 04.00 pm in summer season and the winter season the rhythm of the motor fitness showed a lower value in the morning at 08.00 am, moderate value at noon 12.00 pm, and peak value in the evening at 04.00 pm.

DISCUSSION OF THE RESULTS

The influence of circadian rhythms in human physical performance has been reported in several studies (Atkinson and Reilly, 1996; Drust *et al*., 2005; Redlin and Mrosovsky, 1997; Reilly, 1990). There are some reports on clear relationship between circadian rhythms and Physical activities involving aerobic fitness, anaerobic fitness, fine and gross motor skills (Bessot *et al*., 2007; Kline *et al*., 2007; Reilly *et al*., 2007). Many of our habits, actions and the daily activities have been influenced by the rhythmic oscillation of biological process. According to the Winget *et al*., (1985) many physiological changes associated with the athletic performance have also been shown to follow the circadian rhythms. Cappaert (1999) also reported that many physiological functions like resting levels of sensory motor, perceptual, and cognitive performance and several neuromuscular, behavioural, cardiovascular, and metabolic variables have been found to occur in the early evening, in line with peak body temperature rhythm. The present study has showed that the selected motor performance and physiological functions have been altered in different time periods of the day among the both sprinter and jumper athletes.

It has been observed from the present study that the motor performance of the athletes changed at different time periods of the day. The motor fitness variables like speed, agility, strength/power and endurance of the athletes has been measured by 50 yard run, shuttle run, SBJ and 600 yard run respectively in both sprinter and jumpers in affected by different time periods of the day during summer and winter season. Therefore, the motor fitness performance in winter has increased with the increase in the day hours and reached to the peak level during afternoon at 4.00 pm. Thereafter, the motor fitness performance has showed increasing tendency. So, the results of the present study reveal that the motor fitness performance exhibits the circadian rhythm. The nature of the circadian rhythm in motor fitness performances is of moderate value in the morning, lower value at noon and the peak value reaches in the afternoon/evening in summer season. The reason behind

this can be that in early morning hours of summer season, athletes feel easy to perform aerobic activities due to the moderate temperature prevailing in the atmosphere. On contrasting, in winter season athletes feel very easy to perform aerobic activities during the early evening hours due to the temperature effect. This may be reason in which both resting heart rate and respiratory rate has been found to be better in the early morning hours (08.00 am) (Afonso *et al*., 2009).

The variation in performance which has been observed in the data of the present study is in consonance with many leading researchers (Atkinson and Reilly, 1996; Drust *et al*., 2005; Redlin and Mrosovsky, 1997; Reilly, 1990). Many of these researchers have indicated that from morning to afternoon there is a change in environment temperature with diurnal variation as a consequence, body temperature changes with minimum being in the morning and maximum during afternoon. Furthermore, they have indicated that these changes have a strong influence in body metabolism, calcium release in the muscle fibre, mental activity, sleep-wake cycle, which may be attributed in the final motor performance in selected test. From this observation, it is evident that due to these changes in body external environment as a consequence of circadian rhythm the significant improvement of performance is observed in selected activity. Perhaps for this reason many competition for example weightlifting, wrestling etc where power has a crucial role to play performance are being conducted in the afternoon. Considering the influence of circadian rhythm on performance if competition is being conducted in the afternoon accordingly, the athlete will be benefited maximum but it is also doubtful whether the organizer in various competitions are aware of the changes in performance due to circadian rhythm. In Olympics, it has been observed that marathon is being conducted when temperature is maximum to accommodate TV viewer worldwide. Competition should be conducted after considering the circadian rhythm influence on athletic performance. Training should be conducted by accepting this variation.

The effect of circadian rhythms on sporting performance and some other related variables have been dealt with such as maximal and resting heart rate, maximum isometric power, hormonal adaptations, flexibility, reaction time, body temperature, isokinetic leg power, anaerobic power and capacity has been revealed by many studies (Bougard *et al*., 2009; Afonso *et al*., 2006; Sedliak *et al*., 2007; Reilly and Waterhouse, 2009; Wyse *et al*., 1994; Hill and Smith, 1991). According to the Waterhouse *et al*., (2005), the Body temperature is one of the important basic variables of circadian rhythm and many sporting performance elements follow body temperature changes. The temperature is not constant geographically throughout the day. According to the change of the temperature in a day both physical and physiological qualities are varied. According to Reilly (1992), the body temperature and motor performance both are closely related. In the present investigation, when the subject's body temperature at various times is measured, it has been revealed that body temperature has increased gradually from morning to afternoon in both summer and winter season. The body

temperature measured at 4.00 pm is seen as statistically higher than the body temperature level obtained at 8.00 am and 12.00 pm; similar result has been reported by Venugopal *et al*., (2010). Both the physical and physiological variables differed significantly with the reference to change of temperature in a day (Navamani, 2004). He also found that the above physical variables during the evening hours (14.00 hrs) were significantly higher. Therefore, the results of the present study confirm a causal link between body temperature and exercise performances. Indeed, the increase in core temperature in the afternoon could enhance the conduction velocity of the action potentials and the metabolic reactions increasing. However, the present study's results also showed a significant correlation between body temperature and motor fitness Indeed, the increase in core temperature in the afternoon could enhance the conduction velocity of the action potentials and the metabolic reactions increasing, therefore, the muscle power also increase.

The results of the present study have been supported by the results of previous findings that the motor performance of the athletes shows circadian variations (Reilly, 1990; Atkinson and Reilly, 1996 ;). According to Reilly, (1994), many components of motor performances are closely related to body temperature which reaches to peak level in the evening. Reilly (1994) also suggested that the functions of the lungs, cardio vascular system, kidneys, muscular activity and cognitive abilities have been regulated by circadian rhythms. The maximum efficiency of the players was observed in the late afternoon (Ferrario *et al*., 1982). The grip strength of the athletes happens to be greatest during the day hours and least in night (Kleitman, 1963). Kleitman (1963) and Garai (1992) reported that the accuracy of the performances of the athletes reach to maximum level at 12.00 hours and minimum in the early morning. Reilly and Garrett, (1998) proved that the various sports performances are influenced by the different times throughout the day and it was also depend on the intensities and duration of the exercise. Many studies have documented the fluctuations and changes in athletic performance at various hours of the day. The isokinetic muscle strength of the knee-lowering muscles significantly change in different hours of the day and the muscle strength increases in the evening (Bambaichi *et al*., 2005 34). The fat oxidation was highest in both obese and normal men observed in the evening (Mohebbi and Azizi, 2011). According to the Jourkesh *et al*., there is significant difference in the maximum anaerobic power at the different time periods of the day; however, there have been no significant changes in speed, strength at different hours of the day in present study. Winget *et al*., (1985) reported that circadian rhythm in motor fitness may also be due to the circadian rhythmin psychological parameters. Subjective alertness and variation in mental performance have been reported to exhibit circadian rhythm with peak value in afternoon Winget et al, (1985) , Brown (1949), Thayer (1970), Dermer (1972).Psychological parameters associated with arousal also exhibit pronounced circadian rhythm with high values during day and lower value during night Conroy and Mills (1970). Most of the world records and athletes peak performances are

usually gained in the evening time, because during the evening hours the internal temperature of athletes body is maximum (Reilly and Garratt, 1998)

Results of the present study indicated that the physiological parameters were at peak level in the afternoon. Different physiological factors such as body temperature, pulse rate, blood pressure, cardiovascular functions, respiratory functions, blood compositions etc. involved in the alteration of motor fitness performances with circadian variations. Most of the physiological functions of the human have been influenced by the circadian rhythm along with the physical activity (Sollberger, 1965; Moore Ede et al, 1983). Circadian variations in cardio vascular functions make significant contributions to athletic performances, since these variations influence: the rate of delivery of oxygen, glucose and hormones to various systems, the removal of metabolites from these organs, the distribution of metabolic heat from core to periphery, and the relative impact of physical exercise upon cardiovascular function itself (Winget et al, 1985). According to Winget et al, (1985) the circadian rhythms in cardiac function (stroke volume, cardiac output, and heart rate) peak around 17:00 hrs. The blood pressure is also at the peak level during afternoon, associated with the minimal capillary resistance due to circadian rhythm (Doring and Riecke, 1976; Kanabrocki *et al*., 1973). *Reilly et al*., (2001) pointed out that the circadian rhythm in heart rate responses had significant variation after exercise. The cardiovascular system is most resistant to the impact of position or postural changes during the physical activity (Aschoff and Aschoff, 1969; Hossman *et al*., 1980).

As far as this current investigation is concerned, there are certain limitations. The cardiac output or stroke volume is not measured during the study period. The hormonal status like the concentration of cortisol and testosterone of the subjects has not been measured during the study period. Only male subjects were selected for the experiment; females were not selected because the physiological conditions of females may change according to their menstrual cycle (Dunne *et al*., 1991; Freedman and Girgis, 2000; Kuwahara *et al*., 2005). So, effects of circadian rhythm may be affected by other physiological factors in females.

From the present study it can be concluded that the physical and physiological activity is higher in afternoon and/or evening in comparison to morning time. The cardiovascular system is influenced in the different time periods of the day in different seasons. Physical efficiency is higher in evening and/or afternoon compare to morning hours, is probably due to efficient regulation of cardiovascular system, and by the autonomic nervous system. However, reflex autonomic and cardiovascular activities are efficient in athlete subjects compared to normal subjects.

TESTING HYPOTHESIS

1) First hypothesis stated that there may be positive relationship between the both physiological and motor fitness parameter with different time of the day.The findings of the study showed that there was significant positive relationship between the some physiological and motor fitness parameter with different time of the day. However there was no significant relationship in few parameters.So as per the assessment of significance, null hypothesis was partially rejected.

2) The second hypothesis stated that therewas significant difference among the different time periods of the day on the selected motor fitness and physiological parameter of the athletes.The findings of the study showed that there was significant difference in agility, explosive power, endurance, resting blood presser, and body temperature. Hence the second hypothesis on the above said parameters was accepted. However there was no significant difference in speed, strength, resting pulse rate, at different time of day hence null hypothesis was partially rejected

3) The third hypothesis stated that there was no effect of seasonal circadian variation in selected motor fitness and physiological parameter among the athletes. The finding of the study showed that there was significant deference observed thus null hypothesis was rejected.

CONCLUSION

Results of the present investigation lead to draw the following conclusion:

i. Total motor fitness shows circadian rhythm with changing values at different periods of the day. This circadian rhythm becomes different with seasonal variation.

ii. During winter the motor fitness reaches its peak value in afternoon and lowest in the morning. In summer also the motor fitness becomes highest in afternoon but it becomes lowest at noon.

iii. Specific motor fitness components of sprinters and jumpers – the agility, power and endurance exhibit circadian rhythm with their peak values in afternoon.

iv. Other motor fitness components of both the groups considered in this study – the speed, arm strength and abdominal strength endurance do not exhibit circadian rhythm either in winter or summer.

v. Physiological parameters in resting condition – the systolic, diastolic blood pressures and body temperature how circadian rhythm with the trend of increasing from morning to afternoon in both the seasons. But, the trend becomes a decreasing one from evening.

vi. The pulse rate at resting condition does not show any circadian variation.

vii. In both the season almost all the physiological parameters(except pulse rate) showed significant positive correlation with total physical fitness parameters in case of both the sprinters and jumpers at different time of the day.

RECOMMENDATION

On the basis of the results of the study and conclusions drawn, the following recommendation may be made for further investigation and for practical purpose.

RECOMMENDATION FOR FUTURE RESEARCH

The following recommendations were made for future investigation in the light of the results of the present study

i) It was recommended that similar research may be conducted collecting data for the entire duration of a day (24 hours) and also with the subjects both male and female of different age groups, subjects with different levels of participation in different games and sports.

ii) It was recommended that more study may be conducted to analyze the circadian rhythms in motor skills and also in the other components of fitness such as maximum strength, balance, adaptation ability, orientation ability, coupling, etc.

iii) It was recommended that the physical trainers and coaches should prepare the training and competition schedule on basis of the nature of circadian variation and plans for travel of the athletes in their respective games.

RECOMMENDATION FOR PRACTICAL APPLICATION

i) Training programmed for games and sports should be prepared on the basis of the nature of circadian rhythm in motor fitness and physiological parameter.

ii) For preparing the competition schedule nature of circadian rhythm should be considered.

iii) For the intercontinental championship, world championship and Olympic Games change of time of competition from the time of training is an essential feature. In these cases, long-term planning for adaptation with the change in time of training should be done.

Reference

1. Afonso, L. D. S., Santos, J. F. B. D., Lopes, J. R., Tambelli, R., Santos, E. H. R., Back, F. A., ... & Lima, J. R. P. D. (2006). Maximal heart rate on treadmill at different times. *RevistaBrasileira de Medicina do Esporte*, *12*, 318-322.
2. Atkinson, G., & Reilly, T. (1996). Circadian variation in sports performance. *Sports medicine*, *21*(4), 292-312.
3. Atkinson, G., & Reilly, T. (1996). Circadian variation in sports performance. *Sports medicine*, *21*(4), 292-312.
4. Atkinson, G., Edwards, B., Reilly, T., & Waterhouse, J. (2007). Exercise as a synchroniser of human circadian rhythms: an update and discussion of the methodological problems. *European journal of applied physiology*, *99*(4), 331-341.
5. Bessot N, Nicolas A, Moussay S, Gauthier A, Sesboue B, Davenne D (2006). The effect of pedal rate and time of day on the time to exhaustion from high-intensity exercise. Chronobiol International, 23(5): 1009–1024.
6. Bessot, N., Moussay, S., Clarys, J. P., Gauthier, A., Sesboüé, B., &Davenne, D. (2007). The influence of circadian rhythm on muscle activity and efficient force production during cycling at different pedal rates. *Journal of Electromyography and Kinesiology*, *17*(2), 176-183.
7. Bishop D, Edge J, Goodman C (2004). Muscle buffer capacity and aerobic fitness are associated with repeated-sprint ability in women. European Journal of Applied Physiology, 92(4-5): 540-547.
8. Bishop D, Girard O, Mendez-Villanueva A. (2011). Repeated-sprint ability – part II: Recommendations for training. Sports Med. 41: 741–56.
9. Bougard, C., Moussay, S., Gauthier, A., Espié, S., &Davenne, D. (2009). Effects of waking time and breakfast intake prior to evaluation of psychomotor performance in the early morning. *Chronobiology International*, *26*(2), 324-336.

10. Boussetta N, Abedelmalek S, Aloui K, Souissi N (2017). The effect of air pollution on diurnal variation of performance in anaerobic tests, cardiovascular and hematological parameters, and blood gases on soccer players following the Yo–Yo Intermittent Recovery Test Level-1. Chronobiology International, 34(7): 903-920.
11. Brown FM, Neft EE, LaJambe CM (2008). Collegiate rowing crew performance varies by morningness-eveningness. The Journal of Strength & Conditioning Research, 22(6): 1894-1900.
12. Bruyn, L.; Lamoureux, T. Literature Review: Cognitive Effects of Thermal Strain; Defence Research and Development Canada: Toronto, ON, Canada, 2005
13. Cappaert TA (1999). Time of day effect on athletic performance: An update. The Journal of Strength & Conditioning Research, 13(4): 412-421.
14. Cappaert, T. A. (1999). Time of day effect on athletic performance: An update. *The Journal of Strength & Conditioning Research*, *13*(4), 412-421.
15. Carrier, J., & Monk, T. H. (2000). Circadian rhythms of performance: new trends. *Chronobiology international*, *17*(6), 719-732.
16. Chin CY, Chow GCC, Hung KC, Kam LH, Chan KC, MokYT, Cheng NM (2015). The diurnal variation on cardiovascular endurance performance of secondary school athlete student.Asian Journalof SportsMedicine, 6(2):e22697.
17. ChtourouH, AlouiA, HammoudaO, ChaouachiA, ChamariK, Souissi N (2013). Effect of static and dynamic stretching on the diurnal variations of jump performance in soccer players. PloS One, 8(8):doi:10.1371/journal.pone.0070534
18. ChtourouH, Engel FA, FakhfakhH, FakhfakhH, HammoudaO, SouissiN, SperlichB (2018). Diurnal variation of short-term repetitive maximal performance and psychological variables in elite judo athletes. Frontiers in Physiology, 9:1499.
19. Chtourou H, Souissi N (2012).The effect of training at a specific time of day: a review. J Strength Cond Res. 26(7):1984–2005.
20. Chtourou, H., &Souissi, N. (2012). The effect of training at a specific time of day: a review. *The Journal of Strength & Conditioning Research*, *26*(7), 1984-2005.
21. Chtourou, H., Aloui, A., Hammouda, O., Chaouachi, A., Chamari, K., &Souissi, N. (2013). Effect of static and dynamic stretching on the diurnal variations of jump performance in soccer players. *PloS one*, *8*(8), e70534.
22. Conroy, R. T. W. L., & Mills, J. N. (1970). *Human circadian rhythms*. Churchill.

23. Copes, K., &Rosentswieg, J. (1972). The effects of sleep deprivation upon motor performance of ninth-grade students. *The Journal of sports medicine and physical fitness*, *12*(1), 47-53.
24. Crockford, G. W., & Davies, C. T. (1969). Circadian variations in responses to submaximal exercise on a bicycle ergometer. *The Journal of physiology*, *201*(2), 94P-95P.
25. Cruz R, de AssisManoel F, MeloBP, da Silva SF (2014). Circadian cycle and ıts ınfluence on parameters of aerobic training. American Journal of Sports Science and Medicine, 2(2): 65-69.
26. Da Silva JF, Guglielmo LG, Bishop D (2010). Relationship between different measures of aerobic fitness and repeated-sprint ability in elite soccer players. The Journal of Strength & Conditioning Research, 24(8): 2115-2121
27. Daan, S., &Aschoff, J. (1975). Circadian rhythms of locomotor activity in captive birds and mammals: their variations with season and latitude. *Oecologia*, *18*(4), 269-316.
28. Dalton B, McNaughton L, Davoren B (1997). Circadian rhythms have no effect on cycling performance. International Journal of Sports Medicine, 18(7): 538–542. doi:10.1055/s-2007-972678
29. Draper N, Whyte G (1997). Here's a new running based test of anaerobic performance for which you need only a stopwatch and a calculator. Peak Performance, 96: 3-5
30. Drust, B., Ahmed, Q., &Roky, R. (2012). Circadian variation and soccer performance: Implications for training and match-play during Ramadan. *Journal of sports sciences*, *30*(sup1), S43-S52.
31. Drust, B., Waterhouse, J., Atkinson, G., Edwards, B., & Reilly, T. (2005). Circadian rhythms in sports performance—an update. *Chronobiology international*, *22*(1), 21-44.
32. Durnin J, Womersley J (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 Years. British Journal of Nutrition, 32(1): 77-97.
33. Edwards, B, Reilly, T., Atkinson, G., Waterhouse, J., Farrelly, K., &Fairhurst, E. (2007). Diurnal variation in temperature, mental and physical performance, and tasks specifically related to football (soccer). *Chronobiology international*, *24*(3), 507-519.
34. Emek, C. A. N., Kutlay, E., Özkol, M., &Çetinkaya, C. (2016). The effect of circadian rhythm on some physical and physiological parameters in male taekwondo athletes. *Pamukkale Journal of Sport Sciences*, *7*(1), 12-24.
35. Faria IE, Drummond BJ. Circadian changes in resting heart rate and body temperature, maximal oxygen consumption and perceived exertion. Ergonomics 1982; 25: 381-6
36. Ferrario, S., Agius, I., & Morisot, A. (1992). Daily variations of xylemic exudation rate in tomato. *Journal of plant nutrition*, *15*(1), 69-83.
37. Ferrario, V. F., & VF, F. (1982). Ritmicircadiani in atletimilitari.

38. Fitzgerald, J. M., Adamis, D., Trzepacz, P. T., O'Regan, N., Timmons, S., Dunne, C., & Meagher, D. J. (2013). Delirium: a disturbance of circadian integrity?. *Medical hypotheses*, *81*(4), 568-576.
39. Hill CM, Hill DW. Influence of time of day on responses to the profile of mood states. Percept Mot Skills 1991 ; 72: 434
40. Hill DW, Cureton K1, Collins MA. Circadian specificity in exercise training. Ergonomics 1989; 32 (I): 79-92
41. Hill DW, Cureton KJ, Collins MA, et al. Diurnal variations in responses to exercise of "morning types" and " evening types". J Sports Med Phys Fitness 1988; 28: 213-9
42. Hill, D. W., & Smith, J. C. (1991). Circadian rhythm in anaerobic power and capacity. *Canadian journal of sport sciences= Journal canadien des sciences du sport*, *16*(1), 30-32.
43. Hill, D. W., Cureton, K. J., & Collins, M. A. (1989). Circadian specificity in exercise training. *Ergonomics*, *32*(1), 79-92.
44. Holland, G. J. (1968). Effects of limited sleep deprivation on performance of selected motor tasks. *Research Quarterly. American Association for Health, Physical Education and Recreation*, *39*(2), 285-294.
45. Hossmann, V., Fitzgerald, G. A., &Dollery, C. T. (1980). Circadian rhythm of baroreflex reactivity and adrenergic vascular response. *Cardiovascular research*, *14*(3), 125-129.
46. Hower, I. M., Harper, S. A., & Buford, T. W. (2018). Circadian rhythms, exercise, and cardiovascular health. *Journal of circadian rhythms*, *16*.
47. Hower, IM , Harper, S., Buford, TW (2018). Circadian rhythms, exercise, and cardiovascular health. Journal of Circadian Rhythms, 16(1): doi: http://doi.org/10.5334/jcr.164
48. Huang, X.D. Study on the Correlation between Heart Rate and Blood Lactate in Adolescent Middle and Long Distance Runners and Their Application in Training; Wuhan Institute of Physical Education: Wuhan, China, 2007. (In Chinese)
49. Iannone, L. P. (1988). *The effect of morning and evening aerobic class participation on adult mood states* (Doctoral dissertation, Southern Connecticut State University).
50. Innominato, P. F., Focan, C., Gorlia, T., Moreau, T., Garufi, C., Waterhouse, J., &Bjarnason, G. A. (2009). Circadian rhythm in rest and activity: a biological correlate of quality of life and a predictor of survival in patients with metastatic colorectal cancer. *Cancer research*, *69*(11), 4700-4707.
51. Jarraya S, Jarraya M, Chtourou H, Souissi N (2014). Diurnal variations on cognitive performances in handball goalkeepers. Biological Rhythm Research, 45(1): 93-101.

52. Jones, H., George, K., Edwards, B., & Atkinson, G. (2008). Effects of Time of Day on Post-Exercise Blood Pressure: Circadian or Sleep-Related Influences?. *Chronobiology international*, *25*(6), 987-998.

53. Kanabrocki, E. L., Sothern, R. B., Sackett-Lundeen, L., Ryan, M. D., Johnson, M., Foley, S., &Nemchausky, B. (2008). Creatinine clearance and blood pressure: a 34-year circadian study. *La ClinicaTerapeutica*, *159*(6), 409-417.

Counter signed by Supervisor

Date

Signature of the Candidate

Date