Circadian Cyclecity of Selected Vascular Variables, Cardiac Variables and Body Temprature in Athletes

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ABSTRACT

The main objective of the present study was to correlate vascular, body temperature and cardiac circadian rhythm to sports performance capacities in such a way as to enable us to forecast and understand the reason for the peak and the valleys of the performance and all the areas in between a day. Study was conducted on 19 male Indian national team's athletes. There mean age, height and weight was 21.03 (+3.73) years, 174.5 (+ 6.81) cm and 46.12 (+ 7.79) kg, respectively.

Circadian Variations, viz., oral body temperature, systolic and diasystolic blood pressure; and cardiac circadian variable, viz., heart rate, were monitored for 25 hours. Heart rate was monitored at an interval of one minute; body temperature and blood pressure were monitored at 30 min interval.

Vascular, body temperature and cardiac, circadian rhythms are highly influenced by exogenous correlate, thus measured for 25 hours period, at rest. Hence, the measures were analysed taking the mean value of total 25 hour; were analysed by applying (ANOVA) Analysis of Variance, using SPSS version 10.0 statistical software package.

Researcher didn't find the significance relation of metabolic and cardiac circadian cyclecity, even thou the various studies revealed significant changes in metabolic and cardiac circadian cyclecity. It might be due to the various psychological, physiological, as well as climatic and other factors, highly influenced exogenous correlate.

INTRODUCTION

Circadian rhythms, in metabolism, are important source of variation in athletic performance, since body temperature directly influences metabolic rate and energy production.

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The Homoiotherms animal are capable to maintaining constant body temperature, It has been found that different part of body, even different organs, have different temperatures and this is a normal phenomenon, However, the average temperature, as measured, has been found to lie within a constant body temperature. Although, core temperatures are most reliable, yet for practical advantage, oral temperature is in use. Body temperature is a fundamental variable in circadian rhythmicity. Many aspects of human performance such as strength, reaction time, coordination, etc. vary with the time of day, in close association with the body temperature curve.

Circadian variations in cardiac and vascular function make significant contribution to athletic performance. The various studies reveal that circadian rhythm of heart rate increases during normal peak activity hours whether the individual is active or not. Thus, a person's heart rate will be 20% faster at noon than at mid night even if he or she is sleeping.

Circadian rhythm, in blood pressure and heart rate, is highly influenced by exogenous factors such as sleep, posture, ingestion of food, activity 5% to 15% of 24h mean and an acrophase around 15:00 h.

Circulatory and cardiac rhythms are also partially independent, even in close association with body temperature.

METHODOLOGY

Nineteen athletes of Junior and Senior level (six sprinters, six-jumpers, and seven middle and long distances runners) volunteered for this study, during Junior and Senior National Coaching Camp held at Patiala, from November 1999 to June 2000. All were male athletes with mean (+SD) age of 21.03 (+3.73) years; mean height of 174.5 (+ 6.81) cm; and mean weight of 46.12 (+ 7.79) kg.

All were involved in systematic training. To each individual, the investigator described the purpose of the study and control of activity during experimental days. Investigator also had taken prior permission from their coaches and the authority concerned.

Study Design

During 1st phase of 24 hours, variation in heart rate, oral temperature and blood pressure were monitored, at rest; when no training programme was administered. While heart rate was monitored by sports tester at every one minute interval, the blood pressure was monitored by Sphygmomanometer, every ½ hour, and the oral temperature by clinical thermometer every hour. In a day, maximum three subject were studied.

Eight to ten hour before, the polar sport tester was set over the chest of subjects to avoid any excitement. The subjects were also introduced to Sphygmomanometer and Thermometer.

The actual testing started from 6.00 a.m. to 7.00 a.m. on the next day. During these 25 hours, the subjects were absolutely at rest when the heart rate, blood pressure, and body temperature were recorded. All subjects abstained from caffeine and alcohol consumption; and refrained from running and other strenuous activity, for 12 hours prior of actual testing started. In order to confirm the above, indirect evidence that sports performance varies with the time of day, the breakfast, food, and tea timing were fixed and only two cups of tea a day were allowed, one in the morning and one in the evening, during data collection.

The morning wake up time, from bed, was fixed at 6.00 a.m. when the first reading was recorded. Then, after daily routines, subjects were provided the breakfast from 8.00 a.m. to 9.00 a.m. The lunch and dinner was provided from 1.00 p.m. to 2.00 p.m. and 8.00 p.m. to 9.00 p.m., respectively. The morning tea with breakfast and evening tea at 4.00 p.m. to 5.00 p.m. were permitted, as per their willingness.

The subjects were allowed to go to bed at 11.00 p.m. and next day they woke up at 6.00 a.m. then allowed to be free from daily routines. It was ensured that the subjects had good sleep during and even before the night of experiment days. The rest was sufficient to enable the subjects recover from each session.

The subjects were escorted to the field or laboratory half an hour before the start of the tests. The subjects were provided breakfast in between 1st and 2nd session, in the 2nd phase. The lunch was provided at 1.00 p.m. to 2.00 p.m., in the second phase also.

Data Collection

The 25 hours data were collected for cardiac, vascular, and body temperature variables and circadian rhythms at rest, i.e., heart rate, blood pressure (systolic & diastolic), and body temperature.

The reart rate data were collected by polar sports tester PE 4000 system (Polar Electro, Finland) at an interval of 1 minute, for 25 hours, from 06:00h to next days 07:00 h; and the average for each hour was calculated.

The blood pressure data were collected by sphygmomanometer, twice in each hour, from 06:00 h to 23:00 h, then next day 06:00 h to 07:00 h, and the average of each hour was counted.

The oral (body) temperature data were collected by thermometer, at an interval of each hour, from 06.00 h to 23:00 h; then next day from 06:00 h to 07:00 h. Only sleeping time, blood pressure and body temperature were not measured in order to provide the subjects an undisturbed sleep.

Statistical Analyses

Circadian rhythms are highly influenced by exogenous correlate thus the circadian variables viz. body temperature, vascular variable and cardiac variable were measured for 25 hours period. Hence, the measures were analysed taking the mean value of total 25 hour by applying (ANOVA) analysis of variance, using SPSS version 10.0 statistical software package.

Result & Discussion

The main aim of the present study was to investigate the influence of circadian variation on performance. So, the data of 19 subjects for the circadian variation of body temperature, cardiovascular variation (heart rate, systolic & diastolic blood pressure), at rest, for 25 hours were recorded and (ANOVA) analysis of variance was applied. The whole circadian variation were not found statistically significant; because, the above said circadian variations are highly sensitive and synchronised with the exogenous factors. The present study was designed for practical use; so, normal routines of food and climatic condition and sleeping hours were the unavoidable limitations of this study; thus, specific dynamic action (SDA) of food desynchronised the circadian rhythms as fig. 1 to 4 show the affect of SDA, on heart rate, body temperature, systolic blood pressure and diastolic blood pressure. These variables increase suddenly just after the breakfast, lunch and dinner; and then again settle down after some time. As various studies reveal that circadian variation may be affected by, exercise and specific dynamic action (SDA) of food. Fasting and absolute bed rest abolished this affect. The climatic conditions are also the reason of desynchronising the circadian cyclecity. As the inherent properties of the circadian rhythms have been investigated in isolation studies, Nelson, W. (1979) also found in his studies that participants isolated from all external time signals showed significant circadian cyclecity from 24 h to 25 h. Even thou circadian variations for 24 h were not found statistically significant, the amplitude and range of the rhythm showed notable change in the circadian variation of heart rate, body temperature, systolic blood pressure and diastolic blood pressure, as shown in Table 1

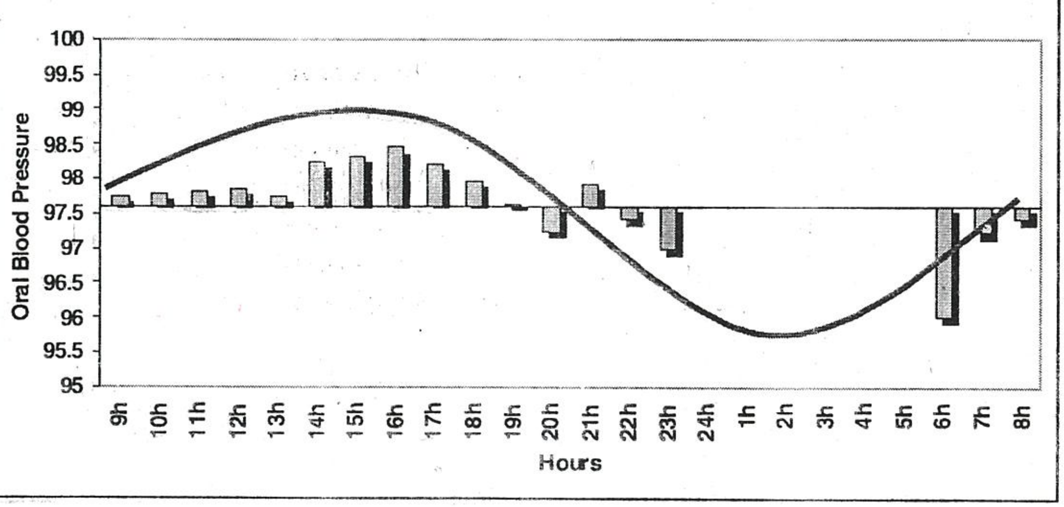
Table-1: The Mensor, Amplitude, Range of Rhythm, and Change in Amplitude

Variable	Mensor	Amplitude	Range of rhythm	Peaks		Change in RoR
				Hight	Low	
Body Temperature (degree F)	97.61 (± 0.29)	0.89	2.5	98.5	96.0	2.54%
Heart Rate (Beat/min.)	65.39 (± 6.20)	11.70	25.59	77.1	51.6	33.08%
Systolic Blood Pressure (mm hg)	108.09 (± 4.74)	10.33	26.42	118.4	92.0	22.30%
Diastolic Blood Pressure (mm hg)	71.77 (± 5.03)	6.32	14.52	78.1	63.6	18.57%

RoR is the Range of Rhythm.

The Table 1 and Fig. 1, show that acrophase of metabolic circadian rhythm i.e. body temperature reaches it's acrophase at around 16:00 h, with a change of 2.54% in range of rhythm as compared to morning 06:00 h while dips during sleep, which was not measured in order to ensure undisturbed sleep of subjects. This finding is supported by Shephard (1984), Hill (1988) Fig. 1 is not showing the data from 00:00 h to 05:00 h because the subjects were sleeping. Any kind of disturbance at that time might have affected the circadian rhythm. As shown in fig. 1, the hypothesised curve drawn by the computer, in this figure, shows the lowest peak at around 03:00 h.

Fig. 1 : The Oral Body temperature rhythm



The Table 2 and Fig. 2. showing that cardiac circadian rhythm of heart rate is reaching at its acrophase at 15:00 h, with the change of 33.1% in range of the rhythm, with a dip around 03:00 h.

The heart rate measure (65 b/min.), range of rhythm (26) and amplitude 12 are true. These findings are supporting by the study of Reilly who also found the acrophase around 15.00 h.

The systolic blood pressure blood pressure, as shown in Fig.3, reached its acrophase around 16:00 h, with the change of the range of rhythm upto 22.30% and an amplitude of 10.33 mm hg. These characteristic were supported by various studies that maximum value was found in between 16:00 h to 17:00 h.

Fig.2: The Heart Rate Circadian Rhythm

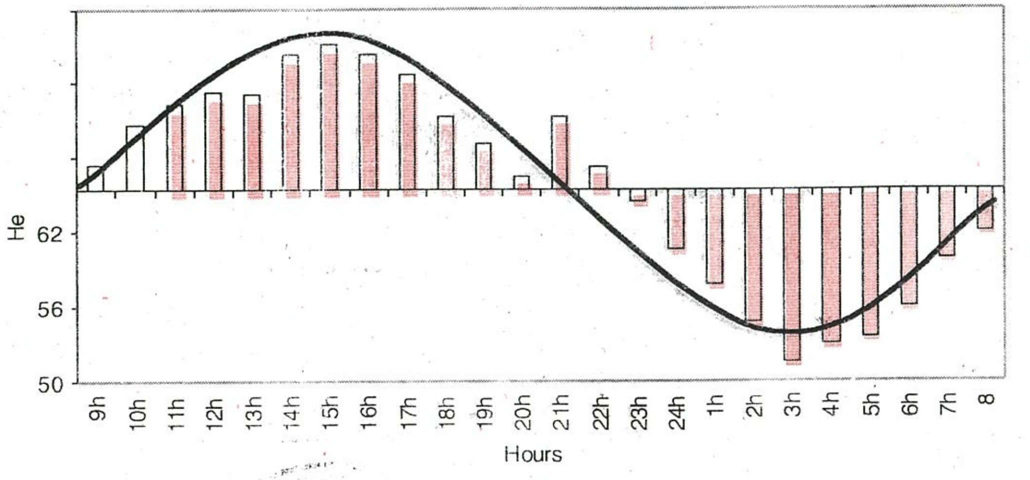
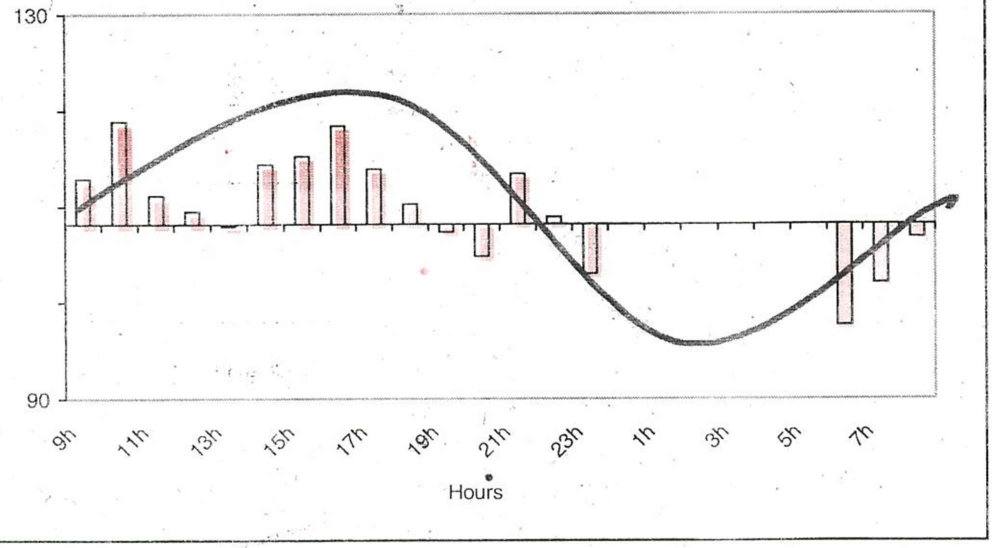


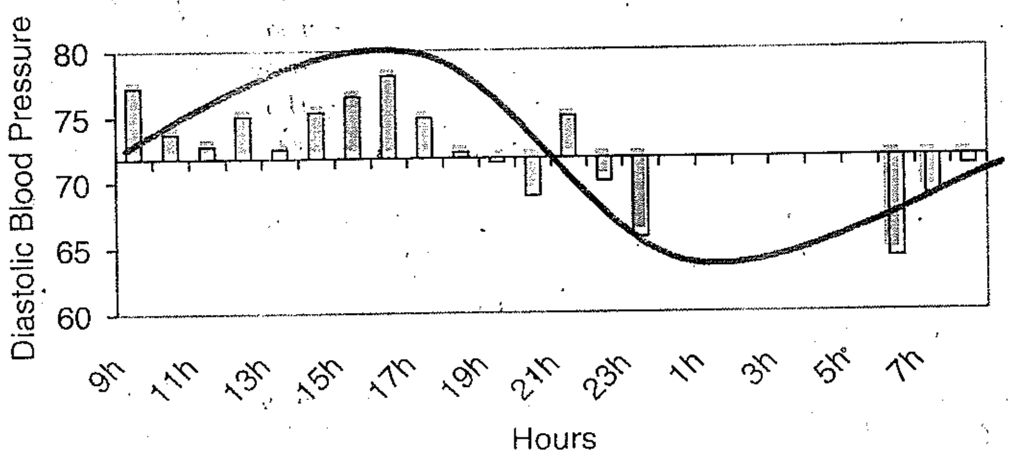
Fig. 3 : The Systolic Blood Pressure circadian rtythm



The Systolic blood pressure measurement is (108.09) calculated with recorded data. So, the measurement may not be true due to non availability of the five hours of sleeping data which could not be recorded. Thus, the systolic blood pressure rhythm is hypothesised rhythm as shown in fig. 3.

The diastolic blood pressure rhythm's measurement calculated 71.77 and amplitude found 6.32. The change of range of rhythm of 18.57%, in comparison to morning 06:00 h reached on its maximum around 16:00 h. These results are supported by Reilly et al (1984) and Winget et al (1985). This rhythm also does not have true mensor and range of rhythm, the drawn line of rhythm, is hypothesised line as shown in Fig. 4.

fig. 4: The Diastolic Blood Pressure Circadian Rhythm



The other common characteristic found during the present study in that all four circadian rhythm showed pre lunch dip around 12:00 h to 13:00 h. This characteristic is supported by Winget et al (1985) who found that there is a characteristic drop in performance around lunch time 12:00 h to 14:00 h; and it is unclear whether this performance drop is linked to digestive processes or is a characteristic of circadian rhythm. Various studies reveal that the peak is more pronounced when the work begins and it is associated with a corresponding drop in epinephrine level.

Another characteristic shown by all types of rhythm was that after breakfast, lunch and dinner there was a sudden rise in performance. It could be due to the fact that specific dynamic action (SDA) of food influences the rhythm. Is is also supported by Winget et al(1985).

Circadian Cyclecity

Circadian cyclecity of physiological variables are shown in Table 2. The difference of values at 22nd hour, 23rd hour, and 24th hour (for body temperature, heart rate, systolic blood pressure and diastolic blood pressure) are the difference values in-between 24:00th ~ 02:00th, 24:00th ~01:00th, 25:00th ~ 01:00th reading. The cyclecity completes in between the -ve and +ve value hours.

Table - 2 : Circadian Cyclecity of Physiological Variables

Variable	Difference value of			Circadian Cycle (Hours)
	24:00th ~ 02:00th	24.00th ~ 01:00th	25.00th ~ 01:00th	
Oral Body Temperature	-1.22	-0.61	0.59	23rd to 24th
Heart Rate	-3.27	1.73		22nd to 23rd
Systolic Blood Pressure	-10	-5.58	3.92	23rd to 24th
Diastolic Blood Pressure	-5.26	-0.53	6.42	23rd to 24th

The heart rate circadian cyclecity is completed first; then followed by diastolic blood pressure and followed by systolic blood pressure; and at last oral body temperature completes the circadian cyclecity. The Kimble Daniel (1998) study also finds circadian cyclecity at around 24 h.

Heart rate shows early completion cause heart rate is very much sensitive and has a tendency to react immediately towards any exogenous stimuli by the suppressed secretion of hormones. Many studies have proved that hormones differ with the magnitude of light. At morning, the hormone level increases with the increase of "magnitude of light". Thus, in early morning, after wake up, the heart rate is affected vigorously by the increase of hormone level. Various studies reported that melatonin, nonaderline and cortisol level affect the athletic performance. correlated with the magnitude of light.

By analysing individual, the circadian cyclecity lies in between 22 h to 25 h. This may be due to the fact that subject had to leave to the bed as per instructions after recording of the first reading of body temperature and blood pressure. But, their wake up time could be different. Thus, the heart rate cycle was influenced by the hormones. The other psychological factor should not be forgotten here which could also have an influence over the heart rate.

There is considerable individual variation in circadian cyclecity due to fact of the suppressed secretion of various hormones and their level, such as melatonin, epinephrine, nonaderline, cortisol etc. So, the individual difference of circadian rhythmicity depends upon psychological stresses, motivation, lighting, social interactions, dietary constituents, age, and post lunch dip phenomenon etc.

CONCLUSION

The four circadian rhythms viz. oral body temperature, heart rate, systolic blood pressure and diastolic blood pressure were investigated at rest for 24-hour cycle. These four circadian rhythms.

The cardiac circadian cycle is completed in between 22 h to 23 h; followed by vascular circadian rhythm i.e. diastolic blood pressure circadian cycle which is completed in 23 h to 24 h. It is followed by the systolic blood pressure circadian cycle which is completed in 23 h to 24 h. The oral body temperature takes the longest time to complete circadian cycle at 23 h to 24 h. Simultaneously, body temperature circadian cycle is also completed in between the 23 h to 24 h.

This means metabolism repeats its cycle approximately in 24 h; but, this cycle is highly influenced by exogenous correlates and desynchronised. These exogenous correlates are lighting, social interaction, dietary constituents, and other psychological factors, which influence and suppress the secretion over the hormones.

The cardiac circadian rhythm reaches its acrophase at 15:00 h approximately and dips around 03:00 h, approximately. The vascular circadian cycle, i.e., the cycle of systolic and diastolic blood pressure rhythm reaches at acrophase around 16:00 h, and the oral body temperature also reaches its acrophase around the 16:00 h.

This means the body metabolism reaches its peak around 15:00 h to 16:00 h. So, this time is good for physical performance; but, the aerobic physical performance has some reservations regarding the climatic conditions. The reinvestigation in future may rule out this reservation.

REFERENCES

Atkinson, G. & Reilly, T. (1996). Circadian variation in sports performance. Sports Medicine. 21:292-312.

Chatterjee, C. C. (1992). Human Physiology. A. K. Chatterjee publication Calcutta India :21 to 23.

Crackes, J. (1986). Circadian Rhythms: The right time. Track technique summer, 96: 3071 - 3072.

Hill, D. W. et al (1988). Diurnal variation in response to exercise of "Morning type" and "Evening type". Journal Sports Medicine Physical Fitness. 28:213-9.

Ilmarien, J. et al (1980). Circadian variation of physiological function related to physical work capacity. Scand. J. work Environ. Health. 6:112 - 22.

Jin, P. (1989). Change in heart rate, nonradrenaline, cortisol and mood during Tai Chi. J. psychosom Res.33 (2): 197 - 206.

Kimble, D. P. (1998). Biological psychology. Holt Rinehert & Winston Inc. New York : 303 - 307.

Lewy, A. J. et al (1980). Light suppress melatonin secretion in humans. Science 210: 1267 - 1269.

Nelson, W. et al (1979). Methods for consignor rhythmometry. Chronobiologia. 6: 305 -23

Reilly, T. et al (1984). Some Circulatory responses to exercise at different time of day. Med. Sci. Sports Exercise. 16:477 -82.

Shephard, R.J. (1984). Sleep Biorhythm and human performance. Sports Medicine. 1:11-37.

Swoyet, J. et al (1984). Choronobiology in clinical laboratory. In Haus H editors. Chronobiology, New York. : 533 - 43.

Winget, C.M. et al (1985). Circadian rhythm and athletic performance. Medicine Science Sports Exercise 17:498 - 516.

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