ORIGINAL ARTICLE

EFFECT OF CIRCADIAN RHYTHM ON THE BLOOD PRESSURE ADJUSTMENT IN RESPONSE TO A PHYSICAL STRESS

Muhammad Tariq Aftab, Nimrah Miraj, Sobia Masood, Sehba Shamim, Shafaq Fayyaz

Department of Pharmacology & Therapeutics, Karachi Medical and Dental College, Karachi, Pakistan

Background: Many studies have shown a relationship between circadian rhythm and certain physiological functions and pathological changes in the body. Blood pressure is highly sensitive in this regard. The role of circadian rhythm in controlling the blood pressure requires further exploration. This study was conducted to investigate variability of blood pressure adjustment due to circadian rhythm after a physical stress. **Method:** Data was collected from 29 undergraduate students after consent and briefing them the nature and purpose of the study. Blood pressure changes in the morning and afternoon after same physical stress were noted. **Result:** It was found that circadian rhythm has significant effect ($p<0.05$) on systolic and diastolic blood pressures in the morning (from 8 to 9 AM) and afternoon (from 2 to 3 PM). This difference becomes insignificant ($p>0.05$) in these two phases of the day due to larger changes ($p<0.05$) in these two parameters by same exercise. But after five minutes the adjustment of systolic and diastolic Blood pressures in so effective that a significant ($p<0.05$) difference is again retained in the systolic and diastolic blood pressures. **Conclusion:** The blood pressure controlling mechanism becomes more responsive with circadian rhythm to control the larger changes of blood pressure effectively.

Keywords: Circadian Rhythm, Blood Pressure, Physical Stress, Blood Pressure control

INTRODUCTION

Circadian rhythm is an endogenously driven 24-hour cycle in biochemical, physiological or behavioural processes. The periodic light-dark cycle is the main environmental synchroniser used in humans for characteristic stepping of this cycle[1] especially related to cyclical change in hormonal levels. The exposure to a cyclic light stimulus can induce strong resetting of the human circadian pacemaker and affects the pacemaker's amplitude of oscillation as well as its phase.[2] The classical phase markers for measuring the timings of circadian rhythm are melatonin secretion from pineal gland, core body temperature and plasma level of cortisol.[3]

Body's major processes depend upon circadian rhythm, i.e., various hormonal secretions.[4] Many researchers have found a relationship between circadian rhythm and certain physiological functions like brain activity[5] and pathological changes like incidence of Myocardial Infarction[6]. Blood pressure (BP) is highly sensitive to circadian rhythm.[7,8] As per normal physiology, there is a rather marked rise in BP upon waking. It is morning or 'AM' surge systolic BP rises approximately 3 mm Hg/hour for the first 4–6 hours post-waking while the rate of rise of diastolic BP is approximately 2 mm Hg/hour.[8] Both these changes keep the blood pressure of the morning different from the blood pressure after the 4–6 hours of post-waking.

This study was designed to see the role of this natural system in adjusting the blood pressure after physiological stress to raise blood pressure.

MATERIAL AND METHODS

After approval from the Ethical Committee, 30 students of Karachi Medical and Dental College were randomly selected for the study. They were 18 to 21 (Mean 19.5) years of age, and male to female ratio was 1:3 without any history of illness or drug use in the last 6 months, or any addiction or any congenital anomaly or disability. Informed written consent was obtained from all subjects.

The blood pressure was measured with a digital sphygmomanometer. Right arm was used with a cuff 1 Cm up from elbow, rested in 45º with forearm on a table at the level of apex beat.[9]

The exercise was to climb 61 up and down stairs within 5 minutes. These stairs were to lift a volunteer up to 23 feet from the ground after which an apparent breathlessness was felt by the volunteer and the observer.

First set of blood pressure was recorded in the morning (8:15–8:45 AM) and consisted of blood pressure measurement before exercise, immediately after exercise and 5 minute after exercise.

The second set of blood pressure was recorded in the afternoon (2:30–2:45 PM) of the same day after following the same procedure as adopted in the morning.

Twenty-nine volunteers completed both the phases and 1 volunteer left before the second phase of the experimentation.

The data was analysed using SPSS. Paired *t*-test was applied to see the differences between parameters and $p<0.05$ was taken as significant.

RESULTS

Table-1 shows systolic and diastolic BP in 29 subjects in the morning and in the afternoon. Mean systolic BP was 112.17±13.35 in the morning and 111.41±11.44 in the afternoon. A statistical significant difference ($p<0.05$) was found between them. Mean diastolic BP was 74.34±9.97 in the morning and 72.76±11.44 in the afternoon. A statistical significant difference ($p<0.05$) was also found between them.

Table-2 compares the exercise induced rise in systolic and diastolic BP in the same 29 volunteers. Systolic BP was increased from 124.31±12.08 in the morning to 127.34±18.06 mm Hg in the afternoon. The rise was statistically insignificant ($p>0.05$). Diastolic blood pressure was raised from 74.90±7.37 in the morning to 75.55±8.65 mmHg in the afternoon. The rise was statistically non-significant ($p>0.05$).

Table-3 shows a comparison of exercise induced changes in systolic and diastolic BP in the two phases of the day in 29 volunteers. Change in systolic BP was 12.15±2.02 in the morning but 15.95±2.92 mmHg in the afternoon; and in diastolic BP it was 00.56±0.01 in the morning but 2.79±0.52 mmHg in the afternoon. The rise was statistically significant ($p<0.05$) in both the cases.

Table-4 shows systolic and diastolic BP after 5 minutes of exercise in 29 volunteers in the two phases of the day. Systolic BP was 112.72±9.13 mmHg in the morning but 111.83±11.11 mmHg in the afternoon. The change was statistically significant ($p>0.05$). Diastolic BP after 5 minutes was 71.03±6.81 mmHg in the morning but 70.86±9.04 mmHg in the afternoon. The change was statistically significant ($p>0.05$).

Table-1: Resting systolic and diastolic BP in the morning and afternoon (n=29, Mean±SE)

Phase	Systolic BP (mmHg)	Diastolic BP (mmHg)
Morning	112.17±13.35	74.34±09.97
Afternoon	111.41±11.44	72.76±11.44
p	0.041	0.048

Table-2: Exercise-induced systolic and diastolic BP in the morning and afternoon (n=29, Mean±SE)

Phase	Systolic BP (mmHg)	Diastolic BP (mmHg)
Morning	124.31±12.08	74.90±7.37
Afternoon	127.34±18.06	75.55±8.65
p	0.153	0.537

Table-3: Exercise-induced changes in BP (n=29, Mean±SE)

Parameter	Morning	Afternoon	*p*
Systolic BP	12.15±2.02	15.95±2.92	0.022
Diastolic BP	00.56±0.01	02.79±0.52	0.018

Table 4: Systolic and diastolic BP after 5 minutes of exercise (n=29, Mean±SE)

Parameter	Morning	Afternoon	*p*
Systolic BP	112.72±9.13	111.83±11.11	0.042
Diastolic BP	71.03±6.81	70.86±9.04	0.038

DISCUSSION

Our study strongly supports that blood pressure and its adjustment is controlled by the components of circadian rhythm. The significant difference in systolic and diastolic blood pressures in our study, is in support of this physiology. The blood pressure generally declines from mid-afternoon on (especially if an individual is employed outside of their home) and reaches its nadir between midnight and 3 AM.[10] This fact is also reflected in our results as both the systolic and diastolic blood pressures are significantly less in the afternoon that is after 8 hours of wakening compared to morning. This 24-hour cycle of blood pressure then repeats itself and is typically quite reproducible in an individual as long as activity levels are similar for the 24-hour time intervals being compared.[7,11]

The dynamicity of blood pressure controlling mechanism is a significant factor for physical well-being. Is this dynamicity being maintained in different phases of the day? Are the components which play important role in maintaining the blood pressure, adopted with circadian rhythm to adjust blood pressure as per changed requirement? Our data respond these questions properly. Systolic and diastolic BP in the morning and afternoon are significantly different before exercise but becomes insignificantly dissimilar after exercise. The response of the blood pressure controlling mechanism looks to be more active and this difference becomes significant again after 5 minutes of the exercise. It means that the same exercise in the same volunteers produces greater effect in the afternoon as compared to morning. But this change is short lived as after a little time the two blood pressures normalise again showing greater activity of blood pressure controlling mechanism in the afternoon.

In both normotensive and hypertensive individuals, blood pressure and heart rate fluctuate according to both mental and physical activity levels, especially during wakefulness and sleep. A logical explanation of quick control of blood pressure in the afternoon as our study shows, stems out on considering neurohormonal control of cardiovascular system. Nocturnal blood pressure and pulse rate change track sympathetic nervous system activity typically. Sympathetic activity diminishes while asleep with changes in the sympatho-adrenal branch (epinephrine) governed by both posture and sleep. Thus epinephrine concentrations are notably diminished during sleep and begin to increase in conjunction with morning wakening.[12] At a minimum, norepinephrine concentrations trend downward while asleep and do not significantly increase until a postural stimulus (upright position) is added to the arousal process. Absolute values for morning norepinephrine concentrations, although typically higher than sleep values, are not necessarily the highest values reached during the 24-hour time period.[13]

The level of cortisol also has effects on blood pressure, cortisol starts increasing at night and its peak level reaches in the morning, then its level starts decreasing. Whenever its level increases due to any reason there will be a rise in blood pressure level but the effect of the endogenous circadian rhythm in most healthy persons is of relatively small magnitude.[14]

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Address for Correspondence:

Dr. Muhammad Tariq Aftab, Professor of Pharmacology and Therapeutics, Karachi Medical and Dental College, Karachi, Pakistan. **Cell:** +92-300-2258875
Email: drtariqaftab@yahoo.com