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ORIGINAL ARTICLE

The impact of chronotype on VO_2max in university students at two different times of the day

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Abstract

Background and Study Aim: To choose the ideal training or performance times, it is crucial to assess VO_2 max performance across different time-of-day particular chronotypes. This study aimed to investigate the differences in VO_2 max between the chronotype of university students during the morning and evening time of the day.

Material and Methods: Fifty-two university students (26 morning type and 26 evening type) with mean age 23.05± 2.07 years, weight 66.71±4.31Kg and height of 170.90±5.18 cm and BMI of 22.75±1.91kg/m^2 were recruited based on the results of the Horne-Ostberg Morningness- Eveningness Questionnaire (MEQs) participated in this Cross-over study. VO_2 max was measured directly by gas collected using mouth tube breath to breath through the use of the gas analyzer the AD instrument (model-ML206) with an incremental graded maximal exercise test done on the treadmill.

Results: The morning type group's VO_2 max was significantly better in the morning hour than it was in the evening (p=.013), and when the VO_2 max of the evening type group was measured in the morning and evening hours and compared, there was a statistically significant difference in favour of the evening hours (p=.004). Additionally, there is no discernible difference between the VO_2 max of the morning type and the evening type group either in the morning hours or the evening hours, but trends indicate that the morning type group has a higher VO_2max in the morning hour and the same is true for the evening type group in the evening hour.

Conclusions: The findings of this study showed an interaction between chronotype and time of the day in VO_2 max. For endurance training, trainers should consider the individual's chronotype and time of the day for exercise prescription.

Keywords: chronotype, VO_2max, morning type, evening type, morningness-eveningness questionnaire

Introduction

Chronotype refers to an individual's preferred timing of sleep and wakefulness, which can be categorized as morning types, evening types, or intermediate types [1]. The highest amount of oxygen a person can take during maximum exhaustive exercise is called maximal oxygen uptake (VO_2 max), and it stays constant over time despite increasing exercise intensity [2, 3]. Maximal oxygen consumption measures how much oxygen is used by active muscles [4]. It is expressed in absolute units of L/min or relative units of mL/kg/min VO_2 max [5] One of the most often used metrics in exercise physiology is maximal oxygen uptake (VO_2 max). VO_2 max is the most accurate indicator of young people's aerobic fitness [6] in many sports and is a prerequisite for peak performance [7]. Clinical research has employed VO_2 max, considered a measure of endurance in various ways [8]. It is a population-wide indicator of cardiovascular disease risk and physical fitness [9].

Due to various bodily situations throughout the day, such as arousal, hunger, jet lag, etc., body responses can sometimes vary. The circadian rhythm is connected to these reactions (i.e. body-clock) [10, 11]. At the same time, the body clock is thought to impact how well people function physically. The results of Chtourou et al. [12] about the impact of the circadian cycle on aerobic activity and maximal oxygen absorption (VO_2 max) were conflicting. Since the 1980s, many studies have studied the impact of the day on endurance exercises. While some studies have indicated that VO_2 max is significantly higher in the morning [13] [14], others have reported that VO_2 max performance

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is higher in the afternoon [15, 16]. Morning participants did not raise their VO_2 max, however evening participants did. Morning participants had a lesser increase in VO_2max compared to evening participants [17]. Most studies, including those by [16, 18, 19], revealed that the VO_2 max is a stable function unaffected by diurnal fluctuations. Hence, it is yet unknown how cardiovascular endurance performance varies during the day with respect to chronotype of individuals.

To our knowledge, none of the previous studies discussed how chronotype affects VO_2 max in university students at diurnal variation, despite previous studies examining the diurnal influence on collegiate students and adult athletes. In order to choose the ideal training or performance times, it is crucial to assess VO_2max performance for university students across different time-of-day particular chronotypes. Therefore this study aimed to examine the relationship between different chronotypes and VO_2 max in university students during the morning and evening.

Materials and Methods

Participants

Fifty-two male university students (26-morning type and 26 evening type) with mean age 23.05± 2.07 years, weight 66.71±4.31Kg, height of 170.90±5.18cm and BMI 22.75±1.91 participated in this cross-sectional study. Subjects who participated in any exercise training during the past three months, suffering from a musculoskeletal injury, have a medical condition that makes exercise dangerous or have a history of or current symptoms of cardiovascular illness (such as angina, shortness of breath, or uncontrolled hypertension) were excluded from study participation. The study was conducted at the Research Lab of Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, and ethical approval was taken from the Institutional Ethics Committee of Jamia Millia Islamia (approval letter no. 18/3/215JMI/IEC/2019). The study was conducted from January 2022 to March 2023.

Research Design

We used Horne and Ostberg Morningness and Eveningness Questionnaires (MEQs), to identify the different chronotype of the individual and MEQs scores ranging from 16 to 86. Scores ranges 42 to 58 imply "intermediate type," while scores between 41 and below imply "evening type." Scores of 59 and above imply morning type [17, 20].

The relative humidity and lab temperature for the tests on the subjects were the same for all the participants. Additionally, subjects were instructed to abstain from heavy meals, coffee, tea, and physical activity at least two hours before the testing. Before beginning the testing procedure, a thorough medical evaluation and clinical examination were conducted. According to Lehmler et al. [21], anthropometric measurements of age, height, and weight were made, and the (BMI) ranged from 18.5 to 24.9 kg/m2; each subject by dividing their weight in kilograms by their height in square meters, the BMI was computed.VO_2 max was determined by direct method during incremental graded treadmill test. The gas was collected using mouth tube in open circuit using a gas analyzer the instrument AD (model-ML206) VO_2max was determined directly breath by breath. The participants in the study underwent a graded maximum exercise test (Telineyhtyma, Kotka, Finland), with the first stage's speed set at 8 km/h for each stage for one minute till exhaustion [22] a on a treadmill. The VO_2 max was measured at 9-11 am and 4-6 pm for both the chronotype and 48 hours were the washout period for each participant.

Participants were invited to arrive in the morning or two to three hours after their last meal. Before starting, they were given a brief explanation and demonstration of the categorized exercise test protocol. The participants were required to use a mask attached to a device that calculated the total amount of gas exhaled and breathed throughout the test.

All subjects received a session of familiarization and initial instructions on how to walk on a treadmill. The O_2 and CO_2 analysis equipment was calibrated in advance of each test. Every 10 seconds, the heart rate and respiratory gas exchanges were averaged. For the graded test, the VO_2 max matched the VO_2max achieved in two consecutive 10-second periods. Participants were deemed to have reached their VO_2max if at least three of the following circumstances applied: (a) VO_2 plateaus despite a faster running pace; (b) a respiratory exchange ratio (RER) of greater than 1.1 at the end; (c) overt indications of fatigue in the individuals; and (d) a heart rate that was within ten beats per minute of the age-predicted maximal HR [23].

Statistical Analysis

The data were reported as mean ± SD. The Shapiro-Wilk test was employed to determine whether the data were normal, and the results showed normal distribution. All variables presented a normal distribution in the test ($p > .05$). Paired sample t-test was used to compare the variable according to the time of the day (morning and evening hours) within the group and the variables with chronotype and the time of day were compared using the independent sample t-test (morning time with Morning type and Evening type) and evening time Evening type and Morning type). $P < .05$ set for significant value. All the analysis was performed by the Statistical Package for the Social Sciences (IBM SPSS) software version 21.0

Result

Table 1 showed VO_2 max of same chronotype at two different times of the day and table 2. Showed VO_2 max of two different chronotype at same time of the day.

VO_2 max in the morning time compared to the evening time of the morning chronotype group was significantly better (t=2.66, p= .013 < .05) at 95 % of confidence interval difference. The mean ± SD VO_2 max of morning type in the morning was 41.83± 4.58, and in the evening was 40.41 ± 4.73. When the VO_2 max of the evening chronotype group measured in the morning and evening time was compared a statistically significant difference was found in favor of evening hours (t=-3.20, p=.004 < .05) at 95 % of confidence interval difference. The mean ± SD VO_2 max of evening type in the morning was 41.30± 5.27 and in the evening was 42.90 ± 5.35.

Additionally, there is no discernible difference in VO_2 max of the morning type and evening type group in the morning hours and also evening hours but trends shows morning type group has better VO_2max in the morning hour and also same for the evening type group has better VO_2 max in the evening hour.

Discussion

This study's objective was to compare the results of two different chronotypes and the time of the day on VO_2 max in university students, which can be used to assess the endurance capacity of the individual. Our finding showed significant differences in the VO_2 max of two chronotypes at two different times of the day. The morning type has better VO_2 max in the morning and the evening type has better VO_2 max in the evening. Our study is consistent with Carter et al. [14], which observed that the evening type had higher VO_2 max and produced more torque in the late afternoon or evening than in the morning. A study in competitive athletes indicated that morning-type athletes had earlier time-of-day peaks in VO_2max determined, whereas the peaks of the evening types were later in the day and displayed greater diurnal fluctuation; the bleep test showed less diurnal variation [15].

In addition, there was no significant difference between the two chronotypes at the same time of the day, either in the morning or in the evening on VO_2 max, but the trend indicates morning chronotype had better VO_2 max in the morning as compared to their mean ± SD of morning and evening chronotype while evening chronotype had better VO_2 max in the evening while comparing mean ± SD morning and evening chronotype which is consistent with one study found that there is no effect of chronotype on diurnal variation [26]. The effect of time of day on VO_2 max has revealed that there are linear mixed effects and no significant changes in VO_2 max between different times of the day, no fixed effects of time, and no pairwise comparison of time points reached. The time of day when peak VO_2 max was achieved was approximately equally distributed between 10:00am, 4:00pm, and 9:00pm [27].

Only a few studies have examined responses to physical activity at various times of the day and discovered that diurnal variations are particular to chronotype. For instance, those who slept late had

Table 1. VO_2 max of the same chronotype at two different times of the day

Chronotype	Time of the day	Mean ±SD	N	Paired Differences				t- value	P - value
				Mean	Std. deviation	95% CI			
						Lower	Upper		
Morning Type	Morning VO_2 max	41.83± 4.58	26	1.41	2.70	.32	2.50	2.66	.013*
	Evening VO_2 max	40.41 ± 4.73	26						
Evening Type	Morning VO_2 max	41.30± 5.27	26	-1.59	2.54	-2.62	-.57	-3.20	.004*
	Evening VO_2 max	42.90 ± 5.35	26						

NOTE: * - p < .05

Table 2. VO_2 max of two different chronotypes at the same time of the day.

Time of the day	Chronotype	Mean ±SD	N	Mean Difference	95% CI		t - value	p- value
					Lower	Upper		
Morning VO_2 max	Morning type	41.83± 4.58	26	.53	-2.22	3.28	.38	.70
	Evening type	41.30± 5.27	26	.53	-2.22	3.28		
Evening VO_2 max	Morning type	40.41 ± 4.73	26	-2.48	-5.29	.33	-1.77	.08
	Evening type	42.90 ± 5.35	26	-2.48	-5.29	.33		

higher VO_2 max levels [24], generated more torque and had higher cerebral and spinal excitability levels [28] in the morning compared to the evening, and morning heart rate recoveries were slower than evening ones [29]. However, the morning people in this investigation displayed no diurnal fluctuation in VO_2 max [24, 28]; nonetheless, spinal excitability increased in the evening, whereas cortical excitability increased in the morning [28]. Exercise in the evening may appear more difficult to morning-type people compared to morning [30]. There is minimal indication that participants' habitual training time influenced the time of day at which they reached their peak VO_2 max since no effect was statistically significant [27].

Only two studies, accounting for chronotype, have examined diurnal variation in directly measured performance (such as time trials) [31, 32]. A survey of 16 college rowers found that morning types performed better in the morning than the evening hour on the 2000-meter ergometer time trial, but neither chronotype nor evening chronotypes showed any diurnal fluctuation in performance [31]. Similarly, the morning chronotype swam faster in the morning 200 m time trials than neither chronotype did in the evening hours trials among 26 skilled adult swimmers [32]. Considering all of the information, It makes sense to hypothesize that evening chronotypes' circadian typology may favour competition in the afternoon, whereas morning chronotypes may be better adapted to events occurring earlier in the day. However, none of these data indicate whether a certain chronotype performs better than another at a particular time of day, which is consistent with our finding. There are few limitations of this study. The sample size was small. Only male participants were recruited for this study. So this study cannot be generalized to female population.

Conclusions

Chronotype of the individual affects the VO_2 max of the individual, but there are no significant effects of chronotype at the time of the day on VO_2 max. It is crucial to comprehend the potential effects of performance at specific times of day with distinct chronotypes.

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