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Association of Chronotype and Social Jetlag with Obesity Indicators amongIndian Primary School Teachers: A Cross-Sectional Study

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Abstract

Background

The interrelationship between circadian typology, mismatch between internal body clock and social schedules, and excess adiposity is not yet fully established; especially in populations residing at Asian countries like India. This study was conducted with an objective to assess the association between Chronotype, Social Jetlag, and anthropometric and body composition parameters of obesity in a cohort of school teachers from Pune district in India.

Methods

This is a preliminary sectional analysis of an ongoing cross sectional study, representing analysis of data from 170 teachers. Multistage cluster sampling technique was used for sampling. Data on Chrontoype, Social Jetlag, dietary and lifestyle habits were collected using validated scales or their modified adaptations. Obesity was assessed using anthropometric parameters and body composition analysis. Data was analysed using IBM SPSS registered software version 31.0. Descriptive statistics, Chi-square test, 'Spearman's Rank Correlation test', and Regression analyses were conducted.

Results

Majority of the participants were middle-aged adult females, married, post-graduates, urban residents and belonged to 'Hindu' religion. Majority of the participants were 'Moderately Morning types'; and had Mean 'Mid-sleep timing on free days, sleep corrected' and Social Jet lag as 2:43 am and 51 minutes. Overall the participants were obese with Mean BMI as 26.5; and 64.7% were categorized as 'Obese' according to ICMR criteria. No association was observed between chronotype and any obesity parameter. Asignificant but weak association was observed between higher levels of Social Jetlag and higher Subcutaneous Fat percentage; independent of sleep quality and total sleep duration. A significant association was observed between higher levels of Social Jetlag and lower Skeletal Muscle Mass Ratio; independent of chronotype, sleep quality, total sleep duration, demographic and lifestyle parameters.

Conclusion

Chronotype was not significantly associated with any obesity parameters in this population. Higher Social Jetlag was significantly associated only with higher subcutaneous fat and lower skeletal muscle mass; but no association was observed with Body Mass Index, Waist Circumference, Whole body fat percentage or Visceral fat percentage. Role of Social Jetlag needs more explopration for its association and role in metabolic health amongst Indian populations.

Introduction

Obesity is a global epidemic affecting all socioeconomic strata. Obesity is multifactorial and multidimensional in nature, and its pathophysiology is yet to be explored fully. In recent times, Chronobiology has gained increasing attention in the field of obesity [1]. Chronobiology deals with internal biological clock that creates a timely rhythm and regulation of sleep-wake processes in living species like humans. This rhythm regulates various bodily

processes related to metabolism and endocrine systems [2]. Differences in these rhythms exist between individuals in terms of their sleep and wake timings, alertness as well as behavioural preferences. This individual characterization is called as 'Chronotype' [3]. Persons can be broadly classified into 'Morning Chronotype' (MC), 'Intermediate/'Neither Morning nor Evening' chronotype' (IC) and 'Evening chronotype' (EC) based on their position on a continuum ranging from extreme morningness to extreme eveningness. Morningness or 'Morning type persons' show larger tendency towards early rising, are able to perform mentally and physically at their best in the morning or daytime hours, and go to bed early. Eveningness or 'Evening type persons' show larger tendency towards getting up comparatively at a later timing, staying up or going to bed later timings at night as compared to 'Morning type persons', and are able to perform best mentally and physically in the late afternoon or evening [4]. The concept of differences in individual circadian rhythm are supported by genetics too [5]. Social Jetlag (SJL) is relevantly newer but an important concept in chronobiology, which represents the discrepancy between biological sleep timing and socially imposed schedules. It is measured as the difference between mid-sleep timing on workdays and work-free days in a typical week.

Chronotype and SJL have been closely associated with obesity indicators and dietary patterns, physical activity, lifestyles as well as sleep parameters. A meta-analysis suggested that persons with evening chronotype had significantly higher levels of Body Mas Index (BMI), Waist Circumference (WC), higher total cholesterol level and lower high density lipoprotein cholesterol (HDL-C) levels [6, 7]. A review by Barrientos-Salinas et al (2026) explains that evening chronotype is associated with body composition as well as sarcopenia, and muscle loss [8]. Few studies have also found that evening type persons had higher total body fat percentage (BF%) and lower skeletal muscle mass index [9]. Similarly, higher SJL has been associated with higher BMI, fat mass, fat mass index, BF% and WC [10, 11]. In addition to direct association with obesity parameters, several dietary and lifestyle risk factors of obesity have been associated with evening chrontoype and higher SJL too. Evening types and persons with higher SJL have been associated with less adherence to a healthy diet [12], delays in meal timing, breakfast skipping tendancy, high food consumption at night time, lower consumption of protein, vegetables, and fruits & higher consumption of sweets, caffeine, and alcohol [10, 13, 14]. Additionally, these persons have also been found to have poorer sleep quality, lower physical activity as compared to morning type persons [8, 15, 16]. However, in contrary to this, there are several studies conducted across globe that did not found this association as stastistically significant for BMI, WC, body fat percentage, fat free mass, fat free mass percentage, hip circumference, total cholesterol levels, High-density lipoprotein (HDL), Low-density lipoprotein (LDL), Triglyceride levels [17, 18, 19]. A systematic review did not identify significant association between higher SJL and higher BMI [6]. Similar to obesity indicators, some studies could not find any association with dietary habits, levels of physical activities and sleep duration too [13, 18, 20, 21].

Hence, it can be speculated that there is an ambuigiuty regarding assoation of chronotype and SJL with obesity parameters. Larger evidences suggests a positive association with BMI and WC, but there are very few studies examining relationship with body composition parameters. Moreover, the available studies show large clinical and methodological heterogeneity. Most of these studies have assessed morningness-eveningness preference using MEQ scale, but there are comparatively lesser studies where mid-sleep timing was used which represents the individual's phase of entrainment. Majority of these studies are concentrated on european or american populations. There is dearth of data from Asian countries like India. Currently available studies regarding chronotype or SJL on Indian populations mostly represent children, adolescent or young adult populations, but barely on middle-aged or older-adults. Indian school teachers comprise an important part of the society in developing healthy future generations as a role model for their lifestyles, habits and overall health status. Available literature suggests that Indian school teachers largely suffer from overweight, obesity, abnormal WC, abnormal serum triglyceride levels, as

well as follow unhealthier habits like eating junk food outside [22, 23, 24]. Additionally, sedetary nature of work [25] and high levels of psychological stress [26] negatively impacts their personal health, and predisposes them to obesity. Hence, this study was conducted with an objective to assess association of Chronotype and SJL with various obesity indicators amongst an population of primary school teachers from Pune district in India.

Methods

Study design, and settings and sampling technique:

This paper represents a preliminary sectional analysis of an ongoing cross sectional study being conducted in primary school teachers employed at government and private schools in Mulshi tehsil of Pune district. The government schools have been grouped into various 'Kendra' as an administrative unit. A multistage cluster sampling technique was planned, with Kendras considered as primary clusters. The sample size for the full study was calculated using Slovin's formula based on a total population of teachers across all Kendras in Mulshi tehsil. This paper is based on an interim analysis of data collected from 170 participants across 5 out of 20 Kendras, covering 5 government and 3 private schools, with all available teachers in the schools included. All teachers who were present at the time of data coellction, and ready to participate and give consent were included in the study. Those who were on sleep medicine or had travelled to a different time zone in last one month were excluded.

Ethics approval and consent to participate:

This study was conducted in accordance with the 'Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants, 2017', and Helsinki Declaration and its current amendments. Ethical approval for this study was obtained from the Independent Ethics Committee of the Symbiosis International (Deemed University), Pune (Approval number: SIU/IEC/181-A). A written informed consent was obtained from all participants prior to data collection. Participation was voluntary. Confidentiality of the data and anonymity of the participants were strictly maintained.

Data collection and tools:

The data was collected between November 2025 to March 2026 through personal interactions, using questionnaires and physical examinations. Pilot testing was done to check the clarity, feasibility, and suitability of the study tools for administrating in the target population.

Height and Waist Circumference (WC) were measured using a measuring tape. Weight and Body fat analysis were assessed using the Bioelectrical Impedance Analysis (BIA) machine - 'Omron Karada Scan body Composition Monitor HBF-375^{TM} [27]. This machine has been prevalidated and used in various epidemiological studies in indian populations [28,29]. The prediction formulae used in this machine are reliable to assess various parameters of body composition in epidemiologic studies [30,31].

Chronotype: Chronotype was measured using the 'Morningness Eveningness Questionnaire' (MEQ) which is a validated self-report scale, developed by Horne & Ostberg, 1976 [32]. It assess mornignness-eveningess preference with help of 19 subjective questions related to sleep-wake timing, alertness, etc. Based on cut-off points of the total score of 19 questions, the participants can be categorised into five chronotype: 'Definitely Morning type', Moderately Morning type', 'Neither Morning nor Evening type', 'Moderately Evening type', and 'Definitely Evening type'. We translated the original English version of MEQ in Marathi language version using 'Translation-Back Translation' method. The internal consistency of the translated Marathi version in the current sample was assessed using

Standardized Cronbach's alpha, yielding a coefficient of 0.639. Though slightly below the traditional threshold of 0.70, this value can be considered acceptable for an modified instrument in a new linguistic context, considering the scale measures various aspects of circadian rhythm and has a broad range of items. We also administered the 'Munich Chronotype Questionnaire' (MCTQ) in the participants which is a validated scale to assess the individuals' phase of entrainment using data of actual sleep-wake [33]. By using MCTQ, we calculated the Mid-Sleep timing on Free days, sleep-corrected (MSFsc) and SJL. The MSFsc is considered as objective measurement of chronotype. By assessing correlation between Total MEQ score and MSFsc score, we calculated the concurrent validity of the Marathi translated version of MEQ scale. A statistically significant moderate negative correlation (Spearman's rho (p): -0.596, p-value:< 0.001) was observed between these two variables suggesting as total MEQ score increases (represents morningness), the MSFsc score decreases (represents morningness). This highlighted strong concurrent validity of the Marathi translated MEQ version.

Perceived Stress Scale (PSS-10): Perceived Stress Scale is a widely used self-report validated scale to measure the degree to which individuals perceive their lives as stressful, and their ability to cope up with life events and daily challenge [34]. We used a shortened version with 10 questions (PSS-10) which was developed by Cohen & Williamson. The scale was developed by Total PSS score is calculated by summing up score allotted to each scale item. Total PSS score ranges from 0 to 40. Higer scores indicate higher perceived stress.

Pittsburgh Sleep Quality Index (PSQI): It is a self-report validated scale that measures seven components of sleep viz. Subjective sleep quality', 'Sleep latency', 'Sleep duration', 'Habitual sleep efficiency', 'Sleep disturbances', 'Use of sleeping medication', and 'Daytime dysfunction'[35]. Each item is scores from 0 to 3, with score 0 suggesting lowest, and score 3 sugegsting highest sleep disturbances. The Global PSQI score is calculated by sum of scoring of each item. Global PSQI score represents overall sleep quality of the individual. It 0 to 21, where lower score suggests better sleep quality. The cut-off levels have been set for the global score as 0 to 5 suggest Good sleep quality, and score of more than 5 suggest poor sleep quality.

Dietary assessment was conducted using a simplified questionnaire developed based on food frequency questionnaire [36], and it was vetted by a qualified nutritionist. Consumption of various food groups in a typical month was explored.

Physical activity assessment was conducted using a modified version based on 'International Physical Activity Questionnaire - Short Form' (IPAQ-SF) [37]. Involvement of participants in various physical activities over a typical week were explored.

In addition to this, various information regarding fctors influencing circadian rhythm of an individual, such as duration of mobile phone use in night, were explored using relevant questions.

Statistical analysis:

The data were analyzed using the IBM® 'Statistical Package for the Social Sciences' (SPSS) SPSS registered version 31.0. All obesity indicators viz. BMI, WC, BF%, VF%, SF%, SMMR, chronobiological indocators viz. total MEQ score, MSFsc and SJL were analysed as continuous variables. Additionally, these parameters were also assessed considering their categorization. BMI values were categorised as per ICMR criteria. The total MEQ score values were categorised in two ways: as per the MEQ scale standard cut-off values, and categorizing the total MEQ score into five equal quintiles. SJL scores were categorised into Low SJL (Less than 1 hour) and High SJL (1 hour or more). Descriptive analysis was done by calculating means, medians, standard deviations, frequencies, and percentages. Normality of the data distribution was assessed using Shapiro–Wilk test and visual methods of Histogram and Q–Q

plot. Corrrelations between two continuous variables were assessed using ‘Spearman’s Rank Correlation test’, and the correlation coefficients were denoted by Spearmans ‘ρ’ (rho). Association between a categorical and a continuous variable that is not normally distributed were analysed by using Maan-Whitney U test and Kruskal-Wallis test. Associations between two categorical variables was assessed using Chi-square test. Crude correlations between chronobiological and obesity parameters were analysed using ‘Spearman’s Rank correlation Coefficient Matrix’. Adjusted analyses were performed to understand effect of confounders in the association between chronobiological parameters and obesity parameters. The adjusted analysis was performed for each obesity variable using Multiple Linear Regression and using hierarchial regression models. Model 1 included only chronobiological parameters i.e. MEQ, MSFsc and SJL. Model 2 included demographic variables viz. age and sex in addition to Model 1. Model 3 included lifestyle factors viz. total daily sleep duration, sleep quality, perceived stress levels, duration of mobile phone use at night, physical activity levels, consumption of eggs, chicken/mutton, seafood, fruits, dryfruits, junk foods, green leafy vegetables. Additionally, we included a submodel 1 where Sleep duration and sleep quality were added to chronobiological parameters, where asosociation of SJL was identified with an obesity indicator. Multicollinearity was assessed using variance inflation factor (VIF), and model assumptions were checked. Unstandardized coefficients (B) of Spearman’s Rank correlation and ‘p’ values were reported.

Results

Demographic characteristics of the participants: A total of 170 teachers participated in the study. Majority were females, married, belonged to ‘Hindu’ religion, had educated till postgraduate level, and resided at urban areas. Mean age of the participants was 41.6 years, and most of them were of age between 26 to 45 years. Details of the demographic characteristics of the participants are presented in Table 1.

Table 1: Demographic characteristics of the participants

Sr. No.	Variable	frequencies	Percentage
A	**Age (in years)**		
	Range: 22-59; Mean: 41.6; Median: 40.0; Standard Deviation: 8.74		
1	18 to 25 years	2	1.2
2	26 to 45 years	108	63.5
3	> 45 years	60	35.3
	Total	170	100
B	**Sex**		
1	Male	30	17.6
2	Female	140	82.4
	Total	170	100
C	**Religion**		
1	Hindu	146	85.9
2	Muslim	3	1.8
3	Christian	2	1.2
4	Bouddh	16	9.4
5	Other	2	1.2
6	Not Responded	1	0.6
	Total	170	100
C	**Marital status**		
1	Unmarried	10	5.9
2	Married	146	85.9
3	Divorced	1	0.6
4	Separated	3	1.8
5	Widow	10	5.9
	Total	170	100.0
D	**Level of Education**		
1	12^{th} standard	2	1.2
2	Diploma	23	13.5
3	Graduate	67	39.4
4	Postgraduate	78	45.9
	Total	170	100.0

E	Type of residential area		
1	Urban	102	60.0
2	Rural	54	31.8
3	Semi urban	14	8.2
	Total	170	100.0

Chronobiological, obesity and lifestyle profile of the participants: Table 2 summarizes chronobiological and obesity profile of the participants. Mean total MEQ score was 63.3 suggesting overall morningess in the participants. As per standard cut-off points mentioned by MEQ scale developers, it was identified that most of the participants were 'Moderately Morning Types' (61.2%). Additionally, it was observed that most of the participants belonged to the category of 4^{th} quintile (22.4%), suggesting overall morningess. Mean MSFsc and SJL was 2:43 am and 51 minutes respectively. Majority of the participants were from 'Obese'category (64.7%) as per ICMR criteria for BMI categorization for Indian populations. Additionally, the mean values of BMI (26.5) and WC (91.9) also suggested that the population was obese overall.

Table 2: Chronobiological and obesity profile of the participants

Sr. No.	Variable	Frequency	Percentage	Mean	Median	SD	Range
A	**Chronobiological parameters**						
1	Total MEQ score	-	-	63.3	64.5	6.9	34-76
2	MEQ categories as per standard cut-off scores						
a	Definitely Morning types	29	17.1	-	-	-	-
b	Moderately Morning types	104	61.2	-	-	-	-
c	Neither type	36	21.2	-	-	-	-
d	Moderately Evening types	1	0.6	-	-	-	-
e	Definitely Evening type	0	0	-	-	-	-
	Total	170	100				
3	Total MEQ score quintiles						
a	1^{st} quintile	35	20.6	-	-	-	-
b	2^{nd} quintile	36	21.2	-	-	-	-
c	3^{rd} quintile	32	18.8	-	-	-	-
d	4^{th} quintile	38	22.4	-	-	-	-
e	5^{th} quintile	29	17.1	-	-	-	-
	Total	170	100				
4	MSFsc (Timing: HH:MM)	-	-	2:43 am	2:41 am	44 min	1:05 am to 4:58 am
5	SJL (in minutes)	-	-	51	47	36	-23 to 157
B	**Obesity parameters**						
1	BMI	-	-	26.5	26.3	4.3	16.6 to 39.1
2	BMI categories as per ICMR criteria						
a	Underweight	3	1.8	-	-	-	-
b	Normal	34	20.0	-	-	-	-
c	Overweight	23	13.5	-	-	-	-
d	Obese	110	64.7	-	-	-	-
	Total	170	100.0				
3	WC	-	-	91.9	92.0	11.1	60 to 124

4	Body fat percentage	-	-	35.6	36.6	5.6	19.3 to 46.7
5	Visceral fat percentage	-	-	10.3	9	5.6	1 to 29.5
6	Whole body subcutaneous fat percentage	-	-	29.2	29.7	6.9	12.2 to 44.4
7	Whole body skeletal muscle mass ratio	-	-	24.1	23.2	3.4	18 to 34.9
SD: Standard Deviation							

Lifestyle habits of the participants were explored. Mean daily sleep duration was approximately 7 hours. Mean and Median Global PSQI score was 4.9 and 4.5 suggesting good sleep quality. However, more than 1/3rd of the participants recorded 'Poor' sleep quality (35.3%). Mean and Median total score of PSS scale was 15.5 and 16.0 suggesting medium level of perceived stress amongst the participants overall. Mean duration of mobile phone use in night time was 75 minutes. Mean and Median physical activity METs were 5177 and 4227 minutes per week. On average Non-vegetarian food consumption was approximately 2 to 4 days per month. Mean days per month for consumption of fruits, green leafy vegetables, dryfruits, sprouts, Milk and milk products, fermented food items, and junk food items were 13.1, 14.9, 13.1, 13.2, 16.7, 4.4 and 3.7 respectively. 75.3% of the participants mentioned that they consume breakfast daily. Only 3.68% of the particiants mentioned that they frequently wake up at night and eat food. Lifestyle habits of the participants are described in the Table no. 3.

Table no. 3: Lifestyle habit parametrs of the participants

Sr. No.	Variable	Frequency	Percentage	Mean	Median	SD
C	**Lifestyle habits**					
1	Total weekly sleep duration (hours)	-	-	7.1	7.0	1.0
2	Sleep Quality (Global PSQI score)	-	-	4.9	4.5	2.1
3	Sleep Quality categories (Based on global PSQI score)					
A	Good (1-5)	110	64.7	-	-	-
b	Poor (>5)	60	35.3	-	-	-
	Total	170	100	-	-	-
3	Keeping lights On while sleeping					
	Yes	21	12.4	-	-	-
	No	149	87.6	-	-	-
	Total	170	100	-	-	-
4	Perceived stress level (Total PSS score)	-	-	15.5	16.0	5.8
5	Perceived stress level categories based on Total PSS score					
A	Low	62	36.5	-	-	-
B	Medium	104	61.2	-	-	-
c	High	4	2.4	-	-	-
	Total	170	100	-	-	-
6	Duration of mobile phone use at night (minutes)	-	-	75 (N=31)	60 (N=31)	48.4 (N=31)
7	Physical activity (Total MET per week)	-	-	5177	4227	4009.5
8	Consumption of various food groups (Days per month)					
a	Fruits	-	-	13.1	11	8.7
b	Falbhajya	-	-	20.1	20	8.3
c	Green Leafy Vegetables	-	-	14.9	12	8.3
d	Legumes/Seeds	-	-	11.3	8	8.9
e	Dryfrtuits	-	-	13.1	10	10.5
f	Fish And Sea Food	-	-	2.6	1	3.9
g	Eggs	-	-	4.9	4	6.0
h	Chicken Or Mutton	-	-	3.5	2.5	3.9

i	Cereals	-	-	24.8	28	8.2
j	Sprouts	-	-	13.2	12	8.0
k	Milk and Milk Products	-	-	16.7	16	11.5
l	Oils	-	-	26.2	28	6.6
m	Sweets	-	-	8.8	8	8.0
n	Fermented Food	-	-	4.4	4	4.0
o	Junk Foods	-	-	3.7	3	3.8
9	Consumption of morning tea/coffee daily					
a	Yes	123	72.4	-	-	-
b	No	47	27.6	-	-	-
	Total	170	100	-	-	-
10	Consumption of breakfast daily					
a	Yes	128	75.3	-	-	-
b	No	42	24.7	-	-	-
	Total	170	100	-	-	-
11	Type of meal when most portion of daily food is consumed					
a	Breakfast	27	16	-	-	-
b	Lunch	115	68	-	-	-
c	Evening snacks	4	2	-	-	-
d	Dinner	31	18	-	-	-
	Total	170	100	-	-	-
12	Habit of waking up from night sleep to eat					
a	Yes	11	6.5	-	-	-
b	No	159	93.5	-	-	-
	Total	170	100	-	-	-
SD: Standard Deviation						

Inferential analysis: Normality analysis suggested that chronobiological and obesity parameters were not distributed normally. Significant correlations were observed within obesity-related variables with moderate to strong correlation coefficients. Increase in BMI and WC was correlated with increase in BF%, VF%, SF% ($p < .001$); and decrease in SMMR ($p < .001$). Overall, generalised obesity (BMI) was significantly correlated with abdominal obesity

(WC and VF%). Significant correlations were observed within chronobiological parameters too. Total MEQ score was significantly negatively correlated with MSFsc (ρ=-0.581, p<.001) and SJL (ρ=-0.441, p<.001). This suggested good validity of the data since increase in Total MEQ score (morningness) was significantly correlated with decrease in MSFsc (morningness). MSFsc and SJL scores were significantly positively correlated with each other (ρ= -0.384, p<.001) suggesting later sleep timings were related with more mismatch with social schedule.

The correlations between the chronobiological and obesity parameters were very weak and not significant. Only one significant but weak correlation was observed in crude correlation analysis; it was between SJL and SF% (ρ =0.187, p=0.015). It suggested that increase in SJL is associated with increase in subcutaneous fat percentage in participants. Table no. 4 presents the Spearman correlation coefficient (rho) matrix to depict crude correlations between chronobiological and obesity parameters.

Table no. 4: Spearman correlation coefficient (rho) matrix between chronobiological and obesity parameters

Correlations										
		WC	**BMI**	**BF%**	**VF%**	**SF%**	**SMMR**	**MEQ**	**MSFsc**	**SJL**
WC	**ρ**	1.000	.764**	.436**	.707**	.481**	-0.341**	-.023	-.012	-.056
	Sig. (2-tailed)	.	<.001	<.001	<.001	<.001	<.001	.771	.879	.470
	N	170	170	170	170	170	170	170	170	170
BMI	**ρ**	.764**	1.000	.641**	.889**	.655**	-.489**	.031	-.002	.010
	Sig. (2-tailed)	<.001	.	<.001	<.001	<.001	<.001	.685	.978	.893
	N	170	170	170	170	170	170	170	170	170
BF %	**ρ**	.436**	.641**	1.000	.518**	.835**	-.813**	-.050	-.009	.053
	Sig. (2-tailed)	<.001	<.001	.	<.001	<.001	<.001	.516	.906	.494
	N	170	170	170	170	170	170	170	170	170
VF%	**ρ**	.707**	.889**	.518**	1.000	.394**	-.298**	.066	-.041	-.123
	Sig. (2-tailed)	<.001	<.001	<.001	.	<.001	<.001	.394	.595	.111
	N	170	170	170	170	170	170	170	170	170
SF%	**ρ**	.481**	.655**	.835**	.394**	1.000	-.878**	-.102	.030	.187*
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	.	<.001	.187	.696	.015
	N	170	170	170	170	170	170	170	170	170
SMMR	**ρ**	-.341**	-.489**	-.813**	-.298**	-.878**	1.000	-.004	.072	-.099
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	.	.961	.351	.201
	N	170	170	170	170	170	170	170	170	170
MEQ	**ρ**	-.023	.031	-.050	.066	-.102	-.004	1.000	-.581**	-.441**
	Sig. (2-tailed)	.771	.685	.516	.394	.187	.961	.	<.001	<.001
	N	170	170	170	170	170	170	170	170	170
MSFsc	**ρ**	-.012	-.002	-.009	-.041	.030	.072	-.581**	1.000	.384**

	Sig. (2-tailed)	.879	.978	.906	.595	.696	.351	<.001	.	<.001
	N	170	170	170	170	170	170	170	170	170
SJL	**ρ**	-.056	.010	.053	-.123	.187*	-.099	-.441**	.384**	1.000
	Sig. (2-tailed)	.470	.893	.494	.111	.015	.201	<.001	<.001	.
	N	170	170	170	170	170	170	170	170	170

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

ρ: Spearman's Rank Correlation Coefficient (rho)

WC: Waist Circumference

BMI: Body Mass Index

BF%: Whole Body Fat percentage

VF%: Visceral Fat percentage

SF%: Whole Body Subcutaneous Fat percentage

SMMR: Skeletal Muscle Mass Ratio

MEQ: Total MEQ score

MSFsc: Mid-Sleep timing on Free days, sleep-corrected

SJL: Social Jetlag

The relationship between chronobiological and obesity parameters was also assessed using categories of BMI, quintiles of Total MEQ score and SJL categories. No group differences across quintiles of Total MEQ score were observed for BMI (p=0.593), WC (p=0.851), BF% (p=0.311), VF% (p=0.653), SF% (p=0.530), and SMMR (p=0.281). No group differences across low and high SJL categories were observed for BMI (p=0.406), WC (p=0.777), BF% (p=0.525), VF% (p=0.804), SF% (p=0.065), and SMMR (p=0.369). No group differences were observed between BMI catgories for total MEQ score (p=0.574), MSFsc (p=0.428), and SJL (p=0.999). No association was observed between MEQ quintiles and BMI categories ($\chi^2 = 7.306$, $p = 0.837$). No association was observed between SJL categories and BMI categories ($\chi^2 = 1.923$, $p = 0.588$).

Adjusted analysis were conducted to check effect of confounding factors in correlations between chronobiological and obesity parameters. No significant multicollinearity was observed and all VIF values were less than 2, and model assumptions were found to be acceptable.

The crude association observed between SJL and SF% remained significant in Model 1 ($B = 0.039$, $p = 0.019$). It further remained significant ($B = 0.035$, $p = 0.041$) after additional adjustment for sleep quality and total sleep duration in Submodel 1. However, this association lost statistical significance in adjusted Model 2 and Model 3. This

suggested that the association between SJL and SF% was independent of total MEQ score, MSFsc score, sleep duration and sleep quality; but it may be confounded or mediated by demographic and lifestyle-related variables.

A significant association was observed between SJL and SMMR in all three adjusted models (Model 1: B = -0.022, p =0.008), (Model 2: B = -0.012, p = 0.026), Model 3 (B = -0.014, p = 0.014). These findings suggested that the participants with greater mismatch between biological and social sleep timing i.e. higher SJL tended to have lower skeletal muscle mass. This relationship was independent of Total MEQ score, MSFsc score, sleep duration, sleep quality, age, sex and various lifestyle related factors.

In Model 2, age was significantly associated with almost every obesity variable viz. BMI (B=0.183, p<.001), WC (B=0.453, p<.001), BF% (B = 0.245, p < 0.001), VF% (B = 0.312, p<0.001), SF% (B=0.273, p<0.001), and SMMR (B=-0.177, p<0.001). These associations were significant in Model 3 also. The findings suggested that generalised as well as central obesity increases, and muscle mass decreases with the increasing age. In Model 2, 'female' sex was significantly associated with higher BMI (B=1.770, p= 0.039), higher BF% (B = 9.345, p < 0.001), higher SF% (B=10.897, p < 0.001), and lower SMMR (B=-6.007, p<0.001). These associations were significant in Model 3, except for BMI. This suggested that females have significantly higher total body fat, subcutaneous fat and lower skeletal muscle mass as compared to males, independent of chronobiological and lifestyle parameters; whereas the association of female sex with higher BMI may be confounded by lifestyle parameters.

In Model 3, a significant association was observed between duration of night time mobile phone use and WC. (B=0.055, p=0.030). The findings suggested that longer duration of mobile phone use at night was significantly associated with higher waist circumference, independent of chronobiological, demographic and lifestyle parameters.

Discussion

This study was conducted in primary school teachers working in government and private primary schools from Mulshi block in Pune district in India. Majority of the participants were females. Overweight and obesity are largely prevalent amongst Indian school teachers. Our study findings were in line with this, since Mean BMI of participants was 26.5 Kg/m², and 13.5% and 64.7% of the participants in this study were overweight and obese according to the ICMR criteria [38]. Available studies regarding chronotype on Indian middle-aged and older adults suggest large prevalence of morning types in the participants [39,40]. Morningness was largely prevalent in participants of this study too. Mean MEQ score of the participants in our study was 63.3; and 78.2% of our participants were identified in the category of 'Definitely Morning' and 'Moderately morning' types, according to cut-off suggested by MEQ scale developers [32]. Majumdar & Sahu (2020) highlight that assessment of circadian preference and its relationship with obesity amongst Asian populations needs more research, since most of the available studies on chronotype are accumulated in European and American countries [41].

We did not find significant association between eveningness and higher values of BMI, WC and any body composition parameters of obesity. The regression analyses also found similar results. Very few studies have checked this relationship by two ways in same participants viz. categorizing the participants into various chronotype groups as well as by treating MEQ score as a continuous variable. In a study on European adults, no significant differences were observed for WC and VF % in groups of participants with various chronotypes. But regression analysis showed lower MEQ score (eveningness) was significantly associated with higher WC and VF% [42]. In our study, both types of analyses show negative results suggesting lack of association between chronotype and obesity. Our study findings support the few studies which mention no significant association between

eveningness and higher values of obesity indicators [6,42,43], We also found that this relationship was not dependent upon any demographic, sleep, dietary and lifestyle parameters. This was incontrary to previous studies where sociodemographic indicators [44], sleep disturbances [45], dietary practices [46] have been observed to influence the relationship.

We did not find any association of SJL with BMI, WC, BF% and VF%. This was in contrary to larger amount of literature supporting significant association between higher SJL and higher levels of obesity indicators, especially BMI and WC. However, we found significant association of higher SJL with increased levels of SF% independent of chronotype, sleep duration and sleep quality. But this association was probably been influenced by lifestyle factors as per adjusted model analysis. We could not find any previous studies to support or oppose this finding. Subcutaneous fat is an important component of toal body fat; and its role in metabolic health is still not fully explored. Hence, this finding opens a new area of research in chronobiology and obesity interrlations. We also found an significant association between higher levels of SJL and lower SMMR, independent of chronotype, demographic and lifestyle parameters. This was in contrary to a study on young german students where no significant association was identified between SJL and skeletal muscle mass [47]. Skeletal muscle mass [48] and sarcopenia [49] are important parameters in terms of obesity and cardiometabolic health. The relationship needs to be explored by conducting more studies in future since there is very limited research on interrelationship between SJL and skeletal muscle mass.

This study is one of the very few studies which explored relationship between chronobiological parameters amongst middle aged and older adults indian populations. One of the strengths of the study was that we examined chronotype through subjective i.e. morningness-eveningess preference, as well as objective measure i.e. MSFsc. Very few studies have used both of these indicators while exploring association with obesity. Additionally, we used anthropometric as well as body composition parameters of obesity in the study Both the parameters of chronotype displayed similar results for association with obesity indicators. Our study had a limitation that majority of the participants were females. Hence, our study findings are less representative for Indian male adults.

Conclusion

No association was identified between chronotype and obesity parameters amongst Indian school teachers. SJL was not associated with BMI, WC, BF%, and VF%. Higher SJL levels were associated with higher SF% and lower skeletal muscle mass. Role of SJL in metabolic health needs deeper exploration. There is a need to undertake more studies in Indian adult populations to explore the interrelationships between chronotype, SJL and obesity indicators.

Declarations

Ethics approval and consent to participate: This study received ethical approval from the Independent Ethics Committee of the Symbiosis International (Deemed University), Pune (Approval number: SIU/IEC/181-A dated 17.05.2025). A written and signed informed consent or participation in the study was obtained from all participants prior to data collection. Participation was voluntary. Confidentiality of the data and anonymity of the participants were strictly maintained.

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and/or analysed during the current study are not publicly available due to confidentiality issues, but are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: S.B. & S.J. conceptualized and designed the study and were responsible for methodology and development of instruments. S.B. conducted data collection. S.B. & S.J. contributed to data analysis. S.B. undertook project administration under the supervision of S.J. S.B. drafted the manuscript. S.J. reviewed and edited the manuscript. All authors contributed to the reviewing, supervision, and final edition of this manuscript. All authors read and approved the final manuscript.

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References

1. Broussard JL, Van Cauter E. Disturbances of sleep and circadian rhythms: novel risk factors for obesity. Curr Opin Endocrinol Diabetes Obes. 2016;23(5):353–9.
2. Reddy S, Reddy V, Sharma S. Physiology, circadian rhythm. InStatPearls [Internet] 2023 May 1. StatPearls Publishing.
3. Roenneberg T. What is chronotype? Sleep Biol Rhythms. 2012;10(2):75–6.
4. Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. Circadian typology: a comprehensive review. Chronobiol Int. 2012;29(9):1153–75.
5. Kalmbach DA, Schneider LD, Cheung J, Bertrand SJ, Kariharan T, Pack AI, Gehrman PR. Genetic basis of chronotype in humans: insights from three landmark GWAS. Sleep. 2017;40(2):zsw048.
6. Zhang R, Cai X, Lin C, Yang W, Lv F, Wu J, Ji L. The association between metabolic parameters and evening chronotype and social jetlag in non-shift workers: A meta-analysis. Front Endocrinol (Lausanne). 2022;13:1008820.
7. Teixeira GP, Guimarães KC, Soares AG, Marqueze EC, Moreno CR, Mota MC, Crispim CA. Role of chronotype in dietary intake, meal timing, and obesity: a systematic review. Nutr Rev. 2023;81(1):75–90.
8. Barrientos-Salinas R, Dahdah N, Alvarez-Luis J, Vilarrasa N, Garcia-Roves PM. Identifying Chronotype for the Preservation of Muscle Mass, Quality and Strength. Nutrients. 2026;18(2):221.
9. Oshita K, Ishihara Y, Seike K, Myotsuzono R. Associations of body composition with physical activity, nutritional intake status, and chronotype among female university students in Japan. J Physiol Anthropol. 2024;43(1):13.
10. Arab A, Karimi E, Garaulet M, Scheer FA. Social jetlag and obesity: a systematic review and meta-analysis. Obes Rev. 2024;25(3):e13664.
11. Mei-Yu LI, Yi-No KA, Pei-Shan TS. Association between social jetlag and components of metabolic syndrome: a systematic review and meta-analysis. J Nurs Res. 2024;32(5):e354.

12. Ekiz Erim S, Sert H. The relationship between chronotype and obesity: A systematic review. Chronobiol Int. 2023;40(4):529–41.
13. Mazri FH, Manaf ZA, Shahar S, Mat Ludin AF. The association between chronotype and dietary pattern among adults: a scoping review. Int J Environ Res Public Health. 2020;17(1):68.
14. Rusu A, Ciobanu DM, Inceu G, Craciun AE, Fodor A, Roman G, Bala CG. Variability in sleep timing and dietary intake: a scoping review of the literature. Nutrients. 2022;14(24):5248.
15. Bodur M, Baspinar B, Özçelik AÖ. A cross-sectional evaluation of the relationship between social jetlag and diet quality. Chronobiol Int. 2021;38(11):1557–68.
16. Shibata M, Fujibayashi M, Shibata S, Kuzuhara K, Tanida K. Association between social jetlag and objective physical activity among female university students of Japan: a cross-sectional study. Sleep Sci. 2024;17(02):e151–6.
17. Mercanoğlu Z, Karahan TÖ, Yüksel EA, Garipoğlu G. The Association Between Chronotypes, Eating Behavior, and Obesity Risk Among Undergraduate Students: A Cross-Sectional Study. Bau Health Innov. 2026;4(1):10–8. 10.14744/bauh.2026.32042.
18. Loch LD, Correa GI, Araújo IF, Portugal A, Bennemann GD, Mazur CE, Welter Wendt G, Ferreto LE, Panis C, Rossi CE, Casaril KB. Chronotype and Social Jetlag: Impacts on Nutritional Status and Dietary Intake of University Students. Obesities. 2026;6(1):3.
19. Bouman EJ, Beulens JW, Groeneveld L, de Kruijk RS, Schoonmade LJ, Remmelzwaal S, Elders PJ, Rutters F. The association between social jetlag and parameters of metabolic syndrome and type 2 diabetes: a systematic review and meta-analysis. J Sleep Res. 2023;32(3):e13770.
20. Zeraattalab-Motlagh S, Lesani A, Majdi M, Shab-Bidar S. Association of chronotype with eating habits and anthropometric measures in a sample of Iranian adults. Br J Nutr 2022 Jun 22:1–9. 10.1017/S0007114522001842
21. Al Abdullatif RA, Alkahtani S, Finlayson G, Alhussain MH. Chronotypes and their association with obesity-related lifestyle behaviors among young female adults. Int J Environ Res Public Health. 2023;20(2):1305.
22. Monica SJ, John S, Madhanagopal R. Metabolic Syndrome among Female School Teachers: A Sedentary Occupational Sector. Indian J Occup Environ Med. 2023;27(3):229–34.
23. Kumar P, Jangra P, Nara K. Level and associated factors with physical activity among Indian public school teachers. Health sport rehabilitation. 2023;9(3):6–23.
24. Mini GK, Sangeeth KS, Sarma PS, Thankappan KR. Clustering of non-communicable disease risk factors among school teachers: A cross-sectional study in Kerala, India. Clin Epidemiol Glob Health. 2025;32:101951.
25. Abirami MJ, Raj Kala A. Health implications of school teachers–a review. Int J Health Sci Res. 2018;8(5):350–9.
26. Kavitha B, Veigas J, Mannadath N. Work Stress among School Teachers: A Systematic Literature Review. Soc Med (Soc Med Publ Group). 2025;18(2):110–7.
27. OMRON Healthcare India, Omron. HBF 375 Body Composition Monitor [Internet]. India: OMRON Healthcare India; [cited 2026 May 2]. Available from: https://www.omronbrandshop.com/weighing-scale/omron-hbf-375-body-composition-monitor/?srsltid=AfmBOor2pzBqUrjTtqyMBmqqEPyqfHj9eiIGTNMC4sHPvnCHhLweKtSH
28. Sandeep KS, Singaraju GS, Reddy VK, Mandava P, Bhavikati VN, Reddy R. Evaluation of body weight, body mass index, and body fat percentage changes in early stages of fixed orthodontic therapy. J Int Soc Prev Community Dent. 2016;6(4):349–58.
29. Yogesh M, Mody M, Patel J, Shah S, Makwana N, Nagda J. Bioelectrical impedance analysis predicts prehypertension and hypertension: A hospital-based cross-sectional study. J Family Med Prim Care.

2024;13(10):4336–42.
30. Sun SS, Chumlea WC, Heymsfield SB, Lukaski HC, Schoeller D, Friedl K, Kuczmarski RJ, Flegal KM, Johnson CL, Hubbard VS. Development of bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys. Am J Clin Nutr. 2003;77(2):331–40.
31. Chandru S, Bhupal DP, Krishnappa L, Veluswamy SK. Test–Retest Reliability of a Commercially Available Bioelectrical Impedance-Based Body Composition Analyzer in India. J Soc Indian Physiotherapists. 2025;9(2):218–22.
32. Horne JA, Östberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol. 1976;4(2):97–110.
33. Roenneberg T, Wirz-Justice A, Merrow M. Life between clocks: daily temporal patterns of human chronotypes. J Biol Rhythms. 2003;18(1):80–90.
34. Cohen S, Williamson GM, the United States. Perceived stress in a probability sample of. 1988. In S. Spacapan & S. Oskamp, editors, The social psychology of health: Claremont symposium on applied social psychology (pp. 31–67). Sage.
35. Bysse DJ, Reynolds Iii CF, Monk TH. The Pittsburgh Sleep Quality Index (PSQI): a new instrument for psychiatric research and practice. Psychiatry Res. 1989;28(2):193–213.
36. University of Cambridge. The EPIC-Norfolk Study: Food Frequency Questionnaire [Internet]. Cambridge, United Kingdom: University of Cambridge; 2026 [cited 2026 May 4]. Available from: https://www.epic-norfolk.org.uk/images/ffq.pdf
37. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35(8):1381–95.
38. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, Joshi SR, Sadikot S, Gupta R, Gulati S, Munjal YP. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. Japi. 2009;57(2):163–70.
39. Chauhan S, Pandey R, Vakani K, Norbury R, Ettinger U, Kumari V. Sleep quality mediates the association between chronotype and mental health in young Indian adults. Npj Mental Health Res. 2024;3(1):31.
40. Minz S, Pati AK, Mohapatra M, Pati UC, Sahu P, Acharya PK, Kumari RB, Satpathy R. Patterns in behavioural sleep variables and social jetlag in elderly people of Western Odisha. Chronobiol Int. 2024;41(4):473–84.
41. Majumdar P, Sahu S. Morningness orientation is an important determinant to circadian misalignment and tolerance: an Asian perspective. Chronobiol Int. 2020;37(1):2–8.
42. De Amicis R, Galasso L, Leone A, Vignati L, De Carlo G, Foppiani A, Montaruli A, Roveda E, Cè E, Esposito F, Vanzulli A. Is abdominal fat distribution associated with chronotype in adults independently of lifestyle factors? Nutrients. 2020;12(3):592.
43. Bodur M, Bidar ŞN, Yardimci H. Effect of chronotype on diet and sleep quality in healthy female students: night lark versus early bird. Nutr Food Sci. 2021;51(7):1138–49.
44. Say YH, Nordin MS, Ng AL. Association of chronotype and sleep behaviors with mental well-being, eating behaviors, and adiposity traits: a cross-sectional study among a sample of urban Malaysian adults. BMC Public Health. 2025;25(1):1168.
45. Suh S, Yang HC, Kim N, Yu JH, Choi S, Yun CH, Shin C. Chronotype differences in health behaviors and health-related quality of life: a population-based study among aged and older adults. Behav Sleep Med. 2017;15(5):361–76.

46. Keenan GS, Hosseni S, Bendall RC. Chronotype predicts body mass index via emotion regulation strategy use and emotional eating. Brain Behav. 2025;15(5):e70542.
47. Krueger B, Stutz B, Jankovic N, Alexy U, Kilanowski A, Libuda L, Buyken AE. The association of chronotype and social jet lag with body composition in German students: The role of physical activity behaviour and the impact of the pandemic lockdown. PLoS ONE. 2023;18(1):e0279620.
48. Seo JA. Skeletal Muscle Should Not Be Overlooked. Diabetes Metab J. 2021;45(2):173–4.
49. Choi KM. Sarcopenia and sarcopenic obesity. Korean J Intern Med. 2016;31(6):1054–60.