Resolving Power of Modified Engelmann Scale for Determining Chronotype in Human Population

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ABSTRACT Five hundred and eighty two subjects responded on a modified Engelmann's questionnaire designed to determine chronotypes. The results clearly reveal that predominantly human subjects were morning active (75%). Of the remaining, 16% were evening active and 9% were intermediate type. The resolving power of the questionnaire was further confirmed by the study of the characteristics of oral temperature rhythm in a sample of 10 healthy human subjects. The conclusions obtained by using the scale was well supported by the results of sleep analysis and also by the data o.. body temperature time series analyzed with the help of cosinor and power spectrum methods.

Several physiological rhythms in humans under externally as well as internally synchronized state maintain a constant phase relationship between themselves. Therefore, from the phase location of one rhythm, it would be possible to locate phases of other clinically important rhythms. In this context circadian rhythm in body temperature assumes significance, specially because it has been considered as a marker rhythm for several other rhythmic functions in humans (Reinberg et al., 1980, 1983, 1984; Motohashi et al., 1987). The characteristics of circadian rhythm in body temperature may vary as a function of geographic location (Buguet et al., 1988; Colquhoun et al., 1978). Furthermore, the human population can be divided into two distinct sub-populations, *viz.*, lark type and owl type individuals (Östberg, 1973) and that the characteristics of body temperature rhythm have also been shown to vary as a function of morningness and eveningness. But it is time consuming to find out the morning active and evening active persons in the population by studying their temperature rhythm. Therefore, a questionnaire was developed with the help of which morning active and evening active persons were determined instantly. The resolving power of the questionnaire was confirmed by the characteristics of oral temperature rhythm and analyses of sleep data in an individual.

SUBJECTS, MATERIALS AND METHODS

A Survey to Ascertain Chronotype in Human Population: A specific questionnaire (Appendix I) was designed to ascertain the frequency of morningness and eveningness in human population of Raipur located 21°14'14" N latitude and 81°38'5" E longitude, 260m above mean sea level. The original questionnaire was obtained from Prof. Wolfgang Engelmann, University of Tuebingen, Germany, modified and made suitable for Indian conditions. Whether a subject is morning active or evening active was based on a score scale. There were in all nine questions, and each of the first six questions have four different alternative answers (Appendix I). Then each answer has a code with a corresponding numerical value known to the investigator. An individual was classified as morning active or evening active based upon sum total of the scores. A subject may have a score inbetween 6 (the lowest possible) and 24 (the highest), where A, B, C, and D correspond to 1, 2, 3 and 4, respectively.

582 subjects filled the questionnaire. The information collected from the subjects,

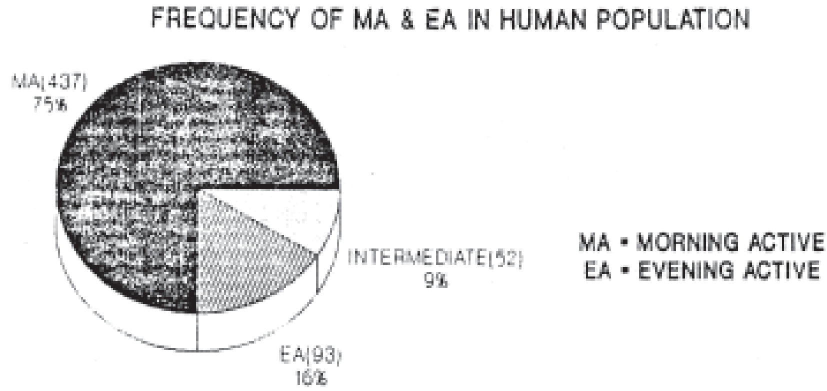

Fig. 1. Frequency distribution of morningness and eveningness in local human population. Based on information taken on questionnaire from 582 mixed subjects, irrespective of age, sex and working habits. (*See* materials and methods for details)

irrespective of sex, age, and working habits revealed 75% morning active individuals, 16% evening active individuals and 9% intermediate type individuals (Fig. 1). Out of 582 subjects 10 apparently healthy subject volunteered for further study.

Subjects: All the ten subjects, 6 morning active and 4 evening active included in this study, were postgraduate, students of Pt. Ravishankar Shukla University, Raipur. During the study period subjects followed their normal routine and were requested to maintain their diary regarding sleep duration, sleep quality and medications etc. The subjects were asked to measure oral temperature using a standard clinical thermometer 4 to 6 times daily. Error free data were collected from each subject as long as possible with a minimum of 10 days.

Statistical Analysis: The data on oral temperature self-measured by the subjects, were subjected to cosinor analysis for documenting a circadian rhythm (τ = 24h) (Nelson et al., 1979; Gupta and Pati, 1992). Various end points, *viz.*, mesor (rhythm-adjusted mean), amplitude (half of the difference between the highest and the lowest value) and acrophase (timing of the highest value) were computed.

Table 1 : Prominent circadian periods* for oral temperature in healthy human subjects

Subject code	*Period (in h)*
C # 01	24
C # 02	13.8 (24)[a]
C # 03	24
C # 04	24
C # 05	12 (24)
C # 06	24
C # 07	24
C # 08	12 (24)
C # 09	24
C # 10	24

* by power spectrum analysis [a]next prominent period, if the first one is not 24

A power spectrum method (De Prins et al., 1986) was used to detect prominent periods in individual time series. This method is suitable for time series with missing data as well as for data collected with unequal time intervals (Motohashi et al., 1987). Other conventional statistical techniques were also employed wherever required.

RESULTS

Prominent circadian periods obtained by spectral analysis for oral temperature rhythm (OT) in each subject is summarized in table 1. Significant circadian rhythm was validated for each subject (Table 2). However, 95%

Table 2 : Cosinor summary : Circadian rhythm in oral temperature of 10 healthy human subjects.

Subject code	*Chronotype*	*Data point*	*Rhythm detection*	*Rhythm-adjusted mean M±1 SE*	*Amplitude, A (95% CL)*	*Acrophase, φ in h (95% CL)*
C # 01	MA	60	< 0.001	36.96±0.05	0.31(0.12—0.50)	16.7 (14.6—18.9)
C # 02	EA	60	0.006	36.82±0.03	0.13(0.04—0.22)	18.5 (14.6—22.4)
C # 03	MA	104	< 0.001	36.95±0.02	0.16(0.07—0.25)	16.9 (14.9—19.4)
C # 04	MA	94	< 0.001	36.97±0.01	0.18(0.11—0.24)	14.3 (13.3—15.5)
C # 05	MA	56	< 0.001	37.07±0.06	0.40(0.15—0.65)	13.6 (11.5—15.1)
C # 06	EA	55	0.001	36.29±0.03	0.16(0.05—0.26)	02.6 (00.5—04.7)
C # 07	MA	44	0.01	36.75±0.04	0.16(0.04—0.30)	11.3 (08.0—14.6)
C # 08	EA	40	0.007	36.84±0.02	0.11(0.02—0.20)	19.3 (15.6—23.0)
C # 09	EA	40	< 0.001	36.45±0.06	0.34(0.14—0.54)	20.4 (17.6—23.2)
C # 10	MA	40	< 0.001	36.46±0.05	0.43(0.19—0.67)	14.2 (12.7—15.7)

CL = Confidence limit MA = Morning active EA = Evening active

confidence limits for circadian amplitude in OT rhythm in all the subjects overlapped with each other (Table 2).

The acrophase timing varied as function of chronotype (morning type/evening type) of the individuals. It was found that the peaks of oral temperature rhythm occurred earlier in morning active individuals (Fig. 2).

Sleep Analysis: As regards to bed time, inter-individual difference was noticed (Fig. 3). The evening active individuals, during the period of study usually went to bed in the early morning. Subject # 08 was exceptional in that he slept usually at around 03:00. He was a postgraduate student, a hosteler and during the study period he read till early hours of the day. However, his average sleep duration was quite comparable with other subjects. Qualitatively, all the subjects had good uninterrupted sleep without any kinds of problem. This was based on daily diary of individual subjects.

DISCUSSION

The results of this study clearly established, by way of using modified Engelmann Scale,

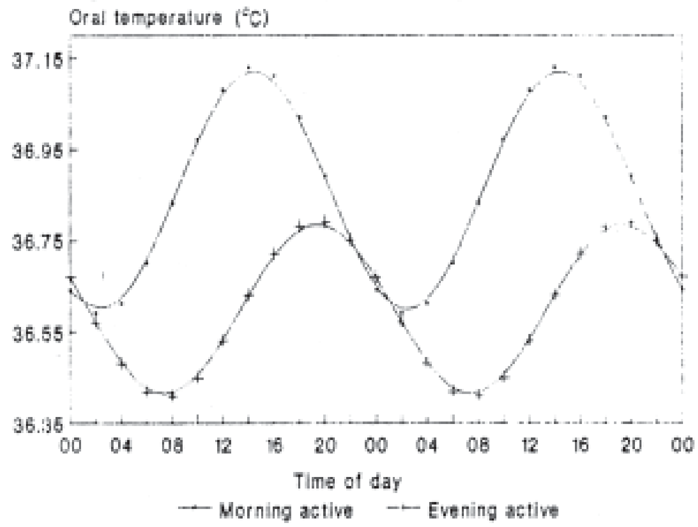

Fig. 2. An illustrative example of circadian rhythm in oral temperature (°C) of a group of morning active and evening active subjects. Y (t) = M + A. Cos (ωt + φ) continuous curves fitted to data obtained during wakefulness span only. Where, M = rhythm-adjusted mean; A = amplitude, half of the difference between the highest and the lowest value; ω = angular frequency; t = time; φ = acrophase, timing of the highest value with local mid-night as the phase reference

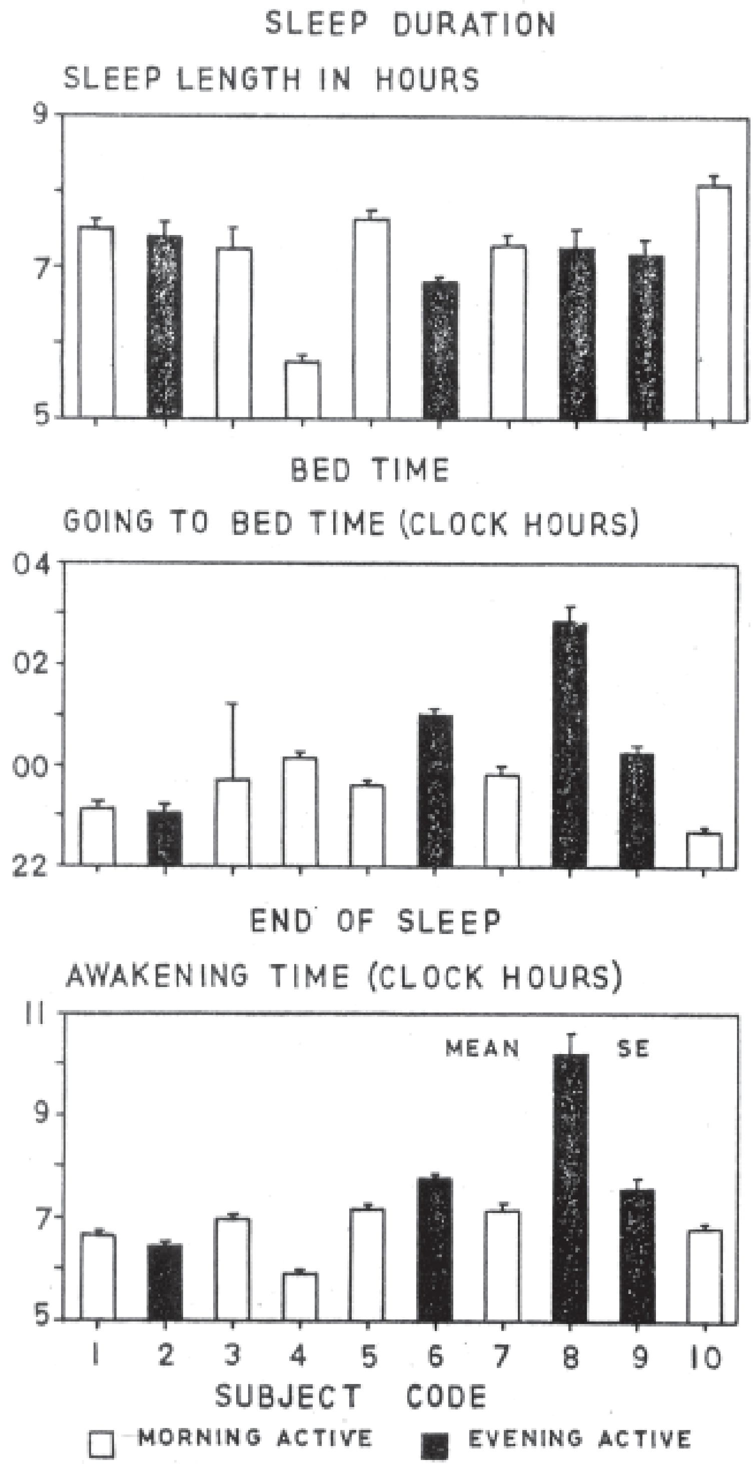

Fig. 3. Averaged of sleep length, bed time and awakening time in 10 healthy human subjects. For morningness and eveningness of subjects *see* table 2 also

two types of personalities, *viz.*, morning type and evening type in human population. It was observed that both spectral analysis and cosinor analysis of individual time series provided complementary results.

When acrophase timing of the temperature rhythm was observed it was found that the subjects classified as evening active on Engelmann's modified scale had the peak acrophase timing in the late evening hours, (around 19.4±0.55 h) and morning active individuals had peak timing (14.5±0.85 h) about 4.9 hours earlier. Further when the compatibility of questionnaire was tested with sleep analysis it was found that three out of four evening active individuals went to bed during the late night hours. This was further confirmed by the day to day sleep analysis of individuals. These findings lead us to the conclusion that the modified Engelmann Scale may serve as one of the easy and short methods to find out the chronotype of an individual.

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