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TO COMPARE THE COGNITIVE ABILITY OF PRECLINICAL MEDICAL STUDENTS AT DIFFERENT TIMES OF THE WORKING DAY AND CORRELATE THIS WITH THEIR MORNINGNESS-EVENINGNESS STATUS

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ABSTRACT

Introduction: Student's cognitive levels have been implicated with their learning ability, whether they are the morning type or evening type. Morningness-eveningness refers to individual differences in circadian phase position of spontaneous sleep-wake rhythms and to subject alertness. **Objective:** To determine if there is an association between time of day and cognitive levels. **Methodology:** This project was a questionnaire study, and 137 volunteers were recruited from Year 2 preclinical medical students Batch 8 in MAHSA University. Pre-study, each research subject filled in a Student's Circadian Rhythm questionnaire. Word-finding crossword puzzles were used to estimate the cognitive level of subjects and were administered at two fixed times during a normal working day. **Results:** Our results indicate that 32.12% of the students are of the evening type, 9.49% are of the morning type and 58.39% of the students tested were neither morning nor evening types. We also found no relationship between their status (morning-type or evening-type) and their cognitive level, as most of the students performed better in the mornings. **Conclusion:** Our study has shown that the cognitive level is higher in the morning as compared to the evening in all types of students.

Keywords: Cognition, Diurnal variation, Morningness-eveningness, Circadian Rhythm

INTRODUCTION

Circadian rhythm is a biological clock that governs the behavior and physiology of most species. This circadian rhythm can be synchronized to external time and environmental factors but also can persist in the absence of external signals. Any change in a person's circadian rhythm can impair health (Vitaterna, Takahashi & Turek, 2001).

Cognitive level is the ability of mental action or progress of acquiring knowledge and understanding through thoughts, experiences and senses (English Oxford Living Dictionaries, 2018).Bloom's Taxonomy classifies 6 cognitive levels: knowledge, comprehension, application, analysis, synthesis and evaluation (University of Central Florida, 2001).

Most previous studies that have demonstrated a positive effect of circadian rhythm on cognitive levels have been restricted to the temperate regions of the world (Blatter & Cajochen, 2007; Cagno *et al.*, 2014; Cavallera *et al.*, 2011;Diaz-Morales & Escribano, 2014;Karagul *et al.*,

2017;Mishra & Jha, 2014;Wesensten *et al.*, 2002; Valdez, Ramiraz & Garcia, 2012).The natural climate in Malaysia does not have large swings of temperatures or climate; it is therefore assumed that climate will not be the factor on cognitive levels, unlike the previous studies. However, it has been noticed that students are often sleepy or groggy during morning classes and may not be as cognitively sharp as later in the day. This study was conducted to find out if there is any correlation between cognitive levels and the time of day to determine the best timing of academic and assessment sessions for preclinical medical students in Malaysia.

OBJECTIVES

1) To determine the morningness-eveningness of preclinical medical students

2) To assess the cognitive performance of such students in the morning and evening

3) To determine if there is any correlation between students' cognitive levels and morningness-eveningness status

METHODOLOGY

i. Study Design

This research was a Cross Sectional study involving students who were assessed at two fixed times in one day.

ii. Study Area

MAHSA University, Faculty of Medicine

iii. Sampling Frame

We recruited 2nd Year Medical Students Batch 8 of MAHSA University

iv. Sample Size

This project was a questionnaire study; volunteers were recruited from Year 2 preclinical medical students Batch 8 in MAHSA University. 137 volunteers were recruited. Our calculated sample size is 132 with confidence level is 95% and significance level 0.05.

v. Inclusion Criteria

Preclinical medical students in a private medical institution.

vi. Exclusion Criteria

Preclinical medical students who are on any long-term medication.

vii. Student's Circadian Rhythm questionnaire

Pre-study: Each research subject filled in a standard Morningness-Eveningness questionnaire (Horne & Ostberg, 1976). The total scores obtained from the questionnaire classified the volunteers into: Morning Type, Moderately Morning Type, Neither Either, Moderately Evening Type and Definitely Evening Type. We then manually grouped the 5 categories into 3 categories: Morning Type, Neither Either and Evening Type.

viii. Cognitive test

Word-finding crossword puzzles were used to estimate the cognitive level of subjects. The test is suitable for testing subjects without cultural bias. This was administered twice on the same day; morning and late afternoon, and a fixed time interval of 5 minutes was given to each subject on each occasion to allow reliable comparisons in cognitive levels.

ix. Analysis of data

The morningness-eveningness scores obtained from the Morningness-Eveningness questionnaire was compared and correlated with cognitive level, gender and race of the subjects. IBM SPSS STATISTIC VERSION 23 was used for statistical analysis after data collection was completed.

LITERATURE REVIEW

Circadian rhythm is basically a 24-hour internal clock that is running in the background of our brain and cycles between sleepiness and alertness at regular intervals.

Morningness-eveningness refers to individual differences in circadian phase position of spontaneous sleep-wake rhythms and alertness. Individuals can be classified as either Morning Types (MTs), Evening Types (ETs) or the intermediate type-Neither Types (NTs) with the latter being the most common classification. Based on previous research done, morningness-eveningness of an individual may influence the performance of cognitive tasks performed. In addition, previous research has demonstrated that university students are generally more biased towards eveningness. This is likely due to a phase delay in melatonin secretion which has been reported in adolescence (Horne & Ostberg, 1976).

A person's biological rhythm is the oscillation in the diurnal physiology of human beings. There are variations in alertness and sleepiness. Alertness is high during the day and sleepiness is high during the night-time. Cognitive performance correlates with alertness and is better during the day and worse during the night. Circadian rhythm can vary with age; there are changes in phases of the circadian rhythm that affects which affects the cognitive performance over the course of time. There is a delay in the sleep-wake cycle of adolescents. Elderly people have shown to be more morning-type people individuals. An increase in reaction time and a lower performance in neurophysiological tests have been found in the afternoon. In addition, elderly people have lower amplitude in circadian rhythms of cognitive performance (Valdez, Ramirez & Garcia, 2012).

Some studies show that there is an effect of circadian rhythm on daily dynamic balance performance. A study by Gribble P.A. and Hertel J in 2003 claimed dynamic balance performance in the morning is better than the afternoon and evening performance (Karagul *et al*., 2017). Besides, it has been shown that the normal performance of the rhythmic gymnasts does not change at any time of the day, but their dynamic balance performance reaches a peak in the morning (Cagno *et al*., 2014). Athletic performance occurring before or after the circadian peak value could result in lower performance efficiency. The range of performance due to circadian rhythm variation is estimated to be 10% to 30% of the daily mean, according to Klein (1979). Moreover, the changes in body temperature are also a factor that affects the circadian rhythm.

Based on a recent study, academic performance of the students can vary in males and females according to Mind and Society in 2014. For example, a study by Rosina Lao in 1980 found that females perform significantly better than males, academically. However, the interaction between the effect of the morningness-eveningness preference and gender was not found to be significant. Therefore, the academic performance of the male and female students does not depend on morningness-eveningness preference of a student (Mishra & Jha, 2014).

Based on research done by Randler (2008),cigarette smoking has been associated with delayed sleep onset and diminished sleep duration. It has been found that smokers are more likely to experience poor sleep as compared to non-smokers. Another study by Adan, Prat, and Sanchez-Turet (2004) found differences in mood and activation between high- and low-dependent smokers and non-smokers. Wittmann *et al*. (2006) proposed that correlations between smoking and chronotype are most probably a consequence of social jetlag, that is to say, the discrepancies between social and biological timing rather than a simple association with different chronotypes (Mishra & Jha, 2014).

According to Spanagel *et al*., (2005) from their research paper entitled "Alcohol Consumption and the Body's Biological Clock in 2005," a circadian clock represents an adaptation to daily alterations in the environments. Alcohol consumption will interfere with the transmission processes in the central nervous system, thus affecting the activity of biologically system. Drinking alcohol can disrupt the biological clock of a person (Spanagel *et al*., 2005).

Research on Circadian Rhythms in cognitive performance by Blatter and Cajochen (2007), showed the effects of time and extended episodes of forced wakefulness on cognitive performance. It, therefore, becomes important in determining the most favourable time of the day for teaching in order to optimize the school timetables. This pioneer study on circadian and sleep research noticed a diurnal variation in speed and accuracy of cognitive performance with best results in the afternoon and poorest in the morning and late night. Cognitive performances included the behavioral responses to different tasks regarding complexity, memory and language (Blatter & Cajochen, 2007).

Based on the research on "Racial Differences in the Human Endogenous Circadian Period" by Smith *et al*., (2009), difference in race had an influence in the human circadian clock. They found that Tau measured in subjects living on an ultradian Light-Dark cycle averaged 24.2 hours, and they reported racial differences in Tau (Smith *et al*., 2009).

African American subjects had larger phase advances and smaller phase delays, relative to Caucasian subjects (Smith *et al*., 2009). The racial differences in Tau and circadian phase shifting have important implications for developing solutions to the problems such as jet lag and shift work, and for the diagnosis and treatment of circadian rhythm based sleep disorders. However, such research had not been done on Asians yet.

Participation in cognitively stimulating leisure activities such as crossword puzzles may improve cognitive levels according to Pillai *et al*., (2011) and given the wide availability and accessibility of Crossword puzzles, they were used in this study to assess the cognitive level of volunteers.

RESULTS

137 students volunteered to participate in this study. Based on chart 1.1, 58% (80) of the volunteers belonged to the neither either type, 32% (44) were evening type followed by 10% (13) of morning type. For the profile analysis, the neither either group was excluded as shown in chart 1.2. After excluding the neither either group, student categories lean towards evening type which is 77% (44).
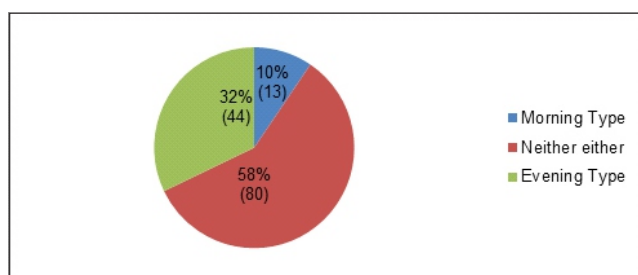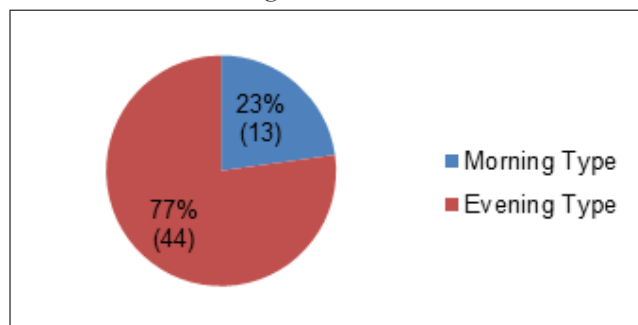

Chart 1.1: Student categories

Chart 1.2: Student categories excluding neither either group

As shown in chart 2.1, in our sample 67% (38) were females and 33% (19) were males. In the female category as shown in chart 2.2, there was a significant difference between morning type and evening type with a p-value of 0.000, whereas the male category had no difference in student categories with a *p*-value of 0.251 (table 1.3).
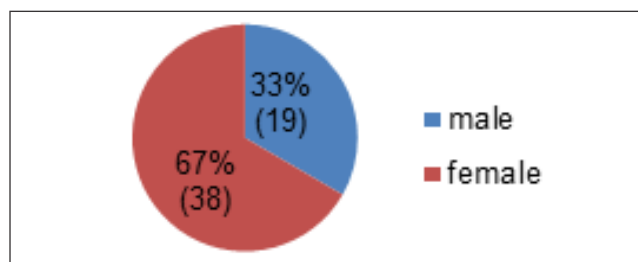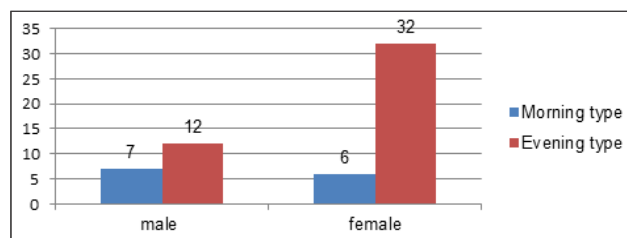

Chart 2.1: Gender

Chart 2.2: Gender

Table 1.1: Cross-tabulation of males

Male

	Observed N	Expected N	Residual
Morning type	7	9.5	-2.5
Evening type	12	9.5	2.5
Total	19		

Table 1.2: Cross-tabulation of females

Female

	Observed N	Expected N	Residual
Morning type	6	19.0	-13.0
Evening type	32	19.0	13.0
Total	38		

Table 1.3: Chi square test of gender and morningness-eveningness

Test Statistics

	Male	Female
Chi-Square	1.316[a]	17.789[b]
Df	1	1
Asymp. Sig.	.251	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.5.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 19.0.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 19.0.

Chart 3.1 shows that there were 30% (17) volunteers less than 20 years of age, 61% (35) volunteers were between 21 and 22, and 9% (5) volunteers were more than 23 years of age. We see in the tables 2.1 to 2.4,

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 19.0.Chart 3.1 shows that there were 30% (17) volunteers less than 20 years of age, 61% (35) volunteers were between 21 and 22, and 9% (5) volunteers were more than 23 years of age. We see in the tables 2.1 to 2.4, volunteers less than 20 and 21 to 22 years of age were significantly different in their p-values of 0.029 and 0.000 respectively. Meanwhile, volunteers aged more than 23 years of age showed no significant difference with a p-value of 0.655. Chart 3.2 showed that as age increases, the volunteers tend to become more morning type, however due to research having a small sample size, no definite conclusion can be made based on this data. Based on chart 4.1, it is shown that only 7% (4) of the sample were smokers and it is a very small sample as compared to non-smokers who were of 93% (53) of our study sample. By referring chart 4.2 and table 3.3, non-smokers were significantly more evening types with a p-value of 0.000. Smokers tended to be morning types but again, due to the small sample size of smokers, no conclusion can be made.
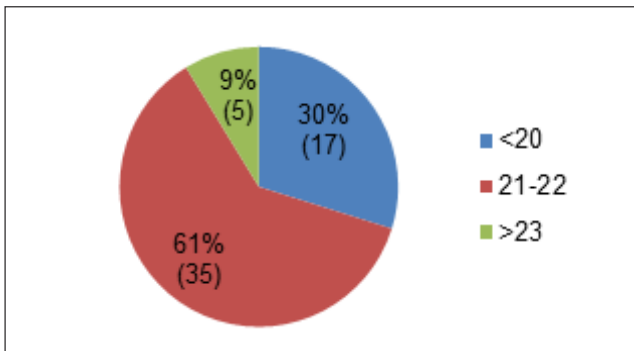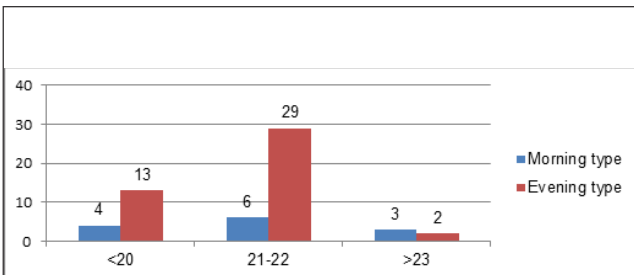

Chart 4.1: Smoking status
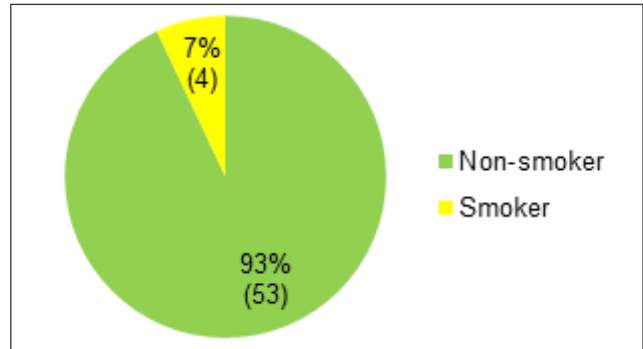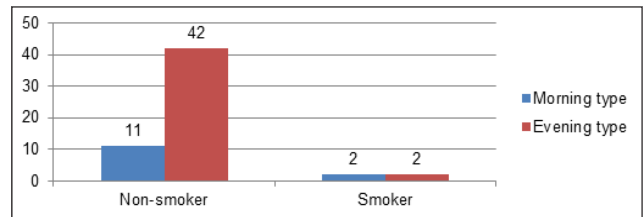

Chart 4.2: Smoking status

Table 2.1: Cross-tabulation of volunteers aged <20

<20			
	Observed N	Expected N	Residual
Morning type	4	8.5	-4.5
Evening type	13	8.5	4.5
Total	17		

Table 2.2: Cross-tabulation of volunteers aged 21-22

21-22			
	Observed N	Expected N	Residual
Morning type	6	17.5	-11.5
Evening type	29	17.5	11.5
Total	35		

Table 2.3: Cross-tabulation of volunteers aged >23

>23			
	Observed N	Expected N	Residual
Morning type	3	2.5	.5
Evening type	2	2.5	-.5
Total	5		

Chart 3.1: Age

Chart 3.2: Age

Table 2.4: Chi-square test of age and morningness -eveningness Test Statistics

	<20	21-22	>23
Chi-Square	4.765[a]	15.114[b]	.200[c]
Df	1	1	1
Asymp. Sig.	.029	.000	.655

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.5.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 17.5.

c. 2 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.5.

Table 3.1: Cross-tabulation of non-smokers

Non-smoker

	Observed N	Expected N	Residual
Morning type	11	26.5	-15.5
Evening type	42	26.5	15.5
Total	53		

Table 3.2: Cross-tabulation of smokers

Smoker

	Observed N	Expected N	Residual
Morning type	2	2.0	0.0
Evening type	2	2.0	0.0
Total	4		

Table 3.3: Chi square test of smoking status and mor -ningness eveningness Test Statistics

	Non-smoker	Smoker
Chi-Square	18.132[a]	0.000[b]
Df	1	1
Asymp. Sig.	.000	1.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 26.5.

b. 2 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.0.

As for drinking status [chart 5.1] we categorised our student sample into non/rare drinkers [77% (44)] and frequent drinkers [23% (13)]. Refer to table 4.3, non/rare drinker are more evening types with a *p*-value of 0.000; frequent drinkers showed no difference between morning and evening type. Refer to chart 6.1 and chart 6.2, regarding racial differences among the 57 subjects, the Chinese were 33% (19) followed by Indian 25% (14), then other races with 23% (13) which were made up of Bumiputera and international students. Lastly the Malays represented 19% (11) of our subjects. Table 5.5 shows our analysis. Chinese were significantly more evening type people with a *p*-value of 0.000. Besides that, other races were also significantly more evening type people. However, the Malays and the Indians both showed no difference in morningness-eveningness with *p*-values of 0.763 and 0.593 respectively.
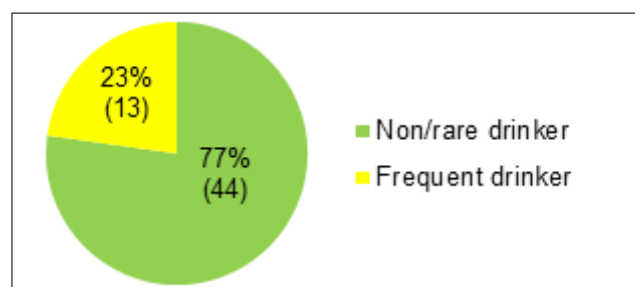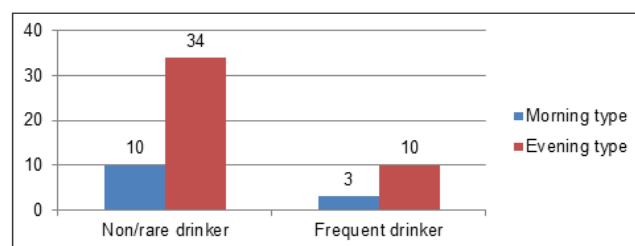

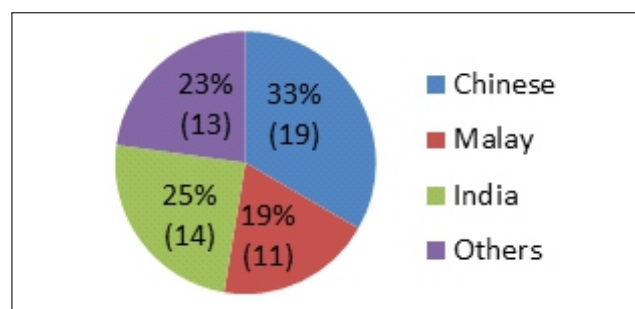*Chart 5.1: Drinking status*
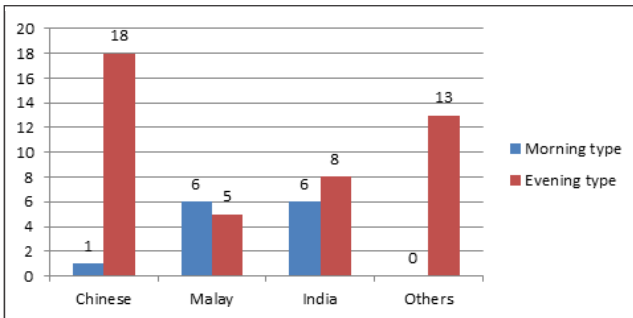

Chart 5.2: Drinking status

Chart 6.1 Race

Chart 6.2 Race

Table 4.1: Cross-tabulation of non/rare drinkersNon/rare drinker

	Observed N	Expected N	Residual
Morning type	10	22.0	-12.0
Evening type	34	22.0	12.0
Total	44		

Table 4.2: Cross-tabulation of drinkers

Drinker

	Observed N	Expected N	Residual
Morning type	3	6.5	-3.5
Evening type	10	6.5	3.5
Total	13		

Table 4.3: Chi square test of drinkers and morningness-eveningness

Test Statistics

	Non/rare drinker	Drinker
Chi-Square	13.091[a]	3.769[b]
Df	1	1
Asymp. Sig.	0.000	0.052

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 22.0.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.5.

Table 5.1: Cross-tabulation of Chinese

Chinese

	Observed N	Expected N	Residual
Morning type	1	9.5	-8.5
Evening type	18	9.5	8.5
Total	19		

Table 5.2: Cross-tabulation of Malay

Malay

	Observed N	Expected N	Residual
Morning type	6	5.5	0.5
Evening type	5	5.5	-0.5
Total	11		

Table 5.3: Cross-tabulation of Indian

Indian

	Observed N	Expected N	Residual
Morning type	6	7.0	-1.0
Evevning type	8	7.0	1.0
Total	14		

Table 5.4: Cross-tabulation of other races

Others (Bumiputera and international students)

	Observed N	Expected N	Residual
Evening type	13	13.0	0.0
Total	13[a]		

a. This variable is constant. Chi-Square Test cannot be performed.

Table 5.5: Chi-square test of races and morningness-eveningness

Test Statistics

	Chinese	Malay	India
Chi-Square	15.211[a]	.091[b]	.286[c]
Df	1	1	1
Asymp. Sig.	.000	.763	.593

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.5.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.5.

c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.0.

On tests of cognition, chart 7.1 shows, there were a higher percentage of 73% (100) who performed better in the morning while only 21% (29) who performed better in the evening. Refer to chart 7.2 and table 6.2, despite volunteers being morning type, evening type and neither either, most volunteers significantly

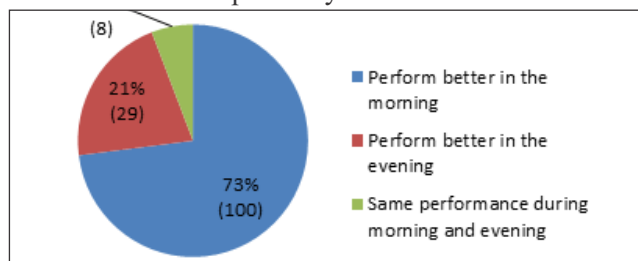performed better in the morning with p-values of 0.013, 0.000 and 0.000 respectively.
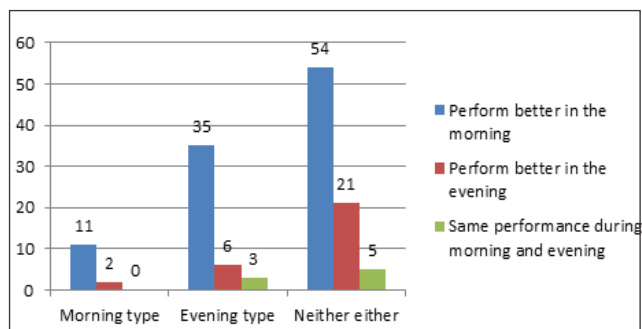

Chart 7.1 Cognitive level

Chart 7.2 Cognitive level

Table 6.1: Cross-tabulation of morningness-eveningness and cognitive level

			Performance comparison between morning and evening			
			Same performance during morning and evening	Perform better in the morning	Perform better in the evening	Total
Morningness and Eveningness	Morning type	Count	0	11	2	13
		Expected Count	.8	9.5	2.8	13.0
	Neither either	Count	5	54	21	80
		Expected Count	4.7	58.4	16.9	80.0
	Evening type	Count	3	35	6	44
		Expected Count	2.6	32.1	9.3	44.0
Total		Count	8	100	29	137
		Expected Count	8.0	100.0	29.0	137.0

Table 6.2: Chi-square test of cognitive level and student categories

Test Statistics

	Morning type	**Evening type**	**Neither either**
Chi-Square	6.231[a]	42.591[b]	46.825[c]
Df	1	2	2
Asymp. Sig.	.013	.000	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.5.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 14.7.

c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 26.7.

Table 6.3: Chi-square test of cognitive level and student categories

Chi-Square Tests

	Value	**df**	**Asymptotic Significance (2 sided)**
Pearson Chi-Square	4.045[a]	4	0.400
Likelihood Ratio	4.913	4	0.296
Linear-by-Linear Association	1.134	1	0.287
N of Valid Cases	137		

a. 4 cells (44.4%) have expected count less than 5. The minimum expected count is 0.76.

DISCUSSION

In our study, results showed that students were predominantly neither either types (58%, 80 volunteers) on tests of morningness-eveningness. This could be due to various other lifestyle variables such as coffee drinkers, as caffeine can affect the circadian rhythm (Wesensten *et al*., 2002). Therefore, the evening type students who consume caffeine in the morning can result in neither either type students. Unfortunately, we had not checked the level of coffee consumption in our study.

According to a study Murcia in 2014, older adolescents reported to be more evening-oriented (Diaz-Morales & Escrbano, 2014). This showed a similar result to our study which was also mainly older adolescents. During adolescence, several changes not only physically but also psychologically appear. One of them is the preference for evening hours which has been related to three of the most important areas in this stage of life: school performance, personality styles, and health, which in turn, can affect psychological functioning. Nevertheless, other aspects such as sleep habits, health habits and personality styles can influence morningness-eveningness according to Fernández-Ríos and Buela-Casal in 2009 (Diaz-Morales & Escrbano, 2014).Hence, in our analysis, we excluded the neither either group, to avoid confusion.

Both genders are predominantly evening type. By comparison, females are significantly more evening people as compared to males in our study. Based on a study in Palmerstone North in 2011, results showed that male participants were more evening-oriented than females (Cavallera *et al*., 2011). Our results also showed that males are more evening type of people, however female are more evening-oriented than male. Recently a very large sample of individuals consisting of 8,972 pre-adolescents, adolescents, and adults (5,367 females and 3,605 males) were surveyed by Tonetti, Fabbri, and Natale in 2008, who noticed that time preference started to shift toward eveningness from the age of 13, and that females reached their peak in eveningness earlier (at about 17 years of age) than did males (about 21 years of age). Moreover, the authors noticed that the ideal sleep time preference advanced for both men and women with increasing age (Cavallera *et al*., 2011). Our study has similar findings; however due to the small sample size for morning people and evening people as 80 students were excluded from the profile analysis, we cannot draw a definitive analysis. As a recommendation to any future study, the sample size should increase.

The age range of our volunteers were 19 to 25 years old. Based on our present observations, most of the younger respondents, who were ages 22 years and

below was predominantly evening type. Meanwhile, most of the older respondents, who were ages 23 and above were morning type people. From a previous study younger children have been found to lean towards being morning type, and older children toward the evening type with optimal time of day preference being identified as shifting towards eveningness in adolescents (Kim *et al.*, 2002).Despite our study having a similar pattern to previous studies, no conclusion can be deduced from it as there were only 5 volunteers more than 23 years of age which does not provide significant data.

Our study observed that most of the non-smokers were significantly evening type people, whereas there was no significant difference between percentages of morning people and evening people among smokers. According to a study by Randler (2008), smokers were more evening type and had a greater difference in wake-up times between weekdays and weekends as compared to non-smokers. This is probably because smokers are found to likely experience poor sleep than non-smokers. This is because cigarette smoking has been associated with delayed sleep onset and diminished sleep duration (Cavallera *et al.*, 2011).Our study oppose the statement, this may due to small sample size for smoker, and insufficient data collection such as coffee consumption by the respondent because some studies suggested that smokers are more likely dependent on caffeine as a stimulant which could be a reason to shift the evening people to become more evening type (Patterson *et al.*, 2016).Studies suggest there are relationship between smoking status and sleeping problems, which cannot be shown in our study (Bellatorre *et al.*, 2016). Future studies should involve more smokers to better analyse the relationship between smoking status or how other stimulants affect the circadian rhythm.

According to the race analysis, Chinese were found to be significantly evening type. A previous study found that African Americans have a shorter free-running endogenous circadian period (Tau) than Caucasians. This is the first report of racial differences in human (Tau protein analysis) according to Smith *et al.*, (2009). In addition, the study presents evidence that there are racial differences in the amount that the human circadian clock can be phase-shifted with bright light

exposure and a shifted sleep/dark schedule, such that African Americans have larger phase advances, and smaller phase delays, relative to Caucasian subjects. The study concluded there was a relationship between races and circadian rhythm; however, Asian races were not included in the research. Our study, which involves mainly Asians, strongly support that there is a relationship between Asian races and circadian rhythm.

Our study also showed that cognitive level is higher in the morning as compared to the evening in all type of students. Hence, there is no relationship between the student cognitive level and morningness-eveningness. The previous studies were not done in normal healthy young adults in Malaysia, therefore there are no comparable statements.

CONCLUSION and RECOMMENDATION

Preclinical medical students are predominantly evening type; however their cognitive levels are higher in the morning. There were no correlations found between students' morningness-eveningness status and cognitive level. Some other findings are: female, students aged between 21-22, and Chinese race were significantly more evening type. In addition, non-smokers and non-alcohol drinkers were observed to be more evening type. Therefore, classes and assessments should be held in the morning. Students should also know their circadian rhythm to achieve their academic goals.

There are few limitations in this study which need to improve in further study. This includes voluntary response sample, environmental factors, consistency, and sample bias. Volunteers tend to have similar lifestyle and personalities, they tend to produce same outcome; therefore, any future study should use random sampling. The cognitive tests assessed in the morning and evening were being performed at different locations in the University, hence results in many factors may vary that may possibly influence the results of performance. The volunteers were only being assessed once instead of many days of week.

Lastly, all the volunteers were recruited from the same institution, hence this study cannot represent the general population. As a recommendation, biochemical assay should be used in further studies to obtain more accurate

results of morningness-eveningness.

REFERENCES

Adan, A., Prat, G. & Sánchez-Turet, M. (2004). Effects of Nicotine Dependence on Diurnal Variations of Subjective Activation and Mood. *Addiction*, 99(12), pp 1599-1607.

Bellatorre, A., Choi, K., Lewin, D., Haynie, D. & Simons-Morton, B. (2016). Relationships Between Smoking and Sleep Problems in Black and White Adolescents. *Sleep*, 40(1).

Blatter, K. & Cajochen, C. (2007). Circadian Rhythms in Cognitive Performance: Methodological Constraints, Protocols, Theoretical Underpinnings. *Physiology & Behavior*, 90(2-3), pp196-208.

Cagno, A.D., Fiorilli, G., Iuliano, E., Aquino, G., Giombini, A., Battaglia, C., Piazza, M., Tsopani, D. & Calcagno, G. (2014). Time of-Day Effects on Static and Dynamic Balance in Elite Junior Athletes and Untrained Adolescents. *International Journal of Sports Science & Coaching*, 9(4), pp 615-625.

Cavallera, G.M., Boari, G., Labbrozzi, D. & Bello, E. (2011). Morningness-Eveningness Personality and Creative Thinking Among Young People Who Play Recreational Sport. *Social Behavior and Personality: An International Journal*, 39(4), pp 503-518.

Díaz-Morales, J. & Escribano, C. (2014). Consequences of Adolescent's Evening Preference on School Achievement: a Review. Consecuencias de la mayor vespertinidad durante la adolescencia para el funcionamiento psicológico: una revisión. *Anales de Psicología,* 30(3).

English Oxford Living Dictionaries. (2018). Cognition. Definition of cognition in English by Oxford Dictionaries. Retrieved from: https://en.oxforddictio -naries.com/definition/cognition.

Horne, J.A. & Östberg, O.(1976). A Self-Assessment Questionnaire to Determine Morningness -Evening -ness in Human Circadian Rhythms. *International Journal of Chronobiology*, 4(2), pp 97-100.

Karagul, O., Nalcakan, G., Dogru, Y. & Tas, M. (2017). Effects of Circadian Rhythm on Balance Performance. *Polish Journal of Sport and Tourism*, 24(3), pp155-161.

Kim, S., Dueker, G.L., Hasher, L. & Goldstein, D. (2002). Children's Time of Day Preference: Age, Gender and Ethnic Differences. *Personality and Individual Differences*, 33(7), pp1083-1090.

Klein, D.C. (1979) Circadian rhythms in the pineal gland. In: Endocrine Rhythms. Ed: Krieger, D.T. New York: Raven Press. 203–223.

Mishra, S. & Jha, M. (2014). Academic Performance in Relation to Gender and Morningness-Eveningness Preference. *Mind and Society*, 3 (I & II), pp 32-35.

Patterson, F., Malone, S.K., Lozano, A., Grandner,

M.A. & Hanlon, A. (2016). Smoking, Screen-Based Sedentary Behavior, and Diet Associated with Habitual Sleep Duration and Chronotype: Data from the UK Biobank. *Annals of Behavioral Medicine*, 50(5), pp 715-726.

Pillai, J.A., Hall, C.B., Dickson, D.W., Buschke, H., Lipton, R.B. & Verghese, J. (2011). Association of Crossword Puzzle Participation with Memory Decline in Persons Who Develop Dementia. *Journal of the International Neuropsychological Society*, 17(06), pp 1006-1013.

Puzzles.ca. (n.d.). FREE Printable Word Search Puzzles. Retrieved from: https://www.puzzles.ca/wordsearch/

Randler, C. (2008). Differences Between Smokers and Nonsmokers in Morningness-Eveningness. *Social Behavior and Personality: an international journal*, 36(5), pp 673-680.

Smith, M., Burgess, H., Fogg, L. & Eastman, C. (2009). Racial Differences in the Human Endogenous Circadian Period. *PLoS One,* 4(6).

Spanagel, R., Rosenwasser, A.M., Schumann, G. & Sarkar, D. (2005). Alcohol Consumption and the Body Biological Clock. *Alcoholism: Clinical & Experimental Research*, 29(8), pp1550-1557.

University of Central Florida. (2001). Bloom's Taxonomy. Retrieved from: http://www.fctl.ucf.edu/TeachingAndLearningResources/CourseDesign/BloomsTaxonomy/

Valdez, P., Ramírez & García, A. (2012). Circadian Rhythms in Cognitive Performance: Implications for Neuropsychological Assessment. *Chrono Physiology and Therapy*, 2, pp 81-92

Vitaterna, M.H., Takahashi, J.S.& Turek, F.W. (2001). Overview of Circadian Rhythms. *Alcohol Research & Health*, 25(2), pp 85-93.

Wesensten, N., Belenky, G., Kautz, M.A., Thorne, D.R., Reichardt, R.M. & Balkin, T.J. (2002). Maintaining Alertness and Performance During Sleep Deprivation: Modafinil Versus Caffeine. *Psychopharmacology*, 159(3), pp 238-247.