DIURNAL PREFERENCES AND SCHOOL ACHIEVEMENT IN SECONDARY SCHOOL PUPILS

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doi: 10.18355/PG.2024.13.2.3

Abstract
Diurnal preferences, also known as chronotypes, are individual differences in biological rhythms that influence physical and mental activity during certain parts of the day. This study investigates the relationship between diurnal preferences and school achievement in students in vocational engineering subjects, with a focus on the practical implications for educational strategies. The research population comprised 209 (100%) pupils from a vocational engineering school. We identified chronotypes (morning, evening and neutral chronotypes) using the Morning and Evening Types Questionnaire - The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976). We assessed school achievement (study results) by the arithmetic mean of school grades in vocational engineering subjects. The results showed that pupils with the morning chronotype performed significantly better in school achievement than those with the evening chronotype ($p = 0.015$). These findings underscore the need to consider individual biological rhythms in educational strategies.

Key words
diurnal preferences, chronotypes (morning chronotype, evening chronotype, neutral chronotype), school achievement (study results), vocational engineering subjects, pupils

Introduction

Diurnal preferences refer to an individual's tendency to be more physically and mentally active at certain times of the day. These preferences, also referred to as biorhythms, are often biologically rooted. They represent fluctuations or cyclical changes in biological processes. They occur with varying but regular frequency and persist or flow freely even when organisms live in a stable environment without external time signals after all external environmental input has been removed, such as a person in a cave or isolated bunker (Plháková, 2013; Pollak, Thorpy, & Yager, 2010; Illnerová & Sumová, 2008). These preferences are related to circadian rhythms - the basic and most well-known rhythms with a period $\tau = 24$ hours (Plháková, 2013; Atkinson, Atkinson, Smith et al., 2003). In vocational engineering courses that emphasise specific technical skills or knowledge needed for particular occupations or fields, it is crucial to understand how these preferences relate to school achievement.

Diurnal preferences

People differ in when they naturally tend to get up and go to sleep if circumstances allow and when they reach their peak performance during the

day. This preference determines whether a person is more of a „morning“ or „evening“ chronotype, which is technically referred to as a diurnal preference or chronotype (Di Milia, 2005; Carrier, Monk, 2000). Breus (2017) defines diurnal preferences as diurnal fluctuations in the body that involve cyclical changes in hormone and enzyme levels and variations in the cardiovascular system over 24 hours. Malá (2017) states that diurnal preferences represent the preferred time of day for optimal performance. It is a relatively stable behavioural characteristic dependent on intrinsic (circadian hours, gender and age) and extrinsic factors (e.g. amount of exposure to daylight). Previous research by Wojtachnio (2022), Merikanto, Kantojärvi, Partonen et al. (2021), Yamazaki, Goel (2020), Turco, Biscontin, Corrias et al. (2017), Carpen, von Schantz, Smits et al. (2006) suggest that differences between chronotypes are in part determined mainly by polymorphisms in gene hours, which affect their stability, binding properties, and hence endogenous period length. Tankova, Adan, and Buela-Casal (1994) observed that the human chronotype may change to some extent with age. Children usually have an early chronotype; in puberty and adolescence, on the other hand, the chronotype is delayed (shifts towards the evening chronotype); around the age of 20, in most, but not all individuals, it again begins to transition and shift towards the neutral or early chronotype. This trend continues for the rest of life, making early morning preferences predominant among adults and seniors (Tankova, Adan, & Buela-Casal, 1994; Kerkhof, 1985). One reason for the shift towards an early chronotype and more significant sleep fragmentation in older people may be that the eye's sensitivity to light deteriorates during the ageing process, leading to greater desynchronisation of rhythms (Duffy, Dijk, Hall et al., 1999). Research by Adan, Natale (2002) shows that, in general, the morning chronotype occurs more frequently in girls and the evening chronotype in boys. They dealt with intersex differences in the biological synchronisers in the form of sex hormones. Other research, such as Preckel, Fischbach, Scherrer et al. (2020) and Randler, Frech (2009), report that they did not find any sex differences in the morning or evening chronotype frequency. Chronotype is also related to the relationship with physical activity and its timing, diet and overall sleep hygiene (Janečková, Dostál, Plháková, 2013).

Some associations between diurnal preferences and school achievement

School success and failure (school performance, achievement) reflect how much a pupil can engage in the learning process and how effectively he or she can develop personal skills within the school environment. We speak of school success when a pupil's school performance meets the expectations of the teacher or the school system. In case the pupil's school performance does not meet these expectations or does not reflect his/her actual capabilities and abilities, we speak of school failure (Malá, 2017; Urbanovská, Škobrtal, 2012; Průcha, Walterová, Mareš, 2009; Vágnerová, Klégrová, 2005; Čáp, Mareš, 2001; Gajdošová, 1998; Hvozdík, 1986). The key indicator of a pupil's school success or failure is his/her school achievement (the arithmetic mean of all school grades), while the quality of acquired knowledge and skills is measured using an assessment system based on a five-grade scale

(Urbanovská, Škobrtal, 2012; Vágnerová, 2001; Čáp, Mareš, 2001; Kusák, Dařílek, 2001). School achievement in the context of diurnal preferences (Jedlička, Koťa, & Slavik, 2018; Randler, Nafital, 2016; Escribano, Díaz-Morales, Delgado et al., 2012; Mateo, Díaz-Morales, Barreno et al., 2012; Randler, Frech, 2009; Šimečková, Skočovský, Mareš, 2003; Giannotti, Cortesi, Ottaviano, 1997) represents a complex phenomenon, which is influenced by various determinants such as the level of aspirations, the performance motivation of the pupil, his/her personal characteristics and health condition, the social environment, the educational practices, and the dynamics of the pupil-teacher relationship.

Studies by Mareš (2013), Roenneberg, Wirz-Justice, and Merrow (2003) have given some attention to the relationship between diurnal preferences, sleep duration, time of day, and school achievement, reflecting the fact that late diurnal preferences are tested before they reach their peak school achievement. The effect of diurnal preferences on school achievement is early in the morning and negligible in the early afternoon. The morning chronotype tends to perform better in the morning, while the evening chronotype performs better in the evening (Černák, 2009). Werner, Lebourgeois, Geiger et al. (2012) found no significant difference in school achievement between the morning and evening chronotypes in the afternoon. A possible explanation for the poorer school achievement in late diurnal preferences is that chronic sleep deprivation impairs cognitive abilities (Zucconi, Ferri, 2014). Pupils who prefer evening hours for their activity face disadvantages during early morning exams compared to those organised later in the day.

Also suggestive are the findings of Ferrante, Goldin, Sigman et al. (2023), Goldin, Sigman, Braier et al. (2020), Preckel, Fischbach, Scherrer et al. (2020), Cole (2014), Díaz-Morales, Escribano (2013), Beşoluk (2011), Callan (2010), and Randler, Frech (2006) that school achievement is related to chronotype, with better school performance for students with an early preference. Also, experimental studies by Ďuríková, Sarmány-Schuller (2014), Škorvagová, Sarmány-Schuller (2005) focused on the differences between morning and evening chronotypes in the context of their school achievement. Both studies report that the evening chronotype tends to perform worse on memory tests in the early morning. In contrast, the morning chronotype experiences a decline in school performance in the evening. Pupils with a morning preference reported learning more efficiently but forgetting more quickly. The results of these studies, along with research by Ferrante, Goldin, Sigman et al. (2023), Škorvagová (2020), and Škorvagová (2017), point to associations between diurnal preferences and pupils' school achievement. Research (Ďuríková, Sarmány-Schuller, 2014; Škorvagová, Sarmány-Schuller, 2005) on diurnal preferences and their relation to school achievement is gaining importance in the context of education and highlights the need to take diurnal preferences into account when developing educational strategies and school timetables in order to better adapt the learning environment to the individual needs of pupils.

The aim of the research

In our research, we sought to investigate how diurnal preferences are related

to school achievement in vocational engineering subjects.

Theoretical basis

1. Diurnal preferences
   Diurnal preferences describe an individual tendency to be more physically and mentally active during specific times of the day. These preferences are often biologically rooted and related to circadian rhythms.
2. Vocational subjects
   Vocational subjects focus on specific technical skills or knowledge needed for a particular profession or discipline.

Methods

The research population consisted of 209 (100%) students in the first and second year of the Secondary Vocational School of Mechanical Engineering in Kysucké Nové Mesto with an average age of 16 to 17 years. We assessed their diurnal preferences using The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976), which consists of 19 items related to diurnal situations and preferences, such as waking and sleeping times, subjective perceptions of alertness and performance at different times of the day, and time preferences when performing mentally demanding tasks. Based on total scores, we divided participants into three main categories: morning chronotype (59-86 points), evening chronotype (16-30 points), and neutral chronotype (31-41 points). The questionnaire of morning and evening types called the Morningness-Eveningness Questionnaire (MEQ) by Horne and Östberg (1976) was translated and validated by Fiala, Klepáč (1988) and Skočovský (2003). The test's internal consistency is high: Cronbach's alpha coefficient is 0.86 (Skočovský, 2003). Adjusted item-to-item correlations ranged from 0.20 to 0.74 (Skočovský, 2003). In the research by Škorvagová (2020), the summative index had acceptable internal consistency, with a Cronbach's alpha coefficient of 0.734. School achievement data were obtained from the school information system and reflected the arithmetic mean of school grades in all vocational engineering subjects.

Results

a) Types of diurnal preferences

Based on an analysis of the Morning and Evening Types Questionnaire - The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976), we found the following distribution of diurnal preferences among the 209 participants in our study. We present the results in Table 1.

Table 1 Distribution of chronotypes by diurnal preference

Types	n	%
Morning chronotype	99	47.40
Evening chronotype	73	34.90
Neutral chronotype	37	17.70
Total	209	100.0

Legend: n = number of participants, % = percentage of participants

b) The association of school achievement with diurnal preferences

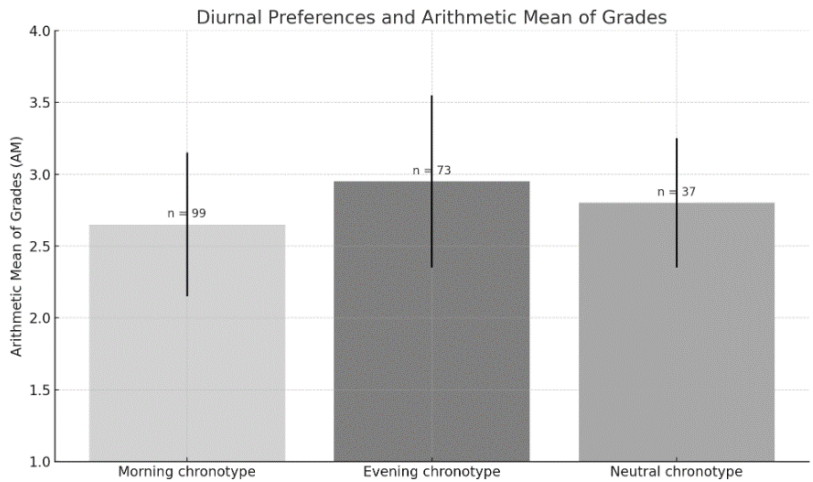
In the next part of our analysis, we examine the possible relationship between students' diurnal preferences and their academic achievement in vocational engineering subjects. Table 2 and Chart 1 overview the observed correlations between diurnal preferences and school performance.

Table 2 Diurnal preferences and average school grades in vocational engineering subjects

Diurnal preferences	n	AM	SD
Morning chronotype	99	2.65	0.50
Evening chronotype	73	2.95	0.60
Neutral chronotype	37	2.80	0.45

Legend: n = number of participants, AM = arithmetic mean of school grades in vocational engineering subjects, SD = standard deviations of morning, evening and neutral chronotype

Chart 1 Average school grades in vocational engineering subjects by diurnal preference



The morning chronotype (n = 99) achieves an average school achievement (AM) of 2.65 with a standard deviation (SD) of 0.50. The evening chronotype (n = 73) has an average school achievement (AM) of 2.95 with a standard deviation (SD) of 0.60. The neutral chronotype (n = 37) has an average school achievement (AM) of 2.80 with a standard deviation (SD) of 0.45.

The arithmetic mean of school grades indicates that the morning chronotype has, on average, better school grades in vocational engineering subjects than the evening and neutral chronotypes. The evening chronotype has the worst average school grades. The morning chronotype has slightly lower variability (SD = 0.50) than the evening chronotype (SD = 0.60), indicating that school grades are more consistent than the grades of the evening chronotype

students. The neutral chronotype has the lowest variability (SD = 0.45). The data suggest that diurnal preferences may be related to school achievement in vocational engineering subjects. The morning chronotype achieves better school grade point averages and has relatively more consistent results than the evening and neutral chronotypes. These findings may be crucial for educational strategies and tailoring instruction according to individual student chronotypes.

The next step was to compare the mean school grades in vocational engineering subjects between the different chronotypes of diurnal preferences, using an ANOVA test (analysis of variance) in our analysis (Table 3).

Table 3 ANOVA test results

Source of variation	SS	df	MS	F	p-value
Between groups	0.0933	2	0.04665	3.789	0.024
Inside the groups	2.7867	207	0.01346	-	-
Total	2.88	209	-	-	-

Legend: SS = sum of squares (a measure of the total variation in the data), df = degrees of freedom, MS = mean sum of squares, F = ratio between the variation in the data between groups and the variation in the data inside the groups, p-value = probability

The differences in school achievement in vocational engineering subjects between diurnal preferences are statistically significant. We conducted the post-hoc analysis results using Tukey's HSD test to compare the school grade point averages between each pair of diurnal preferences, and we summarised them in Table 4 below.

Table 4 Results of post-hoc analysis between diurnal preferences

Comparison of groups	Difference in averages	p-value
Morning chronotype vs. evening chronotype	+0.30	0.015
Morning chronotype vs. neutral chronotype	+0.15	0.200
Evening chronotype vs. neutral chronotype	-0.15	0.180

Legend: p-value = probability

The difference in mean school grades between the morning and evening chronotype is +0.30, with p = 0.015, indicating that the morning chronotype performs better than the evening chronotype.

The difference between the early chronotype and the neutral chronotype is +0.15, with a p-value = 0.200, indicating that this difference in school grades is not statistically significant and is probably not significant.

The difference in mean school grades between the evening and neutral chronotypes is -0.15, with p = 0.180. This difference is not statistically significant.
The analysis's results suggest that diurnal preferences are related to pupils' academic achievement in vocational engineering subjects, with the most pronounced difference observed between the morning and evening chronotypes.

Discussion

As part of the study, we analysed the association between students' diurnal preferences and their school achievement in vocational engineering subjects. The research used data obtained from The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976), which allowed us to categorise participants into groups according to their preference for activity at different times of the day - morning chronotype, evening chronotype and neutral chronotype. The aim was to investigate how these biologically determined predispositions relate to school achievement. We found that diurnal preferences are significantly related to school achievement. In our analysis, using the ANOVA test and post-hoc analysis of Tukey's HSD test, we found statistically significant differences in school achievement between the morning and evening chronotypes, with the morning chronotype showing better school achievement than the evening chronotype. Ďuríková, Sarmány-Schuller (2014) reported similar findings. They highlighted the chronopsychological aspects of learning and pointed out that diurnal preferences can significantly influence pupils' school achievement. This correlation with our findings supports the argument that diurnal preferences represent a significant factor in the educational process. These findings highlight the importance of considering students' diurnal preferences when planning school activities and suggest that traditional morning starts to the school day may promote the school achievement of the morning chronotype. Adapting their schedules concerning diurnal preferences resonates with the suggestions of Horne, Östberg (1975). Integrating our findings with these theoretical underpinnings provides an impetus for adapting educational strategies to be consistent with students' natural preferences. In the context of school achievement, Preckel, Fischbach, Scherrer et al. (2020), Tonetti, Natale, and Randler (2015), Vollmer, Pötsch, and Randler (2013), and Randler and Frech (2009) found that the morning chronotype tends to have better school achievement. Kelly and Lee (2014) report that traditional early school day starts may be more beneficial for the morning chronotype and support moving the start of the school day to a later time to meet better the needs of all students, especially those with the evening chronotype. Findings from research by Roenneberg, Wirz-Justice, and Merrow (2003) on the epidemiology of human circadian rhythms suggest that synchronisation of biological hours with the external environment, including the school schedule, is crucial for optimal mental and physical performance. These findings reiterate the need for schools to consider more flexible school day arrangements that allow students to tailor their school activities to their natural time preferences. Our findings also suggest that pupils without a

strong preference for morning or evening hours perform steadily regardless of the time of day. This finding may have implications for designing flexible and inclusive educational strategies that respect pupils' diurnal preferences. Goldstein, Brooks (2024), Scherrer, Preckel (2021), Vollmer, Pötsch, Randler (2013), Preckel, Lipnevich, Boehme et al. (2012), Randler, Frech (2009), van Dongen, Dinges (2000) emphasise that different chronotypes may have different optimal times for learning and school performance. Flexibility in school scheduling may be vital to optimising their school performance for a neutral chronotype that does not show a strong preference for morning or evening hours. Kelly, Lee (2014) again argue for shifting the start of school days to later times to better accommodate the needs of the evening chronotype. In the context of our findings, the neutrality of diurnal preferences provides suggestive insights into the need for broader educational approaches. Malá (2017), who examined the impact of diurnal preferences on school achievement and motivation, thinks that school systems should consider accommodating extreme chronotypes and those who fall into the neutral chronotype category.

Current research has several methodological and analytical limitations affecting its interpretation and applicability. One of the main methodological limitations is the scaling and categorisation of participants based on the Morning and Evening Type Questionnaire - The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976). This questionnaire categorises participants according to their responses, which can lead to subjective biases. Different individual interpretations of the questions may affect the categorisation accuracy into morning, evening, and neutral chronotypes. Another significant limitation is the variability of the research population. We researched a specific population of students, which may limit the generalizability of the findings. Regional and cultural differences may affect the results and their applicability to a broader population. Analytical limitations include the use of statistical tests. Although ANOVA and post-hoc Tukey's HSD tests identified significant differences, it was not possible to establish a causal relationship between diurnal preferences and school achievement. Also, the corresponding factors in diurnal preferences, such as lifestyle, sleep habits, and family environment, and in school achievement, such as learning styles, cognitive abilities, teaching methods, and others, were not adequately controlled. In addition, the reliability and validity of the instruments used, such as the Morning and Evening Types Questionnaire-The Morningness-Eveningness Questionnaire (MEQ) (Horne, Östberg, 1976), to determine school achievement based on a single indicator, may be questionable if they are not regularly validated and updated according to current standards of psychometric research. The results suggest adapting school activities based on students' diurnal preferences. Schools might consider flexible school starts or offering different blocks of time for different chronotypes of pupils. The findings support implementing diversified educational strategies that would reflect pupils' biological rhythms and thus optimise their school performance. In the future, it would be advisable to research a more extensive and diverse research population to ensure greater generalizability of the findings. Also, longitudinal studies and

causal research plans could provide a deeper understanding of the relationship between diurnal preferences and school achievement and allow for the identification of causal relationships. This research provides insights into the relationship between diurnal preferences and school achievement. However, further research is needed to confirm and extend these findings.

Conclusion

Research on diurnal preferences and their relation to school achievement in vocational engineering subjects has yielded several findings. Based on data from 209 (100%) students, diurnal preferences are statistically significantly related to school achievement. The morning chronotype pupils performed better than the evening chronotype, while the neutral chronotype showed stable performance regardless of the time of day. These findings highlight the need to adapt school timetables and learning strategies to reflect pupils' diurnal preferences and promote optimal school achievement for all chronotypes. Further research works on more extensive and diverse population samples, and longitudinal studies are needed to validate and extend our findings. This research represents a step towards integrating chronobiological aspects into the educational process, which may lead to an awareness of the need to adapt school systems to the needs of pupils.

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