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Effect of circadian rhythm on decayed, missing, filled teeth index and endodontic treatment

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Purpose: This study aimed to investigate the association between individuals' circadian typology and oral health status, as measured by the Decayed, Missing, and Filled Teeth (DMFT) index, as well as the prevalence of endodontic treatment.

Methods: Chronotypes were determined using the Morningness-Eveningness Questionnaire, which was administered through face-to-face interviews. The questionnaire comprised 26 items and was completed by 349 participants. In addition, each participant's oral health status was evaluated by recording their DMFT index and the presence of endodontically treated teeth through clinical examination and dental records. Statistical analyses of continuous variables, including means and standard deviations, were conducted using chi-square and analysis of variance tests. A p-value of <0.05 was considered to indicate statistical significance.

Results: No statistically significant differences were observed among the three chronotype groups (morning-, intermediate-, and evening-types) regarding the mean number of endodontically treated teeth (p>0.05). However, a significant difference in DMFT scores was found across the chronotype groups (p<0.05), with the lowest values observed in morning-types (4.14±1.952) and the highest in evening-types (5.48±2.686).

Conclusion: The results suggested that circadian rhythm may influence oral health status. Specifically, individuals with an evening-types appear to exhibit a greater predisposition to dental caries, which may increase their risk of requiring endodontic treatment if caries remain untreated.

Keywords: Circadian rhythm; DMFT index; endodontics.

Introduction

Circadian rhythm refers to the biochemical, physiological, and behavioural changes following a 24-hour cycle. The term "circadian" originates from the Latin words circa, meaning "approximately", and diem, meaning "a day" (1,2). Circadian rhythms are crucial in regulating a wide range of physiological processes, including the sleep-wake cycle, hunger and satiety, and the functions of various systems such as the endocrine, gastrointestinal, immune, respiratory, cardiovascular, and metabolic systems (3). This biological clock is governed by the suprachiasmatic nu-

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cleus in the brain and is influenced by external cues such as light and darkness (4), which in turn affect melatonin secretion (5).

Melatonin is secreted by the pineal gland, the smallest endocrine gland in the human body (6). Being sensitive to light, melatonin reaches its peak secretion levels between 2:00 and 4:00 a.m. in humans. In adults, melatonin secretion typically begins between 9:00 and 10:00 p.m. and subsides between 7:00 and 9:00 a.m. (7). A decrease in melatonin levels is associated with a reduction in antioxidant activity, which results in increased production of reactive oxygen species (ROS) in saliva (8). Elevated levels of ROS in saliva contribute to the development of dental caries (9). Since melatonin is a circadian hormone, the relationship between circadian rhythm and the formation of dental caries is evident (4).

Dental caries is a prevalent and non-communicable condition that, according to the World Health Organization, affects approximately 2.3 billion individuals worldwide, corresponding to 32% of the global population (10). The pathogenesis of dental caries is primarily driven by the metabolic activity of cariogenic bacteria, which ferment dietary sugars and carbohydrates, leading to a decreased intraoral pH and subsequent demineralization of dental hard tissues over time (11,12).

Multiple studies suggest that poor sleep quality and insufficient sleep are linked to greater dental caries experience, as indicated by higher decayed–missing–filled teeth (DMFT) scores (13,14). Short sleep duration activates the sympathetic nervous system and compromises immune function, exacerbating the host's vulnerability to bacterial infections, including dental caries (15). Moreover, reduced salivary flow, commonly observed with sleep deprivation, diminishes the oral cavity's capacity to buffer acids and facilitate the remineralization of enamel (16,17). Conversely, excessive sleep duration may disrupt the circadian regulation of salivary secretion, potentially altering the composition of the oral microbiome and contributing to increased caries risk (18).

Chronotype refers to an individual's genetically influenced predisposition towards preferred sleep-wake patterns (19). Chronotypes are typically classified into three categories: Morning-, intermediate-, and evening-types. Morning-types tend to wake early and feel most alert during the early hours of the day, whereas evening-types prefer staying awake until late at night and often require an alarm to wake during the late morning or early afternoon. Intermediate-types exhibit no strong inclination towards either extreme, generally falling between them (20).

Individuals with an evening chronotype are more likely to exhibit irregular sleep schedules, which can contribute to a reduced salivary flow (21). Furthermore, evening-types are more prone to unhealthy lifestyle behaviours—such as missing breakfast, brushing their teeth less frequently, and late-night eating—which collectively contribute to poorer oral hygiene compared to morning-types (22,23).

The Decayed, Missing, and Filled Teeth (DMFT) index is calculated by quantifying the number of teeth in an individual's mouth that are decayed, missing due to caries, or filled due to previous carious lesions (24). Higher DMFT scores have been associated with poor sleeping reports due to the influence of inadequate sleep on immune system function, which can impair the body's ability to effectively combat cariogenic bacteria (13,14,25).

The null hypothesis of this study was that there is no significant difference in DMFT index and number of endodontically treated teeth among the individuals with different circadian rhythm. Therefore, the present study was aimed to investigate the association between individuals' circadian typology and oral and endodontic health status.

Materials and Methods

This cross-sectional study was conducted at the Bezmialem Vakif University between June and September 2021. The study was approved by the Ethics Committee of Bezmialem Vakif University (Date: 22/10/2019, No: 20/374) and conducted according to the Helsinki Declaration. A power analysis was conducted using the program package G*Power 3.1.2 (University of Duesseldorf, Duesseldorf, Germany), with an alpha level of 0.05 and a power of 0.80. The effect size was determined based on previous studies (2,23), and results indicated that a minimum of 208 respondents was required.

A total of 349 participants, aged 18 years or older, who were systemically healthy, aware of their sleep patterns, and knowledgeable about their oral treatments, completed a structured questionnaire comprising 26 items. The first seven questions collected demographic data (e.g., age, gender) and information related to the DMFT index, as well as the number of teeth that had undergone or required endodontic treatment.

The Morningness-Eveningness Questionnaire, originally developed by Horne and Östberg in 1976, was used to assess chronotype (26). This instrument comprises 19 Likert-type items designed to categorize individuals into morning-, intermediate-, or evening-type chronotypes. All questionnaires were administered via face-to-face interviews.

Clinical examinations were performed by an endodontist with 5 years of clinical experience to determine participants' DMFT scores and the number of teeth that had received or required endodontic treatment. The presence of endodontic treatment was assessed through intraoral clinical examination and radiographic evaluation.

Statistical Analysis

The data obtained were analyzed using SPSS version 22 (IBM, Armonk, NY, USA). Descriptive statistics (mean and standard deviation) were computed for continuous variables. Chi-square and analysis of variance (ANOVA) tests were used to assess statistical associations. For parameters showing significant differences in ANOVA, the Tukey HSD post hoc test was applied. A significance level of $p<0.05$ was considered statistically significant.

Results

On examining the distribution of participants across the chronotype groups, it was determined that the evening-type group comprised 117 (33.5%), the morning-type group 84 (24.1%), and the intermediate-type group 148 (42.4%) participants.

Statistical analysis revealed no significant differences in age across the three chronotype groups ($p=0.174$). The groups' age distributions, based on minimum and maximum values, were comparable, and the mean ages were also closely aligned across the groups. However, the morning-type group had a lower mean age than the other two groups (Table 1).

Statistical analysis revealed a significant difference in DMFT values between the three chronotype groups ($p=0.001$). The morning-type group exhibited the lowest DMFT score, while the evening-type group had the highest (Table 2).

No statistically significant differences were found in the average number of teeth with endodontic treatment between the three chronotype groups ($p=0.173$). The minimum and maximum values for the number of teeth with endodontic treatment were similar in all three groups, and the mean values were also closely aligned. However, the morning-type group had a lower average number of teeth with endodontic treatment than the other two groups (Table 3).

Table 1. Age distribution across chronotype groups (One-Way ANOVA)

Chronotype	N	Mean Age (Years)	Standard Deviation (SD)	Min Age	Max Age	p
Evening-type	117	33.03	11.951	18	63	0.174
Morning-type	84	29.99	10.801	19	64	
Intermediate-type	148	32.12	11.430	18	65	
Total	349	31.91	11.487	18	65	

($p<0.05$).

Table 2. Comparison of mean DMFT values across chronotype groups (One-Way ANOVA with Tukey HSD post hoc test)

Chronotype	N	Mean DMFT	Standard Deviation (SD)	Min DMFT	Max DMFT	p
Evening-type	117	5.48A	2.686	0	13	0.001
Morning-type	84	4.14B	1.952	1	10	
Intermediate-type	148	5.09C	2.393	0	13	
Total	349	4.99	2.448	0	13	

Groups labelled with different letters (A, B, C) differ significantly from each other according to Tukey HSD post hoc test ($p<0.05$).

Table 3. Comparison of mean number of endodontically treated teeth across chronotype groups (One-Way ANOVA)

Chronotype	N	Mean Number of Endodontically Treated Teeth	Standard Deviation (SD)	Min	Max	p
Evening-type	117	1.62	1.639	0	9	0.173
Morning-type	84	1.23	1.365	0	8	
Intermediate-type	148	1.53	1.445	0	7	
Total	349	1.48	1.498	0	9	

($p<0.05$)

Table 4. Comparison of gender distributions by chronotype (Chi-Square Test)

		Gender		χ2	p
		Female	Male		
Chronotype					
Evening-type	n (%)	58 (49.6%)	59 (50.4%)	0.635	0.728
Morning-type	n (%)	42 (50.0%)	42 (50.0%)		
Intermediate-type	n (%)	80 (54.1%)	68 (45.9%)		
Total	n (%)	180 (51.6%)	169 (48.4%)		

(p<0.05).

No statistically significant differences were found in the gender distribution between the three chronotype groups (p=0.728). No significant differences were observed in the distribution of male and female participants across the three groups (Table 4).

Discussion

It is well-established that individuals with different chronotypes exhibit varying levels of saliva production (21). Roestamadji et al. (27) noted that sleep deprivation increases cortisol secretion, leading to a decrease in saliva pH levels. In turn, this heightens susceptibility to dental caries. The present study focused the association between individuals' chronotypes and their dental-endodontic status and an increased risk of dental caries was observed in individuals with an evening chronotype. Notably, individuals in the morning chronotype group showed lower DMFT scores and fewer endodontically treated teeth, while the evening chronotype group exhibited higher values. Research has demonstrated that sleep deprivation places stress on the sympathetic nervous system, which alters the acidity and buffering capacity of saliva, presenting a risk factor for dental caries. These findings further emphasize the significant impact of sleep patterns on oral health (15).

Studies have shown a relationship between sleep deprivation of children and an increase in the number of S. mutans colonies in saliva (28-30). This finding suggests that sleep patterns may significantly impact children's oral health. An increased risk of dental caries in primary and permanent teeth was observed in Japanese children who stayed awake until late (29). The present study found that the morning chronotype group was associated with better oral health. In conclusion, the observation that sleep patterns play an important role in oral health, and that morning chronotypes may have better dental health, is consistent with the study by Arvidsson et al. (28).

In the present study, significant differences in DMFT values were found among the groups, with the evening chronotype group showing higher DMFT values than the morning and intermediate chronotype groups. This result suggested that the increased bacterial growth in the mouth overnight may elevate the risk of dental caries. The higher DMFT values in the evening chronotype group may reflect the effects of sleep deprivation and the increased bacterial colonization in the mouth during the night. In conclusion, the relationship between DMFT values and sleep patterns indicates that sleep deprivation may negatively affect oral health and increase the risk of dental caries. The null hypothesis was rejected.

Research by Sardana et al. (31) indicated that sleep deprivation weakens the immune system, increasing bacterial growth in the mouth, which could lead to caries formation. The lower DMFT values observed in the morning chronotype group in the present study supported the concept that regular sleep habits may help maintain oral health. Therefore, further research is required to better understand the relationship between sleep patterns and dental caries.

Based on the findings of Gaeta et al. (32), poor sleep quality is strongly associated with the development of apical periodontitis (AP), and insufficient sleep increases the risk of AP development. Similarly, it has been reported that the DMFT index is positively correlated with AP. These results suggested that sleep quality and DMFT values are important factors affecting oral health when considered together (32). In the present study, the lower DMFT values in the morning chronotype group suggest that sleep habits may directly impact oral health. Although no statistically significant difference was found between the chronotype groups regarding the number of teeth requiring endodontic treatment (p>0.05), this number was lower in the morning chronotype group. The similar distribution of individuals with endodontically treated teeth across the three groups may be explained by a tendency to prefer tooth extraction over root canal treatment due to various economic and social factors.

In our study, a statistically significant difference in DMFT indices was found between the chronotype groups, with the lowest value observed in the morning chronotype group and the highest in the evening chronotype group. However, no significant difference was found between the groups regarding the number of teeth requiring endodontic treatment. This finding may stem from the differences in the scope and clinical significance of the two parameters. The DMFT index is a comprehensive oral health indicator that includes decayed, missing, and filled teeth and provides a holistic view of an individual's overall dental health status. However, endodontic treatment represents a more limited clinical condition, typically involving severely decayed lesions that have affected the pulp. Therefore, while the prevalence of caries and treatment history may vary among individuals, this does not always result in the need for endodontic treatment. Additionally, the decision to perform endodontic treatment depends on not only clinical findings but also factors such as access to healthcare, treatment attitudes, physician preferences, and economic conditions. In this context, the notable differences observed in the DMFT index suggest that morning chronotype individuals may have more regular oral hygiene habits and preventive health behaviours. However, the fact that the need for endodontic treatment is less affected by these habits may have prevented the inter-group differences from becoming statistically significant.

A strength of the present study is that only systemically healthy individuals were included, which reduced potential confounding factors and increased the internal validity of the results. Systemic diseases such as diabetes mellitus, cardiovascular disorders, and immunosuppressive conditions have been shown to negatively affect oral health by elevating DMFT scores, increasing the risk of apical periodontitis, and compromising endodontic treatment outcomes (e.g., higher DMFT in diabetic patients, and lower RCT success in diabetics) (33–37). By excluding individuals with such conditions, the observed associations between chronotype and oral health parameters in this study are less likely to have been influenced by these systemic factors, thereby enhancing the study's internal validity.

This study has several limitations. It did not consider other significant factors that could affect oral health, such as dietary habits, smoking, and stress, which may have influenced the results. Another limitation is that the relationship between endodontic treatment and circadian rhythm was assessed solely based on the number of teeth requiring endodontic treatment or those that had already undergone treatment. Future studies could investigate the effects of circadian rhythm on AP.

Conclusion

Within the limitations of this study, it has been determined that circadian rhythm affects oral health. Individuals with an evening chronotype are more prone to dental caries. Therefore, it is recommended that these individuals pay more attention to their oral hygiene and undergo regular dental check-ups.

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