A Study on Knowledge of how circadian rhythm (Sleep Wake Cycle) influences oral defence and periodontal health Among Dental Professionals

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Abstract

Background: Circadian rhythm plays a crucial role in regulating immune function and inflammatory responses, which are fundamental to oral defence and periodontal health. Disruption of the sleep–wake cycle has been increasingly implicated as a risk factor for periodontal disease; however, awareness among dental professionals remains unclear.

Methods: A descriptive cross-sectional, questionnaire-based survey was conducted among 150 dental students and practitioners in Chennai using a pre-validated structured questionnaire. Data were collected electronically and analysed descriptively, with results expressed as frequencies and percentages.

Results: Overall, 86% were aware of the association between sleep and oral health, and 93.33% reported curricular exposure to circadian rhythm concepts. Nearly half (45.33%) experienced gingival bleeding during periods of poor sleep. A strong majority (86.67%) agreed that sleep quality influences immunity.

Conclusion: The study demonstrates good awareness regarding circadian rhythm and periodontal health, though experiential gaps persist. Integrating chrono dentistry concepts into dental education and practice may strengthen preventive oral healthcare.

Keywords: Circadian rhythm; Sleep–wake cycle; Periodontal health; Oral defence; Chrono dentistry

Introduction

Circadian rhythm refers to the endogenous, approximately 24-hour biological cycle that regulates a wide range of physiological and behavioural processes, including the sleep–wake cycle, hormone secretion, metabolism, immune function, and cellular repair mechanisms[1].These rhythms are primarily governed by a central biological clock located in the suprachiasmatic nucleus of the hypothalamus and are synchronized with environmental cues such as light, food intake, and physical activity[2].In recent years, growing scientific interest has highlighted the pivotal role of circadian rhythm in maintaining systemic health, with disturbances in this tightly regulated cycle being associated with metabolic disorders, cardiovascular diseases, impaired immunity, and chronic inflammatory conditions[3].

Oral health, particularly periodontal health, is increasingly recognized as being influenced by circadian regulation. The oral cavity is continuously exposed to microbial challenges, and its defence depends on a dynamic balance between host immune responses, saliva secretion, epithelial turnover, and inflammatory regulation[4]. These protective mechanisms are not static but exhibit circadian variation. Salivary flow rate, composition, antimicrobial peptide secretion, gingival crevicular fluid flow, and immune cell activity fluctuate across the day, contributing to time-dependent changes in oral defence. Disruption of circadian rhythm,

therefore, has the potential to compromise these protective functions, rendering periodontal tissues more susceptible to inflammation and disease[5].

Periodontal disease is a chronic inflammatory condition initiated by dysbiotic dental plaque biofilms and modulated by the host immune response. Increasing evidence suggests that circadian misalignment can exacerbate periodontal inflammation by altering immune surveillance, increasing oxidative stress, and dysregulating inflammatory mediators. At the molecular level, clock genes such as BMAL1, CLOCK, PER, and CRY play essential roles in regulating immune homeostasis and inflammatory pathways within periodontal tissues[3]. Dysregulation of these genes due to poor sleep quality, irregular sleep–wake patterns, or shift work has been linked to enhanced periodontal tissue breakdown and delayed healing responses[5].

Sleep disturbances, including short sleep duration, poor sleep quality, and conditions such as obstructive sleep apnea, have been identified as emerging risk factors for periodontal disease. Individuals with chronic sleep deprivation often exhibit impaired immune responses, elevated pro-inflammatory cytokine levels, and reduced tissue repair capacity, all of which contribute to periodontal breakdown [6]. Occupational factors such as night-shift or rotating-shift work further exacerbate circadian disruption and have been associated with a higher prevalence and severity of periodontitis. Despite this growing body of evidence, awareness of the relationship between sleep, circadian rhythm, and oral health remains inconsistent, particularly among dental students and practitioners [7].

The present study was undertaken to assess the knowledge and awareness regarding the influence of circadian rhythm (sleep–wake cycle) on oral defence and periodontal health among dental professionals in Chennai.

Materials and methods

A descriptive cross-sectional, questionnaire-based survey was conducted to assess knowledge regarding the influence of circadian rhythm (sleep–wake cycle) on oral defence mechanisms and periodontal health. The study comprised a sample of 150 participants recruited from Chennai. Data were collected using a pre-validated, structured questionnaire developed to capture comprehensive information across multiple domains, including demographic characteristics and knowledge-related parameters.

The survey was administered electronically via Google Forms to enhance accessibility and maximize response rates. Prior to participation, all respondents were clearly informed about the aim of the study, assured of confidentiality and anonymity, and notified that participation was completely voluntary, in adherence to standard ethical research guidelines. The collected data were systematically entered into Microsoft Excel and analysed using descriptive statistical methods, with results expressed as frequencies and percentages. The findings were subsequently presented through appropriate tables and graphical representations to facilitate clarity and ease of interpretation.

Results

A total of 150 participants were included in the study, providing a comprehensive overview of knowledge, awareness, and perceptions regarding the influence of circadian rhythm (sleep–wake cycle) on oral defence mechanisms and periodontal health. The study population showed a female predominance (63.33%), while 36.67% of respondents were male. With respect to age distribution, the largest proportion of participants belonged to the 26–30 years age group (36.0%), followed closely by those aged 20–25 years (34.0%). Participants aged more than 30 years constituted 25.33%, whereas a smaller fraction (4.67%) were below 20 years of age[Fig 2].Regarding professional status, the respondents were almost evenly distributed, with postgraduates forming 34.0%, undergraduates 33.33%, and dental practitioners 32.67%, ensuring balanced representation across different stages of professional training and practice[Fig3].A notably high proportion of participants (93.33%) reported that they had learnt about circadian rhythm as part of their curriculum, while only 6.67% indicated no formal curricular exposure[Fig 4]. In line with this, 86.0% of respondents were aware of the link between sleep and oral health, whereas 14.0% lacked such awareness, highlighting a generally good foundational knowledge but with identifiable gaps[Fig 5].

When assessing perceived clinical experiences, 45.33% of participants reported having experienced gum bleeding during periods of poor sleep, suggesting a substantial proportion noticing a possible association between sleep disturbances and periodontal symptoms. In contrast, 27.33% denied experiencing such symptoms, and an equal proportion (27.33%) were uncertain, indicating variability in personal observation and awareness of symptom–sleep correlations [Fig 19].

Participants' beliefs regarding systemic implications of sleep were strongly affirmative. Nearly half of the respondents (46.0%) strongly agreed that sleep quality affects immunity, and an additional 40.67% agreed, together accounting for 86.67% expressing a positive belief in the sleep–immunity relationship. Only 12.0% were unsure, and a minimal 1.33% disagreed, underscoring a strong consensus on the role of adequate sleep in maintaining immune function [Fig 4].

Figures and Statistical Interpretation

Figure 1

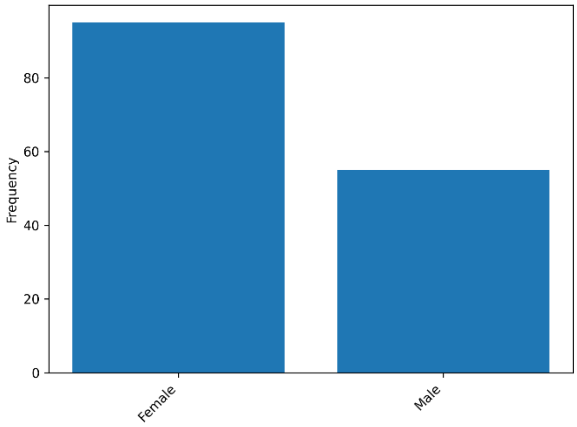

Figure 1 shows the gender distribution of the study participants. Females constituted the majority of respondents (63.33%), while males accounted for 36.67%. The association between gender and knowledge regarding circadian rhythm and periodontal health was found to be statistically significant ($\chi^2 = 15.279$, $p = 0.0005$).

Figure 2

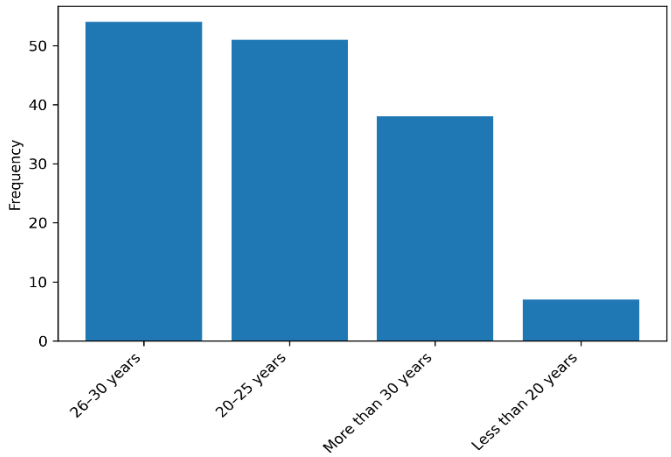

Figure 2 illustrates the age distribution of respondents, with the highest proportion belonging to the 26–30 years age group (36%), followed by 20–25 years (34%). Participants aged above 30 years constituted 25.33%, while those below 20 years formed a minority (4.67%). The association between age and awareness was highly significant ($\chi^2 = 149.177$, $p < 0.001$).

Figure 3

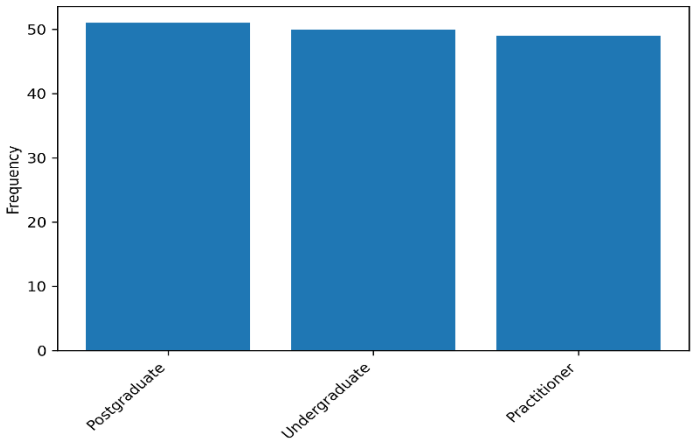

Figure 3 depicts the professional status of the respondents, showing an almost equal distribution among postgraduates (34%), undergraduates (33.33%), and practitioners (32.67%). Chi-square analysis revealed no statistically significant association with the outcome variables.

Figure 4

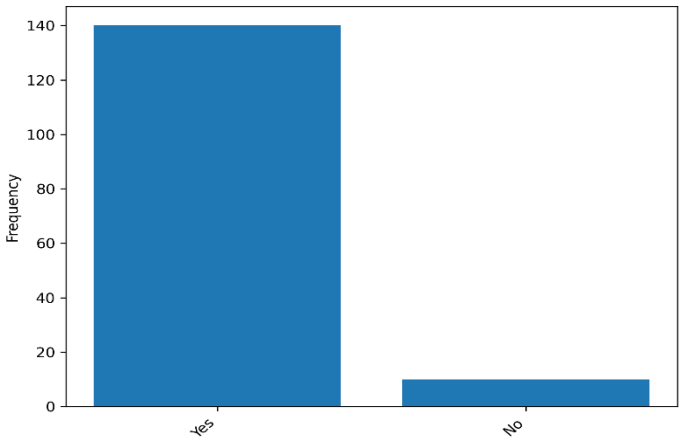

Figure 4 shows that a vast majority of participants (93.33%) reported learning about circadian rhythm as part of their curriculum. However, this variable did not show a statistically significant association ($\chi^2 = 3.851$, $p = 0.1458$).

Figure 5

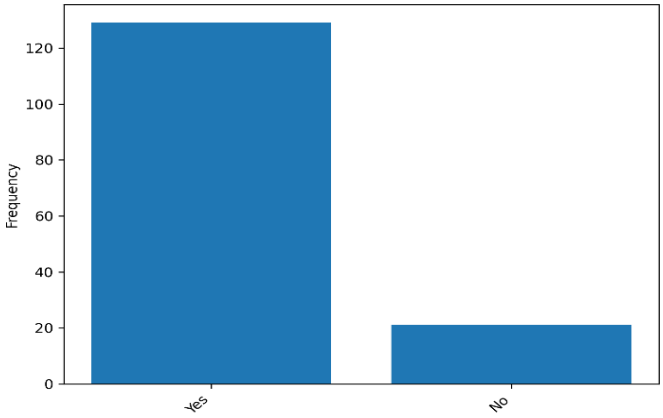

Figure 5 demonstrates that 86% of respondents were aware of the link between sleep and oral health. This awareness showed a statistically significant association ($\chi^2 = 7.069$, $p = 0.0292$).

Figure 6

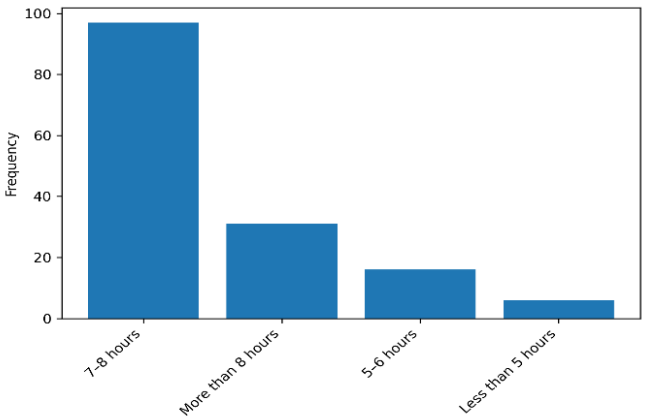

Figure 6 represents the average sleep duration per day. Most participants reported sleeping 7–8 hours (64.67%), followed by more than 8 hours (20.67%). The association between sleep duration and periodontal health awareness was found to be statistically significant ($\chi^2 = 18.833$, $p = 0.0045$).

Figure 7

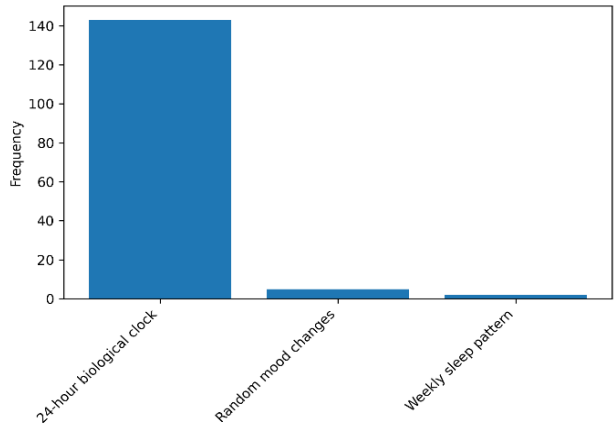

Figure 7 indicates that 95.33% of respondents correctly identified circadian rhythm as the body's 24-hour biological clock. This understanding showed a statistically significant association ($\chi^2 = 11.404$, $p = 0.0224$).

Figure 8

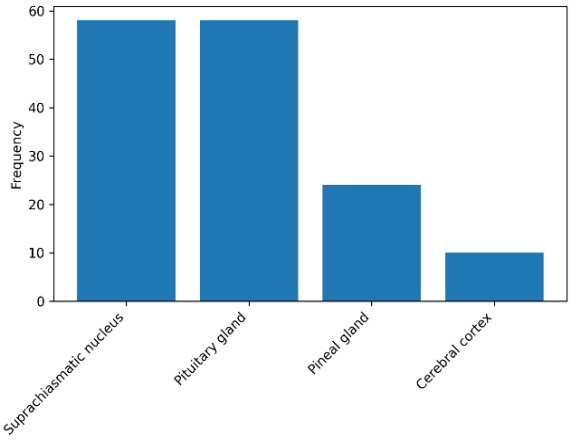

Figure 8 illustrates participants' knowledge regarding the master clock regulating circadian rhythm. The suprachiasmatic nucleus and pituitary gland were equally chosen (38.67% each). This variable demonstrated a statistically significant association ($\chi^2 = 14.010$, $p = 0.0295$).

Figure 9

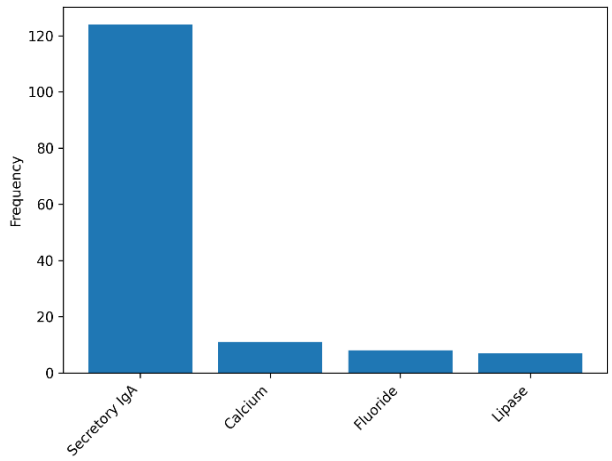

Figure 9 shows that secretory IgA was identified by the majority (82.67%) as the salivary component exhibiting circadian variation. This association was highly significant ($\chi^2 = 25.835$, $p = 0.0002$).

Figure 10

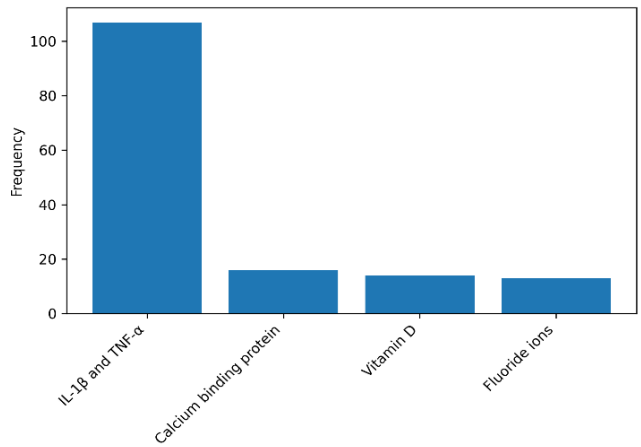

Figure 10 demonstrates that most respondents (71.33%) identified IL-1β and TNF-α as periodontal markers increased by circadian rhythm disruption. The association was found to be statistically significant ($\chi^2 = 32.484$, $p < 0.001$).

Figure 11

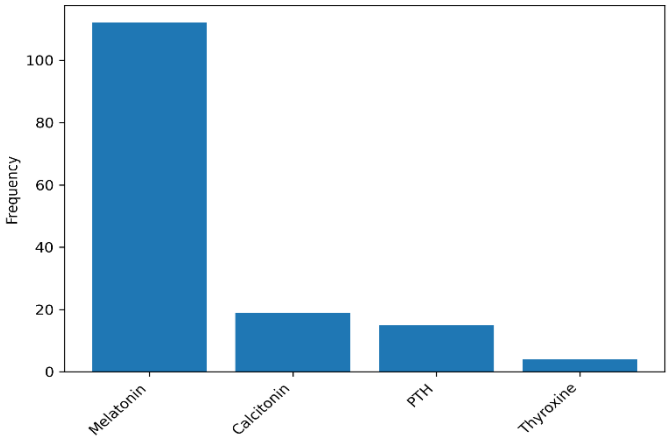

Figure 11 depicts responses regarding the hormone linking circadian rhythm with periodontal bone metabolism, with melatonin being selected by 74.67% of participants. This showed a statistically significant association ($\chi^2 = 22.388$, $p = 0.001$).

Figure 12

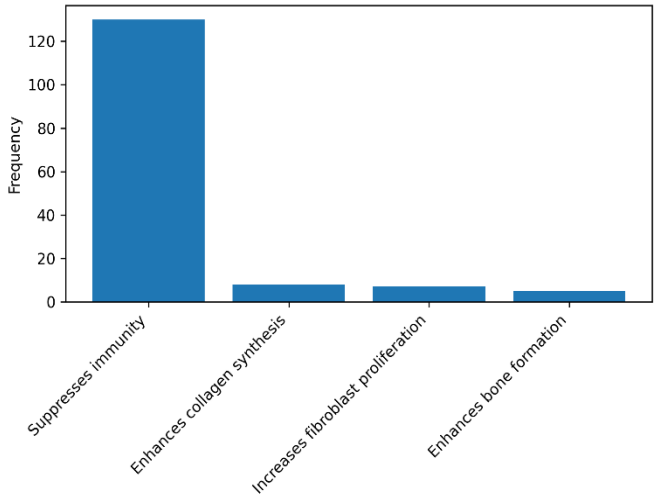

Figure 12 shows that the majority (86.67%) believed that early-morning cortisol peaks suppress immune defense and increase susceptibility of periodontal tissues. However, this association was not statistically significant ($\chi^2 = 12.339$, $p = 0.0548$).

Figure 13

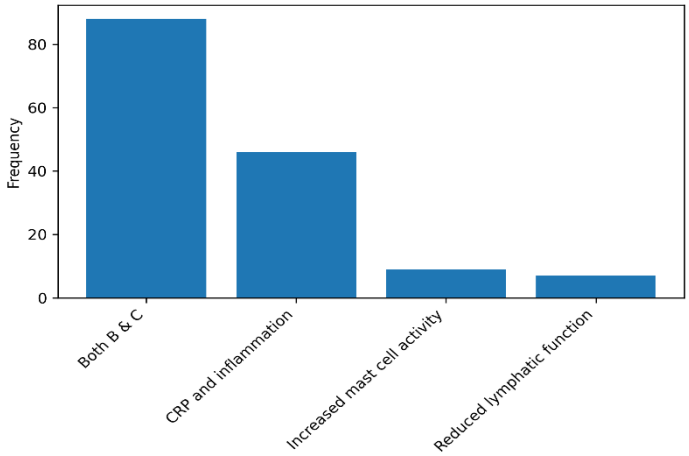

Figure 13 illustrates that 58.67% of respondents attributed increased periodontal destruction due to poor sleep to combined systemic inflammation and immune dysregulation. This finding was not statistically significant ($\chi^2 = 3.697$, $p = 0.7175$).

Figure 14

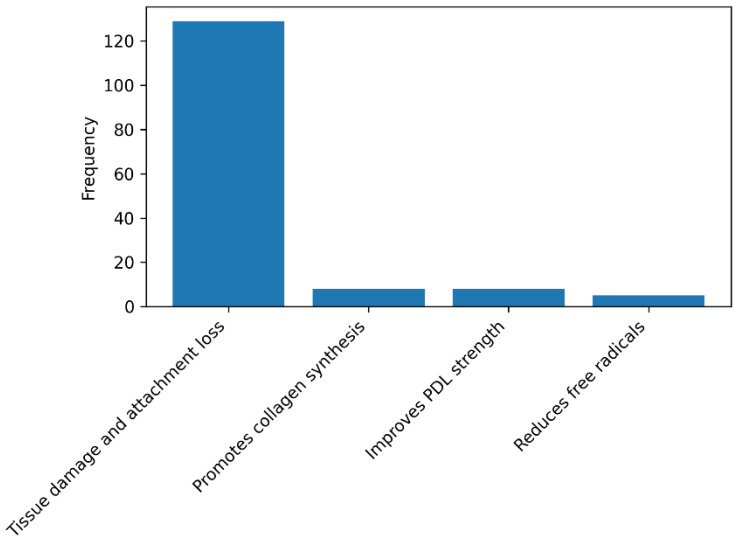

Figure 14 shows that 86% of participants agreed that irregular sleep cycles increase oxidative stress leading to periodontal tissue damage and attachment loss. This association was statistically significant ($\chi^2 = 22.237$, $p = 0.0011$).

Figure 15

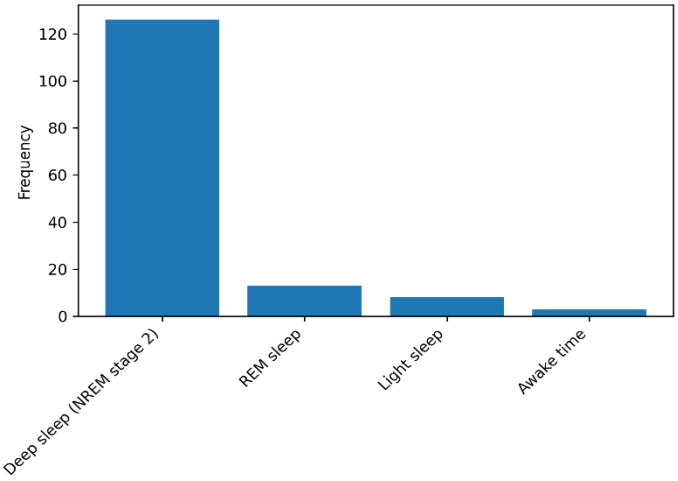

Figure 15 depicts that deep sleep (NREM stage 2) was identified by 84% of respondents as the sleep phase most critical for periodontal healing and immune function. This association was statistically significant ($\chi^2 = 16.701$, $p = 0.0104$).

Figure 16

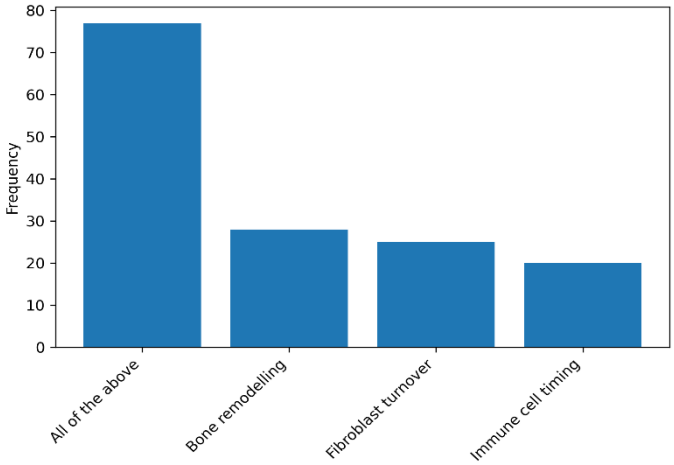

Figure 16 shows that over half of the respondents (51.33%) believed circadian clock genes influence periodontium through multiple pathways. This association was not statistically significant ($\chi^2 = 8.474$, $p = 0.2054$).

Figure 17

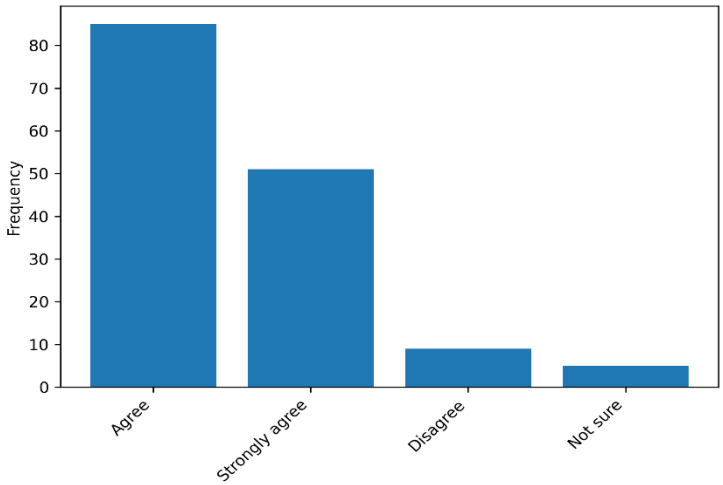

Figure 17 demonstrates that the majority of respondents either agreed (56.67%) or strongly agreed (34%) that skipping nighttime brushing worsens plaque buildup. This association was statistically significant ($\chi^2 = 14.291$, $p = 0.0265$).

Figure 18

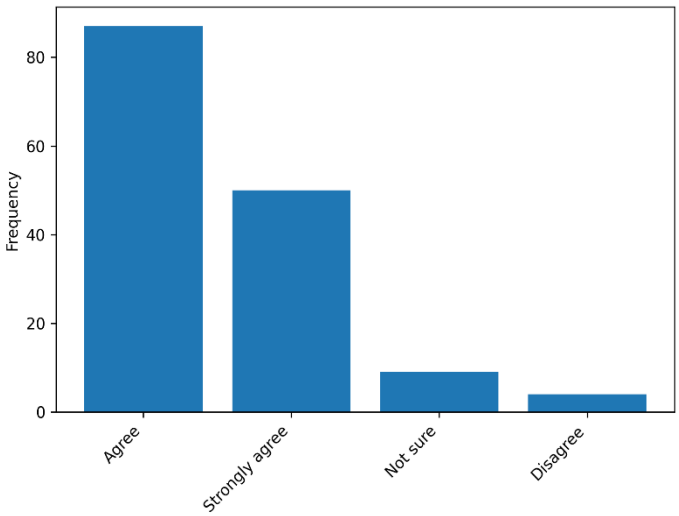

Figure 18 illustrates that most participants agreed (58%) or strongly agreed (33.33%) that circadian rhythm significantly affects periodontal health. However, this association was not statistically significant ($\chi^2 = 6.843$, $p = 0.3356$).

Figure 19

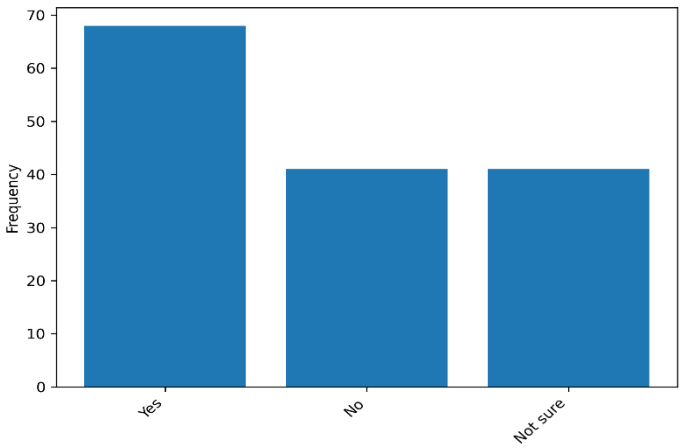

Figure 19 shows that 45.33% of respondents experienced gum bleeding during periods of poor sleep. This variable demonstrated a statistically significant association ($\chi^2 = 15.376$, $p = 0.0040$).

Figure 20

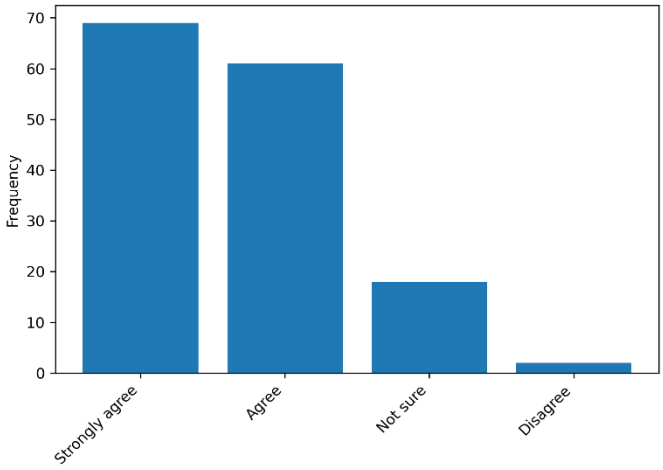

Figure 20 demonstrates that the majority of respondents either strongly agreed (46%) or agreed (40.67%) that sleep quality affects immunity. This association was found to be highly significant (χ^2 = 31.075, $p < 0.001$).

Discussion

The present study adds to the growing body of evidence emphasizing the importance of circadian rhythm and sleep–wake cycles in maintaining oral defense mechanisms and periodontal health. Our findings demonstrated a high level of awareness (86%) among dental students and professionals regarding the link between sleep and oral health, with nearly half of the participants (45.33%) reporting personal experiences of gingival bleeding during periods of poor sleep. Additionally, an overwhelming 86.67% of respondents either agreed or strongly agreed that sleep quality directly influences immunity. These perception-based findings align well with and complement existing epidemiological, molecular, and clinical studies discussed below.

Large-scale population-based evidence showed that stronger circadian rhythmicity was associated with a 3% reduction in periodontal disease risk per standard deviation increase, while evening chronotypes exhibited a 23% higher risk of periodontal disease[8].While our study did not directly assess chronotype or circadian rhythmicity scores, the high proportion of participants acknowledging the sleep–oral health connection suggests growing professional awareness of these risk patterns. The experiential reports of gum bleeding during poor sleep in our cohort may represent early clinical manifestations of the same circadian misalignment effects identified by Wang et al. at the population level[8].

At the molecular level, the role of circadian clock genes, particularly BMAL1, in periodontal homeostasis. Downregulation of BMAL1 due to circadian rhythm disruption was shown to exacerbate inflammation, oxidative stress, and periodontal tissue destruction[9].Although our study did not investigate genetic or biomarker-level mechanisms, the strong consensus among participants regarding sleep–immunity interactions indirectly supports these findings. The belief held by most respondents that poor sleep compromises immunity is biologically plausible given BMAL1's role in immune regulation and inflammatory control[9].

Sleep quality as a determinant of periodontal health has been further substantiated by Carra et al. (2024), who identified sleep disorders such as obstructive sleep Apnea as significant risk factors for periodontal disease[10]. Similarly, Qun Zhou et al. reported that extremely short sleep duration (≤5 hours) significantly increased the risk of periodontitis [11]. In our study, although sleep duration and specific sleep disorders were not quantified, the self-reported association between poor sleep and gingival bleeding reinforces the concept that inadequate or disturbed sleep may translate into measurable periodontal symptoms even among younger, educated populations.

Beyond periodontal inflammation, circadian rhythms also play a crucial role in oral tissue development, as described in[12,13], where clock genes regulate enamel and dentin formation in response to environmental cues. Disruption of these molecular clocks may result in developmental and structural vulnerabilities in oral tissues, a concept central to the emerging field of Chrono dentistry[19]. While our study focused primarily on awareness and perceptions rather than developmental outcomes, the high curricular exposure to circadian rhythm concepts (93.33%) among participants suggests that future dental professionals are increasingly equipped to integrate chronobiology into preventive and therapeutic decision-making.

Occupational circadian disruption was clearly demonstrated in the study , where rotating shift workers exhibited significantly poorer periodontal health and a higher prevalence of periodontitis compared to fixed day shift workers. Severe sleep disturbances and smoking further amplified periodontal risk[15].Although our cohort largely comprised students and early-career professionals rather than shift workers, these findings provide an important contextual extension to our results, indicating that circadian disruption not only influences perceptions and symptoms but also translates into clinically evident periodontal disease in high-risk occupational groups [15].

Importantly, some studies have suggested that interventions targeting sleep quality, physical activity, and circadian alignment may mitigate periodontal risks. This aligns with the implications of our findings, as the high level of awareness observed in our study represents a critical first step toward preventive strategies. Educated dental professionals who recognize the sleep–oral health link are better positioned to counsel patients on lifestyle modification, sleep hygiene, and holistic risk factor management [16].

Conclusion

In conclusion, while previous studies provide robust epidemiological, molecular, and occupational evidence linking circadian rhythm disruption to periodontal disease, our study contributes a knowledge- and perception-based perspective within a dental academic and professional population. The convergence of our findings with existing literature underscores the need to formally integrate circadian health, sleep assessment, and Chrono dentistry principles into dental education, clinical practice, and preventive oral health strategies.

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