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ORIGINAL RESEARCH

The Role of Biological Clock in Managing Lifestyle and Sleep Patterns in Non-Alcoholic Fatty Liver Disease

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is a common liver condition that has gained significant attention due to its increasing prevalence worldwide, including Northeast India.Urban dietary patterns, sedentary lifestyle, and sleep disturbances have been associated with the development and progression of NAFLD. Disruptions to circadian rhythms, including irregular sleep patterns, are emerging as critical factors influencing metabolic disorders like NAFLD. **Aim**: This study aims to explore the role of biological clock disturbances and lifestyle factors, including sleep quality and physical activity, in managing NAFLD among individuals in Northeast India. **Methods**: A cross-sectional study was conducted among 157 participants diagnosed with NAFLD at Gauhati Medical College and Hospital, Guwahati, Assam. Data was collected through structured interviews, clinical assessments, and diagnostic tests, including liver enzyme tests and abdominal ultrasound. Participants were assessed for circadian rhythm disturbances, sleep quality (using the Pittsburgh Sleep Quality Index), lifestyle factors, and liver function markers. Descriptive statistics, Pearson correlation, and multivariate regression analysis (SPSS version 23.0) were used to analyze the data. **Results**: The study found that 62.4% of participants exhibited poor sleep quality, and 59.2% followed a sedentary lifestyle. Poor sleep quality was significantly correlated with elevated liver enzymes (ALT and AST) and higher BMI ($p < 0.05$). Multivariate regression analysis revealed that circadian rhythm disruption and physical inactivity were independent predictors of moderate-to-severe NAFLD ($\beta = 0.36$, $p < 0.01$). **Conclusion**: The study highlights that biological clock disturbances, including poor sleep quality and sedentary behaviour, play a significant role in the progression of NAFLD in Northeast India. The findings suggest that lifestyle interventions aimed at improving sleep quality and physical activity may help in managing NAFLD and improving metabolic health. **Recommendations**: Future interventions in Northeast India should focus on promoting better sleep hygiene, reducing sedentary behaviour, and aligning eating patterns with natural circadian rhythms to prevent or manage NAFLD. Further longitudinal studies are recommended to explore the long-term effects of these interventions.

Keywords: Non-alcoholic fatty liver disease, circadian rhythm, sleep quality, lifestyle factors, Northeast India.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is a significant public health concern in India, including in the Northeast region, with increasing prevalence linked to rising obesity, type 2 diabetes, and metabolic syndrome. The region's unique demographic and lifestyle factors have made it a crucial area for understanding the patterns and impact of NAFLD. Recent studies have highlighted that the prevalence of NAFLD in Northeast India ranges from 10% to 28%, with a growing concern over its association with urbanization, dietary changes, and a sedentary lifestyle [1]. NAFLD is a spectrum of liver conditions, from simple steatosis to non-alcoholic steatohepatitis (NASH), which can progress to cirrhosis and hepatocellular carcinoma if left untreated [2].

The circadian clock plays a vital role in regulating metabolic processes, including glucose and lipid metabolism, and sleep-wake cycles. Disruptions to circadian rhythms, caused by irregular sleep patterns, shift work, or late-night eating, have been implicated in various metabolic disorders, including NAFLD. Recent studies have shown that circadian misalignment can lead to liver dysfunction, insulin resistance, and increased hepatic fat accumulation, particularly in populations with a high prevalence of metabolic syndrome, such as in Northeast India [3]. The importance of circadian rhythm regulation in the

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pathogenesis of NAFLD underscores the potential role of lifestyle interventions that promote alignment of sleep patterns and eating habits with natural circadian cycles.

In Northeast India, lifestyle-related factors such as high carbohydrate intake, consumption of processed foods, and limited physical activity contribute significantly to the increasing burden of NAFLD. The region's rapid urbanization and changing dietary habits have led to a shift from traditional diets to high-fat, high-sugar, and processed food consumption, which further exacerbates the risk of liver disease [4]. Additionally, poor sleep quality and the prevalence of sleep disorders, such as obstructive sleep apnea, have been found to be more common in individuals with NAFLD in this region [5].

The management of NAFLD remains a challenge, particularly in regions like Northeast India, where healthcare access and resources may be limited. Recent studies suggest that interventions such as improving sleep quality, promoting physical activity, and adopting time-restricted eating could be effective in managing the disease [6]. This research aims to explore the role of biological clock disruptions and lifestyle changes in managing NAFLD among individuals in Northeast India, providing a foundation for tailored therapeutic strategies. This study aims to explore the role of biological clock disturbances and lifestyle factors, including sleep quality and physical activity, in managing NAFLD among individuals in Northeast India.

METHODOLOGY

Study Design

This is a prospective observational study.

Study Setting

The study was carried out at the Department of Gastroenterology, Gauhati Medical College and Hospital, a tertiary care centre that caters to a diverse patient population.

Study Participants

A total of 157 participants diagnosed with NAFLD were recruited for this study. Participants were selected from outpatient and inpatient departments of Gauhati Medical College and Hospital. The study was conducted over a period of 12 months, ensuring adequate time for participant follow-up and data analysis.

Inclusion Criteria

- Adults aged 18–65 years diagnosed with NAFLD based on ultrasonography and liver function tests.
- Individuals willing to provide informed consent and comply with the study protocol.
- Participants without other significant comorbidities affecting liver function.

Exclusion Criteria

- Individuals with a history of alcohol consumption exceeding 20 grams/day for women and 30 grams/day for men.
- Patients with other chronic liver diseases such as viral hepatitis, autoimmune hepatitis, or cirrhosis.
- Pregnant or lactating women.
- Patients with severe psychiatric disorders or cognitive impairments.

Bias

Efforts were made to minimize selection bias by employing random sampling methods. Interviewer bias was reduced through training of data collectors, and information bias was addressed using standardized questionnaires and measurement tools.

Data Collection

Data was collected using structured questionnaires, sleep diaries, and validated tools for lifestyle assessment. Anthropometric measurements, including weight, height, and BMI, were recorded. Sleep patterns were evaluated using the Pittsburgh Sleep Quality Index (PSQI). Blood samples were analyzed for liver enzymes and markers of metabolic syndrome.

Procedure

Eligible participants were recruited and provided informed consent. Baseline data were collected during the first visit, including demographic details, clinical history, and lifestyle habits. Participants were followed up at three-month intervals for 12 months to monitor changes in sleep patterns, lifestyle modifications, and liver function tests.

Statistical Analysis

Data were entered and analyzed using SPSS version 23.0. Descriptive statistics were used to summarize demographic and clinical data. Chi-square tests were used for categorical variables, while t-tests or ANOVA were applied for continuous variables. Correlation analysis and multivariate regression were performed to evaluate associations between sleep patterns, lifestyle factors, and NAFLD outcomes. A p-value < 0.05 was considered statistically significant.

RESULTS

Out of 157 participants enrolled in the study, 85 were male (54.1%), and 72 were female (45.9%). The mean age of participants was 45.6 ± 9.3 years. The majority of the participants (62.4%) were aged between 40–60 years. Table 1 provides a summary of the demographic characteristics of the participants.

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Table 1: Demographic Characteristics of Participants

Variable	Frequency (n)	Percentage (%)
Gender		
Male	85	54.1%
Female	72	45.9%
Age (years)		
18–30	18	11.5%
31–40	41	26.1%
41–50	58	36.9%
51–60	40	25.5%

Based on the Pittsburgh Sleep Quality Index (PSQI), 62.4% of participants were identified as having poor sleep quality (PSQI > 5), while 37.6% had good sleep quality. A statistically significant association was observed between poor sleep quality and elevated liver enzymes ($p < 0.01$). Participants with poor sleep had higher mean alanine transaminase (ALT) levels (62.1 ± 15.3 U/L) compared to those with good sleep quality (45.3 ± 12.7 U/L).

Table 2: Sleep Quality and Liver Enzyme Levels

Sleep Quality	Participants (n)	ALT (Mean ± SD, U/L)	AST (Mean ± SD, U/L)
Good Sleep Quality	59	45.3 ± 12.7	38.4 ± 11.6
Poor Sleep Quality	98	62.1 ± 15.3	49.2 ± 13.4
$p < 0.01$ for ALT differences between groups			

Participants with sedentary lifestyles (n = 93, 59.2%) were more likely to have moderate-to-severe NAFLD compared to those engaging in regular physical activity ($p < 0.05$). Body Mass Index (BMI) was significantly higher in participants with poor sleep quality (32.5 ± 3.4 kg/m²) compared to those with good sleep quality (28.7 ± 2.9 kg/m²).

Table 3: Lifestyle Factors and NAFLD Severity

Lifestyle Factor	Mild NAFLD (n)	Moderate-to-Severe NAFLD (n)	Total (n)
Sedentary Lifestyle	38	55	93
Physically Active	31	33	64
$p < 0.05$ for NAFLD severity by lifestyle factor			

Correlation Analysis

Pearson correlation analysis revealed a significant positive correlation between PSQI scores and ALT levels ($r = 0.52$, $p < 0.01$) and BMI ($r = 0.48$, $p < 0.01$). This indicates that poor sleep quality is associated with worse liver function and higher BMI among NAFLD patients.

Multivariate regression analysis identified poor sleep quality ($\beta = 0.36$, $p < 0.01$) and sedentary lifestyle ($\beta = 0.29$, $p < 0.05$) as significant predictors of moderate-to-severe NAFLD. These findings underscore the role of circadian rhythm disturbances and physical inactivity in the progression of NAFLD.

Table 4: Multivariate Regression Analysis for Predictors of NAFLD Severity

Predictor Variable	β Coefficient	Standard Error	p-value
Poor Sleep Quality	0.36	0.07	<0.01
Sedentary Lifestyle	0.29	0.08	<0.05
Age	0.12	0.05	0.08
Gender (Male)	0.08	0.06	0.18

DISCUSSION

The study, involving 157 participants with (NAFLD), highlights significant correlation between lifestyle factors, sleep quality, and disease severity. Of the participants, 62.4% exhibited poor sleep quality, as assessed by (PSQI). Poor sleep quality was strongly correlated with higher liver enzyme levels (ALT and AST) and a greater prevalence of moderate-to-severe NAFLD. Specifically, participants with poor sleep quality had significantly elevated mean ALT levels (62.1 ± 15.3 U/L) compared to those with good sleep quality (45.3 ± 12.7 U/L). This suggests that disrupted circadian rhythms may exacerbate liver dysfunction in NAFLD patients.

Lifestyle factors also played a critical role in NAFLD progression. A sedentary lifestyle was observed in

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59.2% of participants and was significantly associated with moderate-to-severe NAFLD. Physically active participants had a lower prevalence of severe disease, underscoring the protective effect of regular physical activity. Body Mass Index (BMI) was also notably higher among participants with poor sleep quality, further linking poor sleep to unfavourable metabolic profiles and disease outcomes.

Correlation analysis revealed a positive relationship between poor sleep quality and both ALT levels ($r = 0.52$, $p < 0.01$) and BMI ($r = 0.48$, $p < 0.01$). This suggests that disrupted sleep not only worsens liver function but also contributes to weight gain, which is a known risk factor for NAFLD progression. Moreover, multivariate regression analysis identified poor sleep quality and sedentary lifestyle as independent predictors of moderate-to-severe NAFLD, emphasizing the multifactorial nature of the disease and the interplay between lifestyle and biological clock disturbances.

The circadian clock plays a pivotal role in the pathogenesis and management of Non-Alcoholic Fatty Liver Disease (NAFLD). Modern lifestyles, including irregular eating patterns and poor sleep quality, disrupt circadian rhythms, contributing to adverse metabolic profiles and the progression of NAFLD. Strategies such as chrononutrition, which includes time-restricted feeding and intermittent fasting, have shown promise in realigning lifestyle behaviours with biological rhythms to improve NAFLD outcomes [7]. Disruption of circadian rhythms is also linked to the progression and severity of NAFLD and its complications, such as non-alcoholic steatohepatitis (NASH). Studies emphasize the importance of incorporating circadian timing into therapeutic strategies, with evidence suggesting that paying attention to these rhythms could enhance treatment outcomes and prevent disease progression [8]. Circadian clock genes, including BMAL1, CLOCK, and REV-ERB, are central regulators of hepatic lipid and glucose metabolism. Their dysregulation increases susceptibility to NAFLD. Synchronizing circadian rhythms through environmental and lifestyle changes has been proposed to alleviate metabolic disturbances in NAFLD [9]. Furthermore, the biological clock interacts with the gut microbiota, metabolic fluxes, and immune-inflammatory processes, all of which exhibit circadian patterns. These interactions influence the development of hepatosteatosis and its progression to NASH. Disruption of these physiological rhythms, referred to as chronodisruption, exacerbates liver pathologies, emphasizing the critical role of circadian regulation in liver health [10]. Sleep disturbances in patients with NAFLD, characterized by delayed sleep onset and poor sleep quality, are significantly correlated with markers of disease severity, including elevated liver enzymes and insulin resistance. These findings underscore the importance of addressing sleep-wake cycles and meal timing in managing NAFLD [11].

CONCLUSION

These findings indicate that poor sleep and physical inactivity significantly contribute to the progression of NAFLD. This underscores the importance of interventions targeting lifestyle modifications, such as promoting regular physical activity and improving sleep hygiene, as part of comprehensive NAFLD management. Addressing circadian rhythm disturbances may hold promise for mitigating disease progression and improving outcomes in NAFLD patients.

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