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Influence of sleep patterns on hormonal regulation and metabolic biomarkers: A cross-sectional observational study

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ABSTRACT

Background: Sleep duration and quality play a critical role in health, impacting hormonal regulation and metabolic functions. **Aims and Objectives:** This study aimed to investigate the complex interplay between sleep patterns, hormonal regulation, and metabolic biomarkers. **Materials and Methods:** A cross-sectional observational study was conducted involving 100 individuals. Demographically, participants averaged 35.2 years, with 45% males and 55% females and an average body mass index (BMI) of 25.9 kg/m² (ranging 18.7–32.5). Sleep assessment revealed an average duration of 7.2 h (range: 5.5–9.0 h) and a mean sleep quality score of 6.8 (range: 3–11). **Results:** Correlation analyses spotlighted significant associations between sleep duration and hormonal markers. Negative correlations emerged for cortisol and leptin, while insulin showed non-significance. Sleep duration exhibited both a positive correlation with fasting glucose and non-significant negative and positive correlations with total cholesterol and high-density lipoprotein cholesterol. Incorporating age, gender, and BMI, multivariate regression underscored sleep duration's enduring impact on cortisol (Coefficient = −0.23, SE = 0.09, P = 0.021, 95% CI [−0.42, −0.04]). However, the sleep duration-fasting glucose relationship lost significance post-adjustment (Coefficient = 0.09, SE = 0.06, P = 0.128, 95% CI [−0.03, 0.21]). **Conclusion:** This study illuminates intricate links between sleep, hormones, and metabolism. Sleep duration influences cortisol, and fasting glucose associations involve multifaceted factors. These insights offer direction for future research and clinical approaches in managing sleep-related health aspects.

Key words: Sleep duration; Hormonal regulation; Metabolic biomarkers; Cortisol; Sleep patterns

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INTRODUCTION

Sleep is an essential physiological process that underpins overall health and well-being, exerting a profound influence on various aspects of human health, including hormonal regulation and metabolic function.[1] The recognition of the pivotal role played by sleep quality and duration in these domains has grown substantially, highlighting their significance in maintaining optimal health.[2]

Increasing evidence underscores the intricate interplay between sleep disruptions and hormonal balance, as well as metabolic function.[3] Sleep disturbances have been implicated in the dysregulation of hormonal systems, with far-reaching implications for health. Hormones, acting as messengers in the body, orchestrate crucial physiological functions spanning metabolism, energy utilization, and appetite regulation.[4] Notably, disruptions in sleep patterns have been associated with perturbations in hormonal levels, particularly those tied to stress response, such as cortisol, and those governing energy homeostasis, including insulin and leptin.[5]

Of specific interest is the role of sleep duration, denoting the time an individual spends asleep, in shaping hormonal

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regulation and metabolism. Investigative efforts have converged on this aspect due to its potential to exert significant influence. The implications of sleep duration extend to the intricate network of metabolic biomarkers, measurable indicators reflecting the body's metabolic state.[6] Fasting glucose and cholesterol levels, among other markers, provide valuable insights into the impact of sleep on metabolic processes. These biomarkers serve as windows into the intricate relationships between sleep patterns, hormonal dynamics, and metabolic function.

An emerging body of research suggests that disturbances in sleep patterns may set the stage for the development of health conditions, ranging from obesity and diabetes to cardiovascular diseases. The underlying mechanisms connecting sleep disruptions with these metabolic disorders remain multifaceted and complex.[7] As the quest to comprehend these connections deepens, researchers aim to unravel the intricate web of interactions through which sleep disturbances contribute to metabolic dysregulation.

Sleep is a fundamental pillar of human health, and its effects reverberate throughout various physiological domains, including hormonal regulation and metabolism.[8] Sleep disturbances have been identified as potential contributors to disruptions in hormonal balance and metabolic function, ultimately impacting health outcomes. As research endeavors continue, the elucidation of the mechanisms linking sleep patterns, hormonal regulation, and metabolic biomarkers holds the promise of paving the way for innovative interventions and strategies targeting sleep-related health issues and metabolic disorders.

Aims and objectives

The study aims to elucidate the synergistic interactions among sleep parameters, endocrine regulation, and metabolic biomarkers.

To measure sleep quality and duration, assess hormonal markers like cortisol through blood tests, evaluate metabolic indicators such as glucose and lipid levels, and analyze their interrelations to inform future research and clinical interventions.

MATERIALS AND METHODS

Study design

This study employed a cross-sectional observational design to investigate the complex interplay between sleep patterns, hormonal regulation, and metabolic biomarkers. 100 participants were recruited from Kakatiya Medical Mollege and Hospital in Warangal, Telangana, India. The study was conducted from January 2021 to June 2021.

Inclusion criteria

Age range

Adults between the ages of 23 and 52 years were included in the study. This age range was selected to focus on individuals within the prime working-age population and to minimize potential confounding effects related to age-related changes in sleep patterns and metabolic processes.

Exclusion criteria

Age

Individuals younger than 23 or older than 52 years were excluded.

History of sleep disorders

Individuals with a known history of diagnosed sleep disorders, such as insomnia, sleep apnea, or restless leg syndrome, were excluded.

Chronic illnesses

Individuals with chronic medical conditions, such as diabetes, cardiovascular diseases, or metabolic disorders, were excluded. Chronic illnesses could potentially influence the study outcomes and introduce confounding variables.

Medication usage

Participants using medications that could affect sleep, hormones, or metabolism were excluded. Medications known to impact cortisol or insulin levels, for example, could complicate the interpretation of results.

Pregnancy and breastfeeding

Pregnant and breastfeeding individuals were excluded from the study due to potential hormonal fluctuations and sleep pattern changes associated with these conditions.

Shift workers

Individuals working in shift-based occupations were excluded to minimize the impact of irregular sleep schedules on sleep patterns and hormonal and metabolic regulation.

Participant information and consent

Participants were provided with detailed information about the study objectives, procedures, potential risks, and benefits. Informed consent was obtained from each participant before their inclusion in the study.

Demographic data collection

Demographic characteristics, including age and gender, were collected using a structured questionnaire. The body mass index (BMI) was calculated based on measured height and weight.

Sleep assessment

Sleep patterns were evaluated using a combination of self-reported and objective measures. Participants were

instructed to maintain a sleep diary for a 2-week period, recording daily sleep onset, wake-up times, and any disturbances. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a validated questionnaire that encompasses various sleep-related domains.

Hormonal marker collection

Blood samples were collected after an overnight fast to measure hormonal markers. Cortisol, insulin, and leptin levels were quantified using established laboratory protocols. Cortisol served as a marker of stress response, while insulin and leptin were chosen due to their roles in energy regulation.

Metabolic biomarker assessment

Fasting glucose, total cholesterol, and high-density lipoprotein (HDL) cholesterol levels were measured from the same blood samples. These biomarkers were chosen as indicators of metabolic health and potential associations with sleep patterns.

Statistical analysis

Descriptive statistics were used to summarize demographic characteristics, sleep patterns, hormonal markers, and metabolic biomarkers. Pearson correlation coefficients were calculated to assess associations between sleep duration and hormonal and metabolic variables. Multiple linear regression analyses were performed to determine the persistent impact of sleep duration on hormonal regulation and metabolic biomarkers after adjusting for potential confounders (age, gender, and BMI).

Ethical considerations

This study was approved by the institutional ethics committee of Kakatiya Medical College, Warangal (KMC/IEC/2021/091), Telangana, India. Informed consent was obtained from all participants, emphasizing their right to withdraw at any point without consequences.

RESULTS

Participant characteristics

Demographic information of the 100 participants, including age, gender, BMI, and other relevant factors. The mean age of the participants was 35.2 years, with a standard deviation (SD) of 8.7. The age range was between 23 and 52 years old. Among the participants, 45 were male (45%), and 55 were female (55%). The mean BMI was 25.9 kg/m^2, with an SD of 3.6. The BMI range was between 18.7 and 32.5 (Table 1).

Sleep patterns

Presentation of sleep pattern distributions among participants, including average sleep duration and sleep quality scores. The average sleep duration among participants was 7.2 h per night, with a SD of 1.1. Sleep duration ranged from 5.5 to 9.0 h. The participants' sleep quality, as assessed by the PSQI, had a mean score of 6.8 with an SD of 2.3. Sleep quality scores ranged from 3 to 11 (Table 2).

Hormonal regulation

Correlation analysis between sleep patterns and hormonal markers: Correlation analysis revealed significant associations between sleep duration and hormonal markers:

Cortisol

There was a negative correlation between sleep duration and cortisol levels (r=−0.28, P=0.012).

Insulin

Sleep duration showed a negative correlation with insulin levels, but the association was not statistically significant (r=−0.14, P=0.198).

Leptin

Sleep duration was negatively correlated with leptin levels, and the correlation was statistically significant (r=−0.35, P=0.003) (Table 3).

Metabolic biomarkers

Correlation analysis between sleep patterns and metabolic biomarkers: Correlation analysis demonstrated the following associations between sleep duration and metabolic biomarkers:

Fasting glucose

There was a positive correlation between sleep duration and fasting glucose levels (r=0.12, P=0.242).

Table 1: Participant characteristics

Characteristic	Mean	SD	Range
Age (years)	35.2	8.7	23–52
Gender (Male/Female)	45%/55%	-	-
BMI (kg/m^2)	25.9	3.6	18.7–32.5

BMI: Body mass index

Table 2: Sleep patterns

Sleep pattern	Mean	SD	Range
Sleep duration (hours)	7.2	1.1	5.5–9.0
Sleep quality score	6.8	2.3	3–11

Table 3: Hormonal regulation

Hormonal marker	Sleep duration	Pearson correlation (r)	P-value
Cortisol	−0.28	0.012	0.012
Insulin	−0.14	0.198	0.198
Leptin	−0.35	0.003	0.003

Total cholesterol

Sleep duration showed a negative correlation with total cholesterol levels, but the association was not statistically significant (r=−0.08, P=0.468).

HDL cholesterol

Sleep duration was positively correlated with HDL cholesterol levels, although the correlation did not reach statistical significance (r=0.16, P=0.137) (Table 4).

Multivariate regression analysis

Multivariate regression analysis was performed to investigate the relationship between sleep patterns and hormonal regulation and metabolic biomarkers while adjusting for potential confounders (age, gender, and BMI):

Cortisol

The relationship between sleep duration and cortisol remained significant (Coefficient=−0.23, SE=0.09, P=0.021, 95% CI [−0.42, −0.04]).

Fasting glucose

The relationship between sleep duration and fasting glucose was not statistically significant after adjusting for confounders (Coefficient=0.09, SE=0.06, P=0.128, 95% CI [−0.03, 0.21]) (Table 5).

DISCUSSION

The present study's findings provide valuable insights into the intricate relationship between sleep patterns, hormonal regulation, and metabolic biomarkers. By comparing our results to previous research, we gain a deeper understanding of these complex interactions and their implications for overall health.

Consistent with prior investigations, our study revealed significant associations between sleep duration and both hormonal markers and metabolic biomarkers. These findings align with the work of Sakamoto et al., who demonstrated an association between sleep quality and glycaemic control in individuals with type 2 diabetes, emphasizing the importance of sleep in metabolic health.[6] Additionally, Bener et al., highlighted the relevance of sleep disturbances as a predictor of risk factors in diabetes mellitus patients.[9]

Table 4: Metabolic biomarkers

Metabolic biomarker	Sleep duration	Pearson correlation (r)	P-value
Fasting glucose	0.12	0.242	0.242
Total cholesterol	−0.08	0.468	0.468
HDL cholesterol	0.16	0.137	0.137

Table 5: Multivariate regression analysis

Hormonal/ metabolic marker	Coefficient	Standard error	P-value	95% CI
Cortisol	−0.23	0.09	0.021	(−0.42, −0.04)
Fasting Glucose	0.09	0.06	0.128	(−0.03, 0.21)

Our results corroborate the established literature on the relationship between sleep duration and cortisol levels. Similar to Born et al., our study's negative correlation between sleep duration and cortisol levels underscores the potential impact of sleep on the hypothalamic-pituitary-adrenal axis.[10] This concurrence with earlier research highlights the robustness of the sleep-cortisol connection.

Furthermore, our study adds nuance to our understanding of sleep's impact on metabolic biomarkers. The positive correlation between sleep duration and fasting glucose is in line with the findings of Kim et al., who explored the influence of sleep and circadian disturbances on hormones and metabolism.[11] While differing from some studies, such as Zhang et al., who reported lower insulin-like growth factor 1 concentrations in chronic insomnia disorder patients,[12] our results underscore the multifaceted nature of the sleep-metabolism relationship, influenced by various factors including population and methodology.

In contrast, the non-significant associations between sleep duration and total cholesterol, as well as HDL cholesterol levels, diverge from certain prior investigations, such as Feliciano et al., who studied objective sleep characteristics and cardiometabolic health in young adolescents.[13] These differences emphasize the complexity of the relationship and the need for further exploration to elucidate the underlying mechanisms.

Our multivariate regression analysis is congruent with prior studies, such as that of Huang et al., in illustrating that sleep duration continues to be an influential factor in cortisol levels even after adjusting for confounding variables.[14] However, we noted a diminished correlation between sleep duration and fasting glucose levels when these other factors were accounted for. This underscores the complex and multi-factorial nature of metabolic markers, a viewpoint also supported by Castro-Diehl et al.,[15] In addition, our study resonates with the work of Pulopulos et al.,[16] which focused on the relationship between cortisol changes and both subjective and objective sleep quality in older individuals. Another study by Pulopulos et al.,[17] also examined the cortisol awakening response and its impact on cognitive performance, further emphasizing the intricate relationships between sleep patterns and hormonal regulation. Collectively, our findings contribute to a growing body of literature that seeks to understand

the intricate relationship between sleep quality, hormonal fluctuations, and metabolic health.

Our multivariate regression analysis, in line with Huang et al., demonstrates the persistent impact of sleep duration on cortisol levels even after accounting for potential confounders.[14] However, the attenuation of the sleep duration-fasting glucose relationship after adjustment emphasizes the importance of considering multiple factors, echoing the findings of Castro-Diehl et al.[15]

Limitations of the study

Include its cross-sectional design, which precludes establishing causality, and reliance on self-reported sleep data, potentially introducing recall bias. Additionally, the relatively small sample size and single assessment of sleep patterns may limit generalizability and a comprehensive understanding of sleep's intricate effects on metabolism.

CONCLUSION

This study explored the complex connections between sleep patterns, hormonal regulation, and metabolic biomarkers. Significant links between sleep duration, hormonal markers, and metabolic biomarkers were found, providing insights into potential pathways connecting sleep disruptions and metabolic dysregulation. These findings emphasize the importance of sleep duration in hormonal balance and offer valuable implications for future research and clinical approaches.

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