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The Impact of Sleep Quality on Immune Function, Hematological Parameters, and Thyroid Hormone Levels

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Abstract

Immune and endocrine system regulation, as well as physiological homeostasis, are all significantly impacted by sleep quality. Numerous biological changes, such as differences in thyroid hormone levels and hematological indices, have been associated with sleep deprivation and poor sleep quality. This study aims to investigate the relationship between university students' sleep quality and specific hematological markers and thyroid hormones. A cross-sectional study was conducted on 130 students (male and female) with a mean age of approximately 23 ± 2 years from the Technical Institute-Baqubah. Blood samples (5 ml) were collected from each participant under aseptic conditions. Then, hematological parameters including WBC, RBC, Hb, PCV, and PT were analyzed using an automated hematology analyzer. Serum samples were separated and used to measure thyroid hormones (T3, T4, and TSH). The results demonstrated that poor sleep quality was related to a significant increase in WBC count, indicating a potential inflammatory response. In contrast, hemoglobin levels and packed cell volume were significantly lower among participants with poor sleep quality. Additionally, elevated levels of T4 and TSH were observed in individuals with inadequate sleep duration. The study found that insufficient sleep is associated with major changes in thyroid function and blood components, such as decreased hemoglobin and increased white blood cell counts. High levels of the hormones T4 and TSH were also observed, which could point to a thyroid-stimulating axis issue. The results show that sleep deprivation has localized rather than systemic effects.

Keywords: Sleep quality, Hematological parameters, Thyroid hormones, Immune system, Endocrine regulation.

Introduction

Sleep deprivation is, defined as the complete lack of sleep or a significant decrease, typically lasting one to two days, with, waking hours extending beyond the 16-18 hours. According to the International denomination of Sleep Disorders (ICD-3), chronic sleep reduction is a disorder characterized by excessive sleepiness in the daytime as a result from routinely sleeping blow than required amount for optimal functioning of health, on a near-daily basis for at least three months. Population studies, have indicated a steady

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increase in the prevalence of adults sleeping below than six hours per night over extended periods, a trend that also affects children and adolescents (1). Sleep is a neurophysiological process; it is essential to biological pathways that are vital to the health of the body and brain (2). Homeostatic and circadian systems act in a complex and dynamic way to establish the onset and duration of sleep and awake (3). The homeostatic drive rises with the duration of wakefulness, signifying an increase in the need for sleep. The complicated structure of organ clocks that regulates behavior and metabolic outputs with environmental stimuli gives rise to the circadian process. In contrast to the natural lead to sleep, the circadian rhythm promotes the onset of sleep during night and favors wakefulness. Childhood and adolescence bring about major changes in sleep patterns (4), and during these years, sleep problems can be common. A complicated interaction between chronological age, developmental stage, genetic, behavioral, environmental, and social factors affect sleep patterns and needs. Adults should get at least seven hours of sleep every night in order to maintain good health.(5).

The modern factors including social demands, smartphone addiction, and poor diet that correlate with the modern life 24-7 society cause the phenomenon of chronic sleep deprivation which is defined as sleeping less than the recommended amount or, better to say, the intrinsic sleep need beside the medical problems which include sleep apnea and insomnia (6). Atherosclerosis, hypertension, and type 2 diabetes are disease which the immune system plays a significant role in their development and progression which its considered major causes of death (7). One of the most clinical validated biomarkers and routine measured check of systemic inflammation and immune response is White blood cell (WBC) count (8). The elevation in the results of total WBC count and its subtypes (such as neutrophils, monocytes and lymphocytes) are an independent predictor of major health outcomes such as high blood pressure, diabetes, cardiovascular disease, and death rate (9), even among young and healthy individuals at baseline. Furthermore, research indicates that sleep is essential for hematopoiesis (10). Hematopoietic stem cells (HSCs) and hematopoietic progenitor cells (HSPCs) are continuously produced, grow, and distinguished throughout an individual's life to become mature, specialized blood cells like leukocytes (white blood cells), thrombocytes (platelets), and erythrocytes (red blood cells) (11,12,13,14) .Erythropoietin stimulates RBC production in response to low partial pressure of oxygen (pO_2) (15). The major function of EPO is to effectively regulate the body's oxygen levels , by promoting the daily generation of new red blood cells to make up for their short lifespan of 110–120 days . The quantity of EPO in circulation increases as Hb concentration falls. Erythropoietin release is directly influenced by the oxygen levels in the body (16, 17, 18). The biological processes of humans that occur during sleep its affect, such as hemoglobin formation, which plays a crucial role in transporting oxygen from the lungs to all body tissues and carbon dioxide from body tissues back to the lungs (19). A reduction in the hemoglobin levels affect the incidence of anemia, where there is a decrease in the number of red blood cells in the blood stream , abnormality of the hemoglobin content of red blood cells, or both. Hormones and sleep have a well-established relationship that is essential for normal physiological functioning. Moreover, almost all hormones have a 24-hour cycle that is somewhat altered by sleep. Particularly, sleep has a significant impact on thyroid-stimulating hormone (TSH), which in turn affects both the duration and the quality of sleep (20). The hypothalamic pituitary thyroid (HPT) axis and the cycle of sleep interact to regulate energy and metabolic functions; a disturbance in one of them causes dysregulation of the other. Determining the causes and

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effects of the association between sleep and the HPT axis is therefore important (21). This study intends to investigate the levels of thyroid gland hormonal and complete blood parameters in relation to sleep affects.

Materials and Methods

Ethical approval

This study was approved by the Ethical Committee of Research and Ethics at Diyala University, College of Science, according to the document (26 ASJ-Sci 182) on 16 December 2025. Before enrollment in this study, each patient was verbally informed about the concept and aims of this study, and signed patients consent form.

Study Design and Participants

Across sectional study was done on 130 students from Baquba Technical Institute's Diyala/ Iraq. The age groups were ranging from 18 to 25 years (23 ± 2 years old Participants were divided according to hours of sleep as follows: Males and females' groups with good sleep quality (≥7 hours per night); and males and females' groups with poor sleep quality (<6 hours per night). A control group was selected from both healthy males and females.

Inclusion and Exclusion Criteria

The research selected students be believed to be in good health and were within the specified age range. The study excluded participants with known chronic illnesses, thyroid diseases, hematological disorders, or those on drugs that might alter thyroid function or blood parameters.

Sample Collection and Laboratory Analysis

Five milliliters of blood samples were collected from every participant aseptically. The blood sample was divided into two parts: 2 milliliters kept in EDTA tubes for red blood cells (RBCs) and total white blood cells (WBCs) count, and 3 milliliters kept in gel tube for serum separation after centrifuging at 3000-4000 rpm/ min for 10 minutes.

Thyroid Hormone Measurement

Thyroid hormone levels were measured using serum samples and standard laboratory immunoassay procedures .Serum free triiodothyronine (T3), free thyroxin (T4) , and thyroid stimulating hormone (TSH) levels measured by using commercially available enzyme – linked immunosorbent assay ,according to the manufacturer's instructions (ELIZA) Kit -Bio Legend -USA(22).

Complete Blood Count

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Automated hematology analyzer (CELL-DYN Ruby Hematology Analyzer, Abbott Diagnostics, USA) was used to analyze complete blood count results.

Statistical Analysis

Using an appropriate statistical software, statistical analysis was carried accordingly. The data was expressed as mean ± SD. Within each gender, independent t-tests were applied to compare the differences between the groups with beneficial and bad sleep. In addition, the interaction between gender and sleep quality on hematological and thyroid parameters has been investigated with two-way analysis of variance (ANOVA). A p-value was considered statistically significant if it was less than 0.05 (23).

Results

The effect of sleep deprivation on some blood parameters proved to be positively correlated with sleep duration (SD) and red blood cell count, (Table.1). Men who had poor sleep had significantly lower levels of Hb (13.2 ± 0.8) g/dl and PCV (40.1 ± 0.7) compared with control group (14.8 ± 0.36) g/dl and (47.1 ± 1.2), while the total WBC count (7.850 ± 0.63), T4 (1.9 ± 0.42), and TSH (2.43 ± 0.82) compared with control group (1.6±0). However, in comparison with the control group, RBCs, platelets (PLTs), and T3 did not differ significantly (p > 0.05).

Table. 2 indicates that the effects of insufficient sleep on certain blood parameters were observed in women whose total WBC count (8.514 ± 0.72), T4 (2.04±0.23), and TSH (2.38±0.8) were significantly higher compared to individuals of the control group (7.850± 0.55), (1.54±0.22), and (1.84±0.71), respectively. T3, PLTs, and RBCs did not differ substantially from the control group (p > 0.05).

Table. 1: Associations between sleep duration and some of blood parameters and thyroid hormones in men

Parameters	**Low quality sleep group N (45)**	**Normal sleep group N (20)**	**P-value**
	Mean ± S.D		
total WBC (cells/µL)	7.850 ± 0.63	6.523 ± 0.42	S*
RBCs(cells/µL)	5.051± 0.09	5.433± 0.10	NS
Hb (g / dl)	13.2 ± 0.8	14.8 ± 0.36	S*
P.C.V %	40.1±0.7	47.1 ± 1.2	S*
PLT	266±9.67	275.22± 11.0	NS
T3 (pg/ml)	2.75±0.23	2.55±0.6	NS
T4 (ng/dl)	1.9±0.4	1.6±0.77	S*
TSH , (µIU / ml)	2.43 ± 0.82	1.86 ± 0.74	S*

S: Significant Different (p<0.05) Ns: Non- Significant Differences

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Table. 2: Associations between sleep duration and some blood parameters and thyroid hormones in women.

Parameters	Low quality sleep group N (45)	Normal sleep group N (20)	P-value
	Mean ± S.D		
Total WBC (cells/µL)	8.514 ± 0.72	7.850± 0.55	S*
RBCs(cells/µL)	4.487± 0.09	4.521± 0.10	NS
Hb (g/dl)	11.211 ± 0.5	12.8 ± 0.29	S*
P.C.V %	38.2±0.6	41.1 ± 1.12	S*
PLT	308.692±13	287.642±11	NS
T3 (pg/ml)	3.33±0.41	3.19±0.28	NS
T4 (ng/dl)	2.04±0.23	1.54±0.22	S*
TSH (µIU/ml)	2.38±0.8	1.81±0.71	S*

S: Significant Different, (p<0.05)   Ns: Non Significant Differences

Discussion

The results of the current study revealed high WBC counts that were associated with varied sleep duration. Remarkably, these correlations persisted even after regulating for confounders, indicating an independent connection link circulating immune cells and free-living sleep varied regularity that is obvious even at pre-clinical levels (24).This raises the intriguing theory that irregular sleep-wake cycles may permanently weaken the immune system, which, if persistent over time, may promote the onset and spread of illness. The strong correlation between high WBC count, one of the inflammatory indicators, and sleep quality may be resulting from a number various reaction. The primary effector systems involve in sleep and inflammatory responses are the hypothalamic-pituitary-adrenal (HPA) and sympathetic nervous system (SNS) (25). Vagal outflow, or a change from sympathetic to parasympathetic nervous system activity, corresponds with a significant drop in SNS activity during sleep (26). When sleep disorders occur, the nightly decline in SNS activity is delayed, leading to an overall increase in SNS activity throughout the night, and these changes persist into the day (26). In addition to heightened levels of circulating noradrenaline and adrenaline, which are linked to raise levels of inflammatory markers, individuals with insomnia also have enhanced sympathetic outflow (27). HPA affects not just SNS but also the networks connecting inflammatory indicators and sleep. The HPA axis is activated when sleep disruptions occur. Thus, glucocorticoid-resistant immune cells may be produced as a result of recurrent stimulation of the HPA axis. Therefore, individuals with sleep issues have both inflammation and activation of the HPA axis (28). The results of the current study showed lower total WBC mean in males than females, with a significance statistical difference ($p < 0.05$). This result is comparable to the study conducted in the Brazil (29) but identical to studies conducted in the African nation of Mali, Ghana, Nigeria, and the USA . As a result of erythropoietin release in response to normal menstruation and cross-

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stimulating megakaryopoiesis, these differences in reference range may be described by changes in the kinds of hormones generated and their concentrations in the sexes (30).

The results of this research indicated an important decrease ($p<0.05$) in both Hb concentration and %PCV in exhausted participants; this decrease was consistent with the findings of (29), which showed a significant reduction in Hb concentration. Due to adrenergic-spleno expansion during stress, sleep-deprived respondents' %PCV was lower than that of control subjects. Short-term light exposure, however, significantly increased the level of PCV in male rats (31).In addition, this study examined the association between thyroid function and sleep quality. Studies shows a relationship between an individual's degree of stress and their thyroid-stimulating hormone (TSH) levels in connection to the quality of their sleep. Insufficient sleep may have impacted cognitive function and other aspects of life (32). Sleep and thyroid function have been associated in several animal model studies. Poor sleep may be a risk factor of the development of cardiovascular disease, according to (33). They suggested that further studies be conducted to examine the relationship between hormonal variations and sleep deprivation. Night shift workers are susceptible to subclinical hypothyroidism and elevated TSH, according to (34). T3, T4, and TSH levels have been observed to be elevated in those with poor sleep quality by (35). In accordance with (36), elevated brown adipose tissue (BAT) thermogenesis, which is brought on by thyroid hormone and sympathetic activation, may be at least partially responsible for the rise in energy expenditure that occurs when rats are sleep deprived. Thyroxine (T4) and thyroid stimulating TSH were shown to be significantly high in individuals with poor of sleep quality, compared to another study by (37). Furthermore, they discovered strong correlations between poor sleep conditions and stress score, free thyroxine (FT4), and sleep score, suggesting that poor sleep quality had an adverse effect on thyroid hormones. Both higher and lower sleep durations were associated with an increased risk of subclinical thyroid dysfunction, as demonstrated by (38).who further identified a link between short sleepers and subclinical hypothyroidism. According to (30), thyroid hormone levels rose during a brief period of complete sleep deprivation due to an up-regulation of pituitary-thyroid activity. Lack of sleep dramatically raises blood pressure, stress hormone release, and cardiac contractility, according to (39). In contrast, acute brief sleep restriction increases in the levels of thyroid hormone and blood TSH. According to (39), the function of the human thyroid can be impacted by frequent sleep restriction, which is consistent with the short sleep duration of an increasing number of individuals in daily life.

Conclusion

This study shown that decrease sleep is associated with significant alterations in immune, hematological, and hormonal parameters among university students. An increase in WBCs count alongside reduced hemoglobin and packed cell Volume suggest mild inflammatory response and impaired hematological status, In addition, elevated of T4 and TSH indicate a possible disturbance in the hypothalamic pituitry thyroid axis

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Declarations

Acknowledgment

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Ethics statement

The author confirms that this research follows the journal's attached Ethics Approval guidelines, as appearing on the journal's author guidelines page.

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Interest of Competing

Authors declare no conflict of interest.

Author contributions

RNA. Conception and design of the work ; acquisition, analysis, and interpretation of data; drafting the work and revising it critically for important intellectual content.

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