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THE IMPACT OF IMPROPERLY ILLUMINATED WORK ENVIRONMENTS ON HUMAN NERVOUS SYSTEM ACTIVITY AND VISUAL ACUITY

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Abstract:

This scientific article analyzes the impact of improperly illuminated work environments on human health, particularly on nervous system activity and visual acuity. Lighting level is one of the key factors of occupational hygiene, and insufficient illumination can lead to cognitive fatigue, visual strain, stress, and neurophysiological dysfunction. The article examines visual fatigue caused by inadequate illumination, disturbances of the melatonin rhythm, and declines in brain activity. Based on the abstract, the article is structured in alignment with SanPiN, EN 12464-1, and WHO recommendations.

Keywords: Lighting, nervous system, visual acuity, hygiene, lux meter, visual fatigue, cognitive stress, work environment, ergonomics, melatonin, lighting standards.

INTRODUCTION. In modern industrial, office, and educational environments, one of the most critical components of human–environment interaction is the quality of lighting. Lighting conditions not only ensure visual comfort but also exert significant influence on the nervous system and physiological functions. Light participates not only in visual perception but also affects non-visual pathways (through intrinsically photosensitive neurons), modulating melatonin secretion, circadian rhythms, cardiovascular function, and neuroactivity.

Numerous studies have demonstrated that visually uncomfortable, insufficient, inappropriate, or flickering lighting conditions are associated with visual fatigue, decreased contrast sensitivity, and impaired visual performance. For instance, the article titled *"Influence of Lighting on Visual Performance"* shows that different lighting regimes significantly affect visual efficiency, reducing task performance.

Furthermore, limitations in the spectral composition of modern LED lighting systems may negatively affect mitochondrial activity and cellular energy processes. Excessive short-wavelength components of LED lamps may create additional strain on both visual and non-visual systems.

Through visual and non-visual pathways, light triggers a range of physiological cascades. Intrinsically photosensitive retinal ganglion cells (ipRGCs) transmit light signals to the suprachiasmatic nuclei, playing a crucial role in circadian regulation. Differences in light intensity and color temperature have also been shown to influence heart rate, electrodermal activity, and neuroactivity.

Unstable or improperly selected lighting regimes may negatively affect long-term occupational health, productivity, and human resource sustainability. For this reason, human-centric lighting systems remain a key topic of discussion in offices, factories, and educational institutions.

This article aims to identify how improperly illuminated work environments influence the nervous system and visual acuity, via which mechanisms this impact occurs, and what feedback interactions are involved. Additionally, based on existing scientific research and published data, recommendations for optimizing lighting conditions are proposed.

MATERIALS AND METHODS.

Literature review: Fifteen international and local sources were analyzed in the preparation of this article, including PubMed, ScienceDirect, WHO, ILO Encyclopaedia, Apollo Hospitals, Ziyonet, Arxiv.uz, and others. Each source presents scientific evidence regarding the relationship between lighting levels, nervous system activity, and visual acuity.

Analysis of scientific articles: Research published on PubMed, ScienceDirect, and IEEE Xplore platforms was reviewed. The methodologies, measurement criteria, and outcomes of experimental studies were compared. Indicators such as visual fatigue, melatonin rhythm disruption, stress level, and visual strain were used for analytical conclusions.

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Comparative analysis: Lighting standards outlined in EN 12464-1, GOST 12.1.046-85, and the national document Lex.uz No. 486 were compared. Differences between local (SENDI laboratories) and international (WHO, ILO) approaches were evaluated. Methods used for hygienic assessment of lighting in medical institutions were examined comparatively.
Methodological approach: The article was written using a theoretical-analytical method. Although statistical analysis was not conducted directly, statistical indicators provided by authors (e.g., stress indices, visual fatigue scores) were incorporated. The structure of the article is based on regulatory documents, experimental findings, and hygienic assessment methodology.

RESULTS. Based on the analysis of scientific literature, it was determined that the level of illumination in the work environment has a direct impact on human health, particularly on the activity of the nervous system and visual acuity. In poorly lit environments, neurophysiological activity of the central nervous system declines, leading to reduced attention, slower reaction time, and increased cognitive fatigue. Insufficient lighting may elevate stress hormone levels, disrupt sleep rhythms, and cause autonomic imbalance. The sensitivity of neurons and neuroglia to light impulses defines their functional state, confirming that the activity of the nervous system is highly dependent on lighting conditions.
Research related to visual acuity demonstrates that in dimly lit environments, visual clarity decreases, contrast sensitivity declines, and ocular strain and visual fatigue increase. Workers exposed to spectrally inadequate lighting conditions exhibit changes in heart rate, cognitive fatigue, and reduced user satisfaction. Employees working under long-term LED illumination report increased visual discomfort symptoms. Local sources confirm that the physiology of the visual organs is directly influenced by lighting conditions. Visual overload not only reduces efficiency but may also cause long-term damage to eye health.
According to hygienic assessment standards, the minimum lighting level in workplaces must not be below 300 lux. European standards state that the illumination level should range from 300 to 750 lux depending on the type of work performed. Both local and international regulations define uniformity, safety, and efficiency criteria for lighting in production environments. Lux meter measurements conducted in numerous institutions revealed lighting levels below hygienic standards, indicating a potential negative impact on visual and nervous system functions.
The influence of lighting on melatonin production, sleep quality, emotional state, and overall health has been scientifically documented. Disruption of melatonin rhythms decreases sleep quality, adversely affecting the nervous system and cognitive performance. Neurobehavioral effects of lighting—including changes in emotional state, motivation, and cognitive activity—have been shown to be directly linked to illumination levels. These factors determine a person's attitude toward work, psychological well-being, and stress resilience.
Individuals working in improperly illuminated environments frequently experience the following symptoms: eye itching, dryness, reduced visual clarity, headaches, rapid fatigue, sleep disturbances, difficulty concentrating, depressive mood, anxiety, and changes in heart rate. These symptoms are strongly associated with insufficient lighting and often result in decreased productivity and long-term health risks.
The relevance of this topic lies in the fact that modern work environments—particularly enclosed indoor spaces—depend primarily on artificial lighting. Negative symptoms related to lighting are increasingly observed among computer users, healthcare workers, office staff, and industrial employees. This highlights the need to improve hygienic assessment systems, enforce lighting standards, and ergonomically optimize the work environment.
A number of pharmacological and hygienic measures are available for prevention and symptom relief. Artificial tear eye drops, B-group vitamins (especially B6 and B12), melatonin modulators, and adaptogens such as *Eleutherococcus* and ginseng are recommended for reducing visual fatigue. Additionally, ensuring adequate workplace illumination, eye-rest exercises, optimal screen distance, and maximizing natural light are important hygienic strategies.
Modern approaches addressing lighting ergonomics, visual comfort, and eye health have also been proposed. An ergonomically inadequate lighting system negatively affects not only visual organs but also overall work productivity. The placement of light sources, distribution of illumination, and spectral composition are crucial factors for eye health. Local literature provides theoretical foundations regarding the hygienic importance of lighting, types of natural and artificial illumination, physiology of the visual organs, and sanitary-hygienic requirements.
Comparative analysis revealed notable differences between local and international lighting standards. Indicators defined in EN 12464-1 and GOST were compared, and lux meter assessments conducted in local institutions showed lower levels than international norms. Visual fatigue and nervous system disturbances were more frequently observed among workers exposed to inadequate lighting conditions. This underscores the necessity of hygienic evaluation and optimization of the work environment. Furthermore, mismatch between lighting levels and work type, improper placement of light sources, and spectral

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imbalance may negatively affect visual and nervous system functions. These findings emphasize the importance of considering hygienic, ergonomic, and physiological requirements in the design of lighting systems.

DISCUSSION. The hygienic significance of lighting levels in the work environment has been confirmed by numerous scientific studies, demonstrating its direct influence on human health, work productivity, and psychophysiological state. Based on the literature reviewed in this article, the neurophysiological, visual, and hygienic aspects of lighting were analyzed comprehensively. Studies focusing on its effects on nervous system activity (ILO Encyclopaedia, WHO, Apollo Hospitals) report that low illumination disrupts melatonin rhythms, increases stress hormone levels, reduces attention, and intensifies cognitive fatigue. For example, a WHO observational study conducted in 2020 found that workers in poorly lit environments experienced impaired sleep quality and emotional instability. Clinical observations from Apollo Hospitals indicate that light impulses influence neuronal activity, contribute to autonomic imbalance, and decrease motivation levels.

Studies on visual acuity and visual fatigue (PubMed, ScienceDirect, IEEE Xplore) confirm that insufficient lighting increases ocular strain, reduces contrast sensitivity, and diminishes visual clarity. In an experiment conducted by Lee et al. (2020), insufficient illumination in screen-based work environments intensified visual discomfort, headaches, and rapid fatigue. Kim et al. (2019) reported altered heart rate and reduced cognitive performance under LED lighting conditions.

A comparison with regulatory documents shows that Lex.uz Resolution No. 486, GOST 12.1.046-85, and EN 12464-1 establish minimum and optimal lighting standards. Practical assessments conducted by SENDI laboratories (2022) revealed that lighting levels in many institutions fall below hygienic requirements. These findings have been cited in this article. The differences between local and international approaches were considered through comparative analysis. Local sources (Ziyonet, Arxiv.uz) provide theoretical foundations on natural and artificial lighting, physiology of visual organs, and sanitary-hygienic requirements, while international literature offers statistically supported data on the neurobehavioral and visual effects of lighting.

Regarding preventive measures and hygienic recommendations, Chen et al. (2021) suggest the use of artificial tear drops, B-group vitamins, melatonin modulators, and adaptogenic preparations to reduce visual fatigue. Ivanova et al. (2018) emphasize the importance of maintaining adequate workplace illumination, performing eye-relaxation exercises, and maximizing natural light as effective hygienic measures. Ergonomic approaches presented in *Nature Neuroscience* and *SpringerLink* highlight experimental findings regarding the placement of lighting sources, spectral composition, and distribution characteristics, which significantly affect eye health. These approaches were integrated into the article as theoretical foundations.

Overall, the analysis confirms that the hygienic assessment of lighting is a critical factor not only from a technical standpoint but also in terms of human health and work efficiency. The regulatory documents, scientific sources, and empirical evidence presented in this article collectively support a comprehensive approach to addressing lighting-related challenges.

CONCLUSION.

1. Based on the scientific sources reviewed, it was determined that illumination level is an essential physiological factor for nervous system activity and visual acuity. Insufficient illumination may lead to cognitive fatigue, decreased attention, melatonin rhythm disruption, and visual strain.
2. Findings reported by experimental researchers (ILO Encyclopaedia, WHO, PubMed, ScienceDirect) indicate that workers exposed to low illumination exhibit elevated stress hormone levels, reduced sleep quality, and increased visual discomfort symptoms. These results were incorporated into the theoretical analysis presented in this article.
3. Problems associated with visual acuity—particularly among screen-based workers—have been experimentally confirmed to be linked to inadequate illumination. Reduced contrast sensitivity, ocular strain, and rapid fatigue are strongly associated with the spectral composition and ergonomic characteristics of the lighting environment.
4. National and international regulatory documents — Lex.uz Resolution No. 486, GOST 12.1.046-85, and EN 12464-1 — outline the minimum and optimal illumination levels. Lux meter assessments conducted by SENDI laboratories demonstrate that lighting levels in some institutions fall below hygienic standards, emphasizing the need for stronger sanitary supervision.
5. Optimizing the lighting environment, ensuring proper visual ergonomics, and designing task-appropriate lighting systems are among the priorities of modern occupational hygiene. Preventive measures such as eye-relaxation exercises, utilization of natural lighting, spectral balance management, and adherence to hygienic recommendations are strongly encouraged. Future research should focus on statistical monitoring of illumination levels, spectral analysis, visual ergonomics, and development of practical recommendations for task-specific lighting systems. Such an approach will

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provide a comprehensive, scientifically grounded perspective on lighting-related challenges.

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