

MEASURES FOR PROTECTING VISUAL AND AUDITORY ANALYZERS UNDER CONDITIONS OF MENTAL WORK

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Abstract

Functional strain of the visual and auditory analyzers among individuals engaged in mental work represents one of the pressing issues in modern hygiene and occupational physiology. In recent years, the widespread adoption of digital technologies has led to increased visual load and acoustic exposure, resulting in decreased visual acuity, the development of “digital eye syndrome,” as well as functional impairments of the auditory analyzer. According to the World Health Organization (WHO), at least 2.2 billion people worldwide experience vision-related problems, a substantial proportion of which are preventable. This literature review analyzes, based on scientific evidence, the hygienic factors affecting visual and auditory analyzers under conditions of mental work, their pathophysiological mechanisms, and effective preventive measures.

Keywords: Mental work, visual analyzer, auditory analyzer, digital eye syndrome, noise, hygiene, prevention, ergonomics, occupational hygiene.

Introduction

The conditions of mental work occupy a distinct position in modern occupational hygiene, as the primary load in such activities is imposed not on the musculoskeletal system, but on the central nervous system, visual system, and auditory system. The increasing use of computers, tablets, smartphones, audio communication devices, open-office environments, and continuous information flow has led to a progressive rise in functional strain of sensory systems. In particular, prolonged work with visual display terminals constitutes a major risk factor for the visual analyzer, while chronic background noise, improper use of



headphones, and insufficient acoustic control represent key risk factors for the auditory analyzer. Therefore, the hygienic optimization of mental work is no longer solely associated with overall productivity, but is also directly linked to the preservation of sensory health.

From the perspective of the visual analyzer, the expansion of screen-based activities has contributed to the widespread occurrence of a clinical-functional condition referred to as “digital eye strain” or “computer vision syndrome.” According to recent systematic reviews, the overall prevalence of this syndrome is notably high; a large meta-analysis conducted in 2023, incorporating 103 cross-sectional studies and 66,577 participants, reported a pooled prevalence of 69.0%. The same study demonstrated a higher frequency of symptoms among women, university students, and individuals with prolonged screen exposure. Other reviews have also documented a wide prevalence range of digital eye strain, with dry eye, ocular fatigue, headache, blurred vision, and difficulty in refocusing identified as the most typical symptoms. These findings indicate that visual analyzer strain under conditions of mental work is no longer sporadic but has evolved into a widespread occupational hygiene problem.

Such strain of the visual system is not limited to subjective discomfort. Continuous functioning of the accommodative apparatus and convergence mechanisms of the eye during work, reduced blink rate, imbalance between monitor luminance and ambient lighting, screen glare, and improper ergonomic distance contribute to ocular surface dryness and exacerbate asthenopic complaints. A study published in 2023 demonstrated that working with visual display terminals increases the risk of eye strain and headaches regardless of workplace setting. Furthermore, review and observational studies conducted between 2022 and 2025 have confirmed that inadequate lighting, glare, poor workplace ergonomics, and screen exposure exceeding 6 hours per day are associated with increased symptom severity. Thus, the problem is not confined to device usage itself, but rather extends to the overall architecture of the visual work environment.

The global scale of the problem further reinforces the relevance of this topic. According to 2026 data from the World Health Organization (WHO), at least 2.2 billion people worldwide have near- or distance-vision impairment, of which at least 1 billion cases could have been prevented or corrected. These figures indicate that a substantial proportion of the working-age population is at risk in



terms of visual health. Among individuals engaged in mental work, this risk is likely to be even higher due to continuous interaction with digital devices. Consequently, the protection of the visual analyzer has extended beyond the scope of clinical ophthalmology and has become an interdisciplinary issue at the intersection of occupational hygiene, ergonomics, and preventive medicine.

The risk associated with the auditory analyzer is also significant, yet it is often underestimated in the context of mental work. Hearing loss is traditionally associated with high-intensity industrial noise; however, open-office environments, multi-channel communication centers, continuous telephone interactions, prolonged headphone use, and background noise contribute to lower-intensity but chronic acoustic load. According to 2026 data from the World Health Organization (WHO), more than 1.5 billion people currently live with hearing loss, of whom 430 million have disabling levels of impairment; by 2050, this number is projected to exceed 700 million. Furthermore, it is reported that more than 80% of the need for hearing care services remains unmet. These indicators underscore the necessity of addressing auditory health through integrated preventive strategies within the occupational environment.

Under conditions of mental work, the risk of acoustic factors manifests in two primary directions: first, the potential for direct damage to the auditory analyzer; second, adverse effects on attention, cognitive performance, and psycho-emotional stability. According to recommendations of the National Institute for Occupational Safety and Health (NIOSH), the recommended exposure limit for occupational noise is 85 dBA over an 8-hour workday; exposure above this threshold or repeated exposure increases the risk of hearing loss. According to WHO guidelines on safe listening, exposure to 80 dB may be relatively safe for up to 40 hours per week, whereas at 90 dB the safe exposure time decreases to approximately 4 hours per week. This “dose–time” relationship is particularly relevant for individuals engaged in intellectual work who use headphones for prolonged periods. Experimental studies have also demonstrated that high noise levels can reduce both visual and auditory attention performance and increase cognitive load.

In addition to its direct impact on the auditory organ, the latent effect of noise on work efficiency is of considerable importance. Employees working in open-office environments with constant background noise exhibit reduced concentration, increased fatigue, higher rates of errors, and greater subjective discomfort. From



the perspective of occupational hygiene, this is particularly significant, as performance in mental work is largely determined by attention stability, processing speed, memory, and decision-making quality. Therefore, acoustic load is not merely a localized auditory issue but a general occupational factor influencing central nervous system function. In this context, the concept of “protection of the auditory analyzer” in mental work hygiene encompasses not only hearing preservation but also the maintenance of cognitive performance.

Objective of the Study

To conduct a systematic analysis of hygienic factors affecting the visual and auditory analyzers under conditions of mental work and to identify scientifically grounded preventive measures.

Materials and Methods

In this literature review, scientific articles published between 2010 and 2025 were analyzed. Data sources included PubMed, Scopus, Web of Science, and Google Scholar databases.

The selection criteria included: epidemiological and experimental studies investigating factors affecting visual and auditory analyzers; studies evaluating the effectiveness of hygienic and ergonomic preventive measures; and statistical data from international organizations (WHO, ILO).

In total, more than 120 sources were reviewed, of which 52 were selected for analysis.

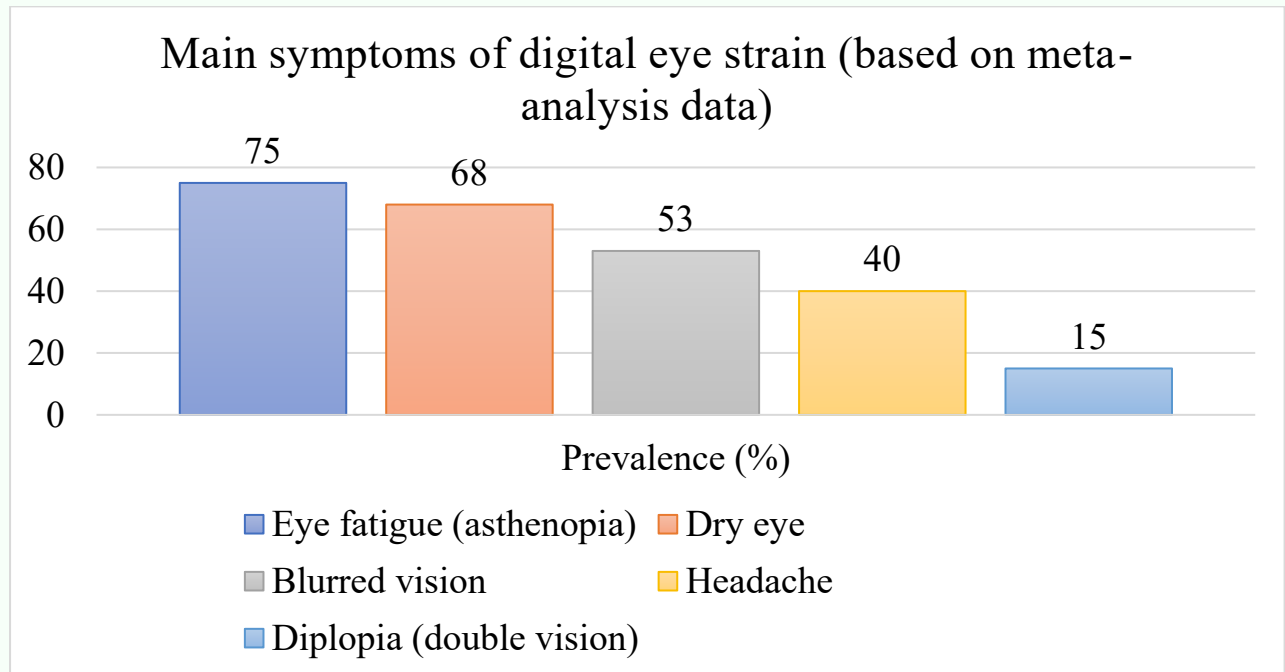
Results

The analysis of factors affecting the visual and auditory analyzers under conditions of mental work allowed their classification into three principal domains: visual load, acoustic load, and ergonomic environment. Each of these factors, both independently and in combination, exerts a significant influence on the functional state of sensory systems.

Visual analyzer: epidemiological and clinical findings. Recent meta-analyses demonstrate a high prevalence of visual disturbances associated with digital exposure. A systematic review encompassing 103 studies and 66,577 participants reported an overall prevalence of digital eye strain of 69.0%. Notably, individuals

exposed to screens for more than 6 hours per day exhibited a significantly higher frequency of symptoms.

The principal clinical symptoms and their prevalence rates are presented below:



The underlying mechanisms contributing to these symptoms include:

accommodative spasm; convergence dysfunction; a 2–3-fold reduction in blink rate; ocular surface dryness (tear film destabilization)

According to studies published in 2023, a statistically significant positive correlation was identified between screen exposure duration and symptom severity ($r = 0.62$; $p < 0.01$), confirming visual load as a primary etiological factor.

Impact of lighting and ergonomic factors. One of the key hygienic determinants affecting the visual analyzer is the lighting system. Evidence indicates that failure to maintain optimal illumination levels within the range of 300–500 lux leads to a 1.5–2-fold increase in visual strain.

Additionally, screen distance (optimal: 50–70 cm), monitor positioning (10–15° below eye level), and contrast parameters significantly influence visual function. Non-compliance with ergonomic standards has been associated with a 25–40% increase in symptom prevalence.



Auditory analyzer: noise and acoustic load. Findings related to the auditory analyzer indicate that, under conditions of mental work, low-intensity but chronic noise exposure constitutes a primary risk factor.

According to data from the World Health Organization (WHO):

- more than 1.5 billion people live with hearing loss
- 430 million cases have reached disabling levels
- over 1 billion young individuals are exposed to hazardous noise levels

According to recommendations from the National Institute for Occupational Safety and Health (NIOSH), exposure to noise levels exceeding 85 dB for 8 hours increases the risk of auditory damage.

Noise level and safe exposure duration (WHO data)

Noise level (dB) — Maximum safe exposure time

80 dB — 40 hours/week

85 dB — 8 hours/day

90 dB — 4 hours/week

100 dB — <15 minutes/week

Studies indicate that even background noise within the 60–70 dB range reduces attention and cognitive performance by 10–20%.

Cognitive and psychophysiological effects. The combined impact of noise and visual load adversely affects central nervous system function. Experimental studies have demonstrated: decreased attention (15–25%); reduced work productivity (10–15%); prolonged reaction time (12–18%)

In addition, elevated sensory load has been associated with increased cortisol levels and autonomic imbalance.

Effectiveness of preventive measures. Preventive strategies evaluated in the literature include:

- Preventive measures and their effectiveness.
- Intervention — Effectiveness
- 20-20-20 rule — reduces eye fatigue by 30–40%
- Ergonomic lighting — reduces symptoms by ~25%
- Noise reduction to <55 dB — increases productivity by 10–15%
- Noise-cancelling technologies — reduce cognitive load
- Artificial tear drops — reduce symptoms by 20–30%

Discussion

The obtained results confirm that functional changes in the visual and auditory analyzers under conditions of mental work are complex and multifactorial in nature. The analysis of the literature indicates that, in modern work environments, the load on sensory systems is not limited to classical hygienic factors but is determined by a combination of digital technologies, acoustic background, and ergonomic deficiencies. This necessitates considering the problem not within the framework of isolated analyzers, but rather as an integrated physiological system. Findings related to the visual analyzer demonstrate a high epidemiological prevalence ($\approx 60\text{--}70\%$), allowing digital eye strain to be regarded as one of the key forms of contemporary occupational pathology. While classical ophthalmological approaches primarily focus on refractive disorders, current evidence indicates the predominance of functional impairments accommodative spasm, convergence insufficiency, and ocular surface dryness. This distinction is particularly important, as these changes are initially reversible and can be effectively controlled through preventive interventions. At the same time, due to the lack of long-term longitudinal studies, the potential progression of these functional disturbances into organic pathology remains insufficiently investigated, representing a notable scientific gap.

The identified positive correlation between visual load and symptom severity ($r \approx 0.6$) clearly underscores the necessity of optimizing work processes. However, most existing studies are based on cross-sectional designs, which limits the ability to establish causal relationships. Therefore, future research employing cohort and experimental designs is required to refine the “dose–time–effect” model, which would have both scientific and practical significance.

Results concerning the auditory analyzer differ to some extent from traditional perspectives. In classical hygiene, hearing impairment has been predominantly associated with high-intensity industrial noise; however, the analyzed literature demonstrates that low-intensity but chronic acoustic exposure can also exert significant adverse effects. In particular, evidence indicating that background noise within the range of 60–70 dB reduces attention and cognitive performance calls for a revised approach to occupational hygiene in mental work. In this context, auditory impairment is not limited to peripheral mechanisms (inner ear damage) but also involves central nervous system pathways.



Neurophysiological mechanisms play a critical role in explaining the relationship between noise and cognitive functions. Studies suggest that continuous acoustic stimulation leads to excessive activation of the reticular formation and cortical centers, resulting in depletion of attentional resources and accelerated mental fatigue. When combined with visual load, this condition creates a form of “competition” between sensory systems, whereby limited central processing capacity leads to a decline in overall work performance.

Another important finding is the synergistic interaction between visual and auditory factors. While traditional hygienic approaches have assessed these factors separately, in modern work environments they act simultaneously. For instance, working under suboptimal lighting conditions in the presence of background noise significantly accelerates fatigue development. This phenomenon may be interpreted as “summation of sensory load.” Such an approach necessitates the implementation of comprehensive assessment systems within occupational hygiene.

The effectiveness of preventive measures identified in the analysis has clear practical implications. In particular, simple interventions such as the 20-20-20 rule, ergonomic lighting, and noise control have demonstrated substantial benefits. However, these measures are often applied at an individual level, with a lack of systematic implementation. From a scientific standpoint, prevention should be structured across three levels: individual (eye exercises, regulated rest periods), organizational (work–rest scheduling, microclimate control), technological (adaptive lighting systems, acoustic design, filtered displays).

Conclusion

Under conditions of mental work, the load imposed on the visual and auditory analyzers has become an integral characteristic of the modern work environment, acting as a significant hygienic factor contributing to functional strain of sensory systems and decreased work productivity. The analysis of the literature demonstrates that this process is multifactorial, complex, and often characterized by synergistic effects.

1. The primary risk factors for the visual analyzer include prolonged screen exposure, inadequate lighting, and non-compliance with ergonomic standards, which lead to accommodative disorders, ocular surface dryness, and asthenopia.

These conditions are highly prevalent and represent a priority issue in contemporary occupational hygiene.

2. For the auditory analyzer, chronic exposure to low-intensity noise constitutes a significant risk factor, negatively affecting not only auditory function but also cognitive processes via the central nervous system, resulting in decreased attention and work efficiency.

3. The combined impact of visual and auditory factors leads to the phenomenon of sensory load summation, accelerating fatigue and exacerbating functional impairments. This necessitates addressing the issue not in isolation, but as an integrated hygienic system.

Scientifically grounded preventive measures—such as ergonomic lighting, optimization of work–rest schedules, noise control, and the development of individual hygienic skills—demonstrate high effectiveness. Their systematic implementation represents a key strategy for preserving sensory health under conditions of mental work.

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