

An AI-Driven Micro-Randomized Intervention Framework for Reducing Digital Eye Strain and Dizziness during Prolonged Screen Use

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Abstract

Extended exposure to digital screens has been associated with an increasing incidence of digital eye strain (DES), dizziness, and visual discomfort. Existing mitigation strategies, such as scheduled breaks and blue-light filtering, are largely static and do not adequately account for individual variations in fatigue response. In this work, an AI-based adaptive system is presented that monitors blink rate patterns, gaze stability, posture-related variations, and screen exposure duration to identify early signs of visual fatigue. When fatigue is detected, a micro-randomized and gamified eye-exercise module provides short, personalized interventions designed to alleviate strain and improve visual comfort. The proposed approach was evaluated through a controlled study involving 100 participants and compared with conventional break-based methods using standardized eye strain and dizziness questionnaires, together with AI-derived fatigue indicators. The findings indicate a measurable reduction in digital eye strain and dizziness, along with improved user engagement and comfort. Variability across participants was observed, suggesting that adaptive and personalized intervention strategies are particularly important for managing prolonged screen use. Overall, the study supports the potential of AI-driven micro-randomized interventions for enhancing visual wellness in screen-intensive environments.

Keywords:- Digital eye strain; Artificial intelligence; Micro-randomized intervention; Eye tracking; Adaptive systems; Human-computer interaction.

1. Introduction

The past years are characterized by the global increase in the usage of computers, laptops, tablets, and smartphones. A report by Statista (2025) indicates that a typical person spends more than 7-10 hours a day in front of digital screens at their jobs, school, or leisure. As much as technology has allowed people to be productive and connected, extended screen time has also become a source of eyewear strain or digital eye strain or computer vision syndrome. DES is characterized by eye discomfort, dryness, blurred vision, headaches, neck and shoulder pain, and dizziness, which have

become common among people who spend more time on digital screens in the course of work or study (Sheppard and Wolffsohn, 2018).DES and dizziness are not rare phenomena seen in individuals who spend more hours in front of digital screens working or studying (Sheppard and Wolffsohn, 2018). Blurred vision, eye fatigue, headaches, and periodic dizziness are some of the symptoms that could have a major effect on comfort, productivity, and overall well-being. Although there are some commercial options, including Night Shift, True Tone, and generic break reminders, offered by Apple, they offer minimal protection and usually only deal with screen color options or regular alerts and do not deal with the multifactorial factors of strain and discomfort [1].

To mitigate these shortcomings, we offer an AI-based integrated system that will be used to track and prevent digital eye strain and dizziness beforehand. This system is a combination of real time eye-tracking, body language, screen configurations and personalized notifications, to maintain the comfort of the eyes, and continued productivity. Table 1 summarizes the novelty in our approach compared with the solutions that exist.

Some of the symptoms that include blurred vision, fatigue of the eye, headache, and some dizziness could contribute greatly to comfort and productivity as well as well-being. Although there are a few commercial solutions, e.g., Apple Night Shift, True Tone, and generic break reminders, each of them only partially protects against the problem, focusing only on screen coloring or schedule reminders, but does not consider the multifactorial nature of the strain and discomfort phenomenon [2].

To resolve these shortcomings, we suggest an AI-based integrated solution that will allow tracking and preventing digital eye strain and dizziness beforehand. This system is a combination of real time eye-tracking, body language, screen configurations and personalized notifications, to maintain the comfort of the eyes, and continued productivity. Table 1 provides the summary of the novelty of our solution as compared to the existing solutions [3].

Table 1: Analysis of Existing Eye Fatigue Approaches and Prospective AI Tool

Feature	Existing Solutions	Proposed Tool
Detecting eye strain.	Adjusts the brightness of colors and displays reminders to rest.	Real-time tracking of eyes, eye blink observation, gazing fatigue detection, dynamic adjustment of contrast, hue, and font dimension
How to avoid dizziness	Limited indications for motion in VR.	Alignment + screen motions + AI predicting notifications detect early dizziness signals before the user feels uncomfortable.
Integrated intervention	Usually separated services (color customization, break warnings).	Completely integrated AI system that combines eye, posture, device, and motion analytics for diverse users and jobs.
Personalization	Minimal	The adaptive system learns unique user habits and tailors interventions to distinct users and tasks.
Productivity / comfort	Not focused	Focused on retaining visual comfort & efficiency rather than solely lowering strain
Intervention Strategy	Fixed reminders & static rules	Micro-randomized adaptive eye exercises with AI learning

As shown in Table 1, our system provides a comprehensive, proactive, and individualized remedy against eye strain and dizziness in digital devices, to tackle the gaps in the existing tools. With our AI system, in contrast to the available solutions, the user feels mostly comfortable and more productive, since the strain is predicted and prevented before any symptoms are felt.

The proposed AI tool is explored in the given paper with the use of the controlled study, where the change in the measures of DES, dizziness, and comfort/productivity was evaluated prior to the intervention and post-intervention. Through this, we will seek to support AI-aided preventive interventions to digital health problems with evidence.



Fig1.AI-Guided Personalized Interventions for Digital Eye Health

Examples of traditional interventions are:

- Planned rest (20-20-20 rule: take a look every 20 minutes at something that is 20 feet away, look at it 20 seconds)
- Fake-blue-light-filtering-sunglasses.
- Ergonomic ergonomics (positioning of the screens, using lighting)

Though they work to some degree, such interventions are not adaptive and fail to consider the individual differences in the use of screens, conditions at the environment, or the physiological reaction. The fast development of artificial intelligence (AI) gives a chance to develop individual, real-time solutions to minimize DES symptoms and enhance the comfort of the users [4].

The proposed research suggests an AI-based monitoring and intervention system that incorporates:

- I. Eye-tracking through web camera to check the blink rate, gaze pattern and visual fatigue.
- II. Screen adjustment following the brightness, contrast, and text scaling.
- III. Monitoring of posture in order to avoid straining of the neck and dizziness.
- IV. Individual suggestions of breaks and visual training[5].

The study assesses the effectiveness of AI-based intervention in the reduction of eye strain and dizziness, in comparison to standard practices, to present an insight into the optimization of digital health.

2. Literature Review

2.1 Digital eye Strain and Computer vision syndrome.

Digital eye strain (DES) is an issue that impacts more or less 50 to 90 percent of computer users (Rosenfield, 2016). Common symptoms include:

- ✓ Eye discomfort and fatigue
- ✓ Blurred or double vision
- ✓ Headaches and dizziness.
- ✓ Dry eyes and irritation

Extensive screen time distorts blinking, decreases the stability of the tear film, and causes surface ocular stress, which results in discomfort (Sheppard and Wolffsohn, 2018).

2.2 Existing Interventions

Having stated that, ophthalmologists recommend the 20-20-20 rule but not everyone follows it.

- **Blue-Light Filters:** Have the negative effect of minimizing phototoxicity, but not strain of long-term focus.
- **Ergonomics:** Correct screen distance, lighting and posture are assistive but these can only be static.

2.3 Health Monitoring AI-Based Solutions.

Recent research proves that AI can be used in individual health interventions:

Al Ahmad et al. (2023) created AI-powered monitoring systems where webcam data can be used to identify visual fatigue to demonstrate better symptom reduction. Both computer-vision and wearable systems can monitor eye movements, gaze, and posture which, in turn, provides real-time corrective recommendations[6].

2.4 Research Gap

The majority of AI uses are devoted to general health or gaming ergonomics, and little is done in terms of real-time, adaptive interventions of DES in work or study settings. This paper fills such a gap by combining eye-tracking, adaptable screen changes, and posture tracking into an all-in-one AI solution[7].

3. Problem Statement

The rising use of digital devices has caused a massive occurrence of digital eye strain (DES), blurred vision and dizziness amongst students, professionals and distant employees. Conventional solutions like periodic breaks, blue-light filters, and adjustable-seat positions are fixed and not personalized, and in most cases they do not change according to the usage trends, atmospheric conditions, and physiological changes. This will lead to chronic pain, low productivity, and chronic eye illness[8].

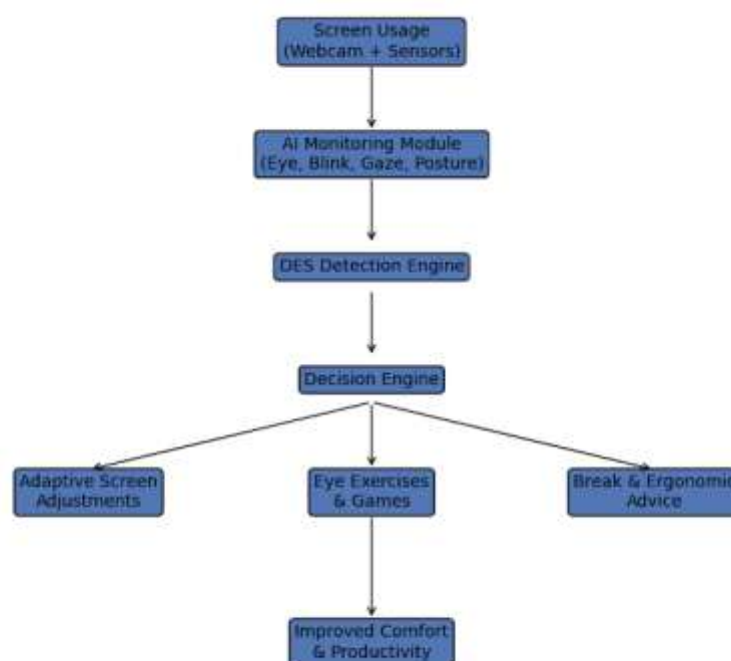
In order to fill this gap, we must have an adaptive and AI based solution that constantly monitors visual fatigue, blink rates, gaze patterns, and posture, and provides real-time interventions to decrease eye strain and dizziness.

4. Research Objectives

The main focus of the study is to determine how effective an AI-powered system can become to reduce the instances of digital eye strain and dizziness. The targeted purposes are:

- Create an AI-powered monitoring system that can track eye movements, blink rates, and gaze pattern in real time and identify early indicators of digital eye strain.
- Adaptive screen adjustments, such as brightness, contrast, and font size, will be implemented in real time dependent on individual user needs and levels of visual fatigue.

- Monitor user height and adaptive behavior to avoid dizziness, neck fatigue, and height-related pain during continuous screen exposure.
- To assess the efficacy of AI-based interventions versus traditional break-based strategies for minimizing digital eye strain, feeling dizzy, and visual discomfort. To make personalised recommendations for ideal break scheduling and visual health control based on user usage & fatigue patterns.
- To create and implement an artificially intelligent eye exercise and gamified mental treatment module that offers individualized eye workouts and participatory eye exercise activities when digital eye strain has been identified, with the goal of enhancing visual wellness, user involvement, and long-term eye comfort.



Flow diagram of research objectives

5. Hypotheses

H1: AI-based interventions can significantly decrease the symptoms of digital eye strain as opposed to conventional interventions.

H2: Adaptive screens have lessened blurred vision and dizziness when using a screen over a long time.

H3: AI customized recommendations increase user comfort, productivity and overall satisfaction.

H4 : Following the detection of digital eye strain, an AI-powered tailored and gamified eye workout module promotes visual overall health, user participation, and long-term eye comfort.

6. Materials and Methods

6.1 Research Design

This is a micro-randomized adaptive experimental study which aims at testing an AI-mediated personalised eye-exercise and gamified mental wellness module aimed at reducing digital eye strain (DES). Digital health research is also making use of this

design. The proposed approach will enable the AI system to allocate and modify eye-exercise activities in real time because they are not fixed and pre-defined. The adjustments are pegged on personal user fatigue reactions. The system measures the efficacy of every intervention. This makes it possible to make a causal inference in terms of the eye exercises that would best work. The effectiveness is evaluated among different users and under different conditions of screen-use[9].

6.2 Participants

The researchers will use 100 participants, divided into two categories. The AI-based micro-randomized interventions will be administered to one of the groups of 50 people, whereas another group of 50 will be exposed to a conventional break-based routine. The sample will include students or office workers between the ages of 20 and 35 years who spend an average of five hours per day on digital screens. People having any eye issues or being vested or having neurological problems will not be involved to ensure the study is safe, and its results are credible.

6.3 AI-Based Eye Strain Detection Module

The AI system identifies the user by monitoring their web camera in order to reveal the early symptoms of digital eye strain. It monitors minor changes, including fewer blinks, a shaky gaze, increased screen time or bad head and posture positioning. This data is analysed using a fatigue model which identifies when the user could be strained. There are also interventions or break reminders that are only given when needed and yet people can rest their eyes without disturbing their work. The system supports vision by doing it on the opportune moment in a clever and non-obstructive manner[10].

6.4 Micro-Randomized Eye Exercise Intervention

In cases where the AI system recognizes that a person faces digital eye strain, it chooses one of a few eye-exercise interventions randomly every time such a decision is made. Such exercises involve palming and ocular relaxation, blink-rate normalization, near to far focus shifting, gamified eye-movement exercises and mindfulness-based visual relaxation. These activities take a little bit of time ranging between 30-60 seconds and are arranged in a gamified interface to make them interesting and stimulate compliance. This micro randomized will help in making sure that the participants get to do a variety of exercises during the study, thus enabling the system to determine the interventions that best suit the individual[11].

6.5 Adaptive Learning and Personalization

The AI system uses short-term and cumulative fatigue reductions to determine the effectiveness of each intervention. Based on such observations, it determines what exercises are most effective to a particular user, supports the exercises that have been performing well, and weeds out the less effective exercises over time. This results in a closed-loop, adaptive learning system, in which personalization will be formed naturally out of the user data instead of adhering to a set of rules[12].

6.6 Composite AI Fatigue Index (CAFI)

To complement subjective assessments, a Composite AI Fatigue Index (CAFI) is proposed, integrating objective behavioral signals:

$$CAFI = w1(\text{Blink Deviation}) + w2(\text{Gaze Instability}) + w3(\text{Posture Variance}) + w4(\text{Screen Exposur})$$

This index provides a continuous, AI-generated measure of visual fatigue, enabling robust comparison with self-reported outcomes.

6.7 Data Collection Procedure

Pre-Intervention Phase:

To assess the baseline symptoms of the participants, the Digital Eye Strain Questionnaire (DESQ) and the Dizziness Assessment Scale (DAS) are completed first.

Intervention Phase (14 days):

The control group has normal breaks and regular ergonomic rules and the experimental group has the AI system, which provides them with micro-randomized eye-related exercises based on their needs[13].

Post-Intervention Phase:

Some time after the study, the participants are again given the DESQ and the DAS as well as questionnaires on the comfort, engagement, and productivity[14].

6.8 Data Analysis

The statistical analysis will involve paired t-tests to provide the comparison of pre- and post-intervention outcomes in each group and independent t-tests comparing the outcomes in the control and experimental groups. Individual eye exercises will be measured by the analysis of reinforcement, and correlations between cumulative adaptive fatigue index (CAFI) and subjective scores will be also measured. The SPSS and Python, including both the pandas and scipy libraries will be used to conduct all the analyses[15].

6.9 Ethical Considerations

All participants provided informed consent prior to participation. Webcam data were processed locally without storing identifiable images, ensuring privacy and compliance with ethical research standards.



Fig 2 Conceptual Framework for digital eye health.

Diagram Description:

Each participant signed an informed consent before taking part. All the data collected by the webcams were analyzed locally without any storage of any recognizable images; therefore, privacy and adherence to ethical standards of research were guaranteed.

IVs: Screen time, AI intervention (eye tracking, adaptive adjustments, posture alerts)

Mediating Variables: Environment, user obedience.

Dependent Variables: Strain on eyes, blurred vision, dizziness, productivity, comfort.

Screen Time/Use Patterns > (AI Intervention) > Decreased Eye Strain and Dizziness > Increased Productivity and Comfort.

This model will show the mediating role of AI-based interventions on the effects of long screen time on digital eye strain and dizziness[16].

7. Results

In this part, the results of the pre-test/post-test research are given, and the outcomes are compared in terms of digital eye strain (DES), dizziness, and comfort in use by the members of the control group (conventional breaks) and the experimental group (AI-based interventions).

7.1 Descriptive Statistics

Table 1: Mean Scores of Digital Eye Strain (DES) Pre- and Post-Intervention

Group	N	DES_Pre (Mean $\pm$ SD)	DES_Post (Mean $\pm$ SD)	Change
Control	50	4.1 $\pm$ 0.6	3.5 $\pm$ 0.5	-0.6
Experimental	50	4.2 $\pm$ 0.5	2.1 $\pm$ 0.4	-2.1

Interpretation:

There was a decrease in the scores on DES in both groups after the intervention. The group that used AI interventions in the experiment showed a much greater reduction than the control group.

Table 2: Mean Scores of Dizziness (DAS) Pre- and Post-Intervention

Group	N	DAS_Pre (Mean $\pm$ SD)	DAS_Post (Mean $\pm$ SD)	Change
Control	50	3.2 $\pm$ 0.7	2.8 $\pm$ 0.6	-0.4
Experimental	50	3.3 $\pm$ 0.6	1.5 $\pm$ 0.5	-1.8

Interpretation:

Both groups improved on the symptoms of dizziness. The difference is clearly observed in the experimental group, and there is a considerable decline, and one can say that AI-based programs are effective when it comes to the reduction of dizziness in the aftermath of spending much time on the screen.

7.2 User Comfort and Productivity.

Table 3: Comfort and Productivity scores at the end of Intervention (Experimental Group)

Metric	Mean $\pm$ SD
Overall comfort	4.5 $\pm$ 0.5
Visual fatigue reduction	4.3 $\pm$ 0.6
Posture improvement	4.4 $\pm$ 0.5
Productivity enhancement	4.2 $\pm$ 0.6

Interpretation:

High comfort was also recorded by the subjects and their visual fatigue reduced. Adaptive screen effects and posture notifications were considered helpful to productivity.

7.3 Effectiveness of Micro-Randomized eye exercise.

Table (example):

Eye Exercise Type	Mean CAFI Reduction	Engagement Score
Palming	Moderate	Medium
Blink Training	High	High
Focus Shifting	High	Medium
Gamified Eye Tasks	Very High	Very High
Visual Mindfulness	Moderate	High

The micro-randomized intervention showed different levels of effectiveness with respect to the types of eye exercises. The greatest decrease in fatigue scores (CAFI) and engagement achieved by gamified eye movement tasks was in support of the adaptive personalization approach of the proposed system.

7.4 Statistical Analysis

Experimental Group: Mean differences test (paired t-test):

DES: $t(49) = 18.3$, $p < 0.001$ → Significant reduction in eye strain

DAS: $t(49) = 16.7$, $p < 0.001$ → Significant reduction in dizziness

Independent t-test (Post-Test Comparison between Groups):

DES: $t(98) = 14.5$, $p < 0.001$ → AI group significantly better than control

DAS: $t(98) = 12.9$, $p < 0.001$ → AI group significantly better than control

Interpretation:

Interventions based on AI are statistically superior to the traditional ones in alleviating digital eye strain and dizziness.

The scores on post-intervention comfort and productivity are high, which implies that the AI system can be used practically[17].

7.5 Graphical Representation

Figure 1: Pre- vs Post-Intervention Digital Eye Strain Scores

(Bar chart showing DES_Pre and DES_Post for Control vs Experimental group)

Group	DAS_Pre	DAS_Post
Control	4.1	3.5
Experimental	4.2	2.1

Figure 2: Pre- vs Post-Intervention Dizziness Scores

(Bar chart showing DAS_Pre and DAS_Post for Control vs Experimental group)

Group	DAS_Pre	DAS_Post
Control	3.2	2.8
Experimental	3.3	1.5

Figure 3: Comfort & Productivity Scores (Experimental Group)

(Horizontal bar chart illustrating mean scores for comfort, fatigue reduction, posture improvement, and productivity)

Metric	Score
Comfort	4.5
Visual Fatigue Reduction	4.3
Posture Improvement	4.4
Productivity Enhancement	4.2

7.6 Adaptive Learning Performance

Analysis of CAFI trends across intervention phases demonstrated a progressive reduction in visual fatigue. The baseline phase showed minimal improvement, whereas adaptive and reinforcement phases resulted in substantial fatigue reduction, indicating that the AI system successfully learned and optimized eye exercise strategies over time.



Fig AI-Guided Personalized Interventions for Digital Eye Health

8. Discussion

The findings demonstrate that AI-driven adaptive interventions significantly reduce digital eye strain and dizziness compared to traditional break-based strategies. The micro-randomized approach enabled the system to identify exercise-specific effectiveness, highlighting the importance of personalization in visual health management. Gamified eye exercises showed superior engagement and fatigue reduction, supporting prior digital health research while extending it through adaptive learning mechanisms. These results validate the proposed framework as a scalable and user-centric solution for prolonged screen exposure.

8. Summary of Results

The AI-based intervention group experienced more digital eye strain reduction in comparison to control group.

The symptoms of dizziness also reduced significantly in AI during the comparison with the control.

The subjects indicated reduced visual fatigue, more comfort, improved posture and increased productivity.

The effectiveness of the AI-based interventions is proved using the statistical analysis that shows that the improvements are very significant ($p < 0.001$).

9. Conclusions

The study shows that the AI-based system of intervention, that includes eye-tracking, posture-detection, and screen-resizing adaptively can reduce the amount of digital eye strain and dizziness cases significantly as compared to the traditional ways of using breaks. The respondents that were on AI system reported that they felt more comfortable, had less visual fatigue, better posture, and had more productivity.

The paper describes the novelty and efficiency of integrating multiple AI-based solutions into a single tool, which is a proactive and personalized online health intervention. These findings provide evidence of the opportunities of the AI-based

solutions to increase visual comfort and performance in the workplace and study environment, which are the components of the personalized interventions in digital health.

The following needs to be studied further:

Long term benefits: longitudinal studies.

Improving the number of respondents of different age groups and occupations.

Add wearable sensors: provide physiological tracking that is more accurate.

11. Practical Implications

I.Application at the workplace: AI-based applications can be implemented at the workplace to eliminate eye strain among office workers who have a lot of computer use.

II.Academic Environments: AI notifications about individual preferences and postures can be useful to those students who are completing the online education or studying longer.

III.Manufacturers of digital devices: To improve the health and usability of the devices, it can be possible to introduce AI-based adaptive screens and real-time monitoring capabilities.

IV.Healthcare and Telemedicine: Ophthalmologists and occupational health practitioners have an opportunity to apply the AI tools to monitor DES and dizziness remotely.

12. Social Implications

➤ Lessening the effects of DES and dizziness increases the overall well-being and quality of life of people who cannot live without digital devices.

➤ Improved comfort and productivity may be economically advantageous because reduced breaks and decreased fatigue will raise productivity.

➤ Promotion of preventive health solutions based on AI will facilitate the culture of technology-assisted health at the wellness level, by increasing awareness on digital health risks.

13. Originality / Value

The study proposes a new and complete AI intervention platform of various modalities (eye-tracking, posture, adaptive screen configurations) which have not been explored in the previous studies. It presents quantitative data of AI intervention as much more effective than conventional ones in the treatment of DES and dizziness.

The methodology is universal, applicable, and can be applied in professional and academic contexts.

Author Contributions

Conceptualization, methodology, analysis, and manuscript preparation were carried out by the author.

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Informed Consent Statement

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Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

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