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# The Effect of Using The Eye Protection Feature on The Incidence Rate of Eye Fatigue (Asthenopia)

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**Abstract:**
**Background:** The rapid increase in smartphone use among medical students has raised concerns about digital eye strain (asthenopia). Prolonged exposure to blue light from smartphone screens can lead to eye fatigue, including dry eyes, blurred vision, and headaches. Although smartphones are equipped with eye protection features, these are often underutilized. **Aim:** To examine the effect of smartphone eye protection features on asthenopia among medical students at the Faculty of Medicine, Universitas Muslim Indonesia. **Methods:** A quasi-experimental pretest–posttest control group study involving 104 medical students evaluated the effect of activating the smartphone eye protection feature on asthenopia using the Visual Fatigue Index, with changes analyzed by the McNemar test ($p < 0.05$). **Results:** Prior to intervention, 71 respondents (68.3%) experienced asthenopia, while none used the eye protection feature. After intervention, among the 52 respondents who activated the eye protection feature, 35 (67.3%) showed improvement in asthenopia symptoms, while only 15 (28.8%) continued to experience eye fatigue ($p < 0.001$). Conversely, in the control group (n=52), 29 respondents (55.8%) who initially had no symptoms developed asthenopia, demonstrating a significant worsening of eye health ($p < 0.001$). The findings indicate a statistically significant reduction in asthenopia incidence among users of the eye protection feature. **Conclusions:** The use of smartphone eye protection features significantly reduces the incidence and severity of asthenopia among medical students with prolonged smartphone use. By filtering blue light, this feature improves visual comfort and serves as an effective and practical preventive measure against digital eye strain.
**Keywords:** Asthenopia, blue light, digital eye strain, eye protection feature, medical students, smartphone use, visual fatigue



## INTRODUCTION

The rapid advancement of technology in the global era has led to a significant increase in smartphone usage worldwide. Smartphones are widely used because they offer various features that facilitate users' daily activities. Today, smartphone use has become an integral part of modern life worldwide. According to smartphone sales reports in Indonesia by Katadata Indonesia (2016), smartphone sales increased by approximately 20 million units annually between 2016 and 2019. It has been reported that there were more than 92 million smartphone users in Indonesia (Ayu et al., 2018).

According to the Ministry of Communication and Information Technology of the Republic of Indonesia (2015), Indonesia is projected to become the fourth-largest country in the world in terms of active smartphone users, following China, India, and the United States. The largest proportion of smartphone users consists of adolescents aged 15 to 20 years (Ayu et al., 2018). In recent years, the number of mobile devices in Indonesia has increased significantly. Reports indicate that in 2022, more than 370 million devices were connected to mobile telecommunications networks, exceeding the country's total population of approximately 277 million. The study also revealed that the three activities most frequently performed for relatively long durations were online video streaming, online meetings, and online learning. The primary device used for these activities was the smartphone (Santoso et al., 2023).

On average, people in Indonesia spend more than two hours per day using their smartphones. A survey conducted by Kumorowati et al. (2016) found that the average daily duration of smartphone use in Indonesia exceeded 181 minutes, making Indonesia the country with the longest average smartphone usage time in Southeast Asia. This situation has contributed to Indonesia becoming one of the countries in Southeast Asia with a high prevalence of eye disorders related to smartphone screen radiation. One of the main causes of these eye disorders is exposure to blue light emitted from smartphone screens, which can lead to eye fatigue after viewing the screen for more than two hours (Ayu et al., 2018).

Despite these facts, many users remain unaware that the portable communication devices they use daily are equipped with features designed to reduce the risk of eye health problems. In addition, excessive dependence on smartphone use may negatively affect students' sleep quality. These risks are primarily associated with exposure to blue light radiation emitted from device screens (Santoso et al., 2023). The most common symptoms of eye fatigue caused by blue light exposure include dry eyes, itching, and a burning sensation resulting from prolonged smartphone use. Eye fatigue occurs when the pupils respond more slowly due to continuous and prolonged light exposure, a condition known as eye strain or asthenopia (Ayu et al., 2018).

Eye health problems are not limited to adults and the elderly; they are also prevalent among school-aged children. Rahmat et al. (2017) reported that out of 107 students, 58 experienced eye fatigue. Among these students, 23 developed eye fatigue due to gadget use exceeding six hours per day. Continuous gadget use for more than six hours can cause asthenopia. Eye fatigue may result from pupil and retinal fatigue caused by prolonged exposure to blue light (Ayu et al., 2018).

Based on the background described above, the researchers are interested in conducting a study entitled "The Effect of Using the Eye Protection Feature on the Incidence of Eye Fatigue (Asthenopia)."

Research on asthenopia/digital eye strain due to smartphone use has grown as the duration of smartphone use has increased. Previous literature shows:

1. Exposure to blue light from smartphone screens has an impact on visual impairments such as dry eyes, blurred vision, and headaches in students and college students (Chawla, Mohan, Ayu, Santoso, Rosenfield).
2. The blue light filter/eye protection feature has been theoretically proven to reduce exposure intensity and improve visual comfort. However, its use is still low due to a lack of user awareness.
3. Previous experimental studies have tended to focus on subjective perceptions of eye strain, duration of use, and visual acuity factors, rather than on measurements of before-and-after changes in the medical student population.
4. Eye protection modes such as Night Shift, Eye Care, and Eye Comfort Shield have been suggested. Still, their impact has not been widely evaluated in intensive academic contexts such as those of medical students.

Thus, the latest state-of-the-art confirms that Asthenopia increases in educated young generations. Blue light filters are considered an inexpensive and practical intervention. However, empirical evidence from quasi-experiments with specific groups, such as medical students, remains limited.

## LITERATURE REVIEW

Digital eye strain (DES), also referred to as asthenopia, is a collection of visual and ocular symptoms resulting from prolonged use of digital devices such as smartphones, tablets, and computers. Common symptoms include eye fatigue, dryness, blurred vision, irritation, burning sensation, and headaches. Recent studies have shown that the prevalence of DES has increased substantially due to the widespread and prolonged use of smartphones, particularly among students and young adults (Chawla et al., 2020; Mohan et al., 2021).

Blue light is an electromagnetic wave that forms part of visible light, with wavelengths ranging from 400 nm to 500 nm, making it a potential hazard to visual health. Several strategies have been recommended to minimize the risks of blue light exposure, including reducing gadget use at night, consuming antioxidant-rich foods, using anti-radiation glasses, and utilizing blue light filters on electronic devices (Santoso et al., 2023).

Reducing radiation exposure by using built-in blue light filters on mobile devices is considered an effective strategy, as most modern devices are equipped with this feature. In addition to reducing the blue light radiation spectrum, built-in filters have been shown to improve visual comfort and reduce eye fatigue (Santoso et al., 2023).

One effective approach to reducing the negative effects of blue light emitted by smartphones is the use of the eye protection feature. According to Lawrenson et al. (2017), the eye protection feature can automatically adjust screen brightness and color temperature based on ambient lighting conditions. This feature works by filtering blue light, thereby increasing visual comfort and reducing eye fatigue while allowing non-harmful light to pass through. As a result, the screen display appears warmer in tone (Ayu et al., 2018).

Many students use their smartphones without activating the eye protection feature and are unaware of its existence. Others activate the feature but do not fully understand its function (Ayu et al., 2018).

Students generally have limited awareness of the long-term eye health effects caused by prolonged blue light exposure from smartphone screens and tend to disregard environmental lighting conditions while using their devices. They frequently use smartphones in low-light environments, such as rooms illuminated by low-wattage bulbs or even without any lighting. Preliminary study results showed that the incidence of eye fatigue among smartphone users who did not activate the eye protection feature was 27.37%, whereas the incidence among users who activated the feature was 20.67%. This represents a reduction in eye fatigue of 6.7% with the use of the eye protection feature. The average duration of smartphone use without the eye protection feature was 515 seconds, while the average duration with the feature activated was 791 seconds (Ayu et al., 2018).

Based on recent literature, digital eye strain is increasingly prevalent due to extensive smartphone use (Chawla et al., 2020; Mohan et al., 2021). While eye protection features show potential benefits for reducing subjective asthenopia symptoms (Putri et al., 2022;

Santoso et al., 2023), findings remain inconsistent across studies. Furthermore, limited research has focused on quantifying the incidence rate of asthenopia associated explicitly with the use of built-in eye protection features on smartphones. Therefore, further investigation is required to clarify the effectiveness of these features in reducing eye fatigue among smartphone users.

There is a lack of quasi-experimental research on the use of smartphones' built-in protection features. Much of the previous research was survey or observational.

1. Lack of pretest–posttest research with controls like this study did—low exploration of the use of eye protection features in intensive user populations. The literature mentions that these features exist; however, have not been evaluated on the effectiveness of feature activation vs non-activation in real academic workload conditions.
2. Lack of specific data on medical students. Many studies include general student or adolescent populations. populations with high learning pressure, such as medical students, are rarely the focus.
3. Lack of standard instrument-based measurements (Visual Fatigue Index). Previous research has measured more subjectivity. The use of VFI provides a quantitative objective standard.

Awareness & usage gap. Studies show that the feature exists but is rarely used→. This study validated the effect of before–and–after activation on users who had never used the feature.

## METHOD

### Study Design

This study employed a quasi-experimental pretest–posttest control-group design to examine the effect of using the eye protection feature on the incidence of eye fatigue (asthenopia). The design was selected to allow comparison of asthenopia symptoms before and after intervention between participants who activated the eye protection feature and those who did not. The study was conducted among students of the Faculty of Medicine, Universitas Muslim Indonesia, Class B, Class of 2022.

### Population and Sample

The study population comprised all students of the Faculty of Medicine, Universitas Muslim Indonesia, Class B, Class of 2022, totaling 135 students. A non-probability purposive sampling technique was used, with participants selected based on predefined inclusion and exclusion criteria. The sample size was determined using the Slovin formula, with a 5% margin of error, resulting in a minimum required sample of 101 students. To anticipate incomplete data or dropouts, 104 students were included in the study.

**Inclusion and Exclusion Criteria**

Participants were included if they were aged 18-25 years, experienced asthenopia as determined by the research questionnaire, and provided informed consent to participate in the study. Students were excluded if they had diagnosed ocular conditions such as conjunctivitis or keratitis or if they used anti-radiation glasses or contact lenses, as these could influence visual fatigue outcomes.

**Operational Definition of Variables**

The independent variable in this study was the use of the eye protection feature on smartphones, defined as the activation or non-activation of the built-in blue light filtering feature available on various smartphone brands, including Eye Comfort Shield (Samsung), Eye Care (Oppo), Night Shift (iPhone), Reading Mode (Xiaomi), and Eye Protection (Vivo). This variable was measured on a nominal scale and categorized as using or not using the eye protection feature. The dependent variable was eye fatigue (asthenopia), defined as a collection of symptoms, including dry eyes, eye strain, visual fatigue, difficulty focusing, and headaches, resulting from prolonged smartphone use. Asthenopia was measured using the Visual Fatigue Index (VFI) questionnaire and categorized according to VFI cutoffs, with higher scores indicating greater eye fatigue. This variable was measured on an ordinal scale.

**Research Instruments and Data Collection Procedures**

Data were collected at the Faculty of Medicine, Universitas Muslim Indonesia, South Sulawesi Province, from July 2024 to August 2025 using a structured questionnaire that included respondent characteristics and the Visual Fatigue Index (VFI). The questionnaire was administered both online and offline after informed consent was obtained. Data processing involved editing, coding, cleaning, and tabulation. Data analysis was conducted using SPSS, with univariate analysis to describe variable distributions and bivariate analysis to evaluate the effect of activating the smartphone eye protection feature on asthenopia using the Visual Fatigue Index, with changes analyzed by the McNemar test ($p < 0.05$).

## RESULT AND DISCUSSION

This study was conducted at the Faculty of Medicine, Universitas Muslim Indonesia, in South Sulawesi Province, involving 104 students as the research sample. The samples were obtained through a questionnaire that asked about the use of the eye protection feature on smartphones and symptoms of eye fatigue. The research data included information on the use of the eye protection feature, the duration and viewing distance of smartphone use, and students' complaints of eye fatigue during the period from July 2025 to August 2025.

**Table 1. Distribution of Respondents' Characteristics**

| Variable | Frequency | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Male | 25 | 24.0 |
| Female | 79 | 76.0 |
| **Age (years)** | | |
| 19 | 2 | 1.9 |
| 20 | 17 | 16.3 |
| 21 | 62 | 59.6 |
| 22 | 21 | 20.2 |
| 23 | 2 | 1.9 |
| Use of Visual Aids | | |
| Anti-radiation glasses | 0 | 0 |
| Contact lenses | 0 | 0 |
| Not using | 104 | 100.0 |
| **Viewing Distance from Smartphone** | | |
| < 50 cm | 97 | 93.9 |
| ≥ 50 cm | 7 | 6.1 |
| **Average Duration of Smartphone Use** | | |
| >4 hours | 104 | 100.0 |
| **Total** | **71** | **100.0** |

Source: ***Primary Data***

Of the 104 respondents, 25 (24.0%) were male, and 79 (76.0%) were female. Respondents aged 19 years accounted for two individuals (1.9%), while those aged 20 years accounted for 17 individuals (16.3%). The largest age group was 21 years, consisting of 62 respondents (59.6%). Respondents aged 22 years numbered 21 (20.2%), and those aged 23 years numbered 2 (1.9%). All 104 respondents (100%) did not use anti-radiation glasses or contact lenses. A total of 97 respondents (93.9%) used smartphones at a distance of less than 50 cm, while seven respondents (6.7%) used them at a distance of 50 cm or more. All 104 respondents (100%) reported using smartphones for more than 4 hours per day.

**Table 2. Frequency Distribution of Asthenopia Before and After Intervention**

| Asthenopia Status | Pre-intervention | | Post-intervention | |
|---|---|---|---|---|
| | *n* | % | *n* | % |
| Asthenopia | 71 | 68.3 | 67 | 64.4 |
| No Asthenopia | 33 | 31.7 | 37 | 35.6 |
| **Total** | 104 | 100 | 104 | 100 |

***Source:* Primary Data**

Before the intervention, 71 respondents (68.3%) experienced asthenopia, while 33 (31.7%) did not. After the intervention, the number of respondents experiencing asthenopia decreased to 67 (64.4%), while those without asthenopia increased to 37 (35.6%). The total number of respondents remained 104 at both measurement time points.

**Table 3. Frequency Distribution of Eye Protection Feature Use Before and After Intervention**

| Eye Protection Use | Pre-intervention | | Post-intervention | |
|---|---|---|---|---|
| | *n* | % | *n* | % |
| Yes | 0 | 0 | 52 | 50.0 |
| No Asthenopia | 104 | 100 | 52 | 50.0 |
| **Total** | 104 | 100 | 104 | 100 |

***Source:* Primary Data**

Before the intervention, all 104 respondents (100%) did not use the eye protection feature. After the intervention, 52 respondents (50.0%) used the eye protection feature, while the remaining 52 respondents (50.0%) did not. The total number of respondents measured remained 104 at both time points.

**Table 4. Analysis of Asthenopia Symptoms in the Eye Protection Group Before and After the Test**

| Pre-Test | Post-Test Asthenopia | Post-Test No Asthenopia | n | p-value |
|---|---|---|---|---|
| Asthenopia | 15 | 35 | 52 | < 0.001 |
| No Asthenopia | 2 | 0 | | |

***Source:* McNemar Test**

Among respondents who experienced asthenopia at the pre-test, 15 continued to experience it at the post-test, while 35 improved and no longer experienced it. Among respondents who did not experience asthenopia at the pre-test, two developed asthenopia at the post-test, and none remained free of asthenopia. The total number of respondents analyzed in this group was 52. The McNemar test showed a statistically significant difference in asthenopia symptoms before and after the test ($p < 0.001$).

**Table 5. Analysis of Asthenopia Symptoms in the Non–Eye Protection Group Before and After the Test**

| Pre-Test | Post-Test Asthenopia | Post-Test No Asthenopia | n | p-value |
|---|---|---|---|---|
| Asthenopia | 21 | 0 | 52 | < 0.001 |
| No Asthenopia | 29 | 2 | | |

***Source: McNemar Test***

Among respondents who experienced asthenopia at the pre-test, 21 respondents continued to experience asthenopia at the post-test, and none improved to a non-asthenopia condition. Among respondents who did not experience asthenopia at the pre-test, 29 developed asthenopia at the post-test, while only 2 remained without it. The total number of respondents analyzed in this group was 52. The McNemar test indicated a statistically significant change in asthenopia symptoms between the pre- and post-test periods ($p < 0.001$).

**Eye Protection Feature**

The eye protection feature is a display mode that filters light to protect visual function and prevent eye strain. This mode reduces light emitted by smartphones by lowering light saturation, producing a warmer, yellowish screen appearance. Its primary function is to minimize visual fatigue during prolonged smartphone use (Ayu et al., 2018). Smartphone usage has increased significantly among university students, particularly medical students, as smartphones play a crucial role in supporting daily academic activities. These activities include accessing learning materials such as presentation files, e-textbooks, lecture modules, and various institutional digital learning platforms. In addition, smartphones enable students to conveniently search for scientific journals and research articles through online databases such as PubMed, ScienceDirect, and Google Scholar, without limitations of time and place. This accessibility greatly facilitates task completion, presentation preparation, and the continuous development of medical knowledge (Ramadani et al., 2022).

Consequently, smartphones have become essential devices for medical students. However, continuous and excessive smartphone use without adequate supervision or rest intervals may negatively affect health, particularly ocular health. Excessive smartphone use leads to continuous activation of the eye muscles, increasing visual strain and causing asthenopia (Wiryawan et al., 2021). These complaints are primarily caused by exposure to blue light emitted from smartphone screens, which can induce eye fatigue after more than two hours of continuous viewing. Blue light falls within the high-energy visible (HEV) spectrum, which, although perceptible to the human eye, can cause retinal damage with prolonged exposure. The cornea and lens are unable to block or reflect blue light effectively, allowing it to reach the macula and potentially result in cellular degeneration (Ayu et al., 2018).

One effective strategy to reduce the adverse effects of blue light exposure is the use of the eye protection feature. Activating this feature on smartphone screens has been shown to reduce eye fatigue during prolonged use. Similar features—such as Safety Care, Blue Light Filter, and Eye Care—are widely available across various smartphone brands (Ayu et al., 2018). Prior to the intervention, all 104 respondents (100%) did not use the eye protection feature. After the intervention, 52 respondents (50.0%) activated the feature, while the remaining 52 respondents (50.0%) did not. Questionnaire results demonstrated that respondents who activated the eye protection feature experienced a reduction in Visual Fatigue Index (VFI) scores and a decreased proportion of asthenopia cases after the intervention, whereas the control group showed minimal improvement. These findings indicate an association between the use of eye protection features and reduced eye fatigue symptoms.

This result is consistent with a study by Santoso et al. (2023), which reported that more than half of respondents were unaware of the blue light filter feature on their devices. However, those who were aware also understood its protective function. The use of blue light filters was identified as an effective solution to minimize the risks of blue light exposure by improving visual comfort and reducing eye strain through spectral filtering. Similarly, Chiu and Liu (2019) demonstrated that the Eye Care filter on Infocus M310 smartphones effectively filtered blue light wavelengths between 415–455 nm while maintaining brightness and color contrast. This finding was supported by Cheng et al. (2014), who reported improved visual comfort among subjects experiencing eye fatigue when using blue light filters during near-vision tasks. Prolonged near-work activities that require continuous accommodation and ocular muscle contraction can ultimately lead to asthenopia.

Overall, increased frequency and duration of gadget use are associated with a higher risk of eye health problems, particularly due to prolonged exposure to high-energy visible blue light. This exposure may reach the macular region and contribute to retinal degeneration, as the cornea and lens cannot adequately block blue light (Riska et al., 2020).

**Incidence of Eye Fatigue (Asthenopia)**

Asthenopia, commonly referred to as eye fatigue or eye strain, is a term for a cluster of symptoms involving visual, ocular, and musculoskeletal discomfort. In the literature, asthenopia is often referred to as Computer Vision Syndrome (CVS) or Digital Eye Strain (DES), which describes explicitly symptoms triggered by prolonged use of digital devices (Putu et al., 2021). Asthenopia is characterized by nonspecific symptoms, including eye strain, fatigue, discomfort, irritation, burning sensations, and headaches. More specific symptoms may include photophobia, blurred vision, diplopia, itching, dry eyes, and foreign body sensation. According to the International Classification of Diseases, 10th Revision (ICD-10), asthenopia is classified as a subjective visual disorder, with symptoms closely related to the type, intensity, and duration of near-vision activities such as reading, watching television, and using computers or smartphones (Chandra et al., 2018).

Asthenopia may be caused by excessive gadget use, particularly from blue light emitted by digital screens, which can reduce visual contrast and clarity. Factors such as viewing distance and duration of use have been shown to significantly contribute to eye fatigue, with symptoms including watery eyes, blurred vision, and reduced visual acuity (Siagian et al., 2024). In this study, prior to the intervention, 71 respondents (68.3%) experienced asthenopia, while 33 respondents (31.7%) did not. After the intervention involving partial use of the eye protection feature, the proportion of respondents experiencing asthenopia decreased to 67 individuals (64.4%), while those without asthenopia increased to 37 individuals (35.6%). These findings suggest a reduction in eye fatigue following the intervention.

The results align with findings by Assagaf et al. (2021), who reported that eye fatigue was the most common symptom among medical students at Universitas Pattimura Ambon. Furthermore, Melvi et al. (2023) identified a significant relationship between smartphone viewing distance and asthenopia, explaining that closer viewing distances increase accommodative demand and ciliary muscle workload, thereby increasing the risk of eye fatigue. This association was further supported by Yondii (2022), who found a significant relationship between gadget use duration and asthenopia among medical students. Collectively, these findings reinforce the conclusion that excessive smartphone use is significantly associated with eye fatigue symptoms (Liana et al., 2022).

**Effect of Eye Protection Feature Use on Eye Fatigue (Asthenopia)**

In modern society, gadget use has become widespread across all age groups. Commonly used devices include smartphones, laptops, tablets, and, to a lesser extent, televisions. These devices emit blue light radiation, which may negatively affect visual health, particularly refractive conditions. Medical students, who rely heavily on gadgets and prolonged reading activities, are especially vulnerable to refractive disorders such as myopia and astigmatism (Herryawan et al., 2021). Eye fatigue symptoms commonly associated with blue light exposure include dry eyes, itching, and burning sensations, resulting from delayed pupillary responses and prolonged exposure to light (Ayu et al., 2018).

The eye protection feature serves as an effective preventive measure to reduce the adverse effects of blue light exposure. This feature filters blue light, regulates brightness, and adjusts screen color temperature, thereby improving visual comfort during extended smartphone use (Ayu et al., 2018). In this study, none of the respondents used the eye protection feature before the intervention, whereas after the intervention, half of the respondents activated the feature. Correspondingly, the proportion of asthenopia cases decreased after the intervention. Statistical analysis using Spearman, Wilcoxon, and McNemar tests demonstrated a significant relationship between eye protection feature use and reduced asthenopia symptoms ($p < 0.001$), indicating meaningful improvement in visual complaints among users.

These findings are consistent with Citrawathi et al. (2019), who reported that smartphone eye protection features reduced eye fatigue by 67.81% and increased usage duration by 56.30%. Similarly, Savista and Adilah (2024) found significantly lower eye fatigue among users of blue light filters than among non-users. Rosenfield (2019) also reported that blue light filters effectively reduce eye fatigue after prolonged computer use. Overall, blue light filters reduce the amount of harmful light reaching the eyes, thereby lowering visual strain. These filters may be applied as physical screen protectors or software-based applications that modify screen color temperature (Hans et al., 2023).

The main novelties of this article are:

1. Direct evaluation of smartphone's built-in eye protection features through real interventions
2. Not only does it discuss blue light theoretically, but it also tests the Impact of Feature Activation in users who are 100% not initially using the feature.

3. Use of quasi-experimental pretest–posttest design with control group. → provide cause-and-effect evidence, not just correlation. This is rare in studies of this kind.
4. Application of VFI instruments in the context of medical students. Gives novelty to: Intensive academic population. The frequency of use > 4 hours/day has not been highlighted much.
5. Shows the comparison of intervention vs non-intervention effects. The data show a significant decrease in asthenopia in the intervention group. The opposite effect in controls empirically demonstrates the feature's effectiveness.

## CONCLUSION

This study demonstrates that using the eye protection feature on smartphones significantly reduces eye fatigue (asthenopia) among medical students at the Faculty of Medicine, Universitas Muslim Indonesia. Before the intervention, the majority of respondents reported asthenopia symptoms, reflecting the high visual burden associated with prolonged smartphone use. After implementing the eye protection feature, a reduction in the proportion of respondents with asthenopia was observed, particularly among those who actively used it.

Statistical analysis confirmed a significant difference in asthenopia symptoms before and after the intervention in the group using the eye protection feature, indicating that filtering blue light and adjusting screen color temperature can improve visual comfort and reduce eye strain. In contrast, respondents who did not use the eye protection feature tended to show no improvement or even a worsening of symptoms, emphasizing the role of unfiltered blue light exposure in the development of asthenopia.

Overall, these findings suggest that activating the eye protection feature on smartphones can be a simple, practical, and effective preventive measure to reduce eye fatigue among students who use digital devices for extended periods. Therefore, the routine use of this feature, along with appropriate screen-use habits, is recommended to support visual health in the academic environment.

This article makes a new contribution by empirically testing the effectiveness of smartphones' built-in eye protection features using a quasi-experimental pretest–posttest design with controls among medical students who had not previously used the feature. This study closes the gap in the lack of intervention evidence in intensive academic populations and in the use of standardized instruments such as VFI. The novelty lies in the real comparative evaluation of eye protection features against the incidence of asthenopia, which showed a significant reduction compared to the control group.

## Implication

The findings of this study have important practical and academic implications. Practically, the results suggest that activating the eye protection feature on smartphones can be a practical, low-cost, and easily accessible strategy to reduce eye fatigue (asthenopia) among medical students who are required to use digital devices for prolonged periods. Educational institutions, particularly medical faculties, may consider promoting digital eye health awareness by encouraging students to use built-in eye protection features, maintain appropriate viewing distances, limit continuous screen time, and observe regular rest intervals. Academically, this study contributes to the growing body of evidence on the role of blue light reduction in preventing digital eye strain and provides a basis for further research on non-pharmacological interventions to improve visual comfort among high-risk populations, such as students and healthcare professionals.

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