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Republic of Iraq
Ministry of Higher Education
and Scientific Research
University of Babylon / College of Medicine
Department of Community Medicine

PREVALENCE OF DIGITAL EYE STRAIN AMONG THE STUDENTS OF COLLEGE OF MEDICINE / UNIVERSITY OF BABYLON

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Abstract

The pervasive use of digital devices in educational settings raises concerns about Digital Eye Strain (DES), a condition characterized by visual discomfort and eye fatigue. This cross-sectional study aimed to assess the prevalence and factors contributing to DES among medical students at the University of Babylon. Employing a structured questionnaire, data were collected from 600 students across six academic stages, focusing on symptoms, device usage habits, and mitigation strategies. Statistical analysis, including hypothesis testing with a predefined significance level of $\alpha = 0.05$, was used to explore the association between screen time and the occurrence of DES. Results indicate a high prevalence of DES, with 97.7% of participants reporting symptoms, although severity varied significantly across the cohort. Prolonged screen exposure was closely linked to increased symptom severity, particularly in students with pre-existing eye conditions and those who wear glasses. Notably, female students and higher academic stages reported DES symptoms more frequently. These findings underscore the necessity for targeted interventions, such as educational programs on digital hygiene and regular eye examinations, to mitigate the impact of DES. This study contributes to the understanding of

DES in academic environments, highlighting the need for policy changes and individual practices that prioritize ocular health in the digital age.

Contents

Chapter 1

Introduction

In today's era, technology plays a crucial role in shaping our daily lives, bringing about improvements in communication, access to information, and efforts to reduce paper use, reflecting a shift towards more environmentally friendly practices as incidence. However, this digital advancement comes with its own set of challenges, particularly digital eye strain. This condition, as identified by the American Optometric Association, includes symptoms like eye discomfort, blurred vision, and headaches, resulting from long hours spent in front of computer screens, smartphones, and other digital devices.

This issue highlights a significant concern in modern society: the impact of our growing reliance on technology on our health. The prevalence of digital eye strain illustrates the need for a balance between the benefits of digital devices and the importance of maintaining good eye health. It calls for increased awareness about the potential negative effects of prolonged screen time and the development of strategies to mitigate these

impacts. Addressing digital eye strain is essential in ensuring that individuals can continue to use technology effectively without compromising their well-being, emphasizing the importance of adapting our habits to maintain health in a digitally dominated world.

1.1 Definition

Strain as a term in physics, engineering, and material science express the deformation of a property related to concerned sample compared to its original state after application of certain effector. In medical terms, which not differ in principle, refer to alteration the state and configuration of the subject to a negative state. As stated earlier, the use of digital devices has increased significantly across all age groups, making daily usage of digital devices of its all types for professional, educational and social activities a normal part of the basic daily life, including medical student populations. This daily using reflect on the life aspects lead cause several effects from physical stress, and eyes complaints which "digital eye strain" one of it. Digital Eye Strain (DES) or Computer vision syndrome (CVS), the terms used interchangeably, is defined by The American Optometric Association has designated it as the "complex of eye and vision problems related to near work that are experienced during or related to computer use" [1]. It is usually due to focusing of eyes on a computer or other display device for protracted, uninterrupted periods of time and the eye muscles being unable to recover from the strain due to lack of adequate sleep [2]. With the rise of the coronavirus disease 19 (COVID-19) pandemic, required online learning has become a popular approach to teaching and learning in

universities and schools, Thus, the COVID-19 pandemic has added even more fuel to the already existing fire of the digital revolution [3] . This is of clinical importance and brings attention to researchers because of the increasing prevelance of DES,a worldwide data show nearly 60 million people suffering from DES and 1 million new cases occurred each year [4]

1.2 Risk Factors

DES emerging from prolonged exposure to digital screens, manifests as a spectrum of eye-related discomforts and symptoms. There are a multi-faceted risk factors contributing to DES, underscoring its prevalence and proposing mitigation strategies [5], stated as:

- Prolonged Use of Digital Devices: The cornerstone of DES risk is the duration spent before screens. As individuals immerse themselves in digital worlds for work, education, or leisure, they inadvertently strain their eyes.
- Proximity and Viewing Angles: The risk of DES escalates with incorrect screen proximity and angles. Optimal screen placement a comfortable distance where the eyes can easily focus and a position slightly below eye level can mitigate this risk. Such positioning aids in reducing the need for the eyes to constantly readjust focus, alleviating potential strain.
- Posture: The influence of posture on DES is often underestimated. Awkward postures adopted during device use not only contribute to

musculoskeletal issues but also to eye strain. A neutral, ergonomic posture ensures that viewing angles and distances remain optimal, minimizing the risk of strain.

- Unaddressed Vision Problems: Minor vision problems, if left uncorrected, can amplify the risk of developing DES. Regular eye examinations are crucial to ensure that prescriptions are up to date and that emerging vision issues are addressed promptly, thereby reducing unnecessary eye strain.

- Inappropriate Eyewear: Eyewear suited for computer use can exacerbate DES. Specialized computer glasses or adjusted lens prescriptions cater to the specific distances involved in screen work, offering a significant preventive measure against eye strain.

- Lack of Breaks: The importance of taking regular breaks during screen time cannot be overstated. The 20-20-20 rule taking a 20 second break to look at something 20 feet away every 20 minutes serves as a simple yet effective strategy to counteract the effects of prolonged screen exposure.

Furthermore, gender plays a role in the susceptibility to DES, with studies indicating a higher prevalence among females (69%) compared to males (60%). This disparity may stem from hormonal differences, distinct work habits, or a higher likelihood of females to report symptoms [6]. The convergence of these risk factors illuminates the complexity of DES and the necessity for a holistic approach to prevention and management. Awareness and education on ergonomic practices, regular eye care, and

the judicious use of digital devices are paramount. By addressing these factors, individuals can significantly reduce their risk of DES, fostering a healthier, more sustainable interaction with digital technology.

1.3 Signs and Symptoms

DES is an umbrella term expressed by one or more ocular symptoms, mainly caused by using a computer. The symptoms can be broadly classified into four categories:

- Asthenopic symptoms include eye strain, tired eyes, and sore eyes
- ocular surface-related symptoms include watering, irritation, and dry eyes
- visual symptoms include blurred vision, slowness in changing focus, and double vision
- and extraocular symptoms include neck, back, and shoulder pain. [7]

The most common symptom is a sense of eye discomfort. This may be in the form of watering, redness, and itching in the eyes. The patients may complain of dryness in the eyes [8]. More recently, it has been reported that the most common health issues among computer users are visual and ocular issues [9]. When we stare at a screen, our blink frequency decreases from the average of 17 times per minute to about 4 times per minute. The decreased blink rate will cause the surface of our eyes to dry out leading to the symptoms above [10]. These symptoms are typically transient and go away at the end of the day. Most of these symptoms will return and get

worse in the future if no action is taken [11, 12].

1.4 Research Objectives

This research aims to investigate the prevalence, severity, and associated risk factors of digital eye strain (DES) among medical students at the University of Babylon. The objectives include employing a validated questionnaire to comprehensively assess DES symptoms, device usage habits, and related risk factors among the student population. By securing a statistically significant sample size representing diverse demographics and academic stages, the study intends to analyze the prevalence, frequency, and severity of DES symptoms, along with evaluating the types, durations, and contexts of digital device usage among participants. Furthermore, the research seeks to calculate the overall prevalence rate of DES among medical students and identify demographic and behavioral risk factors contributing to higher rates of DES, thereby pinpointing at-risk student groups for targeted interventions and preventive measures. Through these objectives, the study aims to provide valuable insights into the prevalence and risk factors of DES among medical students, facilitating the development of effective strategies for DES prevention and management within the university setting.

Chapter 2

Methodology

To meet our research objectives, a cross-sectional study is opted, which is recognized for its efficiency, cost-effectiveness, and ability to provide dependable insights into subsets of the study sample [13]. This methodological approach is deemed particularly appropriate, aligning with the aims of the research study. Specifically, this study focuses on a carefully selected demographic: the medical students enrolled at the University of Babylon (UOB). It utilizes questionnaire as the research instrument for its data collection strategy, ensuring a comprehensive evaluation of the relevant variables within the specified population segment.

2.1 Study Design

Utilizing a structured questionnaire for data collection, this method helps to assess the prevalence of digital eye strain among medical students at a specific point in time, providing a snapshot of the issue. The questionnaire,

developed with expert input, includes questions on symptoms, device usage, and mitigation strategies, ensuring comprehensive data gathering.

The study was conducted in accordance with the protocol was approved by the Ethics Committee of University of Babylon - College of Medicine (Approval No. 4 - 25 (17/3/2024)). Informed consent was obtained from all individual participants included in the study. Data will be collected through a survey in which ethical standards, including informed consent and participant anonymity, are prioritized. The analysis will involve statistical methods to identify key trends and factors associated with digital eye strain. This approach is aimed at yielding insights that can inform effective interventions to address this health concern among medical students.

2.1.1 Variables and Measurement Methods

study questionnaire, composed of 24 questions, is organized into two distinct sections, each serving a specific purpose within the overall research framework. The first section aims to gather demographic information and background data on the participants, including age, gender, academic stage, and other relevant variables that could influence the study outcomes. The second section delves into the core subject matter of the research, focusing on eye health symptoms. 15 of the total questions are dedicated to identifying the prevalence, frequency, and severity of these symptoms among the surveyed population, thereby facilitating a comprehensive analysis of eye health within this group. This approach provides a balanced collection of both quantitative and qualitative data, supporting

a nuanced understanding of the research topic and enabling a targeted exploration of the identified research aims. The two major questionnaire sections presented as follows:

- A set of 9 question devised to help extrapolate non-medical/demographic related findings, like age, gender, stage, lifestyle factors, and digital device usage.
- A set of 15 questions provided to shape a medical/statistical context for digital eye strain most common symptoms, including:
  - Headache
  - Foreign body sensation
  - Eye pain
  - Eye Dryness
  - Burning sensation
  - Watery tearing
  - Blurry vision
  - Eyelids heaviness
  - Eye itching
  - Eye redness
  - Difficulty focusing on near objects
  - Increased sensitivity to the light
  - Eyesight worsening
  - Double vision

  each question is answered in qualitative scale parameter comprising (not suffering, mild (sometime,often), and severe (sometimes,

often)), which helps to represent granular translation of each symptom.

2.1.2 Digital Eye Strain Score System

As mentioned, the questionnaire took 24 question, including 15 categorical qualitative scaled parameter (not suffering, Mild (sometime,often), and severe (sometimes, often)). These parameters are transformed into single quantitative parameter through a score criteria, mapped in this manner :

- 0 for (not suffering)
- 0.5 for (mild sometimes)
- 1 for (mild often)
- 1.5 for (severe sometimes)
- 2 for (severe often)

following mathematical representation used to count the total score for each individual:

$$\sum_{i=1}^{15} n_i$$

the resultant sum of each participant fall in range of 0 to 30 (2 x 15). The criteria took a reversed approach to CVSS17 system [14]. This scoring system implies that higher scores indicate more severe or frequent symptoms of Digital Eye Strain. The score represents a useful and more descriptive tool to use in conjunction with statistical results which gives more depth insight into the statistical observations. furthermore, a cutoff (threshold) The threshold score effectively serves as a benchmark to distinguish between different levels of symptom severity.

2.1.3 Hypothesis Testing

To assess the impact of digital device usage on eye health among medical students, and to rigorously test different criteria as (gender, wearing glasses, etc) that is hypothetically associated with increased prevalence of Digital Eye Strain (DES), we formulated a null hypothesis H_0 stating there is no difference in DES prevalence among students with varying criterion. An alternative hypothesis H_1 proposed that students having these parameters exhibit a higher prevalence of DES. A significance level α of 0.05 was predetermined, representing a 5% risk tolerance of falsely attributing differences in DES prevalence to chance. Utilizing a structured questionnaire, data on symptoms, device usage, and mitigation strategies were collected. The p-value, derived from statistical tests, guided our decision-making process; values at or below 0.05 led to the rejection of H_0 in favor of H_1, suggesting a significant association between screen time and DES. This methodological framework underpins our investigation, aiming to discern the correlation between digital device exposure and the incidence of DES among the student population. Its worth mentioning that α of 0.05 is strikes a balance between Type I errors (falsely rejecting the null hypothesis) and Type II errors (falsely failing to reject the null hypothesis). Lowering the threshold (e.g., to 0.01) reduces the risk of Type I errors but increases the risk of Type II errors (failing to detect a true effect). Conversely, a higher threshold (e.g., 0.10) reduces the risk of Type II errors but increases the risk of Type I errors.

2.2 Study Sample and Setting

This study focuses on a carefully selected demographic: the medical students enrolled at the University of Babylon (UOB). To insure that the study findings express broader students body of college of medicine, a subset of randomly selected, individually surveyed medical students to the study questionnaire. Anonymity and Confidentiality of participants are highly considered. in terms of feasibility considerations, the study aimed for 600 participants (25% of total college students) plus 6% as replacement respondents, 100 participant to represent each stage. The administration of this survey is scheduled to occur within the premises of the College of Medicine in (4 - 26) of March 2024.

2.3 Data Collection and Management

The selection of a paper-based questionnaire for gathering data stems from a thorough consideration of its intrinsic advantages [15]. These advantages include, but are not limited to, a higher likelihood of achieving viable and reliable data, an anticipated increase in response rates attributable to the direct and personal nature of the data collection environment (positive engagement), and a minimization of potential errors often encountered with more technologically dependent methodologies. Such a traditional yet robust approach facilitates a more nuanced understanding of the study nature, thereby contributing significantly to the reliability and validity of the research outcomes. Majority of the study researchers (17 member) conduct questionnaire practically and gather and asses the results accord-

ingly. The collection process is followed by a digitizing the data through a online spreadsheet shared between study members. Furthermore, the data is processed through a combination of tools, mainly python, SPSS, MS Excel, tools flexibility helps to facilitate charts, complex cross tabulation, and unique data processing approaches.

Chapter 3

Results

This study was conducted with the primary objectives of determining the prevalence of digital eye strain among students at the medical college of (UOB) and providing a comprehensive overview of the key trends, frequencies, and severity of symptoms associated with digital eye strain. A detailed survey was administered to 600 students, divided equally across six academic stages, with 100 students from each stage. After excluding responses that did not meet the pre-established research criteria, including those compromised by human errors, a total of 600 valid responses were analyzed. The participants for this study were randomly selected and surveyed using a paper-based questionnaire, which consisted of 24 questions, 15 of which were directly related to identifying symptoms of digital eye strain.

The demographic composition of the survey respondents, as presented in table (3.1), was 39.2% male (235 students) and 60.8% female (365 students), spanning ages from 17 to 28 years. This age range was chosen to

Table 3.1: Participants sociodemographic Characteristics Overview

Variable	Value	N (%)
Age	Mean $\pm$ SD	21.1 $\pm$ 2
Gender	Male	235 (39.2)
	Female	365 (60.8)
Current Academic Year	1st	446 (19.13)
	2nd	365 (15.65)
	3rd	392 (16.81)
	4th	510 (21.87)
	5th	331 (14.19)
	6th	287 (12.31)
	Total	2331 (100)
Wearing Glasses	Yes	339 (56.5)
	No	261 (43.5)

accurately represent the demographic scope of the study. The analysis of age distribution indicated an average age of 21.1 years (SD : $\pm$ 2), encompassing a diverse group of individuals at various academic stages within the College of Medicine.

The data presented in the figure (3.1) illustrates the prevalence of visual conditions and the duration of experienced symptoms among the medical students surveyed. Chart (a) indicates that a plurality of students, 44%, reported no visual conditions, while myopia was prevalent in 42% of the respondents, demonstrating a significant occurrence of nearsightedness within the student population. Hyperopia was considerably less common, affecting only 3.3% of participants, and the remaining 10.7% reported various other visual issues.

Chart (b) sheds light on the recency of eye examinations among the

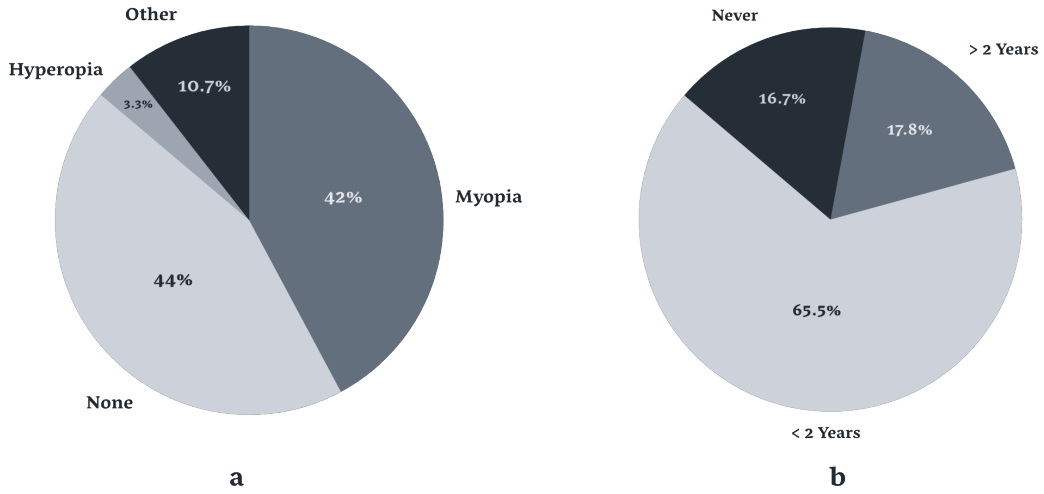

Figure 3.1: a : Pre existing eye problem distribution of participants, b : vision test frequency distribution

students: a substantial 65.5% had their last vision check less than 2 years ago, indicating regular eye care habits. In contrast, 17.8% have not had an eye exam for more than 2 years, and 16.7% have never had their vision checked.

The chart (3.2) depicts the frequency of device usage among the surveyed students, indicating a predominant use of tablets and phones. Specifically, tablets are most commonly used with 457 students (42.47%) favoring them, closely followed by phones at 422 students (39.2%). Laptop use, while still notable, is considerably less prevalent, with 112 students (10.4%) reporting them as not their primary device. Desktop PCs and other devices, such as TVs or handheld gaming devices, are the least used, with PCs at 42 students (3.9%) and other devices at 43 students (4%). This distribution suggests a strong trend towards portable and accessible technology, with traditional desktop PCs being much less favored in this demographic.

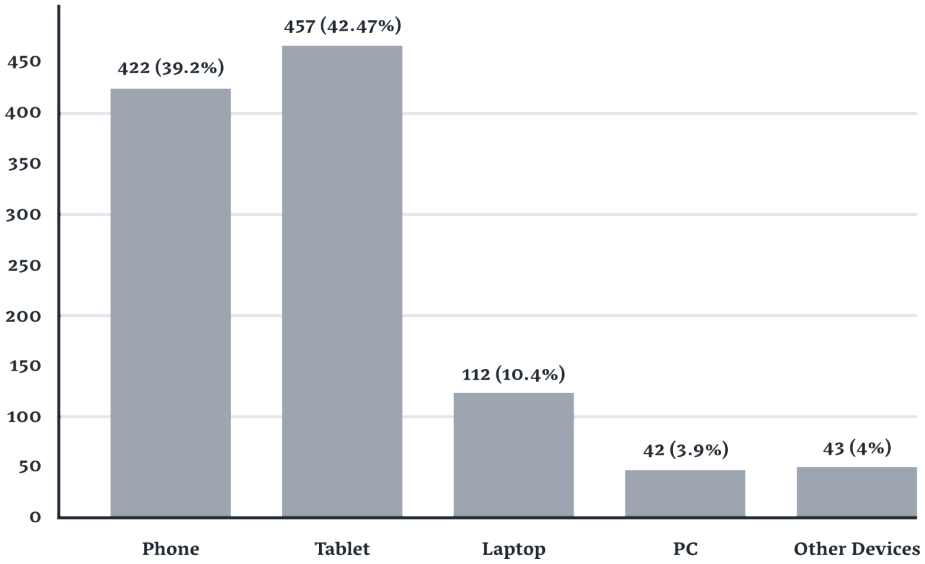

Figure 3.2: Frequencies of devices been used by study participants

To give a general ovierview of symptomology ratios for the study sample, two table constructed to represent symptoms severity (table 3.2), and symptom frequency (table 3.3). The tables present an extensive analysis of the symptoms of digital eye strain experienced by study sample, detailing the frequency of both mild and severe symptoms. For mild symptoms, 'Burning Sensation' was most common, with 338 individuals (56.33%) experiencing it, followed by 'Watery Tearing Eyes' and 'Eye Itching'. Severe symptoms were less common, though 'Headache' was reported by 177 individuals (29.5%), the most of any severe symptom listed. 'Foreign Body Sensation' was the least common symptom, with 202 individuals (33.67%) experiencing it mildly and 46 (7.67%) severely.

Furthermore, the breakdown of symptom frequency reveals a nuanced pattern of occurrence. Burning Sensation often occurred mildly in 74 individuals (18.14%) but was severe in only 18 (4.41%). Eye Itching was fre-

quently mild for 76 (20.54%) and severely affected 32 (8.65%). The data indicates that while mild symptoms are more prevalent, a significant number of individuals experience severe symptoms, particularly with Headache and Blurred Vision, which could impact daily functioning. Overall, Headache had the highest total prevalence at 78.17%, signaling it as a major concern within the sample population.

Table 3.2: Symptoms Severity Overview

Symptom	Mild		Severe		Total (Against 600)	
	N	%	N	%	N	%
Burning Sensation	338	56.33%	70	11.66%	408	68%
Eye Itching	291	48.50%	79	13.17%	370	61.67%
Foreign Body Sensation	202	33.67%	46	7.67%	248	41.33%
Watery Tearing Eyes	329	54.83%	101	16.83%	430	71.67%
Excessive Blinking	225	37.50%	69	11.50%	294	49.00%
Eye Redness	268	44.67%	67	11.17%	335	55.83%
Eye Pain	249	41.50%	70	11.67%	319	53.17%
Eyelids Heaviness	147	24.50%	42	7.00%	189	31.50%
Eye Dryness	191	31.83%	88	14.67%	279	46.50%
Blurred Vision	250	41.67%	119	19.83%	369	61.50%
Double Vision	99	16.50%	41	6.83%	140	23.33%
Near Objects Focusing Difficulty	159	26.50%	51	8.50%	210	35.00%
Increased Sensitivity to Light	246	41.00%	115	19.17%	361	60.17%
Headache	292	48.67%	177	29.50%	469	78.17%
Eyesight Worsening	157	26.17%	82	13.67%	239	39.83%

To present each stage with its symptomolgy findings, a heatmap figure is facilitated to represent symptoms frequency, severity, and gives comparative indication between stages through color darkness value. The heatmap (figure 3.3) portrays the incidence and severity of digital eye strain symptoms among students at different stages of medical education. It categorizes symptoms and distinguishes between mild and severe cases. The data reveals a trend where headaches are a predominant complaint, with a notable increase in reports as students progress through their aca-

Table 3.3: Symptoms Frequency Overview

Symptom	Mild			Severe			Total
	Often	Sometimes	Total	Often	Sometimes	Total	
Burning Sensation	74 (18.14%)	264 (64.71%)	338 (82.84%)	18 (4.41%)	52 (12.75%)	70 (17.16%)	408
Eye Itching	76 (20.54%)	215 (58.11%)	291 (78.65%)	32 (8.65%)	47 (12.70%)	79 (21.35%)	370
Foreign Body Sensation	65 (26.21%)	137 (55.24%)	202 (81.45%)	21 (8.47%)	25 (10.08%)	46 (18.55%)	248
Watery Tearing Eyes	115 (26.74%)	214 (49.77%)	329 (76.51%)	51 (11.86%)	50 (11.63%)	101 (23.49%)	430
Excessive Blinking	73 (24.83%)	152 (51.70%)	225 (76.53%)	26 (8.84%)	43 (14.63%)	69 (23.47%)	294
Eye Redness	80 (23.88%)	188 (56.12%)	268 (80.00%)	27 (8.06%)	40 (11.94%)	67 (20.00%)	335
Eye Pain	73 (22.88%)	176 (55.17%)	249 (78.06%)	20 (6.27%)	50 (15.67%)	70 (21.94%)	319
Eyelids Heaviness	52 (27.51%)	95 (50.26%)	147 (77.78%)	15 (7.94%)	27 (14.29%)	42 (22.22%)	189
Eye Dryness	61 (21.86%)	130 (46.59%)	191 (68.46%)	41 (14.70%)	47 (16.85%)	88 (31.54%)	279
Blurred Vision	90 (24.39%)	160 (43.36%)	250 (67.75%)	59 (15.99%)	60 (16.26%)	119 (32.25%)	369
Double Vision	32 (22.86%)	67 (47.86%)	99 (70.71%)	21 (15.00%)	20 (14.29%)	41 (29.29%)	140
Near Objects Focusing Difficulty	59 (28.10%)	100 (47.62%)	159 (75.71%)	29 (13.81%)	22 (10.48%)	51 (24.29%)	210
Increased Sensitivity to Light	94 (26.04%)	152 (42.11%)	246 (68.14%)	61 (16.90%)	54 (14.96%)	115 (31.86%)	361
Headache	109 (23.24%)	183 (39.02%)	292 (62.26%)	90 (19.19%)	87 (18.55%)	177 (37.74%)	469
Eyesight Worsening	57 (23.85%)	100 (41.84%)	157 (65.69%)	49 (20.50%)	33 (13.81%)	82 (34.31%)	239

demic stages. Similarly, symptoms like eye redness and vision blurring are common, underscoring a significant occurrence of eye discomfort within the student body. On the other hand, conditions such as double vision and difficulty focusing on near objects are reported less frequently but are nonetheless present across all stages. This pattern suggests that certain eye strain symptoms are persistent and possibly exacerbated by the demands of medical training. The heatmap offers a visual summary of the data, highlighting areas of concern.

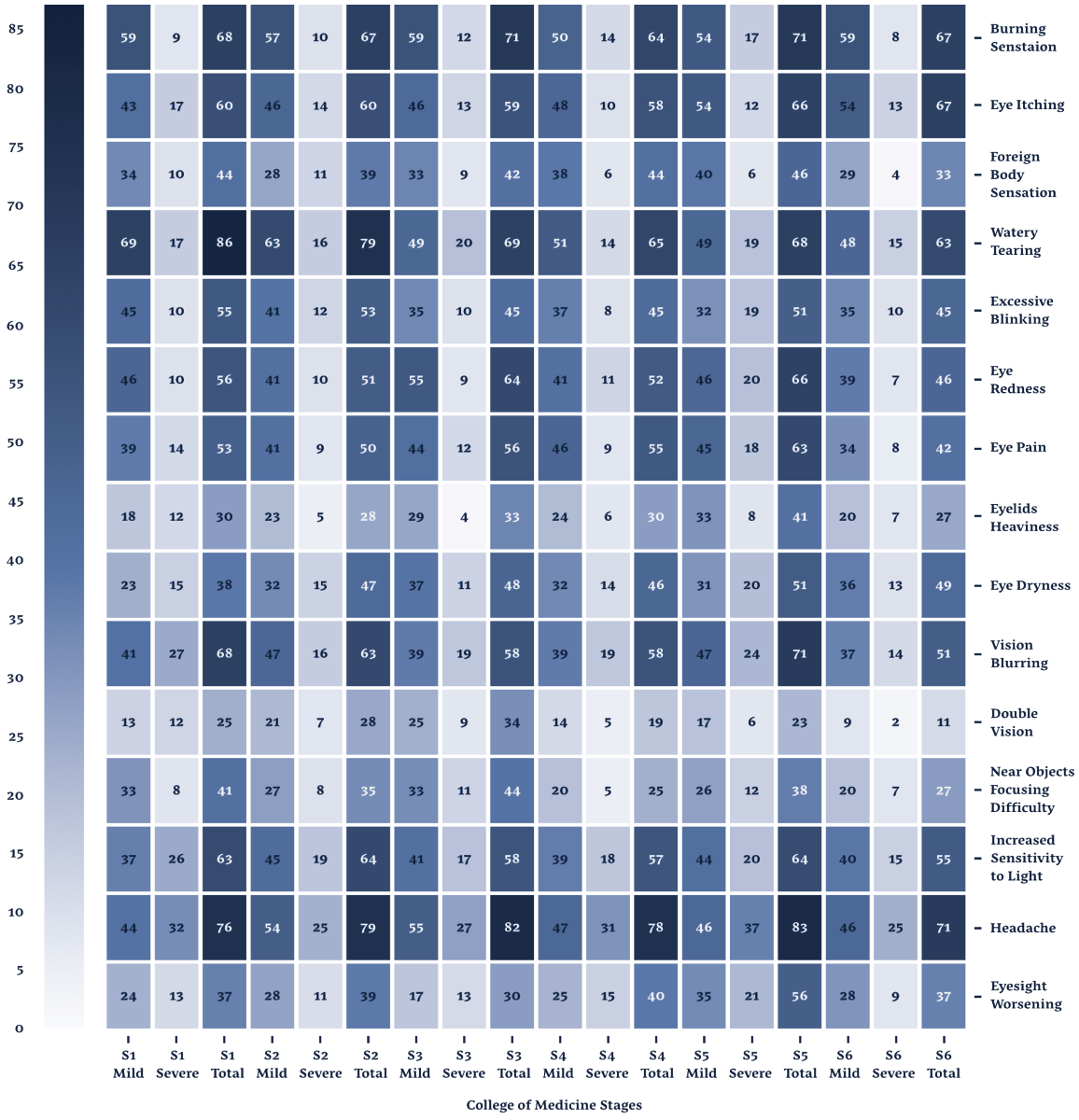

Figure 3.3: Distribution heatmap of symptoms frequency and severity in contrast of college of medicine 6 stages

Out of the 600 participants surveyed, only 14 (2.3%) indicated they experienced no symptoms, thereby revealing that a significant majority of 586 participants (97.7%) reported experiencing some level of symptoms

associated with digital eye strain.

The DES score system was applied to evaluate symptoms related to device usage among participants, based on responses to 15 questions. Descriptive statistics of the DES scores within the dataset yielded an average (mean) score of 7.30, with a SD of 5.01, signifying a varied range of symptom severity among participants. The median score was determined to be 6.5, while the most frequently occurring score (mode) was 4. The scores ranged from a minimum of 0, indicating no symptoms, to a maximum of 28 out of a possible 30. A concentrated clustering of scores was observed between 3.5 and 10.

As presented in the figure (3.4), the histogram outlines the distribution of DES scores across the study's participant population. The range of DES scores from 0, indicating no symptoms, to upwards of 28, denoting severe symptomatology. The distribution is notably skewed toward less density of symptoms frequency and severity, that the majority of participants registering scores on the lower end, which implies that a significant portion of the sample experiences minimal indicators of digital eye strain. Conversely, as DES scores escalate, the frequency of such reports precipitously declines, pointing to a smaller subset of the sample experiencing higher intensity symptoms. This trend persists even beyond the median score of 6.5, reveal a stark contrast in the prevalence of mild versus moderate to severe digital eye strain symptoms within the surveyed group. The data thus suggest that, while digital eye strain is present to some degree across the cohort, its severity is not uniformly distributed, with most participants reporting lower-end scores indicative of less frequent or less severe symptoms.

With the maximum possible score being 30, a score significantly lower than 30 but well above the median (6.5) could be considered indicative of significant digital eye strain. This is because it would reflect a broad range of symptoms being experienced with some frequency and severity. By requiring a score of 6.5 or more, the criteria aim to identify individuals who experience these symptoms frequently and with enough severity that it could impact their daily life, rather than those who might occasionally have mild symptoms. This threshold helps to distinguish between those who might simply have a rare or minor discomfort from digital device use and those who are experiencing a more substantial level of eye strain that could benefit from further attention or intervention. a threshold score of 6.5 was set. Using this criterion, 306 participants (51%) were identified. Additionally, when employing a higher threshold of 10, the number of participants categorized with significant digital eye strain symptoms reduced to 161 (26.8%). This scoring system facilitates the differentiation between those with occasional or minor discomfort from digital device usage and those experiencing more considerable levels of eye strain warranting further examination or intervention.

Furthermore, utilizing DES score, the table (3.4) offers a statistical summary of Digital Eye Strain (DES) scores ≥ 6.5. The data covers the six stages, with the count of participants ranging from 47 to 60 across the stages. For Stage 1 students, the mean DES score is 11.38 (SD : 4.28), and the median score is 10.50. Stage 2 shows a slight decrease in the mean score to 11.15 and a larger SD of 4.79, indicating greater variability in scores. Stage 3 continues the trend with a mean of 11.02 and the lowest median score of 9.50 among all stages.

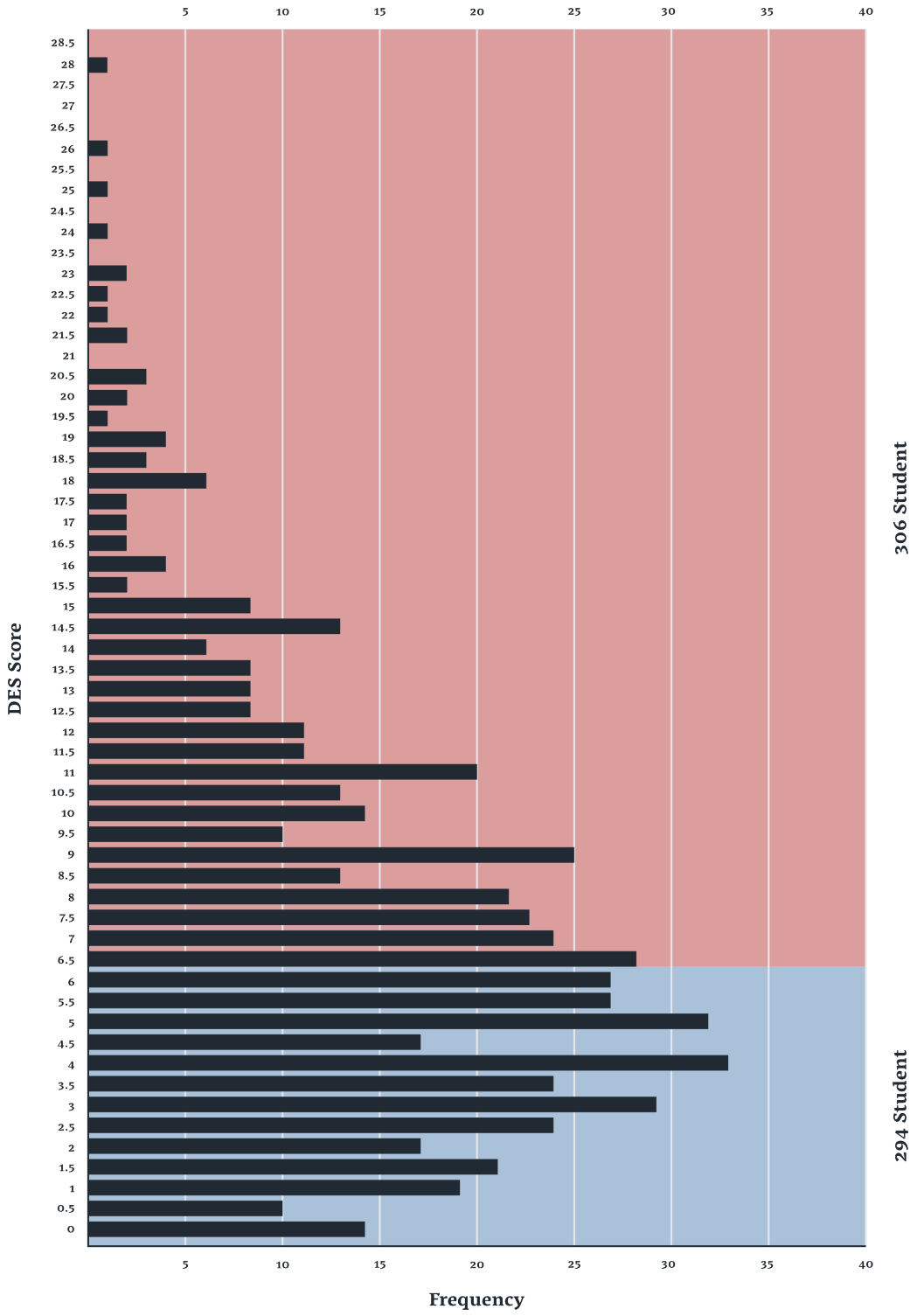

Figure 3.4: DES Score Histogram

Table 3.4: Statistics summery of DES Scores after applying a threshold of ≥ 6.5, by stage

Stage	N	Mean	SD	Median	Mode	Min	Max	25%	75%
Stage 1	52	11.38	4.28	10.50	7.5	6.5	23.0	7.50	13.75
Stage 2	48	11.15	4.79	10.00	8.0	6.5	28.0	7.88	12.50
Stage 3	51	11.02	4.29	9.50	7.0	6.5	22.5	8.00	13.50
Stage 4	47	10.88	4.47	10.00	6.5	6.5	25.0	7.50	12.50
Stage 5	60	11.73	4.01	11.25	6.5	6.5	26.0	8.75	14.12
Stage 6	48	9.97	3.06	9.00	9.0	6.5	19.0	7.50	11.12

Stage 4 students have a mean DES score of 10.88, and like Stage 2, a median score of 10.00. The students in Stage 5 present with the highest mean score of 11.73 and a median score of 11.25, suggesting a higher overall eye strain in this group. Conversely, Stage 6 shows a marked decrease in both the mean and median scores to 9.97 and 9.00, respectively, indicating the lowest level of reported eye strain among the stages.

Mode scores across the stages reveal that the most frequently occurring score varies, although the lowest score (Min) remains consistently at 6.5 for all stages. The maximum (Max) scores fluctuate significantly across stages, with Stage 2 reaching the highest score reported at 28.0.

The interquartile range (25th percentile to the 75th percentile) generally indicates the middle spread of the scores, which also varies across stages, suggesting differences in the distribution and intensity of DES symptoms as students progress through their education.

The table, thus, encapsulates the variation in DES scores across different educational stages, highlighting the fluctuating nature of eye strain symptoms experienced by medical students.

In case of exposure time to digital devices screens during daily study time, there are 4 main categories, less than 4 hours, 4 to 6 hours, 6 to 10 hours, and more than 10 hours presented in the table (3.5). The table categorizes the symptoms of digital eye strain experienced by participants according to their severity and correlates them with the daily screen exposure time. The symptoms examined. A trend can be discerned where symptoms classified as mild are more frequently reported than severe symptoms across all categories of screen exposure time. Notably, headache was the most prevalent symptom among participants with long screen exposure times (>10 hours), with 79.31% of participants experiencing this symptom. The proportion of participants experiencing mild versus severe symptoms did not vary dramatically with increased screen time. However, there was a general trend indicating an increase in the total percentage of participants experiencing symptoms as screen time exceeded 10 hours, suggesting a correlation between prolonged exposure to digital screens and the exacerbation of digital eye strain symptoms.

The data presented in the table provide a comprehensive analysis of the prevalence and severity of various symptoms associated with digital eye strain among participants, segmented by their daily screen exposure time. Key observations include:

- Burning Sensation: A relatively stable percentage of participants report a burning sensation across all screen time categories, though there is a slight increase in the 'severe' category with higher screen exposure.
- Eye Itching and Watery Tearing: These symptoms demonstrate a

Table 3.5: Symptoms distribution by duration category of study time, noting that presented percentages are relative to each category total

Symptom	Severity	< 4 H (n: 35)	4 - 6 H (n: 144)	6 - 10 H (n: 276)	> 10 H (n: 145)
Burning Sensation	Mild	23	72	139	64
	Severe	4	14	31	27
	Total (%)	26 (74.29%)	101 (70.14%)	185 (69.29%)	96 (66.21%)
Eye Itching	Mild	16	72	139	64
	Severe	5	17	32	25
	Total (%)	21 (60%)	89 (61.8%)	171 (64%)	89 (61.38%)
Foreign Body Sensation	Mild	9	53	96	90
	Severe	6	4	9	60
	Total (%)	15 (42.86%)	60 (41.67%)	115 (42.39%)	60 (41.38%)
Watery Tearing	Mild	17	83	147	82
	Severe	8	23	44	26
	Total (%)	25 (71.43%)	106 (73.6%)	191 (71.54%)	108 (74.48%)
Excessive Blinking	Mild	14	54	108	55
	Severe	6	14	25	9
	Total (%)	17 (48.57%)	69 (47.92%)	133 (48.19%)	79 (54.48%)
Eye Redness	Mild	17	65	121	65
	Severe	6	20	22	19
	Total (%)	23 (65.7%)	85 (59%)	143 (53.56%)	84 (57.93%)
Eye Pain	Mild	14	54	116	63
	Severe	4	9	39	9
	Total (%)	18 (51.43%)	70 (48.61%)	144 (55.99%)	87 (60%)
Eyelids Heaviness	Mild	10	35	61	41
	Severe	4	9	15	14
	Total (%)	14 (40%)	44 (30.56%)	76 (28.46%)	55 (37.93%)
Dryness	Mild	13	49	87	48
	Severe	6	17	35	18
	Total (%)	19 (54.29%)	66 (45.83%)	122 (46.69%)	72 (49.66%)
Vision Blurring	Mild	8	62	122	58
	Severe	7	31	45	36
	Total (%)	15 (42.86%)	93 (64.58%)	167 (62.55%)	94 (64.83%)
Double Vision	Mild	7	26	39	23
	Severe	4	11	9	18
	Total (%)	11 (31.43%)	37 (25.69%)	49 (18.75%)	43 (29.66%)
Difficulty Focusing on Near Objects	Mild	8	39	97	53
	Severe	4	9	20	18
	Total (%)	12 (34.29%)	48 (33.33%)	97 (36.33%)	53 (36.55%)
Increased Sensitivity to The Light	Mild	12	48	137	69
	Severe	7	29	31	18
	Total (%)	19 (54.29%)	77 (53.47%)	168 (62.32%)	97 (66.9%)
Headache	Mild	15	79	137	61
	Severe	6	35	82	54
	Total (%)	21 (60%)	114 (79.17%)	219 (82%)	115 (79.31%)
Eyesight Worsening	Mild	8	40	74	39
	Severe	2	19	33	16
	Total (%)	10 (28.57%)	59 (40.97%)	107 (41.3%)	55 (37.93%)

relatively consistent increase in both mild and severe categories as screen time rises, suggesting a dose-response relationship between screen time and these symptoms.

- Excessive Blinking: The percentage of participants experiencing this symptom mildly is significant, yet it does not show a dramatic increase with longer screen exposure.
- Eye Redness: A decrease in the proportion of mild symptoms with increased screen time is noted, while severe symptoms rise, indicating that longer exposure may worsen the severity.
- Eye Pain and Eyelid Heaviness: Both symptoms exhibit a trend where an increase in screen time correlates with a higher percentage of participants reporting both mild and severe symptoms.
- Dryness: The frequency of dryness as a symptom peaks in the 6-10 hours screen exposure group, slightly decreasing afterward for longer exposures.
- Vision Blurring and Double Vision: These symptoms show a clear escalation in reported frequency as screen time increases, with the highest percentages found in participants with the most prolonged exposure.
- Difficulty Focusing and Increased Sensitivity to Light: Both conditions display a modest yet consistent increase in reported cases in correlation with screen time, more so for severe cases.
- Headaches: This symptom is particularly notable for its high prevalence at over 10 hours of screen time, with a striking 82% reporting mild headaches, suggesting a strong association with extended screen use.

- Eyesight Worsening: Interestingly, while there is a general increase in reported cases with more screen time, the percentage of severe cases does not significantly spike, indicating that while more participants may notice a decline in eyesight, it does not necessarily become acutely worse with longer screen time.

In summary, the data imply that increased screen time is generally associated with both a higher frequency and severity of digital eye strain symptoms, with the most pronounced effects observed in headache frequency, vision blurring, and difficulty focusing.

Table 3.6: Symptom Severity Distribution by Gender, percentages are counted relative to each gender total (Males : 235, Females : 365)

Symptom	**Females (N %)**	**Males (N %)**	**p-value**
Burning Sensation	267 (73.15%)	141 (60.0%)	0.001
Eye Itching	233 (63.84%)	137 (58.3%)	0.220
Foreign Body Sensation	171 (46.85%)	77 (32.77%)	<0.001
Excessive Blinking	189 (51.78%)	105 (44.68%)	0.106
Watery Tearing	271 (74.25%)	159 (67.66%)	0.097
Eye Redness	218 (59.73%)	117 (49.79%)	0.020
Eye Pain	214 (58.63%)	105 (44.68%)	0.001
Eyelids Heaviness	127 (34.79%)	62 (26.38%)	0.038
Dryness	193 (52.88%)	86 (36.6%)	<0.001
Vision Blurring	243 (66.58%)	126 (53.62%)	0.001
Difficulty Focusing on Near Objects	133 (36.44%)	77 (32.77%)	0.404
Double Vision	90 (24.66%)	50 (21.28%)	0.391
Increased Sensitivity to the Light	238 (65.21%)	123 (52.34%)	0.002
Headache	308 (84.38%)	161 (68.51%)	<0.001
Eyesight Worsening	163 (44.66%)	76 (32.34%)	0.003

In other point of view, a cross tabulation between gender categories and different symptoms (table 3.6) is facilitated in which summarizes the distribution of symptom severity among female and male students, with statistical significance evaluated at a p-value threshold of less than 0.05. Females reported a higher percentage of burning sensation, eye itching,

and watery tearing compared to males, with burning sensation showing a statistically significant difference ($p = 0.001$). Foreign body sensation was reported by 46.85% of females and 32.77% of males, with this difference being statistically significant ($p < 0.001$). Notable gender differences were also observed in symptoms such as eye redness, eye pain, and eyelid heaviness, all showing higher percentages in females and statistical significance. Dryness and vision blurring were more prevalent in females, with p-values indicating significant differences. Difficulty focusing and double vision did not show a statistically significant difference between genders. Increased sensitivity to light and headaches were markedly more common in females, with headaches having a high statistical significance ($p < 0.001$). Additionally, females reported a higher occurrence of eyesight worsening, with a p-value of 0.003. Overall, the table suggests that there are significant gender differences in the experience of digital eye strain symptoms.

Another valid comparing point is weather the participant is wearing glasses or not. The table (3.7) presents the association between various symptoms of digital eye strain and the status of glasses wear among students. Those wearing glasses reported a higher incidence of all listed symptoms compared to those not wearing glasses. Specifically, the prevalence of headache was highest among glasses wearers at 80.83%, as opposed to 74.71% in non-glasses wearers. Symptoms such as watery tearing and burning sensation were also more common among glasses wearers, at 74.34% each, compared to 68.2% and 59.77% respectively for those not wearing glasses.

Vision blurring showed a marked difference, with 72.86% of glasses

Table 3.7: Symptoms and Glasses Wearing Cross Tabulation, percentages are expressed relative to each group total number (Wearing : 339, Not Wearing : 261)

Symptom	**Wearing Glasses**	**Not Wearing Glasses**	**Total**
Burning sensation	252 (74.34%)	156 (59.77%)	408
Eye itching	229 (67.55%)	141 (54%)	370
Foreign body sensation	138 (40.7%)	110 (42.15%)	248
Excessive blinking	175 (51.62%)	119 (45.59%)	294
Watery tearing	252 (74.34%)	178 (68.2%)	430
Eye redness	195 (57.52%)	140 (53.64%)	335
Eye pain	209 (61.65%)	110 (42.15%)	319
Eyelids heaviness	125 (36.87%)	64 (24.5%)	189
Dryness	192 (56.64%)	87 (33.33%)	279
Vision blurring	247 (72.86%)	122 (46.74%)	369
Difficulty focusing on near objects	146 (43%)	64 (24.52%)	210
Double vision	97 (28.61%)	43 (16.48%)	140
Increased sensitivity to the light	227 (66.96%)	134 (51.34%)	361
Headache	274 (80.83%)	195 (74.71%)	469
Eyesight worsening	184 (54.28%)	55 (21%)	239

wearers experiencing this symptom against 46.74% of those without glasses. Increased sensitivity to light and eye redness were also reported significantly more by glasses wearers. For more serious concerns like eye pain and dryness, glasses wearers reported these symptoms at rates of 61.65% and 56.64%, notably higher than their counterparts.

Notably, eyesight worsening was reported by over half of the glasses wearers (54.28%), a figure that starkly contrasts with the 21% of non-glasses wearers, indicating a potential correlation between glasses wearing and

the perception of deteriorating vision. Other symptoms like difficulty focusing on near objects, eyelids heaviness, and double vision were also more prevalent among those wearing glasses. This data highlights a clear pattern where glasses wearers experience a higher rate of digital eye strain symptoms across the board.

Symptom	PEED (N %)	Not having PEED (N %)	P-Value
Burning Sensation	250 (74.4%)	158 (59.8%)	<0.001
Eye Itching	228 (67.9%)	142 (53.8%)	0.001
Foreign Body Sensation	144 (42.9%)	104 (39.4%)	0.440
Excessive Blinking	180 (53.6%)	114 (43.2%)	0.014
Watery Tearing	259 (77.1%)	171 (64.8%)	0.001
Eye Redness	195 (58.0%)	140 (53.0%)	0.253
Eye Pain	209 (62.2%)	110 (41.7%)	<0.001
Eyelids Heaviness	123 (36.6%)	66 (25.0%)	0.003
Dryness	191 (56.8%)	88 (33.3%)	<0.001
Vision Blurring	257 (76.5%)	112 (42.4%)	<0.001
Difficulty Focusing on Near Objects	150 (44.6%)	60 (22.7%)	<0.001
Double Vision	102 (30.4%)	38 (14.4%)	<0.001
Increased Sensitivity to the Light	232 (69.0%)	129 (48.9%)	<0.001
Headache	273 (81.3%)	196 (74.2%)	0.050
Eyesight Worsening	193 (57.4%)	46 (17.4%)	<0.001

Table 3.8: Symptom severity comparison between participants with pre-existing eye disease (PEED) compared to not having

The table compares the severity of symptoms between participants with and without pre-existing eye disease, revealing significant differences in the occurrence of various symptoms. Those with pre-existing eye conditions reported higher percentages of nearly all symptoms, particularly burning sensation (74.4% vs. 59.8%), eye itching (67.9% vs. 53.8%), and watery tearing (77.1% vs. 64.8%).

Statistically significant differences, indicated by a p-value of less than 0.05, were observed in many symptoms. Notably, vision blurring was reported by 76.5% of participants with pre-existing eye disease, compared to

only 42.4% of those without, highlighting a substantial difference. Difficulty focusing on near objects, double vision, and increased sensitivity to light were also significantly more common among those with pre-existing conditions.

Symptoms like foreign body sensation and eye redness did not show a statistically significant difference, suggesting that these symptoms may not be as influenced by pre-existing eye conditions.

Headache, while still more common among those with pre-existing conditions (81.3% vs. 74.2%), presented a p-value on the threshold of significance, suggesting a more marginal difference.

Overall, the table clearly indicates that individuals with pre-existing eye disease are more prone to experiencing a range of digital eye strain symptoms with greater severity. This suggests the need for targeted interventions to manage symptoms more effectively in this subgroup.

Chapter 4

Discussion

The study's findings reveal a notable prevalence of digital eye strain (DES) among medical students at UOB, with 97.7% of participants reporting some level of DES symptoms, which initially paints a picture of widespread ocular discomfort within this population. This high prevalence rate, however, demands a nuanced interpretation, especially when considering the distribution of DES scores.

A closer examination of the DES scores provides a more detailed perspective on the severity of the symptoms experienced. When applying a threshold score of 6.5, we observe that 51% of participants score above this threshold. This differentiation is critical as it suggests that just over half of the affected student population experiences symptoms severe enough to potentially impact their daily functioning. Conversely, the remaining 49% of students, while experiencing some level of symptomatology, report milder symptoms that fall below this threshold.

This dichotomy is crucial for understanding the actual impact of DES

on the student population. The data indicate that while a majority of students encounter some form of digital eye strain, the intensity of their experiences varies significantly. Specifically, the finding that only 51% of participants report a DES score of 6.5 or higher illuminates the fact that a substantial portion of the sample experiences mild symptoms.

Moreover, the utilization of a higher DES score threshold (e.g., 10) further refines our understanding of symptom severity across the population. The number of participants categorized with significant digital eye strain symptoms decreases notably under this stricter criterion, underscoring the conclusion that a smaller subset of the population encounters moderate to severe levels of DES. This gradation of symptom severity, evidenced by the distribution of DES scores, supports the inference that, although widespread, the majority of DES cases among the students lean towards milder manifestations.

even though, higher occurrence frequency as presented in table (4.1), that presents a comparison with other studies, shows that headache, burning sensation, and watery tearing are top 3 symptoms among participants.

Table 4.1: Prevalence comparison among different research studies, showing top 3 symptoms expressed by participants, ordered from higher to lower

Study	Symptom 1	Symptom 2	Symptom 3
Agbonlahor et al (2019) [16]	Headache 48.8%	Eye strain 27.0%	Blurred vision 14.4%
Mekonnin et al (2021) [17]	Blurred vision 40.6%	Eye strain 30.4%	Headache 29.0%
Moore et al (2021) [18]	Eye strain 72.6%	Headache 64.7%	Dry or irritated eyes 56.0%
Gammoh et al (2021) [19]	Tearing 59%	Headache 53%	Itching 51.4%
Altalhi et al (2020) [20]	Heavy eyelids 87.7%	Affected eyesight 65%	Itchy eye 63%
Iqbal et al (2018) [21]	Blurred vision 31%	Dry eye 28%	Headache 26%
Sengo et al (2023) [22]	Heavy eyelids 87.7%	Headache 84.6%	Burning 83.4%
Present Study	Headache 78.17%	Burning Sensation 68%	Watery Tearing 71.67%

A notable trend among participants is using mobile and easily accessible technology, precisely, extensive use of tablets and phones, as indicated by 42.47% and 39.2% of participants respectively. However, this convenience comes at the cost of increased vulnerability to DES, especially as device usage duration escalates. For instance, headaches and vision blurring, experienced by 79.31% of participants engaging with screens for more than 10 hours.

Gender and the use of corrective glasses emerged as significant factors influencing the prevalence and severity of DES symptoms. Females reported a higher incidence of almost all symptoms compared to their male counterparts, with statistically significant differences in the reporting of burning sensation (73.15% females vs. 60% males, $p = 0.001$) and eye pain (58.63% females vs. 44.68% males, $p = 0.001$). Study results aligns with findings that the likelihood of a female scoring severe DES is 1.5 times higher than that of a male. This may be explained by the fact that, as various studies have shown, females exhibit a higher amplification of somatic symptoms than males [23, 24, 25, 26].

Additionally, glasses wearers reported more symptoms across the board compared to non-glasses wearers, suggesting that those already experiencing ocular issues may be at an increased risk for DES.

Pre-existing eye conditions (myopia, oculomotor abnormalities, cataract, glaucoma, presbyopia, and wearing contact lenses) further exacerbated the severity of DES symptoms [27]. Participants with pre-existing eye disease reported higher percentages of nearly all symptoms, with vision blurring being significantly more prevalent among this group (76.5% with pre-existing conditions vs. 42.4% without, $p < 0.001$). This finding empha-

sizes the importance of regular eye examinations and early intervention to mitigate the progression of DES symptoms.

An interesting observation emerged when analyzing the data by academic stage. Symptoms such as headache, eye redness, and vision blurring showed a trend of increasing severity as students progressed in their academic careers. This could reflect the intensifying academic demands and subsequent increased digital screen engagement. For instance, Stage 5 students exhibited the highest mean DES score of 11.73, indicating a peak in eye strain symptoms. Conversely, Stage 6 students reported lower mean and median scores (9.97 and 9.00, respectively), possibly due to a shift in study patterns or increased awareness and management of DES symptoms.

Despite the study's strengths, including its comprehensive survey and diverse sample, it is not without limitations. The reliance on self-reported data may introduce bias, and the absence of a longitudinal design prevents understanding of symptom progression over time. Future research should therefore include longitudinal studies and explore the efficacy of specific interventions, such as ergonomic workshops or software that encourages breaks, in mitigating DES.

In conclusion, the findings underscore the critical need for policies and practices aimed at managing screen time and promoting ocular health among students. Educational institutions should consider implementing ergonomics workshops, eye health education, and regular screenings to mitigate the impact of DES. Additionally, the significant correlation between DES and factors such as gender, use of glasses, and pre-existing eye conditions highlights the need for targeted interventions. Ultimately,

fostering an environment that prioritizes student health and well-being is essential in addressing the challenges posed by the digital age.

4.1 Prevention

Prevention is the main strategy for management of digital eye strain [28].

Regularly taking brief breaks can help to relax the eyes' accommodation process and reduce eye strain. The most popular preventive measure for relieving CVS symptoms was taking breaks from computer use [29]. It'll be simple to practice taking short breaks between tasks if you adhere to 20/20/20 rule [1], which states that one should gaze at something 20 feet away for 20 seconds after 20 minutes of computer use.

When using the digital device , it is crucial to make sure that the brightness, contrast, and screen lighting are all set to their ideal levels. The room's luminance shouldn't be more than three times that of the screen's mean luminance [30]. moreover, the frequency of CVS symptoms was significantly lower when eye drops were used. Through using eye drops to rewet the ocular surface and increase tear volume, you can improve dynamic visual acuity and minimize symptoms of ocular tiredness, dryness, and difficulty focusing [29]. Persistent symptoms despite these changes mark the need for an ophthalmic exam.

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