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CHANGES IN DIOPTRIC POWER OF GLASSES AMONG MYOPIC STUDENTS AT FK UDAYANA DURING ONLINE LEARNING 2020-2021

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ABSTRACT

Background: The prevalence of myopia and the diopter power of myopic glasses among adolescents have increased since the COVID-19 pandemic. Several studies reported an increase of 0.9 D within 7 months after the pandemic, compared with 0.6 D per year before the pandemic. This study aimed to identify factors influencing changes in the diopter power of glasses among myopic students at the Faculty of Medicine, Udayana University, during online learning in 2020–2021.

Methods: This descriptive quantitative study used a cross-sectional design. Data were collected using a questionnaire.

Results: Most respondents were 21 years old, female, engaged in outdoor activities for more than 3 hours, spent over 4 hours using digital screens, had adequate room lighting, and maintained an upright sitting position while using digital devices. Before online learning, most respondents had mild myopia (<3 D) in both eyes. The most common increase in myopic diopter power after online learning was 0.5–1 D in both eyes.

Conclusion: Progressive myopia risk factors, including outdoor activity, digital screen time, room lighting, and reading position while using digital devices, did not significantly affect changes in the diopter power of glasses among myopic students at the Faculty of Medicine, Udayana University, during online learning in 2020–2021.

Keywords: Glasses, Progressive Myopia Risk Factors, Diopter.

INTRODUCTION

Myopia, also known as nearsightedness, is one of the most common eye diseases in the world.[1] It is estimated that more than 50% of the population in industrialized countries suffers from myopia, and this number continues to rise over time.[2] The World Health Organization (WHO) states that around half of the global population may be nearsighted by 2050. Other studies also mention that by 2050, nearly 1 billion people will experience high myopia. The prevalence of myopia in Europe is reported to be 30.6% and continues to increase. A similar trend also occurs in North America and Australia. According to a study conducted in the United States, the prevalence of myopia among children aged 12–17 years increases from 12% in 1971 to 31.2% in 2004, indicating a global increase in the prevalence of myopia.[3]

In recent decades, several reports show a dramatic increase in myopia among school-aged children, especially in Asia. For instance, between 1983 and 2000, the prevalence of myopia among 7-year-old children in Taiwan increases markedly from 5.8% to 21%. In urban areas of East Asia, approximately 80–90% of children graduate from high school with some degree of myopia, and around one-fifth of them have high myopia. Environmental factors are thought to play an important role in this trend, as the prevalence of myopia among school-aged children in rural areas remains relatively low. For example, the prevalence of myopia among school children in rural Mongolia is reported to be approximately 5.8%.[3] Based on a study

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conducted in China involving 123,535 children, approximately 64,335 (52.1%) are male. The analysis demonstrates substantial myopia progression, with an increase of approximately 0.3 diopters compared with previous years. The prevalence of myopia identified through photoscreening in 2020 is significantly higher than that reported during 2015–2019. During 2015–2019, the prevalence of myopia is 5.7% among 6-year-olds, 16.2% among 7-year-olds, and 27.7% among 8-year-olds. In contrast, photoscreening in 2020 shows a significant increase in myopia prevalence across these age groups, reaching 21.5%, 26.2%, and 37.2%, respectively.[4] Valid data on the prevalence of myopia among adolescents in Indonesia remain limited. However, one available reference is a study conducted by Saminan (2013), which reports that 26% of 1,043 individuals aged over 21 years in Riau have myopia.[5]

The prevalence of myopia among adolescents continues to increase since the COVID-19 pandemic. The pandemic forces 190 countries to close some or all educational institutions for months, affecting at least 1.5 billion school-age children. This situation leads many countries to implement e-learning systems, which have implications for the health and behavior of young people. Print textbooks are replaced with e-books, and face-to-face learning shifts to online video conferences. Indirectly, the e-learning system requires students to increase their use of digital screens and reduce outdoor activities. Both factors significantly increase the risk of myopia progression.[6] Based on literature studies, adolescents use electronic devices more frequently during the COVID-19 pandemic.[7] In addition, data from various journals indicate that before the pandemic, adolescents spend an average of 0.67 hours/day using electronic devices, which increases to 5.24 hours/day after the pandemic begins.[8] According to Ganne et al. (2020), screen time of 6 hours or more per day increases the risk of myopia by seven times.[9] Some electronic devices, such as smartphones, tablets, laptops, and computers, emit blue light with a short wavelength. Exposure to blue light emitted by these devices suppresses the production of melatonin, a hormone responsible for inducing sleep, thereby disrupting the circadian rhythm and altering sleep patterns. This disruption negatively affects both sleep quality and quantity in adolescents.[7] Poor sleep quality and quantity increase the risk of vision deterioration, including myopia.[10]

Myopia is generally caused by a refractive error due to excessive axial elongation of the eye. Optically, myopia can be corrected with glasses, contact lenses, and refractive surgery.[11] Although myopia can be corrected, it can lead to complications and is the sixth leading cause of blindness worldwide. Furthermore, several studies seek ways to slow myopia progression because of its association with more serious pathological conditions, such as macular degeneration, retinal detachment, glaucoma, and cataracts.[2] Myopia is also often associated with a decreased quality of life, particularly in terms of vision, and has significant social and economic impacts on affected individuals. A study on myopia reports that myopic macular degeneration (MMD) leads to a global productivity loss of 6 billion dollars.[11]

Glasses are the first modality used for treating myopia in adolescents because they provide clear vision with minimal side effects. Glasses for myopia correction use concave lenses to focus light more posteriorly, allowing clear visual focus on the retina.[12] During the COVID-19 pandemic, in addition to the increase in the prevalence of myopia, there is also an increase in the diopter power of glasses among myopic patients. A study by Wang et al. (2021) reports a substantial shift in myopia (approximately 0.3 D) among children aged 6–8 years. In contrast, previous years show only a 0.1 D shift in children of the same age. This finding indicates that the pandemic has a significant impact on the increase in diopter power among myopic patients in the adolescent age group.[4] This finding is supported by a study conducted in China, which reports that the increase in myopia diopter power among adolescents before the COVID-19 pandemic is approximately 0.6 D per year, whereas after the pandemic, the increase reaches approximately 0.9 D within 7 months.[13] Given the growing concern regarding myopia among students during the COVID-19 pandemic, this research is crucial to understand changes in the diopter power of glasses among myopic students at the Faculty of Medicine Udayana.

LITERATURE REVIEW

Definition and Epidemiology of Myopia

Myopia was optically defined in relation to retinal image formation. According to the latest version of the WHO, myopia was a refractive error caused by light entering the eye parallel to the optical axis and being focused in front of the retina when ocular accommodation was relaxed. This occurred due to an overly curved cornea and an excessively long eyeball.[14] Myopia was categorized into axial and refractive myopia. Axial myopia was caused by the elongation of the eyeball, a development that occurred during childhood and adolescence. On the other hand, refractive myopia was relatively rarer and involved the

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refractive elements of the eye.[15]

Over the past three decades, the prevalence of myopia increased sharply. According to the WHO, the myopic population was expected to reach half of the global population by 2050. This development was especially observed in East Asia, Europe, and North America. The prevalence of myopia in adults was reported to be around 40-60%. Factors associated with the increasing incidence of myopia included a lack of outdoor activity, high levels of parental education and occupation, type of schooling, and age factors.[16] The increase in prevalence and degree of myopia was attributed to factors such as increased schoolwork, reduced outdoor time, and insufficient sunlight exposure. Graduate school students, followed by jobs that required 8 hours of continuous computer work, were at high risk for an increase in the degree of myopia. A cohort study found that about 10% of myopic students who spent time in front of a computer experienced an increase in myopia. A study conducted by Bullimore et al. (2021) reported that 21% of contact lens users aged 20 to 40 experienced an increase of at least 1 diopter over a period of 5 years.[2]

Classification of Myopia

The classification of myopia based on its degree was divided into three categories: mild myopia (<3 diopters), moderate myopia (3-6 diopters), and severe myopia (>6 diopters).[17] Acquired myopia or school myopia was commonly found in children attending primary, secondary, and higher education. From the age of 6, the annual progression rate of myopia in children was around 1 diopter, with the highest progression occurring between the ages of 11 and 13. In some cases of school myopia, there was usually an influence of genetic susceptibility, due to varying prevalences in different regions. More than 200 gene variants associated with myopia were identified. However, no genes were found to have a dominant influence on the progression of school myopia. Therefore, factors other than genetics played a more dominant role in the progression of school myopia, one of which was environmental factors. Environmental factors such as educational stress, work duration and intensity, lack of outdoor time, and increased screen time due to online learning during the COVID-19 pandemic worsened the prevalence of school myopia in the near future.[18]

Risk Factors for Myopia

Age

Age was the highest independent risk factor in the development of myopia. Children aged 6-7 years with a myopia degree of 1.25 diopters had a higher risk of myopia progression compared to older children. A study showed that the progression of myopia in children aged 6-7 years was approximately 1.70 diopters higher than in children aged 8 years and older. Based on this study, administering myopia treatment to younger patients had greater benefits and effectiveness compared to other age groups.[19]

Gender

Gender was another risk factor in the development of myopia. Numerous studies compared the prevalence of myopia between male and female subjects. Myopia was more prevalent in male subjects compared to females. Other factors significantly influenced the difference in myopia prevalence between boys and girls, including limited access to education for girls, educational disparities between regions, unhealthy lifestyle patterns, outdoor activities, and near-vision tasks.[20]

Risk Factors for Progressive Myopia

Outdoor Activity

Outdoor activity was an important factor in the development of refractive errors over the past 20 years. Many hypotheses suggested that time spent outdoors and physical activity could reduce the risk of myopia, based on the lower prevalence of myopia in rural areas and in individuals who worked primarily outdoors. This was supported by the theory that people would have a greater distance of vision when engaging in outdoor activities, thus requiring less accommodation. According to several studies, children exposed tolight intensity up to 20,000 lux showed significant inhibitory effects on eye growth. Therefore, increased lighting in classrooms with high educational intensity played a major role in inhibiting the progression of myopia.[20]

Digital Screen Time

Digital screen time referred to the time spent staring at electronic screens. This factor became the most influential in the progression of myopia in recent times. Over the past two decades, the use of digital devices became a part of daily life worldwide. With digital devices, people could integrate into schools in many countries. Digital devices became crucial in near-vision tasks, and their use was correlated with the increased progression of myopia.[20] The use of smartphones became widespread around 10 years ago following the launch of the first smartphone. Over the last decade, mobile device usage significantly increased. For example, in 2014, smartphone usage was 22%, which increased to 37% in 2019. The age at

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which children began using smartphones also became younger (ages 1-6) with usage durations of 1-2 hours per day.[21]

In a study by Juliari et al., it was noted that teenagers who used digital devices for more than 4 hours a day experienced a reduction in mucin 5AC levels in the eye, which impacted the progression of eye diseases such as computer vision syndrome (CVS) and myopia. A study involving children with and without refractive errors showed that children with myopia spent more time using digital screens than those without myopia. Children with myopia spent an average of 2.7 hours per week playing video games, compared to 2.2 hours per week in emmetropic children and 1.4 hours per week in hyperopic children. Smartphones were used by children for gaming (29%), watching videos (20%), and learning (19%). The increase in digital screen time among children since the introduction of smartphones in the last decade led to a decrease in outdoor activities. This contributed to a higher progression of myopia in urban areas, where educational systems and technology were more advanced.[21]

Room Lighting

Indoor lighting was one of the factors affecting comfort in the work environment. Lighting could come from natural sources, such as sunlight, or artificial sources, such as lamps. Poor lighting in the workspace increased the eye's accommodation power. Increased accommodation caused the eyeball's surface to bulge. Prolonged bulging of the eyeball could lead to changes in the eye's structure, causing images not to focus on the normal focal point (the fovea). Proper lighting intensity that met standards helped keep the eye muscles relaxed, reduced eye strain, and saved work time. On the other hand, insufficient lighting that did not meet standards led to eye fatigue, decreased work efficiency, headaches, and could cause refractive errors, including myopia.[22]

Workers who suffered from myopia needed proper lighting to avoid further progression. According to a study by Khoiriyah et al. (2019), visual acuity disturbances were closely related to lighting intensity. This was also supported by research by Hakimah Hasan (2018), which stated that dim lighting during near-vision tasks worsened visual acuity.[22]

Reading Position with Gadgets

Reading was a complex neurophysiological process that involved not only accommodation and convergence but also fixation and the regulation of the eye's saccadic movements through six extraocular muscles. The pressure between the eyelids and the eye could also vary during reading. This was not only caused by anatomical differences but also by variations in posture and eye alignment. If these factors occurred continuously, they could lead to stretching of the sclera, which was an anatomical change at the back of the eye that impacted the progression of myopia.[23]

Some studies indicated that lying down or prone positions could lead to the progression of myopia by causing elongation of the eyeball due to contraction of the extraocular muscles. This happened because different gaze directions caused varying tensions on the extraocular muscles. Additionally, the pressure from the eyelids could affect the shape of the cornea and the viewing angle.[17]

Several studies mentioned that lying down while reading on a device prevented the body from relaxing due to the tension from the eye muscles following the position of the device. Furthermore, this position caused the eye to experience high accommodation due to continuous contraction of the ocular muscles. This led to axial elongation of the eye, resulting in increased diopter power in myopic individuals.[17]

MATERIALS AND METHODS

This study was a descriptive quantitative cross-sectional study using data from electronic questionnaires (Google Form) distributed to the 2020-2021 cohort of Udayana University Medical Faculty students. The research was conducted at the Faculty of Medicine, Udayana University, from January 2024 toJune 2024. The study had been approved by the Udayana University Medical Faculty Ethics Committee with ethical clearance number 0168/UN14.2.2.VII.14/LT/2024.

The sampling technique used in this study was total sampling. The data collected came from participants who met the inclusion criteria, namely: all Udayana University Medical Faculty students from the 2020 and 2021 cohorts who were registered administratively, had myopia, and were willing to participate in the study by completing an informed consent form. Data that did not meet the inclusion criteria were filtered based on the following exclusion criteria: subjects who were unwilling to participate in the study and subjects who did not know their eyeglass prescription.

The data were processed using the Statistical Package for the Social Sciences (SPSS) version 25, Microsoft Excel, and Microsoft Word. Respondent characteristic data were analyzed univariately and presented in

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frequency distribution tables. Additionally, to determine the relationship between risk factors for progressive myopia and the increase in eyeglass diopter power in students, the data were presented in tables
showing the significance levels for each variable. After performing a normality test, the data were analyzed using the chi-square method to determine which factors significantly affected the increase in diopter power in the eyeglasses of Udayana Medical Faculty students. The statistical significance level was set at $P < 0.05$.

RESULT

The subject of this study was all students of the Faculty of Medicine, Udayana University, from the 2020 and 2021 cohorts who suffered from myopia and wore minus glasses. This study used primary data collected through an electronic questionnaire (Google Form) that had been tested for validity and reliability by the researcher within the Faculty of Medicine, Udayana University. The total number of samples obtained during the research period was 102 samples from students of the 2020 and 2021 cohorts, selected using the total sampling method.

Table 1. Respondent Characteristics

Characteristics	Eye Section	Mean ± SD	Frequency (N=102)
Age (Years)		20.95±0.635	
Gender			
Male			34 (33.3%)
Female			68 (66.7%)
Outdoor Activities			
<3 Hours			34 (33.3%)
>3 Hours			68 (66.7%)
Digital Screen Time			
<4 Hours			3 (2.9%)
>4 Hours			99 (97.1%)
Room Lighting			
Insufficient			13 (12.7%)
Adequate			89 (87.3%)
Device Reading Position			
Lying Down			24 (23.5%)
Sitting Upright			78 (76.5%)
Diopter Power Before Online			
<3,00 D	Right		65 (63.7%)
	Left		67 (65.7%)
3,00-6,00 D	Right		37 (36.3%)
	Left		35 (34.3%)
>6,00 D	Right		0 (0%)
	Left		0 (0%)

Total 102 participants were included in this study, all of whom had bilateral myopia. The characteristics of the study participants are presented in Table 5.1 included age, sex, outdoor activity, digital screen time, room lighting, reading position while using digital devices, and eyeglass diopter power before online learning.
The analysis showed that the mean age of the participants was 20.95 ± 0.635 years. Sex distribution analysis showed that the majority of participants were female (68 participants, 66.7%). Most participants engaged in outdoor activities for more than 3 hours (68 participants, 66.7%). Analysis of digital screen time showed that almost all participants had more than 4 hours of daily screen time (99 participants, 97.1%). Most participants used digital devices under adequate room lighting conditions (89 participants, 87.3%). Analysis of reading position while using digital devices showed that the majority of participants used an upright sitting position (78 participants, 76.5%). Regarding eyeglass diopter power before online learning, most participants had mild myopia, with the highest proportion having a diopter power of <3.00 D in both the right and left eyes.

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Table 2. Univariate Analysis of the Profile of Diopter Power Increase After Online Learning

Variable	Eye Section	Frequency (N=102)
Increase in Diopter Power After Online		
<0,50 D	Right	16 (15.7%)
	Left	19 (18.6%)
0,50-1,00 D	Right	46 (45.1%)
	Left	41 (40.2%)
>1,00 D	Right	11 (10.8%)
	Left	12 (11.8%)
Did Not Increase	Right	29 (28.4%)
	Left	30 (29.4%)

The results of this study showed that the majority of participants experienced an increase in the diopter power of their myopic eyeglasses after online learning, as presented in Table 5.2. The analysis showed that the most common increase in eyeglass diopter power was 0.50–1.00 D.

Table 3. Bivariate Analysis of Outdoor Activities and the Increase in Diopter Power After Online Learning

Variable	Eye Section	Diopter Increase	Outdoor Activities		P Value
			<3 hours	>3 hours	
Increase in Glasses Diopter Power After Online Learning	Right	<0,50 D	9 (8.8%)	7 (6.9%)	0.128
		0,50-1,00 D	11 (10.8%)	35 (34.3%)	
		>1,00 D	4 (3.9%)	7 (6.9%)	
		Did Not Increase	10 (9.8%)	19 (18.6%)	
	Left	<0,50 D	8 (7.8%)	11 (10.8%)	0.612
		0,50-1,00 D	11 (10.8%)	30 (29.4%)	
		>1,00 D	5 (4.9%)	7 (6.9%)	
		Did Not Increase	10 (9.8%)	20 (19.6%)	
	Total		34 (33.3%)	68 (66.7%)	

The results of this study showed that the majority of students who experienced an increase in eyeglass diopter power of 0.50–1.00 D in both the right and left eyes engaged in outdoor activities for more than 3 hours, as presented in Table 5.3. The analysis yielded a p-value of 0.128 ($p > 0.05$) for the right eye and 0.612 ($p > 0.05$) for the left eye.

Table 4. Bivariate Analysis of Digital Screen Time and the Increase in Diopter Power After Online Learning

Variable	Eye Section	Diopter Increase	Digital Screen Time		P Value
			<4 hours	>4 hours	
Increase in Glasses Diopter Power After Online Learning	Right	<0,50 D	0 (0%)	16 (15.7%)	0.371
		0,50-1,00 D	2 (2%)	44 (43.1%)	
		>1,00 D	1 (1%)	10 (9.8%)	
		Did Not Increase	0 (0%)	29 (28.4%)	
	Left	<0,50 D	0 (0%)	19 (18.6%)	0.355
		0,50-1,00 D	2 (2%)	39 (38.2%)	
		>1,00 D	1 (1%)	11 (10.8%)	
		Did Not Increase	0 (0%)	30 (29.4%)	
	Total		3 (2.9%)	99 (97.1%)	

The results of this study showed that the majority of students who experienced an increase in eyeglass diopter power of 0.50–1.00 D in both the right and left eyes had more than 4 hours of daily digital screen time, as presented in Table 5.4. The analysis yielded a p-value of 0.371 ($p > 0.05$) for the right eye and 0.355 ($p > 0.05$) for the left eye.

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Table 5. Bivariate Analysis of Room Lighting and the Increase in Diopter Power After Online Learning

Variable	Eye Section	Diopter Increase	Room Lighting		P Value
			Insufficient	Adequate	
Increase in Glasses Diopter Power After Online Learning	Right	<0,50 D	1 (1%)	15 (14.7%)	0.818
		0,50-1,00 D	6 (5.9%)	40 (39.2)	
		>1,00 D	2 (2%)	9 (8.8%)	
		Did Not Increase	4 (3.9%)	25 (24.5%)	
	Left	<0,50 D	1 (1%)	18 (17.6%)	0.738
		0,50-1,00 D	6 (5.9%)	35 (34.3%)	
		>1,00 D	2 (2%)	10 (9.8%)	
		Did Not Increase	4 (3.9%)	26 (25.5%)	
	Total		13 (12.7%)	89 (87.3%)	

The results of this study showed that the majority of students who experienced an increase in eyeglass diopter power of 0.50–1.00 D in both the right and left eyes used digital devices under adequate room lighting conditions, as presented in Table 5.5. The analysis yielded a p-value of 0.818 ($p > 0.05$) for the right eye and 0.738 ($p > 0.05$) for the left eye.

Table 6. Bivariate Analysis of Device Reading Position and the Increase in Diopter Power After Online Learning

Variable	Eye Section	Diopter Increase	Device Reading Position		P Value
			Lying Down	Sitting Upright	
Increase in Glasses Diopter Power After Online Learning	Right	<0,50 D	5 (4.9%)	11 (10.8%)	0.558
		0,50-1,00 D	9 (8.8%)	37 (36.3%)	
		>1,00 D	4 (3.9%)	7 (6.9%)	
		Did Not Increase	6 (5.9%)	23 (22.5%)	
	Left	<0,50 D	5 (4.9%)	14 (13.7%)	0.415
		0,50-1,00 D	8 (7.8%)	33 (32.4%)	
		>1,00 D	5 (4.9%)	7 (6.9%)	
		Did Not Increase	6 (5.9%)	24 (23.5%)	
	Total		24 (23.5%)	78 (76.5%)	

The results of this study showed that the majority of students who experienced an increase in eyeglass diopter power of 0.50–1.00 D in both the right and left eyes used an upright sitting position while using digital devices, as presented in Table 5.6. The analysis yielded a p-value of 0.558 ($p > 0.05$) for the right eye and 0.415 ($p > 0.05$) for the left eye.

DISCUSSION

Glasses are a widely used modality in the management of myopia. In addition to their relatively high availability, glasses provide clear vision without causing side effects for the wearer. However, without definitive therapy, continuous use of glasses combined with poor gadget-use habits leads to an annual increase in the diopter power of glasses among individuals with myopia. This is particularly evident after the COVID-19 pandemic, as increased gadget use has an impact on individuals with myopia. The literature shows an increase in myopia diopter power of approximately 0.90 D over seven months during the COVID-19 pandemic, compared with approximately 0.60 D over one year before the pandemic.[13]

Respondent Characteristics

Globally, myopia most commonly begins between the ages of 8 and 13 years and reaches its peak development between the ages of 20 and 30 years.[24] These data support the findings of the present study, which show a mean subject age of 20.95 ± 0.635 years. Additionally, a study by Alifina et al. (2021) shows similar results, with 9 out of 30 medical students from the 2019 cohort at Andalas University having myopia at the age of 20 years.[25] Furthermore, a study by Basu et al. (2016) reports that the majority of myopia cases occur among individuals aged 19–21 years.[26]

A study conducted by the International Myopia Institute on myopia in young adults reports that myopia typically stabilizes by the age of 18; however, progression still occurs. Moreover, education is

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identified as a significant factor influencing the high prevalence of myopia among university students. This is associated with prolonged near-work activities, such as reading and writing on gadgets, as well as a lack of outdoor activities. Prolonged near-work activities lead to greater accommodation, resulting in axial elongation of the eyeball. This issue is further exacerbated during the COVID-19 pandemic, which increases the risk of myopia among university students.[27]

A global study conducted by Rudnicka et al. (2016) mentions that, based on 143 articles published from 42 countries, women are twice as likely to develop myopia as men.[28] These data support the findings of the present study, in which 68 of the 102 students with myopia are female. In addition, these findings are supported by a study conducted by Alifina et al. (2021), which reports that 22 of the 30 medical students from the 2019 cohort at Universitas Andalas are female and have myopia.[25]

Research by Jung et al. (2012) states that women are more susceptible to myopia because they spend more time performing near-work activities and engage less in outdoor activities than men. Prolonged near-work activities lead to hyperopic defocus, which stimulates axial elongation and contributes to the development of myopia.[27] Moreover, research by Jacobsen et al. reports that men tend to have better visual acuity because they have flatter corneas than women, resulting in a higher prevalence of myopia among women than men.[25]

The analysis conducted by the researcher on outdoor activities shows that the majority of subjects (66.7%) engage in outdoor activities for more than 3 hours. This finding is consistent with a study by Salsabila et al. (2022), which reports that among 62 students from SDN Mampang Jakarta, 14 students (22.6%) have insufficient outdoor activity, 23 students (37.1%) have moderate outdoor activity, and 25 students (40.3%) engage in sufficient outdoor activities.[29]

Several global studies indicate that outdoor activity serves as a protective factor against myopia progression. A study conducted in China reports that adolescents who increase their outdoor activities by 40 minutes experience slower myopia progression than the control group.[30] Additionally, research by Alifina et al. (2019) reports that among 60 medical students at Universitas Andalas, 42 students (70%) engage in outdoor activities for less than 3 hours, while 18 students (30%) spend more than 3 hours outdoors.[25] These findings differ from those of the present study. The differences may be attributed to several factors, such as respondents being unaware of the exact duration of their outdoor activities, as well as other predisposing factors, including genetics and digital screen time, which may influence the progression of myopia.

Several global studies mention that the intensity and duration of digital screen time have negative effects on myopia progression.[31] These data support the findings of the present study, in which nearly all subjects (97.1%) report more than 4 hours of digital screen time. This finding is consistent with the study by Primadiani et al. (2016), which reports that among 59 medical students at Universitas Diponegoro, 9 students (15.3%) have screen time of less than 4 hours, while 50 students (84.7%) have more than 4 hours of screen time. Based on the findings of the present study and those of Primadiani et al. (2016), screen time intensity appears to influence the incidence of myopia. This finding is further supported by research conducted by Bettina et al. (2014), which reports that prolonged near-work activities contribute to increased myopia progression.[32]

The analysis conducted by the researcher on room lighting shows that the majority of subjects (87.3%) have adequate lighting while using digital devices. This finding is supported by the study conducted by Primadiani et al. (2016), which reports that among 59 medical students at Universitas Diponegoro, 2 students (3.4%) experience insufficient lighting while using digital devices, whereas 57 students (96.6%) have adequate lighting. Based on the findings of the present study and those of Primadiani et al., room lighting does not appear to significantly affect myopia progression. This is further supported by the findings of Primadiani et al., which show a p-value of 1 ($p > 0.05$), indicating no statistically significant relationship between room lighting and myopia progression.[32]

However, the findings of the present study differ from those reported by Rahayu et al. (2022), which report that among 55 respondents working in the eyelash extension sector in Kejobong District, 36 respondents (65.5%) have lighting that does not meet the standard, while 19 respondents (34.5%) have adequate lighting.[33] Research by Wardani et al. also suggests that inadequate lighting may contribute to myopia progression. The differences in findings may be attributed to several factors, such as respondents being unaware of the lighting conditions in their environment, the lack of appropriate equipment to measure light intensity in rooms where digital devices are used, and other predisposing factors, including genetics, outdoor activity, and digital screen time,

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which may influence myopia progression.

The analysis conducted by the researcher on reading posture while using digital devices shows that the majority of subjects (76.5%) use an upright sitting posture. This finding differs from the study conducted by Primadiani et al. (2016), which reports that among 59 medical students at Universitas Diponegoro, 38 students (64.4%) use a lying posture while using digital devices, whereas 21 students (35.6%) use an upright sitting posture. The difference in findings between the present study and that of Primadiani et al. suggests that reading posture does not significantly influence myopia progression. This is further supported by the findings of Primadiani et al., which show a p-value of 0.15 ($p > 0.05$), indicating no statistically significant relationship between reading posture and myopia progression.32 A global study states that individuals with myopia aged 16-25 years tend to have mild myopia (<3.00 D).[34] This finding supports the results of the present study, in which the majority of subjects have mild myopia (<3.00 D) in the right eye (63.7%) and left eye (65.7%). This finding is further supported by a study conducted by Ashan et al. (2022), which reports that among 33 medical students from the 2016 cohort at Universitas Baiturrahmah, the majority of respondents have mild myopia (<3.00 D) in the right eye (66.7%) and left eye (69.7%).[35]

Based on the findings of the present study and those of Ashan et al. (2022), mild myopia is the most common type of myopia among medical students. This type of myopia is non-progressive and is not associated with degenerative retinal changes. In contrast, high myopia, which has a diopter power greater than 6.00 D, is more likely to be influenced by genetic factors and often leads to retinal pathologies. On the other hand, mild myopia is typically associated with predisposing factors, such as outdoor activity and digital screen time.[35]

The analysis based on the category of increased diopter power among medical students at the Faculty of Medicine, Udayana University, who participate in online learning shows that the majority experience an increase of 0.50–1.00 D in the right eye (45.1%) and left eye (40.2%). This finding is consistent with the study by Syifa et al. (2020), which reports that among 59 medical students from the 2017 cohort at Universitas Hasanuddin, 46 students (78%) experience myopia progression, while 13 students (22%) do not. This finding is further supported by the study conducted by Syifa et al., which reports a significant correlation between the duration of digital screen time, outdoor activities, and the progression of myopia.[36] A similar finding is also reported by Nintyastuti (2016), who states that prolonged gadget use contributes to the risk of myopia progression, with a significance value of 0.017.[37]

A global study also reports that nearly 90% of individuals with myopia stabilize between the ages of 21 and 24 years.[24] However, this may vary depending on an individual's habits. One of the major impacts of the COVID-19 pandemic is the increased use of digital devices.[38] Prolonged and intensive use of digital devices causes the ciliary muscles to become stiff, resulting in a more convex eye lens. This causes the eye to have difficulty focusing on distant objects. Furthermore, prolonged device use leads to eye fatigue, with radiation from digital device screens being one of the primary contributing factors. A study by Hayatillah reports that among 60 respondents, 24 have excessive digital device use (5–10 hours/day), while 36 have moderate use (<5 hours/day). Continuous near-vision activity over a prolonged period leads to biochemical changes in the sclera through a stretching mechanism that typically occurs after 30 minutes of accommodation. The accumulation of prolonged near-vision activities causes continuous accommodation, resulting in sustained scleral stretching. Consequently, images are formed in front of the retina when the eye attempts to focus on distant objects, resulting in myopia.[39]

The Relationship Between Risk Factors for Progressive Myopia and the Increase in Diopter Power of Glasses in Students

The analysis of outdoor activity and the increase in the diopter power of glasses among students at the Faculty of Medicine, Udayana University, shows p-values of 0.128 ($p > 0.05$) for the right eye and 0.612 ($p > 0.05$) for the left eye. These results indicate that outdoor activity has no statistically significant effect on myopia progression. These findings are consistent with the study by Salsabila et al. (2023), which reports a p-value of 0.327 ($p > 0.05$), indicating that outdoor activity has no statistically significant influence on myopia progression.[29]

Some theories suggest that outdoor activity serves as a protective factor against myopia because it improves the depth of focus and optical clarity of the eye. Additionally, increased outdoor light intensity mediates the release of dopamine in the retina, which reduces axial elongation of the eyeball, one of the causes of myopia progression. This theory is commonly referred to as the light-dopamine hypothesis.[25] Another theory related to the protective effect against myopia progression involves vitamin D.

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Vitamin D levels increase with exposure to direct sunlight. Increased vitamin D may have beneficial effects on the ciliary muscles by influencing the flexibility of the ciliary ring in maintaining tension on the crystalline lens, thereby helping to slow myopia progression.[40]

The analysis of digital screen time and the increase in the diopter power of glasses among students at the Faculty of Medicine, Udayana University, shows p-values of 0.371 ($p > 0.05$) for the right eye and 0.355 ($p > 0.05$) for the left eye. These results indicate that digital screen time has no statistically significant effect on myopia progression. These findings are consistent with the study by Primadiani et al. (2019), which reports a p-value of 0.58 ($p > 0.05$), indicating that the duration of gadget use has no statistically significant effect on myopia progression.[32]

Myopia progression can occur in individuals who continuously force their eyes to focus on near-work activities for prolonged periods, resulting in sustained accommodation. According to a study by Kinge et al. (2020), a significant relationship exists between myopia progression and the time spent on near-work activities, such as using digital devices. This relationship is also influenced by the saccadic components of the eye, which affect the extraocular muscles, leading to earlier eye fatigue and contributing to the progression of myopia.[32]

The analysis of room lighting and the increase in the diopter power of glasses among students at the Faculty of Medicine, Udayana University, shows p-values of 0.818 ($p > 0.05$) for the right eye and 0.738 ($p > 0.05$) for the left eye. These results indicate that room lighting has no statistically significant effect on myopia progression. These findings are consistent with the study by Primadiani et al. (2019), which reports a p-value of 1.00 ($p > 0.05$), indicating that light intensity has no statistically significant effect on myopia progression.[32]

Several global studies suggest that adolescents with myopia tend to spend more time in environments with light intensity below 1000 lux (dim lighting) than those without myopia. This condition results in faster axial elongation of the eyeball among adolescents with myopia.[41] Dim lighting reduces the quantity and intensity of light entering the eyes, causing objects to appear blurred. Consequently, the eyes experience greater visual strain, which contributes to the progression of myopia.[32]

The analysis of reading position and the increase in the diopter power of glasses among students at the Faculty of Medicine, Udayana University, shows p-values of 0.558 ($p > 0.05$) for the right eye and 0.415 ($p > 0.05$) for the left eye. These results indicate that reading position has no statistically significant effect on myopia progression. These findings are consistent with the study by Primadiani et al. (2019), which reports a p-value of 0.15 ($p > 0.05$), indicating that gadget use position has no statistically significant effect on myopia progression.[32]

Parsinnen et al. explain that reading on a digital device is a complex neurophysiological process involving not only accommodation and convergence but also the regulation of fixation and saccadic eye movements while maintaining tension in the six extraocular muscles. Pressure between the eyelid and the eyeball also varies during digital device use because of anatomical factors as well as differences in posture and eye alignment. Theoretically, several studies suggest that lying or prone positions may cause suboptimal contraction of the extraocular muscles, which may influence myopia progression. This is supported by the theory that reading on a digital device while lying down results in different gaze directions for each eye. Consequently, unequal contraction of the extraocular muscles occurs and may alter corneal shape because of differences in pressure between the right and left eyes, thereby influencing myopia progression.[32]

Several global studies report that myopia generally stabilizes between the ages of 20 and 30 years if its onset occurs between 8 and 13 years, whereas myopia with an onset after the age of 20 years still has the potential to become progressive.24 A limitation of the present study is that it cannot determine the onset of myopia in each student, making it difficult to assess myopia progression among students at the Faculty of Medicine, Udayana University, who participated in online learning. In addition, data collection relies on subjects self-reported responses to the questionnaire. involve measurements using the Snellen Chart to obtain more accurate results.[42]

CONCLUSION AND RECOMMENDATION

Based on the results of the Changes in Diopter Power of Glasses in Myopic Students at FK Udayana During Online Learning 2020-2021 with 102 samples that met the inclusion criteria, it can be concluded that:

1. The risk factors for progressive myopia that were studied, such as outdoor activities, digital screen time, room lighting, and device reading posture, did not have a significant effect on the changes in diopter power of glasses in myopic students at FK Udayana during online learning in 2020-2021.

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Based on the limitations of this study, it was hoped that future research would conduct objective measurements on samples using media and measurement tools that comply with the standards for myopia, which would lead to more accurate research results.

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