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Relationship Between Body Mass Index (BMI) and Leptin Levels in Students with Myopia at the Faculty of Medicine, University of North Sumatra

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ABSTRACT

Myopia is a refractive disorder whose prevalence continues to increase globally and represents a significant eye health problem among adolescents and young adults. In addition to genetic and environmental factors, metabolic factors are thought to play a role in the development and severity of myopia. This study aims to analyze the relationship between Body Mass Index (BMI) and leptin levels and the degree of myopia in students at the Faculty of Medicine, University of North Sumatra. This study employed an observational analytical design with a cross-sectional approach involving 50 students with myopia. The data collected included BMI, visual acuity, degree of myopia, and serum leptin levels, and were analyzed using Chi-square, one-way ANOVA, and Kruskal–Wallis tests based on data distribution. The results showed a significant relationship between BMI and leptin levels ($p < 0.001$), with leptin levels increasing as BMI rose, particularly in the obese group. BMI was also significantly associated with the degree of myopia ($p < 0.001$), with moderate to severe myopia being more common in obese subjects. Additionally, leptin levels were significantly associated with myopia severity ($p < 0.001$), with higher levels observed in moderate and severe myopia compared to mild cases. The study concludes that BMI and leptin levels are associated with the degree of myopia in college students, indicating the role of metabolic factors in myopia progression. These findings may serve as a basis for developing prevention and management strategies through a multidisciplinary approach that includes nutritional and metabolic aspects.

INTRODUCTION

Refractive abnormalities are disturbances in the process of light refraction by the refractive media of the eye, which include the cornea, aqueous humor, lens, and vitreous humor, or are caused by the axial length of the eyeball (Özbey & Emine, 2025; Woo, 2023). In individuals with normal eyes (emmetropia), there is an optimal balance between the refractive power of the optical media and the length of the eyeball so that incoming light rays are focused precisely on the macula lutea of the retina. In this condition, the image falls directly on the retina without the need for accommodation, especially when viewing distant objects (Mansjor, 2001).

The balance of refraction in the optical system of the eye is largely determined by the anterior surface curvature of the cornea as well as the axial length of the eyeball. Among all refractive media of the eye, the cornea has the greatest refractive power. Meanwhile, the crystalline lens plays an important role in the accommodation process, which is the adjustment of focus when viewing objects at close range. The axial length of the eyeball varies between individuals. If there is a disturbance in corneal curvature (e.g., too flat or too steep) or a change in axial length (longer or shorter than normal), then light rays will not be properly focused on the macula lutea. This condition results in refractive errors, which may manifest as myopia, hyperopia, or astigmatism (Goss et al., 2010).

Myopia is a highly significant refractive error, not only because of its high global prevalence but also due to its potential contribution to visual morbidity and increased risk of serious vision-threatening conditions such as retinal detachment and glaucoma. The prevalence of myopia is increasing worldwide and is projected to affect nearly 50% of the global population by 2050. Factors such as increased screen time and reduced outdoor activity have been identified as major contributors to this trend (Holden et al., 2016).

Myopia is associated with decreased visual acuity for distant objects without optical correction, which may limit eligibility for certain professions requiring optimal distance vision. The inability to see clearly at a distance due to uncorrected myopia can impair daily activities and productivity (Goss et al., 2010). Management of myopia is generally performed by prescribing a negative (concave) spherical corrective lens with the minimum power necessary to achieve maximum visual acuity (Ilyas, 2013). Body Mass Index (BMI) is an indicator of nutritional status used to classify individuals based on weight relative to height. Several studies have explored the association between BMI and myopia, but findings are inconsistent. A study in the United States reported that an increase in BMI was associated with a higher risk of myopia, with each 1 kg/m^2 increase in BMI raising the risk by 1% (Qu et al., 2023). In contrast, studies in China demonstrated an inverse L-shaped relationship, where the risk increased up to a BMI of 25 kg/m^2 but was not significant beyond that point (Wang et al., 2024). A large study in Israel involving more than 1.3 million adolescents showed a J-shaped association between BMI and myopia, with higher risk observed in individuals with both low and high BMI (Peled et al., 2022). Additionally, a study in South Korea found that a higher percentage of total body fat was associated with increased odds of myopia in young adults (Kim et al., 2023).

Research by Lee et al. (2022) shows that obesity in children and adolescents is significantly associated with an increased prevalence of high myopia, which carries a risk of long-term visual complications. The study found that children with high BMI were more likely to experience axial elongation of the eyeball, a major factor in the development of myopia. This finding suggests that excessive body growth, including the accumulation of adipose tissue, can influence the structure and function of the eye during the growth period (Lee et al., 2022).

Furthermore, Nitzan et al. (2024) state that visual impairment, including myopia, is more commonly observed in adolescents with extreme BMI values, whether underweight or obese. This supports the hypothesis that balanced nutritional status plays an important role in healthy visual development. Therefore, maintaining BMI within normal limits is important not only for general health but also for preventing myopia and other visual disorders (Nitzan et al., 2024).

The biological mechanisms underlying the relationship between BMI and myopia are not yet fully understood. Current hypotheses include the role of adiposity in influencing axial length, as well as hormonal and metabolic changes that may affect ocular development. Additionally, a sedentary lifestyle often associated with high BMI may reduce time spent outdoors, which has been shown to be protective against myopia (Liu et al., 2024).

Leptin is a 16 kDa hormone secreted by adipocytes (fat cells) in proportion to fat mass. It is a key regulator of energy and weight homeostasis: leptin signals satiety to the hypothalamus and modulates glucose metabolism, thermogenesis, and neuroendocrine function. In obesity, circulating leptin levels are chronically elevated, reflecting leptin resistance. Leptin also plays a role in the immune system—many immune cells express leptin receptors and respond by adopting a pro-inflammatory phenotype. Thus, leptin acts as a link between nutritional and inflammatory status: elevated leptin levels during energy surplus amplify inflammatory signaling in tissues (Ramos-Lobo & Donato, 2017; Kiernan & MacIver, 2021).

There are limited studies directly examining leptin in relation to myopia; however, some evidence suggests that metabolic signaling may influence eye growth. Systemic metabolic dysregulation (such as hyperglycemia and insulin resistance) has been hypothesized to induce axial elongation (Li et al., 2023). In a Mendelian randomization analysis, genetically lower leptin levels (and higher HbA1c levels) were associated with increased myopia risk, suggesting that impaired leptin signaling may promote ocular elongation. The study also reported that low adiponectin levels increased risk, indicating complex glycemic influences. Population-based studies further suggest a link: obese children (who typically have chronically elevated leptin levels) are more likely to develop myopia. For example, one large survey reported that obese adolescents were approximately 3.8 times more likely to develop high myopia compared to their normal-weight peers (Han et al., 2023). Because retinal dopamine has anti-myopiogenic effects, increases in leptin during puberty (alongside reductions in dopamine) may contribute to axial elongation. However, to date, no studies have directly tested the effects of leptin on retinal dopamine or axial length, and current evidence does not establish leptin as a causal factor in dopamine-mediated eye growth (Carr & Stell, 2017).

Based on this background, it is important to investigate "Relationship Between Body Mass Index (BMI) and Leptin Levels in Students with Myopia at the Faculty of Medicine, University of North Sumatra." This study aims to analyze the association between Body Mass Index (BMI), leptin levels, and the degree of myopia in this population. The findings are expected to provide both theoretical and practical contributions. Theoretically, this study may enhance scientific understanding of the role of metabolic factors in the development and severity of myopia. Practically, the results may serve as a basis for developing preventive and management strategies through a multidisciplinary approach that includes nutritional, metabolic, and ophthalmological aspects. In addition, this study is expected to increase awareness among students and healthcare professionals regarding the importance of maintaining metabolic health as part of comprehensive eye health promotion.

METHOD

The research conducted was an observational analytical research with a cross sectional design. The purpose of this study is to determine the relationship between Body Mass Index and Leptin Levels with Myopia Patients in Students of the Faculty of Medicine, University of North Sumatra.

Data collection processes included:

1) Submitted a research application letter at the Department of Ophthalmology of Faculty of Medicine USU/Hospital Prof. CPL University of North Sumatra.

2) Apply for an "ethical clearance" research permit from the USU Health Research Ethics Committee to the research site at the Prof. CPL Hospital of the University of North Sumatra.
3) Conducting research data collection at the Poly Mata of Prof. CPL University of North Sumatra Hospital.

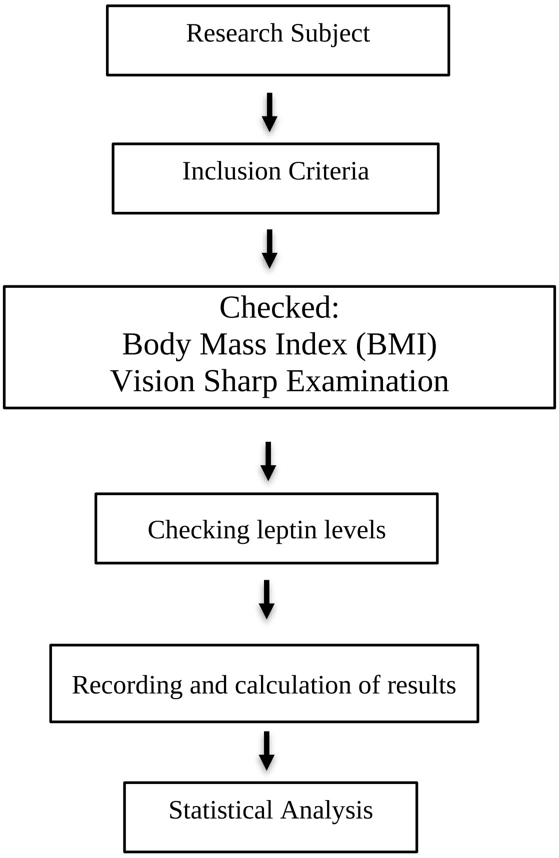

Figure 1. Research Flow

Source: Developed by the authors, 2026

After the data were collected, they were analyzed using data management techniques. The data obtained were processed using statistical software, namely Statistical Product and Service Solutions (SPSS). Demographic data such as gender were categorized into male and female, while data on age, weight, height, results of visual acuity examination of the left and right eyes, and leptin levels were presented as means.

Data analysis in this study used univariate and bivariate analyses. Univariate analysis aimed to determine the distribution of respondent characteristics, while bivariate analysis was performed using the Chi-square test to determine the relationship between BMI and the degree of myopia. Meanwhile, to determine the relationship between leptin levels and myopia, a one-way ANOVA test was used if the data were normally distributed. If the data were not normally distributed, the Kruskal–Wallis test was used. The level of significance was set at 95%.

RESULTS AND DISCUSSION

Eye Examination Results

Table 1 presents the results of eye examinations in 50 FK USU students who suffer from myopia, including the distribution of the right eye (OD) and left eye (OS), as well as the classification of the degree of myopia.

Table 1. Results of Eye Examination in FK USU Students & Myopia Degree

Eye Examination Results	n (%)
All OD	
1/60	2 (4)
2/60	3 (6)
3/60	8 (16)
4/60	5 (10)
5/60	7 (14)
6/60	7 (14)
6/30	4 (8)
6/15	2 (4)
6/24	4 (8)
6/21	5 (10)
6/18	1 (2)
6/9	1 (2)
6/7,5	1 (2)
Visus OS, n (%)	
1/60	1
2/60	3
3/60	6
4/60	8
5/60	9
6/60	7
6/30	3
6/24	4
6/21	3
6/18	2
6/15	2
6/9	1
6/7,5	1
Degree of Myopia, n (%)	
Lightweight	20 (40)
Medium	25 (50)
Weight	5 (10)

Source: Primary data of the processed research, 2026

Eye examinations in 50 FK USU students who suffered from myopia showed sharp variations in vision (visus) in both the right eye (OD) and the left eye (OS) before correction. In the right eye, the vision is spread from 1/60 to 6/7.5. The highest frequency was recorded at 3/60 vision (16%), followed by 5/60 and 6/60 vision at 14% respectively. Meanwhile, in the left eye, the distribution of vision also varies in the same range. Visus 5/60 was the most dominant (18%), followed by visus 4/60 (16%) and 6/60 (14%).

Based on the classification of degrees of myopia, most subjects experienced moderate myopia (50%, n = 25), followed by mild myopia (40%, n = 20), and 10% (n = 5) had severe myopia.

Leptin Levels in Myopia Sufferers

Table 2 presents the distribution of leptin levels in 50 FK USU students suffering from myopia, including mean values, standard deviation, median, and minimum to maximum range.

Table 2. Leptin Levels in FK USU Students with Myopia

Variabel	**n = 50**
Leptin, ng/mL	
Rerata ± SD	5,57 ± 4,49
Median (Min – Mak)	4,1 (0,19 – 17,1)

Source: Primary data of the processed research, 2026

The mean serum leptin level was 5.57 ± 4.49 ng/mL, with a median value of 4.1 ng/mL. The range of leptin levels ranges from 0.19 ng/mL to 17.1 ng/mL.

The Relationship between BMI and Leptin Levels in FK USU Students with Myopia

Table 3 shows the results of the analysis of the relationship between the Body Mass Index (BMI) category and leptin levels in FK USU students with myopia, including a comparison of average leptin levels between BMI groups as well as the results of the One-Way ANOVA statistical test and the Tamhane posthoc test.

Table 3. Relationship between BMI and Leptin Levels in FK USU Students with Myopia

Variabel	**n**	**Leptin, ng/mL**	**p**	**Posthocb**	
				Overweight	**Obesity**
IMT					
Normoweight	14	1,34 ± 0,75	<0,001a	0,516	<0.001
Overweight	11	1,73 ± 0,76			<0.001
Obesity	25	9,62 ± 2,50			

aOneway Anova, bTamhane

Source: Primary data of the processed research, 2026

Table 3 shows the existence of a significant relationship between the categories. Body Mass Index (BMI) with leptin levels in FK USU students with myopia. In general, the higher the BMI category, the higher the average leptin level observed. Subjects with obese status (n = 25) had mean leptin levels of 9.62 ± 2.50 ng/mL, much higher than the normoweight (1.34 ± 0.75 ng/mL) and overweight (1.73 ± 0.76 ng/mL) groups.

Statistical analysis using One-Way ANOVA showed a meaningful relationship between BMI and leptin levels ($p < 0.001$). Furthermore, Tamhane's posthoc test revealed that the increase in leptin levels mainly occurred in the comparison between the obese group and the other two groups ($p < 0.001$), while there was no significant relationship between leptin levels in the normoweight and overweight groups ($p = 0.516$). These findings reinforce the positive association between nutritional status—particularly obesity, and leptin levels in this myopic student population.

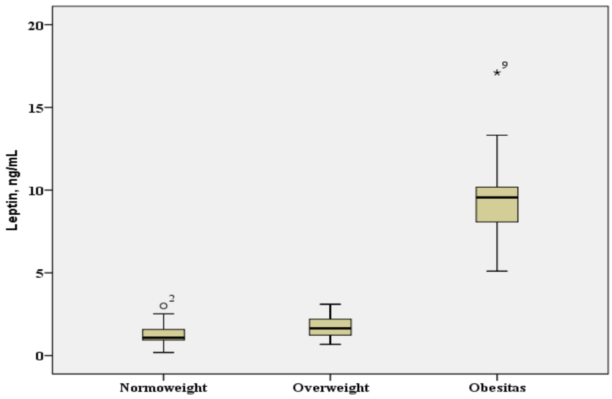

Figure 2. Boxplot Chart of Differences in Leptin Levels based on BMI in FK USU Students with Myopia

Source: Primary research data processed by the authors, 2026

The relationship between BMI and degrees of myopia

Table 4 presents the relationship between the Body Mass Index (BMI) category and the degree of myopia in FK USU students with myopia, with statistical analysis using the Kruskal-Wallis test.

Table 4. Relationship between BMI and Myopia Degree in FK USU Students with Myopia

Variable	Degree of Myopia			p
	Lightweight	Medium	Weight	
IMT				
Normoweight	10 (71,4)	4 (28,6)	0	<0.001*
Overweight	10 (90,9)	1 (9,1)	0	
Obesity	0	20 (80)	5 (20)	

*Kruskal Valais

Source: Primary data of the processed research, 2026

Using the Kruskal Wallis test, there was a significant relationship between BMI category and degree of myopia ($p < 0.001$). In the normoweight group, most subjects (71.4%) experienced mild myopia and 28.6% moderate myopia, with no cases of severe myopia found. A similar pattern was seen in the overweight group, where mild myopia predominated (90.9%) and only 9.1% had moderate myopia; There were no subjects with severe myopia. In contrast, in the obesity group, not a single case of mild myopia was found; In fact, most (80%) have moderate myopia and 20% have severe myopia.

These findings suggest a tendency that increased BMI, particularly in the obesity category, is associated with a greater degree of myopia, while normal or overweight nutritional status is more associated with mild myopia.

The Relationship of Leptin Levels with the Degree of Myopia

Table 5 shows the relationship between serum leptin levels and myopia degrees in FK USU students with myopia, supplemented by the results of the Kruskal-Wallis non-parametric statistical test and the Dunn posthoc test to compare leptin levels between groups of myopia degrees.

Table 5. Relationship between Leptin Levels and Myopia Degree in FK USU Students with Myopia

Degree of Myopia	n	Leptin Level, ng/mL	fort	Posthocb	
				Medium	Weight
Lightweight	20	1.62±0.81	<0.001	<0.001	0,001
Medium	25	8,65 (0,76-13,32)			0,788
Weight	5	10.96±4.11			

[a]Kruskal Valais, [b]Dunn

Source: Primary data of the processed research, 2026

The analysis showed a significant relationship between leptin levels and the degree of myopia ($p < 0.001$). Subjects with mild myopia (n = 20) had low mean leptin levels, which was 1.62 ± 0.81 ng/mL. In contrast, in the moderate myopia group (n = 25), leptin levels tended to be much higher, with a median of 8.65 ng/mL (range 0.76–13.32). In severe myopia (n = 5), the average leptin level reached 10.96 ± 4.11 ng/mL.

The Dunn posthoc test confirmed that leptin levels in the mild myopia group were significantly lower compared to the moderate ($p < 0.001$) and severe ($p = 0.001$) groups. However, there was no significant difference between leptin levels in the moderate and severe myopia groups ($p = 0.788$). These findings suggest a positive association between increased leptin levels and increased degrees of myopia, especially between mild versus moderate/severe myopia, indicating the potential role of leptin as a metabolic biomarker associated with myopia severity in this student population.

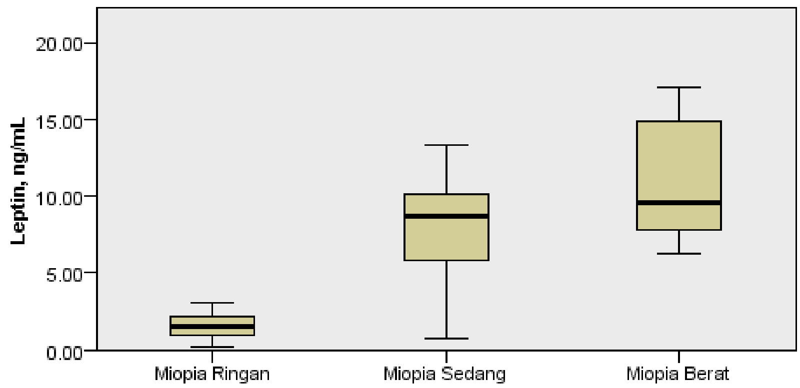

Figure 3. Boxplot Chart of Differences in Leptin Levels by Degree of Myopia in FK USU Students with Myopia

Source: Primary research data processed by the authors, 2026

Basic Characteristics of Research Subjects

Based on the BMI classification, as many as 14 subjects (28%) were included in the normoweight category (normal BMI), 11 subjects (22%) were categorized as overweight, and as many as 25 subjects (50%) were obese. These findings indicate that half of the myopia students in this sample had an obese nutritional status. People with obese BMI tend to suffer from hyperopic because the eyeball is shorter with a shallower vitreous space and a more curved corneal curvature (Djuartina et al., 2020).

Based on the results of a study on 50 students of the Faculty of Medicine, University of North Sumatra (FK USU), significant variations in visual acuity (visus) were found before correction was made. In the right eye (OD), the highest frequency was recorded in the 3/60 vision (16%), while in the left eye (OS), the 5/60 vision was the most dominant (18%). These data showed that most study subjects experienced a substantial decrease in long-distance vision acuity, which clinically manifested as moderate myopia (50%) and mild myopia (40%).

These findings are in line with the context of Berhane et al.'s (2022) research which states that myopia is a growing problem among medical students. In the study, the prevalence of myopia in medical students reached 16.7%, where a decrease in long-distance vision was the main clinical presentation. The high rate of visual impairment in medical students in this study can be attributed to the extreme intensity of academic activities (Berhane et al., 2022).

Medical students spend most of their time reading and other close-up activities. Mechanistically, prolonged close activity (>7 hours per day) has been shown to increase the risk of myopia by up to 4.35 times. This is because prolonged close work triggers ciliary spasm, which is a stimulus for axial elongation of the eyeball (Berhane et al., 2022).

The Relationship of Body Mass Index to Leptin Levels

Based on the results of the study on 50 FK USU students, it was found that there was a statistically significant positive relationship between the Body Mass Index (BMI) category and serum leptin levels ($p<0.001$). Subjects with obese status had average leptin levels of 9.62±2.50 ng/mL, which was significantly higher than the normoweight (1.34±0.75 ng/mL) and overweight (1.73±0.76 ng/mL) groups. Based on the results of data analysis on FK USU students with myopia, it was found that there was no significant relationship between normoweight and overweight BMI categories and serum leptin levels ($p=0.516$). These findings suggest that increased accumulation of fat tissue in students with myopia is followed linearly by increased secretion of the hormone leptin into the bloodstream (Subarjati & Nuryanto, 2015).

These findings are strongly supported by a study by Agbogu-Ike et al. (2021) which reported that plasma leptin concentrations increased significantly as the BMI category increased. In the study, obese individuals had a median leptin level of 61.8 ng/mL, much higher than the normal weight group (28.6 ng/mL). Agbogu-Ike et al. (2021) assert that leptin is synthesized and secreted by adipocytes (fat cells) in white adipose tissue, so that leptin levels in circulation reflect the total amount of energy stores or fat mass in the body (Agbogu-Ike et al., 2021). However, these findings are in line with the basic principles of leptin pathophysiology discussed by Patil et al. (2020) which state that leptin is secreted by adipose tissue and its levels reflect the total amount of fat tissue, especially subcutaneous fat. In the study, a very contrasting difference in leptin levels was found when comparing the obese group with the control group (non-obesity), where the average leptin in obese children reached 52.66 ng/ml compared to only 4.35 ng/ml in the non-obese group (Patil & Srinivas, 2020).

he Relationship of Body Mass Index and Myopia

The results of the analysis showed a statistically significant relationship between the BMI category and the degree of myopia ($p < 0.001$). In the obesity group, no subjects with mild myopia were found; The majority (80%) had moderate myopia and 20% had severe myopia. In contrast, in the normoweight and overweight groups, mild myopia dominated (71.4% and 90.9%).

These findings are strongly supported by the journal Qu et al. (2023) that examined the population in the United States, where a linear relationship between BMI and myopia was found. Based on the journal, every 1 kg/m² increase in BMI was associated with a 1% increased risk of myopia. In addition, individuals with a BMI of > 29.9 have a 25% higher risk of developing myopia compared to normal weight (Qu et al., 2023).

In line with this, the journal Lee et al. (2022) in their study of children and adolescents in South Korea reported that the obese group had a risk of up to 3.77 times greater risk of experiencing high myopia than the group with normal weight. This reinforces the hypothesis that excessive growth of fatty tissue may affect the anatomical structure of the eye, specifically the extension of the axial length of the eyeball (Lee et al., 2022).

The Relationship of Leptin Levels to Myopia

This study also found a positive correlation between serum leptin levels and the degree of myopia ($p < 0.001$). The average leptin level in the obesity group reached 9.62 ng/mL, much higher than the normoweight group (1.34 ng/mL). Subjects with severe myopia had the highest leptin levels (mean 10.96 ng/mL) compared to moderate and mild myopia.

Mechanistically, the journal source explains that leptin is a systemic hormone that plays a central role in metabolism and interacts with LRP2 (Low-density Lipoprotein Receptor-related Protein 2), a large endocytic receptor that is strongly expressed in the ocular epithelium. Disruptions in the leptin pathway through LRP2 in ocular tissue are thought to be involved in the induction and progression of myopia. Animal models show that increased serum leptin concentrations are associated with excessive elongation of the vitreous space, a key feature in pathological myopia (Kozyraki & Cases, 2017).

Leptin is thought to work as a bridge between nutritional status and ocular remodeling. Leptin has angiogenic properties that can increase the expression of VEGF (Vascular Endothelial Growth Factor) in retinal endothelial cells, which plays a role in sclera remodeling and axial elongation. In addition, chronically elevated leptin levels in obese individuals (leptin resistance) can trigger the STAT3 signaling pathway, a pathway that is also involved in the development of myopia. Metabolic dysregulation such as insulin resistance and hyperleptinemia collectively form a risk environment that promotes abnormal eye growth (Kozyraki & Cases, 2017; Ba & Li, 2024).

However, there were specific findings of interest in the Dunn posthoc test, where no statistically significant difference in leptin levels was found between the moderate myopia and severe myopia groups ($p=0.788$). These findings are specifically supported by a literature review in the journal Pieńczykowska et al. (2025). In the journal, it was stated that increased leptin levels can fluctuate and indirectly can distinguish between moderate and severe degrees of myopia. This confirms the findings in this study that after reaching a threshold of a certain degree of severity (moderate myopia), fluctuations in leptin levels no longer show a linear or significant difference when transitioning to more severe degrees of myopia (Pieńczykowska et al., 2025).

CONCLUSION

Based on the description above, it can be concluded that, first, there were 50 students with myopia at the Faculty of Medicine, University of North Sumatra in 2020 and 2021 with 24 men (48%), 26 women (52%) and the average age of children was 22.72 + 0.7 years. The average weight and height of the 2020 stambuk students were 71.3 + 14.44 kg and 162.83 + 7.8 cm. Second, an eye examination of the study subjects showed that in the right eye, the vision was spread from 1/60 to 6/7.5. The highest frequency was recorded at 3/60 vision (16%). While in the left eye, vision 5/60 is the most dominant (18%). Third, it was found that 14 subjects (28) had normal BMI, 11 subjects (22%) were overweight, and 25 subjects (50%) were obese. Fourth, the average leptin level in the study subjects was 5.57 + 4.49 ng/mL. Fifth, there was a significant relationship between the Body Mass Index (BMI) of the obesity group and leptin levels ($p < 0.001$). There was no significant relationship between Body Mass Index (BMI) in the normoweight and overweight groups and leptin levels ($p=0.516$). Sixth, there was a significant relationship between BMI and the degree of myopia, namely ($p<0.001$). Seventh, there was a significant relationship between leptin levels and the degree of myopia, namely ($p<0.001$). However, this study has several limitations, including the relatively small sample size and the cross-sectional design, which limits the ability to establish causal relationships. Therefore, future research is recommended to use larger sample sizes and longitudinal or experimental designs to further explore the causal mechanisms between metabolic factors and myopia progression. In addition, it is suggested that preventive strategies for myopia should incorporate a multidisciplinary approach, including nutritional management, lifestyle modification, and regular eye examinations, especially among students who are at high risk.

REFERENCE

Agbogu-Ike, O. U., Ogoina, D., & Onyemelukwe, G. C. (2021). Leptin concentrations in non-obese and obese non-diabetic Nigerian Africans. *Diabetes, Metabolic Syndrome and Obesity*, *14*, 4889–4902.

Ba, M., & Li, Z. (2024). The impact of lifestyle factors on myopia development: Insights and recommendations. *AJO International*, *1*, 100010.

Berhane, M. A., Demilew, K. Z., & Assem, A. S. (2022). Myopia: An increasing problem for medical students at the University of Gondar. *Clinical Ophthalmology*, *16*, 1529–1539.

Biladina, B., Herlina, S., & Hidayah, F. K. (2024). Pengaruh faktor riwayat keluarga miopia dan indeks massa tubuh terhadap prevalensi miopia pada siswa SMP Wahid Hasyim Kota Malang. *Jurnal Kedokteran Komunitas*, *12*(1), 56–62.

Carr, B. J., & Stell, W. K. (2017). The science behind myopia. In H. Kolb, E. Fernandez, B. Jones, et al. (Eds.), *Webvision: The organization of the retina and visual system* [Internet]. University of Utah Health Sciences Center.

Djuartina, T., Wijaya, A., Prastowo, N. A., & Wijaya, S. (2020). Korelasi antara berat badan, tinggi badan, indeks massa tubuh dan rasio lingkar pinggang-panggul dengan hiperkifosis torakal dan hiperlordosis lumbar pada pelajar sekolah menengah atas. *Jurnal Indon Med Assoc*, *70*(8), 167–172.

Goss, A. D., & Grosvenor, T. P. (2010). *Optometric clinical practice guideline: Care of the patient with myopia* (pp. 3–26, 37–41). American Optometric Association.

Han, X., Hu, Y., Jin, G., et al. (2023). Causal relationships between circulating adipokines and myopia: A Mendelian randomization study. *Ophthalmic Genetics*, *44*(1), 28–37.

Holden, B. A., Fricke, T. R., Wilson, D. A., et al. (2016). Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology*, *123*(5), 1036–1042. https://doi.org/10.1016/j.ophtha.2016.01.006

Ilyas, S. (2013). *Ilmu penyakit mata* (Edisi 4, hlm. 65, 67, 72–78). Balai Penerbit FKUI.

Kiernan, K., & MacIver, N. J. (2021). The role of the adipokine leptin in immune cell function in health and disease. *Frontiers in Immunology, 11*. https://doi.org/10.3389/fimmu.2020.622468

Kim, J., Lim, D. H., Han, K., et al. (2023). The relationship between myopia and obesity in adults: The Korea National Health and Nutrition Examination Survey. *Korean Journal of Ophthalmology*, *37*(3), 210–218. https://doi.org/10.3341/kjo.2023.0102

Kozyraki, R., & Cases, O. (2017). LRP2: A myopic hotspot between environment and genetics. *Advances in Ophthalmology & Visual System*, *7*(1), 259–263.

Lee, S., Lee, H. J., Lee, K. G., & Kim, J. (2022). Obesity and high myopia in children and adolescents: Korea National Health and Nutrition Examination Survey. *PLOS ONE*, *17*(3), e0265317. https://doi.org/10.1371/journal.pone.0265317

Li, F. F., Zhu, M. C., Shao, Y. L., Lu, F., Yi, Q. Y., & Huang, X. F. (2023). Causal relationships between glycemic traits and myopia. *Investigative Ophthalmology & Visual Science*, *64*(3), 7. https://doi.org/10.1167/iovs.64.3.7

Liu, Y., Wang, Y., Zhao, Z., et al. (2024). Digital screen time and myopia: A systematic review and meta-analysis. *JAMA Network Open*, *7*(3), e2330598. https://doi.org/10.1001/jamanetworkopen.2023.30598

Mansjor, A. M. (2001). *Kapita selekta* (Edisi 3, Jilid 1, hlm. 72). Media Aesculapius FK UI.

Nitzan, I., Shakarchy, N., Megreli, J., et al. (2024). Body mass index and visual impairment in Israeli adolescents: A nationwide study. *Pediatric Obesity*, *19*(1), e13083. https://doi.org/10.1111/ijpo.13083

Özbey, M. E., & Emine, A. (2025). LIGHT-REFRACTING STRUCTURES: CLINICAL ANATOMY OF THE OPTICAL MEDIA OF THE EYE. *Overview of Head & Neck Clinical Anatomy*, 25.

Patil, L. G. C., & Srinivas, S. (2020). Correlation of serum leptin levels with clinical and biochemical parameters in obese children. *International Journal of Contemporary Pediatrics*, *7*(4), 795–800.

Peled, A., Hamiel, U., Laufer, H., et al. (2022). Myopia and BMI: A nationwide study of 1.3 million adolescents. *Obesity*, *30*(8), 1531–1538. https://doi.org/10.1002/oby.23491

Pieńczykowska, K., Bryl, A., & Mrugacz, M. (2025). Link between metabolic syndrome, inflammation, and eye diseases. *International Journal of Molecular Sciences*, *26*(5), 2174.

Qu, Y., Huang, H., & Zhang, H. (2023). Association between body mass index and myopia in the United States population in the National Health and Nutrition Examination Surveys 1999 to 2008: A cross-sectional study. *European Journal of Medical Research*, *28*, 561. https://doi.org/10.1186/s40001-023-01542-4

Ramos-Lobo, A. M., & Donato, J., Jr. (2017). The role of leptin in health and disease. *Temperature*, *4*(3), 258–291. https://doi.org/10.1080/23328940.2017.1327003

Subarjati, A., & Nuryanto. (2015). Hubungan indeks massa tubuh dengan kadar leptin dan adiponektin. *Journal of Nutrition College*, *4*(2), 428–434.

Wang, Y., Li, Y., Li, J., et al. (2024). Association between weight status and myopia in Chinese children and adolescents: A nationwide cross-sectional study. *Nutrients*, *16*(2), 260. https://doi.org/10.3390/nu16020260

Woo, T. M. (2023). Eye and Vision Disorders. *Burns' Pediatric Primary Care-E-Book: Burns' Pediatric Primary Care-E-Book*, *20*, 456.