JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

CORRELATION BETWEEN AXIAL LENGTH AND THE OCCURRENCE OF REFRACTIVE ERRORS

Kevin Arfa Ryan[1], Maharani[2], Arnila Novitasari Saubig[2], Riski Prihatningtias[2*]
[1]Undergraduate Program, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
[2]Department of Ophthalmology, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
* Corresponding Author : E-mail : riskiprihatningtias@gmail.com

ABSTRACT

Background: Refractive errors result in difficulty in focusing on an object clearly, leading to blurred vision. A recent study by the WHO has reported that refractive errors have become the leading cause of visual impairment. The development of refractive errors has been a significant concern over the last two decades due to its high prevalence worldwide. One possible condition that may occur in individuals with refractive errors is a change in axial length. Axial length is defined as a measurement from the corneal surface to the retinal surface. **Aims:** To analyze the correlation between axial length and the occurrence of refractive errors in myopia and hypermetropia patients at the Ophthalmology Department of Diponegoro National Hospital. **Methods:** This observational analytical study with a cross-sectional design was conducted on 36 eyes from 18 patients; each suffering from myopia and hypermetropia at the Ophthalmology Department of Diponegoro National Hospital. Patients provided informed consent, and then the axial length was measured using ultrasound biometry. Data analysis was performed using univariate analysis and Spearman correlation bivariate analysis. **Results:** The results of the Spearman statistical test showed a significant correlation between the axial length and the occurrence of myopia (p=0.003) with a moderate correlation strength and the occurrence of hypermetropia (p=0.000001) with a strong correlation strength. **Conclusion:** The axial length has a significant correlation with the occurrence of refractive errors, especially in myopia and hypermetropia patients.

***Keywords*:** *Axial length, refractive errors, myopia, hypermetropia.*

INTRODUCTION

According to the World Health Organization (WHO), refractive errors are very common eye disorders. Refractive errors prevent the eyes from focusing clearly on an object, leading to blurred vision. The development of refractive errors has been a major concern in the last two decades due to their high prevalence worldwide.[1] A recent WHO report indicates that refractive errors are the leading cause of visual impairment and the second leading cause of vision loss globally, accounting for 43% of visual impairments.[2] In Indonesia, the prevalence of refractive errors is 22.1%, making it the most common among all eye disorders. Based on the results of the Rapid Assessment of Avoidable Blindness (RAAB) survey conducted between 2014-2016 in 15 provinces, the main causes of visual impairment and blindness were cataracts (70-80%) and refractive errors (10-15%).[3] The most common refractive errors include myopia, hypermetropia, and astigmatism.

In the United States, Australia, and Western Europe, 25%, 16%, and 27% of the adult population, respectively experience myopia.[4] The prevalence rate in Asia is even higher among students, with over 80% in Southeast Asia.[4,5] Moreover, high myopia rates vary from 0.2% to 13.1% in the general population, with the highest prevalence occurring in Asian populations.[4] In Indonesia, the prevalence of myopia with a refractive error greater than -0.5 D among young adults over the age of 21 is 48.1%[6]

Myopia is a vision disorder where individuals find it difficult to see and focus on distant objects. Without correction, visual acuity in myopic patients continues to deteriorate, potentially leading to high myopia.[7] People with myopia, especially high myopia, are at higher risk of cataracts, glaucoma, and chorioretinal disorders such as retinal detachment. Therefore, high myopia ranks as the fifth most common cause of permanent blindness and a significant public health issue globally.[4,5]

According to the Ministry of Health in Indonesia, refractive errors account for 70% of blindness cases.[8] Considering the high prevalence of myopia in Southeast Asia, while studies indicate a high prevalence of hypermetropia in Europe, drawing conclusions is challenging. Most of these studies were conducted on older adults, and the high prevalence of hypermetropia in this age group is a normal finding due to age-related refractive index changes.

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

Hypermetropia itself is a vision disorder where individuals find it difficult to see and focus on close objects. Individuals with uncorrected hypermetropia may experience symptoms such as blurred vision, eye strain, accommodative/binocular dysfunction, amblyopia, and/or strabismus.

Changes in the axial length may occur in individuals with refractive errors, both myopia and hypermetropia.[7] Axial length is the distance measured from the corneal surface to the retinal surface. Children with myopia have longer axial lengths and deeper vitreous chambers compared to emmetropic children (Ramle et al., 2021).[8] Additionally, individuals with hypermetropia have shallow anterior chamber depths and shorter axial lengths compared to myopic and emmetropic eyes. Lourdes Llorente et al. stated that the average axial length in myopia is 25.16 ± 1.23 mm, whereas in hypermetropia, it is 22.62 ± 0.76 mm. Therefore, axial length is a component that influences the occurrence of refractive errors.

METHODS

This study is an analytical observational research with a cross-sectional design, conducted using samples of patients with myopia and hypermetropia at the Ophthalmology Department of Diponegoro National Hospital who met the inclusion and exclusion criteria. Inclusion criteria for this study include being above 13 years old and willing to participate in the research with informed consent. Exclusion criteria include a history of eye trauma, previous use of orthokeratology lenses, having more than one refractive disorder, a history of eye surgery, and undergoing intraocular surgery.

The sampling method used in this study is purposive sampling, and a total of 36 eyes from 18 patients with myopia and hypermetropia were included. The research was conducted in June 2023 at the Ophthalmology Department of Diponegoro National Hospital. The independent variable in this study is the axial length, while the dependent variables are myopia and hypermetropia.

Data analysis includes univariate and bivariate tests. Univariate analysis is used to determine the distribution of variables in the form of frequency tables and percentages. Bivariate analysis is conducted to examine the relationship between variables.

Data were analyzed using SPSS Statistics program. The relationship between axial length and the occurrence of refractive errors analyzed by the Spearman correlation test since the data distribution is non-normal. A significant relationship is established if the p-value is less than 0.05.

RESULTS

General Characteristics of the Sample

The study was conducted on 36 eyes from 18 patients, each suffering from myopia and hypermetropia. The samples were collected by measuring the axial length in both eyes of the patients. The distribution of the data is as follows :

Table 1. General Characteristics of Variables

Variable	Myopia	Hypermetropia	P-Value
Sample	36	36	
Age			
Maximal	39	68	
Minimal	20	39	
Mean	22,61	52,28	0,000
Gender			
Female (%)	67	83	
Male (%)	33	17	
Dioptric Power			
Maximal	-5,25	3,25	
Minimal	-0,5	0,5	
Mean	-2,333	1,673	0,000
Axial Length			
Maximal	26,76	24,5	
Minimal	19,29	19,67	
Mean	23,288	22,796	0,251

[1] Significant ($p < 0,05$)

Based on the table, the average age in the myopia group was lower than in the hypermetropia group. The hypermetropia group also showed a wider age range compared to the myopia group. The statistical test yielded a p-value of 0.000, indicating a significant difference in average age between the myopia and hypermetropia groups ($p < 0.05$).

Regarding gender, females had a higher ratio than males in both the myopia and hypermetropia groups. In this study, the total number of female samples dominated, comprising 27 out of 36 respondents.

In terms of visual acuity or dioptric power, a p-value of 0.000 was obtained, indicating a significant difference in average visual acuity between myopia and hypermetropia groups. The myopia group

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

exhibited a more varied range of dioptric power compared to the hypermetropia group.

Meanwhile, in the variable of axial length, a non-significant difference in the average was found between the myopia and hypermetropia groups. This lack of significance was due to the distribution of axial length data in both groups falling within the same range, between 20-25 mm.

Table 2. Correlation between Axial Length and Age

Variable		Axial Length	
		Myopia	Hypermetropia
Age	**p**	0,023	0,010
	r	0,201	-0,210

[1] Significant (p < 0,05)

According to the table, in the analysis of the correlation between axial length and age in the myopia group indicating that the axial length has a significant correlation with age in the myopia group. Additionally, the obtained correlation coefficient r of 0.201 indicates a weak positive statistical correlation, suggesting that as the axial length variable increases, the age variable also increases in the myopia group.

Meanwhile, in the analysis of the correlation between axial length and age in the hypermetropia group also indicating a significant correlation between axial length and age in the hypermetropia group. Additionally, the obtained correlation coefficient r of -0.210 indicates a weak negative statistical correlation, suggesting that as the axial length variable increases, the age variable decreases in the hypermetropia group.

Table 3. Correlation between Axial Length and Gender

Variable		Axial Length	
		Myopia	Hypermetropia
Gender	**p**	0,687	0,203
	r	-0.068	-0.215

[1] Significant (p < 0,05)

Based on the table, in the analysis of the correlation between axial length and gender in both the myopia and hypermetropia groups indicating that axial length does not have a significant correlation with gender.

Correlation between Axial Length and Myopia

Table 4. Correlation between Axial Length and the Occurrence Myopia

Variable		Axial Length
Dioptric power	**p**	0,003
	r	0,480

[1] Significant (p < 0,05)

Based on the table, the analysis of the correlation between axial length and the occurrence of myopia using the Spearman correlation test indicating that the axial length has a significant correlation with myopia. Additionally, the obtained correlation coefficient r of 0.480 indicates a moderate positive statistical correlation, suggesting that as the axial length variable increases, the dioptric power variable also increases in the myopia group.

Correlation between Axial Length and Hypermetropia

Table 5. Correlation between Axial Length and the Occurrence Hypermetropia

Variable		Axial Length
Dioptric power	**p**	0,000001
	r	-0,707

[1] Significant (p < 0,05)

Based on the table, the analysis of the correlation between axial length and the occurrence of hypermetropia using the Spearman correlation test indicating that that the axial length has a significant correlation with hypermetropia. Additionally, the obtained correlation coefficient r of -0.707 indicates a strong negative statistical correlation, suggesting that as the axial length variable increases, the dioptric power variable decreases in the hypermetropia group.

DISCUSSION

Correlation between Age and the Occurrence of Refractive Errors: Myopia and Hypermetropia

In this study, the age range observed for myopia was 20-39 years, with an average of 22.61 years. Rahmat Albar et al. (2023) found that most myopia develops during school-age years with the majority of myopic respondents were in the age range of 19-20 years, constituting 57.5%.[9] Factors influencing myopia development include genetic factors that progressively develop in children with habits of

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

reading at close distances. It can be concluded that myopia is prevalent among young adults.[10]

For hypermetropia, the age range observed was 39-68 years, with an average of 52.28 years that indicates a broader age range for the hypermetropia group compared to the myopia group. The broader range can be attributed to the fact that hypermetropia can occur from a young age to old age. Studies by Ribka Dwi (2021) suggested that 2.31% of children aged 10-18 years suffered from hypermetropia. Additionally, research by Tien Ying Wong et al. indicated that hypermetropia was most prevalent among individuals aged 60-69 years.[10] Genetic factors play a significant role in the development of hypermetropia, outweighing environmental influences.[11]

Correlation between Axial Length and the Occurrence of Myopia

In the Spearman correlation test, it was found that there is a significant relationship between the axial length and the occurrence of myopia, with a p-value of 0.003. These results align with several previous studies. Rahmat Syuhada's study in 2017 stated that the comparison between the average axial length in myopia patients and normal individuals yielded significant results. The study mentioned that myopia patients have an average axial length ranging from 22.78 to 25.76 mm, while in normal individuals, it is between 22.5 to 24.08 mm.[12]

Veena Bhardwaj et al. (2021) found that myopia patients tend to have a longer axial length compared to normal eyes, hypermetropia patients, and astigmatism patients in several age groups. Additionally, it was observed that the axial length increases as individuals with myopia age, as supported by Paul Chamberlain's study in 2021.[13]

In contrast, in normal eyes, there is an initial increase in axial length, followed by a decrease in the rate of axial length increase at a certain age. This phenomenon is supported by the theory that the increase in axial length occurs due to underlying physiological factors, as mentioned in the study by Min Woo Lee in 2020.[13] Furthermore, individuals with high degrees of myopia exhibit a significant increase in axial length.[14]

These findings are consistent with Ilyas's theory in 2009, which states that the focal point of the optical system is in front of the macula lutea. This situation can occur due to overly strong optical systems (refractive errors in distant vision) or eyeballs that are excessively elongated, leading to axial myopia. Axial myopia occurs when the length of the eye's orbital axis is longer than the focal point of the refractive media.

Correlation between Axial Length and the Occurrence of Hypermetropia

The results of the Spearman correlation test in this study indicate a significant relationship between the axial length and the occurrence of hypermetropia, with a p-value of 0.000001. These findings are consistent with several previous studies. Additionally, Veena's research in 2013 suggested that individuals with hypermetropia tend to have shorter axial lengths compared to normal eyes.

In the study by Samaneh in 2020, it was mentioned that the theory of increased axial length is believed to start from changes in the choroidal thickness level. In hypermetropic eyes, there is a thickening of the choroid layer, leading to a reduction in the distance to the retinal pigment epithelium.[8] This theory aligns with the results of this study, indicating an average axial length of 23.288 mm in the myopic group, while in the hypermetropic group, it is 22.796 mm. These findings are supported by a similar study by Lourdes et al., which stated that the axial length in hypermetropia patients (22.62 ± 0.76 mm) is lower than that in myopia patients (25.16 ± 1.23 mm). Rebecca et al. (2023) found that in the 12-13 years age group, children with myopia show a faster increase in axial length at a rate of ≥ 0.20 mm/year, whereas children with hypermetropia exhibit a slower increase at a rate of < 0.20 mm/year.[15]

Correlation test between the axial length and the age variable in the hypermetropic group yielded a p-value of 0.010 and r-value of -0.210. The Spearman test indicates a weak correlation between the axial length and the age variable in the hypermetropic group. Additionally, individuals with hypermetropia tend to experience a shortening of the axial length during adulthood. Susan's study in 2023 also stated that there is a progressive shortening of the axial length accompanied by an increase in hypermetropic visual acuity over time. In another study, Zoraida et al. mentioned that in the hypermetropic group, no significant differences were found between the initial

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

and final measurements of the axial length during a specific time range.

These research findings are in line with Soumyadeep's theory in 2023, suggesting that in axial hypermetropia, there is a shortening of the anteroposterior axial length due to genetic predisposition. A shortening of 1 mm in the axial length can result in 3 diopters of hypermetropia.

CONCLUSION

The axial length has a moderate significant correlation with the occurrence of myopia in patients at the Ophthalmology Department of the National Diponegoro Hospital. Similarly, the axial length also has a strong significant relationship with the occurrence of hypermetropia in patients at the Ophthalmology Department of the National Diponegoro Hospital. The direction of the relationship in both variables is negative due to several factors outside the measured variables affecting these results. These factors include genetic factors, age, gender, and visual acuity, although they were not measured in this study.

ETHICAL APPROVAL

The research was conducted after obtaining ethical clearance from the Ethics Committee in Health and Medical Research (KEPK) Faculty of Medicine, Diponegoro University, Semarang, with no. 161/EC/KEPK/FK-UNDIP/V/2023.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

No specific funding was provided for this article.

AUTHOR CONTRIBUTIONS

Kevin Arfa Ryan developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. Kevin Arfa Ryan, Riski Prihatningtias, and Maharani contributed to the final version of the manuscript. Arnila Novitasari Saubig, Riski Prihatningtias and Maharani supervised the project provided.

ACKNOWLEDGEMENTS

This work was supported by the Department of Ophthalmology, Faculty of Medicine, Diponegoro University.

REFERENCES

1. Demir P, Baskaran K, Theagarayan B, Gierow P, Sankaridurg P, Macedo AF. Refractive error, axial length, environmental and hereditary factors associated with myopia in Swedish children. Clin Exp Optom. 2021;104(5):595–601.
2. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. J Curr Ophthalmol. 2018;30(1):3–22.
3. Niwele TO, Laras DS. Angka kejadian kelainan refraksi yang tidak terkoreksi pada anak. J Penelit Kesehat STIKes Dharma Husada Bandung. 2022;XVI:415–28.
4. Fan Q, Wang H, Jiang Z. Axial length and its relationship to refractive error in Chinese university students. Contact Lens Anterior Eye. 2022;45(2):101470.
5. Jonas JB, Ang M, Cho P, Guggenheim JA, He MG, Jong M, dkk. IMI prevention of myopia and its progression. Investig Ophthalmol Vis Sci. 2021;62(5):8–10.
6. Wulandari M, Mahadini C. Chengqi, Tongziliao and Yintang Point Acupuncture in Improving the Case of Myopia Visus. J Vocat Heal Stud. 2019;2(2):56.
7. Aliviana B. Hubungan antara Panjang Aksial Bola Mata dan Derajat Miopia dengan Tekanan Intraokular. Med Heal Sci J. 2020;4(1):13–8.
8. Saiyang B, Rares LM, Supit WP. Kelainan Refraksi Mata pada Anak. Med Scope J. 2021;2(2):59–65.
9. Rahmat Albar, Dilla Wirmaningsih, Nabila Azzahra, Yusni Atifah. Analisis Penderita Rabun Jauh (Miopi) pada Mahasiswa Statistika Angkatan 2019 Universitas Negeri Padang. Pros Semin Nas Biol. 2023;2(2 SE-Articles):889–98.

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i2.41855
JKD (DMJ), Volume 13, Number 2, March 2024 : 60-65

10. Novalinda R. Koreksi Secara Subjektif Terhadap Penderita Hipermetropia Di Super Optical Padang. Menara Ilmu. 2020;14(01):86–90.
11. Witjaksono A, Parida D. Hubungan Derajat Kelainan Hipermetropia Dengan Kinerja Akademik Menggunakan Metode Simulasi Pada Siswa Sekolah Dasar Jembar Bandung. J Sehat Masada. 2019;XIII(2502–5414):1979–2344.
12. Syuhada R, Detty AU, Sabrina Z. Perbandingan Panjang Aksial Mata Pada Penderita Miopia Dengan Emetropia Di Poliklinik Mata Rumah Sakit Pertamina Bintang Bandar Lampung. J Ilmu Kedokt dan Kesehat. 2017;4(3):177–82.
13. Chamberlain P, Lazon de la Jara P, Arumugam B, Bullimore MA. Axial length targets for myopia control. Ophthalmic Physiol Opt. Mei 2021;41(3):523–31.
14. Lee MW, Lee S-E, Lim H-B, Kim J-Y. Longitudinal changes in axial length in high myopia: a 4-year prospective study. Br J Ophthalmol. Mei 2020;104(5):600–3.
15. Leighton RE, Breslin KM, Richardson P, Doyle L, McCullough SJ, Saunders KJ. Relative peripheral hyperopia leads to greater short-term axial length growth in White children with myopia. Ophthalmic Physiol Opt. September 2023;43(5):985–96.