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Correlation Between Axial Length and Amplitude of Accommodation in Myopia Patients

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ABSTRACT

Background: Myopia is the most common refractive disorder and is a global concern because it can cause more serious eye problems. Excessive prolonged axial growth of the eyeball can lead to myopia. The amplitude of accommodation is the strength of the eye accommodation during the minimum and maximum accommodation conditions. Based on the above data, the researchers wanted to assess the relationship between eyeball length and accommodation amplitude in myopia patients.
Method: The research was conducted at the Hospital of Prof CPL University of North Sumatra from November 2023 to March 2024. Data analysis was done analytically and presented in the form of data tabulation.
Result: This study included 54 myopia patients, 27 males and 27 females, who visited the eye clinic. The mean age of the subjects was (52%). The mean age of the subjects was 23 years old with the youngest being 22 years old and the oldest being 24 years old. The mean of axial length for mild myopia, moderate myopia and severe myopia were 24.51 cm, 25.75 cm and 28.38 cm respectively. The lowest NPA value was found in severe myopia (27.33 cm) and the highest in mild myopia (43 cm). The lowest NPC value was found in mild myopia (36.61 cm) and the highest in severe myopia (38.56 cm). There was a significant relationship between eyeball length and accommodation amplitude with a Spearman correlation value of -0.685 as well as after cycloplegic administration with a Spearman correlation value of 0.438. NPA values showed an increase when receiving spherical correction, whether accompanied by cycloplegics or not, and a decrease when not receiving spherical correction. NPC values showed a decrease in all treatments.
Conclusion: There is a correlation between axial length and amplitude of accomodation values (NPA and NPC) in patients with myopia.

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INTRODUCTION

One of the most important aspects of life is sharp eyesight. Sharp eye vision is influenced by several ocular structures such as the axial length of the eyeball, cornea, crystalline lens and retina. The structure of the eyeball will undergo a process of emmetropization from childhood to adulthood. Emmetropization is the process of changes in the ocular structure and length of the eyeball with the aim of achieving a state of emmetropia. As a result, the anterior chamber will become shallower, the eye lens will become thicker, the vitreous chamber will become shorter and the axial length of the eyeball will lengthen. In simple terms, emmetropization is the process of active adjustment of the axial length of the eyeball to the refractive power of the cornea and lens. When the axial length of the eyeball is appropriate or ideal, a person can achieve normal vision, or a condition of emmetropia (1,2).

Emmetropia is an eye condition in which there are no refractive errors or abnormalities. In eyes that experience emmetropia, incoming light can be focused precisely on the retina without requiring additional correction, such as glasses or contact lenses. In other words, an emmetropic eye has an axial length that is in line with the refractive power of the cornea and lens, ensuring that the image formed on the retina falls exactly at the focal point. Thus, individuals with emmetropic eyes tend to have normal vision without difficulty seeing objects both near and far (3,4).

However, if excessive growth in the axial length of the eyeball occurs during the emmetropization process, the patient may experience myopia. Myopia or often known as nearsightedness is an ophthalmological disease that most often occurs regardless of age, both in children, adolescents and adults. Impaired visual acuity can cause discomfort and other difficulties in carrying out daily activities which will ultimately reduce the individual's productivity. Myopia can cause children to have difficulty learning, which can reduce the child's interest in learning and impact the child's development and performance at school. However, there are still many who think that this refractive error is just a simple disorder. If not treated immediately, one of the complications of myopia is blindness (5).

Myopia cases will continue to increase as time goes by. This is due to the increasing development of technology; children are starting to spend more time reading and learning via devices. Apart from that, during the COVID-19 pandemic, many people around the world implemented a work from home system, causing our eyes to be exposed to digital screen time more often and rarely doing outside activities, both of which are risk factors for myopia. According to the World Health Organization, it is estimated that by 2050, an estimated 4750 million people in the world will experience myopia (49.8%) and around 9.8% of the world's population will experience severe myopia (6-8).

Myopia is a refractive error in the eye that occurs when parallel rays enter the eye and produce an image that falls in front of the retina when the eye does not accommodate. This disorder can occur if there is a mismatch between the optical power of the eye and the length of the eyeball. In the case of myopia, the length of the eyeball tends to be longer compared to its optical power. The severity of myopia can also be classified based on the lens strength, where severe myopia has a value of > 6 D, moderate myopia has a strength of between 3–6 D, while mild myopia has a lens strength of < 3 D (9).

The eye's ability to see an object at a certain distance clearly depends on the eye's accommodation ability. Accommodation is the mechanism by which the eye changes focus from far to near images. This occurs when the ciliary muscles in the zonular fibers contract and change the shape of the lens. Simply put, accommodation is the ability of the lens to convex with the help of the ciliary muscles. There are several structures in the eye that play a role in the accommodation process or are often referred to as the accommodation apparatus. With the help of the power of accommodation, we are able to see objects clearly from any distance. One parameter that is related or related to refractive errors and eye disorders is the amplitude of accommodation (10).

The amplitude of this accommodation power is greatest during childhood and will continue to decrease with age. The amplitude of accommodation is the amount of accommodation or the difference in the strength of the eye's accommodation between two states, namely when the eye is in a state of minimal accommodation and when the eye is in a state of maximum accommodation. Simply put, the measurement formula is the diopter value at the far point minus the near point of accommodation (11).

Accommodation amplitude has been known to be related to refractive errors, although previous research findings have shown varying results. Several studies noted that individuals with myopia tend to have higher accommodation amplitude values than those with emmetropia. However, contradictory findings were also noted in several other studies. Chiranjit et al (2018) once investigated the correlation between myopia and accommodation amplitude, finding that myopia patients had higher accommodation amplitude values (12). In addition, the study showed that accommodation amplitude values decreased with age, and the decrease occurred more rapidly in women than men. This finding is in line with research by Abraham et al that the accommodation amplitude value in myopia sufferers is higher than in emmetropia (13).

Similar research was also carried out by Sok Lin which showed that there was a correlation between refractive status and accommodation amplitude. This research involved 110 medical and nursing students at Universiti Sains

Malaysia. However, the results show that individuals with myopia tend to have lower accommodation amplitudes, which is contrary to the findings of previous studies (14).

On the other hand, a number of studies have been carried out to evaluate whether the axial length of the eyeball has a direct relationship with the amplitude of accommodation. Faramarzi et al. (2015) conducted related research using 62 healthy subjects with an age range of 40-49 years (15). The results of this study indicate that there is no significant correlation between axial length and accommodation amplitude. Similar findings were also found by Abraham, involving a larger sample size, namely 162 emmetropic subjects in the age range of 35-50 years (16).

Ramin (2020) then conducted a similar study involving 295 healthy subjects in the age range of 33-53 years. The method involves measuring the amplitude of accommodation using the "push-up" method. Nevertheless, the results are also in line with previous studies, showing that there is no significant correlation between eyeball length and accommodation amplitude in healthy subjects (17).

However, to date no research has been conducted on myopic samples. Theoretically, in myopic patients, there is an elongation of the axial length of the eyeball, which can cause a decrease in the amplitude of accommodation.

In addition, there was a significant difference in the accommodation amplitude values before and after using cycloplegics. Cycloplegics work by blocking muscarinic receptors in the ciliary body, which causes relaxation of the ciliary muscle and prevents contraction of the iris sphincter muscle. As a result, the eye loses the ability to accommodate, causing a decrease in the amplitude of accommodation. Therefore, the use of cycloplegics is often applied to obtain more accurate examination results (18,19).

With this background, it is hoped that this research can provide answers regarding the relationship between eyeball length and accommodation amplitude in myopia sufferers. In addition, it is hoped that this research can explain whether there are differences in accommodation amplitude values according to the degree of myopia severity.

METHOD

This research is cross sectional in nature where the target population is all individuals aged 20-24 years. The population covered in this study were students at the Faculty of Medicine, University of North Sumatra, Medan. During the research period, they meet the inclusion criteria and do not meet the exclusion criteria and are willing to take part in the research by filling out the research consent form. The population of this study were all students from the Faculty of Medicine who suffer from myopia at Prof. Hospital. CPL University of North Sumatra. The number of samples is 18 samples in each group, there are 3 treatment groups, so the minimum sample required is 54 samples. The sampling technique used in this research was purposive sampling.

RESULTS

Characteristics of Research Subjects

This research was attended by 54 students from the Faculty of Medicine who suffer from myopia. Subjects were divided into three groups with 18 people each suffering from mild, moderate and severe myopia. All subjects met the inclusion criteria, table 1 displays the demographic characteristics of the research subjects.

Table 1. Demographic Characteristics of Research Subjects

Character	Degree of Myopia		
	Mild	**Moderate**	**Severe**
Gender, n (%)			
Male	11 (61,1)	5 (27,8)	11 (61,1)
Female	7 (38,9)	13 (72,2)	7 (38,9)
Age, n (%)			
22 years old	8 (11,1)	1 (5,6)	5 (27,8)
23 years old	8 (44,4)	3 (16,7)	6 (33,3)
24 years old	8 (44,4)	14 (77,8)	7 (38,9)

The number of male subjects with mild and severe myopia was 11 people each (61.1%) and in the moderate myopia group there were 5 people (27.8%). The subjects' ages were in the range of 22 to 24 years.

Eyeball Length Based on Degree of Myopia

Table 2 displays the mean value, standard deviation (SD), lowest and highest values of eyeball length based on the degree of myopia.

Table 2. Eyeball Length Based on Degree of Myopia

Eyeball Length, mm	Degree of Myopia		
	Mild	Moderate	Severe
Average ± SD	24,51 ± 0,25	25,75 ± 0,82	28,38 ± 1,50
Median (Min-Max)	24,53 (24,07-24,99)	25,87 (24,34-26,81)	28,41 (24,24-30,69)

The longest eyeball length was seen in the severe myopia group with a mean of 28.38 mm and the shortest in mild myopia sufferers with a mean of 24.51 mm.

Amplitude of Accommodation Based on Degree of Myopia

Table 3 displays the mean values, standard deviation (SD), lowest and highest values of accommodation amplitude based on NPA and NPC parameters before and after cycloplegic administration based on the degree of myopia.

Table 3. Accommodation Amplitude Based on Degree of Myopia

Variable	Degree of Myopia		
	Mild	Moderate	Severe
NPA Before Correction			
Mean ± SD	43 ± 2,89	32,67 ± 8,56	27,33 ± 7,94
Median (Min-Max)	42 (36-47)	32 (20-47)	25 (16-42)
NPA After Correction			
Mean ± SD	50 ± 0	50 ± 0	50 ± 0
Median (Min-Max)	50	50	50
NPC Before Correction			
Mean ± SD	36,61 ± 13,18	35,22 ± 14,11	38,56 ± 12,65
Median (Min-Max)	40 (14-50)	33 (12-50)	41 (10-50)
NPC After Correction			
Mean ± SD	8,44 ± 1,46	12,22 ± 8,97	21,11 ± 8,49
Median (Min-Max)	8 (6-12)	8 (8-38)	22 (8-36)

The lowest NPA value before cycloplegic administration was seen in the severe myopia group with a mean of 27.33 and the highest was seen in the mild myopia group with a mean of 43. After being given cycloplegic all myopic subjects showed the same NPA value, namely 50.

Based on the NPC value before cycloplegic administration, the lowest was seen in the mild myopia group with a mean of 36.61 and the highest was seen in the severe myopia group with a mean of 38.56. After being given cycloplegic, the lowest NPC value was in the mild myopia group with a mean of 8.44 and the highest was in the severe myopia group with a mean of 21.11.

Relationship between Eyeball Length and Amplitude of Accommodation Before Giving Cycloplegics to Mild, Moderate and Severe Myopia Sufferers

Table 4 displays the results of the analysis of the relationship between eyeball length and accommodation amplitude before administering cycloplegics to sufferers of mild, moderate and severe myopia.

Table 4. Relationship between Eyeball Length and Amplitude of Accommodation Before Giving Cycloplegics to Patients with Mild, Moderate and Severe Myopia

	Degree of Myopia	NPA		NPC	
		p*	r	p*	r
Eyeball Length	Mild	0,223	-0,208	0,622	-0,085
	Moderate	0,260	-0,193	0,850	-0,033
	Heavy	0,272	-0,188	0,394	-0,147
	all myopia	<0,001	-0,685	0,767	-0,029

*Spearman

Using the Spearman correlation test, no significant relationship/correlation was found between eyeball length and NPA and NPC before administering cycloplegics to patients with mild, moderate and severe myopia. However, there was a significant relationship between eyeball length and NPA if analyzed without categorizing the degree of myopia (p<0.001). The correlation value obtained is -0.685. A negative correlation sign indicates that there is a negative correlation between the length of the eyeball and the NPA, meaning that the longer the eyeball, the NPA value will decrease. The resulting level of correlation strength is a strong correlation (r value > 0.6 – 0.8).

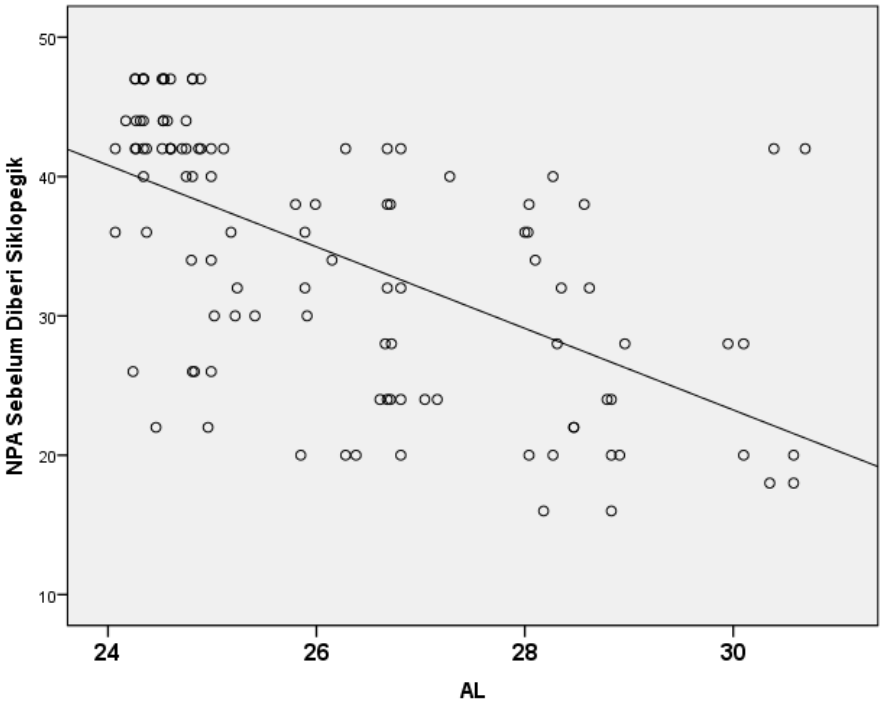

Figure 1. Scatterplot graph of the correlation between axial length and NPA Before Giving Cycloplegics

The Relationship between Eyeball Length and Accommodation Amplitude After Giving Cycloplegics to Mild, Moderate and Severe Myopia Sufferers

Table 5 displays the results of the analysis of the relationship between eyeball length and accommodation amplitude after administering cycloplegics to sufferers of mild, moderate and severe myopia.

Table 5. Relationship between Eyeball Length and Accommodation Amplitude After Giving Cycloplegics to Mild, Moderate and Severe Myopia Sufferers

	Degree Myopia	NPC	
		p*	r
Length of eyeball	Mild	0,362	0,157
	Moderate	0,803	-0,043
	Severe	0,113	-0,268
	All Myopia	<0,001	0,438

*Spearman

Using the Spearman correlation test, no significant relationship/correlation was found between eyeball length and NPC after administration of cycloplegics in patients with mild, moderate and severe myopia. However, there was a significant relationship between eyeball length and NPC if analyzed without categorizing the degree of myopia (p<0.001). The correlation value obtained is 0.438. A positive correlation sign indicates that there is a positive correlation between the length of the eyeball and the NPC, meaning that the longer the eyeball, the more the NPC value will increase. The level of strength of the resulting correlation is a moderate correlation (r value > 0.4 – 0.6). Meanwhile, a correlation analysis cannot be carried out between eyeball length and NPA after cycloplegic administration because the NPA data is homogeneous (all NPA values are the same).

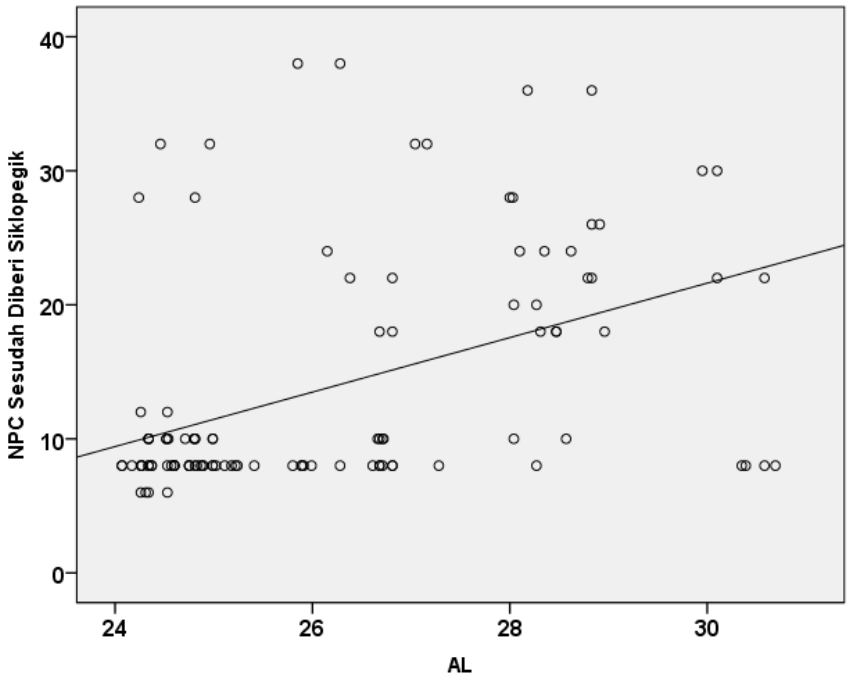

Figure 2. Scatterplot graph of axial length correlation with NPC After cycloplegic administration

Differences in Accommodation Amplitude Before and After Spherical Correction

Table 6 shows the results of the analysis of differences in NPA and NPC values between before and after spherical correction. The NPA values showed an increase after spherical correction for all myopia groups. Using the Wilcoxon test, a significant difference in NPA values was obtained between before and after cycloplegic administration (p<0.001). Meanwhile, the NPC value showed a decrease after spherical correction for all myopia groups. Using the Wilcoxon test, a significant difference in NPC values was obtained between before and after spherical correction (p<0.001).

Table 6. Differences in Amplitude of Accommodation Before and After Spherical Correction

	Degree of Myopia	Before Correction	After Correction	p
NPA	Mild			
	Mean ± SD	43 ± 2,89	50 ± 0	<0,001*
	Median (Min-Max)	42 (36-47)	50	
NPA	Moderate			
	Mean ± SD	32,67 ± 0,82	50 ± 0	<0,001*
	Median (Min-Max)	32 (20-47)	50	
NPA	Severe			
	Mean ± SD	27,33 ± 7,94	50 ± 0	<0,001*
	Median (Min-Max)	25 (16-42)	50	
NPA	All Myopia			
	Mean ± SD	34,33 ± 9,46	50 ± 0	<0,001*
	Median (Min-Max)	36 (16 – 47)	50	
NPC	Mild			
	Mean ± SD	36,61 ± 13,18	8,44 ± 1,46	<0,001*
	Median (Min-Max)	40 (14-50)	8 (6-12)	
NPC	Moderate			
	Mean ± SD	35,22 ± 14,11	12,22 ± 8,97	<0,001*
	Median (Min-Max)	33 (12-50)	8 (8-38)	
NPC	Sever			
	Mean ± SD	38,56 ± 12,65	21,11 ± 8,49	<0,001*
	Median (Min-Max)	41 (10-50)	22 (8-36)	
NPC	All Myopia			
	Mean ± SD	36,8 ± 13,15	13,93 ± 8,85	<0,001*
	Median (Min-Max)	40 (10-50)	9 (6-38)	

*Wilcoxon

Differences in Amplitude of Accommodation Before and After Administration of Cycloplegics Without Spherical Correction

Table 7 shows the results of the analysis of differences in NPA and NPC values between before and after cycloplegic administration without spherical correction. The NPA value showed a decrease after cycloplegic administration for all myopia groups. Using the Wilcoxon test, a significant difference in NPA values was obtained between before and after cycloplegic administration without spherical correction ($p<0.001$). Meanwhile, the NPC value showed a decrease after administering cycloplegics without spherical correction for all myopia groups. Using the Wilcoxon test, a significant difference in NPC values was obtained between before and after cycloplegic administration without spherical correction ($p<0.001$).

Table 7. Differences in Amplitude of Accommodation Before and After Giving Cycloplegics Without Spherical Correction

	Degree of Myopia	Before administering cycloplegics without spherical correction	After cycloplegic administration without spherical correction	p
NPA	Mild			
	Mean ± SD	43 ± 2,89	34,67 ± 2,99	<0,001[a]
	Median (Min-Max)	42 (36-47)	34 (30-42)	
NPA	Moderate			
	Mean ± SD	32,67 ± 0,82	27,11 ± 7,2	<0,001[b]
	Median (Min-Max)	32 (20-47)	26 (16-38)	
NPA	Severe			

	Mean ± SD	27,33 ± 7,94	22,06 ± 7,07	<0,001[b]
	Median (Min-Max)	25 (16-42)	21 (12-34)	
NPA	All Myopia			
	Mean ± SD	34,33 ± 9,46	27,94 ± 7,93	<0,001[a]
	Median (Min-Max)	36 (16 – 47)	30 (12 – 42)	
NPC	Mild			
	Mean ± SD	36,61 ± 13,18	27 ± 9,03	<0,001[a]
	Median (Min-Max)	40 (14-50)	30 (10-40)	
NPC	Moderate			
	Mean ± SD	35,22 ± 14,11	26,89 ± 9,88	<0,001[a]
	Median (Min-Max)	33 (12-50)	29 (12-40)	
NPC	Severe			
	Mean ± SD	38,56 ± 12,65	29,22 ± 9,23	<0,001[a]
	Median (Min-Max)	41 (10-50)	32 (10-40)	
NPC	All Myopia			
	Mean ± SD	36,8 ± 13,15	13,93 ± 8,85	<0,001*
	Median (Min-Max)	40 (10-50)	9 (6-38)	

[a]Wilcoxon, [b]T Dependent

Differences in Amplitude of Accommodation Before and After Administration of Cycloplegics with Spherical Correction

Table 8 shows the results of the analysis of differences in NPA and NPC values between before and after cycloplegic administration with spherical correction. NPA values showed an increase after cycloplegic administration for all myopia groups. Using the Wilcoxon test, a significant difference in NPA values was obtained between before and after cycloplegic administration with spherical correction (p<0.001). Meanwhile, the NPC value showed a decrease after administering cycloplegics without spherical correction for all myopia groups. Using the Wilcoxon test, a significant difference in NPC values was obtained between before and after cycloplegic administration with spherical correction (p<0.001).

Table 8. Differences in Amplitude of Accommodation Before and After Giving Cycloplegics with Spherical Correction

	Degree Myopia	**Before administering cycloplegic with spherical correction**	**After administering cycloplegic with spherical correction**	**p**
NPA	Mild			
	Mean ± SD	43 ± 2,89	50 ± 0	<0,001*
	Median (Min-Max)	42 (36-47)	50	
NPA	Moderate		50 ± 0	
	Mean ± SD	32,67 ± 0,82	50	<0,001*
	Median (Min-Max)	32 (20-47)	50 ± 0	
NPA	Severe		50	
	Mean ± SD	27,33 ± 7,94	50 ± 0	<0,001*
	Median (Min-Max)	25 (16-42)	50	
NPA	All Myopia			
	Mean ± SD	34,33 ± 9,46	50 ± 0	<0,001*
	Median (Min-Max)	36 (16 – 47)	50	
NPC	Mild			
	Mean ± SD	36,61 ± 13,18	27 ± 9,03	<0,001*
	Median (Min-Max)	40 (14-50)	30 (10-40)	
NPC	Moderate			
	Mean ± SD	35,22 ± 14,11	26,89 ± 9,88	<0,001*
	Median (Min-Max)	33 (12-50)	29 (12-40)	

NPC	Severe			
	Mean ± SD	38,56 ± 12,65	29,22 ± 9,23	<0,001*
	Median (Min-Max)	41 (10-50)	32 (10-40)	
NPC	All Myopia			
	Mean ± SD	36,8 ± 13,15	13,93 ± 8,85	<0,001*
	Median (Min-Max)	40 (10-50)	9 (6-38)	

*Wilcoxon

Differences in Changes (Delta) in Accommodation Amplitude Before and After with and Without Cycloplegic Administration and With and Without Spherical Correction

Table 9 shows the results of the analysis of differences in changes in NPA and NPC values between before and after with and without cycloplegic administration and with and without spherical correction.

Table 9. Differences in changes (Delta) in the amplitude of accommodation before and after with and without cycloplegic administration and with and without spherical correction

	Degree Myopia	Before and after spherical correction without cycloplegics	Before and after cycloplegic administration without spherical correction	Before and after cycloplegic administration and spherical correction	p
NPA	Mild				
	Mean ± SD	-7 ± 2,89	8,33± 2,59	-7±2,89	<0,001[a]
	Median (Min-Max)	-8 (-14--3)	8 (0-13)	-8 (-14--3)	
NPA	Moderate				
	Mean ± SD	-17 ± 8,56	5,56±3,09	-17±8,56	<0,001[a]
	Median (Min-Max)	-18 (-30- -3)	6 (-2-9)	-18 (-30--3)	
NPA	Severe				
	Mean ± SD	-22,67±7,94	5,28±2,05	-22,67±7,94	<0,001[a]
	Median (Min-Max)	-25 (-34- -8)	4 (1-8)	-25 (-34--8)	
NPA	All Myopia				
	Mean ± SD	-15,67 ± 9,46	6,39 ± 2,92	-15,67 ± 9,46	<0,001[a]
	Median (Min-Max)	-14 (-34- -3)	8 (-2 – 13)	-14 (-34- -3)	
NPC	Mild				
	Mean ± SD	28,17 ± 12,84	8,33± 2,59	28,72 ± 12,99	<0,001[a]
	Median (Min-Max)	32 (6-44)	8 (0-13)	32 (6 – 44)	
NPC	Moderate				
	Mean ± SD	23 ± 113,15	9,61 ± 6,11	24 ± 13,34	<0,001[b]
	Median (Min-Max)	22 (2 – 42)	8 (2 – 20)	22 (2 – 44)	
NPC	Severe				
	Mean ± SD	17,44 ± 8,97	8,33 ± 5,54	19,56 ± 8,93	<0,001[b]
	Median (Min-Max)	17 (2 – 40)	6 (0 – 20)	21 (4 – 40)	
NPC	All Myopia				
	Mean ± SD	22,87 ± 12,40	9,09 ± 5,62	24,09 ± 12,29	<0,001[a]
	Median (Min-Max)	22 (2 – 44)	8 (0 – 20)	22 (2 – 44)	

[a]Friedman, [b]Repeated Anova

For NPA values, for all categories of myopia degrees and all myopia sufferers showed an increase in NPA between before and after spherical correction without cycloplegic administration with the lowest increase in mild myopia subjects with a mean of -7 ± 2.89 and the highest in severe myopia subjects with mean -22.67±7.94. The same results were also shown before and after administration of cycloplegic and spherical correction. However, between before and after administering cycloplegics without spherical correction, there was a decrease in the NPA

value. By using the Friedman test, it was found that there were significant differences in changes in NPA between the three data groups (p<0.001).

Meanwhile, for NPC values, for all categories of myopia degrees and all myopia sufferers, it showed that there was a decrease in NPC values between before and after spherical correction without cycloplegic administration with the lowest increase in subjects with severe myopia with a mean of 17.44 ± 8.97 and the highest in mild myopia subjects with a mean of 28.17 ± 12.84. The same results were also shown between before and after administration of cycloplegic and spherical correction, and between before and after administration of cycloplegic without spherical correction, there was a decrease in NPC values. The decrease in NPC values appeared to be the highest between before and after administration of cycloplegic with spherical correction for all degrees of myopia. Meanwhile, the lowest decrease occurred in observations between before and after cycloplegic administration without spherical correction. By using the Friedman test, it was found that there were significant differences in NPC changes between the three data groups (p<0.001).

To find out which groups are significantly different, a posthoc test (continued) is carried out. Table 10 displays the results of posthoc test analysis of differences in changes in accommodation amplitude before and after with and without cycloplegic administration and with and without spherical correction.

Table 10. Posthoc Test of Difference in Change (Delta) in Amplitude of Accommodation Before and After with and Without Cycloplegic Administration and With and Without Spherical Correction

Degree of Myopia	Accommodation Amplitude	P Value	
		Before and after without spherical correction with cycloplegics	Before and after with spherical correction with cycloplegic
	NPA		
Mild	Before and after spherical correction without cycloplegics	<0,001[a]	1,000[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]
Moderate	Before and after spherical correction without cycloplegics	<0,001[a]	1,000[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]
Severe	Before and after spherical correction without cycloplegics	<0,001[a]	1,000[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]
All of Myopia	Before and after spherical correction without cycloplegics	<0,001[a]	1,000[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]
	NPCs		
Mild	Before and after spherical correction without cycloplegics	<0,001[a]	1,000[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]
Moderate	Before and after spherical correction without cycloplegics	<0,001[b]	0,021[b]
	Before and after without spherical correction with cycloplegics		<0,001[b]
Severe	Before and after spherical correction without cycloplegics	<0,001[b]	<0,001[b]

	Before and after without spherical correction with cycloplegics		<0,001[b]
	NPCs		
All of Myopia	Before and after spherical correction without cycloplegics	<0,001[a]	0,055[a]
	Before and after without spherical correction with cycloplegics		<0,001[a]

For the NPA value, there was no significant difference in the change in NPA value between before and after spherical correction without cycloplegic and the change in NPA value between before and after spherical correction with cycloplegic administration for all degrees of myopia (p>1,000). However, between before and after spherical correction without cycloplegic with changes in NPA values between before and after administering cycloplegic without spherical correction and between before and after spherical correction with cycloplegic with changes in NPA values between before and after administering cycloplegic without spherical correction there were significant differences (p<0.001). For NPC values, each group showed significant differences. However, in all subjects with myopia, the NPC value between before and after spherical correction without cycloplegic and the NPC value between before and after spherical correction with cycloplegic did not have a significant difference (p=0.055).

DISCUSSION

This research was conducted on 54 students of the Faculty of Medicine, University of North Sumatra, 27 men and 27 women, who fit into the criteria for mild, moderate and severe Myopia to assess eyeball length and Accommodation Amplitude. This aims to assess the relationship between eyeball length and Accommodation Amplitude in patients with Myopia. In this study the average age of the subjects was 23 years with the lowest age being 22 years and the highest being 24 years. The number of male subjects with mild and severe myopia was 11 people each (61.1%) and in the moderate myopia group there were 5 people (27.8%). The subjects' ages were in the range of 22 to 24 years.

Accommodation Amplitude checks are carried out using Royal Air Force (RAF) rules until the fixation target becomes blurred. This is in line with what is recommended by the American Academy of Ophtalmology published in San Francisco 2022-2023. To measure the length of the eyeball itself, researchers used immersion biometry, this is because the immersion biometry method has a lower risk of trauma and infection and faster results when compared to optical techniques (10), (56-57). In 2022, Cooke et.al. conducted trials to compare the accuracy of immersion biometry with optical biometry. The research involved calculating the length of the eyeballs from 1970 eyeballs. After the research and analysis had been completed, it was found that the immersion biometry method was as good as optical biometry when assessed in terms of accuracy (66). In 2017, Naicker et al. concluded that immersion biometry is more accurate than contact biometry in predicting the IOL power required to achieve postoperative refractive targets. However, keep in mind that this method is closely related to the operator's skills. So, operators who are experienced in operation are needed to avoid differences in results.

The results of measuring the length of the eyeball in subjects suffering from mild, moderate and severe myopia were an average of 24.5 ± 0.25 cm, 25.75 ± 0.82 cm and 28.38 ± 1.50 cm. From the analysis that has been carried out. These results are also in line with research conducted by Hou et al. in 2018 which had similar results, namely that there was a correlation between the degree of myopia and the length of the eyeball. Several other studies also concluded that the longer the length of a person's eyeballs, the higher the risk of developing myopia (60). Studies in recent years have also shown that the distribution of eyeball length values in male myopia patients is higher than in females. This is thought to be related to the size of men's eyeballs being larger than women's (67). Another study also found that there was a significant correlation (Spearman 0.37; P<0.05) between eyeball length and a person's body height (68). This is also in line with research conducted on children in Shandong, China, which reported a moderate correlation between a child's body height and the length of his eyeballs (69). Hsu, in research released in the Journal of the Chinese Medical Association, stated that the median value of eyeball length for men

is approximately 0.6 mm longer than for women. Although the mechanism underlying this difference is still unclear, whether it is purely related to height, or whether it involves estrogen and progesterone concentrations (70).

Based on the data processing results of the Amplitude of Accommodation value with the degree of myopia severity, it was found that the lowest NPA value before cycloplegic administration was seen in the severe myopia group with a mean of 27.33 and the highest was seen in the mild myopia group with a mean of 43. After being given the best spherical correction, all myopic subjects showed this value. The same NPA was 50. Based on the NPC value before cycloplegic administration, the lowest was seen in the mild myopia group with a mean of 36.61 and the highest was seen in the severe myopia group with a mean of 38.56. After being given cycloplegic, the lowest NPC value was in the mild myopia group with a mean of 8.44 and the highest was in the severe myopia group with a mean of 21.11. In this study, it was found that there was a pattern of increasing NPA values before correction which was inversely proportional to the severity of Myopia and there was a pattern of increasing NPC length after correction which was in line with the severity of Myopia patients.

This can complement the results of research conducted by Chairanjit et al which concluded that there was a relationship between refractive status and accommodation amplitude and the highest amplitude was seen in myopia patients when compared with emmetropia patients or normal eyes. A similar study was also conducted at the University of Science Malaysia with results showing that myopia patients had a lower amplitude of accommodation. However, a retrospective study conducted by Chaudhary et al. shows different results. The study was conducted on 100 patients who went to an eye clinic for treatment with the final conclusion that the Amplitude of Accommodation in Myopia patients was higher compared to normal patients (12). Wijayati also conveyed the same thing in her research which was released in 2022. He assessed the correlation between NPC and Accommodation Amplitude for 125 elementary school students in grades 1-4 on the students' Myopia progression. Wijayati concluded that a small NPC value is associated with an increase in the severity of myopia and vice versa. In her research, Wijayati calculated the NPC value in the same way as this research, more precisely the same as calculating the NPC value before accommodation. However, in this study there was no significant difference in the NPC value before accommodation with the degree of myopia severity (71). This may occur due to differences in the ages of research subjects which will affect the growth rate of the subject's eyeballs (72).

Next, an analysis was carried out regarding the correlation between eyeball length and accommodation amplitude before and after drug administration. Using the Spearman correlation test, no significant relationship/correlation was found between the length of the eyeball and before administration of cycloplegics in sufferers of mild, moderate and severe myopia. The correlation value obtained is -0.685. A negative correlation sign indicates that there is a negative correlation between the length of the eyeball and the NPA, meaning that the longer the eyeball, the NPA value will decrease. The level of strength of the resulting correlation is a strong correlation (r value > 0.6 – 0.8). Meanwhile, no significant relationship/correlation was found between eyeball length and NPC after administration of cycloplegics in patients with mild, moderate and severe myopia. However, there was a significant relationship between eyeball length and NPC if analyzed without categorizing the degree of myopia ($p<0.001$). The correlation value obtained is 0.438. A positive correlation sign indicates that there is a positive correlation between the length of the eyeball and the NPC, meaning that the longer the eyeball, the more the NPC value will increase. The level of strength of the resulting correlation is a moderate correlation (r value > 0.4 – 0.6). This is not in line with research conducted by Farmazi et al. in 2015. Farmazi stated that there was no significant correlation between axial length and accommodation amplitude. This is likely due to 2 factors, the first is due to the difference in age of the research subjects, namely 40-49 years, while the age of the research sample this time is 20-24 years. Second, the research conducted by Farmazi and other literature was only conducted on healthy subjects and there is no literature that directly investigates the relationship between the axial length of the eyeball and the amplitude of accommodation in myopia patients (15-17). Ulaganathan in 2019 conducted research by assessing daily axial length at 9 pm and 12 am in normal and myopic people. According to him, there is an influence of the speed of eyeball growth on the value of a person's Accommodation Amplitude, but unfortunately he is still not sure whether the speed of eyeball growth really influences the Accommodation Amplitude value or whether it is actually the degree of severity of Myopia for each subject that makes it different. Ulagnathan also disagrees with the research results of Burfield et al., 2018 and Chakraborty et al., 2011. which stated that there was

no significant relationship between the two. He argued that the observations they made were too short, only 1-2 days, whereas he made observations for 6 months (73–75).

For NPA values, for all categories of myopia degrees and all myopia sufferers showed an increase in NPA between before and after spherical correction without cycloplegic administration with the lowest increase in mild myopia subjects with a mean of -7 ± 2.89 and the highest in severe myopia subjects with mean -22.67±7.94. The same results were also shown before and after administration of cycloplegic and spherical correction. However, between before and after administering cycloplegics without spherical correction, there was a decrease in the NPA value. Meanwhile, for NPC values, for all categories of myopia degrees and all myopia sufferers, it showed that there was a decrease in NPC values between before and after spherical correction without cycloplegic administration with the lowest increase in subjects with severe myopia with a mean of 17.44 ± 8.97 and the highest in mild myopia subjects with a mean of 28.17 ± 12.84. The same results were also shown between before and after administration of cycloplegic and spherical correction, and between before and after administration of cycloplegic without spherical correction, there was a decrease in NPC values. The decrease in NPC values appeared to be the highest between before and after administration of cycloplegic with spherical correction for all degrees of myopia. Meanwhile, the lowest decrease occurred in observations between before and after cycloplegic administration without spherical correction. These results are not in line with those presented by Moon et al. in 2018 which stated that giving cycloplegics was able to inhibit the progression of myopia itself, in this context giving cycloplegics did not reduce the NPA value. This happens because cycloplegic drugs work by preventing the accommodation reflex from causing an increase in the NPA value (76,77). On the other hand, the results of the NPC examination are in line with previous journals. The decrease in the NPC value indicates an improvement in the quality of patient convergence, in line with research conducted by Prabhu and Munsamy's research published in 2016 (78,79). Research conducted by Abdi et al. in 2016 showed that spherical correction would provide better convergence results, in his research Abdi used contact lenses to assess the improvements in convergence obtained (82).

After testing the relationship between eyeball length and Accommodation Amplitude after administering cycloplegics and spherical correction, there was a significant difference between changes in NPA values before and after spherical correction without cycloplegics compared to NPA values before and after administering cycloplegics without spherical correction. However, there was no significant difference in changes in NPA values before and after spherical correction without cycloplegic and with cycloplegic for all degrees of myopia ($p>1,000$). A significant difference was also found between the NPA value before and after spherical correction with cycloplegic compared to the change in NPA value before and after cycloplegic administration without spherical correction ($p<0.001$). For NPC values, there were significant differences between groups. However, in all subjects with myopia, there was no significant difference between NPC values before and after spherical correction without cycloplegics, and NPC values before and after spherical correction with cycloplegics ($p=0.055$). These results are consistent with the research of Aicun et al. in 2020 which showed that administration of low doses of cycloplegics, such as atropine 0.01% and 0.02%, resulted in a decrease in accommodation amplitude and an increase in pupil diameter (80). However, research by Mittapali et al. 2022 shows different results. Mittapali evaluated the monocular accommodation effect of cycloplegic administration (Cyclopentolate 1%) in one eye and assessed NPA before and after administration. There was an increase in the mean NPA value after administration of Cyclopentolate 1%, which is not in accordance with theory and previous research. This is likely due to the limited sample size; Mittapali only used 20 samples and did not divide them based on the severity of myopia (80).

CONCLUSION

The majority of sufferers of mild myopia are men (11 peoples), moderate myopia are women (13 peoples), and severe myopia are men (11 peoples) and the entire sample has a history of family members suffering from myopia (100%). The average eyeball length of myopia sufferers who participated in the study was 24.5 mm for mild degrees, 25.75 mm for moderate degrees, and 28.38 mm for severe degrees. The average NPA before correction in patients with mild myopia is 43 cm, moderate myopia is 32.6 cm, and severe myopia is 27.3 cm. The average NPA after correction for mild, moderate and severe myopia sufferers is 50 cm. The average NPC before correction in

patients with mild myopia was 36.1 cm, moderate myopia 35.2 cm, and severe myopia 38.5 cm. The average NPC after correction in patients with mild myopia is 8.4 cm, moderate myopia 12.2 cm, and severe myopia 21.1 cm. There was a significant relationship between eyeball length and NPA before cycloplegic administration in all myopia sufferers. There was a significant relationship between eyeball length and NPC after cycloplegic administration but spherical correction had not been carried out in myopia sufferers. There was a significant difference in NPA and NPC values before and after correction ($p < 0.001$). There was a significant difference in NPA and NPC values before and after cycloplegic administration ($p < 0.001$).

Suggestion

It is necessary to carry out the best spherical correction in myopia patients in order to increase the amplitude of accommodation. Where myopia patients tend to experience a decrease in the amplitude of accommodation, if the best spherical correction is not carried out, this tends to result in conditions of accommodation insufficiency. Patients with a family history of myopia, who have a high risk of developing myopia, require regular eye examinations by an eye doctor to detect changes early. It is hoped that further research will be able to compare the Accommodation Amplitude examination using the RAF rule with a negative lens and a positive lens. Future researchers are expected to be able to add pupillometry examination, which is one component of accommodation.

AUTHOR'S CONTRIBUTION STATEMENT

All authors contributed to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript. Evelyn Angie led the data collection and analysis, Aryani Atiyatul Amra provided guidance on the research methodology, and Masitha Dewi Sari contributed to the interpretation of the data and manuscript revisions. All authors reviewed and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest. There are no personal or financial relationships that could have influenced the research outcomes.

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