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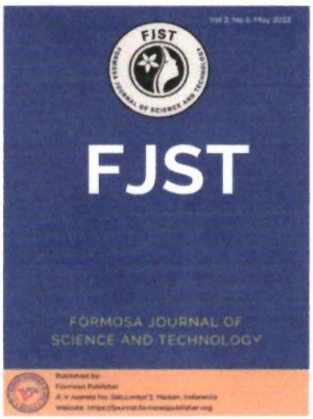

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Exploring the Link between Anisometropia, Binocular Vision Depth Perception, and Amblyopia in School-Aged Children: Insights from a Quantitative Study

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A B S T R A C T

The study examined the relationship between anisometropia degree, binocular vision depth perception, and amblyopia in school-aged children. The research utilized a descriptive quantitative design at Dr. Soetomo Hospital Surabaya from November 2021 to January 2023. The findings indicated a correlation between anisometropia degree and binocular vision depth perception. As the refraction difference increased, the ability to perceive objects with three-dimensional vision diminished. However, no definitive correlation was found between anisometropia degree and amblyopia. To further explore these relationships, future research could involve a broader population, consider additional factors, employ more in-depth study designs, and expand the duration of the study. A more comprehensive understanding of anisometropia, binocular vision depth perception, and amblyopia in children can be attained by addressing these recommendations.

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INTRODUCTION

Measurement of visual function played a critical role in determining the quality of binocular vision. Binocular vision, which allows an individual to use both eyes together, contributes to better three-dimensional perception. Various factors, including precise and accurate measurement of visual function, influence the quality of binocular vision.

Naroo (2011) reported that measurement of visual function related to binocular vision could help detect vision problems that impact both eyes and binocular vision ability. In a study conducted by Simonsz, Lemij, and Van den Berg (1999), it was revealed that measuring visual function in patients with strabismus helped determine the optimal type of binocular vision for each patient.

To avoid irreversible vision damage and ensure optimal vision, measuring visual function related to binocular vision must be done early in patients with strabismus or other visual disorders (Naroo, 2011). McCormack and Nolan (2015) also emphasized that measuring visual function can help detect and correct vision problems that may go unnoticed during regular examinations.

Therefore, measuring visual function related to binocular vision is crucial to ensure optimal vision quality and detect vision problems affecting the eyes and binocular vision ability. This study investigated the relationship between the degree of anisometropia, binocular vision depth, and amblyopia in schoolchildren. Anisometropia, characterized by a significant difference in refractive error between the two eyes, can lead to binocular vision problems and amblyopia. Schoolchildren were selected as the research participants as their vision is still developing at this age, and significant changes in eye health can occur.

Hashemi et al. (2018) reported that anisometropia, a condition where there is a significant difference in refractive error between the two eyes, is common among children and can lead to amblyopia, an inability of the eye to see sharply even after adequate refractive correction. Therefore, this study aimed to investigate the relationship between the magnitude of anisometropia and binocular vision depth and amblyopia in schoolchildren.

To conduct this study, schoolchildren were selected as the research subjects because their eyes are still developing at this age, particularly in terms of binocular vision, and periodic vision measurements can be performed to monitor their vision condition. Pakdel et al. (2021) found that anisometropia is associated with decreased binocular vision depth and an increased risk of developing amblyopia in children.

The research questions for this study were whether there is a relationship between the degree of anisometropia and binocular depth vision and the occurrence of amblyopia in school-aged children. The study aimed to provide useful information for healthcare professionals and parents to better understand eye conditions in children with anisometropia and address vision problems in children.

LITERATURE REVIEW

Anisometropia is a visual condition characterized by a significant variation in refractive power between the two eyes. It occurs when one eye has a different prescription for nearsightedness, farsightedness, or astigmatism than another. This condition can lead to an imbalance in visual clarity, resulting in various visual disturbances and difficulty focusing. Symptoms experienced by individuals with anisometropia include eyestrain, headaches, blurred or double vision, and decreased visual acuity.

Anisometropia can manifest in children and adults; if left untreated, it can have long-term implications for vision. Anisometropia can hinder normal visual development in children and potentially lead to amblyopia, commonly known as lazy eye. Amblyopia arises when the brain favors one eye over the other, causing the weaker eye to have reduced visual acuity. Early detection and treatment of anisometropia in children are critical to prevent the onset of amblyopia and ensure proper visual growth.

Various corrective options are available to manage anisometropia and enhance visual function. These may involve using glasses or contact lenses with different prescriptions for each eye. In some instances, refractive surgeries like LASIK or PRK might be considered to minimize the difference in refractive power between the eyes. Regular eye exams are crucial for individuals with anisometropia to monitor their visual status and ensure appropriate care and treatment.

Amblyopia, also known as lazy eye, is a childhood vision condition characterized by reduced visual acuity in one eye that cannot be corrected with glasses or contact lenses. It occurs when there is an interruption in the normal visual development process, often caused by factors such as misalignment of the eyes (strabismus) or unequal refractive errors between the eyes (anisometropia).

Several studies have been conducted to investigate the causes and treatment approaches for amblyopia. A study by Repka et al. (2003) examined the prevalence of amblyopia in preschool-aged children and found that around 2-3% of children were affected. Another study by Holmes et al. (2019) explored the long-term outcomes of amblyopia treatment. It demonstrated that early intervention using occlusion therapy and optical correction improved visual acuity in affected individuals.

The treatment of amblyopia typically involves a combination of occlusion therapy (covering the stronger eye to encourage visual development in the weaker eye), optical correction, and visual exercises. Various studies have supported the efficacy of these treatments. Stewart et al. (2004) conducted a study evaluating the outcomes of occlusion therapy in children with amblyopia and reported significant improvements in visual acuity. Additionally, Wallace et al. (2018) investigated the effects of binocular treatment in older children with amblyopia and found enhanced visual acuity and depth perception.

In short, amblyopia is a vision disorder that can significantly impact visual acuity in children. Early detection and intervention are crucial for achieving favorable treatment outcomes. The combination of occlusion therapy, optical

correction, and visual exercises has shown promising results in enhancing visual acuity in individuals with amblyopia.

METHODOLOGY

A descriptive quantitative research design was utilized in this study, which was conducted at Dr. Soetomo Hospital Surabaya between November 2021 and January 2023. The study population consisted of children who received outpatient treatment at the hospital and had a difference in refraction between their right and left eyes. To meet the specific inclusion and exclusion criteria, a sample of 36 individuals was selected. Inclusion criteria required good general health and a difference in refraction between the right and left eyes. In contrast, exclusion criteria included non-cooperative behavior, anterior segment abnormalities that could cause amblyopia, posterior abnormalities such as retinal and optic nerve abnormalities, and unwillingness to participate in training.

To collect research data, validated measuring instruments were used. The instruments included an examination of the difference in refraction between the right and left eyes, measurement of binocular depth perception, and identification of the occurrence of amblyopia in school-aged children. Descriptive and correlation statistical techniques were used for data analysis to determine the relationship between the variables investigated.

RESULTS

The study's findings reveal that there is a discrepancy in the prevalence of anisometropia among children who received outpatient care at Dr. Soetomo Hospital in Surabaya concerning gender. The data presented in Table 1 demonstrate that among the total sample of 33 children, 25 are female, while the remaining 11 are male.

Table 1. The Dispersion of Anisometropia According to Gender

Gender	Total Sampel
Female	25
Male	11
Total	36

The data revealed that more females experienced anisometropia than males, as indicated in Table 1. This finding suggests the need to consider gender in managing and preventing anisometropia in children, particularly females. In addition, the study found that anisometropia was predominantly observed in children within the age range of 6-17 years old, as presented in Table 2.

Table 2. The Dispersion of Anisometropia According to Age

Age	Total Sampel
6	1
7	4
8	3
9	3
10	7
11	4
12	3
14	2
15	1
16	1
17	7
Total	36

The data from the study revealed that anisometropia is not limited to a particular age group and can occur at different ages between 6 to 17 years old. Nevertheless, the analysis showed that the highest occurrence of anisometropia was among ten-year-olds, with a total of 7 cases. These findings suggest the importance of regular screening for children in this age group to detect any potential difference in refraction between the right and left eyes that may lead to anisometropia in the future.

Table 3. Refractive Errors and Anisometropia Distribution among Patients

		Frequency
Refractive error	Mild myopia	7
	Moderate myopia	12
	Severe myopia	4
	Myopic astigmatism	13
	Total	36
Anisometropia	0.25	3
	0.50	14
	0.75	1
	1.00	10
	1.50	1
	2.00	5
	3.50	1
	4.00	1
	Total	36

In the study, the research subjects were distributed based on their most common refractive error, where myopic astigmatism was the most prevalent with 13 individuals (36.1%), while severe myopia was the least common with

four individuals (11.1%). The highest degree of anisometropia was 0.50, and it was found in 14 subjects (38.9%). Other degrees of anisometropia were found in only one individual each (2.8%).

Table 4. The Proportion of Patients Who Have Both Anisometropia and Amblyopia

Ambliopia	Visus	Frequency
0	6/6	22
1	6/6.6	4
2	6/7.5	2
4	6/10	2
5	6/12	2
7	6/20	1
10	6/40	1
11	5/60	1
12	2/60	1
Total		36

Anisometropia is a condition with a significant difference in the refractive power between the left and right eyes. This condition can result in amblyopia, where one eye has blurred vision that cannot be corrected with glasses or contact lenses.

The distribution of patients who suffer from amblyopia due to anisometropia with varying degrees of severity can be seen in Table 1. There were 36 patients, with the majority (22 or 62.9%) experiencing mild amblyopia with a visual acuity of 6/6. Meanwhile, the remaining 13 patients (37.1%) had a higher degree of severity with worse visual acuity.

Out of the 13 patients with a higher degree of severity, four patients (11.4%) had a visual acuity of 6/6.6, 2 patients (5.7%) had a visual acuity of 6/7.5, 2 patients (5.7%) had a visual acuity of 6/10, and 2 patients (5.7%) had a visual acuity of 6/12. Only one patient (2.9%) had a visual acuity of 6/20, 1 patient (2.9%) had a visual acuity of 6/40, 1 patient (2.9%) had a visual acuity of 5/60, and 1 patient (2.9%) had a visual acuity of 2/60.

These findings indicate that most patients with anisometropia who suffer from amblyopia have mild to moderate severity. Nonetheless, this condition can still significantly affect the patient's ability to see clearly and perform daily activities. As a result, appropriate treatment and care should be provided to reduce the impact of anisometropia and amblyopia on patients.

Table 5. The Proportion of Patients with Anisometropia in the Bagolini Test

		Frequency
Bagolini	Fusi	29
	Supresi	1
	Skotoma	6
		36

The Bagolini test was used to evaluate the binocular function and detect the presence of anisometropia. During the test, the patient would observe two points of light on a screen projected through polarizing lenses. The doctor would analyze the closure pattern formed when the patient focuses on the two points of light, which could indicate fusion, suppression, or Scotoma. The study revealed that 29 individuals (80.6%) demonstrated fusion, indicating good binocular function. Only one person (2.8%) showed suppression, which means one eye could not produce an image, possibly due to amblyopia or strabismus. Six individuals (16.7%) were found to have Scotoma, which indicates a disturbance in their visual field, possibly caused by optic nerve damage, vascular disorders, or tumors. This data suggests that most individuals tested had a good binocular function, but a few had difficulty merging images from both eyes. Therefore, the Bagolini test is essential in assessing binocular function and helping identify appropriate treatment options for individuals with vision impairments like anisometropia.

Table 6. The Proportion of Patients with Anisometropia in the Worth Four Dot Test (WFDT) Examination

	WFDT distant	**WFDT near**
Fusion	28	33
Suppression	8	2
Diplopia	0	1

The Worth Four Dot Test (WFDT) was a test used to measure stereopsis, which is the ability to see three dimensions with both eyes. The test involved placing four light dots on a screen or test card with special color lenses. The patient was then asked to view the resulting image and respond to the number of dots seen. According to the data collected, 26 people (76.5%) who took the WFDT at a distance had a fusion, indicating that their ability to see three-dimensional images at a distance was functioning well. Only eight people (23.5%) were found to have suppression, meaning that one eye was not active in producing three-dimensional images. No patients experienced diplopia, indicating that patients could see images using only one eye.

In the WFDT near test, 33 people (91.7%) had a fusion, indicating that their ability to see three-dimensional images at close range was functioning well. Only two people (5.6%) experienced suppression, and one person (2.8%) experienced diplopia, indicating that a few patients had disorders in their ability to see three-dimensional images at close range. Based on this data, it can be concluded that the majority of patients who underwent the WFDT test, both distant and near, could see three-dimensional images well. However, a few patients had disorders in seeing three-dimensional images. The WFDT test is essential in evaluating the ability of three-dimensional vision and determining the appropriate treatment steps for patients with anisometropia or other visual impairments.

Table 7. The Categorization of Patients with Anisometropia Based on Their Maples Binocular Vision Degree Distribution

	Frequency
Suppression	9
Simultaneous	1
Superimposed	26

Maples was one of the tests used to measure the degree of binocular vision in patients with anisometropia. According to Table 7, nine people experienced suppression, indicating that one eye was inactive in producing visual images or information. In contrast, only one person experienced simultaneous conditions, where both eyes see objects with the same focus but still experience binocular vision disorders.

A total of 26 people had superimposed conditions, where both eyes saw objects with a different focus but were able to produce good binocular vision. This indicated that, despite significant refractive differences between the two eyes, patients could still see objects clearly and sharply.

Based on the data, it can be concluded that most patients with anisometropia who underwent Maples testing had superimposed conditions, where both eyes could still produce good binocular vision despite significant refractive differences between the two eyes. However, a few patients still experienced suppression or simultaneous conditions, indicating a disruption in binocular vision. Maples testing was essential in evaluating the degree of binocular vision and determining the appropriate treatment steps for patients with anisometropia.

Table 8. The Proportion of Patients with Anisometropia in the Sinoptofor Test

	Frequency
Esotropia+positive stereoscopy	11
Esotropia+positive stereoscopy	17
Esotropia+Negative stereoscopy	5
Orthophoria+Negative stereoscopy	1
Can not	2
Total	**36**

In the TNO stereopsis test, which involved 45 individuals, the distribution of anisometropia patients was found to vary. Among the total participants, 16 individuals were found to have positive Esotropia and Stereopsis, while another 21 individuals also had positive Esotropia and Stereopsis. Meanwhile, five individuals had negative Esotropia and Stereopsis, and one individual had negative Orthophoria and Stereopsis. The type of anisometropia for two individuals could not be identified. Therefore, the majority of anisometropia patients in the TNO stereopsis test had positive Esotropia and Stereopsis, which accounted for 37 of the total 45 individuals examined. Only five individuals had anisometropia with negative Esotropia and Stereopsis, while only one individual had anisometropia with negative Orthophoria and Stereopsis. The type of anisometropia for two individuals

could not be identified. Positive Esotropia and Stereopsis refer to the condition of inwardly turned eyes that are still able to form a good three-dimensional image, while negative Esotropia and Stereopsis refer to inwardly turned eyes that are unable to form a good three-dimensional image. Negative Orthophoria and Stereopsis refer to the condition of aligned eyes that are unable to form a good three-dimensional image.

Table 9. The Distribution of Anisometropia in Arc Seconds

Arc seconds	Frequency
30	3
60	9
120	7
240	7
480	3
800	1
Cannot	6

During the TNO stereopsis test, the distribution of anisometropia in arc seconds varied among the 45 individuals examined. Three individuals had 30 arc seconds, while nine had 60 arc seconds. Seven individuals had 120 arc seconds, and another seven had 240 arc seconds. There were also three individuals with 480 arc seconds and only one individual with 800 arc seconds. Six individuals could not have their arc seconds measured. The examination results indicated that the majority of individuals with anisometropia in the TNO stereopsis test had arc seconds ranging from 60 to 240, with 23 individuals falling within that range. Meanwhile, only four individuals had arc seconds below 60 or above 240. Additionally, six individuals could not have their arc seconds measured. Table 10 shows the relationship between anisometropia and Bagolini, Worth Four Dot Test, Sinoptophore, TNO Test, and Amblyopia.

Table 10. The Correlation Coefficients between Anisometropia and the Tests and Ambliopia

Spearman's rho		Bagolini	WFDT	Sinoptofor	TNO	Ambliopia
anisometropia	Correlation	0.072	-0.343	0.575	0.611	0.134
	Coeficient Sig (2-tailed)	0.675	0.040	0.000	0.000	0.438
	N	36	36	36	36	36

The correlation coefficients between anisometropia and the Bagolini test was 0.072, indicating a relationship between the two but it was not significant.

On the other hand, the correlation coefficient between anisometropia and the WFDT test was 0.343 at the <0.05 level, which means that a significant relationship existed between the two.

Similarly, a significant relationship was found between anisometropia and the Sinoptofor test with a correlation coefficient of 0.575 at the <0.01 level.

The correlation coefficient between anisometropia and the TNO test was 0.611 at the <0.01 level, indicating a significant relationship between the two.

However, no significant relationship was found between anisometropia and amblyopia with a correlation coefficient of 0.134.

DISCUSSION

Anisometropia is a condition in which there is a significant difference in the refractive power of the left and right eyes, leading to varying abilities to focus. Based on Table 2, anisometropia is frequently observed in ten-year-old children. Odedra et al. (2021) found that anisometropia was more prevalent in ten-year-old children than in other age groups.

One possible reason for the higher occurrence of anisometropia in ten-year-old children is due to notable changes in their eyes at this age. Such changes involve alterations in the size, accommodation, and axial length of the eyes, which could lead to discrepancies in the focusing ability of the left and right eyes and enhance the possibility of anisometropia in this age group.

Moreover, ten-year-old children have arrived at a critical stage in their visual development, where their ability to focus and track object movement is growing. As a result, they often engage in activities that need significant eye involvement, like reading, writing, and playing video games. These activities may worsen pre-existing anisometropia or initiate the onset of the condition.

The distribution of research subjects regarding refractive errors reveals that the most commonly encountered refractive error is astigmatic myopia, with 13 subjects (36.1%). In contrast, severe myopia is the least common, with a total of 4 subjects (11.1%). These results may be due to genetic and environmental factors.

Astigmatic myopia is a type of refractive error that makes it difficult for light to focus correctly on the retina due to changes in the shape of the cornea and/or eye lens. This condition usually affects children and adolescents, causing a decrease in their ability to see clearly at near and far distances (Radhan & Midha, 2020).

In contrast, severe myopia is a refractive error that makes it difficult for the eyes to focus on distant objects, and it is often caused by genetic and environmental factors such as prolonged reading or using computer screens.

According to the research results presented in Table 5, 29 out of 36 subjects tested with the Bagolini test had fusion ability, which suggests that most of the subjects in the study had normal or nearly normal visual abilities. Fusion ability is the ability of the eyes to combine images from both eyes into a single, sharp, and complete image (Fang, Zhang & Qian, 2020). This ability is essential for daily activities, particularly for three-dimensional or stereopsis vision.

These research findings provide valuable insight into the subjects' visual condition and can help identify and address any visual complaints or disorders they may have. The results presented in Table 6 indicate that most of the subjects in the study had normal or nearly normal binocular visual abilities at both near and far distances, with 28 subjects having fusion ability at a distance and 33 subjects having fusion ability at near.

Fusion ability is a crucial aspect of daily activities, particularly those requiring detailed vision, such as reading and driving. Therefore, the research findings can help diagnose and plan treatment for patients with binocular vision disorders. The study's results (Table 7) revealed that 28 out of 68 research subjects had fusion on the WFDT far test, while 33 subjects had fusion on the WFDT near test. These findings suggest that the WFDT is an effective tool for evaluating fusion ability at near and far distances, thereby assisting in diagnosing and treating patient binocular disorders. Hatt et al. (2014) also reported similar results, indicating the ability of the WFDT to identify fusion ability at near and far distances in adult subjects. However, more extensive and sophisticated studies are necessary to confirm these findings.

In terms of the relationship between anisometropia and the Bagolini test, a correlation coefficient of 0.072 suggests no significant relationship between the two variables. Nonetheless, a comprehensive evaluation of a person's eye condition and appropriate vision tests are still essential in determining any binocular problems.

Regarding the relationship between anisometropia and the WFD test, a correlation coefficient of 0.343 with a significance level of less than 0.05 indicates a moderate relationship between the two variables. Thus, the results of the WFD test can be used to predict or identify the presence of anisometropia in a person with a reasonably high level of confidence.

In the study's context on the correlation between anisometropia and the TNO test, the results showed a strong relationship between the two variables with a correlation coefficient of 0.611 and a significance level of 0.000. This means that as the difference in refraction or lens power between the right and left eyes (anisometropia) increases, the ability of the eyes to perceive depth (stereopsis) on the TNO test decreases.

This implies that anisometropia can have a negative impact on a person's ability to perform daily tasks such as driving, exercising, or performing work that requires good stereopsis visual acuity.

On the other hand, the study found a weak correlation between the two variables, with a correlation coefficient of 0.134 in the context of the relationship between anisometropia and amblyopia. This suggests that anisometropia does not necessarily lead to amblyopia; conversely, a person can experience amblyopia without having anisometropia.

CONCLUSION AND SUGGESTION

The research shows a correlation between the degree of anisometropia and the ability of the eyes to perceive depth using binocular vision. As the difference in refraction between the eyes increased, the eyes' ability to see objects with three-dimensional vision decreased. Hence, children with anisometropia may face difficulties performing tasks that require good binocular vision.

Based on the research findings, here are some suggestions:

1. Early detection and intervention: Implement early detection programs in schools and clinics to identify anisometropia early and provide timely intervention for improving binocular vision.
2. Vision therapy and rehabilitation: Refer children with anisometropia to vision therapy programs specializing in exercises and techniques to enhance binocular vision and depth perception.
3. Education and awareness: Educate parents, teachers, and healthcare professionals about the impact of anisometropia on binocular vision to create a supportive environment and ensure appropriate interventions for optimal visual abilities.

ADVANCED RESEARCH

The study's limitations include the inability to generalize findings to different populations due to its focus on a specific group of children receiving outpatient care at Dr. Soetomo Hospital in Surabaya. The limited sample of children with differences in refractive levels between their eyes further restricts the applicability of the research findings. Additionally, while a relationship was found between anisometropia degree and binocular vision depth perception, no definite correlation was observed between anisometropia degree and amblyopia. To address these limitations, future research should involve a more diverse population, consider additional factors such as age, gender, family history, and environmental influences, and investigate other variables such as genetics and visual activities. By expanding the scope of research, a more comprehensive understanding of the relationship between anisometropia, binocular vision depth perception, and amblyopia in children can be achieved.

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