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Assessing the relationship between anthropometric factors and refractive errors in school-age children: height, weight, or BMI?

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ABSTRACT

Introduction: Refractive errors (RE) are the leading cause of visual impairment and disability among children globally. Limited research exists on the relationship between anthropometric measures and refractive errors. This study aims to determine the correlation between weight, height, body mass index (BMI), and refractive errors in children.

Methods: This cross-sectional study employed purposive sampling in orphanages across Malang City. Participants were selected based on specific inclusion criteria. Data on their weight, height, BMI, and types of refractive errors were collected as ordinal data. Refractive errors were measured objectively using an auto-refractometer, categorizing refractive errors as myopia and hyperopia based on spherical equivalent results. To minimize subjective bias, we utilized a large sample size and established clear inclusion and exclusion criteria. Additionally, we defined operational definitions for each standardized measurement to ensure consistency and accuracy. Statistical analyses were conducted using an unpaired T-test and Spearman's correlation test with SPSS software.

Results: A total of 362 participants aged 5–18 were included in the study, with 284 participants diagnosed with myopia and 78 with hyperopia. No significant differences were observed in mean body weight, height, or BMI between the myopia and hyperopia groups. Spearman's correlation test indicated no significant relationship between refractive errors and body weight ($p > 0.05$), height ($p > 0.05$), or BMI ($p > 0.05$).

Conclusion: The study found no significant correlation between anthropometric status and the presence of refractive errors in children. Future research should consider more diverse settings and explore additional risk factors contributing to the prevalence of refractive abnormalities in children.

Keywords: Anthropometric status, refractive errors, school-age children.

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INTRODUCTION

Refractive error is a condition where light entering the eye cannot be focused clearly, resulting in a blurry image of the object. The causes include an abnormally long or short eyeball, changes in the cornea's shape, and aging of the eye lens.[1] Refractive disorders in children require prompt attention, as visual impairment (VI) significantly impacts their psychological, educational, and socioeconomic experiences both during childhood and into adulthood.[2] There are four types of refractive errors: myopia, hyperopia, astigmatism, and presbyopia.[1]

Among the 66 million school-age children (5–19 years), 10% suffer from refractive errors, with only 12.5% of this group using corrective lenses. This condition negatively affects children's intellectual development and learning processes, potentially reducing their creativity and productivity. In Indonesia, the prevalence of visual impairment due to refractive errors is 22.1%.[3] Myopia, the most common refractive error, has the highest incidence among adolescents (14–16 years), with studies indicating an increase in prevalence over the past two decades.[4] Hyperopia, on the other hand, is more common in older adults but can also occur in children, often due to hereditary factors.[5]

The growth of children is linked to the development of the eyeball structure. A study conducted in China found a connection between height, weight, and myopia.[6] Other research suggests that taller, heavier children with a higher body mass index (BMI) are more likely to develop myopia.[7] However, studies on the influence of height, weight, and BMI on refractive errors in Indonesian children are limited. Therefore, this research aims to investigate the impact of anthropometric status—specifically height, weight, and BMI—on refractive status in school-age children in Malang, Indonesia.

METHODS

This analytical observational study, using a cross-sectional design, was conducted by the Ophthalmology Department of Saiful Anwar Hospital and the Faculty of Medicine, Universitas Brawijaya, at orphanages in Malang City, Indonesia, from June 2021 to October 2021. The inclusion criteria included children aged 5–18 years who were able to undergo visual acuity examinations and anthropometric measurements, and who provided informed consent before data collection. Children who were uncooperative during the visual examination or had ocular abnormalities in either eye were excluded.

The study sample size was determined using purposive sampling. To minimize subjective bias, we included a large number of subjects and established clear inclusion and exclusion criteria. Operational definitions were standardized for each measurement. A total of 403 children participated in the study. Measurements included body height, body weight, body mass index (BMI), and visual acuity. Standardized equipment such as weighing scales, stadiometers, LVRC charts, auto-refractometers, trial lens sets, and trial frames were used.

According to the CDC chart, participants were categorized by BMI and age (undernourished, well-nourished, overweight, and obese), body weight and age (underweight, normal weight, and overweight), and body height and age (short stature, normal stature, and tall stature). Refractive errors were classified into myopia and hyperopia groups, and their nutritional status was compared. Visual acuity was objectively measured using an auto-refractometer and classified based on spherical equivalent results. The spherical equivalent was calculated as the spherical diopter plus half the astigmatism diopter, and refractive errors were categorized as follows: low myopia (-0.25D to -3D), moderate myopia (-3.25D to -6D), high myopia (over -6.25D), low hyperopia (+2.00D or less), moderate hyperopia (+2.25D to +5.00D), and high hyperopia (over +5.25D).

Data for each child were recorded in a Microsoft Excel file. To analyze the relationship between anthropometric status and refractive status in children in Malang City, SPSS (Statistical Package for the Social Sciences) version 25 for Windows was used. Given that this is an unpaired ordinal correlative analytic study, Spearman's correlation test was employed. Both descriptive and inferential statistical techniques were utilized to investigate and interpret the data.

RESULTS

A total of 416 subjects were initially included in this study. However, 54 subjects were excluded due to various factors such as non-cooperation during the refraction examination, not meeting the inclusion criteria, or having emmetropia (normal vision) results. This left 362 subjects, consisting of 284 with myopia and 78 with hyperopia. The diagnoses of myopia and hyperopia were established based on spherical equivalents from objective refraction performed by an ophthalmologist.

The characteristics of the study subjects are presented in Table 1. In the myopia group, the majority of subjects were female (54.2%), whereas, in the hyperopia group, most subjects were male (57.2%). The mean ages in the myopia and hyperopia groups were not significantly different (14.54 ± 3.23 years and 12.35 ± 3.27 years, respectively). In the myopia group, 27.8% of subjects were underweight, and 6% were overweight. In the hyperopia group, 19.2% of subjects were underweight, and 4.2% were overweight. Analysis of the height-for-age curve showed that 24.6% of the myopia group and 34.6% of the hyperopia group had short stature.

Nutritional status was assessed by measuring BMI and plotting it onto a growth curve. In the myopia group, 6.7% were malnourished, 87.3% were well-nourished, 1.8% were overweight, and 4.2% were obese. In the hyperopia group, 3.8% were malnourished, 93.6% were well-nourished, 1.3% were overweight, and 1.3% were obese.

A comparative analysis was conducted to assess differences in average body weight, height, and BMI between the myopia and hyperopia groups. The bar chart illustrates these differences. The average body weight did not differ significantly between the myopia and hyperopia groups (48.29 ± 14.66 kg vs. 42.56 ± 16.08 kg, p = 0.522). Similarly, the mean height was not significantly different (149.31 ± 12.13 cm vs. 142.35 ± 14.79 cm, p = 0.117). The average BMI also showed no significant difference (21.28 ± 5.01 vs. 20.42 ± 5.27, p = 0.761).

Myopia and hyperopia were classified based on severity levels. Mild myopia was defined as diopters between -0.25 and -3, moderate myopia as diopters between -3.25 and -6, and severe myopia as diopters greater than -6.25. There were 260 subjects

Table 1. Subject characteristics

Data	Myopia (n=284)	Hyperopia (n=78)	p Value
Gender			
Male (n,%)	130 (45.8)	45 (57.2)	
Female (n,%)	154 (54.2)	33 (42.3)	
Age (y.o) (Mean ± SD)	14.54 ± 3.23	12.35 ± 3.27	
Body Weight (kg) (Mean ± SD)	48.29 ± 14.66	42.56 ± 16.08	0.522
Classification of BW/Age			
Underweight (n,%)	79 (27.8)	15 (19.2)	
Normal (n,%)	188 (66.2)	54 (69.2)	
Overweight (n,%)	17 (6.0)	9 (4.2)	
Body Height (cm) (Mean ± SD)	149.31 ± 12.13	142.35 ± 14.79	0.117
Classification of BH/Age			
Short (n,%)	70 (24.6)	27 (34.6)	
Normal (n,%)	211 (74.3)	50 (64.1)	
Tall (n,%)	3 (1.1)	1 (1.3)	
BMI (kg/m^2) (Mean ± SD)	21.28 ± 5.01	20.42 ± 5.27	0.761
Classification BMI/Age			
Undernourished (n,%)	19 (6.7)	3 (3.8)	
Well-nourished (n,%)	248 (87.3)	73 (93.6)	
Overweight (n,%)	5 (1.8)	1 (1.3)	
Obesity (n,%)	12 (4.2)	1 (1.3)	

Note: *significant p-value if < 0.05 *by unpaired t test;* y.o = years old; n=number; SD = standard of deviation; BW = body weight; BH = body height; BMI = Body Mass Index

Table 2. **Correlation test between body weight, body height, and BMI with the level of myopia**

Data	p Value	OR	95% CI
Classification of BW/Age			
Normal*			
Underweight	0.500	0.421	0.178-1.001
Overweight	0.935	1.091	0.133-8.937
Classification of BH/Age			
Normal			
Short	0.052	0.426	0.180-1.009
Classification BMI/Age			
Well-nourished*			
Severely Undernourished	0.653	0.802	0.371 – 1.030
Moderately Undernourished	0.127	0.351	0.091 – 1.347
Overweight	0.432	1.030	0.788 – 3.105
Obesity	0.973	0.965	0.118 – 7.860

Note: *reference variable, significant p-value if < 0.05 *by spearman test*; OR = odd ratio; CI = confidence interval; BW = body weight; BH = body height; BMI = Body Mass Index

Table 3. **Correlation test between body weight, body height, and BMI with the level of hyperopia**

Data	p Value	OR	95% CI
Classification of BW/Age			
Normal*			
Underweight	0.618	1.750	0.194 – 15.780
Overweight	0.764	0.335	0.068 – 5.199
Classification of BH/Age			
Normal			
Short	0.253	3.535	0.404 – 31.108
Classification BMI/Age			
Well-nourished*			
Moderately Undernourished	0.711	2.000	0.051 – 8.250
Overweight	0.074	5.500	0.051 – 8.250

Note: *reference variable, significant p-value if < 0.05 *by spearman test*; OR = odd ratio; CI = confidence interval; BW = body weight; BH = body height; BMI = Body Mass Index

(91.5%) with mild myopia and 24 subjects (8.5%) with moderate myopia. In the hyperopia group, 75 subjects (96.2%) had mild hyperopia, and 3 subjects (3.8%) had moderate hyperopia.

A correlation test was performed to determine the relationship between body weight, height, and BMI with the degrees of myopia and hyperopia. In the myopia group, no significant correlation was found between weight-for-age, height-for-age, and BMI-for-age with the degree of myopia (p > 0.05) (Table 2). Similarly, no significant correlation was found in the hyperopia group (p > 0.05). The results of the correlation test are shown in Table 3.

DISCUSSION

In our present study, we found that the prevalence of myopia was greater than hyperopia in children. The total number of children with myopia was 284; the percentage distribution of girls was higher than boys. Whereas in hyperopia refractive error, there are a total of 78 children, and the majority of them are boys. There are several other factors associated with the prevalence of refractive errors, including gender, ethnicity, family history, socioeconomic status, education of parents, working mothers, screen time, outside activities, and others.[8,9] It is suspected that several factors influence why women experience more myopia refractive errors, namely heredity, lifestyle factors, and environmental factors.[10,11] Girls experience myopia due to a lifestyle and environment that are rarely exposed to sunlight. Sunlight itself is needed for the accommodation power of the eye and the refraction of light on the retina. With sunlight, the eyes get enough light to train their ability to catch the image that will be reflected. It is said that myopia is higher in girls because girls have fewer outdoor activities than boys, so girls have a greater risk of myopia than boys. Outdoor activities such as sports can provide more light intensity, thereby reducing the power of accommodation and reducing the release of dopamine by the retina to reduce eye elongation, thereby reducing the risk of myopia.[12]

In this study, it was found that the average age of those with myopic refractive errors was around 14.54 ± 3.23 years, while the average age of those with hypermetropia refractive errors was around 12.35 ± 3.27 years. This is due to the theory that refractive errors in childhood are more common in school-aged children (9–12 years) than in young adults.[13] A study in China stated that in children who were growing up, refractive errors, especially myopia, were found to be more common in the school-child population. It was found that 20–30% of the population of schoolchildren, especially in elementary and junior high schools.[14] In our results, we had different ages because the samples were aged 5 to 18 years.

Anthropometric status may influence refractive errors, though the mechanism remains uncertain. Previous research has indicated that myopia is more prevalent in taller children, which correlates with increased axial length.[15] Additionally, body mass index (BMI) appears to play a role in refractive errors, particularly in myopia. BMI is associated with variations in axial length, vitreous chamber depth, and corneal curvature. Obese children are more likely to experience hypermetropia due to shorter axial lengths, shallower vitreous chambers, and more curved corneas, potentially influenced by fat deposition. Conversely, individuals with lower BMI tend to have longer axial lengths, deeper vitreous chambers, and flatter corneal curvature.[16]

The results of our study state that there is no relationship between anthropometric status and refractive error. Refractive errors, especially myopia, might be influenced by confounding factors that were not examined in our study. These confounding factors include genetic factors from parents, dietary factors or food for children, and environmental factors. For example, during the COVID-19 pandemic, many schools implemented bravery so that children were rarely outside the home and also had the habit of reading for long periods at close range. Apart from that, the use of gadgets is usually found in children who have undergone a higher level of education, so they easily experience progressive myopia.[17]

In our study, it was found that height, weight, and BMI were not related to refractive errors in children. The research we conducted probably still had to be carried out with a larger number of samples, increased age groups, and attention to confounding variables related to child growth. These variables, such as genetic and environmental factors, as well as food and diet, are consumed by growing children. Cohort research is better to carry out. Several studies recently have found that there is no relationship between anthropometric status and refractive errors, especially myopia, as is the result of this study. Kearney et al. in their research, explained that there was no relationship between weight, height, and BMI and myopic refractive errors. It is said that height, weight, and BMI can change at any time with increasing age.[18]

There is also no relationship between body weight, height, BMI, and refractive errors in hyperopia. There may be no connection because children aged 5–18 rarely experience hyperopia refractive errors. Similar results were also obtained by Kearney et al. It was said that hyperopia refractive errors are unlikely to occur in school-aged children. Generally, school-aged children experience myopic refractive errors due to hereditary factors and long reading activities, so few or even rare school-aged children experience hypermetropic refractive errors.[19] Hereditary factors, activity factors, eye disorders, or diseases such as diabetes or cancer make hyperopia refractive disorders possible in children.[18,20]

Therefore, the strength of this study lies in the large sample size. However, it has limitations, including the lack of subject diversity, as all participants were collected from a single center. Additionally, confounding factors such as genetic influences from parents were not evaluated. Therefore, further analysis considering various factors influencing the prevalence of refractive errors should be conducted in multiple settings.

CONCLUSION

This study did not find any relationship between nutritional status, gender, or type of refractive errors in children. Both boys and girls experienced refractive errors without any significant gender predilection. Children aged 5 to 18 were equally susceptible to refractive errors, regardless of their nutritional status. The most affected age group was between 12 and 14 years old, with myopia being the most prevalent type of refractive error. Statistical analysis indicates no relationship between refractive errors and the child's nutritional status. Based on our findings, we can infer that nutritional status is not the primary factor influencing refractive errors in children.

DISCLOSURES

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Ethical Consideration

This study was approved by The Ethics Committee, Faculty of Medicine, Universitas Brawijaya with approval number 327/EC/KEPK/11/2021.

Conflict of Interest

None.

Author Contribution

All of the authors are involved in conceiving, designing, and supervising the manuscript. RMR conducted the study and analyzed the data. All authors prepare the manuscript and agree for this final version of the manuscript to be submitted to this journal.

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