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The correlation between body mass index and intraocular pressure in children without Down syndrome and children with Down syndrome

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ABSTRACT

Background: Intraocular Pressure (IOP) is the fluid pressure in the eye. Primarily, IOP is influenced by the production and drainage of aqueous humor. The IOP value is in the normal range if the production and drainage of aqueous humor are balanced so that IOP homeostasis must be maintained. Eye dysfunction can occur if the production and drainage of aqueous humour are not balanced. IOP can be influenced by factors such as Body Mass Index (BMI). This study aims to find out whether there is a correlation between BMI and IOP in children without Down syndrome and children with Down syndrome, where children with Down syndrome have one of the eye manifestations in the form of steep and thin corneas which could be one of the factors causing affect the results of IOP measurements.

Methods: The research method used is quantitative-observational with a cross-sectional approach. The total research sample used in this study was 101 children aged 0 to 18 years, with details of 79 children without Down syndrome and 22 children with Down syndrome. Data were processed using the Mann-Whitney hypothesis test and T-test, as well as the Spearman correlation test.

Results: The results of the study showed that there was a difference in IOP between children without Down syndrome and children with Down syndrome ($p < 0.1$), there was a difference in BMI results on IOP in children without Down syndrome and children with Down syndrome ($p < 0.1$), and there was no correlation between BMI and IOP in children without Down syndrome ($p > 0.1$). It was found that there was a correlation between BMI and IOP in children with Down syndrome ($p < 0.1$). It was stated that BMI contributed 91.7% to the increase in IOP.

Conclusion: there was a significant difference in IOP and BMI results on IOP between children with and without Down syndrome. There was no correlation between BMI and IOP in children without Down syndrome, but there was a correlation between BMI and IOP in children with Down syndrome.

Keywords: *Intraocular Pressure, Body Mass Index, Down syndrome, Children.*
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INTRODUCTION

Intraocular pressure (IOP) is the pressure of eye fluid that must maintain homeostasis. IOP will be at the normal value point if the production and drainage of aqueous humour are balanced. Primarily, IOP is influenced by the production and drainage of aqueous humour. If the production and drainage of aqueous humour are not balanced, dysfunction can occur in the eyeball.

Several factors, including body mass index (BMI), can influence IOP values. The BMI variable was chosen in this study because cases of overweight and obesity in children are still a public health problem throughout the world.[1,2] The prevalence of obesity in children according to Riskesdas in 2013, the prevalence of overweight and obesity aged 5-12 years reached 18.8%.[3] In previous research, it was known that increasing BMI values tended to increase IOP values.[4] An uncontrolled increase in IOP values can be complicated by glaucoma, so it is important to detect IOP early during childhood.[5]

Down syndrome is a genetic disorder that most often occurs due to failure to separate chromosome 21 during the division phase, which should only split into two. Still, in the case of Down syndrome, the chromosome splits into three copies.[6,7] The eye manifestations of children with Down syndrome are refractive errors, nystagmus, strabismus, steep and thin corneas, eyelid abnormalities (ptosis), brushfield spots, lacrimal duct obstruction, and keratoconus.[8] Several eye conditions, such as keratoconus and myopia, can impact the intraocular pressure in children with Down syndrome.[9] It is known that the prevalence of glaucoma in the Down syndrome group is higher (11.5%) than in the group without Down syndrome (1.1%).[10] So, to distinguish the

ocular manifestations of children with Down syndrome from those of children without Down syndrome, it is important to conduct an early assessment.

As many as 40% of children with Down syndrome are obese, potentially leading to a greater increase in IOP compared to children without Down syndrome. This is due to the higher energy and nutrient intake observed in children with Down syndrome.[1]

It is also controversial whether higher IOP values among children without Down syndrome and children with Down syndrome are still controversial.[11,12] So, further research needs to be conducted. Research on the correlation between BMI and IOP in children without Down syndrome and children with Down syndrome has never been conducted in Indonesia. Therefore, researchers are interested in undertaking this study.

METHODS

Sample

The study used samples of children without Down syndrome from orphanages in Malang City and children with Down syndrome from Saiful Anwar Hospital, Malang. The inclusion criteria for the study were children aged 0-18 years, willing to be research subjects and agreeing to informed consent, and able to participate in the entire series of eye examinations.

Mechanism for Measuring Body Mass Index

Body Mass Index (BMI) measurement begins with filling out a form and signing an informed consent sheet. BMI measurement is carried out by measuring body weight (kg) and height (m) which are then included in the formulation kg/m^2. The tool for measuring body weight uses a weight scale, while height uses a stadiometer. The results of BMI measurements in children were converted to the 2007 WHO chart based on gender and age.

Mechanism for Measuring Intraocular Pressure

Intraocular pressure (IOP) is measured using different instruments in children with and without Down syndrome. Children without Down syndrome are tested with iCare PRO, while children with Down syndrome are tested with SUOER SW-500. Before the measurement, the eyeballs are anesthetized with 0.5% cendo pantocaine.

Data Collection Procedures

Data was collected from both children without Down syndrome and children with Down syndrome, beginning with the completion of a form and obtaining informed consent. Subsequently, the body weight (kg) and height (m) were measured, and then input into the BMI formula (kg/m^2). Once the BMI value was determined, it generated a BMI chart based on gender and age percentiles.

The IOP examination involved the administration of cendo pantocaine 0.5% as a local anesthetic. Following this, IOP measurements were taken by positioning the tip of the tonopen's probe against the eye's cornea.

Each sample's BMI and IOP results were then entered into Microsoft Excel and Spreadsheets for data processing, utilizing SPSS 25.0.

Data Processing

This study utilized the SPSS 25.0 software for data analysis. A total of 79 children without Down syndrome and 22 children with Down syndrome were included based on the specified criteria. The significance level for this study was set at $\alpha = 0.1$ (10%).

The first step in data processing was to conduct a normality test to compare the IOP in children without Down syndrome and children with Down syndrome. The One-sample Kolmogorov Smirnov test was used for the normality test. Additionally, normality tests were performed to assess differences in BMI results on IOP in both groups of children. The one-sample Kolmogorov Smirnov test was used for children without Down syndrome, while the Shapiro Wilk test was used for children with Down syndrome. The Kolmogorov-Smirnov test was used to examine differences in BMI in both groups of children.

After conducting the normality test, the next step was to test the hypothesis. The Mann Whitney test was used to determine if there is a difference in IOP between children without Down syndrome and children with Down syndrome. Similarly, the Mann Whitney test assessed differences in BMI results on IOP in children without Down syndrome, while the T test was used for children with Down syndrome. The Mann Whitney test was used to examine differences in BMI in both groups of children.

To establish the correlation between BMI and IOP in children without Down syndrome and children with Down syndrome, a correlation test was performed using the Spearman test.

RESULT

Primary Outcome

Differences in IOP between Children without Down Syndrome and Children with Down Syndrome

The normality test for differences in IOP in children without Down syndrome and children with Down syndrome yielded a significant value of 0.0009 ($p < 0.1$), indicating non-normal distribution. Subsequently, the hypothesis test for this issue resulted in a significance value of 0.078 ($p < 0.1$), concluding a disparity in IOP values between children without Down syndrome and those with Down syndrome.

Differences in BMI Results on IOP between Children Without Down Syndrome and Children with Down Syndrome

The difference in IMT results on IOP in children without Down syndrome after the normality test was carried out resulted in significant value data (p-value) for IOP of 0.061 ($p < 0.1$) and BMI of 0.000 ($p < 0.1$). so it is concluded that the data is not normally distributed. The hypothesis test produced a significance value of 0.007 ($p < 0.1$), which means that there was a difference in BMI results on IOP in children without Down syndrome.

In children with Down syndrome, a significant IOP value of 0.142 ($p > 0.1$) was obtained, while a BMI value of 0.200 ($p > 0.1$) concluded that the data was normally distributed. The hypothesis test produced a significance value of 0.074 ($p < 0.1$) so it was concluded that there was a difference in the results of BMI on IOP in children with Down syndrome.

Table 1. **Differences in IOP in Children without Down Syndrome and Children with Down Syndrome**

	Children without Down Syndrome	Children with Down Syndrome
Mean of IOP (mmHg)	17,01 ± 1,66 mmHg	16,18 ± 2,38 mmHg

Table 2. **Differences in BMI between Children without Down Syndrome and Children with Down Syndrome**

	Children without Down Syndrome	Children with Down Syndrome
Mean of BMI (kg/m^2)	22,87 ± 5,58 kg/m^2	18,49 ± 2,49 kg/m^2

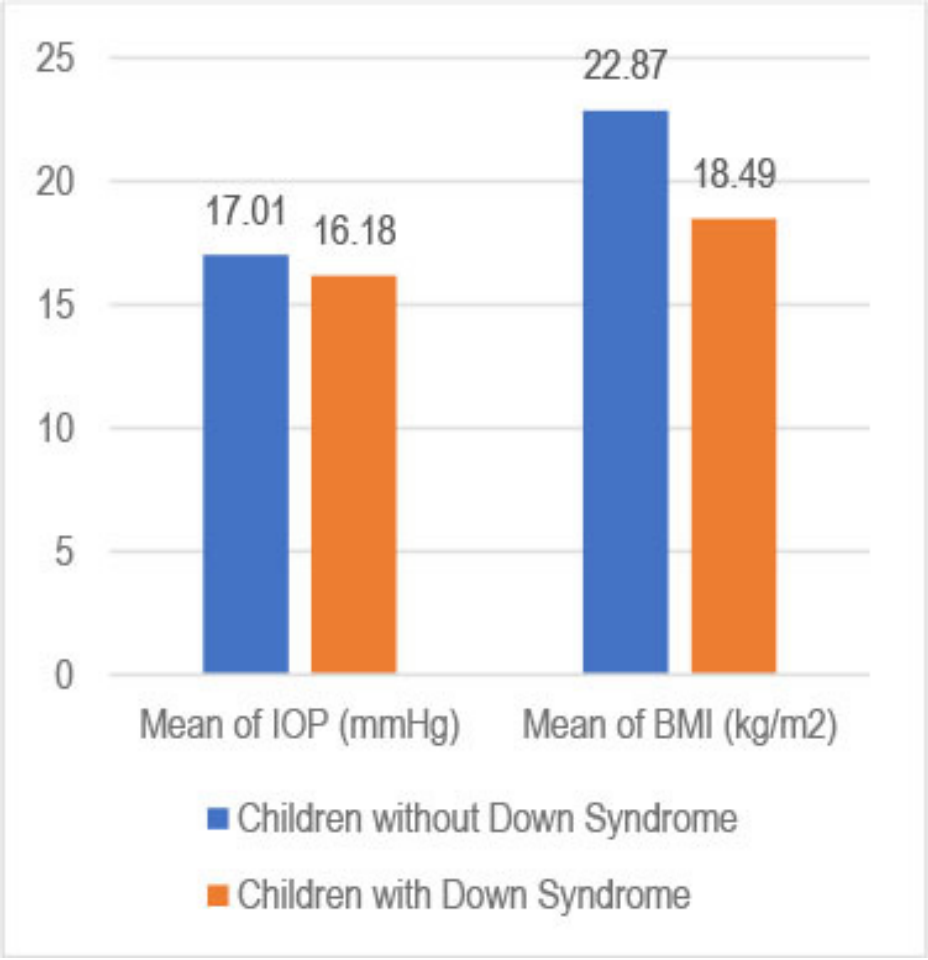

Figure 1. Comparison of Mean IOP and BMI in Children without Down Syndrome and Children with Down Syndrome.

Correlation between BMI and IOP in Children without Down Syndrome and Children with Down Syndrome

The correlation between BMI and IOP in children without Down syndrome and children with Down syndrome was carried out using the Spearman correlation test. It was found that the correlation between BMI and IOP in children without Down syndrome had a significance value of 0.96 ($p > 0.1$), so it was known that there was no correlation between BMI and IOP in children without Down syndrome. Meanwhile, the correlation between BMI and IOP in children with Down syndrome showed a positive correlation of 0.917.

Secondary Outcome

Differences in BMI between Children without Down Syndrome and Children with Down Syndrome

Testing the difference in BMI values between children without Down syndrome and children with Down syndrome using the Kolmogorov-Smirnov test found a significant value (p-value) of 0.000 ($p < 0.1$) which can be concluded that the data is not normally distributed. The next step is to test the hypothesis. Hypothesis testing using the Mann Whitney test showed a significant value (p-value) of 0.000 ($p < 0.1$) so this hypothesis was stated that there was a difference in BMI between children without Down syndrome and children with Down.

DISCUSSION

Primary Outcome

This study shows that body mass index uses units of kg/m^2, while intraocular pressure uses units of mmHg. The results of this study showed that children without Down syndrome and children with Down syndrome had BMI and IOP results that tended to be normal.

In previous research, conducted by Rodriguez, et al., in 2015 and Ugurlu and Altinkurt in 2020 regarding the difference in IOP results in children without Down syndrome and children with Down syndrome is known to still be controversial.[11,12] In this study, it was found that there were differences in IOP results between children without Down syndrome and children with Down syndrome. The results of this study were influenced by the smaller number of samples obtained from children with Down syndrome than children without Down syndrome, so the average IOP value obtained in children without Down syndrome was 17.01 mmHg. In contrast, in children with Down syndrome, it was 16.18 mmHg. Even though it was found that there were differences in IOP values in children without Down syndrome and children with Down syndrome, both IOP values were still in the normal range, namely 10-21 mmHg. Children with Down syndrome have clinical eye manifestations in the form of keratoconus, which means steep and thin corneas.[13] A thin cornea can provide low IOP results. Thin corneas can provide low IOP results, this is because the IOP measurement technique involves direct contact with the cornea. If a thinner cornea is found, it can cause greater corneal deformation under pressure and can affect the readings from the tonometer.[14,15] The results of this study

are consistent with research by Rodriguez in 2015 that children without Down syndrome have greater IOP values than children with Down syndrome.[11]

The results of BMI on IOP in children without Down syndrome and children with Down syndrome in this study stated that there were differences. The difference in BMI results on IOP in children without Down syndrome and children with Down syndrome is known in this study. It was found that the average BMI in children without Down syndrome was 22.87 ± 5.58 kg/m^2 while in children with Down syndrome, it was 18.49 ± 2.49 kg/m^2. So it was found that the average IOP value in children without Down syndrome was 17.01 ± 1.66 mmHg and in children with Down syndrome was 16.18 ± 2.38 mmHg.

It is known that in this study there was a bias factor, namely that the number of children with Down syndrome was found to be less than children without Down syndrome, and the examination tool used to measure children's IOP used two different measurement tools. It is also known that the examiners who took part in the IOP examination were carried out alternately by different people due to the large number of samples of children without Down syndrome, so this created bias in this study.

This research is known to be inconsistent with Pierce et al in 2019 who said that BMI in children with Down syndrome is known to be higher than children without Down syndrome because it is known that children with Down syndrome have several factors that influence children with Down syndrome, namely decreased energy when rest, increased leptin levels in the body, hypothyroidism that is not immediately treated, and low physical activity.[16] If these risk factors are not treated immediately, they can increase body weight, resulting in obesity, heart disease, stroke, and even increased intraocular pressure in the eyes which can result in blurred vision and even blindness. IOP in children with overweight is associated with increased periorbital fat tissue which inhibits perfusion in the choroid, obstruction of ocular blood flow, and increase of blood viscosity, which ultimately can increase outflow resistance from the episcleral veins so that IOP increases.

There was no correlation between BMI and IOP in children without Down syndrome in this study. This research agrees with research conducted by Kadu et al., in 2018, which showed no positive relationship between BMI and IOP. Obesity was not the main risk factor that could cause an increase in IOP.[17] This also agrees with research conducted by Albuquerque in 2013, which found that the correlation between BMI and IOP was very minimal or even nonexistent because each individual had varying anatomical eye factors and complex physiological factors. This can cause variations in IOP results that do not always correlate with BMI.[18,19]

This research does not agree with research conducted by Verdi et al., in 2022 which shows that BMI and IOP have a relationship where the higher the BMI value, the higher the IOP value will be, which is explained in this study by the fact that obesity has a higher IOP value, especially in adolescent girls because of the high tissue they have. Adipose tissue plays a role in the synthesis of the estrogen hormones, which affects IOP.[20]

The correlation between BMI and IOP in children with Down syndrome was found to show a correlation of 0.917. In this study, based on hypothesis testing in children with Down syndrome, BMI contributed 91.7% to the increase in IOP. According to literature written by Chaudary in 2018, as many as 40% of children with Down syndrome experience excessive BMI. This is because children with Down syndrome consume much higher energy and macronutrients than children without Down syndrome.[1] The literature by Bertapelli et al., in 2016 in the journal Hetman and Barg in 2022 showed that children with Down syndrome have the potential to be obese in childhood and adolescence. This is due to resistance to leptin levels, unhealthy eating patterns, and lower physical activity because they have lower muscle tone than children without Down syndrome.[16,21]

Another risk factor caused by excessive weight gain is increased IOP. An increase in IOP is caused by someone who is obese experiencing excessive adipose tissue deposits in the intraorbital area, which can increase blood viscosity and episcleral venous pressure, which can decrease the outflow of aqueous humour. If not immediately prevented, weak visual abilities and even glaucoma can occur.[18]

Secondary Outcome

The differences in BMI results that occurred were found to be that children without Down syndrome had a higher average BMI than children with Down syndrome. Factors that influence the differences in this study are factors that cause bias, namely that the number of samples obtained from children with Down syndrome is much less than that obtained from children without Down syndrome, and measurements of height and weight are carried out by different people alternately. Due to the large population, bias occurs in this study.

This research is not in line with research conducted by Pierce et al., in 2019 said that the BMI in children with Down syndrome was higher than in children without Down syndrome. In this study, it was discovered that the majority of samples obtained were obese.[22,23] Adolescents with Down syndrome have a higher prevalence of overweight and obesity than the adolescent population without Down syndrome.[24,25]

The advantage of this research is that it can help improve the diagnosis, management, and treatment of children's eyes, especially in children with Down syndrome who may have more special needs, as well as being able to take preventive measures or change lifestyle patterns related to BMI, which can affect IOP.

STUDY LIMITATIONS

The limitation of this study is that many factors can influence IOP values besides BMI that were not studied. Another limitation is the limited staff and ability of researchers to measure the population of children without Down syndrome, so it is done alternately so that the results obtained are less than optimal, and the examination tools used for children without Down syndrome and children with Down syndrome use different measurement tools so that it becomes biased. The limited literature discussing the correlation between BMI and IOP in children without Down syndrome

and children with Down syndrome is a limitation in supporting this research.

CONCLUSION

In this study, it was concluded that there was a significant difference in IOP between children without Down syndrome and children with Down syndrome, there was a significant difference in BMI results on IOP between children without Down syndrome and children with Down syndrome, and there was no correlation between BMI and IOP in children without Down syndrome but there was a correlation between BMI and IOP in children with Down syndrome.

Future researchers should take a wider sample so that the research results can be accurate and minimize bias. Conduct further research using other variables such as age, gender, nutritional status, and blood pressure, and it is recommended to measure the variable results using the same researcher and the same examination tools so as not to bias the research. Advice for parents/guardians of children in the future to pay more attention to their children's ideal BMI and their children's eye health.

AUTHOR CONTRIBUTION

All authors have made their contributions for this research. Start by collecting data samples, processing data, writing the manuscript, and approving the finished manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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ETHICAL APPROVAL

Patient has approved this study.

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