Analysis of Risk Factors for Myopia in Adolescents in Urban Environments

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Analysis of Risk Factors for Myopia in Adolescents in Urban Environments

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Abstract. *Myopia or nearsightedness is a visual impairment whose prevalence is increasing, especially among adolescents living in urban areas. This study aims to analyze the risk factors that contribute to the increasing incidence of myopia in adolescents in urban areas. The risk factors studied include near visual activity, exposure to natural light, duration of digital device use, reading habits, and genetic and environmental factors. This study design used a cross-sectional approach involving 300 adolescents aged 12-18 years who were randomly selected from several schools in city X. Data were collected through questionnaires that measured visual habits, daily activity patterns, and family health history, and were strengthened by eye refraction examinations by medical personnel. Data analysis was carried out using logistic regression to identify the relationship between risk factors and the incidence of myopia. The results showed that excessive near visual activity, use of digital devices for more than 4 hours per day, and lack of exposure to natural light were significant risk factors for myopia in adolescents. In addition, genetic factors also play an important role in the predisposition of myopia. These findings are expected to provide a deeper understanding of the factors causing myopia among adolescents and become the basis for formulating effective prevention strategies.*

Keywords *; Myopia, adolescents, visual activity, digital devices, genetic factors, urban environment.*

INTRODUCTION

Myopia or nearsightedness is one of the most common refractive eye disorders worldwide, especially among children and adolescents. Based on a report by the World Health Organization (WHO), the global prevalence of myopia is expected to reach 50% of the world's population by 2050. This trend shows a significant increase, especially in countries with high levels of urbanization. In Indonesia, data from the Ministry of Health shows that the prevalence of myopia in adolescents increased from 20% in 2010 to more than 35% in 2020. This figure is even higher in urban areas, where lifestyle and environment are considered the main triggering factors.

Lifestyle changes in urban environments, such as increased duration of use of digital devices (gadgets), high intensity of near-field visual activities, and reduced time spent outdoors, are the main risk factors for myopia. Previous research by Morgan et al. (2017) revealed that children who spend more time outdoors with sunlight exposure have a lower risk of developing myopia compared to those who spend more time indoors, especially for activities involving near vision such as reading or using digital devices.

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In addition to environmental factors, genetic factors also play an important role in the development of myopia. Saw et al. (2005) showed that children with parents who suffer from myopia have a much higher risk of developing the same condition. However, although genetic factors are important, environmental influences, especially in the context of an urban lifestyle, cannot be ignored.

Further research by Ip et al. (2008) also found that the use of electronic devices for more than 2 hours a day is associated with an increased risk of myopia in adolescents. This is supported by a study conducted in China by He et al. (2015), where it was found that students who spent more than 3 hours per day on near visual activities, especially those involving digital devices, had a two-fold higher risk of developing myopia compared to those with lower screen time.

Given the high prevalence and long-term impact of myopia, especially in growing adolescents, this study aims to explore and analyze in more depth the risk factors contributing to the development of myopia among adolescents living in urban environments. These findings are expected to contribute to efforts to prevent and control myopia through lifestyle changes and more effective interventions.

LITERATURE REVIEW

Research on myopia, especially in adolescents, has been extensive in recent decades, given its increasing prevalence globally. Myopia, or nearsightedness, occurs when light entering the eye is focused in front of the retina, causing distance vision to become blurry. Risk factors for myopia, especially in adolescents living in urban environments, generally include a combination of genetic and environmental factors. The following are some previous studies that discuss risk factors for myopia in adolescents, both from genetic, lifestyle, and environmental aspects.

1. Genetic Factors

Genetic factors play an important role in the development of myopia. Research by Saw et al. (2005) showed that children with parents who suffer from myopia have a two to eight times higher risk of developing myopia than children with parents who do not have myopia. Other genetic studies have shown that there are more than 40 gene loci associated with myopia, although this genetic influence tends to be strengthened by

environmental factors. Another study by Zadnik et al. (1994) showed that despite genetic predisposition, the influence of daily activities, especially those involving near visual activities, can accelerate the development of myopia in individuals with a family history of myopia.

2. Near Visual Activities

The use of digital devices and activities involving near visual activities, such as reading, writing, and studying, have long been associated with an increased risk of myopia in adolescents. Ip et al. (2008) showed that children who engage in near visual activities for more than 2 hours per day have a higher risk of myopia. Another study by Wu et al. (2016) also found that the use of electronic devices, such as smartphones and tablets, significantly contributed to the increasing prevalence of myopia among urban students.

3. Use of Digital Devices

With the increasing use of electronic devices among adolescents, especially in urban environments, myopia is becoming more common. Research by Lingham et al. (2020) confirmed that the use of digital devices for more than 4 hours per day can increase the risk of myopia by two-fold. They also found that high digital screen time can reduce the time spent outdoors, which should protect the eyes from developing myopia. Choi et al. (2017) also found that students who use computers or electronic devices for learning or recreational activities for more than 3 hours a day have a higher risk of developing myopia. This study concluded that the duration and intensity of exposure to digital devices should be controlled to reduce the risk of developing myopia in adolescents.

4. Lack of Exposure to Natural Light

Research by Rose et al. (2008) showed that time spent outdoors, especially with exposure to natural sunlight, has a protective effect on the development of myopia. In the study, it was found that children who spent more than 2 hours per day outdoors had a lower risk of myopia compared to those who spent more time indoors. He et al. (2015), in a study in China, found that students who received more than 3 hours of exposure to natural light per day had a lower risk of developing myopia. Natural light is thought to help prevent eyeball elongation which is the main cause of myopia.

5. Influence of Urban Environment

Urban environments tend to worsen the risk of myopia, especially since adolescents in big cities are more involved in indoor activities that require near vision. According to research by Dolgin (2015), the rate of myopia is higher in urban areas than in rural areas. Urban environments tend to offer less open space and exposure to natural light, while activities such as computer use, playing video games, and intensive studying tend to be higher. In addition, research in Singapore by Saw et al. (2002) showed that the prevalence of myopia in children and adolescents in urban areas can reach more than 60%. This high rate is associated with academic pressure, intense near visual activities, and very little time spent outdoors.

6. Influence of Academic Pressure

In many countries with high rates of myopia, such as China, Singapore, and South Korea, intense academic pressure causes adolescents to spend more time studying and reading, especially indoors. He et al. (2015) noted that students who are involved in intensive academic programs and spend more than 6 hours per day studying or reading are at higher risk of developing myopia.

METHODS

The purpose of this study was to analyze the risk factors that contribute to the incidence of myopia in adolescents in urban areas. The research method used a quantitative approach with a cross-sectional design, where data on risk variables and the incidence of myopia were collected simultaneously.

1. Research Design

This study used a cross-sectional design to identify the relationship between risk factors such as near visual activity, use of digital devices, exposure to natural light, and genetic factors with the incidence of myopia in adolescents in urban environments. Data were collected at certain times from the population studied, and analysis was conducted to determine the relationship between independent and dependent variables.

2. Population and Sample

The population in this study were adolescents aged 12-18 years who lived in urban environments. Stratified random sampling technique was used to select samples from several schools in urban areas, so that adequate representation could be obtained.

The number of targeted samples was 300 adolescents, with the following inclusion criteria:

a. Adolescents aged 12-18 years.
b. Have no history of eye disorders other than myopia.

Research Variables

3. This study involved the following variables:
   a. Dependent Variable: The incidence of myopia, measured through eye refraction examination using a refractometer.
   b. Independent Variables:
      1) Near visual activity: Daily duration spent reading, writing, or working with digital devices.
      2) Digital device usage: Amount of time spent per day using electronic devices such as smartphones and computers.
      3) Exposure to natural light: Time spent outdoors per day.
      4) Genetic factors: Parental history of myopia.
4. Data Collection Instruments
   a. Questionnaire: Collecting data on near visual activity, digital device usage, and natural light exposure from adolescents. The questionnaire used has been validated in previous similar studies.
   b. Eye refraction examination: Conducted by a medical professional using a refractometer to measure the level of myopia of participants.
5. Data Collection Procedures
   a. Stage 1: Demographic data and risk factors were collected through a questionnaire. Participants were asked to answer questions about their near visual activity habits, digital device usage, outdoor time, and family history of myopia.
   b. Stage 2: Eye refraction examination was conducted to determine myopia status. A refractive value of more than -0.50 diopters is considered myopia.
6. Data Analysis

Data were analyzed using SPSS software with the following steps:

a. Descriptive Analysis: To describe the characteristics of the sample and the distribution of myopia incidence and risk factors.

b. Chi-Square Test: Used to test the relationship between independent variables (visual activity, use of digital devices, exposure to natural light, genetic factors) and dependent variables (myopia incidence). The Chi-Square test formula is as follows:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Informasion :

O*i* *:* Observed value

E*i* : Expected value

A p-value < 0.05 indicates a significant relationship.

c. Logistic Regression: Used to determine the most significant risk factors affecting the incidence of myopia after considering all independent variables. The logistic regression formula used is:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$$

Informasion :

P = Probability of myopia occurring.

β_0 = Constant (intercept)

$\beta_1, \beta_2, \ldots, \beta_n$ = Coefficient of independent variables.

$X_1, X_2, \ldots, X_n$ = Independent variables (visual activity, use of digital devices, etc.).

RESULTS

1. Prevalence of Myopia

From 300 samples of adolescents examined, 135 adolescents (45%) had myopia, with eye refraction values ranging from -0.50 to -6.00 diopters. Meanwhile, 165 adolescents (55%) did not have myopia.

2. Relationship between Near Visual Activity and Myopia

Adolescents who spend more than 3 hours per day on near visual activities have a higher risk of developing myopia than those who do near visual activities for less than 3 hours per day.

a. The number of adolescents who have myopia and do near visual activities > 3 hours/day: 90 adolescents.
b. The number of adolescents who do not have myopia and do near visual activities > 3 hours/day: 50 adolescents.
c. The number of adolescents who have myopia and do near visual activities < 3 hours/day: 45 adolescents.
d. The number of adolescents who do not have myopia and do near visual activities < 3 hours/day: 115 adolescents.

From the data above, we can calculate the Odds Ratio (OR) using the formula:

$$OR = \frac{(a/c)}{(b/d)} = \frac{(90/45)}{(50/115)} = \frac{2}{0,43} = 4,65$$

With OR = 4.65, it can be concluded that adolescents who do near visual activities for more than 3 hours per day have a 4.65 times greater risk of experiencing myopia compared to adolescents who do near visual activities for less than 3 hours per day. This result is significant with a p-value <0.01.

3. Relationship between Digital Device Use and Myopia

The use of digital devices also shows a significant relationship with the incidence of myopia. Adolescents who use digital devices more than 4 hours per day have a higher risk of developing myopia.

a. The number of adolescents who have myopia and use digital devices > 4 hours/day: 80 adolescents.
b. The number of adolescents who do not have myopia and use digital devices > 4 hours/day: 60 adolescents.
c. The number of adolescents who have myopia and use digital devices < 4 hours/day: 55 adolescents.

d. The number of adolescents who do not have myopia and use digital devices < 4 hours/day: 105 adolescents.

Calculating the Odds Ratio (OR):

$$OR = \frac{(a/c)}{(b/d)} = \frac{(80/55)}{(60/105)} = \frac{1,45}{0,57} = 2,54$$

From the calculation result of OR = 2.54, it can be concluded that teenagers who use digital devices more than 4 hours per day have a 2.54 times greater risk of experiencing myopia compared to teenagers who use digital devices less than 4 hours per day. This result is significant with a p-value <0.05.

4. Relationship of Natural Light Exposure to Myopia

Article Error

Adolescents who spend less than 2 hours outdoors per day have a higher risk of developing myopia.

a. Number of adolescents with myopia and natural light exposure <2 hours/day: 100 adolescents.
b. Number of adolescents without myopia and natural light exposure <2 hours/day: 80 adolescents.
c. Number of adolescents with myopia and natural light exposure >2 hours/day: 35 adolescents.
d. Number of adolescents without myopia and natural light exposure >2 hours/day: 85 adolescents.

Calculating the Odds Ratio (OR):

$$OR = \frac{(a/c)}{(b/d)} = \frac{(100/35)}{(80/85)} = \frac{2,86}{0,94} = 3,04$$

With OR = 3.04, it can be concluded that adolescents who have less than 2 hours of natural light exposure per day have a 3.04 times greater risk of experiencing myopia compared to those who have more than 2 hours of light exposure per day. This result is also significant with a p-value <0.05.

5. Genetic factors

Genetic factors show a strong association with the incidence of myopia. Adolescents with a history of myopia in parents have a higher risk of developing myopia.

a. Number of adolescents with myopic parents who have myopia: 95 adolescents.
b. Number of adolescents with myopic parents who do not have myopia: 40 adolescents.
c. Number of adolescents without myopic parents who have myopia: 40 adolescents.
d. Number of adolescents without myopic parents who do not have myopia: 125 adolescents.

Calculating the Odds Ratio (OR):

$$OR = \frac{(a/c)}{(b/d)} = \frac{(95/40)}{(40/125)} = \frac{2,38}{0,32} = 7,44$$

With OR = 7.44, it can be concluded that adolescents with a history of myopia in their parents have a 7.44 times greater risk of experiencing myopia compared to adolescents who do not have a history of myopia in their parents. This result is very significant with a p-value <0.01.

DISCUSSION

1. Near Visual Activity

The results of this study are consistent with previous studies showing that near visual activity such as reading and working in front of a computer screen significantly contributes to an increased risk of myopia. Near visual activity that lasts more than 3 hours a day causes increased eye accommodation and can affect the axial length of the eye, which ultimately causes myopia.

2. Use of Digital Devices

Prolonged use of digital devices has also been shown to increase the risk of myopia. This is thought to be because the long duration of device use forces the eyes to work at close range, which increases the burden of eye accommodation.

Excessive use of digital devices also reduces the time children spend outdoors, which can affect eye health.

3. Exposure to Natural Light

   Lack of exposure to natural light can inhibit the production of dopamine in the retina, which functions to prevent axial elongation of the eye. With a lack of exposure to natural light, the risk of myopia becomes greater. The results of this study support the recommendation to increase the time spent playing or doing outdoor activities as a preventive measure for myopia.

4. Genetic Factors

   Genetic factors are one of the most significant variables in increasing the risk of myopia. Children with parents who have myopia have a higher risk of developing myopia, indicating a strong genetic predisposition.

CONCLUSION

This study identified and analyzed the risk factors that contribute to the incidence of myopia in adolescents in urban environments. Based on the results of the study conducted on 300 adolescents, several main conclusions can be drawn:

1. Prevalence of Myopia: The prevalence rate of myopia among adolescents in urban environments reached 45%. This shows that almost half of the adolescent population studied has myopia, which is quite high and indicates the need for attention to eye health among young people.
2. Near Visual Activity: Adolescents who spend more than 3 hours per day on near visual activities such as reading and working with digital devices have a 4.65 times greater risk of developing myopia compared to adolescents who do near visual activities less than 3 hours per day. These results indicate that intense visual habits are closely related to an increased risk of myopia.
3. Use of Digital Devices: Excessive use of digital devices (> 4 hours per day) also significantly increases the risk of myopia with an Odds Ratio (OR) of 2.54. The use of electronic devices such as smartphones, tablets, and computers has become part of adolescents' daily lives, and excessive duration of use contributes to the increasing prevalence of myopia.

4. Natural Light Exposure: Adolescents who spend less than 2 hours per day outdoors have a 3.04 times greater risk of developing myopia. These results emphasize the importance of natural light exposure in preventing the development of myopia. Outdoor activities under sunlight are considered effective in maintaining eye health.
5. Genetic Factors: Genetic factors play a significant role in the occurrence of myopia. Adolescents with a history of myopia in their parents have a 7.44 times greater risk of developing myopia. This suggests that genetic predisposition is one of the main factors in the development of myopia in adolescents.
6. Implications and Recommendations

   Based on these findings, several recommendations can be put forward:

   a. Reducing the duration of near visual activities and use of digital devices by providing sufficient rest time for the eyes.
   b. Increasing the duration of outdoor activities, especially under sunlight, as a preventive measure against myopia.
   c. Education for parents and teachers about the risk of myopia in children, especially those with a family history of myopia, so that preventive measures can be taken early.

Overall, this study concluded that myopia in adolescents in urban environments is influenced by a combination of environmental and genetic factors. Preventive interventions involving visual behavior modification and increased outdoor activity are needed to reduce the prevalence of myopia among adolescents.

LIMITATION

Although this study successfully identified several significant risk factors for the incidence of myopia in adolescents in urban environments, there are several limitations that need to be considered, namely:

1. Cross-Sectional Research Design This study used a cross-sectional design, which only took data at one point in time. As a result, the relationship between risk factors and the incidence of myopia found is associative, not causal. The study cannot prove that these factors directly cause myopia, but only shows a relationship between these variables.

2. Measurement of Visual Activity and Light Exposure Data collection on near visual activity, use of digital devices, and exposure to natural light was carried out through questionnaires filled out by participants. This method relies on the subject's memory, so there may be bias or inaccuracy in self-report. For example, participants may not remember exactly the duration of time spent on near visual activities or outdoors.
3. Other Factors Not Measured This study focused on certain risk factors such as visual activity, use of digital devices, exposure to natural light, and genetic factors. However, there are other factors that may also influence the development of myopia, such as sleep patterns, stress levels, and nutritional status, which were not measured in this study. These factors may provide a more holistic picture if further investigated.
4. Geographic Limitations This study was conducted in only one urban area, so the results may not be generalizable to adolescent populations in other areas, especially in rural or urban areas with different socio-economic characteristics. Myopia can be influenced by environmental factors that are specific to a location.
5. Variation in Refractive Testing Eye refraction testing was performed manually using a refractometer, which, although quite accurate, can have small variations in measurement results. In addition, some subjects may have experienced fluctuations in their vision, which could affect the results of the myopia diagnosis.
6. Limited Study Duration This study was conducted over a relatively short period of time, so it was not able to capture the development of myopia over time. Longitudinal studies that monitor subjects over the long term would provide a clearer picture of how these risk factors contribute to the development of myopia over time.
7. No Control for Preventive Interventions This study did not control for interventions that could prevent or reduce the progression of myopia, such as wearing special lenses or engaging in outdoor activities. Interventional studies could provide more information about effective ways to prevent myopia in adolescents.

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