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The relationship between body mass index and vertebral rotation deformity in adolescents with idiopathic scoliosis

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ABSTRACT

Background: Vertebral rotational deformity is a change in the structure and shape of the spine that can be seen when observed from the transverse plane. Abnormal body mass index can affect vertebral rotational deformity in adolescents with adolescent idiopathic scoliosis. This study aimed to determine the relationship between body mass index and vertebral rotation deformity in adolescents with adolescent idiopathic scoliosis.
Methods: The study used an observational analytic approach with a cross-sectional approach. The study used the sampling technique of simple random sampling and obtained 90 samples. Data was collected by measuring body mass index (BMI) and vertebral rotation deformity. BMI values were obtained by measuring body weight divided by square meters of height, while the Adam forward bending test measured the vertebral rotational deformity using a scoliometer.
Results: Based on the Spearman Rho non-parametric analysis test, the *p*-value = 0.000 ($p < 0.05$) and the correlation coefficient r = 0.657, meaning it has a fairly strong correlation level.
Conclusion: Based on the study's results, it can be concluded that there was a relationship between BMI and vertebral rotation deformity in adolescents with idiopathic scoliosis.

Keywords: adolescents, adolescent idiopathic scoliosis, body mass index, vertebral rotation deformity.
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INTRODUCTION

Poor or improper posture can be a serious problem that affects a person's health and quality of life. Various factors, including lifestyle, occupation, daily habits, and genetics, can cause it. According to the Minister of Health of the Republic of Indonesia, an adolescent is someone aged between 10 years and 18 years.[1] According to population data in 2021 from the United Nations International Children's Emergency Fund (UNICEF), the population of adolescents aged 10-18 years in Indonesia is 46 million, consisting of 48% adolescent girls and 52% adolescent boys. This number is equivalent to 17% of the total productive age in Indonesia.[2]

Adolescent growth has an important influence on their survival in adulthood and old age. During adolescence, there is rapid growth and development, starting from puberty, which will change the bone structure, one of which is rotational deformity and sound, to the activation of several organs. A study explains that there are peak high velocity, peak weight velocity, and peak bone mass in adolescence.[3] Growth and development in adolescents will run in balance if the fulfillment of needs is met. One of them is that nutritional needs in adolescents become influential in bone growth, bone mineralization, rapid changes in body composition, and physical activity.

Nutritional fulfillment and nutritional status of adolescents are important. Based on basic health research data from 2018, there is a prevalence of 25.7% of adolescents aged 13-15 years and 26.9% of adolescents aged 16-18 years in Indonesia. The concern is that 8.7% and 8.1% of adolescents aged 13-18 years are included in the thin and very thin groups. Meanwhile, 16% and 13.5% of adolescents are overweight and obese. These data provide a picture of the nutritional conditions of adolescents in Indonesia that must be improved.[4] This will affect the abnormal body mass index, both underweight and overweight, so that it can inhibit bone growth and development.

An overweight BMI causes an increase in mechanical stress due to gravitational forces on the bones, resulting in faster fatigue and injury. An underweight body mass index results in bone instability in maintaining posture due to decreased estrogen production by adipose tissue, which increases bone mass demolition. The existence of overweight and underweight body mass indexes causes bone mechanical loads and estrogen production to be unstable, which impacts the speed of bone mass demolition and results in vertebral deformity.[5] The existence of vertebral deformity will change the bone structure into three-dimensional planes, namely sagittal, coronal, and transversal, which initially corresponds to the anatomical position to be abnormal as the bones are unstable in supporting posture, resulting

in scoliosis.[6]

Scoliosis is a disorder that causes a curve in the vertebrae or spine as a deviation to the side or lateral direction. All age levels have the potential to experience scoliosis, but the high risk occurs in adolescents from 10-18 years. This is because, at that age, there is rapid bone growth as well as body composition, including bone, muscle, and fat, which is influenced by hormones that begin to be active when entering puberty, such as estrogen and growth hormone if adolescents have habits such as poor diet and activity, it will affect vertebral deformity. Poor diet is associated with an abnormal body mass index, while non-ergonomic activities cause the body to be unstable to maintain body alignment, resulting in scoliosis. According to age, scoliosis is grouped into 3 types: infantile idiopathic scoliosis (IIS), juvenile idiopathic scoliosis (JIS), and adolescent idiopathic scoliosis (AIS). The greatest prevalence occurs in the adolescent idiopathic scoliosis type, which is detected when entering adolescence.[7]

AIS is a structural, lateral, and rotational abnormality of the vertebral curves that appears in adolescents after puberty. The prevalence of adolescent idiopathic scoliosis is recorded at 80% of cases in adolescents aged between 10 to 16 years. In Indonesia, especially Jakarta, one clinic from 1985-2006 recorded about 621 out of 1,585 patients with adolescent idiopathic scoliosis, which means that about 68.9% of adolescents have adolescent idiopathic scoliosis.[8] Other prevalence data in Surabaya in 2017 showed that 5% of cases occurred in elementary school and 4% occurred among junior high school students.[9] Adolescent idiopathic scoliosis can occur in both males and females, but not at the same ratio. The difference in incidence rates in males and females is related to the degree of curvature. Usually, females have a vertebral curvature of 25° or more compared to males.[10] Based on this, adolescent idiopathic scoliosis is a disease that must be treated as early as possible so as not to cause the progressivity of the curvature of the vertebral curve to worsen. One of the things that affect this bone disorder is an abnormal body mass index, which is closely related to the incidence of adolescent idiopathic scoliosis. Therefore, nutritional fulfillment to maintain a balanced body mass index is necessary, especially for adolescents entering a period of rapid growth and development.

Adolescents with idiopathic scoliosis will show progressive changes in posture if not treated as early as possible, ranging from asymmetry of the shoulders, waist, and breasts to rotational deformities.[11] Rotational movement causes the rib angle to turn outward or protrude, resulting in rib asymmetry on the hump on the convex side of the curve. The impact of this not only hampers activities but also disrupts appearance.[12] Adolescents with idiopathic scoliosis will have a vertebral curve that is not symmetrical, allowing for disease complications such as lung compression and causing restrictive lung disease even though the tissue inside is normal.[13]

Research on the relationship between body mass index and adolescent idiopathic scoliosis has been conducted abroad, but there are differences in the results of these studies.[14] In addition, this study has also never been conducted in Bali, while in Indonesia itself, research on this topic already exists, but there are differences in variables. Therefore, researchers want to know the general description of the relationship between body mass index (BMI) and vertebral rotation deformity in AIS.[15] adolescents were chosen because puberty occurs at that age, which causes rapid bone growth and development so that it can be measured reliably.[16] The description of the population of each region is expected to make it easier for researchers to select subjects to be used as research samples by the established criteria. This research is expected to be useful for physiotherapists to add insight. In addition, physiotherapists are also expected to be able to determine appropriate preventive measures and interventions for adolescents with abnormal body mass index so that the risk of adolescent idiopathic scoliosis can be monitored during their development.

METHODS

The research design used in this study is an analytic cross-sectional study with measurements of variables carried out only once at a time. This research design aims to study a disease's etiology or risk factors with momentary measurements without follow-up.[17] The independent variable in this study is body mass index, while the dependent variable is vertebral rotation deformity in AIS. The sample in this study was 90 people of AIS. This study was conducted in several junior high schools to find the diversity of rotational deformities with body mass index, which is normal, underweight, and overweight. The sampling technique in this study was the simple random sampling method, namely by selecting subjects according to the criteria in the affordable population and then selecting the required subjects randomly based on the data sequence number that appears on the random calculator on the computer system. Data was collected by measuring body mass index and vertebral rotation deformity.

Body mass index values were obtained through body weight and height measurements, while vertebral rotational deformity was measured by the Adam forward bending test using a scoliometer. Data analysis in this study was conducted univariate and bivariate. The sampling technique in this study was the simple random sampling method, namely by selecting subjects according to the criteria in the affordable population and then selecting the required subjects randomly based on the data sequence number that appears on the random calculator on the computer system. Data was collected by measuring body mass index and vertebral rotation deformity. BMI values were obtained through body weight and height measurements, while vertebral rotational deformity was measured by the adam forward bending test using a scoliometer. Data analysis in this study was conducted univariate and bivariate.

This study has been approved by the ethics commission of the Faculty of Medicine Udayana University with the number 64/UN14.2.2.VII.14/LT/2023. All patients agreed to be a sample and signed an informed consent.

RESULTS

In this study, the research subjects were junior high school students in Gianyar Regency and Denpasar City with a simple random sampling method that met the inclusion and exclusion criteria of as many

Table 1. Frequency distribution of subject characteristics

Characteristics	Category	Frequency	Percentages (%)
Ages	13	28	31.1
	14	44	48.9
	15	18	20
	Total	90	100
Gender	Female	58	64.4
	Male	32	35.6
	Total	90	100
Body mass index	Underweight	30	33.3
	Normal	30	33.3
	Overweight	21	23.3
	Obese	9	10
	Total	90	100

Table 2. Characteristics of research variables

Variable	Mean	Standard Deviation
Body mass index	0.98	0.683
Deformity	1.77	0.862

Table 3. Cross-tabulation of body mass index on vertebral rotational deformity

Body mass index	Angle of trunk rotation		
	Symmetry	Medium Asymmetric	Severe Asymmetric
Underweight	3	12	15
Normal	20	7	3
Overweight	16	3	2
Obese	5	2	2

Table 4. Relationship between body mass index and vertebral rotation deformity in adolescent idiopathic scoliosis

Variable correlation	Correlation	*p*-Value
Body mass index Deformity	-0.657	0.000

as 90 people. Based on Table 1, it can be seen that the sample's age range is in accordance with the inclusion criteria of adolescents residing in Denpasar City and Gianyar Regency. The highest number of samples was at the age of 14 years, namely 44 people (48.9%). Based on gender, it was obtained that the research subjects with females were 58 people (64.4%) while men were 32 (35.6%). For the body mass index of 100 people, 30 people (33.3%) have an underweight body mass index, 30 people (33.3%) have a normal body mass index, 21 people (23.3%) have an overweight body mass index, and nine people (10%) have an obese body mass index. Based on Table 2, it was found that the mean value of the subject's body mass index was 0.98, with a standard deviation of 0.683. Then, it was also found that the mean value of the subject's scoliosis rotation deformity was 1.77, with a standard deviation of 0.862.

Table 3 shows body mass index data distribution on students' ATR degrees. There were three underweight people with symmetrical degrees, 12 people categorized as underweight with moderate asymmetry, and 15 underweight people with severe asymmetry. In the body mass index with normal categories, 20 people were symmetrical, seven were moderately asymmetrical, and three were severely asymmetrical. For the overweight category, 16 people were symmetrical, three moderately asymmetrical, and two severely asymmetrical. In the obese category, five people were symmetrical, two moderately asymmetrical, and two severely asymmetrical. Table 4 shows a significant relationship between body mass index and vertebral rotation deformity in adolescent idiopathic scoliosis as evidenced by the *p*-value = 0.000 ($p < 0.05$) and the correlation coefficient value of -0.657 and negative. The negative value indicates an unidirectional relationship with a strong correlation level, which is between 0.51 and 0.75. This shows that the lower the body mass index, the higher the risk of vertebral rotational deformity in adolescent idiopathic scoliosis and vice versa.

DISCUSSION

This shows a significant relationship with a fairly strong and inversely proportional correlation between body mass index and vertebral rotation deformity in adolescent idiopathic scoliosis, which indicates that the lower the body mass index, the higher the risk of vertebral rotation deformity in adolescent idiopathic scoliosis.

Body mass index is a method of describing height about a person's weight used to define anthropometric characteristics and classify them into specific groups. In general, body mass index is considered to represent an index of a person's level of fatness. There are several supporting studies that state body mass index also affects vertebral rotational deformity in adolescent idiopathic scoliosis.[17]

Previous research that supports the results of this study is research conducted by Iko Firman (2019). His research discusses the relationship between gender and body mass index with the angle of trunk rotation (ATR) in college students. Angle of trunk rotation is measured by doing the adam's forward bending test, where the subject is asked to bend slowly forward until the position of the shoulders is parallel to the pelvis. The deformity is seen on the subject's back by placing the scoliometer on the vertebral apex or the most clearly visible part, with the number 0 being right on the spinous processes. After analysis, it was found that there was a significant relationship in which a low body mass index had a 0.8 times higher risk factor for vertebral rotation deformity.[18]

The sample of this study was measured

using a scoliometer measuring instrument with Adam's forward bending test, which has previously been tested for sensitivity and specificity. The results of previous research conducted by Jamaluddin Lukman (2018) discuss the sensitivity and specificity test of Adam's forward bending test on a scoliometer for early detection of trunk asymmetry. The data shows that respondents with a low body mass index experience more vertebral rotational deformities than respondents with a high body mass index. In this study, in diagnosing vertebral rotational deformity in respondents using two kinds of methods, namely the first is a scoliometer as a gold standard and, at the same time, a benchmark in connecting with other risk factors, and the second is Adam's forward bending test method which is a benchmark for comparison in diagnostic tests. The results obtained show that there is a relationship between the variables tested. In this study, it can be concluded that the relationship between the examination using a scoliometer and the Adam forward bending test in the diagnostic test method has a significant relationship so that if a positive result is obtained on the Adam's forward bending test, it can give a positive result on the scoliometer, and vice versa.[19]

Research by Jeon Kyoungkyu (2018), which compared low body mass index to scoliosis in students, obtained similar results. The vertebral deformity was measured using raster stereography to direct a halogen light source to the surface behind the vertebrae. After analysis, it was stated that there was a significant relationship between low body mass index and scoliosis, where the lower the body mass index, the higher the risk of experiencing scoliosis.[20]

Based on research conducted by Kim Dong-il (2021) regarding low body mass index and idiopathic scoliosis in children also supports the results of this study. Idiopathic scoliosis was measured using X-rays, while body mass index was measured using a body composition analyzer. The study showed a significant risk reduction of 31% and 34% in underweight and normal compared to severe underweight or low body mass index. The research data was analyzed using the t-test method, and the results showed that low body mass index was closely associated with idiopathic scoliosis.[21]

A similar research was conducted by Kota Watanabe (2017), which discussed physical activity and lifestyle as factors in adolescent idiopathic scoliosis. This study involved 2,759 junior high school students in Japan and was measured using moire topography screening. The sample measurement results obtained 91.6% of subjects with menarche, 68.6% were at 4 or 5 median Cobb angles, and 47.2% were at 15 Cobb angles. When viewed from the body mass index, this study shows a low body mass index experiencing adolescent idiopathic scoliosis. Low body mass index indicates eating problems, excessive exercise, decreased bone mass, or hormone imbalances associated with adolescent idiopathic scoliosis.

Other supporting research was conducted by Wang Weijun (2016), discussing body mass index with adolescent idiopathic scoliosis with the cohort study method. This study used 5299 children aged 15 years and concluded that the greater risk of developing adolescent idiopathic scoliosis is female, which is 7.9% compared to men at 3.4%. Similarly, the body mass index obtained that fat can reduce the risk of developing adolescent idiopathic scoliosis by 14%, which illustrates that a high body mass index can reduce the risk of adolescent idiopathic scoliosis.

The vertebral rotational deformity is described as a clinical manifestation that follows after a diagnosis of adolescent idiopathic scoliosis. Generally, patients will have a vertebral shape that tends to go to the convex or convex side, which can be detected by observing or performing a simple examination using a scoliometer with the Adam forward bending test. The scoliometer with Adam forward bending test is a simple test that is significant and non-invasive to determine the presence of rotational deformities in the vertebrae. Body mass index, closely related to a person's nutritional status, will also affect changes in vertebral structure. This relates to the substrate the muscles need to obtain nutrients to maintain vertebral posture.

A high body mass index has a high percentage of body fat. Estrogen is a hormone formed from body fat. High-fat reserves will increase androgen aromatization to estrogen in granulosa cells and fat tissue, so estrogen levels rise. The hormone that plays a major role in the balance of bone remodeling is estrogen. This hormone will inhibit bone resorption by osteoclasts. This can prevent bone fragility, which causes the bones to become strong and maintain their posture, especially in the vertebrae, so it can reduce the risk of developing adolescent idiopathic scoliosis.

In adolescents, high physical activity impacts changes in posture and, if done ergonomically, will cause musculoskeletal problems. The existence of activities that cause the risk of adolescent idiopathic scoliosis, such as sitting incorrectly for a long time or using a bag, can cause the muscles to become unbalanced in maintaining posture on one side of the muscle. The more force that must be applied in physical activity, the faster the muscles will fatigue or become tense. In someone with an excess body mass index, there tends to be an increase in mechanical stress due to gravitational forces on the musculoskeletal system, which results in fatigue, which causes adolescent idiopathic scoliosis.

The muscles around the scoliosis vertebrae will contracture on the concave side so that the vertebral muscles will stretch weakness on the convex side. On the concave side, the intervertebral joint capsule will contracture, there is compression on the facet joints, the degree of the curve is hypermobility, and at the apex of the curve, there is hypermobility. The ligament capsule shortens or lengthens, resulting in a disbalance between one side and the opposite side hypermobility.

A lower body mass index will increase the risk of vertebral rotational deformity. This is because a low body mass index will supply fewer nutrients to the bones, thereby reducing bone mineral density, which results in weak bones in maintaining posture so that they can be at high risk of developing adolescent idiopathic scoliosis. This condition can occur because low body mass index is associated with low peak bone mass attainment and high bone mass loss.

This study has some limitations. Firstly,

this study only sought the relationship between body mass index and vertebral rotation deformity in adolescents with adolescent idiopathic scoliosis. At the same time, other variables such as gender, physical activity level, and subject hormones have not been controlled by researchers. However, the researcher has attempted to use research subjects with patients with adolescent idiopathic scoliosis who are generally assessed from the results of medical diagnosis, interviews, and observations; namely, the subject can follow instructions from the researcher well. In addition, this study used the probability sampling method to provide opportunities for all members of the population to be selected as samples rather than when using non-probability sampling methods. This study also used a cross-sectional method where data collection was only carried out at one time or simultaneously. Hence, this study was weak enough to determine the relationship between variables.

CONCLUSION

Based on the study's results, a significant relationship existed between body mass index (BMI) and vertebral rotation deformity in adolescents with idiopathic scoliosis. From the calculation results, the correlation coefficient value was 0.657, which means that it has a fairly strong correlation level and a negative value, which means that the lower the body mass index, the higher the risk of vertebral rotational deformity in adolescents with adolescent idiopathic scoliosis.

CONFLICT OF INTEREST

No conflict of interest in this study.

FUNDING

No funding for this study.

ETHICAL CONSIDERATION

The Research Ethics Commission, College of Medicine, Universitas Udayana, stated that this research is ethically feasible with number 64/UN14.2.2.VII.14/LT/2023.

AUTHOR CONTRIBUTIONS

IAJAP conceived the study design, collected and analyzed the data, and drafted the manuscript; GPK, NLNA, and NLPGKS interpreted the data analysis and drafted the manuscript.

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