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RESEARCH ARTICLE

THE EFFECT OF *BODY MASS INDEX* ON SCOLIOSIS IN CHILDREN AGE 4-6 YEARS IN THE KARTASURA REGION

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ABSTRACT

***Background**: Scoliosis is an S- or C-shaped spinal deformity that can occur in early childhood. The prevalence of scoliosis in the world reaches 4.5%. The occurrence of scoliosis can be caused by various risk factors, one of which is body mass index. Body mass index is a measurement to identify nutritional status by measuring body weight and height. **Objective: To obtain sources of** information regarding the influence of body mass index on scoliosis in children aged 4-6 years. **Method**: This research uses a quantitative observational analytical research design with a causal relationship research approach. The sample population was 583 children. The sampling technique used probability sampling, namely proportional random sampling and a research sample of 86 children was obtained based on inclusion, exclusion and dropout criteria. Body mass index measurement identifies criteria based on age and gender with a z-score. Scoliosis measurement using a scoliometer. **Results**: The binary logistic regression test stated that there was no significant influence between body mass index on s c oliosis with a p-value of 0.047 ($p < 0.05$). **Conclusion:** It can be concluded that there is a significant influence of body mass index on scoliosis in children aged 4-6 years with a role of 8.3% in increasing the scoliosis curve.*

INTRODUCTION

Humans are creatures created by Allah SWT who have extraordinary perfection and uniqueness on this earth. Allah's creation has a reason, feelings, senses and of course perfect body posture. Based on the words of Allah SWT in the Al-Qur'an Surah Al-Infitar verses 7&8 which means: " *The One who created you, then perfected your existence and made your (body structure) balanced. In whatever form He desires, He arranges your body"* (Qs. 82: 7&8). A balanced posture was created so that humans can support their body balance in various positions. As time goes by, body posture abnormalities are starting to occur more and more at all ages.

Body posture is formed by the spine which has vertebral curves. Vertebral curves are the curved shape of the spine that can be seen laterally, anteriorly and posteriorly. Vertebrae that experience an increase in abnormal curves can have an impact on spinal abnormalities. According to research by The *American Academy of Orthopedic Surgeons* in 2004, it was detected that around 1.26 million patients with spinal disorders, 93% were diagnosed with scoliosis with 85% of them having idiopathic scoliosis. Based on data *from the National Scoliosis Foundation USA,* the prevalence of scoliosis in the world is 4.5%. Scoliosis is a spinal deformity characterized by changes in the curvature or curve of the spine that forms the letter "S" or "C " and is most common in children and adolescents.

Based on the percentage of cases, scoliosis is mostly idiopathic. The meaning of idiopathic is that the cause is unclear. Several studies show that body mass index is a risk factor for scoliosis. BMI is a measurement used to assess nutritional status related to the problem of being underweight or overweight. BMI aims to determine the ideal body proportions based on age and height, where a person's weight and height vary. Based on the results of the 2022 Indonesian Nutrition Status Survey (SSGI), the weight problem in children under five is 17.1% underweight *and* 3.5% *overweight*. Body weight is the main form of bone mass, which if it is not normal, can have an impact on low bone density and decreased bone mass. This is because the body does not receive sufficient and balanced energy intake and if this occurs in children it will have an impact on the growth and development process

resulting in a decrease in body mass.

In the age range of 4-6 years, children are in The preschool phase is a critical period in psychosocial development. At this time, children begin to develop skills in interacting with other people and adapting to the school environment. The preschool education curriculum implements learning while-playing strategies so that it can arouse children's enthusiasm and great curiosity during the learning process with a learning time duration of 150 to 180 minutes each day and the remaining time before going home is used to rest and play with friends. This period is also the golden period for children which is marked by extraordinary changes in children's growth and development. When the activities carried out by children are mostly sedentary activities which are not proportional to the food intake that enters the body, this can result in weight problems in the form of *overweight* and even obesity (Li et *al* ., 2022). At this time children can also be picky about food according to their wishes, if eating patterns decrease and balanced nutrition is not met it will result in children being underweight or *underweight.* (Zou *et al* ., 2022) . Children whose weight is not normal for their age can disrupt the growth and development process.

The processes of growth and development are interconnected in their formation. Good growth and development in children can form a straight and symmetrical body posture. Bone growth during a child's development period will result in changes in posture, if problems occur this will result in posture disorders due to bone mass that is still not dense. Posture problems in children are thought to be the result of incorrect posture habits that they adopt both at school and at home in their daily lives, where implementing incorrect posture can cause muscle structure to tense, resulting in an unbalanced posture. According to previous research, children spend more than 2 hours per day in sedentary activities, *such* as watching television or playing online games and watching videos on gadgets, and on weekends it increases to 5 hours or more. (Pippi *et al* ., 2020) . Based on this habit, if it is done in a tilted sitting position with the shoulders forward it can have bad consequences for the spine, namely scoliosis.

Another factor that results in scoliosis is based on research by Schlösser *et al* . (2021) stated that genetic factors play an important role

in the development of scoliosis. Based on research by Dou *et al* . (2023) stated that learning activities at school, namely poor positioning when reading and writing at a distance of less than 30 cm and a tilted body can result in scoliosis. Inappropriate school furniture also has an impact on the occurrence of scoliosis, including inadequate table height to provide access for movement of thighs and chairs and distance between blackboards. Based on this, children need more attention in monitoring their health, namely by carrying out screening or early detection which is useful for preventing more fatal deviations when they reach adulthood.

The literature review that has been carried out, shows that previous research on *body mass index* on scoliosis used samples aged over 10 years, measuring instruments using radiography results, namely the *Cobb angle* and research designs using *cross-sectional studies, cohort studies, case-control*, and others, as well as places where research is conducted abroad and other regions of Indonesia; Simanjuntak & Gading, 2019; . On this basis, researchers wish to conduct research using different samples, different methods and different locations. From a preliminary study conducted at Kartasura Kindergarten, it was found that the majority of children had a body weight that was not appropriate for their age, which in the process of growth and development was likely to cause posture problems, namely scoliosis.

Body mass index is related to body weight which is influenced by the food intake consumed. Poor quality of food intake will have an impact on nutritional needs in the body which will result in a deficit of vitamin D and calcium, thus hurting bone density and muscle mass. Food intake is also related to hormonal interactions, such as leptin and adiponectin, which if there is a hormonal imbalance will hurt metabolism and bone development. If food intake and hormones in the body are inadequate, this will result in the structure of the musculoskeletal system becoming poor, resulting in abnormal development of the spine, which becomes curved to one side, thus causing posture disorders in the form of scoliosis. As in Figure 1 below.

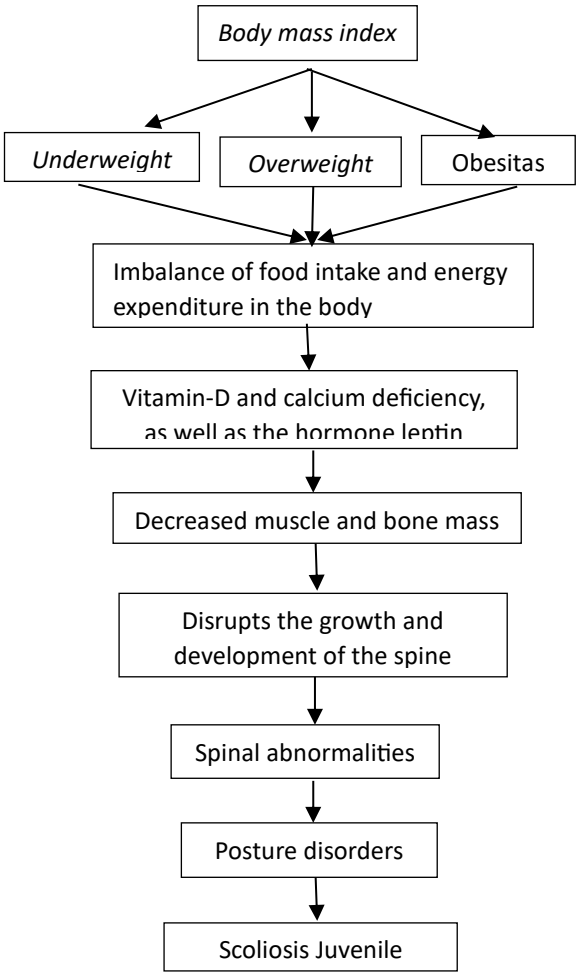

Figure 1. Mechanism of Scoliosis

RESEARCH METHOD

This research uses a quantitative observational analytical research design using a *causal relationship research* approach. The variables in this study consist of independent variables, namely *body mass index* (BMI) and the dependent variable is scoliosis. The sample population includes children aged 4-6 years in the Kartasura area. Spread across 11 kindergartens totalling 583, namely Kindergarten Aisyiyah Makam Haji 1, Kindergarten Aisyiyah Makam Haji 2, Aisyiyah Gonilan Kindergarten, Aisyiyah Pabelan Kindergarten, Aisyiyah Ngadirejo 2 Kindergarten, Aisyiyah Ngadirejo 3 Kindergarten, Aisyiyah Gumpang Kindergarten, Khoirul Ummah Kindergarten, Makarimah Kindergarten, Aisyiyah Pucangan 1 Kindergarten and Aisyiyah Pucangan 2 Kindergarten.

The sample criteria were adjusted to the inclusion and exclusion criteria set by the researcher. The

following are several inclusion criteria, including being willing to be a research sample, gender male and female, the child taking complete measurements, child being able to understand instructions. Furthermore, exclusion criteria include children who have physical limitations/disabilities, children who have experienced injuries, children with *congenital musculoskeletal* or neuromuscular disorders, children with *mental retardation* /mental limitations, children with autism and incomplete measurements. *Body mass index* measurement identifies criteria based on age and gender with *a Z-score*. Scoliosis measurement using a scoliometer.

RESEARCH RESULT

Descriptive Statistical Test Analysis

Table.1 Frequency Distribution of Respondents

Characteristics	Frequency	Percentage (100%)
Age		
4 years	23	2 6.7 %
5 years	37	4 3.0 %
6 years	26	3 0.2 %
Gender		
Man	37	4 3.0 %
Woman	49	5 7.0 %
Degree of Scoliosis		
Asymmetric	39	45.3 %
Symmetrical	47	54.7 %
Body mass index		
Underweight	29	33.7 %
Normal weight	28	32.6 %
Overweight	29	33.7 %

Based on the results of the frequency distribution of respondents, it was found that there were 23 children aged 4 years (2 6.7 %), 37 children aged 5 years (4 3.0 %) and 6 years old as many as 26 children (3 0.2 %). Based on gender, there were 37 children in males (4 3.0 %) and 49 children in females (5 7.0 %). Based on the scoliosis degree category, there were 39 children (45.3 %) experiencing asymmetrical degrees and 47 children (54.7 %) experiencing symmetrical degrees, while in the *body mass index category* there were 29 children (33.7 %) underweight, 28 children (32.6 %) normal and 29 children (33.7 %) overweight.

Normality Test Analysis

The normality test uses *Kolmogorov Smirnov* because the sample size is >50 people.

Table .2 *Kolmogorov Smirnov* Normality Test Results

Variable	p-value	α =0.05	Information
Body mass index	0,000	0.05	Abnormal
Degree of Scoliosis	0,000	0.05	Abnormal

Kolmogorov-Smirnov normality test It was found that the p-value <0.05 indicated that the data was not normally distributed. Data that is not normally distributed can be seen in the interpretation of data visualization from *histograms*, *QQ plots* (*Quantile-Quantile plots*) and *box plots* which can provide an overview of the data distribution. The histogram results are not bell-shaped or asymmetrical, which indicates that the data is not normal. *The QQ plot* results show that there is a deviation or the data does not follow the diagonal line, thus indicating that the data is not normal. *The box plot* results show that there are numbers or dots outside or on the comb line which means there are outliers/outliers. Based on these results, it shows that the data is not normally distributed due to data deviation, outliers and asymmetrical diagrams.

The next test is the logistic regression test, where the requirements for testing the data do not require a data normality test, so if the data is not normally distributed you can continue with the logistic regression test.

Binary Logistic Regression Test Analysis

The bivariate test in this study used a binary logistic regression test. In determining the hypothesis Yuniarti & Hartati's research, (2021) state that the *output results* from the binary logistic regression test are the *Hosmer and Lemeshow Test, Iteration History, Variables in the Equation* and *Model Summary*.

Table .3 Hosmer *and Lemeshow Test* Results

Chi-square	df	p-value
9,690	7	0.207

Hosmer and Lemeshow's results were used to assess the fit of the regression model. Based on the p-value 0.207 > 0.05, it states that Ha is accepted, which means the regression model is suitable for use.

Table.4 *Iteration History* Results

Step 0	*Step 1*
118,476	116.241
118,476	114,804
	113,000
	112,957

Iteration History results are used to assess *model fit*. Based on the -2 log-likelihood value from *step* 0 to *step* 1, there is a decrease in the value, which means the results are declared to *fit* the regression model.

Table .5 Results of *Variables in the Equation*

							95% for EXP(B)	
		B	S.E	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1 [a]	BMI	0.170	0.086	3,932	1	0.047	1,185	1,002	1,402
	Constant	-2,450	1,327	3,410	1	0.065	0.086		

The results of *Variables in the Equation* are used to assess the influence of the independent variable on the dependent variable. Based on the results, the p-value 0.047 < 0.05 shows that the independent variable has a significant influence on the dependent variable.

Table.6 *Model Summary Results*

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
112,957 [a]	0.062	0.083

Model Summary results are used to measure how much the independent variable influences the dependent variable. Based on the value of the Nagelkerke R Square, namely 0.083 or 8.3 %, which means that *body mass index* influences the degree of scoliosis by 8.3 % and 91.7 % is influenced by other factors.

DISCUSSION

1. Respondent Characteristics

Respondents in this study were children aged 4-6 years with the majority aged 5 years. The choice of respondent age was based on considerations from research by Zou *et al* . (2022) that the development of scoliosis usually occurs at the end of childhood and as many as 4% develop at the age of 11-17 years. So it is necessary to carry out regular examinations during childhood to prevent and detect symptoms of scoliosis early.

The majority of respondents were female, namely 57%. This research is in line with research by Zou *et al* . (2023) stated that the prevalence of scoliosis in women is 2.5% greater than in men which is 2%. Gender differences in the occurrence of scoliosis are still not understood but are assumed to be related to differences in anatomy and growth patterns.

2. Body Mass Index

From the results of measurements and calculations *of body mass index* in *Z-score* which is based on age and gender, the majority of children in the underweight and overweight categories obtained results of 33.7% respectively. Based on research conducted by Scaturro *et al* . (2022) stated that low and high *body mass index* is associated with the occurrence of scoliosis, so it is necessary to maintain sufficient body weight during childhood to reduce the risk of scoliosis.

3.Spinal Curves in Children

From the results of measuring scoliosis using a scoliometer, it was found that 45.3% of children had a pathological degree of scoliosis curve. The category of scoliosis in children aged 4-6 years is included in the category of *juvenile scoliosis*. This measurement is in line with research by Baswara *et al* . (2019) that as many as 62 students experienced scoliosis, including 39 students (81.3%) aged >10 years with the *adolescent type of scoliosis*, while 23 students aged 4-9 years with the *juvenile scoliosis type*. Based on this research, the incidence of *juvenile scoliosis* shows a small number. This is also reinforced by the results of this study which show that the scoliometer measurement values tend to be low, so it cannot be used as a reference that children aged 4-6 years experience a degree of spinal curve towards scoliosis.

4.The Effect of *Body Mass Index* on Children with Scoliosis

The effect of *body mass index* on scoliosis in children aged 4-6 years based on the results of logistic regression test analysis found that p-value = 0.047 < 0.05 which indicates that there is a significant influence *of body mass index* on scoliosis so the statistical results H a are accepted

and H 0 is rejected. A review of the *Negelkerke R Square* value or *odd ratio* (OR) shows that the role of *body mass index* in scoliosis affects 8.3 %. You should still be aware of the influence of *body mass index, even though it plays a small role* in influencing the occurrence of scoliosis. These results are by research conducted by Margalit *et al* . (2017) and Jeon & Kim (2021) which state that there is a relationship between low BMI or underweight and high BMI or overweight and obesity on the occurrence of scoliosis.

The growth of children aged 4-6 years is a time of complexity between body weight, food intake and hormones. It is important to realize that the weight of children aged 4-6 years can have an impact on the child's physical growth. Body weight is influenced by eating patterns, which if you experience an eating disorder can result in not getting enough nutrition. Apart from that, the influence of the hormone Leptin in the body is also important, namely causing feelings of fullness and hunger as well as energy expenditure. The leptin hormone can also interact with muscles and bones which will affect muscle strength and bone mineral density. Although this research shows that body weight can affect bone and muscle health, its effect on scoliosis tends to be more complex and the impact is not immediately visible. This is by previous research that 6% of individuals experienced an increase in the scoliosis curve 5 years later.

Apart from body weight, height must also be considered. Height growth is associated with genetic factors which influence 80% and the rest is influenced by environmental factors. According to previous research, the development of the scoliosis curve can be influenced by body height, which has the potential for biomechanical interactions between bone-lengthening growth and spinal curves. Accelerated height growth in late childhood and adolescence can influence the development of scoliosis due to being a critical link in the exacerbation of the curve. However, research results found that not all children experience a period of rapid growth in height and it cannot be confirmed that accelerated height growth will influence the occurrence of scoliosis due to uneven growth or abnormalities in the structure of the spine.

Apart from that, an abnormal *body mass index can affect body mass, thereby disrupting the role of the centre of gravity* (COG) and can also result in changes in *the base of support* that become unbalanced. As a result, the ability of the postural muscles to maintain balance decreases and this can cause uneven pressure on the spine. This pressure can affect the growth of a child's spine which is still growing. Based on this,

it can have an impact on disrupting the child's body posture, namely increasing the risk of scoliosis.

The occurrence of the degree of the spinal curve towards scoliosis is also influenced by other factors that have not been investigated, both internal and external factors that need to be given more attention. Based on theory from previous research, it is stated that the factors that cause spinal disorders are caused by intrinsic factors including adaptation adjustments, psychosocial and physical changes, as well as extrinsic factors in the form of genetic, environmental, behavioural and socio-economic factors. (Sedrez *et al* ., 2015) .

CONCLUSION

Based on the research that has been carried out, it can be concluded that there is an influence of *body mass index* on scoliosis in children aged 4-6 years in the Kartasura area which has a role of 8.3 %. The hypothesis results state that Ha is accepted and H0 is rejected. Based on this, there are several limitations in the research, namely the difficulty in controlling genetic involvement, physical activity, food intake, habits and environment which can influence the assessment of *body mass index* and degree of scoliosis curve, so the information obtained is limited. The difficulty in establishing more specific causes and effects related to *body mass index* and degree of scoliosis is due to using observational studies. The short duration and time of the study are less able to detect long-term *body mass index* in influencing the degree of scoliosis curve.

SUGGESTION

Suggestions that can be used as a guide in further research so that the results obtained are more specific and accurate are to pay attention to and examine several factors related to BMI, including body weight, height, physical activity, food intake and genetics. Using a wider sample to make comparisons of the magnitude of the effect between various ages. Other factors that may be at risk of causing scoliosis in children must also be considered.

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