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Community-Based Screening and Risk Analysis of Adolescent Idiophatic Scoliosis

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ABSTRACT

Introduction: The high prevalence and potential complications of adolescent idiopathic scoliosis (AIS) highlight the importance of early screening to detect scoliosis risk and identify related factors. Early identification allows for timely monitoring of spinal deformities and early intervention, such as bracing. While most studies have focused on school-based populations, community-dwelling adolescents may also be at risk due to differences in daily physical activities and lifestyle patterns. This study aimed to conduct a community-based screening to identify the risk of adolescent idiopathic scoliosis and to analyze the associated risk factors among adolescents living in Seloharjo Village, Bantul, Yogyakarta. **Methoda:** A cross-sectional analytical observational study was conducted among 46 adolescents aged 10–19 years. Data were collected through anthropometric measurements, scoliometer screening, and structured interviews. Data were analyzed using descriptive and bivariate statistics with the Chi-Square (χ^2) test ($p < 0.05$). **Results:** The prevalence of scoliosis risk was 60,9%. Backpack load was the only variable significantly associated with scoliosis risk (p=0,030; cPR=0,14; 95%CI=0,28-0,74). Meanwhile, age, gender, BMI, family history, carrying duration, and carrying method showed no significant association. **Conclusion:** Community-based physiotherapy screening effectively identified scoliosis risk among adolescents. Factors such as backpack load were related to scoliosis occurrence in rural youth.

Keywords: *adolescent idiopathic scoliosis, community-based, risk factors, screening*

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INTRODUCTION

Body posture reflects the alignment and interaction between the muscular, skeletal, and joint structures in response to internal and external stimuli (Baroni et al. 2015). A good posture ensures balanced body load distribution and efficient movement, whereas poor posture may cause muscle tension, imbalance, and deformities such as scoliosis (Souza Junior et al. 2011).

Scoliosis is defined as an abnormal deviation of the vertical spinal axis characterized by lateral curvature and vertebral rotation with a Cobb angle greater than 10°. Based on etiology, scoliosis can be classified as idiopathic, neuromuscular, syndromic, or congenital. Among these, idiopathic scoliosis accounts for about 80% of all cases, with Adolescent Idiopathic Scoliosis (AIS) being the most common subtype affecting individuals aged 10–18 years (Huang et al. 2024).

Globally, the prevalence of AIS ranges from 0.47% to 5.2% in countries such as Germany, Singapore, Korea, Brazil, Turkey, and Greece (Konieczny, Senyurt, and Krauspe 2013). In Indonesia, a study by Komang-Agung, Dwi-Purnomo, and Susilowati (2017) reported a prevalence of 2.93% among school-aged children (9–16 years) in Surabaya with a Cobb angle ≥10°. According to the Kemenkes RI (2021) about National Guidelines for the Management of Adolescent Idiopathic Scoliosis, mild curves may be asymptomatic but have the potential to progress during growth, causing back pain, respiratory difficulties, and postural deformities in more severe cases.

Early detection through screening plays an essential role in preventing curve progression,

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allowing closer monitoring and early interventions such as bracing, which can help avoid costly and invasive surgical procedures (Oetgen, Heyer, and Kelly 2021). Several studies have identified multiple risk factors for AIS, including genetic predisposition, nutritional status, bone density, and paraspinal muscle imbalance (Az-zahra et al. 2024). Moreover, mechanical and lifestyle factors—such as prolonged sitting posture, carrying methods, heavy backpack loads, and carrying duration exceeding 30 minutes have been associated with increased scoliosis risk (Korovessis and Koureas 2018; Haselgrove et al. 2008). Gender, age, and low body mass index (BMI) have also shown correlations with AIS (Zhou et al. 2023).

Most scoliosis studies have focused on school-based populations where screening activities are easier to organize. However, adolescents living in rural communities may also be at risk due to daily physical activities, lifestyle patterns, and limited access to healthcare services. Low awareness among parents and adolescents often leads to delayed recognition of spinal deformities. Therefore, extending screening beyond schools into community settings is crucial to ensure equitable early detection and prevention.

Based on these considerations, this study aimed to conduct a community-based screening to identify the risk of adolescent idiopathic scoliosis and to analyze the associated risk factors among adolescents living in Seloharjo Village, Bantul, Yogyakarta. The findings are expected to provide a scientific foundation for developing sustainable, community-based physiotherapy programs for early scoliosis prevention and intervention.

METHODS

This study employed an analytical observational design with a cross-sectional approach. The research was conducted in Seloharjo Village, Pundong District, Bantul Regency, Yogyakarta, in February 2025. The target population consisted of adolescents aged 10–19 years residing in the area. The sample included adolescents who met the inclusion and exclusion criteria and were selected through purposive sampling.

The inclusion criteria were: (1) adolescents aged 10–19 years residing in Seloharjo Village, Bantul; and (2) willingness to participate in the study. The exclusion criteria were: (1) adolescents with physical or mental disabilities; (2) obesity based on BMI; and (3) a history of injury to the lower limbs or spine. After screening, a total of 46 adolescents were included as study participants.

The variables examined included age, gender, body mass index (BMI), family history of scoliosis, backpack load, backpack carrying method, and carrying duration. The instruments used were a scoliometer to assess the presence or absence of scoliosis risk, a digital scale to measure body weight and backpack load, and a structured questionnaire to identify scoliosis-related risk factors.

Data collection was performed after obtaining ethical approval from the Health Research Ethics Committee of Stikes Surya Global Yogyakarta (No. 4.28/KEPK/SSG/I/2025). The procedure consisted of three stages: (1) measuring height, body weight, and backpack load; (2) performing the Adam's Forward Bend Test followed by scoliometer measurement by a physiotherapist; and (3) conducting interviews using a scoliosis risk factor questionnaire.

Data were analyzed using descriptive and bivariate statistics. The Chi-Square (χ^2) test was applied to determine the association between scoliosis risk and the examined variables, with a significance level set at $p < 0.05$. The results were presented in tables describing frequency distributions and relationships between variables.

RESULTS

Characteristics of Participant

A total of 46 adolescents aged 10–19 years participated in this study.

Table. 1 Characteristic of Participants

Variable	Category	n	%
Age Group	10-14 years	13	28,3
	15-19 years	33	71,7
Gender	Female	27	58,7
	Male	19	41,3
Body Mass Index (BMI)	Underweight	21	45,7
	Normal/ Overweight	25	54,3

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Family history of scoliosis	Present	10	21,7
	Absent	36	78,3
Carrying Method	Both shoulder	41	89,1
	One shoulder	5	10,9
Carrying Duration	10-30 minute	33	71,7
	>30 minute	13	28,3
Backpack Load	Light	15	32,6
	Moderate/Heavy	31	67,4

The demographic and general characteristics of the participants are presented in Table 1 with the most participants were female (58.7%), aged 15–19 years (71.7%), had normal or overweight BMI (54.3%), no family history of scoliosis (78.3%), carried backpacks on both shoulders (89.1%), carried bags for 10–30 minutes daily (71.7%), and had moderate to heavy backpack loads (67.4%).

Prevalence of Scoliosis Risk

The results of the community-based screening using a scoliometer are presented in Table 2.

Table 2. Scoliosis Risk Screening Results

Category	n	%
No risk scoliosis	18	39,1
Risk scoliosis	28	60,9

The screening revealed that 60.9% of adolescents were at risk of scoliosis based on scoliometer examination.

Bivariate Analysis of Scoliosis Risk Factors

The association between scoliosis risk and potential contributing factors was analyzed using the Chi-Square test.

Table 3. Bivariate Analysis of Factor Assosiated With Scoliosis Risk

Variable	Category	(n)		cPR (95% CI)	P
		At Risk	No Risk		
Age group	10-14 years	13	28,3	0,42 (0,11-1,58)	0,343
	15-19 years	33	71,7		
Gender	Female	27	58,7	0,24 (0,06-0,94)	0,072
	Male	19	41,3		
Body Mass Index (BMI)	Underweight	21	45,7	1,08 (0,33-3,56)	1,000
	Normal/ Overweight	25	54,3		
Family history of scoliosis	Present	10	21,7	3,20 (0,59-17,22)	0,150
	Absent	36	78,3		
Carrying Method	Both shoulder	41	89,1	0,96 (0,14-6,39)	0,659
	One shoulder	5	10,9		
Carrying Duration	10-30 minute	33	71,7	1,04 (0,27-3,88)	1,000
	>30 minute	13	28,3		
Backpack Load	Light	15	32,6	0,14 (0,28-0,74)	0,030
	Moderate/ heavy	31	67,4		

cPR= crude Prevalence Ratio; p<0,05 indicates statistical significance

The results are summarized in Table 3. The bivariate analysis showed that backpack load was significantly associated with scoliosis risk (p=0,030; cPR=0,14; 95%CI=0,28-0,74). Meanwhile, no significant associations were found for age (p=0,343), gender (p=0,072), BMI (p=1,000), family history (p=0,150), carrying method (p=0,659), or carrying duration (p=1,000).

DISCUSSION

This study aimed to identify the factors associated with the risk of adolescent idiophatic scoliosis (AIS) through a community-based physiotherapy screening conducted in Seloharjo Village, Bantul, Yogyakarta. The findings showed that 60.9% of the adolescents screened were at risk of scoliosis, with backpack load being the only factor significantly associated with scoliosis risk.

Age and Scoliosis

Based on the bivariate analysis in Table 3, no significant relationship was found between the age groups 10–14 years and 15–19 years with the incidence of scoliosis (p = 0.343; cPR = 0.42; 95% CI = 0.11–1.58). This finding indicates that age differences within the adolescent range are not a major determining factor for scoliosis in the studied population. This aligns with the study by Fu et al. (2024) which reported that ages 16–18 years (1.3%) have a higher risk than ages 10–15 years. Another study by Sung et al. (2021) found that the incidence of idiopathic scoliosis among adolescents aged 10–14 years was 0.841%, compared to 0.7% in those aged 15–19 years.

The nonsignificant relationship may be influenced by the fact that both age groups (10–19 years) fall within the same developmental phase

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early to late adolescence which is characterized by rapid physical growth (growth spurt). This period is considered a critical phase for the onset and progression of scoliosis due to accelerated height growth and rapid skeletal maturation. Puberty is marked by increases in the Risser sign, an important indicator for assessing scoliosis progression (Coillard, Circo, and Rivard 2013). A longitudinal study by Loncar-Dusek, Pecina, and Prebeg (1991) also showed that children undergoing rapid growth during puberty have a higher likelihood of developing scoliosis than those without such growth acceleration. This may explain why risk differences across age groups within the 10–19 range are not substantial because all are within a similarly vulnerable phase for scoliosis development.

Gender and Scoliosis

This study shows no significant relationship between gender and the incidence of scoliosis (p = 0.072), although the cPR value indicates a lower risk among females (cPR = 0.24; 95% CI = 0.06–0.94). This finding differs from literature stating that females are at higher risk for scoliosis (Komang-Agung, Dwi-Purnomo, and Susilowati 2017). However, other studies note that the prevalence of small curves at the early stage of scoliosis is relatively similar in both males and females, with risk differences emerging only in moderate to severe curves (Addai, Zarkos, and Bowey 2020). Factors such as limited sample size may also contribute to differences in sex-related detection rates.

The higher tendency of scoliosis among males in this study may be explained by biomechanical evidence from Zheng et al. (2021), who showed that scoliosis in males tends to have higher spinal rigidity compared to females. Such increased rigidity may reflect deformities that are more noticeable or more progressive, making them easier to detect during screening and potentially increasing the observed incidence among males. The study also noted that rigidity differences were significant only in males for specific curve orientations, providing biological reasoning for the increased risk detected in certain conditions.

Body Mass Index and Scoliosis

This study found no significant association between BMI and the incidence of scoliosis (p = 1.000). However, the findings indicate that low BMI/underweight individuals have a one-fold increased risk of developing scoliosis (cPR = 1.08; 95% CI = 0.33–3.56). This aligns with studies such as Scaturro et al. (2022), which reported that low BMI can be an indicator of inadequate nutritional status, negatively affecting bone density and muscle mass. Since muscle mass—particularly skeletal muscle correlates with postural control, reduced muscle mass may contribute to impaired balance and subsequently increase scoliosis risk (Xu, Zang, and Wu 2023).

Additional evidence suggests that the association between scoliosis and lower BMI is linked to musculoskeletal stability, structural characteristics, and hormonal imbalances that may increase the prevalence of scoliosis or worsen spinal deformities (Zhou et al. 2023). Furthermore, a recent study by Li et al. (2025) identified that in adolescents with idiopathic scoliosis, a lower percentage of total body muscle and a higher percentage of subcutaneous fat were associated with an increased risk of curve progression. Conversely, a higher muscle percentage was found to reduce the likelihood of scoliosis worsening, indicating the protective role of muscle mass in managing progression risk.

Therefore, although no significant association between BMI and scoliosis was found in this study, the increased risk among underweight individuals may reflect more complex body composition factors. This highlights the importance of further research that not only examines BMI but also body composition and other factors such as hormonal profiles that may influence the link between nutritional status and scoliosis development.

Family History and Scoliosis

This study found no significant association between family history and scoliosis incidence (p = 0.150). However, the cPR value indicated a 3.20-fold increased risk (95% CI = 0.59–17,22), suggesting a higher likelihood of scoliosis among individuals with affected family members compared to those without such history. This aligns with Huang et al. (2024), who found that family history is associated with scoliosis risk. Another study by Grauers, Rahman, and Gerdhem (2011) reported that approximately 38% of

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scoliosis risk is influenced by genetic factors, while 62% is due to unique environmental factors.

A literature review by Safutra et al. (2024) noted that genetic polymorphisms are associated with scoliosis, with genes such as MATN1, LBX1, and GPR126 being implicated in scoliosis development. Variations in these gene loci may alter primary gene expression and epigenetic regulation, ultimately affecting cellular activity and contributing to scoliosis. Paria and Wise (2015) further stated that although many risk genes have been identified, each gene contributes only a small proportion to the overall risk, explaining only part of scoliosis variability. Therefore, scoliosis risk arises from interactions between genetic susceptibility and environmental triggers such as growth rate, biomechanical loading, and neuromotor conditions.

Carrying Method and Scoliosis

This study shows that the method of carrying a backpack does not have a significant relationship with scoliosis incidence (p = 0.659). This indicates that variations in backpack-carrying methods whether using two shoulder straps or a single strap are not major determinants of scoliosis in the studied population. Additionally, further analysis showed that carrying a backpack on one shoulder does not increase scoliosis risk compared to carrying it on both shoulders (cPR = 0.96; 95% CI = 0.14–6.39).

This finding is consistent with previous studies Illiyin et al. (2023), which also reported no relationship between backpack-carrying method and scoliosis incidence. EMG-based studies found that two-strap backpacks create more sagittal-plane physical stress than single-strap bags. Although theoretically, two-strap backpacks promote spinal symmetry, some research indicates that backpacks centered between the clavicles cause forward trunk lean, which then induces compensatory upper-body displacement (Qureshi and Shamus 2012). Other ergonomic factors, such as asymmetrical shoulder straps and loads exceeding 10% of body weight, may also contribute to spinal asymmetry.

Duration of Carrying and Scoliosis

The results of this study indicate no significant relationship between the duration of carrying a backpack and the incidence of scoliosis (p = 1.000). However, risk analysis shows a slightly higher risk (cPR = 1.04; 95% CI = 0.27–3.88) among adolescents who carry their backpacks for longer periods. Theoretically, carrying a backpack for extended periods may affect spinal alignment. Carrying a backpack for more than 10 or 20 minutes per day can cause pain due to continuous muscle contraction, leading to muscle fatigue and discomfort (Ath-Thahirah et al. 2024). This is supported by Nugraha et al. (2023), who found that longer backpack-carrying duration is associated with scoliosis in schoolchildren due to cumulative postural load over time.

Backpack Load and Scoliosis

This study found a significant association between backpack load and scoliosis (p = 0.030). However, the prevalence ratio indicated a direction opposite from theoretical expectations. The cPR = 0.14 (95% CI = 0.28–0.74) suggests that adolescents carrying heavier backpack loads had a lower risk of scoliosis than those carrying lighter loads. This means that heavy backpacks were not identified as a risk factor for scoliosis in this study.

This unexpected finding may be influenced by several methodological factors. First, the relatively small sample size may have reduced the stability and accuracy of the risk estimates, making the observed association less representative of the true relationship. Second, the study did not assess backpack load prior to the onset of scoliosis. It is possible that some adolescents had already developed early signs of scoliosis and consequently reduced the weight of their backpacks, leading to a reversed association and potential bias in interpreting the true effect of backpack load on scoliosis risk.

Despite this unexpected result, Rodrigues-Oviedo et al. (2012) found that backpack load was not significantly associated with back pathology, but was significantly associated with back pain—indicating heavier backpacks are more strongly linked to short-term musculoskeletal complaints. Additionally, Kesumayanti et al. (2023) reported that all respondents carried light backpacks (<10% of body weight), yet 26% tested positive for scoliosis. This indicates the study population generally used backpacks within recommended safe load limits, suggesting that factors other than backpack load likely contributed to scoliosis.

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Another important factor influencing scoliosis is physical activity. A literature review by Qi et al. (2023) found a significant association between physical activity and AIS, with low or irregular activity increasing the risk of scoliosis, while moderate to high activity helps prevent or reduce it. Therefore, inconsistencies between this study's findings and theoretical expectations may be explained by the influence of other, more dominant contributing factors.

Thus, further research with stronger study designs is needed, considering additional variables that may influence the development of scoliosis.

CONCLUSION

This study demonstrated that community-based screening is effective in identifying the risk of scoliosis among adolescents in Seloharjo Village, Bantul, with a risk prevalence of 60.9%. Among the various factors analyzed, only backpack load showed a significant association with scoliosis risk ($p = 0.030$). Age, gender, BMI, family history, carrying method, and carrying duration were not significantly associated with scoliosis. These findings indicate that scoliosis risk among adolescents is influenced not only by individual characteristics but also by mechanical factors and daily physical activities. Therefore, further research is needed to explore additional factors such as body composition, physical activity levels, and biomechanical influences that may contribute to scoliosis in adolescents. Moreover, it is important to provide education to adolescents regarding risk factors and preventive measures that may affect the development of scoliosis.

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