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Research article

PREVALENCE OF SCOLIOSIS IN ELEMENTARY SCHOOL STUDENTS AGED 8-11

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Abstract. *Adolescent idiopathic scoliosis (AIS) is a spinal abnormality commonly found in children and adolescents with a prevalence rate of 0.5-5.2%. Data on scoliosis in Indonesia is yet to be available. Our study was aimed at screening and comparing school children with normal posture and with suspected scoliosis (SS). 1059 elementary school students (477 boys, 582 girls) from grade 3 to grade 6 in Jakarta participated in this study. Body mass and height were measured according to the standard technique. Axial rotation of the spine was measured using a scoliometer. Results were classified into two groups: normal if the axial rotation angle was <5° and scoliosis was suspected if the angle was ≥5°. An independent t-test was used to analyze anthropometric differences between the normal and SS group. Statistical significance was set at p<0.05. 74 (7%) of the 1059 students were SS, consisting of 24 (5 %) boys and 50 (8.6 %) girls (OR 1.98, P=0.004). Students at the age of 10 had the highest incidence of scoliosis (27 or 10.1%). Girls with SS were significantly taller and with lower BMI values (138.6 cm vs 134.6 cm, p=0.014; 16.95 kg/m^2 vs 18.50 kg/m^2, p=0.028). The scoliosis rate in elementary students in Jakarta was about 7 % with higher prevalence in girls.*

Key words: *prevalence, scoliosis, screening, school children*

INTRODUCTION

Scoliosis is a lateral deformity of the spine (Bess, Schwab, Lafage, Shaffrey, & Ames, 2013) that can be determined by measuring the vertebral tilt angle or Cobb's angle using an X-ray examination (Kim et al., 2010; Janicki & Alman, 2007). Diagnosis of scoliosis is confirmed if the Cobb angle is 10 degrees or more (Bess et al., 2013; Kim et al., 2010; Janicki & Alman, 2007). However, the X-ray examination is invasive, so it cannot be used as

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the screening tool with a large number of young participants. On the other hand, there are some non-invasive but costly methodologies and devices like the Spinal Mouse (Milenković et al., 2011). Certain simple methodologies and devices can also be used in recognizing signs of scoliosis rather than measuring Cobb's angle. Adam's forward bending test is a direct visual observation to see if there are any abnormalities in the back such as a hump or asymmetry of the back (Horne, Flannery, & Usman, 2014; Coelho, Bonagamba, & Oliveira, 2013). Visual observation can immediately recognize scoliosis with a larger angle, especially when accompanied by vertebral rotation and sternum abnormalities. A vertical hanging rope and a posture analysis grid chart are also often used to assess spine alignment and scoliosis. A scoliometer is a simple device that can be used to measure axial rotation of the spine. The degree of axial rotation has a strong correlation with the Cobb angle with a sensitivity of 87% (Fine & Stokes, 2018). Presently, the scoliometer is available as an application in android device.

The prevalence of scoliosis in adolescents ranges from 0.5-5.2% (Konieczny, Senyurt, & Krauspe, 2013). Adolescent idiopathic scoliosis (AIS) is the most common type of scoliosis found in children and adolescents, and it is more pronounced in females (Kim et al., 2010; Konieczny, Senyurt, & Krauspe, 2013). The pathophysiology of scoliosis is not exactly known, but is allegedly of a multifactorial cause. Genetic factors, nervous system abnormalities, abnormal bone growth, hormonal and metabolic disorders, biomechanical factors, environment and lifestyle are factors that are thought to affect the occurrence of scoliosis (Burwell et al., 2009; Wang et al., 2011; Burwell, Dangerfield, & Freeman, 2008). These factors affect scoliosis in two ways, starting (initiation), then followed by stimulating bone deformity, and increasing the progression of angle deformity (Burwell & Dangerfield, 2012; Grivas, Vasiliadis, Mouzakis, Mihas, & Koufopoulos, 2006).

Children and adolescents with scoliosis are usually considered to have a different body shape. They might look thinner and taller than normal people. This is confirmed by some studies reporting that scoliotic children and adolescents had lighter body mass and greater height than normal adolescents of the same sex and age group (Wang, Wang, Zhu, Zhu, & Qiu, 2016; Ramírez et al., 2013). The anthropometric character of scoliosis patients is thought to be related to the pathophysiology of scoliosis, namely, the influence of leptin as well as somatic and autonomic nerve disharmony (Burwell et al., 2009; Burwell et al., 2008; Burwell, Clark, Dangerfield, & Moulton, 2016).

Health problems due to scoliosis are determined by the degree of scoliosis or the size of Cobb's angle. The greater the degree of scoliosis (or the greater Cobb's angle), the more severe the health problems caused. Scoliosis in particular can cause musculoskeletal disorders such as stiffness, pain, or a feeling of discomfort in the back or pelvis (Janicki & Alman, 2007). When the complaints persist, they can interfere with the child's learning process, school performance, and quality of life.

Scoliosis school screening has been conducted in some countries, especially in developed ones. Scoliosis examination/screening is even mandatory for school children in Japan. to date, scoliosis screening has not been performed and has not yet been included in the Indonesian school health service. There is no national policy regarding scoliosis screening at schools in Indonesia. As the country with the fifth largest population in the world, there is need for Indonesia to include scoliosis school screening as a school health service. Therefore, this study aims to perform scoliosis screenings in elementary school children and to obtain preliminary data on the prevalence of scoliosis.

METHODS

This is a cross-sectional study with a descriptive analytic design. The participants were elementary school students (477 males and 582 females, totally 1059), with an age range of 8-11 years, i.e., from grades three to six of two schools in Jakarta. Written informed consent was obtained from parents after an explanation was provided. Permits and approvals to involve students, schedules, and rooms for examination were obtained from the principal. This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Katolik Indonesia Atma Jaya, Jakarta.

Physical measurements and a scoliometer examination were carried out in the School's Health Service Unit. Height was measured in Frankfort's position using microtoise, without using shoes or footwear, expressed in cm at the nearest 0.1 cm. Body mass was measured using a digital body scale (SECA Robusta 813, German) with the participants in minimal clothing, expressed in kg at the nearest 0.1 kg. The body mass index (BMI) was calculated using the formula: body mass (kg) divided by squared height (m^2).

The scoliosis examination was performed using a scoliometer smartphone application from an android device. The position for examination, the participant bent until the shoulder was aligned with the pelvis. The position of the left and right shoulders should be aligned in such a way that the back deformity is visible. The examiner stands behind the participant while inspected with eyes parallel to the back. The examiner places a smartphone with the scoliometer application straight from left to right in the visible part of the deformity. The center of the scoliometer (marked with a vertical line) was just right at the midline of the spine. The screen part of the device faces the examiner. The angle of axial rotation of the spine can be read on the screen of the device. Based on the measurements, the participants were grouped into two, i.e., into a group with normal posture if the axial rotation angle was less than 5°, and into a group with suspected scoliosis (SS) if the axial rotation was 5° or more (Coelho, Bonagamba, & Oliveira, 2013).

Numerical data are presented as mean values, and categorical data are presented as amounts and percentages (%). The t-test was used to examine differences in height, body mass, and BMI between the normal group and scoliosis group. The Chi-square test was used to examine the relationship between gender and scoliosis. Data and statistical tests were processed using SPSS version 17. The *P* value was significant at the level<0.05.

RESULTS

A total of 1059 students participated in this study, consisting of 477 males and 582 females, with an age range of 8-11 years. Students over 12 years of age were not included because the number was very few. There were 74 students (7%) with SS, consisting of 24 males (5%) and 50 female students (8.6%). The t-test showed that students with SS had greater height and lower BMI values than students with normal posture (138.61 ± 8.48 vs. 135.39±10.93, p = 0.01, and 17.67±2.61 vs 19.37±15.31, p=0.03). The relationship between sex and SS was analyzed using the Chi Square test. It was determined that the females were more at risk of having scoliosis than the males (OR 1.77, 95% CI 1.28-2.36, p<0.01, Table 1).

Table 1 Characteristic differences between students with normal posture and suspected scoliosis

	Normal (n = 985)	SS (n = 74)	*p*
Age (years)	9.48 ± 1.10	9.57 ± 0.99	0.51
Height (cm)	135.39 ± 10.93	138.61 ± 8.48	0.01
Body mass (kg)	35.12 ± 11.63	34.05 ± 6.35	0.43
BMI (kg/m^2)	19.37 ± 15.31	17.67 ± 2.61	0.03
Gender			
Boys	453	24 (5%)	<0.01
Girls	532	50 (8.6%)	

A comparison of the characteristics between students with normal posture and SS was also analyzed separately according to gender. In general, students with SS tended to be taller and slimmer. However, a significant difference was only found in girls. Girls with SS had a greater height (p=0.01) and lower BMI (p=0.03) than ones with normal posture (Table 2).

Table 2 Characteristic differences between participants according to gender

	Boys		Girls	
	SS	Normal posture	SS	Normal posture
Frequency	24 (5%)	453 (95%)	50 (8.6%)	532 (91.4%)
Age (years)	9.54	9.58	9.58	9.39
Height (cm)	138.6	136.3	138.6*	134.6
Body mass (kg)	36.8	37.2	32.73	33.15
BMI (kg/m^2)	19.17	20.28	16.95*	18.50

Note: * Height, p = 0.01; * BMI, p = 0.03

The distribution of SS according to the age group was analyzed. The age group of 10-year-olds had the highest number of SS [N=27 (10.1%)], consisting of 9 male students (7.2%) and 18 female students (12.7%). The smallest number of cases of scoliosis was in the 8-year age group with 13 students (5.2%), consisting of 4 boys (4%) and 9 girls (5.9%). The number of SS increased from 8-10 years in both genders. The overall ratio of scoliosis between girls and boys was 2.08:1 (Table 3).

Table 3 Distribution of scoliosis and males-females ratio according to age

	8 years (N=252)		9 years (N=283)		10 years (N=267)		11 years (N=257)	
	SS	Normal	SS	Normal	SS	Normal	SS	Normal
Boys	4 (4%)	96 (96%)	7 (5.2%)	128 (94.8%)	9 (7.2%)	116 (92.8%)	4 (3.4%)	113 (96.6%)
Girls	9 (5.9%)	143 (94.1%)	13 (8.8%)	135 (91.2%)	18 (12.7%)	124 (87.3%)	10 (7.1%)	130 (92.9%)
Total	13 (5.2%)	239 (94.8%)	20 (7.1%)	263 (92.9%)	27 (10.1%)	240 (89.9%)	14 (5.5%)	243 (94.5%)
Girls-boys ratio	2.25:1		1.86:1		2:1		2.5:1	

Note: The overall girls-boys ratio of scoliosis is 2.08:1

DISCUSSION

Scoliosis in children and adolescents has been widely studied using various devices. This might be one of the few studies using an application scoliometer from an android device to measure abnormality of the spine. The results showed that the estimated frequency of scoliosis in elementary school students in Jakarta was about 7% in which the females were at a higher risk than the male students (OR 1.77). As described in some studies, students with suspected scoliosis had greater height and lighter body mass.

Compared to some previous studies, the prevalence of scoliosis in this study was quite large. The study carried out by Konieczny et al. (2013) using data from several studies in various countries reported that the prevalence of scoliosis in adolescents was 0.47-5.2%. The highest prevalence of scoliosis was found in Germany (5.2%), while the lowest was in Turkey (0.47%) (Kamtsiuris, Atzpodien, Ellert, Schlack, & Schlaud, 2007; Cilli et al., 2009). Beside the methods and diagnostic criteria used, ethnicity and race have a large influence on the difference in scoliosis prevalence. Even among Asian ethnic groups (Chinese, Malay, and Indian), the prevalence of scoliosis is different between ethnic groups (Daruwalla, Balasubramaniam, Chay, Rajan, & Lee, 1985).

Age and age range affect the prevalence of scoliosis. Research on scoliosis in children and adolescents was carried out on different ages and age ranges. Age range in scoliosis studies varies from the youngest at 6 years to the oldest at 17 years (Cilli et al., 2009; Rodríguez-Oviedo et al., 2012; Chowanska, Kotwicki, Rosadzinski, & Sliwinski, 2012). The results of most studies indicated a higher prevalence of adolescent scoliosis in an older age, especially at the age after puberty. Research by Kamtsiuris et al. (2007) found that the prevalence at 11-13 years of age was 6.5% and at the age of 14-17 years, it amounted to 11.1%. A study by Wong, Hui, Rajan, & Chia (2005) reported that the prevalence of scoliosis at the age of 6-10 was 1.37%, which increased to 2.22% at the age of 11-14. In our study, the prevalence of scoliosis also showed an increase with age. The prevalence increased from 6.17% at the age of 8-9 to 7.82% at the age of 10-11. Increased prevalence in older children may be related to the process of time when scoliosis occurs, from normal bone alignment to scoliosis. Accordingly, the prevalence of scoliosis tends to be higher in older age.

Females suffer more from scoliosis than males. Previous studies showed largely that women with scoliosis were more numerous than men at a ratio of 1.5:1 to 3:1, and the ratio increased with age (Konieczny et al., 2013; Cilli et al., 2009; Rodríguez-Oviedo et al., 2012; Wong et al., 2005). Our study showed that the frequency of scoliosis in girls was higher than in boys. The girls-boys ratio on scoliosis increased from 1.86:1 at the age of 9 to 2.5:1 at the age of 11 in the recent study. The possible explanation of the higher prevalence of scoliosis in girls is associated with vertebral bone morphology. Spine slenderness and ectomorphic body shape (thin) in girls are considered risk factors for idiopathic scoliosis (Burwell, 2003).

Scoliosis can be suspected by visual observation when abnormalities such as spinal irregularities, shoulder or pelvic height asymmetry, and back surface asymmetry are present (Kim et al., 2010; Coelho et al., 2013). The scoliometer can be used to measure axial rotation of the spine which is usually present in scoliosis. The measurement must be done carefully, especially in determining a site on the back to place the scoliometer. However, the study by Suh, Modi, Yang, & Hong (2011) reported that the rotation angle of 5° by the scoliometer only had a positive predictive value for Cobb's angle of >10° at

46.4%. Thus, visual observation and a scoliometer are usually used only for screening purposes in the school children population.

Children and adolescents with scoliosis appear thinner and taller than normal. A study by Ylikoski (2003) showed that adolescents with scoliosis are taller than normal adolescents in the same age group. Using software to measure vertebrae length, correction of height in scoliosis was made. The results confirmed that differences in height between normal and scoliosis were much greater. In our study, there was a tendency for scoliosis students to be taller even though the difference is significant only in girls. Greater height of scoliosis might exist due to an early pubertal growth spurt. Scoliotic children and adolescents experience early pubertal growth and therefore, they will be taller than normal at the same age (Burwell et al., 2008a). However, the final height of scoliotic children and adolescents would not be different from normal as a result of early maturation.

In addition to greater height, girls with scoliosis also usually have lighter body mass than normal. Studies by Brazolino et al. (2015) and Tam et al. (2016) showed that adolescents with scoliosis had a lower body mass than normal. A 5-year cohort study by Clark et al. (2014) has proven the effect of scoliosis on body mass. The results indicated that body composition of children and adolescents with scoliosis changed due to changes in fat and muscle mass (Clark et al., 2014). As in the case of body height, our study also reported that scoliotic students had lower BMI than normal, but it was significant only in girls. Slenderness in scoliosis might be related to some mechanisms, pathophysiology of scoliosis involving leptin (Burwell et al., 2016; Liu et al., 2012), increased activity of the sympathetic nervous system (Burwell et al., 2009; Burwell et al., 2008a), and eating disorders (Smith, Latchford, Hall, Millner, & Dickson, 2002).

Posture asymmetry in children and adolescents can be caused by various factors. Scoliosis is the most common cause of postural asymmetry in children and adolescents. In general, scoliosis is caused by multifactorial factors which can be classified into internal factors and external factors. Carrying a schoolbag weighing 10% of one's body mass or more could generate back muscle disturbances leading to scoliosis (Nery, Halpern, Nery, Nehme, & Tetelbom-Stein, 2015). A study by Rodríguez-Oviedo et al. (2012) reported that 26% of students who carry backpacks weighing more than 10% of their body mass experienced lower back pain of which the most likely cause was scoliosis. Carrying a schoolbag is considered to affect posture and gait, causing changes in the head-neck angle, shoulder asymmetry, and lumbar lordosis that can increase the angle of scoliosis (Rodríguez-Oviedo et al., 2012). Other causes of asymmetry associated with scoliosis are sports activities (Jandrić, 2015; Gielen & Van den Eede, 2008).

This research has several limitations. First, the confirmation of scoliosis using an x-ray examination to obtain Cobb's angle was not performed. Second, there were no data on musculoskeletal complaints (pain, aches, spasm/stiffness) in the muscles (neck, back, shoulders, etc.) to assess the presence of scoliosis disorders.

CONCLUSION

Prevalence of scoliosis in elementary school children aged 8-1 was about 7%, with the highest frequency in students aged 10. Girls had a higher frequency of scoliosis than boys. The scoliosis affected students that were taller and slimmer.

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PREVALENCIJA SKOLIOZE MEĐU UČENICIMA OSNOVNIH ŠKOLA STAROSTI 8-11 GODINA

Adolescentna idiopatska skolioza (AIS) je abnormalnost kičmenog stuba koja se obično javlja kod dece i adolescenata sa stopom prevalencije od 0.5-5.2%. Podaci o skoliozi u Indoneziji tek treba da budu dostupni. Aktuelno istraživanje je imalo za cilj da pregledaju i uporede deca školskog uzrasta sa normalnom posturom i sa sumnjom na skoliozu (SS). U ovoj studiji učestvovalo je 1059 učenika osnovnih škola (477 dečaka, 582 devojčica) od 3-ćeg do 6-tog razreda iz Džakarte. Masa i visina tela utvrđivane su standardnom tehnikom. Aksijalna rotacija kičme merena je skoliometrom. Rezultati su klasifikovani u dve grupe: normalni, ukoliko je aksijalni ugao rotacije <5°, i sumnja na skoliozu ukoliko je navedeni ugao ≥5°. Nezavisni t-test je korišćen za analizu antropometrijskih razlika između grupa sa normalnom posturom i sa SS. Statistička značajnost je postavljena na nivo p<0,05. Ukupno 74 (7%) od 1059 učenika bilo je sa SS, i to 24 (5%) dečaka i 50 (8,6%) devojčica (OR 1.98, P=0.004). Učenici u dobi od 10 godina imali su najveću učestalost skolioze (27 ili 10.1%). Devojčice sa SS je bilo značajno više, i ujedno sa nižim vrednostima BMI (138.6 cm vs 134.6 cm, p=0.014; 16.95 kg / m^2 vs 18.50 kg / m^2, p=0.028). Stopa skolioze kod učenika osnovnih škola u Džakarti bila je oko 7% sa većom prevalencijom kod devojčica.

Ključne reči*: prevalenca, skolioza, skrining, školska deca*