

Original Articles: Quantitative Research

ASSOCIATION BETWEEN FUNCTIONAL AEROBIC CAPACITY AND SCOLIOMETER-MEASUREMENT SPINAL DEVIATION IN ELEMENTARY SCHOOL STUDENT: AN IMPLICATION FOR EARLY PHYSIOTHERAUPETIC INTERVENTSION

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Abstract

Background: Early detection of spinal deformities of school-aged students is an important component of early musculoskeletal assessment and physiotherapeutic prevention in school-aged children. A scoliometer measurement 5-7° considered as a positive screening indicator for developing scoliosis and may potentially affect physical function, including functional aerobic capacity.

Objective: The aim of this study is to examine the association between functional aerobic capacity and scoliometer-measured spinal deviation among elementary school students.

Methods: Using cross-section design, the study was conducted among 47 fifth-grade students selected through systematic random sampling. Spinal rotation was assessed by spinal rotation angle deviation using scoliometer. Functional aerobic capacity was measured using the Incremental Shuttle Walk Test (ISWT). ISWT performance was categorized based on predicted values. Data were analyzed using Spearman's correlation with a significance level of $p < 0.05$.

Results: Eighty-seven percent of students showed a 5° spinal rotation (positive scoliosis screening). Most deviations were located in the lumbar region (73%). The majority of students demonstrated below-average to above average aerobic capacity. Female students had higher mean ISWT distances than males. Spearman analysis revealed a very weak positive correlation ($r=0,180$) that was not statistically significant ($p=0.227$).

Conclusion: There is no significant association between spinal deviation angle and functional aerobic capacity in this population. Early scoliosis screening remains essential to support early musculoskeletal assessment and physiotherapeutic prevention in school-aged children.

INTRODUCTION

Idiopathic Adolescent Scoliosis (AIS) is scoliosis without unknown etiology. It is most common type scoliosis. Study of Li et al. (2024) shows that 3,01% from the population experience AIS. There

might asymptomatic at the early adolescent, although found positive scoliosis angle deviation. Some would grow worse during puberty period, some were disappeared. The impact might only mild, pain in the back, but the others might very severe. Female adolescent has more risk than the males, overweight adolescents or undernutrition have more risks compared to normal weight, sedentary adolescent, over using gadget, carrying heavy bag have more risks compared to physically active person carrying light bag. Drinking milk during childhood is suggested and decreasing melatonin hormone lower the risk.

The impact AIS might only mild, pain in the back, but the others might very severe. Higher spinal deviation lead to posture disorder (Giodarmni et al., 2021), respiratory function disorders, limitation of skeletal muscles exercise capacity, and also limitation of exercise in general (Martinez-Llorens et al., 2010). People with Scoliosis angle less than 20° are advised to do exercise, angle between 20°-30° to be advised wearing brace, and angle more than 50° has to go on surgery (Li et al., 2024). Scoliosis with angle 80° or more would sign of breathlessness (U. S. Preventive Services task Force, 2018).

A positive scoliosis screening if the result of scoliometer measurement shows 5-7° rotation deviation and need radiography to scoliosis confirmation (AAOS, 2015). Functional aerobic capacity reflects the ability of the cardiovascular and respiratory systems to supply oxygen during physical activity. The Incremental Shuttle Walk Test (ISWT) is a validated field test used to assess aerobic capacity in children and adolescent (Lanza et al., 2015).

From a physiotherapy perspective, early identification of spinal deviation is essential to prevent progression and functional impairment. Physiotherapists play a critical role in posture correction, therapeutic exercise prescription, and functional capacity optimization. Understanding whether mild spinal deviation is associated with reduced aerobic capacity may guide early physiotherapeutic interventions in school-aged children.

The aim of the study is to find the correlation between functional aerobic capacity and the degree of scoliosis angle. Functional aerobic capacity is measured by Incremental Walk Shuttle Test (ISWT) and the degree of scoliosis is measured by scoliometer.

METHODS

Study Design

This study uses cross-section design.

Settings and Participants

The study was conducted in July 2025 at a private school in Sidoarjo, Indonesia. Participants were the fifth-grade elementary students, selected through systemic random sampling. A total of 47 students met the inclusion criteria.

Inclusion criteria were students aged between 10-15 years old, be able to read and write and be willing to be a respondent. Exclusive criteria were students with asthma or feeling dizzy or sick condition when the study was conducted.

Getting permission from the head of school and the school foundation, a meeting with the student parents was held to explain about the study and asking concession by filling the informed consent, due to the subject under age. Most of the parents were agree, except 3 because the students have asthma. Having the parent's agreement by the informed consent, the participants was selected. The subjects were chosen by systematically random by their attendance number, so that 47 subjects were recruited. This number is more than minimal cross-sectional subjects by Slovin equation, from total 103 students. By 103 population, error margin 0,05, then inserted into Slovin formula $n=103/(1+(103 \times 0,05)^2)$ the result is 28,81, or 29 rounded (Ryan, 2013).

Instruments and Data Collection

The data collected using some google forms by the team. The teams were given instruction and practicing using the google form, practicing ISWT and also using scoliometer application. There were four google forms. The first is demographic data questions to the subjects. Subjects were given number as subject numbers to integrate others measurement on another google form. The second google form was rotation deviation of vertebrae were measured by scoliometer, using application. The third google form was Functional aerobic capacity were measured by Incremental Shuttle Walk Test (ISWT). 5-7° of measuring rotation spinal deviation by scoliometer is considered as a positive screening (AAOS, 2015). The predicted ISWT distance was calculated based on the age, gender and body mass index (BMI) of each subject. Based on the predicted value, then percentage of predicted value on real functional aerobic capacity each participant can be calculated by dividing the ISWT distance by the its predicted value. Last step was categorization of the percentage of predicted value based on cardiorespiratory fitness predicted standard. The categories are Low $\leq 25\%$, Below Average (25%-49%), Above Average (50-74), High (75-97%), Elite ($>97\%$) (Kaminsky et al., 2015).

Data Analysis

Data processing was started by editing process. Data from google forms were integrated based on subject numbers, so that the whole data subjects were gathered. Added by ISWT classification. Then continued by gender, height, weight, BMI, ISWT classification and degree and Regio rotation deviation vertebra coding.

Normality with Kolmogorov-Smirnov showed data distribution were abnormal. Data then analysed by SPSS version 24 to get frequency, mean and correlation by Spearman coefficient.

Ethical Consideration

This study was got bu ethical clearance from STIKES Katolik St. Vincentius a Paulo Surabaya. The certificate number is 39/Stikes Vinc/KEPK/III/2025.

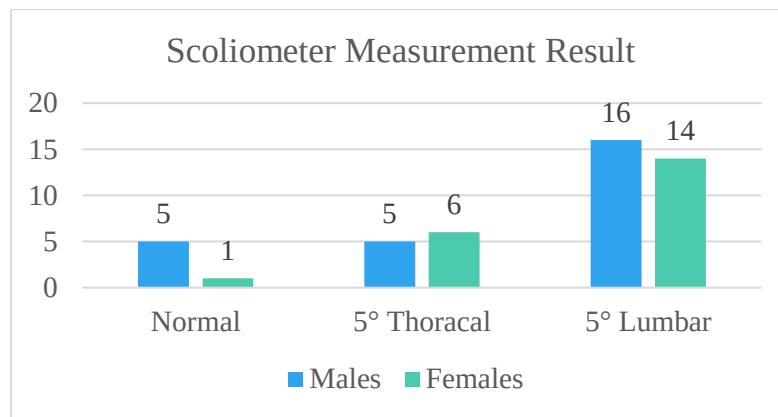
RESULTS**General Data****Table 1.** Subject Demography.

	Category	Male	Female	Total	Precentage
Gender	Male			27	55%
	Female			22	45%
Age	10 y.o	18	19	37	76%
	11 y.o	9	3	12	24%
Height	120-130 cm		3	3	6%
	131-140 cm	8	7	15	32%
	141-150 cm	13	6	19	40%
	151-160 cm	5	5	10	21%
Weight	21-30	10	10	20	43%
	31-40	5	5	10	21%
	41-50	8	4	12	26%
	51-60	3	2	5	11%
BMI					
Underweight	<18.5	14	15	29	62%
Normal	18.5 - 22.9	9	4	13	28%
Overweight	≥ 23				
At risk	23 - 24.9	1	1	2	4%
Obese I	25 - 29.9	2	1	3	6%
Obese II	≥ 30	0	0	0	0%

Subjects were 10 years old (76%) and 11 years old (24%), 55% male and 45% female. Totally minimum height was 126 cm and maximum 157 cm and mean 143.5745 (deviation standard 8.01288). Females height distributed evenly, while 50% of male's height was between 141-150 cm. In the average the male students taller than the female ones. Minimum weight 21 kg and maximum 60 kg, and mean 36.7234 kg (deviation standard 11.00929). 62% students were underweight, 28% normal (more males than females), 10% overweight.

Specific Data

The result of scoliometer measurement (Figure 1.) was 13% (83.3% males and 16.7% females) subjects normal, there were no rotation deviation vertebra. The degree of all deviation was 5° experienced by 87% subjects. 73% deviation was in lumbar Regio (53.3% males and 46.7% females), and 27% (45.4% males and 54.6% females) were in thoracal regio. Adam examination showed that more that more than 50% of the subjects symmetric on hip, shoulder, spinal and head, less than 50% of the subject had symmetric on scapula.

**Figure 1.** Scoliometer Measurement Result.**Table 2.** ISWT Result.

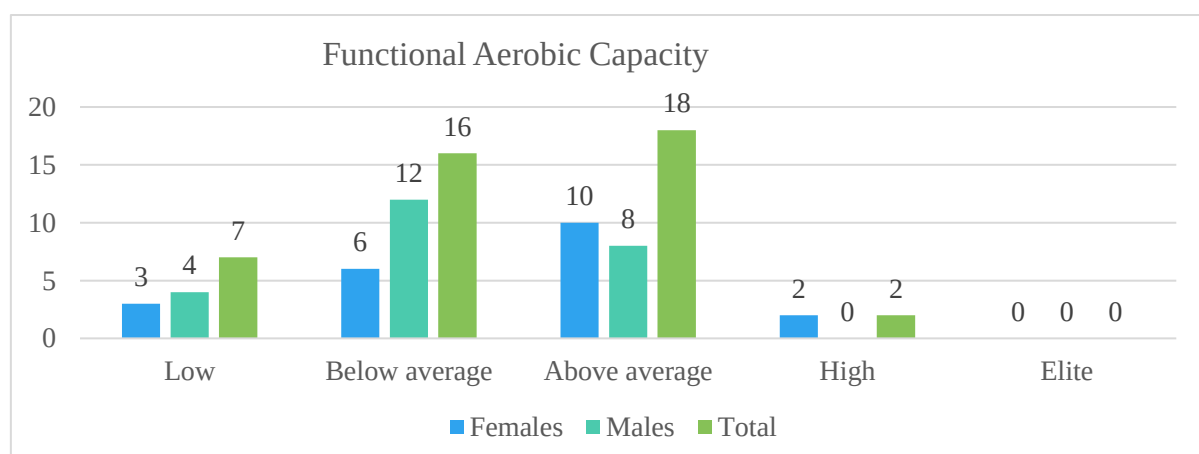
	N	Minimum	Maximum	Mean	Std Deviation
Males	24	170	590	431.67	119.92
Females	21	200	590	463.33	120.93

The table shows that ISWT result on females was higher than males. As ISWT is the VO₂max field test, the result then categorized into fitness level based on percentage of predicted value. First calculating the predicted distance each subject by plugging into equation:

$$\text{ISWT pred} = 845.559 + (\text{sex} \times 193.265) + (\text{usia} \times 47.850) - (\text{body mass index} \times 25.129)$$

(Sex: 0 for female, 1 for male)

The levels are Low (< 25% predicted value), Below Average (25-49%), Above Average (50-74%), High (75-97%) and Elite (>97%) as the functional Aerobic Capacity classicization.

**Figure 2.** Functional Aerobic Capacity.

The Figure 2 shows that the functional aerobic capacity most of the subjects were between below average and above average, some low and only 2 female subjects were high. No subject was in the elite

level. Males were more dominant in the low and below average level; female were more dominant on above average and high level. The percentage distribution of the Functional Aerobic Capacity table states clearer that the no males had high category and more female in the above average category.

Table 3. Frequency Distribution of Functional Aerobic Capacity.

	Female		Males		Total	
	f	%	f	%	f	%
<i>Low</i>	3	14.29	4	17.39	7	16.00
<i>Below average</i>	6	28.57	12	52.17	18	40.00
<i>Above average</i>	10	47.62	8	34.78	18	40.00
<i>High</i>	2	9.52	0	0.00	2	4.00
<i>Elite</i>	0	0.00	0	0.00	0	0.00

Last analysis is the correlation between rotation angle of vertebra and functional aerobic capacity by Spearman analysis. The result was correlation coefficient 0.180. It shows a very weak positive. Significant value ($p=0.227$) was more than 0.05. This says that statistically there is no significant correlation between deviation angle degree and functional capacity.

DISCUSSION

8787% of the subject's experience rotation deviation of vertebra, which is lead to scoliosis. According to AAOS (2015) angle of 5-7° using scoliometer is a positive deviation threshold of scoliosis screening. Indeed 95% of female subjects having scoliosis, and only 80% of the male subjects having spinal deviation. Notes by El-Hawary & Chukwunyerenna (2014) said that in age 3-10 more female having scoliosis than males support this fact. 73% of this had on lumbar Regio, 27% in thoracal. This two Regio are the most effected Regio for scoliosis. Especially for children age between 3-10 years old who are in the developing phase of lung and thoracic cage (El-Hawary & Chukwunyerenna, 2014). This means in this periode there is a big possibility developing scoliosis. Some can be self-recovery, some not. The results of Adam's examination show that more than 50% subjects symmetric on hip, shoulder, spinal and head. This shows that not all spinal rotation deviation followed by scoliosis but may develop becoming scoliosis. This high accidence of scoliosis show that the study actually does the scoliosis screening as an early detection for preventive action.

The females ISWT result (463.33) mean was higher than males (431.67). This is contrary to study of study Lanza et al. (2015) that showed males walk longer than females. Both studies had subjects about the same age, but different mean body mass index (BMI). The Subjects of Lanza's study had about 20 (normal), on the other hand most of the subjects of this study (62%) were underweight. There were more males obese (8%) than the females (5%). The males in this study found talk more

than the females during the test, although has been warned. Rate of Perceived Exertion (RPE) females were higher than males. This score shows that females have higher motivation than the males. This show that the female effort to complete the test were bigger than the males.

The analysis of Spearman shows that there is no correlation between functional Aerobic Capacity and the rotation angle scoliosis degree. This means that subject with deviation of rotation is not always has functional aerobic capacity limitation and vice versa. This result is not the same with study by Saraiva et al. (2018) who studied healthy female adolescents had scoliosis. According to the study subject with scoliosis with angle more than 45° had more limitation of functional aerobic capacity than the one with angle less than 45° and the control group. The degree of the angle could make the difference of the study. Subject with 5° deviation does not give impact on functional aerobic capacity due to no change of thoracic cage, the child flexibility of the joint gives enough space to expand the thorax as well. This normal thoracic volume does not give any decreasing ISWT result yet.

The subject of Saraiva et al (2018) was between 10-18 age girls who may had developed scoliosis from 5° to more 45° and may lead to decreased thoracic volume. The facts that the subject were females lead to higher risk of scoliosis. Compared to the subject of this study were 10-11 years old adolescent with 5° rotation deviation, the thoracic volume of these subjects was normal, thus there was not decreasing functional aerobic capacity. These subjects also grow during COVID pandemic or digital era, which leads them into sedentary lifestyle and have more screen time. This lifestyle may lead to bad posture, including spinal rotation deviation. Despite 87% have 5° rotation deviation, but Adam's examination showed that less than 50% had asymmetric posture. Having rotation deviation is not always followed by scoliosis. This may explain, the correlation between spinal deviation and ISWT result has weak correlation, for not all of subject has spinal rotation also had scoliosis. On the other side this give a window for physiotherapy to prevent further scoliosis.

The weak correlation might be due the homogeneity of scoliometer measurement result. The homogeneity 5° rotation spinal deviation can make a misleading conclusion in finding its correlation with result of ISWT.

IMPLICATION AND LIMITATION

Despite various measurements and assessments were used in the study, there are some limitations of the study. The study was conducted in a specific private school with very specific characteristic; thus, the result should not be generalized to other adolescents. The other limitation is the homogeneity of the spinal rotation deviation angle are 5° and the subject age. These homogeneities can be misleading conclusion. There might be some variables have correlation that should be done to enrich the result of the study.

CONCLUSION

The result of this study shows that there was no correlation between spinal rotation deviation and functional aerobic capacity. Other data of this study show high percentage of the subject had rotation spinal deviation which might develop become scoliosis. There should be more study done to enrich the study for the digital property push adolescents into abnormal posture.

AUTHOR CONTRIBUTION

Martha Sri Astuti : Coordinator, build up state of the art.

Irine Yunila Prastyawati : Coordinator of collecting data.

Sr. Ignata Yuliati SSpS : Analyzing data.

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Martha Sri Astuti : None.

Irine Yunila Prastyawati : None.

Sr. Ignata Yuliati SSpS : None.

CONFLICT OF INTEREST

There is no conflict of interest in this research.

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