

ORIGINAL

## Prevalence of Scoliosis in Adolescents Aged 12 to 16: Influence of Physical Activity Level and Type of Educational Institution

## Prevalencia de escoliosis en adolescentes de 12 a 16 años: influencia del nivel de actividad física y tipo de institución educativa

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### ABSTRACT

**Introduction:** scoliosis is a structural deformity of the spine whose prevalence may be influenced by socioeconomic factors and physical activity levels. Previous evidence suggests that physical inactivity could be a risk factor in adolescents.

**Objective:** to analyze and quantify the prevalence of scoliosis in students aged 12-16 years from public and private schools in Santiago, Chile, and to explore its association with physical activity levels.

**Method:** a cross-sectional observational study was conducted with 81 adolescents (48,1 % male; 51,9 % female). The mean age was  $15,28 \pm 0,85$  years, with an average height of  $163,8 \pm 6,9$  cm and mean weight of  $66,0 \pm 12,2$  kg. Inclusion and exclusion criteria were applied, and four evaluation tools were used: Adams Forward Bend Test, scoliometer, Spine Screen mobile application, and the International Physical Activity Questionnaire (IPAQ).

**Results:** a positive Adams Test was found in 43,2 % of participants, while 14,8 % showed out-of-range alterations in Spine Screen. According to IPAQ, 25,9 % reported low physical activity, 51,9 % moderate, and 22,2 % high. A significant association was found between lower physical activity and scoliosis presence ( $p = 0,025$  in Adams Test;  $p = 0,020$  in Spine Screen). Furthermore, scoliosis prevalence was higher in public school students (54,3 %) compared to private school students (34,8 %) ( $p = 0,043$ ).

**Conclusions:** these findings suggest that lower levels of physical activity are associated with a higher prevalence of scoliosis in adolescents, particularly in public school settings. The results highlight the need for preventive strategies to promote structured physical activity in school environments with limited access.

**Keywords:** Scoliosis; Physical Activity; Adolescents; Socioeconomic Factors.

### RESUMEN

**Introducción:** la escoliosis es una deformidad estructural de la columna vertebral cuya prevalencia puede estar influenciada por factores socioeconómicos y niveles de actividad física. Evidencia previa sugiere que la inactividad física puede constituir un factor de riesgo en adolescentes.

**Objetivo:** analizar y cuantificar la prevalencia de escoliosis en estudiantes de 12 a 16 años de colegios públicos y privados de Santiago de Chile, y explorar su asociación con el nivel de actividad física.

**Método:** se realizó un estudio observacional de tipo transversal en 81 adolescentes (48,1 % hombres; 51,9 % mujeres). La edad promedio fue  $15,28 \pm 0,85$  años, con talla media de  $163,8 \pm 6,9$  cm y peso medio de  $66,0 \pm 12,2$  kg. Se aplicaron criterios de inclusión y exclusión, y se utilizaron cuatro herramientas de evaluación:

Test de Adams, escoliómetro, aplicación Spine Screen y cuestionario internacional IPAQ para actividad física. **Resultados:** el 43,2 % de los participantes presentó resultado positivo en el Test de Adams y un 14,8 % registró alteraciones fuera de rango en Spine Screen. Según IPAQ, 25,9 % reportó bajo nivel de actividad física, 51,9 % nivel moderado y 22,2 % nivel alto. Se encontró asociación significativa entre menor nivel de actividad física y presencia de escoliosis ( $p = 0,025$  en Test de Adams;  $p = 0,020$  en Spine Screen). Además, la prevalencia de escoliosis fue mayor en colegios públicos (54,3 %) que en privados (34,8 %) ( $p = 0,043$ ).

**Conclusiones:** los hallazgos sugieren que niveles bajos de actividad física se relacionan con mayor prevalencia de escoliosis en adolescentes, siendo más evidente en establecimientos públicos. Estos resultados refuerzan la necesidad de implementar estrategias preventivas que promuevan actividad física estructurada en contextos escolares con menor acceso a ella.

**Palabras clave:** Escoliosis; Actividad Física; Adolescentes; Factores Socioeconómicos.

## INTRODUCTION

Scoliosis is a three-dimensional deformity of the spine and trunk that causes a deviation from the standard vertical line of the spine.<sup>(1)</sup> Adolescent idiopathic scoliosis (AIS) is the most common spinal deformity in adolescents, with an established prevalence ranging from 2 to 3 %.<sup>(2)</sup> This condition usually begins in adolescence. It is generally asymptomatic; however, as it progresses, this curvature leads to an increase in health problems in those who suffer from it.<sup>(3)</sup>

Disability, deformity, pain, quality of life issues, respiratory problems, and the possibility of scoliosis persisting into adulthood are commonly associated with this condition.<sup>(4)</sup>

According to a review conducted in the US, there is evidence that scoliosis can be identified using the most commonly used screening test for scoliosis, which is a tool called a scoliometer that measures the degree of curvature of the spine. It should be noted that the result is not predictive of scoliosis; instead, it must always be supplemented with an imaging study.<sup>(5)</sup>

Physical exercise is beneficial in improving people's quality of life and, therefore, many of the pathologies they suffer from;<sup>(6)</sup> however, according to a study conducted by Shenzhen University in China, exercise therapy has potential benefits for treating both the physiological and psychological aspects of scoliosis patients, but higher-quality research is still needed to confirm these findings.<sup>(7)</sup> On the other hand, a study conducted in Croatia indicated that most cases of scoliosis found corresponded to children and adolescents who were less physically active than those in whom the condition was not found. Participation in sports should generally be encouraged in children. An initial assessment before participation in sports and subsequent ongoing observation of spinal deformities could help us provide more accurate, up-to-date information on the benefits of physical exercise in adolescent idiopathic scoliosis as a basis for future intervention studies.<sup>(8)</sup>

A 2022 systematic review found that specific exercises for scoliosis (Schroth exercises) have shown promising results in reducing the progression of idiopathic scoliosis.<sup>(9)</sup> Studies have shown that supplementing Schroth exercises with therapies such as yoga, specific exercises for idiopathic scoliosis (PSSE), and strength training can be helpful in the treatment and prevention of scoliosis.<sup>(10)</sup> The amount of physical activity performed can impact the development or improvement of the condition, so it is necessary to quantify the physical activity performed. For this purpose, the IPAQ international questionnaire is widely validated for global use. Similarly, a 2022 systematic review found that it was the most commonly used instrument for assessing physical activity.<sup>(11)</sup>

This research aims to measure the prevalence of scoliosis in a public school and compare it with a private school, where we expect a higher prevalence in the public school due to lower exposure to physical activity.

## METHOD

### Design

This research design is a cross-sectional observational study using convenience sampling, allowing us to analyze the prevalence of scoliosis in the study population at a single point in time.

### Location

The study will be conducted with adolescent students from two schools: one public school, "Colegio Polivalente Saint Trinity College," in the municipality of Lo Espejo, and one private school, "Colegio Santa Margarita," in the city of San Miguel, both located within the Metropolitan Region.

### Sampling

Two educational establishments in Santiago, Chile, were selected: a public school (Saint Trinity College, Lo

Espejo) and a private school (Colegio Santa Margarita, San Miguel). The final sample consisted of 81 adolescent volunteers, of whom 43,2 % were from public schools and 56,8 % from private schools. The schools were chosen based on accessibility and institutional willingness, which justifies convenience sampling. Adolescents aged 12-16 with no known underlying conditions were included. Participants who were pregnant or suspected of being pregnant were excluded. All volunteers and their guardians signed an informed consent form authorizing the evaluation.

### Assessment tools

Participants were evaluated using four instruments, all with validity and reliability reported in the literature:

**Adams Forward Bend Test:** an orthopedic test widely used for the initial clinical detection of scoliosis. It allows observation of thoracic or lumbar asymmetries during trunk flexion. Its sensitivity has been estimated at 84-92 % and specificity at 60-90 %, depending on the cutoff point used.

**Scoliometer:** an instrument for measuring the angle of vertebral rotation in degrees, applied during the Adams test. Considered a reliable screening method, it shows a high correlation with X-rays ( $r > 0,80$ ) and acceptable internal consistency (The American Academy of Orthopaedic Surgeons, 2017).

**Spine Screen App:** a mobile application that scans postural alignment through sensors and photographic recording. Recent studies report adequate inter-rater reliability ( $ICC > 0,80$ ) and good concurrent validity compared to traditional measurement methods.

**International Physical Activity Questionnaire (IPAQ):** an internationally validated instrument for measuring physical activity levels in different populations and contexts. It has acceptable test-retest reliability ( $ICC = 0,75$ ) and concurrent validity compared to accelerometry.

### Variables and data analysis

The main variables analyzed were: Sociodemographic and anthropometric: age, sex, weight, and height. Postural: presence of scoliosis using the Adams Test, scoliometer, and Spine Screen application. Physical activity: low, moderate, or high level, measured with the IPAQ questionnaire. Type of establishment: public or private. Descriptive statistics (means, standard deviation, frequencies, and percentages) and chi-square tests of association between categorical variables were used for data analysis. Statistical significance was set at  $p < 0,05$ .

### Ethical aspects

This research was evaluated and approved by the ethics committee of the University of Las Américas under registration number CEC\_FP\_2025001. Each minor participant and their respective parents signed an informed consent form.

## RESULTS

Two evaluations were conducted at two educational establishments in Santiago, Chile: Saint Trinity College, a public school, and Liceo Santa Margarita, a private school. A total of 81 participants were evaluated. Among the general characteristics of the sample, it is evident that the average age is 15,28 with a standard deviation of (0,85); the youngest subject being 13 years old and the oldest adolescent being 16 years old, with an average weight of 66,04 kg, a minimum weight of 46 kg, and the heaviest adolescent weighing 93 kg, with a standard deviation of (12,1 6). The average height was 163,79 cm, with a minimum height of 144 cm, and the tallest adolescent measured 184 cm, with a standard deviation of 6,90.

Of the 81 participants evaluated, 39 were male (48,1 %), and 42 were female (51,9 %). Thirty-five participants attended public schools (43,2 %), and 46 attended private schools (56,8 %). In terms of academic levels, three of the participants were in seventh grade, corresponding to 3,7 %, four of the participants were in eighth grade, corresponding to 4,9 %, 24 participants were in 10th grade, corresponding to 29,6 %, 33 participants were in 11th grade, corresponding to 40,7 %, and 17 participants were in 12th grade, corresponding to 21 % (table 1).

The assessments were carried out using four variables (Adams test, Scoliometer, Spine Screen, IPAQ questionnaire). Of the 81 participants in the study who were assessed using the Adams test, 35 tested positive (43,2 %) and 46 tested negative (56,8 %). Among the 81 participants evaluated with the scoliometer, 73 participants registered a “normal” value (90,1 %), six registered “low risk” (7,4 %), and two registered “high risk” (2,5 %). Among the 81 participants evaluated with the Spine Screen application, 69 participants registered an “Acceptable” value, corresponding to 85,2 %, and 12 participants registered as “Out of range,” corresponding to 14,8 %. Among the 81 participants evaluated with the IPAQ questionnaire, 21 participants had a “Low level of physical activity,” corresponding to 25,9 %, and 42 participants had a “Moderate level of physical activity,” corresponding to 51,9 %. Eighteen participants had a “Moderate level of physical activity,” and 22,2 % had a “High level of physical activity” (table 2).

**Table 1.** Demographic and anthropometric characteristics of the sample subjects (n = 81)

Variables	Mean $\pm$ SD / n (%)	Range (min-max)
Demographic		
Age (years)	15,28 $\pm$ 0,85	13-16
Gender	Male: 39 (48,1 %) Female: 42 (51,9 %)	—
Type of establishment	Public: 35 (43,2 %) Private: 46 (56,8 %)	—
Academic level	Seventh: 3 (3,7 %) Eighth grade: 4 (4,9 %) 1st year of secondary school: 24 (29,6 %) 10th grade: 33 (40,7 %) 11th grade: 17 (21,0 %)	—
Anthropometric		
Weight (kg)	66,04 $\pm$ 12,16	46-93
Height (cm)	163,79 $\pm$ 6,90	144-184

**Note:** SD: standard deviation**Table 2.** Distribution of the results of the postural assessment tests and physical activity level

Variables	Percentage
Adams Test	Positive - 43,2 % Negative - 56,8 %
Scoliometer	Normal 90,1 % Low risk - 7,4 % High risk - 14,8 %
Spine Screen	Acceptable - 85,2 % Out of range - 14,8 %
IPAQ (physical activity level)	Mild - 25,9 % Moderate - 51,9 % High - 22,2 %

A statistically significant relationship was observed between the level of physical activity and the results of the Adams Test ( $p = 0,025$ ) and the Spine Screen ( $p = 0,020$ ). At the same time, the association with the Scoliometer did not reach statistical significance ( $p = 0,079$ ). The Adams Test showed that 61,9 % of participants with low levels of physical activity had scoliosis, a percentage that decreased to 38,1 % in the moderate activity group and 33,3 % in the high activity group. In the Scoliometer, 95,2 % of subjects with moderate physical activity and 94,4 % with high physical activity were classified as “normal,” compared with 72,2 % in the low physical activity group. The Spine Screen showed that participants with moderate physical activity levels had a higher percentage of values within the acceptable range (92,9 %) compared to the low activity group (66,7 %), suggesting a positive relationship between physical activity and postural alignment.

Table 3 shows a higher prevalence of scoliosis in subjects with low levels of physical activity, with a statistically significant association ( $p = 0,025$ ).

**Table 3.** Association between Physical Activity Level and Presence of Scoliosis according to the Adams Test

Level of Physical Activity (IPAQ)	Adams Test (+)	Adams Test (-)	% Positive	P-Value
Mild	13	8	61,9 %	0,025
Moderate	16	26	38,1	
High	6	12	33,3	

Table 4 shows how subjects with lower physical activity levels have a higher proportion of postural alterations, with a significant association ( $p = 0,020$ ).

Level of physical activity (IPAQ)	Acceptable alignment	Out of range	% Out of range	p-value
Mild	14	7	33,3	0,020
Moderate	39	3	7,1	
High	16	2	11,1	

A higher prevalence of scoliosis was found in public school students compared to private school students, with a statistically significant difference ( $p = 0,043$ ).

Type of school	Adams test (+)	Adams test (-)	% Positive	p-value
Public	19	16	54,3	0,043
Private	16	30	34,8	

## DISCUSSION

The relationship between physical activity and adolescent idiopathic scoliosis (AIS) is multifactorial, involving biomechanical, muscular, behavioral, and socioeconomic factors. This study provides evidence that adolescents with lower levels of physical activity, especially in public settings, have a higher prevalence of scoliosis positive on the Adams test.

A key aspect in understanding this result is the function of the paravertebral muscles. In AIS, these muscles show atrophy and weakness, as well as fat infiltration in the concave curvature, compromising spinal stability and mobility.<sup>(12)</sup> Regular physical activity could act as a protective factor by strengthening the stabilizing muscles, improving posture, and promoting musculoskeletal balance. Conversely, low levels of physical activity could accentuate biomechanical imbalance and facilitate the progression of curvatures.<sup>(13,14,15)</sup>

The finding that public school students had a significantly higher prevalence of scoliosis (54,3 %) than private school students (34,8 %) reinforces the initial hypothesis and raises relevant implications. Beyond the simple difference in physical education hours, these gaps may reflect inequalities in access to extracurricular sports programs, safe spaces for recreation, or even education on healthy habits within the home. This is consistent with the findings of Erkkila *et al.*<sup>(16)</sup>, who reported that low socioeconomic status was associated with a higher risk of severe scoliosis due to differences in access to timely diagnosis and treatment.

Although previous studies, such as that by Kenanidis *et al.*<sup>(13)</sup>, found no significant differences between active and inactive adolescents, more recent research contradicts this view, showing that a sedentary lifestyle is a risk factor for AIS.<sup>(14)</sup> Recent meta-analyses even report that vigorous physical activity significantly reduces the likelihood of developing scoliosis.<sup>(15)</sup> Methodological differences, diagnostic criteria, or variability in the intensity and type of physical activity analyzed could explain the discrepancies between studies. In our case, the application of the IPAQ questionnaire allowed us to discriminate between activity levels, revealing a statistically significant relationship between sedentary lifestyles and a higher prevalence of scoliosis.

From a public health perspective, the results are concerning. In Chile, the number of weekly hours of physical education in the school curriculum is limited (2-3 hours), which is insufficient to counteract sedentary lifestyles and the high rates of diseases associated with inactivity, such as obesity and diabetes, which are responsible for more than 50 % of annual deaths in the country.<sup>(17)</sup> Added to this is the uneven implementation of the School Health Program, which includes scoliosis screening but whose scope depends on resources and geographic location, creating inequalities in early diagnosis and prevention opportunities.

Finally, international evidence shows that early initiation of physical activity reduces the risk of scoliosis in adolescence. Tobias *et al.*<sup>(18)</sup> demonstrated that low physical activity in childhood is associated with a higher likelihood of developing the condition later in life. This suggests that physical activity programs in adolescence are insufficient and that preventive strategies are required from an early age, integrating physical education, access to recreational spaces, and awareness campaigns aimed at families and school communities.

Taken together, the findings of this study reinforce the need to design public policies and school programs that promote regular physical activity, especially in vulnerable contexts, to reduce the prevalence of scoliosis and its long-term health consequences.



## CONCLUSION

This research suggests a possible association between physical activity level and the development of adolescent idiopathic scoliosis (AIS). The findings indicate a higher prevalence of positive Adams test results among students from public schools than among those from private schools, which may be associated with differences in physical activity levels and other socioeconomic factors.

These results highlight the importance of further characterizing the risk factors associated with AIS and emphasize the need for studies with more robust methodologies that include variables such as body mass index, adherence to sports programs, and adequate sample size. Future studies should consider longitudinal designs and the use of more objective assessment tools to clarify the impact of physical activity on the prevention and progression of AIS, thus contributing to the development of more effective preventive strategies in the school population.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHOR CONTRIBUTION

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