

Original Research Article

A study on screening for scoliosis among school children in the age group of 10-14 using a cost effective and an innovative technique

Sai Sri Akshara Talasila¹, Misha Gorantla^{2*}, Vimala Thomas¹

Department of Community Medicine, ¹Gandhi Medical College, Secunderabad, ²Mallareddy Institute of Medical Sciences, Hyderabad, Telangana, India

Received: 18 April 2017

Revised: 09 May 2017

Accepted: 11 May 2017

*Correspondence:

Dr. Misha Gorantla,

E-mail: misha.gorantla@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Scoliosis refers to a sideways curvature of the spine. Early detection of scoliosis prevents progress into severe scoliosis. In a resource constrained setting like India, there is a need for cost effective solutions for the purpose of screening. Objective of this study is to identify scoliosis among school children, determine risk factors associated with scoliosis and to compare the readings of the Scoliometer device to those obtained from Scoliometer smartphone app.

Methods: The present cross sectional study was conducted in students aged 10-14 years studying in private schools of Hyderabad. All willing students (n=1000) were screened for scoliosis during June-August 2015. They were screened using physical examination (Adams forward bend test), Scoliometer device and Scoliometer App.

Results: A total of 3.3% of the students had positive scoliosis findings when physically examined in standing position and 3.4% were positive for Adam's forward bend test. Around 0.7% of students had a reading $>7^\circ$ when screened using the Scoliometer device and 1% had a reading $>7^\circ$ when screened using the App i.e. similar results were obtained. The risk factors associated with scoliosis found by this study includes prematurity of foetus during delivery and carrying school bag on one shoulder which had statistically significant association with positive scoliotic findings with O.R of 3.6 and 4.3 at 95% CI respectively.

Conclusions: Scoliometer app can replace the expensive Scoliometer device for screening of scoliosis. This can be included in school health programmes.

Keywords: Scoliosis, Scoliometer app, Scoliometer device

INTRODUCTION

The term "scoliosis" derives from the Greek word "skolios" which means curved or crooked. As the word suggests scoliosis refers to a sideways curvature of the spine.¹ The worldwide prevalence of scoliosis, including all forms of the disease, is 1%.² In India, the prevalence among children, adolescents and adults is 0.04%.³

Not only does scoliosis affect the child's physical appearance, it may lead to cardiopulmonary complications, pain symptoms and a feeling of social isolation which has an effect on the child's self-esteem.⁴

Though there has been a tremendous advancement in the management of scoliosis, early detection remains the most successful method to control scoliosis. It is essential

that scoliosis be diagnosed between the ages of 10 and 15 years. If potentially progressive curves can be identified early, appropriate treatment can be instituted in the form of bracing and physiotherapy allowing the patient to avoid surgical treatment.⁵ This necessitates the creation of school screening programmes for scoliosis in India.

Screening programmes are legislated and are a mandatory part of health curriculum in schools of many countries like USA, UK, Japan etc.⁶ School screening for idiopathic scoliosis is usually done by visual inspection of the spine (asymmetry of the shoulders, scapulae, and hips). It also includes Adam's forward bend test which is presently the standard test for screening.⁷ A clinical Scoliometer can also be used to measure the angle of trunk rotation which is expensive in a resource constrained setting like India to use for routine screening.

According to international research firm Strategy Analytics, India will soon overtake the US to become the world's second largest smartphone market by 2017 behind only China, selling an impressive 174 million units per year.⁸

Since 2011, many Smartphone apps have been launched which replicates the function of a standard clinical Scoliometer. These include "Scoliogauge" app, "Scolioscreen", "Scoliometer HD" app etc. In view of the restricted availability of the Scoliometer device in India, the app assumes special importance as a more accurate and cost effective tool.

The "Scoliometer HD" app is available on the Google Play Store as well as the iPhone app store. Unlike the physical device the app increases the range of measurement from 30 to 60 degrees thereby making it possible to screen higher scoliosis curves. It is validated, easy to use, accurate and is available in 17 different languages.^{9,10}

This will empower the communities to play an active role in health care management and if incorporated in the school health programme it can be used for early detection of scoliosis

Objectives

- 1) To identify scoliosis among school children in the age group 10-14 years using Adam's Forward Bend Test, Clinical Scoliometer device and "Scoliometer HD" Smartphone app.
- 2) To determine the risk factors associated with the identified scoliosis (sex, personal habits, physical activities and socio demographic factors)
- 3) To compare the readings of the Scoliometer device with those of the Scoliometer smartphone app.

METHODS

This is a cross-sectional study done on a total of 1000 school students. Students aged 10-14 years studying in

private schools of Hyderabad were screened for scoliosis during June-August 2015. Convenient sampling was used and private schools in the regions closer to the Medical College were selected. Students were selected based on their willingness and consent from their parents. Clearance was obtained from the Ethical Committee at the institute to carry out the study in the proposed manner. Written informed consent was taken from the parent prior to the enrolment of each subject in the study. The screening was conducted in the school premises with permissions from the concerned management by a group of trained medical students who were trained about scoliosis and screening process (physical examination in standing position, Adam's forward bend test and use of Scoliometer device and App by an Orthopedician. Semi-structured questionnaires were sent to the parents of the students through which information about the probable risk factors of scoliosis with focus on birth related factors (type and term of delivery), personal habits (related to posture while sitting and way of carrying school bag), physical activities (frequency and duration), extracurricular activities (swimming, dancing and gymnastics) and socio demographic factors (age and sex) was obtained. Family history was taken note of as congenital scoliosis can be hereditary. Screening was conducted in a well-lit closed area within the school premises where students were provided with basic privacy. Boys and girls were screened separately. Same gender examiners were ensured during screening.

Step 1: Physical examination in standing position

Examiner was seated in order to conduct an accurate screening examination.

The student was made to stand erect, first facing the examiner, and then away from the examiner. Feet were kept together, knees straight, and arms hanging loosely at the sides. With the student in these positions (from the front and back) the examiner checked for: high shoulder, curved spine, uneven shoulder blades, uneven hips or waist creases, unequal distance from arm to side of body (both sides).

Step 2: Adam's forward bend test

The subject was made to bend forward dangling the arms, with the feet together and knees straight. The curve of structural scoliosis is more apparent when bending over. The examiner was made to observe the presence of an imbalanced rib cage, with one side being higher than the other, or other deformities. In this study this test has been taken as a standard for positive scoliotic findings.

Step 3: Measurement of angle of trunk rotation (ATR) with

a) Scoliometer device

An inclinometer, also known as a Scoliometer, measures distortions of the torso. The below given procedure was

followed: The patient was asked to bend over, arms dangling and palms pressed together. The Scoliometer was then placed on the apex of lower (lumbar) middle (thoracolumbar) and upper (thoracic) back to measure the angle of trunk rotation.

b) Scoliometer HD smartphone app

The subjects were simultaneously screened using the Scoliometer HD App and the readings were compared with those of the Scoliometer device. Subjects with positive signs (Adam's forward bend test positive) of scoliosis on physical examination were referred to a physician. Their parents were also informed about the findings. Also those with a scoliometer reading $>7^{\circ}$ ($\Rightarrow 20^{\circ}$ Cobb angle) were referred.

The data was entered in excel sheet and analysed for proportions. Risk factors associated with scoliosis were estimated using odds ratio and 95% confidence intervals. Chi square test was performed to assess statistical significance ($p < 0.05\%$).

Table 1: Association between way of carrying school bag (weight distribution) and positive scoliosis findings (Adam's forward bend test positive).

Weight distribution	Total (n)	Scoliosis positive	Scoliosis negative	Odds ratio (95% CI)
One shoulder	271 (100%)	21 (7.7%)	250 (92.3%)	4.37* (2.15-8.85)
Both shoulders	689 (100%)	13 (1.9%)	676 (98.1%)	
Total	960** (100%)	34 (3.5%)	926 (96.5%)	

* $p < 0.001$, **only 960 out of 1000 responses were received for the above question.

Table 2: Association between maturity of foetus at the time of delivery and positive scoliosis findings (Adam's forward bend test positive).

Term of delivery	Total (n)	Scoliosis positive	Scoliosis negative	Odds ratio (95% CI)
Pre term	47 (100%)	5 (10.6%)	42 (89.4%)	3.64* (1.34-9.89)
Full term	917 (100%)	29 (3.2%)	888 (96.8%)	
Total	964** (100%)	34 (3.5%)	930 (96.5%)	

* $p < 0.05$, **only 964 out of 1000 responses were received for the above question.

In Table 1, a total of 21 (7.7%) among 271 school children who carry their school bag on one shoulder and 13 (1.9%) among 689 who carried it on both shoulders had positive scoliosis findings. The remaining 250 (92.3%) and 676 (98.1%) children who carried the school bag on one and two shoulders respectively were negative for the same. The findings were found to be statistically highly significant ($p < 0.001$) with an odds ratio of 4.37 (95% CI – 2.15-8.85).

No association was found between birth related factors such as folic acid supplementation during pregnancy, mode of delivery and scoliosis ($p > 0.05$).

In Table 2, a total of 5 (10.6%) among 47 school children who were delivered pre-term and 29 (3.2%) among 917 who were delivered at full term of pregnancy had positive scoliosis findings. The remaining 42 (89.4%) and 888 (96.8%) children delivered pre-term and full term

RESULTS

A total of 1000 children constituted the study subjects who were aged between 10-14 years. A total of 133 (13.3%) school children were of the age 10 years. 304 (30.4%), 337 (33.7%), 168 (16.8%) and 58 (5.8%) of them belonged to the age of 11, 12, 13 and 14 years respectively. Among the subjects, 545 (54.5%) were males and 455 (45.5%) were females.

Among the 1000 school children screened, 33 (3.3%) had positive findings of scoliosis on physical examination in standing position. A total of 34 (3.4%) were positive for Adam's forward bend test, 7 (0.7%) and 10 (1%) of them had a reading $>7^{\circ}$ (positive finding) when screened using the Scoliometer device and App respectively.

No association was found between age, sex, posture, use of backrest, involvement in extracurricular activities and presence of scoliosis ($p > 0.05$).

respectively were negative for the test. The findings were found to be statistically significant ($p < 0.05$) with an odds ratio of 3.64 (95% CI – 1.34-9.89).

Comparison between the readings of Scoliometer device and Scoliometer app.

In Table 3, a total of 998 (99.8%) school children had a lower spine reading less than 7° and 2 (0.2%) had a reading in the range of $7^{\circ} - 10^{\circ}$ when screened using both Scoliometer device and Scoliometer HD app. The readings of both the Scoliometer device and Scoliometer HD app were found to be similar. A total of 997 (99.7%) school children had a middle spine reading less than 7° when screened using the Scoliometer device and 995 (99.5%) had a reading less than 7° when screened using Scoliometer HD App respectively. 1 (0.1%) had a reading in the range of $7^{\circ} - 10^{\circ}$ when screened with the device and 3 (0.3%) had similar readings in the app. 2 (0.2%)

had a reading $>10^\circ$ in both. The readings of both the Scoliometer device and Scoliometer HD app were found to be similar. A total of 998 (99.8%) and 997 (99.7%) school children had an upper spine reading less than 7° when screened using the Scoliometer device and Scoliometer HD App respectively. Only 1 (0.1%) had a

reading in the range of $7^\circ - 10^\circ$ when screened using the App and 2 (0.2%) had a similar reading when the App was used. Only 1 (0.1%) had a reading $>10^\circ$ in both. The readings of both the Scoliometer device and Scoliometer HD app were found to be similar.

Table 3: Comparison of spinal deviation readings (ATR- angle of trunk rotation) between Scoliometer device and Scoliometer HD application.

Angle of inclination according to level of spine	Scoliometer device	Scoliometer App
Lower spine (Lumbar)		
<7 degrees	998 (99.8%)	998 (99.8%)
7-10 degrees	2 (0.2%)	2 (0.2%)
Middle spine (Thoraco Lumbar)		
<7 degrees	997 (99.7%)	995 (99.5%)
7-10 degrees	1 (0.1%)	3 (0.3%)
>10 degrees	2 (0.2%)	2 (0.2%)
Upper spine (Thoracic)		
<7 degrees	998 (99.8%)	997 (99.7%)
7-10 degrees	1 (0.1%)	2 (0.2%)
>10 degrees	1 (0.1%)	1 (0.1%)
Total	1000 (100%)	1000 (100%)

DISCUSSION

The present study found that 3.3% of the school children had positive scoliosis findings when physically examined in standing position. However in a study done by Andrew Hendrik et al in South Africa, about 8.2% of total number of school children screened had positive scoliosis findings in standing position.¹¹ We found that about 3.4% of the school children who were screened had positive findings for Adam's forward bend test and were sent for further referral to the physician. This is in agreement with a study done by Lonstein et al in Minnesota in which 3.4% of the school children were positive for Adam's forward bend test.¹²

Scoliometer device and Scoliometer App

In this study a $>7^\circ$ scoliometer reading was taken as cut off which is in accordance with a study done by Raphael et al in Norway.¹³ Among the 1000 school children whose angle of trunk rotation (ATR) was measured, 7 (0.7%) and 10 (1%) had a reading $>7^\circ$ in the Scoliometer device and App respectively. In this study, it was found that gender did not have any statistically significant association with positive scoliosis findings. These findings were consistent with those of a study done by Chan et al in Australia where 4.3% and 1.9% of females and males respectively had positive scoliosis findings.¹⁴ In the present study 4.4% of the school children who engage in physical activity regularly and 2.5% of them who do not engage themselves regularly were found to have positive scoliosis findings. It was found that physical activity had no significant association with positive scoliosis findings. According to a report published by University of Maryland, scoliosis may be

evident in young athletes who engage in vigorous physical activity every day, with a prevalence of 2 - 24%.¹⁵ However, in most cases the scoliosis is minor. Our study found that extracurricular activities had no statistically significant association with positive scoliosis findings. However, according to the report published by University of Maryland, the highest rates of scoliosis are observed among dancers, gymnasts, and swimmers.¹⁵ The scoliosis may be due in part to loosening of the joints, delay in the onset of puberty (which can lead to weakened bones), and stresses on the growing spine. In the present study 7.7% and 1.9% of the school children who carry their school bag on one and both shoulders respectively had positive scoliosis findings. The findings were found to be statistically highly significant ($p < 0.001$) with children who carry their schoolbag on one shoulder at 4.3 (95% CI – 2.15-8.85) times higher risk of scoliosis than those carrying on one shoulder. This was in accordance with a study done by Bettany-Saltikov et al in UK which found a statistically significant association between one shoulder bags and scoliosis.¹⁶ According to the study, carrying bags on one shoulder produces postural deviation and unequal strain on the spinal structures leading to progressive postural scoliosis. In another study done by Son et al in Korea it was found that constant exposure to carrying heavy bags on one shoulder may result in unequal spinal loading potentially leading to trunk and limb asymmetries.¹⁷

In the present study it was found that folic acid supplementation during pregnancy had no significant association with positive scoliosis findings. Deficiency of folic acid during the first three months of pregnancy may lead to neural tube defects like myelomeningocele. In a study done by Trivedi et al in Connecticut, USA it was found that the prevalence of scoliosis among

myelomeningocele patients was as high as 80-90%.¹⁸ In this study 10.6% of the school children who were delivered pre-term and 3.2% of those who were delivered at full term of pregnancy had positive scoliosis findings. It was found that the maturity of foetus during delivery had a highly significant ($p < 0.001$) association with positive scoliosis findings with preterm infants at 3.6 times greater risk of scoliosis than full term ones (95% CI -1.34-9.89). These findings were in agreement with those of a study by Ruth Wynne-Davies in Edinburg, in which positive scoliosis findings were associated with prematurity and low birth weight.¹⁹ In another study done by Philip et al which was based on premature infants found that they have potential to develop scoliosis later in their life due to early exposure of tender muscles and bones to stresses.²⁰

Comparison between Scoliometer device and Scoliometer HD app

In the present study 0.2%, 0.3% and 0.2% of the school children were found to have a scoliometer reading $>7^\circ$ in the thoracic, thoracolumbar and lumbar regions respectively with greater prevalence (43% of the positive cases) of thoracolumbar scoliotic curves. However in a study done by Pokharel et al in Nepal, 50% of the positive cases had thoracic scoliotic curves.²¹ Similarly, 0.2%, 0.5% and 0.3% of the children had $>7^\circ$ App reading for thoracic, thoracolumbar and lumbar regions respectively with greater prevalence (50% of positive cases) of thoracolumbar scoliotic curves. The readings of the Scoliometer device and Scoliometer HD app which are therefore similar. This is in agreement with a study done by Franko et al wherein the findings of the Smart phone app were compared to those of the scoliometer device and thereby the App was validated as an efficient and cost effective tool for screening of scoliosis.⁹ Therefore, the app was found to be more convenient due to its greater availability and cost effectiveness.

ACKNOWLEDGEMENTS

The authors of this study acknowledge and thank all the participants of this study. We extend our gratitude to the ethical committee of Gandhi Medical College for permitting this study to be conducted. We also thank the medical students who were willing to be trained in collecting the data required. We thank the department of community medicine for their guidance throughout the study.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Spine health, Scoliosis- what you need to know, 2017. Available at: [http://www.spine-](http://www.spine-health.com/conditions/scoliosis/scoliosis-what-you-need-know)

- health.com/conditions/scoliosis/scoliosis-what-you-need-know. Accessed on 25 March 2017.
2. Spine universe, scoliosis in children. Available at <http://www.spineuniverse.com/conditions/scoliosis/scoliosis-children>. Accessed on 30 March 2017.
3. Scoliosis India, India's first web portal to raise awareness about scoliosis and kypho-scoliosis. Available at <http://scoliosisindia.blogspot.in/>. Accessed on 30 March 2017.
4. Saikia KC, Duggal A, Bhattacharya PK, Borgohain M. An epidemiological study of school children in Lower Assam. Indian J Orthopaedics. 2002;36(4):243.
5. Spinal research foundation India, Screening procedure for spinal deformity. Available at <http://www.srf-india.org/screeningprocedure.html>. Accessed on 20 March 2017.
6. Reamy Brian V, Slakey Joseph B. Adolescent Idiopathic Scoliosis: Review and Current Concepts. Am Fam Physician. 2001;64:111-6.
7. iscoliosis.com, Scoliosis screening. Available on <http://www.iscoliosis.com/symptoms-screening.html>. Accessed on 30 March 2017).
8. Financial express, India to become world's second largest smartphone market. Available at: <http://www.financialexpress.com/article/tech/india-to-become-worlds-second-largest-smartphone-market/93522/>. Accessed on 25 March 2017.
9. Franko OI, Bray C, Newton PO. Validation of a scoliometer Smartphone app to assess scoliosis. J Pediatric Orthopedics. 2012;32(8):725.
10. Google Play, Scoliometer HD. Available at: <https://play.google.com/store/apps/details?id=com.u.c.scoliometer.pro&hl=en>. Accessed on 12 March 2017.
11. Hendrik A, van Rensburg J. A Study to Determine the Incidence of Scoliosis in School Children within the Metropolis of Johannesburg, South Africa. A dissertation presented to the Faculty of Health Sciences, University Of Johannesburg, 2006. <http://hdl.handle.net/10210/991>. Accessed on 21 March 2017.
12. Lonstein JE, Bjorklund S, Wanninger MH, Nelson RP. Voluntary school screening for scoliosis in Minnesota. J Bone Joint Surg Am. 1982;64:481-8.
13. Adobor RD, Joranger P, Steen H, Navrud S, Brox JI. School screening and point prevalence of adolescent idiopathic scoliosis in 4000 Norwegian children aged 12 years. Scoliosis. 2011;6:23.
14. Chan A, Moller J, Vimporri G, Paterson D, Southwood R, Sutherland A. The case for scoliosis screening in Australian adolescents. Med J Austral. 1986;145(8):379-83.
15. University of Maryland Medical Centre, Scoliosis. Available at: <http://umm.edu/health/medical/reports/articles/scoliosis>. Accessed on 10 March 2017.
16. Bettany-Saltikov J, Cole L. The effect of front packs, shoulder bags and handheld bags on 3D back shape and posture in young university students: an

- ISIS2 study. *Stud Health Technol Inform*. 2012;176:117-21.
17. Son S, Noh H. Gait Changes Caused by the Habits and Methods of Carrying a Handbag. *J PhysTher Sci*. 2013;25(8):969–71.
 18. Trivedi J, Thomson JD, Slakey JB, Banta JV, Jones PW. Clinical and radiographic predictors of scoliosis in patients with myelomeningocele. *J Bone Joint Surg Am*. 2002;84(8):1389-94.
 19. Wynne-Davies, R. Infantile idiopathic scoliosis causative factors, particularly in the first six months of life. *J Bone Joint Surg Br*. 1975;57(2):138-141.
 20. Howard PJ, Worrel CH. Premature infants in later life, Study of Intelligence and Per-sonality of 22 Premature Infants at Ages 8 to 19 Years. *Pediatrics*. 1952;9(5):577 -84.
 21. Pokharel RK, Lakhey RB, Kafle D, Shah LL. Detection of Adolescent Idiopathic Scoliosis among Nepalese Children through the School Screening Program. *Nepal Orthopedic Associat J*. 2013;3(2): 9514.

Cite this article as: Talasila SSA, Gorantla M, Thomas V. A study on screening for scoliosis among school children in the age group of 10-14 using a cost effective and an innovative technique. *Int J Community Med Public Health* 2017;4:2118-23.