

PHYSICS OF SCOLIOSIS SCREENING IN SCHOOL-GOING CHILDREN¹

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ABSTRACT

Scoliosis, lateral curvature of the spinal column, effects children during their growth period. If untreated it may disfigure the body cosmetically and may effect vital organs, such as heart and lungs. Heavy school bags, if improperly worn, donot contribute to scholarship but curvatures of the spinal column in young children. The best way to void these complications is to monitor young children for spinal curvatures. Parents, teachers, school nurses and community health workers may contribute in this direction by creating awareness, education and effective screening programs. A scoliosis screening program is developed which is quick, reproducible and inexpensive. This involves visual observation of the back, forward bending test and moire fringe topography. The tests are integrated to minimize the number of false positives at the same time having a high degree of sensitivity. Our goal is to screen for curvatures of the spinal column at the same time minimizing X-ray exposure to children.

Keywords: Moire fringe topography, scoliosis, human spinal column

INTRODUCTION

The word orthopedics means straight child. In fact, bad posture and gait are the first impressions which one gathers about a prospective candidate during a job interview. It becomes of prime concern for military and paramilitary occupations. To cater for a better body and self image it is necessary that we develop children having straight spines and well-balanced gait.

This paper describes scoliosis screening tests which could be used to detect scoliosis at an early stage so that it could be treated using a combination of exercises and braces. Surgical treatment becomes necessary if the disease progresses to advanced stage. However, since delicate nerves are involved such a course is to be avoided, if possible.

Scoliosis Screening ---- The Need

On a morning one could observe children going to school. How many of them have a proper gait? May be they are not trained to maintain a good posture? May be the bags carried by them are too heavy for them so that their spines are under constant tension. Moreover, the children usually carry them on one side instead of wearing them properly and symmetrically on their backs. It is frequently observed that the children, especially girls, bend a little forward because of the weight of their school bags. table-1 gives an idea of ratio of the weight of the bags of a few children to their own weight. One may well appreciate our point.

Table-1: How heavy are the school bags of our children?

Age of Child (yr)	Weight of Child W_1 (kg)	Weight of School Bag W_2 (kg)	Ratio of Weights W_2/W_1
11.5	32	07	0.22
5.5	16	06	0.38
7.5	16	03	0.19
8.0	21	04	0.19

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During the last few years there has been an increasing awareness about heavy school bags producing spinal problems. Articles and cartoons projecting these problems have appeared in the dailies. Therefore, we are at the first stage of the solution --- identification of the problem. There is a need to develop scoliosis screening tests which are quick, reasonably sensitive and specific as well as easy to conduct on school/basic health unit premises (Ahmad and Hashmi, 19990).

Schools should organize scoliosis screening programs as part of general health care. We recommend that all children between the ages of 5 and 10 should be screened yearly for poor posture and scoliosis (Akram and Kamal, 1991; Kamal and El-Sayyad, 1981; Kamal and Lindseth, 1980; Kamal, Nasreuddin and Waseem, 1996; Nissinen, Heliovaara, Seitsamo, Poussa, 1993; Nissinen, Heliovaara, Tallroth, Poussa, 1989; Nissinen, Heliovaara, Ylikoski, Poussa, 1993; Willner, 1979). Starting screening at the age of 5 shall foster good posture habits. Scoliosis screening of school-age children between the ages of 7 and 14 is compulsory in Japan.

Scoliosis Screening ---- The Physics

The sagittal plane divides the human torso in the right and the left halves which should appear symmetrical when observed from the naked eye. Symmetry, an important concept in particle physics, also plays a vital role in biomechanics of the human body. Forward bending, visual observation, moire imaging all look for this symmetry. Any deviation from symmetry is an indication of further evaluation. If a child is standing/sitting in the anatomical position (for definitions of sagittal plane, anatomical position etc. refer to Kamal, Choudhry and Siddiqui, 1996), there is no torque acting due to gravity. If the leg/hip muscles become weak the child will bend in that direction and a torque shall start acting on the spinal column. This could produce a temporary (a C curve) or permanent (an S curve) deformation. Heavy school bags worn on one side produce the same effect. One way to appreciate the situation is by trying to hold oneself straight while carrying a bucket full of water. If the water is divided equally in two buckets each supported by one hand the task can easily be accomplished.

Another way to look at the mechanism of scoliosis production is to consider bending of beams. A force acting on the center of a beam fixed at both ends shall produce a curve in that beam. From the curvature produced the force acting on the beam can be computed (the inverse problem). Therefore, by computing curvatures of the spinal column one may compute the forces which have produced this curvature. Forces in the reverse direction should, at least in principle, correct that curvature. This may be the scientific basis of construction of braces. Generation of body mold, in three dimensions, with the help of moire fringe topography may help designing the braces in such a way as to impart minimum pressure on skin surfaces while providing appropriate tension to the spinal column. Orthopedists are well aware what happens to the skin of the patients when they have to wear braces 23 out of 24 hours a day.

Scoliosis Screening --- The Techniques

With the child stripped to waist forward bending test of child's back (observed from front with the child holding palms together, feet together, knees not flexed), visual observation of back with the child facing away from the examiner, feet together (level of shoulders, level of scapulae, midline of back, body triangles, spinal dimples, alignment of body with the help of plumb line) and moire imaging of the back (child facing away from the examiner, feet together) should be conducted on level ground.

Moire fringe topography is a noncontact and noninvasive optical technique which provides a three-dimensional map of the human back without using X rays or any other ionizing radiation harmful for a growing child (Akram, 1989; El-Sayyad and Kamal, 1982; Kamal, 1998; Kamal and Yusufzai, 1979; Naseeruddin, Kamal and Firdous, 1997; Takasaki, 1970; 1973; van Wijk, 1980; 1981). The technique is sensitive --- 99% sensitivity is reported in the literature, and reproducible --- Our group found the technique to be 99.5% reproducible (Kamal, 1990; Kamal, Bennoni and Willner, 1994) and can be handled using

various algorithms (Zubairi, 1994). This technique is used for the study of both posture (Kamal, Bukhari and Akram, 199a,b) and gait (Kamal, 1996a; Kamal, Choudhary and Siddiqui, 1996; Siddiqui and Choudhary, 1990; Yosufzai, Kamal and Zubairi, 1995), neurological disorders (Kamal, Akram and Bukhari, 1988; Kamal, Akram, Siddiqui and Khan, 1989) and modeling of human spinal column (El-Sayyad and Kamal, 1981; Kamal, 1982b;c; 1983a,b; 1987; 1996a,c). However, sometimes because of mispositioning subjects a large number of false positives are generated (Adair, van Wijk and Armstrong, 1977). To reduce these false positives (i.e. increase specificity of moire) we take moire topographs on level surface, use an alignment, system (Kamal, 1982a) and correct leg-length inequalities. Further, referral is based on more than one test and not on a single test.

Scoliosis Screening --- The Follow-up

Those showing positive on more than one test (forward bending, visual observation of the back, moire imaging of the back) should be referred to posture clinic where a detailed examination is carried out by a pediatrician/pediatric orthopedist and training imparted to improve posture habits.

At risk cases (e.g. siblings/children of a scoliosis patient, moire positive cases in the general screening) should be followed up till their growth is complete.

Scoliosis Screening --- The Education

No screening and follow-up program could be effective without community support. Therefore, it is of utmost importance to prepare ground for screenings and follow-ups. Also, the parents and the teachers, if properly educated, would be able to spot many cases since they are in close contact with the children. The education program may consist of:

- a Identification of the problem
- b Realization of importance of good posture and gait by children
- c Role of parents/teachers in posture and gait training as well as spotting at-risk cases.

It may be introduced in parent-teacher meetings or during special child guidance courses arranged on school campuses. Media (internet, TV, radio, newspapers, magazines) can also play a role to bring awareness. A humble effort is being done in this direction (Kamal, 1988; 1977 a-c).

EXPERIMENTAL

In order to establish correlation between forward bending and visual observation based on our procedures the following preliminary study was conducted.

Study Design

The study consisted of 9 male students of new Sunrise Public School, New Karachi studying in classes 6-9. The age range was 10-14 years. Standard forward bending (symmetry of both sides of the back) and visual observation of the back (level of scapulae, shape of midline of the back) were conducted. Prior to evaluation level of the floor was checked using a spirit level. The error margin allowed was that any part of the bubble should touch the central mark. In case the floor surface did not meet these criteria one of the following actions were taken:

a Testing place was shifted.

b newspapers were kept on the floor to make the surface level.

Data were collected and analyzed for consistency between the two tests.

Data

The graph (Fig. 1) shows results of forward bending test on the x axis and visual observation of back on the y axis (level of scapulae). For each case number a point is plotted in the respective quadrant. For example forward bending is negative; visual observation is negative for the first case. Therefore, a point is shown at (-1,-1) in the third quadrant. For the fourth case, forward bending is negative; visual observation is positive. Therefore, a point is chosen at (-4,4) in the second quadrant. The symbols C,S beside each point represent whether the midline is straight or having a C or S curve.

RESULTS

The data show that the two tests are highly correlated. There is very little chance of missed cases if decision is based on moire fringe topography, forward bending and visual observation of back.

RECOMMENDATIONS

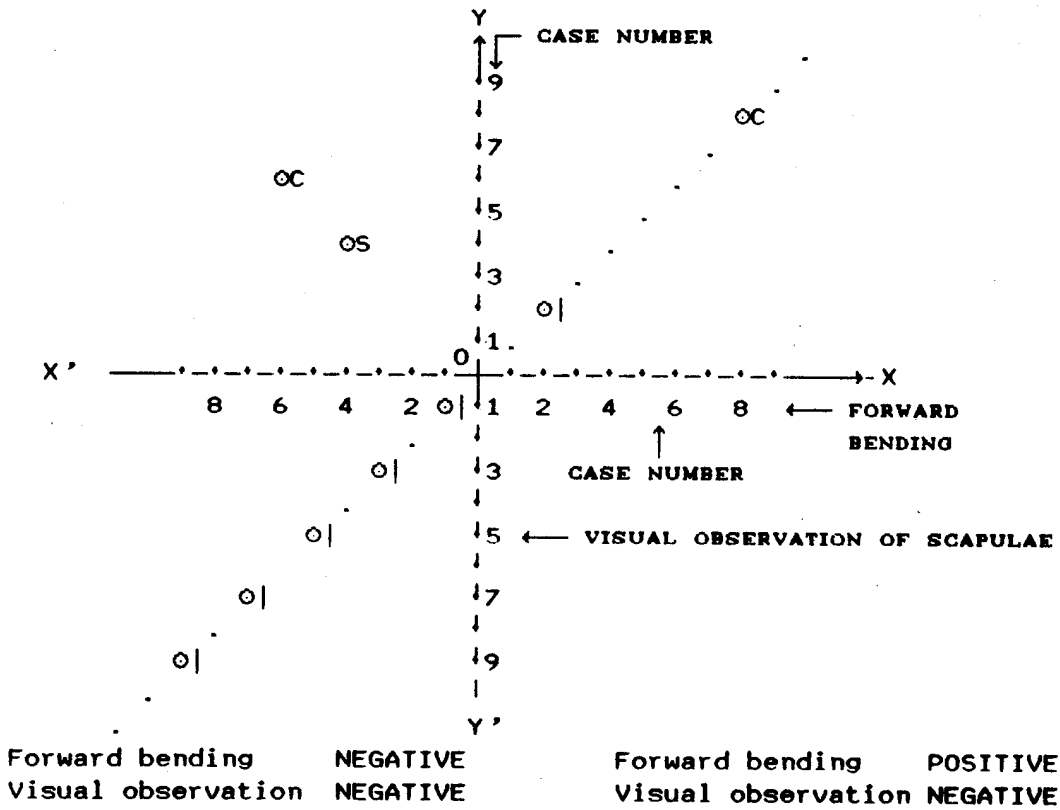
Spinal curvatures caused by subjecting spines to undue tension may be avoided. We are making the following recommendations:

- * School bags should, preferably, be worn symmetrically on the back and not on one side.
- * Unnecessary books should not be carried in the bags.
- * Curricula should be integrated to reduce the number of books carried by a child. There should be only one or two books/workbooks per term having sections for different subjects.
- * Students should be educated about faulty posture habits.
- * Posture clinics should be held regularly in schools.
- * Parents and teachers should keep a watchful eye on children for possible spinal curvatures.
- * Posture and scoliosis screening programs involving visual observation, forward bending and moire imaging should be established in schools for children 5-10 years old.
- * There should be an adequate follow-up for at-risk cases 11 years or older till the growth is complete.
- * There is a need to establish growth standards for our region.
- * Children should have adequate nutrition, their bodies should receive plenty of sunshine and fresh air to develop healthy spinal columns.

DISCUSSION AND CONCLUSION

The results obtained on this small sample are encouraging. However, there is a need to validate these results on a larger sample (> 100 students). Further, correlation of each of these tests should be

Forward bending NEGATIVE Forward bending POSITIVE
 Visual observation POSITIVE Visual observation POSITIVE



LEGEND

- Reference line
- Data point
- |,C,S Shape of mildline of back

Fig. Scatter diagram of screening tests

established with moire fringe topography. There is also a need to establish a multi-level screening for all types of spinal deformities (scoliosis, kyphosis, lordosis). The test(s) at the initial level should be highly sensitive (so that no cases are missed) and the test(s) at the final level should be highly specific (so that the students are not unnecessarily subjected to radiological and orthopedic examinations). The first stage of the screening should also be devised so that it is quick and could be conducted in a semi-private setting. There is also a need to define relative sensitivity, specificity and predictive values of a new test with respect to other clinical tests in use. In short, there is a need for planning administration, awareness and follow-up if we want our children not to suffer during adolescence. This would definitely improve the quality and quantity of accomplishments of our work force. The following concluding remarks deserve consideration.

CONCLUDING REMARKS

- * Scoliosis, if untreated, may harm vital organs and generate poor self image in a person.
- * In the advanced stage major spinal cord surgery (which involves delicate nerves) may be required to arrest scoliosis.
- * If detected early scoliosis may be controlled using a combination of braces and exercises and spinal cord surgery may be avoided.
- * Poor sitting posture may produce back strain in an executive job.
- * There is a dire need to establish scoliosis awareness and prevention programs for school-going children.
- * Scoliosis screening should be quick, easy to be conducted by school nurses and must be highly sensitive (so that no cases are missed).
- * Screening should not result in a large number of false positives referred to orthopedic surgeons (the screening protocol should be highly specific).
- * Moire fringe topography is a highly sensitive technique to detect spinal curvatures. However, it generates a large number of false positives.
- * Scoliosis screening program presented in this paper shall reduce the number of false positives because it is based on three types of screening.

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