

Spinal Postures of Children seated on the floor in Schools in Ahmedabad District, India

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ABSTRACT

Purpose: In some schools in India, children sit on the floor during class time due to non-availability of furniture. The present study was conducted to assess the spinal postures of school-going children when seated in various positions on the floor.

Method: The cross-sectional survey included 62 children by random selection. The boys and girls were from classes 1 - 8. Photographs were taken in four positions: A-standing; B-sitting on the floor while looking at teacher or board; C-sitting on the floor and looking down while writing in books; D-sitting on the floor and copying from the blackboard. Markers were placed on anatomical points: tragus, canthus, C7 vertebra, T12 vertebra, greater trochanter and the lateral malleolus. Craniovertebral angle (CVA), gaze angle, trunk angle and sway angle in degrees were measured using Surgimap software. Differences in mean angles in various positions were compared using Kruskal-Wallis test. Post-hoc analysis was performed using Dunn-Sidak correction test.

Results: Mean CVA in position A (standing) was 54.11+7.0 degrees; in position B it was 41.7+9.2 degrees; in position C it was 43.60+43.09 degrees; and, in position D it was 8.8+16.85 degrees. Mean gaze angle in position A was 20.01+9.18 degrees; in position B it was 26.99+10.15 degrees; gaze angle could not be measured in position C (when the students looked into their books); and, in position D it was 35.08+9.164 degrees. Mean trunk angle in position A was 147.95+9.6 degrees; in position B it was 132.80+10.11 degrees; in position C it was 132.80+10.69 degrees; and, in position D it was 128.64+10.80 degrees. Mean sway angle was 160.91+7.70 degrees in standing position. Statistics

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showed significant difference between the angles in all the different positions ($p < 0.001$).

Conclusion: In schools without appropriate furniture, sitting on the floor leads to a significant alteration in spinal postures among school-going children. Increased stress on the neck and back may predispose these children to early degenerative changes. Suitable furniture needs to be provided and good posture needs to be taught to children.

Limitations: Detailed pain assessment and comparison between higher and lower classes could not be done.

Key words: Craniovertebral angle, gaze angle, sway angle, trunk angle, school-going children

INTRODUCTION

Posture is the alignment and positioning of the body parts with respect to gravity (Dudoniene et al, 2013). Correct posture usually follows the biomechanical principles of the human body and can be assessed by examining the spinal curves that are formed due to the different weight-bearing patterns in different regions of the body. Posture also depends on the muscle strength of different regions (Radzevičienė & Kazlauskas, 2016). Correct posture is an important factor that helps to determine the musculoskeletal health of an individual (Dudoniene et al, 2013).

Phases of childhood and adolescence are crucial for the growth and development of the human body. Significant changes in the posture and health of children occur when they start going to school (Dudoniene et al, 2013). Most of their waking hours are spent in school. From the age of 3-4 years up to 17 years, the time spent at school increases and is generally spent studying indoors. Writing, reading, drawing and related activities require them to sit continuously for long hours (Savanur et al, 2004). Research conducted by Lithuanian scientists show that abnormal posture disorders are very common among the school-going population. They occur in almost 25-30% of the total school population (Radzevičienė & Kazlauskas, 2016).

While most schools in India provide students with chairs or benches and tables in the classroom, there are some schools which do not have these facilities. Children sit on the floor for almost five hours a day depending on the class in which they

study. Such prolonged sitting leads to formation of poor postural habits which in turn may lead to back pain and neck pain (Zacharkow, 1988).

The origins of work-related musculoskeletal disorders are commonly associated with non-optimal postures resulting in postural stress, fatigue, and discomfort (Lehman et al, 2001). Sitting in the same posture for a long time puts an undesirable physiological strain on the muscles, ligaments and discs (Keegan, 1953; Mandal, 1981). A study by Gouda et al (2013) found that almost 93% of the government schools, 81% of private aided and recognised schools, 55% of private recognised and unaided schools, and 54% of private unrecognised schools in rural areas had infrastructure below accepted standards. Due to such infrastructural limitations or sometimes to maintain the traditional custom of Indian culture, the students have to sit on the floor in the classroom (Perooru et al, 2016). In such a classroom, the teacher uses a blackboard which is at a convenient height for him/her in the standing position. However, the blackboard may be at a considerable height when viewed by students sitting on the floor. The students need to extend their necks to look up at the blackboard. At the same time, they need to write in their books which are kept on the floor. This task of looking at the board and then writing in the book requires repetitive bending from the neck and the back. Also, continuously looking at the board or writing in the book can cause the children to maintain postures which may not be ideal at their tender age. A study found that more than half of the students living in rural areas had postural disorders due to weakness of muscles and impairments of muscle tension (Radzevičienė & Kazlauskas, 2016). Sustained postures lead to abnormal length-tension relationships, and ultimately lead to development of weakness in the muscles. Sustained abnormal spinal curves in children can be the cause of major problems in adulthood such as scoliosis, kyphosis, etc.

Objectives

The objectives of the study were to assess neck curvature using craniovertebral angle and gaze angle, and the angle of thoracic spine using trunk angle in standing, sitting and bending while sitting (looking at the board and writing) positions, and the sway angle while standing, in school-going children seated on the floor.

METHOD

Setting

The cross-sectional survey was conducted with 62 children of a government school in Ahmedabad district of Gujarat, India. The school was selected using convenience sampling from among schools which lacked furniture. This was an English medium school where some of the classes did not have benches and tables, so that the children were made to sit on the floor to study.

Sample

Students, both boys and girls of classes 1, 2, 4 and 8 were randomly included in the study. The classes were randomly selected using the lottery method in order to have a broader representation of age. On an average, students sat in the school for 3 hours and 20 minutes, either listening to the teacher, writing or looking at the blackboard. The students were provided information about the nature and purpose of the study and about their role in the study. Students who were willing to participate were then included in the research.

Data Collection

Photographs of the children in four positions were taken, as shown in figures A-D (Appendix 1). The positions were: A- standing; B-sitting on the floor looking at the teacher or looking at the board; C-sitting on the floor, looking down when writing in their books: and, D-sitting on the floor and copying from the blackboard in front of them. These were the positions that they usually assumed when sitting or standing in the classroom. The students were made to sit against a light background with the right side facing the camera. Markers were placed on various anatomical points: the tragus, the canthus, C7 vertebra, T12 vertebra, the greater trochanter (GT) and the lateral malleolus on the right side. The photographs were then taken from a lateral view using a Nikon 3000 digital camera®. The use of photographs to record postural abnormalities is an inexpensive and simple technique (Afaf & Reem, 2012). Photographic posture analysis has acceptable test-retest reliability ($ICC > 0.972$) and excellent inter-rater reliability ($ICC > 0.774$) (Hazar et al, 2015). A literature review suggested malleolus; posterior calcaneal tuberosity; fibular head; tibial tuberosity; greater trochanter of the femur; anterior angle and/or posterior lateral edge of the acromion; spinous processes (particularly C7); inferior angle of the scapula; sternum manubrium;

mental protuberance; and the intertragic notch as possible markers that can be used for photographic analysis (do Rosário, 2014).

Data Analysis

The photographs were analysed using the software Surgimap (Helmya et al, 2015). Photographs were uploaded and angles were marked joining the anatomical landmarks as shown in Figure E. The following postural angles were measured in degrees:

1. Craniovertebral angle (CVA) is defined as the angle between the true horizontal through the spinous process of C7 with a line connecting spinous process of C7 with the tragus.
2. Head tilt angle or gaze angle (HTA) is defined as the angle between the line connecting the tragus of the ear to the canthus of the eye and the horizontal line passing through the tragus.
3. Trunk angle which is the angle formed between the line joining C7 and T12 and the line joining T12 and greater trochanter (GT).
4. Sway angle which is the angle formed between the line joining C7 and T and the line joining GT and lateral malleolus.

The mean and standard deviations were computed and the difference in angles in the various positions was analysed using SPSS version 20.

Ethics Approval

Institutional Ethics Committee approval was obtained for the study. The study was explained in detail to the Head of the school and permission to conduct the study was sought, assuming the Head to be the children's guardian since many of their parents were illiterate. Consent to participate in the study was also taken from the students. They were told that they could leave the study at any time they wanted.

RESULTS

Data of 62 school-going children was collected. Boys and girls studying in standards 1, 2, 4 and 8 were included. Distribution of students by class and gender

is seen in Table 1. Around 26 students (42%) had pain. Table 2 shows mean and SD of angles measured in degrees in various positions.

Table 1: Demographic Distribution of Participants

| Group | Males | Females | Total |
|--------------|--------------|----------------|--------------|
| Class 1 | 7 | 5 | 12 |
| Class 2 | 9 | 10 | 19 |
| Class 4 | 8 | 11 | 19 |
| Class 8 | 8 | 4 | 12 |
| Total | 32 | 30 | 62 |

Table 2: Mean and SD of Angles measured in Degrees

| Position/ Angle | A - Standing | B – Sitting and looking at the teacher | C - Sitting and writing | D - Sitting and looking at board and writing |
|----------------------------|---------------------|---|------------------------------------|---|
| CVA | 54.11 ± 7.0 | 41.7 ± 9.2 | 43.60 ± 43.09 | 8.8 ± 16.85 |
| Gaze angle | 20.01 ± 9.18 | 26.99 ± 10.15 | - | 35.08 ± 9.16 |
| Trunk angle | 147.95 ± 9.6 | 132.80 ± 10.11 | 132.80 ± 10.69 | 128.64 ± 10.80 |
| Sway angle | 160.91 ± 7.70 | - | - | - |

The angles in different positions were compared using Kruskal-Wallis test, as shown in Table 3. The CVA data, in the position of sitting while writing, had 13 negative values which were not included in the analysis. Post-hoc analysis was performed using Dunn-Sidak correction test. There was statistically significant difference between positions A and B, A and C, B and C, and C and D for CVA. For trunk angle and gaze angle, there was statistically significant difference between all the three positions – A, B and C. The results are shown in Table 4.

Table 3: Comparison of the Angles in different Positions

| Angles | Positions | 95% Confidence interval | χ^2 value | P value |
|-------------|------------|-------------------------|----------------|---------|
| CVA | Position A | 52.33 – 55.89 | 169.16 | <0.001 |
| | Position B | 39.38 – 44.04 | | |
| | Position C | 4.51 – 13.07 | | |
| | Position D | 32.66 – 54.55 | | |
| Trunk angle | Position A | 145.51 – 150.39 | 93.813 | <0.001 |
| | Position B | 130.24 – 135.37 | | |
| | Position C | 121.88 – 127.31 | | |
| Gaze angle | Position A | 17.69 – 22.35 | 58.786 | <0.001 |
| | Position B | 24.41 – 29.56 | | |
| | Position D | 32.76 – 37.41 | | |

Table 4: Post-hoc Comparison of the Angles in different Positions

| Angles | Positions | Mean difference | Standard error | P value | 95% Confidence interval |
|-------------|------------------|-----------------|----------------|---------|-------------------------|
| CVA | Position A and B | 12.40 | 4.28 | 0.024* | 1.04 – 23.76 |
| | Position A and C | 45.32 | | <0.001* | 33.96 – 56.68 |
| | Position A and D | 10.51 | | 0.086 | (-0.05) – 21.86 |
| | Position B and C | 32.92 | | <0.001* | 32.66 – 54.55 |
| | Position B and D | -1.89 | | 0.998 | -13.25 – 9.46 |
| | Position C and D | -34.81 | | <0.001* | -46.17 – (-23.45) |
| Trunk angle | Position A and B | 15.14 | 1.82 | <0.001* | 10.75 – 19.54 |
| | Position A and C | 23.35 | | <0.001* | 18.96 – 27.75 |
| | Position B and C | 8.21 | | <0.001* | 3.82 – 12.6 |

| | | | | | |
|------------|------------------|--------|------|---------|-------------------|
| Gaze angle | Position A and B | -6.97 | 1.71 | <0.001* | -11.08 – (-2.85) |
| | Position A and D | -15.06 | | <0.001* | -19.18 – (-10.95) |
| | Position B and D | -8.097 | | <0.001* | -12.21 – (-3.98) |

DISCUSSION

The present study was conducted with the aim of assessing the various spinal angles in different positions among children who attend schools which have no furniture.

The mean CVA (cranio-vertebral angle) in standing was 54.11 ± 7.0 degrees. Normal CVA is around 51.8 ± 7.5 degrees. A decrease implies flexion of lower cervical spine and with that capital extension is seen. A decrease is suggestive of the forward head posture. In the present study, CVA was found to be near normal in standing postures but was seen to decrease considerably when sitting, writing and when looking at the board while writing. This could be because the child seated on the floor has to look up at the teacher who is standing or sitting at a higher level, or to watch the blackboard. CVA was also found to increase in a few students. Statistics showed significant differences between CVA in various positions. The negative values of CVA belonged to children from 2nd and 4th standards. This could be because the board was at a greater height for the younger students. Coban et al (2014) concluded there exists an inverse relationship between CVA and pain scores.

The gaze angle was also taken. The normal gaze angle while standing is 12.6 ± 10.4 degrees. In the present study the mean gaze angle while standing was 20.01 ± 9.18 degrees. Gaze angle could not be measured when the students looked into their books. The gaze angle was found to be significantly increased in all positions of sitting. A greater tilt angle indicates extension of the head relative to the cervical spine.

When the head is bent forward, the weight of the head shifts anteriorly. This increases the force against which the muscles have to work to hold the head erect. The muscles tend to tire faster because of the increased strain and this can lead to pain. A bent neck and altered biomechanics of the spine further increase the bending at the spine and consequently the deformity. It is thus a vicious cycle.

The trunk angle was taken to see the amount of flexion of the trunk. The mean trunk angle while standing was 147.95 ± 9.6 degrees. The normal values are

around 166.5 ± 8.0 degrees (Ruivo et al, 2014). A decrease in the trunk angle implies increased flexion of the trunk, which the present study found in the sitting position. Trunk angle was found to be significantly different while standing and sitting, and between sitting and sitting and looking at the board.

Sway angle is formed by line joining C7 and GT, and line joining GT and lateral malleolus. The normal value is about 173 ± 4.9 degrees. In the present study, sway angle was found to be 160.91 ± 7.70 degrees. A decrease in the sway angle implies lumbar lordosis or an increase in the curve in the lumbar region. It is suggestive of sway back posture. Since the lumbar spine carries more weight than any other region of the spine, it is the responsibility of this area to make major adjustments to load shifts from the gravity line. For example, thoracic kyphosis shifts the line anteriorly so that the lumbar area must increase its lordosis to prevent the body from falling forward. The present study concludes the same in the standing position.

Post-hoc analysis revealed significant difference between the CVA in positions A and B, A and C, B and C, and C and D. There was no significant difference between the CVA in A and D, and B and D. The trunk angle also showed statistically significant difference between A and B, A and C, and B and C. Statistically significant difference was also found between the gaze angle during A and B, A and C, and D and B, and C and D.

Moving from standing to sitting and then looking down or creating a movement of the neck from looking ahead to looking down at the book, causes a flexion movement of the back and the neck. When an individual sits on the floor the spine moves into extreme flexion at the lumbar region. Looking down in this position puts the neck and the thoracic spine also in flexion. Such movements occurring repeatedly and such extreme postures being maintained for longer periods can prove to be harmful to the children in the long term.

The function of the curves of the spine is to increase the load-bearing capacity of the spine. Any alteration in the angle of the curves (an increase or decrease) hampers functioning of the spine in terms of both stability and mobility, which may be seen in these children in the long run.

Previous studies on rural school-going children have assessed prevalence of deformities. A study done in Punjab found more prevalence of knock knees and bow legs, compared to lordosis and kyphosis. However the study used only an observational method in the standing position with no measurements of angles

(Kaur & Mahi, 2017). Another observational study (Radzevičienė & Kazlauskas, 2016) found posture disorders in more than 50% of the rural school-going children, with muscle tightness being present. Contradicting the above findings, a study by Dutta and Dhara (2012) concluded that the traditional sitting posture in India, that is, sitting on the floor with folded knees, caused less muscular stress and greater stability in posture than sitting on the bench, among primary school children. School children from rural areas had better posture than children from urban areas, according to Dudonienė et al (2013). However, their study was based on visual observations and no measurements.

There is a positive association of pain with prolonged and awkward postures. Static and awkward postures increase the prevalence of musculoskeletal disorders in school-going children too, similar to adults (Murphy et al, 2014). Increased prevalence of pain, other musculoskeletal disorders and deformities lead to decreased attendance at school. The students' absence from school leads to increased dropouts and decreased literacy rates which eventually affect the economy and growth of the country. The government should evaluate the rate of dropout from schools and analyse the causes for it. The present study shows the implications of the lack of furniture at school. For a developing country like India, education is a very important area that needs to be worked upon. The government should focus on rural sectors and try to develop better infrastructure so that schools can attract more students.

Limitations

In the present study, analysis was not done to compare differences in angles between children of higher and lower classes. It is possible that children in higher classes showed more postural deviations with sustained postures over the years. Also, complaints of pain were recorded in the present study but only in the form of 'yes' and 'no'. Detailed assessment of pain needs to be carried out to find the severity and site of pain.

In some of the pictures, the angles were so altered that they could not be measured and are kept as missing data. Blinding was not possible, hence participants' awareness that spinal posture was being measured risks bias in their postural behaviour to some extent.

Further studies comparing the posture of children in schools with furniture and children in schools without furniture can be done. The impact on literacy

levels could not be assessed as these children may be from socio-economically backward families where motivation to study may be absent.

CONCLUSION

Sitting on the floor in schools without appropriate furniture does lead to a significant alteration in spinal postures of school-going children. Increased stress on neck and back at school may predispose these children to spinal pain and later on to early degenerative changes of the spine. Suitable furniture needs to be provided and good posture needs to be taught to children. There is a need to provide children with access to a quality educational environment to ensure a better future for them.

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APPENDIX 1: FIGURES**Figure A: Normal standing – Position A Figure B: Normal sitting – Position B****Figure C : Sitting and looking down - Position C**

Figure D: Sitting and writing from the blackboard - Position D



Figure E: Measurement of various angles by joining the anatomical landmarks (Black lines - gaze angle, Craniovertebral angle and trunk angle; Blue lines - Sway angle)

