
WWJMRD 2017; 3(8): 279-287
www.wwjmrd.com
*International Journal*
*Peer Reviewed Journal*
*Refereed Journal*
*Indexed Journal*
*UGC Approved Journal*
*Impact Factor MJIF: 4.25*
e-ISSN: 2454-6615

**Shivani Chowdhury Salian (PT)**
Department of Electrotherapy and Electrodiagnosis, School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai, India

**Varsha Mayekar**
Physiotherapy Intern, School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai, India

**Correspondence**:
**Shivani Chowdhury Salian (PT)**
Department of Electrotherapy and Electrodiagnosis, School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai, India

# Assessment of Kyphotic Index in School Going Children Using Flexicurve

**Shivani Chowdhury Salian (PT), Varsha Mayekar**

**Abstract**
**Purpose:** The present study aimed at assessing Kyphotic Index in school going children using flexicuve and correlating the same with weight of bag, BMI, flexibility, endurance.

**Methodology:** A cross sectional study was performed in 3 schools from SSC board in Mumbai. The sample included 1606 students ranging in age from 6 to 15 years from class 1 until class 10.
Flexicurve was used to measure the kyphotic index. Kyphotic Index was calculated using the formula [(width/length)*100]. Weight of school bags was measured using a standardised weighing scale and the dimensions (length and breadth) of school bag were taken using measuring tape. Flexibility and endurance of the child was assessed and graded. Factors that could affect kyphotic index like weight of the school bag carried, BMI, flexibility of shoulder and spine, mobility of lumbar spine abdominal endurance and classroom ergonomics were assessed and correlated.

**Result:** The normative range for kyphotic index boys in age group 6 to 8 years - 7.73 to 12.13, in age group 8 to 10 years -8.57 to 11.52, in age group 10 to 12 years -8.26 to 11.72, in the age group 12 to 14 years - 8.58 to 12.29, in the age group 14 to 16 years -9.23 to 12.43. Similarly, the normative range for kyphotic index female in age group 6 to 8 years- 7.79 to 12.13, in age group 8 to 10 years - 8.71 to 11.27, in age group 10 to 12 years - 8.26to 11.80, in the age group 12 to 14 years-8.56 to 11.90, in the age group 14 to 16 years -8.77 to 11.96. Very poor correlation was obtained between the various factors and range of kyphotic index of the thoracic spine in both male and female children.

**Conclusion:** The normal ranges showed gender and age variations in school children; and thoracic kyphotic index has very poor association with factors such as BMI, flexibility, abdominal endurance and bag weight.

**Keywords:** Kyphotic index, school going children, flexi curve, flexibility, abdominal endurance.

## Introduction
Schools are important social institutions that involve about 20% of the active members of society. School going children spend a considerable amount of time in schools i.e. 8-10hours, thus providing a safe and healthy environment that can reduce their vulnerability and cause physical complications in them. Several studies have been conducted in schools about the prevalence and related factors such as asthma, allergic rhinitis, atopic dermatitis, Vitamin D deficiency, sleep disorders in children. This shows the importance of screening in students who are at the age of growth which are diagnosed early at this age[1]When a child begins to attend school, their time spend in sitting position is extended, which leads to posturogenesis[2]. The excess stress placed on back and neck muscles causes the child to arch forward his/her head and this change in posture would lead to imbalance in the spinal extensor and flexor muscle groups which in turn would render the child easily fatigable and lethargic. A posterior convex curve in thoracic region is termed as kyphosis. The line of gravity (LOG) passes at a greater distance from the thoracic spine, and creates an increase in the gravitational moment arm. At the same time, tensile stresses increase on the posterior aspects (convexity of curve) which adversely affect the fibres of the posterior annulus and apophyseal joint capsules. Also, increased loading and changes in spinal posture may

compromise the force generating capacity of the back extensor muscle due to alterations in length tension relationships, moment arm lengths and force vector orientations[3].

In 2009, the American Occupational Therapy Association (AOTA) and the American Physical Therapy Association (APTA) recommended not carrying a backpack heavier than 15% (or between 15% and 20%) of the students body weight, in 2012 this was changed to 10% of their body weight[1]. The American chiropractic Association (ACA) recommended that backpack weight should not exceed 5-10% of the child's body weight. Many authors have concluded that the weight of a school backpack should not exceed 10% of the child's body weight, based on the fact that it can affect their spinal posture, foot shape and gait[1]. A child carrying a heavy backpack will lean forward to balance the centre of gravity, which results in a reduction of lumbar lordosis and increased thoracic kyphosis[2]. Such a posture may become habitual and be maintained even after taking the backpack off.

Takahashi and Atsumi were the first to describe the flexi curve. Milne and Lauder described the first method of utilization of the flexi curve in the clinical setting for kyphosis measurement through the kyphosis index[4].

Flexicurve can be used for excellent reproducible measurement in the thoracic and lumbar curvature of the spine in the sagittal plane clinically, making it easy for spine posture evaluation objectively[5].

**Aim:** Assessment of kyphotic index using flexicurve and to correlate the same with weight of the bag, shoulder and back flexibility, mobility of lumbar spine abdominal endurance in school going children.

## Material and Methodology

A cross sectional study was performed in 3 schools from SSC board in Mumbai over a period of 6 months. The sample size was 1606 within the age group of 6 to 15 years from class 1 to class 10 with 2 students being excluded as they presented with structural scoliosis. Data collection was done from three schools in Ulhasnagar and Chembur in Mumbai. The study was approved by the Ethical Committee School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai. An informed ascent was obtained from each subject's parent and teacher before enrolling them in the study. The subject was explained about the methodology and the purpose of the study in the language best understood by them.

School going children from class 1 through class 10, healthy school going children; those who have not undergone any spinal surgeries were included in the study. Children with any known or observed spinal deformity and differently abled children were excluded from the study. A validated questionnaire was used as the case report form. Questions such as the mode of travel; help to carry bags, do they find the bag to be heavy at times, number of breaks in a day, whether they experienced any back pain; etc. were asked before assessing the students clinically. General examination included assessment of height, weight, BMI, weight of the bag, dimensions of the bag.

Flexicurve was used to measure the kyphotic index parameters. For the spinal measurements , the flexible ruler was placed (moulded) on the mid-line contour of the spine between two marked points and then was laid on a piece of graph paper and the spinal curvature was copied by running a pencil along the flexible ruler in order to measure the degree of lordosis and kyphosis . The curve of thoracic spine was determined by locating, palpating and marking C7 and T12 spinal vertebrae. The vailidity and reliability of flexicurve was confirmed from previous studies[4]. The contour of thoracic spine obtained from the flexible curve was carefully traced on the paper, and using the following formula index values were calculated, [6, 7]

**Kyphotic Index = [(width/length)*100]**

Abdominal endurance, flexibility testing of shoulder and neck was graded as per explained in the text[8, 9].

## Results

Statistical calculations were done for the data using the SPSS software. Descriptive analysis was used to analyse the answers to the questionnaire in the case report form. To find out upper limit and lower limit of kyphotic index values in different age categories: the statistical formula used is: Mean +_1.96 SD.

For correlation of Kyphotic Index with different factors like flexibility, abdominal endurance and BMI Spearman's two tails (Non-parametric) test was used. P-value of <0.05 was considered significant for all analyses.

The number of students were categorised according to different age groups and gender. In the age category 6 to 8 years, males are 32.2% whereas females are 30.7% In the age category 8 to 10 years, males are 21.3% whereas females are 24.6% In the age category 10 to 12years, males are 17.2% whereas females are 13.3% In the age category 12 to 14 years, males are 19.8% whereas females are 12.5% In the age category 14 to 16 years, males are 9.5% whereas females are 12.5%. Table 1 shows the age and gender of students included in the study.

**Table 1:** Age and gender classification of school going children included in the study.

| | | | Gender | | Total |
|---|---|---|---|---|---|
| | | | Male | Female | |
| Age Category | 6 TO 8 YRS | Count | 241 | 263 | 504 |
| | | % within Gender | 32.2% | 30.7% | 31.4% |
| | 8 TO 10 YRS | Count | 159 | 211 | 370 |
| | | % within Gender | 21.3% | 24.6% | 23.0% |
| | 10 TO 12 YRS | Count | 129 | 114 | 243 |
| | | % within Gender | 17.2% | 13.3% | 15.1% |
| | 12 TO 14 YRS | Count | 148 | 163 | 311 |
| | | % within Gender | 19.8% | 19.0% | 19.4% |
| | 14 TO 16 YRS | Count | 71 | 107 | 178 |
| | | % within Gender | 9.5% | 12.5% | 11.1% |
| Total | | Count | 748 | 858 | 1606 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

From the questionnaire it was observed that students used all modes of transport like bicycle, bike, car, auto rickshaw, bus and walking too. Higher age groups; from 10 years to 16 years only were found to use bicycles. Maximum school students were observed to be walking to and fro the school with a guardian. Table 2 shows the number of school students using different modes of transport.

**Table 2:** Classification of number of school students using different modes of transport.

| | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bus** | 11 | 12 | 6 | 5 | 0 | 0 | 5 | 2 | 0 | 0 |
| **Auto** | 43 | 41 | 31 | 29 | 18 | 17 | 22 | 20 | 15 | 18 |
| **Car** | 4 | 8 | 4 | 6 | 0 | 2 | 4 | 0 | 0 | 2 |
| **walking** | 137 | 146 | 99 | 141 | 82 | 72 | 97 | 126 | 51 | 72 |
| **Bike** | 45 | 55 | 18 | 26 | 25 | 20 | 12 | 10 | 3 | 10 |
| **Bicycle** | 0 | 0 | 0 | 0 | 4 | 2 | 8 | 4 | 1 | 5 |

63% children took help to carry bag and 37% didn't take help. Help was provided by the guardian (carried the bag) who either walked the student to the school or travelled along with the students to the school.

88% students complained of being tired and fatigue after school. 72% students went for tuition classes after school. It was observed that 87% had their bag extending up to the lower back and 13% had it up to their hip. When asked regarding their type of bag; 95% used vertical bag, 3% used horizontal bag and 2% used cross shoulder sling bags. 9% students felt their bag was not of the appropriate size. When inquired regarding the placement of their bags in their class; 67% students placed their bag behind their back on the bench , 14% on ground, 14% kept it aside and 5% hung it aside on the bench. As a consequence 6 % students felt they did not enough place to sit on the bench in the class due to the placement of their bags; also 6 % students felt the height of the bench they used in the classroom was not of an appropriate height. It was observed that all the students actively participated in the sports activities in school and at home. They also watched television for durations varying from half an hour to 3 hours maximum in all different positions. Effectively, 13 % students complained of back pain. Of which 59% students complained of upper back pain, 33% students complained of pain in low back region and 7 % students complained of cervical pain and 1 % students complained of pain in both the neck and upper back region. 29.3 % students complained aggravation of pain in sitting and 18.6% in bending postures of the spine. Most of the students felt better by lying down in the supine position for relieving pain in the back. 95% students experienced pain during their activities of daily living. In case of female students 95% students complained of back pain during their menstrual cycle and all complained of maximal pain while bending activities during their menstrual cycle. Surprisingly, it was observed that 85% Female took an off from school during their menstrual cycle.

The Normative values for kyphotic index was calculated separately for Males and Female; and was grouped into five age groups. Table 3 shows the normative range of thoracic index values obtained on assessing the Male and girl school students. Table 4 show the p values of the same

**Table 3:** Normative range of values of kyphotic index in Male and Female school studnets of different age group

| | Age Categories | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6 to 8 yrs | | 8 to 10 yrs | | 10 to 12 yrs | | 12 to 14 yrs | | 14 to 16 yrs | |
| | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
| **N** | 241 | 263 | 159 | 211 | 129 | 114 | 148 | 163 | 71 | 107 |
| **Mean** | 2.32 | 2.41 | 2.3 | 2.3 | 2.5 | 2.56 | 3.28 | 2.76 | 4.55 | 4.54 |
| **Std. Deviation** | 0.72 | 0.98 | 1.45 | 0.74 | 0.75 | 0.76 | 3.45 | 0.95 | 0.74 | 0.75 |
| **Lower Limit** | 7.74 | 7.80 | 8.57 | 8.71 | 8.26 | 8.26 | 8.58 | 8.56 | 9.23 | 8.78 |
| **Upper Limit** | 12.14 | 12.14 | 11.52 | 11.28 | 11.72 | 11.81 | 12.29 | 11.91 | 12.43 | 11.96 |

The p values <0.05 in the readings obtained in Males and Female, thereby show a highly significant difference between the values of kyphotic index.

**Table 4:** p value of kyphotic index in Males and Female using ANOVA test

| | | Sum of Squares | | df | | Mean Square | | F | | Sig. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
| kyphotic index | Between Groups | 61.17 | 18.22 | 4.00 | 4.00 | 15.29 | 4.56 | 16.96 | 5.62 | 0 | 0 |
| | Within Groups | 670.02 | 691.30 | 743.00 | 853.00 | 0.90 | 0.81 | | | | |
| | Total | 731.18 | 709.53 | 747.00 | 857.00 | | | | | | |

Post Hoc Tests- for KYPHOTIC INDEX in male and female students was done to evaluate where the differences occurred between groups and the results are as shown in table 5

Post hoc analysis shows that there was highly significant difference in the readings of kyphotic index between the age groups of 6- 8 years, 12-14 years and 14-16 years of male and female students. no difference was observed in the values of thoracic index of students in the age group od 6-8 yrs, 8-10 yrs and 10-12 yrs of age. It is therefore a valuable finding that ascertains that kyphotic index measures cannot be generalised and projected as a single figure but a range of the same varying in different age groups in school going males.

**Table 5:** Values of Post hoc Bonferroni analysis to ascertain difference of thoracic index between the age groups of male and female school students.

| Dependent Variable | Age Category (I) | Age Category (J) | Mean Difference (I-J) | | Significance | |
|---|---|---|---|---|---|---|
| | | | Males | Females | Males | Females |
| Thoracic index | 6 to 8 yrs | 8 to 10 yrs | -0.11 | -0.03 | 1.00 | 1.00 |
| | | 10 to 12 yrs | -0.06 | -0.07 | 1.00 | 1.00 |
| | | 12 to 14 yrs | -.502 | -.27 | 0.00 | 0.03 |
| | | 14 to 16 yrs | -.1 | -.1 | 0.00 | 0.00 |
| | 8 to 10 yrs | 6 to 8 yrs | 0.11 | 0.03 | 1.00 | 1.00 |
| | | 10 to 12 yrs | 0.06 | -0.04 | 1.00 | 1.00 |
| | | 12 to 14 yrs | -.39 | -0.24 | 0.00 | 0.10 |
| | | 14 to 16 yrs | -.78 | -.38 | 0.00 | 0.00 |
| | 10 to 12 yrs | 6 to 8 yrs | 0.06 | 0.07 | 1.00 | 1.00 |
| | | 8 to 10 yrs | -0.06 | 0.04 | 1.00 | 1.00 |
| | | 12 to 14 yrs | -.45 | -0.20 | 0.00 | 0.69 |
| | | 14 to 16 yrs | -.84 | -0.34 | 0.00 | 0.06 |
| | 12 to 14 yrs | 6 to 8 yrs | .50 | .27 | 0.00 | 0.03 |
| | | 8 to 10 yrs | .39 | 0.24 | 0.00 | 0.10 |
| | | 10 to 12 yrs | .45 | 0.20 | 0.00 | 0.69 |
| | | 14 to 16 yrs | -.39 | -0.14 | 0.04 | 1.00 |
| | 14 to 16 yrs | 6 to 8 yrs | .90 | .40 | 0.00 | 0.00 |
| | | 8 to 10 yrs | .78 | .38 | 0.00 | 0.00 |
| | | 10 to 12 yrs | .84 | 0.34 | 0.00 | 0.06 |
| | | 12 to 14 yrs | .39 | 0.14 | 0.04 | 1.00 |

Trunk and Neck flexibility in male and female students- It was analysed and categorised age wise. The following table 6 represents the trunk and neck flexibility in males and females in the grades of fair, average and good according to different age category 6 to 8 years, 8 to 10 years, 10 to 12 years, 12 to 14 years, 14 to 16 years. Most of the students had good flexibility.

**Table 6:** Trunk and Neck flexibility in male students in the grades of fair, average and good according to different age categories

| | | | Age category | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 6 to 8 yrs | | 8 to 10 yrs | | 10 to 12 yrs | | 12 to 14 yrs | | 14 to 16 yrs | |
| | | | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
| Trunk Neck flexibility | Fair | Count | 5 | 9 | 5 | 3 | 0 | 1 | 0 | 0 | 0 | 15 |
| | | % within age cat | 2.10% | 3.40% | 3.10% | 1.40% | 0.00% | 0.90% | 0.00% | 0.00% | 0.00% | 1.70% |
| | Average | Count | 23 | 19 | 8 | 9 | 10 | 6 | 4 | 6 | 2 | 43 |
| | | % within age cat | 9.50% | 7.20% | 5.00% | 4.30% | 7.80% | 5.30% | 2.70% | 3.70% | 2.80% | 5.00% |
| | Good | Count | 213 | 235 | 146 | 199 | 119 | 107 | 144 | 157 | 69 | 800 |
| | | % within age cat | 88.40% | 89.40% | 91.80% | 94.30% | 92.20% | 93.90% | 97.30% | 96.30% | 97.20% | 93.20% |
| Total | | Count | 241 | 263 | 159 | 211 | 129 | 114 | 148 | 163 | 71 | 858 |
| | | % within age cat | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

In 6 to 8years, 2.1% males & 3.4% female had fair flexibility, 9.5% males & 7.2% female had average flexibility and 88.4% males & 89.4% female had good flexibility. In 8 to 10 years, 3.1% males & 1.4% female had fair flexibility,5% males & 4.3% female had average flexibility and 91.8% males 94.3% female had good flexibility.

In 10 to 12 years, 7.8% males & **5.3 %** female had average flexibility and 92.2% males and 93.9 % female had good flexibility.

In 12 to 14years, 2.7% males & 3.7% female had average flexibility and 97.3% males & 96.3% female had good flexibility.

In 14 to 16years, 2.8% males & 1.9% female had average flexibility and 97.2% males & 95.3% female had good flexibility.

Bag weight again was categorised age wise. 6 to 8 years students carried lightest weighted bags with a minimum of 1kg and maximum of 3 kg, while 14 to 16 years students carried a minimum of 2.8 Kg and a maximum of 5.9 Kg. Table 7 represents the bag weight in Males and Female in different age category.

**Table 7:** Weight of the bag carried by school Males and school Female in different age category.

| | Age Categories | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 to 8 yrs | | 8 to 10 yrs | | 10 to 12 yrs | | 12 to 14 yrs | | 14 to 16 yrs | | Total | |
| | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
| N | 241 | 263 | 159 | 211 | 129 | 114 | 148 | 163 | 71 | 107 | 748 | 858 |
| Mean | 2.32 | 2.41 | 2.30 | 2.30 | 2.50 | 2.56 | 3.28 | 2.76 | 4.55 | 4.54 | 2.75 | 2.74 |
| Std. Deviation | 0.72 | 0.98 | 1.45 | 0.74 | 0.75 | 0.76 | 3.45 | 0.95 | 0.74 | 0.75 | 1.89 | 1.11 |
| Minimum | 1.1 | 1 | 1 | 1 | 1.3 | 1.3 | 1.3 | 1.3 | 3 | 2.8 | 1.1 | 1 |
| Maximum | 4.2 | 3 | 8 | 4 | 3.8 | 3.8 | 3 | 5.3 | 5.8 | 5.9 | 8 | 5.9 |

Results of Anova test yielded a significant difference in the weight of bag carried by Male and female students. Further post hoc test also yielded a significant difference between the weight of the bags carried by male and female students in all age categories. Table 8 show the results of Anova test. Table 9 shows the results of Post hoc test used to differentiate in between the categories of age.

**Table 8**: Comparison of bag weight in Male and girl school students using Anova test

| | | Sum of Squares | | df | | Mean Square | | F | | Sig. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Males | Female | Males | Female | Males | Female | Males | Female | Males | Female |
| Bag wt. | Between Groups | 355.92 | 419.07 | 4 | 4 | 88.98 | 104.766 | 28.479 | 140.56 | 0 | 0 |
| | Within Groups | 2321.42 | 635.78 | 743 | 853 | 3.124 | 0.745 | | | | |
| | Total | 2677.34 | 1054.85 | 747 | 857 | | | | | | |

Correlation of kyphotic index with various factors like BMI, Abdominal endurance, right shoulder flexibility, left shoulder flexibility and Bag weight was carried out using Spearman's correlation test of analysis in different age groups.

In all 5 categories of age, i.e. 6 to 8 yrs, 8 to 10 yrs, 10 to 12 yrs, 12 to 14 yrs, and 14 to 16 yrs of males and female coefficient correlation of kyphotic index with factors like BMI, Shoulder flexibility and Bag weight is very poor and may be by chance. Thereby; ascertaining that thoracic kyphotic index does depend on these factors in young, adolescent children. Tables 9 to 13 show the values of correlation co-efficient of all the variables in the 5 groups categorised according to age.

**Table 9:** Correlation of kyphotic index with various factors like BMI, Abdominal endurance, Right shoulder flexibility, Left shoulder flexibility and Bag weight in age category of 6 to 8 years

| | | | Kyphotic index | BMI | Abdomen endurance | Flex RT Shoulder | Flex Lt Shoulder | Bag wt |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Kyphotic index | Correlation Coefficient | 1.000 | -.063 | -.003 | .035 | -.025 | -.035 |
| | | Sig. (2-tailed) | . | .156 | .940 | .434 | .577 | .435 |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |
| | BMI | Correlation Coefficient | -.063 | 1.000 | .056 | .017 | .044 | -.080 |
| | | Sig. (2-tailed) | .156 | . | .212 | .705 | .330 | .072 |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |
| | Abdomen endurance | Correlation Coefficient | -.003 | .056 | 1.000 | .371** | .309** | .123** |
| | | Sig. (2-tailed) | .940 | .212 | . | .000 | .000 | .006 |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |
| | Flex RT Shoulder | Correlation Coefficient | .035 | .017 | .371** | 1.000 | .380** | .090* |
| | | Sig. (2-tailed) | .434 | .705 | .000 | . | .000 | .043 |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |
| | Flex Lt Shoulder | Correlation Coefficient | -.025 | .044 | .309** | .380** | 1.000 | .054 |
| | | Sig. (2-tailed) | .577 | .330 | .000 | .000 | . | .228 |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |
| | Bag wt. | Correlation Coefficient | -.035 | -.080 | .123** | .090* | .054 | 1.000 |
| | | Sig. (2-tailed) | .435 | .072 | .006 | .043 | .228 | . |
| | | N | 504 | 504 | 504 | 504 | 504 | 504 |

Similarly, correlation coefficient values in all age groups showed a very poor correlation between kyphotic index and all the above mentioned factors. Table 10, 11, 12,1and 13 show the correlation coefficient values in all the age groups.

**Table 10:** Correlation of kyphotic index with various factors like BMI, Abdominal endurance, Right shoulder flexibility, Left shoulder flexibility and Bag weight in age category of 8 to 10 years

| | | | Kyphotic index | BMI | Abdomen endurance | Flex RT Shoulder | Flex Lt Shoulder | Bag wt |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Kyphotic index | Correlation Coefficient | 1.000 | -.009 | -.022 | .082 | -.022 | -.139** |
| | | Sig. (2-tailed) | . | .860 | .669 | .116 | .666 | .008 |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |
| | BMI | Correlation Coefficient | -.009 | 1.000 | .057 | .034 | .091 | .097 |
| | | Sig. (2-tailed) | .860 | . | .274 | .516 | .080 | .063 |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |
| | Abdomen endurance | Correlation Coefficient | -.022 | .057 | 1.000 | .441** | .463** | .002 |
| | | Sig. (2-tailed) | .669 | .274 | . | .000 | .000 | .975 |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |
| | Flex RT Shoulder | Correlation Coefficient | .082 | .034 | .441** | 1.000 | .505** | .012 |
| | | Sig. (2-tailed) | .116 | .516 | .000 | . | .000 | .813 |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |
| | Flex Lt Shoulder | Correlation Coefficient | -.022 | .091 | .463** | .505** | 1.000 | .012 |
| | | Sig. (2-tailed) | .666 | .080 | .000 | .000 | . | .825 |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |
| | Bag wt. | Correlation Coefficient | -.139** | .097 | .002 | .012 | .012 | 1.000 |
| | | Sig. (2-tailed) | .008 | .063 | .975 | .813 | .825 | . |
| | | N | 370 | 370 | 370 | 370 | 370 | 370 |

**Table 11:** Correlation of kyphotic index with various factors like BMI, Abdominal endurance, Right shoulder flexibility, Left shoulder flexibility and Bag weight in age category of 10 to 12 years

| | | | Kyphotic index | BMI | Abdomen endurance | Flex RT Shoulder | Flex Lt Shoulder | Bag wt |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Kyphotic index | Correlation Coefficient | 1.000 | -.058 | -.038 | .056 | -.001 | .048 |
| | | Sig. (2-tailed) | . | .364 | .555 | .384 | .987 | .461 |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |
| | BMI | Correlation Coefficient | -.058 | 1.000 | .061 | -.086 | -.043 | -.129* |
| | | Sig. (2-tailed) | .364 | . | .345 | .184 | .508 | .044 |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |
| | Abdomen endurance | Correlation Coefficient | -.038 | .061 | 1.000 | .424** | .447** | -.138* |
| | | Sig. (2-tailed) | .555 | .345 | . | .000 | .000 | .032 |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |
| | Flex RT Shoulder | Correlation Coefficient | .056 | -.086 | .424** | 1.000 | .527** | -.006 |
| | | Sig. (2-tailed) | .384 | .184 | .000 | . | .000 | .927 |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |
| | Flex Lt Shoulder | Correlation Coefficient | -.001 | -.043 | .447** | .527** | 1.000 | .012 |
| | | Sig. (2-tailed) | .987 | .508 | .000 | .000 | . | .848 |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |
| | Bag wt. | Correlation Coefficient | .048 | -.129* | -.138* | -.006 | .012 | 1.000 |
| | | Sig. (2-tailed) | .461 | .044 | .032 | .927 | .848 | . |
| | | N | 243 | 243 | 243 | 243 | 243 | 243 |

**Table 12:** Correlation of kyphotic index with various factors like BMI, Abdominal endurance, Right shoulder flexibility, Left shoulder flexibility and Bag weight in age category of 12 to 14 years

| | | | Kyphotic index | BMI | Abdomen endurance | Flex RT Shoulder | Flex Lt Shoulder | Bag wt |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Kyphotic index | 1.000 | .115* | -.008 | .053 | .086 | .001 | 1.000 |
| | | . | .043 | .887 | .349 | .129 | .986 | . |
| | | 311 | 311 | 310 | 311 | 311 | 311 | 311 |
| | BMI | .115* | 1.000 | .058 | -.026 | -.124* | -.024 | .115* |
| | | .043 | . | .308 | .653 | .029 | .671 | .043 |
| | | 311 | 311 | 310 | 311 | 311 | 311 | 311 |
| | Abdomen endurance | -.008 | .058 | 1.000 | .282** | .304** | .030 | -.008 |
| | | .887 | .308 | . | .000 | .000 | .601 | .887 |
| | | 310 | 310 | 310 | 310 | 310 | 310 | 310 |
| | Flex RT Shoulder | .053 | -.026 | .282** | 1.000 | .447** | .108 | .053 |
| | | .349 | .653 | .000 | . | .000 | .058 | .349 |
| | | 311 | 311 | 310 | 311 | 311 | 311 | 311 |
| | Flex Lt Shoulder | .086 | -.124* | .304** | .447** | 1.000 | .054 | .086 |
| | | .129 | .029 | .000 | .000 | . | .345 | .129 |
| | | 311 | 311 | 310 | 311 | 311 | 311 | 311 |
| | Bag wt. | .001 | -.024 | .030 | .108 | .054 | 1.000 | .001 |
| | | .986 | .671 | .601 | .058 | .345 | . | .986 |
| | | 311 | 311 | 310 | 311 | 311 | 311 | 311 |

**Table 13:** Correlation of kyphotic index with various factors like BMI, Abdominal endurance, Right shoulder flexibility, Left shoulder flexibility and Bag weight in age category of 14 to 16 years

| | | | Kyphotic index | BMI | Abdomen endurance | Flex RT Shoulder | Flex Lt Shoulder | Bag wt |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Kyphotic index | Correlation Coefficient | 1.000 | -.111 | .017 | .048 | .039 | .111 |
| | | Sig. (2-tailed) | . | .138 | .818 | .523 | .602 | .141 |
| | | N | 178 | 178 | 178 | 178 | 178 | 178 |
| | BMI | Correlation Coefficient | -.111 | 1.000 | -.015 | .034 | .109 | .071 |
| | | Sig. (2-tailed) | .138 | . | .841 | .648 | .149 | .343 |
| | | N | 178 | 178 | 178 | 178 | 178 | 178 |
| | Abdomen endurance | Correlation Coefficient | .017 | -.015 | 1.000 | .277** | .450** | -.046 |
| | | Sig. (2-tailed) | .818 | .841 | . | .000 | .000 | .538 |
| | | N | 178 | 178 | 178 | 178 | 178 | 178 |
| | Flex RT Shoulder | Correlation Coefficient | .048 | .034 | .277** | 1.000 | .232** | -.070 |
| | | Sig. (2-tailed) | .523 | .648 | .000 | . | .002 | .353 |
| | | N | 178 | 178 | 178 | 178 | 178 | 178 |
| | Flex Lt Shoulder | Correlation Coefficient | .039 | .109 | .450** | .232** | 1.000 | .073 |
| | | Sig. (2-tailed) | .602 | .149 | .000 | .002 | . | .332 |
| | | N | 178 | 178 | 178 | 178 | 178 | 178 |
| | Bag wt. | Correlation Coefficient | .111 | .071 | -.046 | -.070 | .073 | 1.000 |
| | | Sig. (2-tailed) | .141 | .343 | .538 | .353 | .332 | . |
| | | N | 178 | 178 | 178 | | | 178 |

## Discussion

In the present study, 1606 subjects were screened and assessed from 3 schools in Mumbai. This study aimed to find out kyphotic index and correlate it with various factors like flexibility, abdominal endurance, bag weight and BMI.

In previous studies, thoracic kyphosis was measured on chest radiographs of 316 normal subjects by means of a modification of the Cobb's technique for measuring scoliosis[10]. Also studies have been carried out to assess kyphotic angle using flexi curve in male school going

children[11]. The authors in this study assessed and calculated normative values for kyphotic index in school going children using flexi curve. The normative values for males and female were divided as per the age category.

**Kyphotic index in children**

From the results of the present study, statistically significant difference obtained between the kyphotic indices in male and female students can enable us ascertain that Kyphotic index cannot be generalised in children of different age group. Significant differences were obtained within 6 to 8 years students and in between 12 to 14 years and 14 to 16 years of male and female students.

Also, correlation of kyphotic index with abdominal endurance, flexibility, bag weight and BMI was found to be very poor and it was by chance. In previous studies abdominal endurance and flexibility was done in children and adolescent population which was found to be poor. Abdominal endurance has significance in young population as the abdominal muscles are the true stabilizers of spine which keep the spine in erect posture and prevent injuries related to spine, hence it can be concluded that the strength of the abdominal muscles is particularly important from functional and health reasons, which is important for people in both genders[12]

There are many studies that prove connection of the flexibility with better physical skills, reduced risk of injury, prevention or reduction of pain after exercise, improvement of the co-ordination. Thus poor flexibility can be the reason of subsequent injuries of tendons. Many evidences suggest that maintenance of the flexibility in the joints prevent or greatly removes the pain. Also studies have been done on body mass index in relation to motor fitness components in school going children involved in physical activities[13]. In the present study most of the students had good trunk and neck flexibility.

Correlation of abdominal endurance with Shoulder was found to be very poor and was may be by chance.

Previous studies were done to investigate the effects of postural discomfort on school children due to heavy school bag back pack. Results indicated that the prevalence of postural complaints among school going children was high[14] and there is prevalence of neck pain and back pain among school going children and postural pain was also related to weight of back-pack, number of sitting hours and Body Mass Index (BMI)[15].Another study was done to find the association of backpack weight and postural habits in school going children which concluded that backpack weight had some strong association with postural habits in the studied samples. The backpack weight carried by the school children was reported to be between 7.48% 16.83% of their body weight[16]. In this study, lower limit and upper limit of bag weight in school going children was found. The minimum bag weight is 1 kg and maximum is 8 kgs. Thus, the findings of the present study will help the health professionals to figure as to what extent the maximum weight of school bags have reached and the probable measures to reduce the bag pain related to school bags.

**Conclusion:** Normative values of kyphotic index differ with age and gender in children. Also, kyphotic index does not depend on factors like BMI, flexibility, abdominal endurance and bag weight.

**References**


1. Yadollah Zakeri, Shahram Baraz11, Mahin Gheibizadeh1 et al. - Relationship between Backpack Weight and Prevalence of Lordosis, Kyphosis, Scoliosis and Dropped Shoulders in Elementary Students, Article 6, Volume 4, Issue 6, June 2016.
2. Influence of the Weight of a School Backpack on Spinal Curvature in the Sagittal Plane of Seven-Year-Old Children- http://dx.doi.org/10.1155/2015/817913- https://www.hindawi.com/journals/bmri/2015/817913/ Med Research International, Volume 2015 (2015), Article ID 817913, 6 pages
3. Pamela k. Levangie and Cynthia C. Norkin, Joint structure and function (fifth edition)-first Indian edition 2012 copy right at 2011 by F.A. Davis
4. Rev. Bras. Fisioter, Sao Carlos, and Teixeira FA & Carvalho GA: Reliability and validity of thoracic kyphosis measurements using the flexi curve method, v. 11, n. 3, p. 173-177, May/ June 2007.
5. Tatiana Scheeren de Oliveira,1 Cláudia Tarragô Candotti,2 Marcelo La Torre,1, et al. Validity and Reproducibility of the Measurements Obtained Using the Flexi curve Instrument to Evaluate the Angles of Thoracic and Lumbar Curvatures of the Spine in the Sagittal Plane- Rehabilitation Research and Practice, Volume 2012 (2012), Article ID 186156, 9 pages, http://dx.doi.org/10.1155/2012/186156.
6. Martha R Hinman Flexicurve calculation for the index of kyphosis and lordosis index
7. https://www.researchgate.net/figure/8463558_fig2_Fig-2-Flexicurve-calculation-for-the-index-of-kyphosis-IK-and-index-of-lordosis-IL Aug 2004 · The Spine Journal.
8. Carleen Lindsey Flexicurve Spinal Measurement: Protocol For Clinical Assessment: Kyphosis And Lordosis geriatrictoolkit.missouri edu/flexicurve-spinal-measurement.doc
9. David.J.Magee, Orthopaedic Physical Assessment, chapter 9 lumbar spine, sixth edition, copyright @ 2014.
10. Victor. L. Katch, William. D. Mcardle, Frank.I.Katch, Essentials of Exercise Science 4th edition chapter17.physical activity, exercise, successful aging and disease prevention, copyright@ 2011.
11. GT Fon, MJ Pitt and AC Thies, Jr, Thoracic kyphosis: range in normal subjects- American Journal of Roentgen ology > Volume 134, Issue 5 > Thoracic Kyphosis: Range In Normal Subjects
12. Mohammad Bagher Shamsi, Korosh Veisi, Loghman Karimi, et.al- Normal Range of Thoracic Kyphosis in Male School Children, Hindawi Publishing Corporation ISRN Orthopaedics Volume 2014, Article ID 159465, 5 pages http://dx.doi.org/10.1155/2014/159465
13. Seryozha Gontarev and kalae ruzdija- flexibility and abdominal strength among Macedonian children and adolescents: eurofit protocol. AVAILABLE AT: www.isca.on.www.isca.me Received 3rd September 2014, revised 4th October 2014, accepted 17th October 2014
14. Sharma, R. and Nigam,A.K.-A study of body mass index in relation to motor fitness components of school going involved in physical activities.- journal of exercise science and physiotherapy, volume 7,number 1: 29-33,2011.

15. Avantika Rai and Shalini Agarwal- Assessing the effect of postural discomfort on school going children due to heavy backpacks' J. Ergonomics 2014, S4:011- http://dx.doi.org/10.4172/2165-7556.S4-011
16. Tomar, Ujjawal Singh; Gupta, Nalina. Indian Journal of Public Health Research & Development; Prevalence of Postural Pain among School Going Children in Meerut, India- A Cross Sectional Study- New Delhi 4.2 (Apr-Jun 2013): 264-268.
17. Shyamal Koley, Navneet Kaur- GuruNanakDev University,Amritsar,India Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University,- An Association of Backpack Weight and Postural Habits in School going children of Amritsar, Punjab ,India Article in Anthropologist April 2010.