

## Effects of Prolonged Sitting in Schools on Musculoskeletal Health of School Children in Delhi

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### Abstract

*Prolonged hours of sitting, including static posture, in school during school hours puts extreme physical stress on the muscles and ligaments. Since school children are expected to be in the classrooms for a long duration of four to six hours in a day and do most of the activities seated, it is imperative to observe and analyse the sitting posture musculoskeletal discomfort faced by children during the course of the school day. Also, to find out the incidence of musculoskeletal discomfort among them, the author chose to study a total of 450 students from five public schools of New Delhi. The results revealed that a significant percentage of school children experienced frequent body pain caused by forward bending postures and other awkward postures maintained during long hours of classroom activities. The result of these inappropriate sitting postures can sometimes lead to alteration in the shape of the body, muscle cramps, discomfort in the back and legs. These musculoskeletal problems highlight the need of further research to encourage appropriate sitting postures among school children.*

**Keywords:** *Static postures, musculoskeletal discomfort, prolonged sitting, forward bending posture, classroom activities.*

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### Introduction

School children devote a significant amount of their daytime in the classroom (four to six hours each day) carrying out different activities like sketching, colouring, reading, writing, and other related activities (Savanur et al., 2004).

The built environment in school should allow for ample space for each child to comfortably sit while performing classroom tasks. Not only this, the classrooms should also accommodate needs and requirements of different students by providing enough space in classroom or by providing adjustable furniture or by providing variety of furniture in terms of size of seat, depth of seat, under desk leg space, etc. (Pellegrini, 1995). Research studies have suggested that the built and

communal aspects of the environment in schools need to be connected and should not be dissected. Further, research studies have shown that the children are compliant to diverse surroundings, either by swapping their conduct (Ozdemir & Yilmaz, 2008) or by altering the surrounding (Catling, 2005; Kytta, Kaaja, & Horelli, 2004) at the price of the school authorities (Thomson, 2005).

Continuous sitting in a forward bending position places physical stress on the muscles, ligaments and on vertebral discs. (Bendix, 1987; Brunswic, 1984). For the prevention of musculoskeletal disorders experienced by students, it is important to maintain correct standing and sitting postures while sitting in classrooms. (Cranz, 2000). The human body does different physical movements like leaning forward in an upright position

supported by the vertebral column which has a multi-curved appearance and aligning the body parts around it, with its centre of gravity located in the lumbar region of the trunk. Also, a curvature in the neck region supports the front and back movements of the head. For giving space for the chest organs within the rib cage, and to counterbalance the hip, the vertebral column takes an 's' shape, with the upper thoracic and lower lumbar curvatures positioned opposite to each other (Chakrabarti, 1997).

This study draws from Keegan's work (1962) on body postures and movement who took a series of x-rays of people changing position from lying to standing and reported the major movements that occur in the lumbar section of the spinal column (Fig. 1a), to right angle sitting (Fig. 1c) and bent-over positions (Fig. 1c). Fig. 1b is the natural resting position, while sleeping on a side. The lumbar curve is retained, and the muscles are relaxed and well-balanced. A sitting posture which is the natural resting position (Fig 1d), is a more suitable position and allows the spine to carry the body weight in a more comfortable way. This is 'balanced seating.'

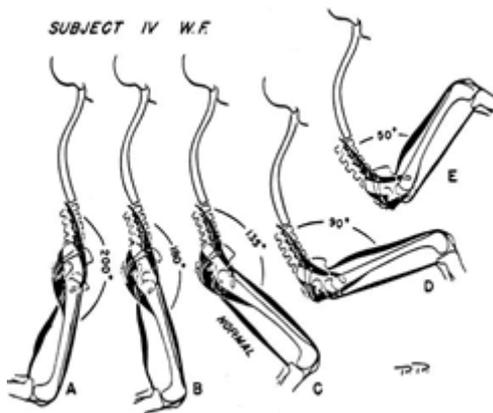


Fig. 1. Effects of altering the thigh-trunk angle in the lateral recumbent posture.

Source: Keegan JJ. Alterations of the lumbar curve related to posture and seating as cited in the Journal of Bone and Joint Surgery, 1953

Knight and Noyes (1999) also highlighted the significance of two different ways of sitting, i.e., going backward while relaxing or looking

at the board, and forward bending while reading or writing. Although the straight posture may look aesthetic but is possible to keep up this posture for one or two minutes and cannot be sustained for long periods. As a result, it leads to tiredness and pain, eventually causing an involuntary shift to bad posture.

In the sitting position, a forward leaning posture is most commonly adopted during writing, but it is also used for various other tasks too. School children spend approximately 80% of their classroom time in this forward leaning position at their desks, as writing tasks occupy most of their daily routine. (Hira, 1980).

By leaning their seats forward, school children prevent twisting their backs, letting the front and back muscles ease out so that they sit in a relaxed position.

Knight and Noyes (1999) also observed that the activities performed by children let them acquire different physical postures. High instances of uneasiness, especially in the neck and back are reported by various research studies for school children in schools. Such musculoskeletal symptoms often impair children's comfort and long term health, thereby affecting their performance in school. Researches have also shown that uncomfortable and inadequate sitting postures while sitting in classrooms are major contributors to children's musculoskeletal discomfort.

## Children and Health Disorders

Studies conducted to examine the effects of continuous sitting and uncomfortable postures in schools on health of children point out several repercussions – back, neck, lumbar and leg tiredness (Daneshmandi, Isanezhad, Hematinezhad, 2008); musculoskeletal spasms on their right hand, back, neck, right shoulders, right elbow and right wrist (A.I Musa, S.O. Ismaila and O.D. Akinyemi, 2011). It was found that school children experienced backache and 8 to 12 years age group experienced lesser lower

back pain in comparison to children of 13 to 14 years of age (Mierau, 1989, Troussier et al., 1994, Burton et al., 1996).

## Rationale of the Research Study

In the previous decade, interest in studying the sitting posture of school children based on the body mechanics has increased. School children are often seen spending their maximum time sitting in classrooms either forward leaning while writing and reading, or sitting pushing their back while listening to the teacher. School children who sit for prolonged hours are at a significantly increased risk of experiencing the adverse effects associated with poor sitting postures.

## Specific Objectives

- To identify the various activities that school children engage in during school hours, particularly those requiring prolonged sitting.
- To observe and analyse the sitting postures adopted by school children while performing different classroom activities.
- To assess the incidence of musculoskeletal discomfort among school children resulting from extended periods of sitting in the classroom.

## Methodology

### Selection of Locale and Sample

The research was conducted in five public schools selected from different regions of Delhi. Sample for the study consisted of both children and teachers. After identification of the schools, the researcher visited the schools, obtained permission from school authorities and selected 450 students and 50 teachers.

Systematic sampling method was employed to select the participants. Thirty students (15 boys and 15 girls) from Classes VI, VII, and VIII representing the age groups of 11, 12 and 13 years from each school were

selected randomly. Randomization was followed even for selecting the sections. This was done by picking random numbers. Through systematic sampling the first unit was chosen randomly, and subsequent units were selected at every fifth interval.

### Tools and Techniques of Data Collection

To fulfil the objectives of the study, the following tools and techniques of data collection were used:

- Classroom observation checklist was used to study the different activities school children were engaged in during the school hours, especially during sitting in the classroom. Physical observations were carried out by the researcher during the classroom hours. Video documentation was done for ease of data collection and to facilitate analysis of data.
- Questionnaire adopted from the standardized Nordic questionnaire for examination of musculoskeletal indications (Kuorinka et al., 1987) was employed to find out musculoskeletal discomfort experienced by children. The questionnaire included questions on experience of musculoskeletal aches in different body parts, degree of pain and frequencies of pain, etc. The questionnaire was administered to the students during physical education classes or during their arrangement classes for ease of the data collection.
- Questionnaire cum interview schedules were prepared for school children and teachers. A few open-ended questions were also incorporated in the questionnaire cum interview schedule for school teachers in order to find out their views regarding the comfortability of furniture in the classrooms.

## Results and Discussion

To study the effects of prolonged sitting among school children in schools, the results and discussion focus on the activity

pattern of school children that children engage in while seated in the classroom. As movement is an integral part of the young child's life and education, for it is through movement that children develop social, emotional, and cognitive skills. For this reason, the study also considers children's participation in physical activities outside the classroom. Postural stress is not only faced by school children while sitting or standing but also by the way they sit on classroom furniture, as incorrect postures may cause pain in various parts of the body. Therefore, forward bending while sitting has been analysed in relation to the musculoskeletal discomfort reported by students during school hours.

### Activity Pattern of School Children

The activity pattern of the children constituted the physical context for this study. In accordance, the first objective of the present study was to examine the

activity pattern of school children while seated in the classroom. The school authorities reported that children spend approximately six to seven hours per day in schools performing various activities, of these about six hours involved sitting for extended and continuous periods.

Regarding the activities performed by the school children while seated in the classroom, analysis indicated that listening to the teacher, reading, writing, crafts and drawing were some of the activities undertaken by them. The data showed that 82.9% of the school children were involved in reading activity, whereas 84.4% of them were involved in writing as classroom tasks. Moreover, 86.9% of school children reported actively listening to the teacher (Fig. 2). Apart from these activities, art and craft and certain other activities such as leisure reading, watching presentations on screen, quizzes, etc. were also found to be undertaken by the school children.

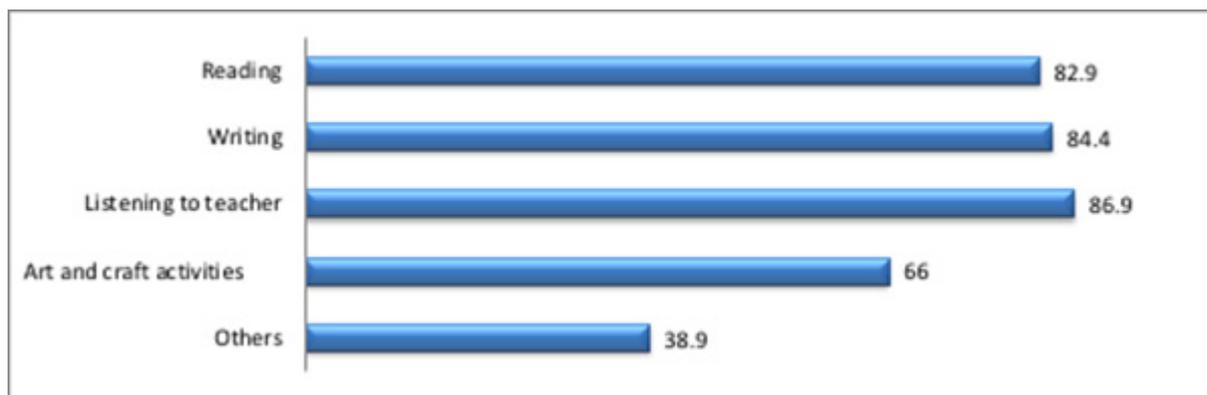


Fig. 2: Activities performed by children in the classroom

It was also observed that most of the children were seated while performing these activities. For conducting the activities, it is important for schools to have adequate classroom space as their immediate environment. It was further found that the children were performing these activities in a classroom environment that was not designed to support the activities they perform while seated. In spite of the significance of school spaces in the lives of children, lawmakers and school management overlook the needs

and demands of children while planning and constructing school environments (Hart, 2002; Matthews & Limb, 1999; Spencer & Wooley, 2000). When building the schools, children's spaces are often compromised by average design and construction standards (Catling, 2005; Collins & Colmen, 2008; Tanner, 2000). Similar situation was observed in the current study where there was an absence of ergonomically designed spaces for children in school classrooms. As also stated by Chakrabarti (1997)

proper space for children's movement in classrooms should be considered.

Analysis of the data further revealed that along with undertaking these compulsory activities, students participated in significant physical activities outside the classroom. These included outdoor games, athletics, cultural, yoga, karate, etc. The school administration reported that besides the academic activities, physical activities were also given due importance in the curriculum because physical activity is particularly essential for the good health and well-being of children. It was found that 86% of school children participated

in physical activities during school hours. This in-activity can pose several health-related risks among children as argued by several scholars (Twisk, J.W. et al., 1997). Data was further scrutinized for student's participation in physical activities both as per their age and gender. The analysis indicated that as far as gender was concerned, 52.9% girls and 47.1% of boys in 10-11 years age group, 48.7% girls and 51.3 % boys in the 12-13 years age group and 50.8% boys and 49.2% girls in >13 years age group were found to be taking part in physical activities outside the classroom (Table 1).

**Table 1 : Children's participation in physical activities outside the classroom (Age and Gender-wise comparisons)**

Participation in Physical Activities				
Age	Gender	Yes	No	Total
10-11 years	Boys	66 (47.1)	10 (52.6)	76(47.8)
	Girls	74 (52.9)	9 (47.4)	83 (52.2)
	Total	140 (100)	19 (100)	159 (100)
12-13 years	Boys	60 (51.3)	14 (56)	74 (52.1)
	Girls	57 (48.7)	11(44)	68 (47.9)
	Total	117 (100)	25 (100)	142 (100)
>13 years	Boys	66 (50.8)	9 (47.4)	75 (50.3)
	Girls	64 (49.2)	10 (52.6)	74 (49.7)
	Total	130 (100)	19 (100)	149 (100)
Total	Boys	192 (49.6)	33 (52.4)	225 (50)
	Girls	195 (50.4)	30 (47.6)	225 (50)
	Total	387 (100)	63 (100)	450 (100)

Note: Figures in parentheses represent percentage

On the whole when combining all age groups, 49.6% of boys reported participation in physical activities, while girls reported for 50.4%. This suggests a near equal number of distributions, however, a slightly higher percentage of boys (52.4%) reported not participating in physical activities compared to girls (47.6%). The slight decline in the participation in physical activities among girls could be attributed to biological and social factors, including discomfort and reduced interest following the onset of

puberty. Similar findings have been reported by Moitra et al, (2021) and Kumar and Shirley (2019) who identified significant gender differences in moderate to vigorous activity levels. In addition, national reports (Katapally, T.R., 2016, Bhawra, J., 2018) highlight that physical inactivity is linked to economic burden and presents a major public health challenge in developing countries such as India.

Hence, regular physical activity is important and must be employed from an early

age. It requires an integrated perspective from all sections, especially from health professionals, teachers and parents to impact the understanding, viewpoints and conduct of young people for physical activities (Rogol et al., 2000).

Research has also indicated that for children, physical activity and movement enhances fitness, fosters growth and development, and helps teach them about their world. Movement is a critical means of conveying, voicing, and studying in young children. It is pertinent for educators to give children as many chances as possible to be physically active in order to learn through movement (Nichols, 1994).

### Forward Bending Posture Adopted by Children

Another objective of the study was to observe and analyse the posture of school children

while they perform various activities while sitting in the classroom. To fulfil this objective the data was gathered through a structured questionnaire to enquire about the problems faced by children while maintaining posture, while sitting in the classroom.

The researcher observed that most of the school children were adopting a forward bending posture to read and write while sitting in the classroom. Mandal's (1981) reported that children take a natural relaxed back position was supported to some extent as it was found that 67.7% of school children were leaning forward while performing on the desk.

Age-wise comparison of the data showed that 34.8% in the 10-11 years age group, 32.8% in the 12-13 years age group and 32.5% of school children in the age group >13 years while doing sitting chores reported forward bending on the desk.

**Table 2: Forward bending posture adopted by children (n-450)**

Forward Bending posture while working on the desk	10-11 years	12-13 years	>13 years	Total
Yes	106 (34.8)	100 (32.8)	99 (32.5)	305 (67.7)
No	52 (36.1)	42 (29.2)	50 (34.7)	144 (32)
NR	1 (100)	0 (0)	0 (0)	1 (0.3)
Total	159 (35.3)	142 (31.5)	149 (33.1)	450 (100)

Note: Figures in parentheses represent percentage

Observational study suggested that children most often adopted forward-leaning postures which have been associated with back aches (Murphy et al., 2007). Bridger and Bendix (2004) suggested that pre-existing back pain is often exacerbated by poor seating positions.

Floyd and Ward (1969) considered the most common postural positions adopted in the classroom and observed that some children spent up to 80% of their time in a forward-slanting posture. Also, similar trend has been noted even in the present study, wherein 67.7% of school children were sitting on the

furniture in a forward-bending position.

### Children's Self-reported Pains while Seated in Classrooms

While sitting in the classrooms school children adopted various postures to perform different activities and often felt discomfort due to inadequate furniture design. In the present study children were asked to indicate any pain experienced by them in their body particularly while seated.

To obtain detailed information on the discomfort experienced by children while being in the classroom the students were

asked to indicate the pain felt by them in different body parts including the wrist joint, lower arm, upper arm, shoulder joint, lower leg, hip and knee joint and others. The results

tabulated in Figure 3 show the various body parts of children they reported having pain in while doing chores in the sitting position in the classrooms.

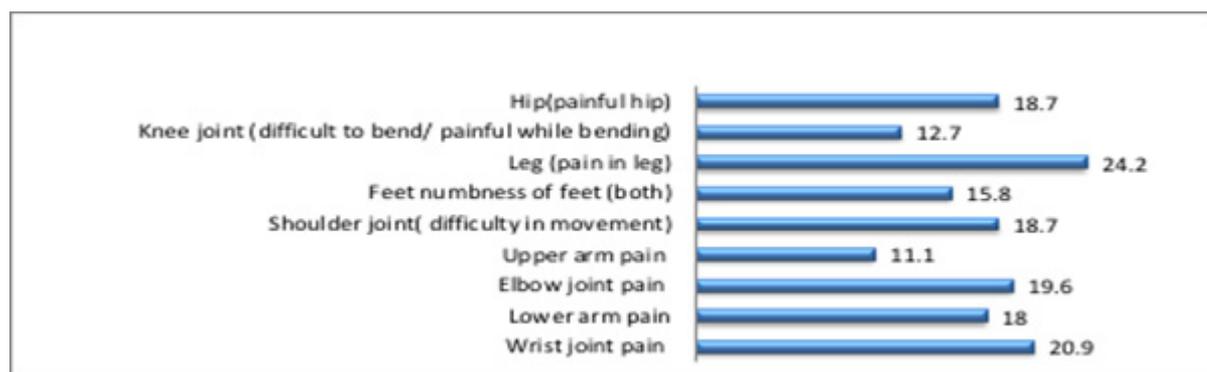


Fig. 3: Pain experienced by school children while working in class (n=450), only 'yes' responses (Multiple responses allowed)

Out of the total sample, 24.2% children experienced pain in leg, 20.9% in the wrist joint, 19.6% in the elbow joint, 18.7% in the hip, 18.7% in the shoulder joint, 18% in the lower arm, 15.8% reported feet numbness, 12.7% in the knee joint, and 11.1% in the upper arm.

Population based studies have revealed that the lifetime prevalence of musculoskeletal discomforts in children and adolescents ranged between 7 and 63% (Kovacs et al., 2003).

#### **Body Pains Experienced by Children (age-wise and gender-wise comparison)**

A standardized Nordic questionnaire for examination of musculoskeletal indications (Kuorinka et al., 1987) was employed which used body map a kind of pain drawings in which children had to mark the area where they felt pains. As the experience of pain is subjective, children's self-reports are considered valid and reliable tools for assessing body pain. A research study by Schott, 2010 also supports this view, wherein Pain Drawings (PDs) were used for respondents to mark the area or colour on

a standardised body chart for assessing the pain experienced by them. The results showed that a greater percentage of girls felt pain in the fingers, shoulder joints, wrists joints, elbow joints, knee joints, arms, thighs, and finger, shoulder joint, wrist joint, elbow joint, knee joint, arm, thighs and hips in the 10-11 years and 12-13 years age group. However, there was a decrease in reported pain among girls in the >13 years age group. As also can be seen from Table 3, girls from the age group of 10-13 years expressed more bodily discomfort than the girls of >13 years age group. This could be due to the physiological changes associated with puberty, which may increase bodily discomfort during this period.

The results also highlighted that more girls than boys reported pain in lower body parts such as thighs, lower legs, and feet (Table 3). This could be due to gender disparities as the bodily traits and biological features of males and females differ significantly. Males and females vary in their muscle strength as females generally have lower muscle strength than males, (Katzmarzyk et al., 1998).

**Table 3: Body pains experienced by children (n-450)**

Part of body experiencing pain	Boys				Girls				Total			
	10-11 Years	12-13 Years	>13 Years	Total (n-225)	10-11 years	12-13 Years	>13 years	Total (n-225)	10-11 years	12-13 years	>13 years	Total (n-450)
Fingers	35 (37.2)	37 (39.4)	22 (23.4)	94 (41.8)	34 (36.2)	36 (52.2)	24 (32.9)	94 (41.8)	69 (36.7)	73 (38.8)	46 (24.5)	188 (41.8)
Wrist joint	28 (40.6)	27 (39.1)	14 (20.3)	69 (30.7)	33 (42.3)	36 (59)	9 (14.3)	78 (34.7)	61 (41.5)	63 (42.9)	23 (15.6)	147 (32.7)
Arm	23 (35.4)	30 (46.2)	12 (18.5)	65 (28.9)	30 (43.5)	28 (52.8)	11 (19)	69 (30.7)	53 (39.6)	58 (43.3)	23 (17.2)	134 (29.8)
Elbow joint	27 (41.5)	27 (41.5)	11 (16.9)	65 (28.9)	29 (42)	32 (57.1)	8 (13.6)	69 (30.7)	56 (41.8)	59 (44)	19 (14.2)	134 (29.8)
Shoulder joint	29 (38.7)	32 (42.7)	14 (18.7)	75 (33.3)	30 (39)	35 (59.3)	12 (17.9)	77 (34.2)	59 (38.8)	67 (44.1)	26 (17.1)	152 (33.8)
Feet	25 (39.7)	27 (42.9)	11 (17.5)	63 (28)	30 (40.5)	31 (56.4)	13 (22.4)	74 (32.9)	55 (40.1)	58 (42.3)	24 (17.5)	137 (30.4)
Lower leg	27 (39.1)	28 (40.6)	14 (20.3)	69 (30.7)	31 (39.7)	30 (51.7)	17 (29.3)	78 (34.7)	58 (39.5)	58 (39.5)	31 (21.1)	147 (32.7)
Knee joint	26 (38.8)	25 (37.3)	16 (23.9)	67 (29.8)	30 (42.9)	31 (55.4)	9 (16.1)	70 (31.1)	56 (40.9)	56 (40.9)	25 (18.2)	137 (30.4)
Thighs	19 (33.3)	25 (43.9)	13 (22.8)	57 (25.3)	27 (38)	34 (73.9)	10 (16.9)	71 (31.6)	46 (35.9)	59 (46.1)	23 (18)	128 (28.4)
Hip	20 (31.3)	28 (43.8)	16 (25)	64 (28.4)	29 (42.6)	27 (55.1)	12 (21.8)	68 (30.2)	49 (37.1)	55 (41.7)	28 (21.2)	132 (58.7)
Neck	27 (37)	31 (42.5)	15 (20.5)	73 (32.4)	36 (40.9)	36 (57.1)	16 (23.9)	88 (39.1)	63 (39.1)	67 (41.6)	31 (19.3)	161 (71.6)

Note: Figures in parentheses represent percentage. Percentages have been calculated for yes responses in the particular age group.

On further comparing the three age groups, it was found that the maximum percentage of pain in body parts was felt by children of the 12-13 years age group. This showed that the pain prevalence in body parts increased as children progressed from 10-11 to 12-13 years. This could be due to pubertal changes and the corresponding increase in anthropometric measures as they grew older. The pain experienced by school children decreased among children in the >13 years age group. This may be because, as they grew older, they became accustomed to classroom furniture and made adjustments, albeit potentially comprising their posture. It was found that among the total sample, the highest percentage of pain was reported in the elbow joint (41.8%) for the 10-11 years

group, in the thighs (46.1%) for the 12-13 years group, and in the lower leg (21.1%) for the >13 years group.

### Back Pain Reported by School Children

A total of 14.1 % of school children reported 'always' having back pain, whereas 46.4% school children reported having back pain 'sometimes' during the day (Table 4). On the other hand, 39.5% never had any back pain while seated. Further, analysis showed significant differences among the children of 10-11 years, 12-13 years and >13 years age group. This is of significant worry taking care of the comparatively young age of the respondents (10-13 years).

**Table 4: Frequency of back pain experienced by child\ (n (age wise comparison) n-450**

Back pain	10-11 years	12-13 years	>13 years	Total	$\chi^2$ value	Sig
Always	16 (25.3)	29 (46.03)	18 (28.5)	63 (14.1)	12.947	.012*
Sometimes	71 (34)	58 (27.8)	80 (38.3)	209 (46.4)		
Never	72 (40.4)	55 (30.9)	51 (28.7)	178 (39.5)		
Total	159 (35.3)	142 (31.6)	149 (33.1)	450 (100)		

Note: Figures in parentheses represent percentage, \*significant at .05 levels

Gender-wise comparison of back pain experienced by school children showed that 49.2 % of boys and 50.8% girls were hurt from back pain. Further, it was seen that a greater percentage of girls reported 'always' having back pain than boys of 10-11 years (53.8% of girls and 46.2% of boys) and 12-13 years age group, i.e. 53.6% of girls and 46.4% of boys. Contrary to this, more boys, i.e. 55.6% of boys and 44.4% of girls reported back pain in >13 years age group (Fig. 4).

An increase in back pain was prominent in girls from 10 to 13 years, whereas >13 years age group, greater percentage of boys reported having back pain. This might be due to sudden transition in their stature from 6th to 7th grade and greater percentage of

boys participating in sports. These findings are in conformity with the studies, wherein it was reported that a greater possibility of back pain had been related with a high level of physical exercise (Balague et al., 1995; Kujala et al., 1999; Jones et al., 2003).

Lebouf-Yde and Kyvik (1998) suggested that premature onset of puberty can be a feasible cause for increased account of back ache among females. On the other hand, Balague et al., (1995) speculated that the traditional image of the male cause boys to downplaying their back ache while Salminen (1984) suggested that boys may repudiate their back ache signs and subsist or agonize about their symptoms less (Salminen et al., 1992).

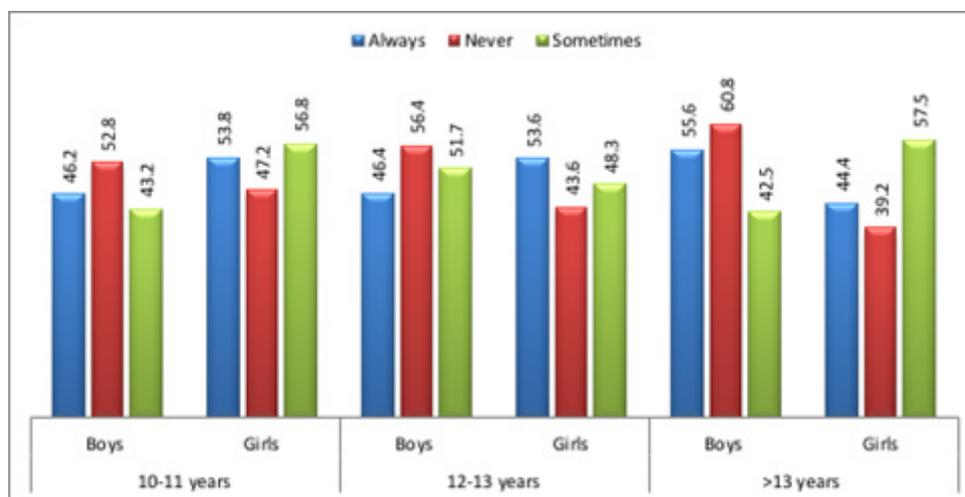


Fig. 4: Back pain experienced by school children (gender-wise and age-wise comparison)

The amalgam of bad posture and poor seating integrated with long span of

stillness can lead to the cause of lower back pain (Genaidy, 1993, Moore et al., 1992).

## Neck Pain Experienced by School Children

Neck pain was experienced by school children, followed by other pains as reported by earlier findings. A higher percentage of boys reported having 'always' than girls for all the three age groups, i.e. 60% of boys and 40% of girls from 10-11 years, 58.6% of boys and 41.4% of girls from 12-13 years, 60% of boys and 40% of girls from >13 years, 60% of

boys and 40% of girls from >13 years (Fig. 5). The greater percentage of boys reporting neck pain could be because of their higher stature measurements in comparison to girls and hence, they had to adopt a forward leaning posture. As per Murphy et al. (2007) when school children feel discomfort for a continuous span of time, they may have to take on bended or static postures thus causing muscular tiredness in the neck.

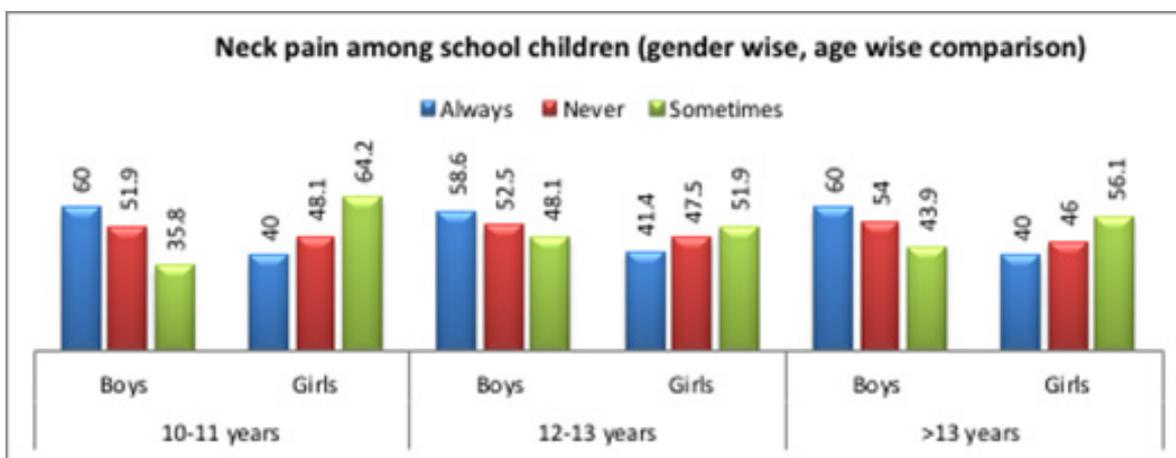


Fig 5: Neck pain among school children (age-wise and gender wise)

School children's sitting posture might be the principal factor that impacts musculoskeletal disorder (MSD). The cause of MSD can also be varied in nature (Chiang et al., 2006). It was found that in boys there is a greater occurrence of musculoskeletal pain than in girls. This could be due to gender disparities as the bodily traits and biological characteristics of boys and girls are different. Mandal (1982) in his research described that 60% of school children while sitting in classrooms accounted for pains in back, neck or shoulder. Salminen et al., (1992) also reported that low back pain was due to an unsuitable school table.

## Conclusion

School is an institution that serves as a second environment after home, designed to enhance children's learning. During their growing years, children spend about a quarter of their day at school, with

approximately 80% of this time spent sitting while performing various activities. Considering the amount of the time spent at school and specifically while sitting, it is essential that school furniture be suitable for the children's physical needs (Savanur et al., 2007) and should support changing postures (Yeats, 1997). A conducive and comfortable classroom environment motivates the students to perform better and encourages the learning process. School work requires them to sit for extended periods of time (Freudenthal et al., 1991; Knight and Noyes, 1999).

During growing years, children undergo many changes that are anatomical, physiological, and psychological in nature. Further school children's stationary and forward-leaning postures place considerable physiological strain on muscles, ligaments, and especially on the vertebral discs. Accurate standing and sitting posture is a primary factor in

preventing musculoskeletal symptoms among children.

Poor posture can be a starting point for fatigue, strain, pain and may result in structural distortion of the body, with muscle cramps, pain in the back and legs, reduced lung capacity, poor circulation, kinks in the bowel and many non-uniformities in the function of the body. The human body is designed to be in motion and the advantages of sitting can only be attained through good posture and exercise.

During the past decade, studies for school children have generated a lot of interest in maintaining their sitting posture based on the biomechanics of the human body. However, relatively little attention has been given to the largest workplace of all – the school. School children are at special risk of suffering from the ill effects of poor postures acquired during prolonged seated periods at school. Hence, more research studies need to be conducted to promote awareness to bring changes in the school environment for the benefit of the children.

## References

- Balague, F., M. L. Skovron, M. Nordin, G. Dutoit, L. R. Pol, M. Waldburger (1995). Low back pain in school children: a case study of familial and psychological factors. *Spine*, 20, pp. 1265-1270.
- Bendix, T. (1987). Adjustment of the seated workplace with special reference to heights and inclinations of seat and table. *Danish Medical Bulletin*, 34 (3), pp. 125-139.
- Bhawra, J., Chopra, P., Harish, R., Mohan, A., Ghattu, K.V., Kalyanaraman, K. and Kotapally, T.R. (2018). Results from India's 2018 report card on physical activity for children and youth. *Journal of Physical Activity and Health*, Vol. 15(s2), pp.S373-S374. doi: 10.1123/jpah.2018-0475.
- Bridger, B. and Bendix, T. (2004). Pelvis and neighbouring segments. In N. J. Delleman, C.M. Haslegrave, and D. B. Chaffin (Eds.), *Working Postures and Movements: Tools for Evaluation and Engineering*. Boca Raton, FL: CRC Press, pp. 168-188.
- Brunswic, M. (1984). Ergonomics of seat design. *Physiotherapy*, 70 (2), pp. 40-43.
- Burton, A.K., Clarke, R.D., McClune, T.D., and Tillotson, K.M. (1996). The natural history of low back pain in adolescents. *Spine*, 21, pp. 2323-8.
- Catling, C. (2005). Children's personal geographies and English primary school and town curriculum. *Children's Geographies*, 3, pp. 325-344.
- Chakrabarti, D. (1997). *Indian Anthropometric Dimensions*. National Institute of Design Publishers Ahmedabad, pp. 96-101,106, 123-129.
- Chiang, H.Y., Karen Jacobs, Gael Orsmond (2006). Gender age environmental associates of middle school students' low back pain. *Work*, 26(2), pp. 197-206.
- Collins, D. and Coleman, T. (2008). Social geographies of education: looking within, and beyond, school boundaries. *Geography Compass*, 2(1), pp. 281-299.
- Cranz, G. (2000). The Alexander technique in the world of design: posture and the common chair. *Journal of Bodywork Movement Therapy* 4 (2), pp. 90-98.
- Daneshmandi, H.I., Isanezhad, A., and Hematinezhad, M. (2008). The effects of classroom furniture on back, neck, lumbar and leg fatigue in student. *Journal of Movement Sciences & Sports - Special Issue, No 1*, pp. 37-44.
- Floyd, W.F., Ward, J.S. (1969). Anthropometric and physiological considerations in school, office and factory seating. *Ergonomics* 12, pp. 132-139.
- Freudentjal, A., Riel, M., Molenbriek, J., Sindere, C. (1991). The effect on sitting posture of a desk with a ten-degree inclination using an adjustable chair and table. *Applied Ergonomics*, 22 (5), pp. 329-336.

- Genaidy, A.M., Waly, S.M., Khali, T.M., and Hidalgo, J. (1993). Spinal compression tolerance limits for the design of manual material handling operations in the workplace. *Ergonomics*, 36(4), pp. 415-434.
- Hart, R. (2002). Containing children: some lessons on planning for play from New York city. *Environment and Urbanization*, 14 (2), pp. 135-148.
- Hira, D.S. (1980). An ergonomic appraisal of educational desks. *Ergonomics* 23 (3), pp. 213-221.
- Jones, G.T., Watson, K. D., Silman, A.J., Symmons, D.P.M., Macfarlane, G.J. (2003). Predictors of low back pain in British school children: a population-based prospective cohort study. *Pediatrics* 111(4), pp. 822-828.
- Katzmarzyk, P.T., R.M. Malina, T.M. Song and C. Bouchard (1998). Television viewing, physical activity and health-related fitness of youth in the Quebec family study. *Journal of Adolescent Health*, 23(5), pp. 318-325.
- Katapally, Tarun Reddy, Shifalika Goenka, Jasmin Bhawra, Subha Mani, Ghattu V Krishnaveni, Sarah Helen Kehoe, Anjana Sankhil Lamkang, Manu Raj, Kathleen McNutt (2016). Results from India's 2016 report card on physical activity for children and youth. *Journal of Physical Activity and Health*, 13(s2), pp.S176-S182. doi: 10.1123/jpah.2016-0393.
- Keegan, J.J. (1953). Alterations of the lumbar curve related to posture and seating. *Journal of Bone and Joint Surgery*, 35A, pp. 589-603.
- Keegan, J.J. (1962). Evaluation and improvement of seats. *Industrial Medicine and Surgery*, 31 (4) (1962), pp. 137-148.
- Knight G. and Noyes J. (1999). Children's behavior and design of school furniture. *Ergonomics*, Vol. 42(5), pp. 747-760.
- Kovacs, Francisco,M; Gestoso, Mario; Gil del Real, María Teresa; López, Javier; Mufraggi, Nicole; Ignacio Méndez, José (2003). Risk factors for non-specific low back pain in schoolchildren and their parents: a population based study. *Pain* 103(3), pp. 259-268.
- Kujala, U.M., Taimela S., Viljanen T. (1999). Leisure physical activity and various pain symptoms among adolescents. *British Journal of Sports Medicine*, 33, pp. 325-328.
- Kumar S.S., Shirley, S.A.(2019). Association of screen time with physical activity and BMI in middle school children at Tamil Nadu, India. *International Journal of Contemporary Pediatrics*, 7(1), pp.78-83. doi: 10.18203/2349-3291.ijcp20195730.
- Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Sorensen, F.B., Andersson, G., Jorgensen, K. (1987). Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics* 18 (3), pp. 233-237.
- Kytta, M., Kaaja M., & Horelli L. (2004). An internet-based design game as a mediator of children's environmental visions. *Environment and Behavior*, 36(1), pp.127-51.
- Leboeuf-Yde, C., Kyvik, K.O. (1998). At what age does low back pain become a common problem? A study of 29,424 individuals aged 12-41 years. *Spine* 23(2), pp.228-234.
- Mandal, A.C. (1981). The seated man (Homo Sedens) the seated work position. Theory and practice. *Applied Ergonomics*, 12(1), pp. 19-26.
- Mandal, A.C. (1982). The correct height of school furniture. *Human Factors*,24, pp. 257-369.
- Matthews, H., and Limb, M. (1999). Defining an agenda for the geography of children: review and prospect. *Progress in Human Geography*, 23 (1), pp. 61-90.
- Mierau, D., Cassidy, J.D., & Young-Hing, H. (1989). Low back pain and straight leg raising in children and adolescents. *Spine*, 14, pp. 526-528.
- Moitra, P., Madan, J., Verma, P. (2021). Independent and combined influences of physical activity, screen time, and sleep quality on adiposity indicators in Indian adolescents. *BMC Public Health*, 21(1):2093. doi: 10.1186/s12889-021-12183-9.
- Moore, B., Dorrel, S.S., Halpern, C.A., Fernandez, J.E., (1992). The ergonomic evaluation of several chairs: a case study. *Advances in Industrial Ergonomics and Safety IV*. Taylor & Francis, London, pp. 267-274.

- Murphy, S., Buckle P., Stubbs, D. (2007). A cross-sectional study of self-reported back and neck pain among English schoolchildren and associated physical and psychological risk factors. *Applied Ergonomics* 38(6), pp. 797-804.
- Musa, A.I, Ismaila, S. O., S. Adejuyigbe, B. and Akinyemi, O.D. (2011). Ergo-effects of designed school furniture and sitting positions on students' behaviour and musculo-skeletal disorder in Nigerian tertiary institutions. *Management Science Letters* 1, pp. 331-334.
- Nichols, B. (1994). *Moving and learning: The Elementary School Physical Education Experience*. St. Louis, Missouri: Mosby-Year Book, Inc.
- Ozdemir, A. & Yilmaz O. (2008). Assessment of outdoor school environments and physical activity in Ankara's primary schools. *Journal of Environmental Psychology*, 28 (3), pp. 287-300.
- Pellegrini, A. D. (1995). *School recess and playground behavior: Educational and developmental roles*. Albany: State University of New York Press.
- Rogol, A.D., Clark, P.A., Roemmich, J.N. (2000). Growth and pubertal development in children and adolescents: effects of diet and physical activity. *American Journal of Clinical Nutrition*, 72, pp. S521-8.
- Salminen, J.J. (1984). The adolescent back. A field survey of 370 Finnish school children. *Acta Paediatrica Scandinavica*, 73 (Suppl. 315), pp. 1-122.
- Salminen, J.J., Pentti J. and Terho P. (1992). Low back pain and disability in 14-year-old school children. *Acta Paediatrica Scandinavica*, 81, pp. 1035-1039.
- Savanur, C. S., Ghosh, S., Dhar, U. and De, A. (2004). An ergonomic study of comparison between school classroom furniture and students' anthropometry. *Proceedings of National Conference on Humanizing Work and Work Environment*, National Institute of Industrial Engineering, April, Mumbai.
- Savanur, C. S., Altekar, C. R. and De, A. (2007). Lack of conformity between Indian classroom furniture and student dimensions: proposed future seat/table dimensions. *Ergonomics*, 50(10), pp. 1612-1625.
- Schott, G.D. (2010). The cartography of pain: the evolving contribution of pain maps. *European Journal of Pain*, 14 (8) (2010), pp. 784-791
- Spencer, C. and Woolley H. (2000). Children and the city: a summary of recent environmental psychology research. *Child: Care, Health and Development*, 26(3), pp. 181-198.
- Tanner, C. K. (2000). The influence of school architecture on academic achievement. *Journal of Educational Administration*, 38(4), pp. 309-330.
- Thomson, S. (2005). "Territorialising" the primary school playground: deconstructing the geography of playtime. *Children's Geographies*, 3(1), pp. 63-78.
- Troussier, B., Davoine, P., De Gaudemaris, R., Fauconnier, J., Phelip, X. (1994). Back pain in school children. A study among 1178 pupils. *Scandinavian Journal of Rehabilitation Medicine*, 26 (3), pp. 143-146.
- Twisk, J.W., Kemper, H.C, van Mechelen, W, Post, G.B. (1997). Tracking of risk factors for coronary heart disease over a 14-year period: a comparison between lifestyle and biologic risk factors with data from the Amsterdam Growth and Health Study. *American Journal of Epidemiology*, 145, pp. 888-98.
- Yeats, B. (1997). Factors that may influence the postural health of schoolchildren. *Occupational Health and Industrial Medicine*, Vol.37, No 4, pp. 156-156 (1).