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Change in cervical range of motion of school students using inclined desk vs. flat desk

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ABSTRACT

INTRODUCTION: It is estimated that school kids spend an average of 10 hours a day sitting down. Unfortunately ergonomics, the design of the right work and studying environment, is largely ignored for kids. A chair is important for good posture, but when task like reading and writing are involved, the height and inclination of desk or table plays a dominant role. The study was conducted with the aim to find the change in cervical range of motion in school students using inclined desk vs. flat desk for at least 5yrs. **MATERIALS & METHODS**: The study had 75 sample of age group between 14 to 18 years amongst which 35 subjects were using flat desk since 5 yrs and. the rest of 40 subjects belonged to the group using 10 degree inclined desk. Their cervical range of motion (flexion, extension, right lateral flexion and left lateral flexion) using goniometer and inch tape method. **DATA ANALYSIS & RESULTS:** cervical ranges of motion (flexion, extension, right lateral flexion, left lateral flexion) were compared in two groups with Z-test as a statistical test in order to justify the null Hypothesis of the study. Students using flat desk were found to have more restricted cervical range of motion than inclined desk users. **DISCUSSION & CONCLUSION:** Students using flat desk top tend to slouch more on the table top while reading and writing. The implementation of ergonomically designed adjustable inclined desk for the school students in their pre-adolescent age is beneficial over the traditional usage of flat desk. The desk height and the degree of inclination should be adjustable according to the need of the individual.

Key Words: Cervical spine, Neck pain, Goniometry, Desk inclination.

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INTRODUCTION

"The most universal physical occupation of civilized human beings is sitting" Surprisingly, high proportion of school students report suffering from musculoskeletal discomfort. This is of great concern because the strongest predictor of having future spinal pain is often considered to be a previous history of such symptoms. Thus, it is important to determine contributory risk factors amongst school students.

It is estimated that school kids spend an average of 10 hours a day sitting down. Unfortunately ergonomics, the design of the right work and studying environment, is largely ignored for kids, although it is given due consideration for adults these days. So for healthy development of children, it is important that the desk and chair can keep pace with their growth.

A chair is important for good posture, but when task like reading and writing are involved, the height and inclination of desk or table plays a dominant role. Despite good chairs, posture with back bent, sagging or twisted can be observed. Problems arrive when such an extreme posture is maintained for long periods of time. However, reading with the trunk upright requires a sharp bent at CERVICAL SPINE, which can not be sustained for long time.

The spine of a newborn infant has none of the adult physiologic curves, i.e. it is in total flexion (kyphosis). The first lordotic curve of vertebral column is noted in the cervical region during first six or eight weeks of life. At this stage of development the newborn extends his or her head from the prone position. The posture of acquired habit has been considered a neuromuscular phenomenon that has its inception in early childhood. The acquired posture is also influenced by daily activities that demand a forward head posture.

There exists a substantial degree of mismatch between the size of the furniture and the anthropometric data of its user. For children between 7 to 12 yrs of age, the chair is too high and too deep and the table is too high. On the other hand, in the age group 12 to 18 yrs, it is found that the smallest student had the best fit. Taller students had more risk of developing spinal pain.

Muscles habitually kept in a stretched position beyond the physiologic resting position tend to weaken. This is known as ***stretch weakness.***

Muscles habitually kept in a shortened position tend to lose their elasticity. These muscles test strong in the shortened position but become weak as they are lengthened. This is known as ***tight weakness.*** Kisner and Colby state that this adaptive shortening of soft tissues and muscle weakness, caused by prolonged poor postural habits is considered to be a ***postural dysfunction*** *(1).* Stress to the shortened structures causes pain, and strength and flexibility imbalances may predispose the area to injury or overuse syndromes that a normal musculoskeletal system could sustain. Good postural habits are necessary to avoid postural dysfunctions.

It is hypothesized that if a student uses a flat desk for long reading and writing hours there is constant neck flexion which keeps the extensors in stretched position beyond the physiologic resting position. This may result in stretch weakness. The other study reveals that constant eccentric loading of cervical extensors could help improve their strength. Thus, the study is planned to find the variation in cervical range of motion in the school students using flat desk vs. those using inclined desk.

If musculoskeletal discomfort during computer use or long hours of desk work is a predictor of adults' musculoskeletal disorders then students need to learn how to protect themselves from injuries as they start their desk work. Also, if a common risk behavior in adults : poor seated postures for extended periods of time becomes a well-established habit at an early age, it is difficult to break in adulthood. A seated posture does not only depend on individual's sitting habit but also on work station and task design.

Work performance are seriously affected by musculoskeletal and visual concerns in adults, we don't know their effect on students' performance. Cardon have shown that a back prevention program in elementary school is effective in teaching back care principles. We need similar programs educating students in ergonomic principles also. Hopefully adjusting their workstation may ensure healthy posture and sound working habits.

With the aim to find the change in cervical range of motion in school students using inclined desk Vs. flat desk for at least 5yrs the study was conducted.

HYPOTHESIS

Null hypothesis: There is no significant difference in cervical range of motion between flat desk and inclined desk users.

Alternate hypothesis: There is significant difference in cervical range of motion between flat desk and inclined desk.

AIMS AND OBJECTIVES

- To determine if the inclination has an effect on individual's cervical range of motion.
- To draw a comparison between the effect of flat desk and 10° inclination desk on cervical range of the individual.
- To observe frequency of pain incidence in the students using different inclination of desk.

REVIEW OF LITERATURE

While sitting, our bodies have to fight gravity. A rigid sitting posture is manageable for a limited time. However, an exclusively static posture can lead to mental and physical impairment due to poor oxygen supply. This causes "The School Headache." The sitting discomfort is aggravated when a child has to work at a table or desk with a horizontal top. The child's back is noticeably rounded and their head is bent back in order to attain the necessary spacing between the eyes and the project at hand [2].

A common reason for adults to sit for long periods of time in poor postures is when using computers [3]. Healthy computer use involves good workstation design features such as appropriate fit of body size to chair and desk height, screen angle and height, and keyboard arrangement, as well as the amount of time spent at the computer. Extended computer use has thus been proposed as a reason for adult back pain [4,5].Computer use is increasingly common among high school students around the world, although whether it constitutes a risk for adolescent back pain has not been established [6,7].

According to a study held in Department of Physical and Rehabilitation Medicine, University Hospital of Turku, the occurrence of neck pain at least once a month was 21.3 and 43.4% and at least once a week was 6.3 and 19.4%. Sex difference was found only at the 4-year follow-up, when subjects were 13–16-year-old. Neck pain was then more common among girls than boys (P<0.001). The intensity of pain increased with the frequency of pain (P<0.001). This study strengthens the results of the previous cross-sectional studies that occurrence of neck pain increases with age, and that neck pain becomes more common among girls than boys in adolescence. Among preadolescents who were originally pain-free, there was only a small proportion who reported frequent neck pain at both 1 and 4 years [8]. Twenty-seven percent of children reported having neck pain, 18% reported having upper back pain, and 22% reported having low back pain. Sam Murphy et al states that the upper back pain was associated with school bag weight (3.4–4.45 kg), school furniture features, emotional problems and previous treatment for musculoskeletal disorders [9]. In 2004 he stated that static postures were also associated with neck and upper back pain [10]. The study conducted by Niemi SM concluded that 21% of girls and 10% of boys suffered from disturbing neck and shoulder symptoms. [11]

The students flexed their head, neck and trunk more forwards compared to the other types of furniture whilst writing. This can be explained by the 15° inclined desktop. Other research with adults found that a horizontal desk resulted in a forward bent position of the neck with the highest muscular loads [12]. The study conducted by M. De Wall stated that on average, the position of the head in the sagittal plane is 6 degrees more erect and the position of the trunk 7 degrees more erect when working at a desk with a 10 degree inclination than when working at a flat desk. The maximal decrease in load observed on the cervical spine was 35% and on the thoracic spine 95% [13]. Reading with the trunk upright requires a sharp bend in cervical spine, which can't be sustained for long time. Furthermore, in this position the reading distance in more than 25 to 35 cm. Consequently, children and adult always bend

forward with curved spine over the table. In forward bend posture of trunk and head, considerable muscle force is needed [14].

M. Marschall et al stated that subjects demonstrate less neck flexion (mean 34.4) when seated on ergonomically designed work station as compared to traditional work station (neck flexion 38.7). It was concluded that use of the ergonomic work station could assist in maintaining a more efficient anatomical alignment of young children when sitting and writing [15]. With a sloped table of 10° the head and trunk showed a more upright posture whilst reading and writing .The load on the back decreased with 29% and on the neck with 21% because of a lower gravitational moment. This inclination is easy to use whilst reading and is not an inconvenience when writing. Pens and paper do not slide down. In the study the decrease in head tilt was 10°, in neck flexion 8-9°. The trunk remained 4° more upright. This is similar to earlier findings [16]. Larger inclination had no effect on the trunk angle and a relatively low effect on the neck . Schoolchildren strongly preferred an inclined table top independently of the height of the furniture. The slope should be adjustable between 0° and 20°. This makes it still possible for children to work together in groups with flat tables [12].

The question of work surfaces for special purpose arises is relation to school desk and tables where much reading and writing are carried on. Eastman and Kamon (1976) made a contribution to this problem. Inclination of the body (measure an angle between the horizontal plane and straight line from the twelfth thoracic vertebrae to eye) were as follows:

Horizontal table : 35-45

Table sloped 12 : 37-48

Table sloped 24 : 40-50

They found an impression of fewer aches and pain in students using flat top [17].

Freudenthal A while studying effect of posture with a ten degree inclination using adjustable chair and table found an average change in position of head from 38.5degree to 29.6 degrees, resulting in an average decrease of moment of force on C7-T1 of 21% [16]. Load moments and myoelectric activity studied by Karin Harms-Ringdahl concluded that extreme positions of the cervical spine do occur in sitting work posture, and level of muscular activity in such positions are low. The load moment for the Occ-C1 joint when the whole neck was flexed was only 1.2 times the value for the neutral position of the head, but for C7-T1 it increases to 3.6 times [18]. Sitting posture in relation to three different desk slopes of 45, 22 and 0° (horizontal) was examined by statometry on 10 subjects who were reading. With increasing desk slope the cervical as well as the lumbar spine were extended, and the head and trunk changed towards a more upright posture. Electromyography (EMG) from the descending part of the trapezius muscle was also recorded during both reading and writing favored a steep slope of the desk for reading, while the opposite was favored for writing [19].

In a study it was found that students of same age group had furniture with desk and seat height bigger while seat height was less. Thus, the furniture didn't match the anthropometric variability among children [20]. Another study conducted by Georgia Panagiotopoulou indicates a mismatch between the students' bodily dimensions and the classroom furniture available to them. The chairs are too high and too deep and desks are also too high for the pupils. This situation has negative effects on the sitting posture of the children especially when reading and writing [21]. The data of a study indicate a substantial degree of mismatch between the students' bodily dimensions and the classroom furniture available to them. Fewer than 20% of students can find acceptable chair/desk combinations [22]. F.H.A.Bex in his study concluded that desk should be lower and adjustable [23].

Anna Lindblad Berkhout et al study confirms the importance of adjustable work tools that recognize anthropometric differences and biomechanics to meet the needs of individual customers during continuous visual display terminal work [24]. In schoolchildren, using individually adjustable saddle-type chairs and desks with comfort curve, a better match between workstations and anthropometric dimensions and

improved working postures are obtained than using conventional workstations [25].

Back education in elementary schoolchildren is efficacious up to 1 year. The role of early back education in preventing back pain at the adult age merits further attention [26]. According to the study conducted in 1994 , increased comfort and decreased symptoms may be used to motivate pupil to sit correctly [27].

METHODOLOGY

Subjects

The study had 75 sample amongst which 35 subjects were using flat desk since 5 yrs in their 8th, 9th, 10th, 11th and current 12th std. the rest of 40 subjects belonged to the group using 10 degree inclined desk since last 5 yrs of their academic session.

Age

The study was conducted in school students of age group between 14 to 18 years to evaluate their cervical range of motion (flexion, extension, right lateral flexion and left lateral flexion) who are using the furniture provided by the school for at least 5 years with daily class teaching hours of 5 hours.

Research Design

The research design is of Diagnostic type determining the frequency with which the weakness of neck muscles and variation in range of motion occur in students due to various type of desks' inclination. The method of examination was used to carry the research.

Sample Design

Finite universe of social unit school is selected to conduct the research. Systematically a sample of 30 students of age group 14-18 yrs are randomly chosen as probability sampling from school using inclined desk and flat desk each. This age group in chosen because the growth spurt is at end, there are clear sex difference and they sit for longer period of time.

Selection Design

Inclusion Criteria

- Student age group 14-18 yrs
- Sample with normal range of BMI
- Usage of particular angled inclination of desk for at least 5 yrs
- Average 4-5 hrs of reading/writing daily

Exclusion criteria

- Postural abnormality like scoliosis, LLD etc. leading to compensatory changes
- ADHD
- Marked deficit in visual acuity
- Established case of cardiac, psychological, systemic disorders

Material required

- Flat desk
- Inclined desk with the inclination of 10degrees
- Chair of fixed height
- Universal 180 degree Goniometer
- Skin marker
- Inch tape

Procedure

Range of motion of the cervical spine

Flexion/Extension:

Goniometer

To measure the range of motion of the cervical spine the subject was made to sit on a chair with his/her back against the back rest to stabilize the thoracic and lumbar spine. The stationary arm of a goniometer was aligned with the lateral side, pointing upward vertically with the axis over the external auditory meatus. The moveable arm was aligned with the base of the nares. The subject moved his/her chin toward the sternal notch to measure cervical flexion and then look up toward the ceiling to measure cervical extension. The

angle between the moveable arm and the line perpendicular to the floor was noted. Normal flexion and extension range of the cervical spine should measure 60°.

Tape method

The subject was made to sit on a chair with his/her back against the back rest to stabilize the thoracic and lumbar spine. He was asked to tuck in the chin and then touch the chin to sternal notch without opening the mouth and the distance between the two were measured. This helped to measure flexion in centimeters. To measure extension the subject was asked to look up to the ceiling, the distance of chin from sternal notch was again measured. The difference from the neutral space between notch and chin was considered extension range.

Right/Left Lateral Flexion

Goniometer

To measure the range of motion of the cervical spine the subject was made to sit on a chair with his/her back against the back rest to stabilize the thoracic and lumbar spine. The stationary arm of a goniometer was aligned to 180 degree with the movable arm. The fulcrum of goniometer corresponded to the tip of the nose. The subject was asked to flex the neck laterally along which the movable arm moved. The angle made by the arm to the vertical axis was noted. The normal range of lateral flexion is 60- 65 degrees

Tape method

The subject was made to sit on a chair with his/her back against the back rest to stabilize the thoracic and lumbar spine. While the subject laterally flexes the neck, distance between the ear lobe and acromion process was measured. This gave the lateral flexion value.

DATA ANALYSIS AND RESULT

The large sample size of 75 was taken out of which 35 were using flat desk and 40 subjects were using inclined desk since 5 yrs. Various cervical ranges of motion (flexion, extension, right lateral flexion, left lateral flexion) were compared in two groups with Z-test as a statistical test in order to justify the null Hypothesis of the study. $P<0.05$ was set as the standard level of significance.

Table 1: Comparison between Mean, Standard Deviation, standard error of flexion, extension, Right Lateral Flexion and Left Lateral Flexion of group using flat desk vs. the group using inclined desk (in ° through goniometer and cm through inch tape).

	Flat Desk			Inclined Desk		
	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error
Flexion(°)	48.26	13.35	2.25	62.48	17.50	2.76
Extension(°)	47.12	14.81	2.5	65.51	14.80	2.34
Right Lateral Flexion(°)	32.88	9.48	1.6	44.11	10.20	1.61
Left Lateral Flexion(°)	32.12	9.08	1.53	43.95	11.05	1.74
Flexion(cm)	2.9	2.2	0.37	2.51	2.51	0.39
Extension(cm)	6.04	1.33	0.22	7	1.78	0.28
Right Lateral Flexion(cm)	9.24	2.75	0.46	6.71	2.78	0.43
Left Lateral Flexion(cm)	9.2	2.5	0.42	7.04	2.64	0.41

Table 2: Comparison between the means of cervical ranges of individuals using flat desk and inclined desk

	Flat Desk	Inclined Desk
Flexion (°)	48.26 ± 2.25	62.48 ± 2.76
Extension (°)	47.12 ± 2.5	65.51 ± 2.34
Right lateral flexion (°)	32.88 ± 1.6	44.11 ± 1.61
Left lateral flexion (°)	32.12 ± 1.53	43.95 ± 1.74
Flexion (cm)	2.9 ± 0.37	2.51 ± 0.39
Extension (cm)	6.04 ± 0.22	7 ± 0.28
Right lateral flexion(cm)	9.24 ± 0.46	6.71 ± 0.43
Left lateral flexion (cm)	9.2 ± 0.42	7.04 ± 0.41

Table 2: Comparison between the means of cervical ranges of individuals using flat desk and inclined desk.

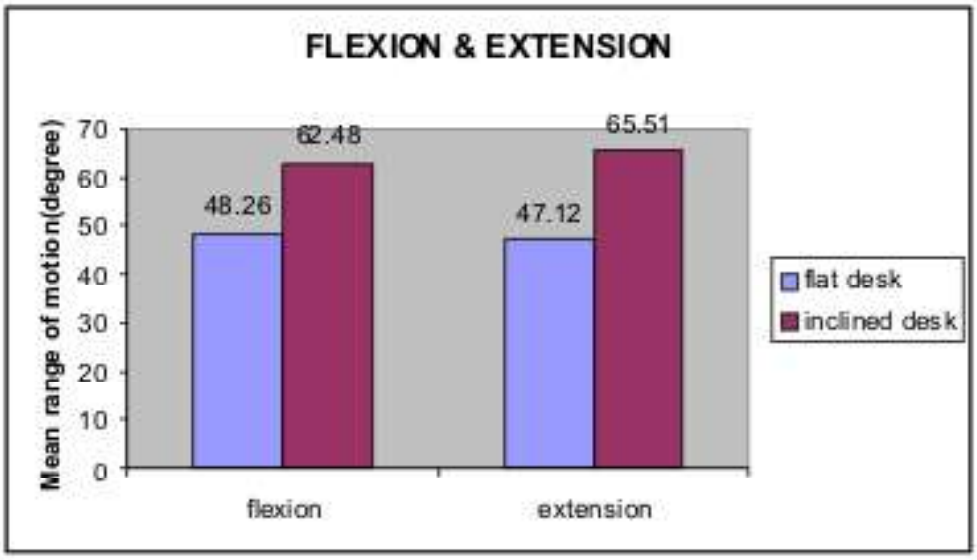
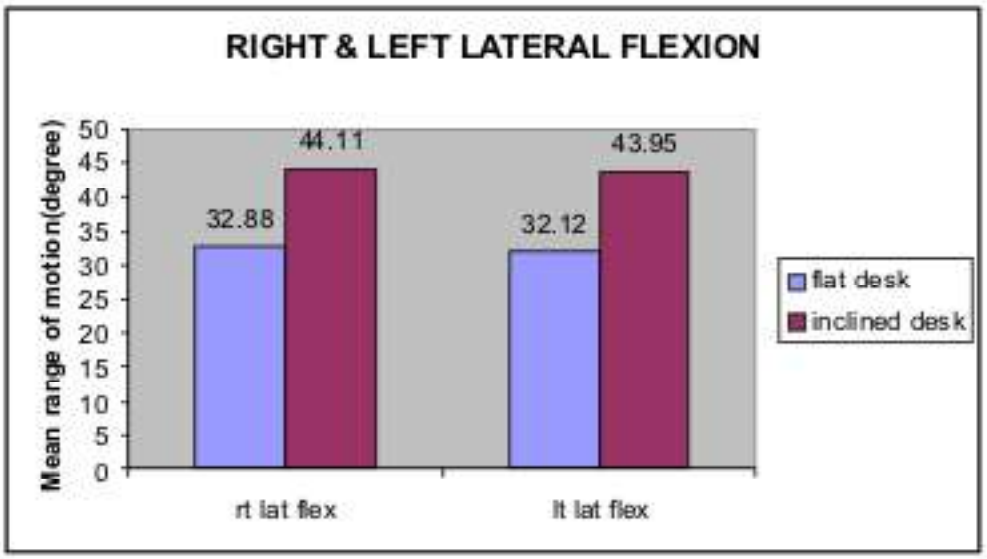


Figure 2: Mean of ranges of right and left lateral flexion through goniometer



The study was conducted to compare the pain free ranges of cervical spine in students using flat desk to those using inclined desk since last 5 yrs.

Figure 1 shows the comparison between the mean of flexion range of motion measured through Goniometer of students using flat desk (48.26 ± 2.25) to those using inclined (62.48 ± 2.76) which proved insignificant when analyzed through Z test (2.2486, $p>0.10$). Thus accepting the null hypothesis. It also compared extension range of motion with the mean value of flat desk (47.12 ± 2.5) to the value of inclined desk (65.51 ± 2.34) which gives a significant change (5.5225, $p<0.05$) rejecting the null hypothesis.

Figure 2 shows Right and Left lateral flexion ranges through universal goniometer comparison between flat and inclined desk with the mean values (32.88 ± 1.6 , 44.11 ± 1.61 respectively).

Figure 3: Mean of ranges of flexion and extension through tape method

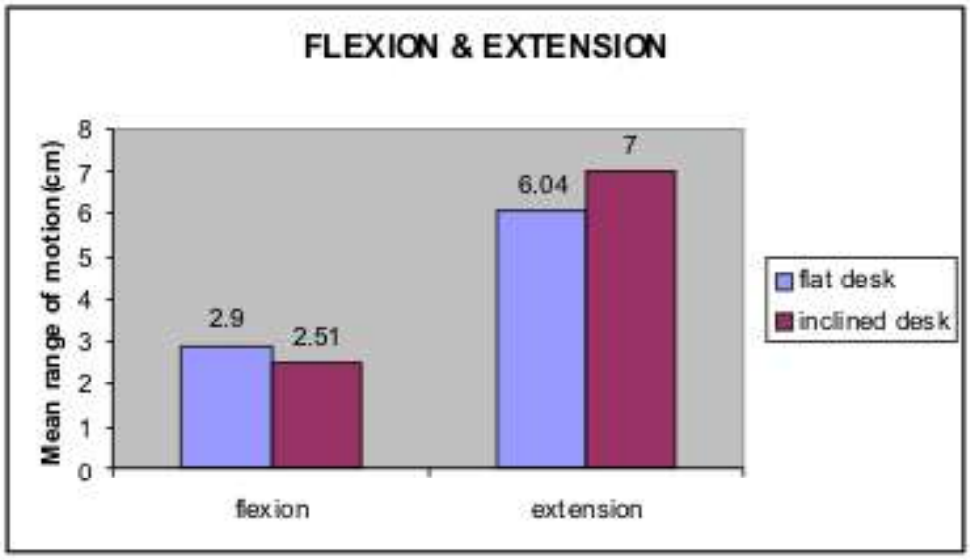
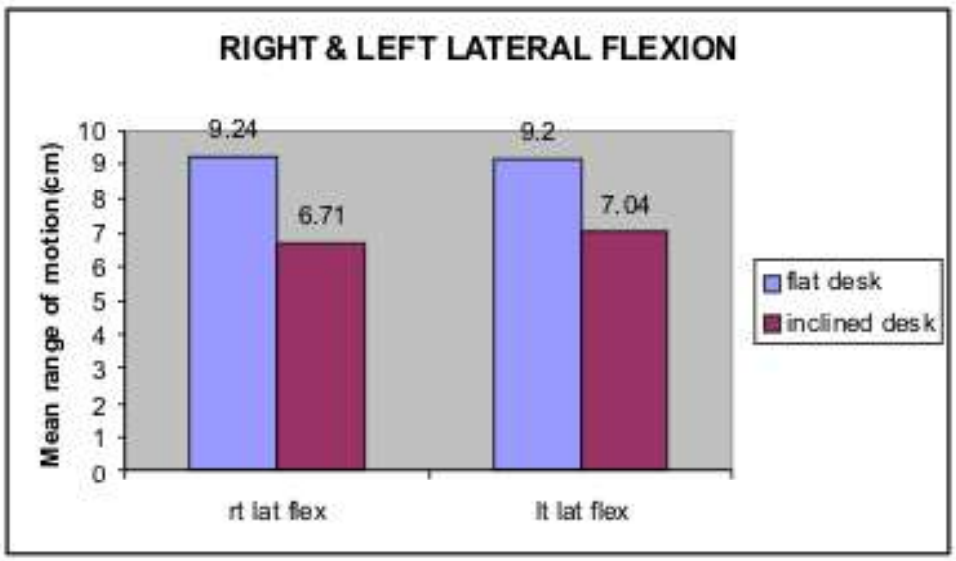


Figure 4: Mean of ranges of right and left lateral flexion through tape method



The statistical analysis proved favorable to the alternate hypothesis (4.9140, $p<0.05$ and 5.0297, $p<0.05$ respectively).

Figure 3 is a comparison between the mean of pain free Flexion (inch tape method) available in flat desk user group (2.9 ± 0.37) with the inclined desk users (2.51 ± 0.39). The Z test values (0.7109, $p>0.10$) rejected the expected result of the study. The analysis of extension between the two groups accepted the alternate hypothesis (2.5885, $p<0.05$) with the mean ranging 6.04 ± 0.22 of flat desk to that of inclined desk 7 ± 0.28.

Figure 4 is the comparison of right lateral flexion of flat desk (9.24 ± 0.46) to that of inclined desk (6.71 ± 0.43). The null hypothesis is rejected through Z test (3.9518, $p<0.05$). The comparison of left lateral flexion of the flat desk users (9.2 ± 0.42) to those using inclined desk (7.04 ± 0.41) proved significant at 3.6265, $p<0.05$.

DISCUSSION

The relationship between poor working postures and the development of neck pain has been widely studied, but whether this can be related back to school sitting posture was the purpose of the study. School pupils' primary tasks require them to sit for the majority of their classroom lessons and education years. Their seated classroom tasks include reading, writing, listening and computer use. As different postures are usually adopted for some of these tasks (e.g. writing compared with listening), chair and desk features may be contrary to recognized safe sitting postures. Furthermore, an uncomfortable body posture can destroy a student's learning interest, even during the most stimulating and interesting lesson.

Of the total seated time, Storr-Paulsen and Aagaard-Hensen (1994) found that approximately 43% of classroom time was spent in a backward-leaning position, whereas 57% was spent leaning forwards e.g. reading or writing. Hence, up to 80% of the pupils' time was, therefore, spent slumped on the desktop. It is reasonable to conclude that the sit up straight and don't slouch' is not the typical pupil sitting posture [28].

The duration of sitting is consistently high throughout pupils' education. Children spend a large part of their school days in the classroom, and yet the effect of the design of school furniture on their behavior and health has received limited attention. As children progress through their education years, the percentage of time they are expected to be physically active i.e. not sitting, reduced from 73% in the preschool category to 19% in the mid-high school years. As schoolchildren spend most of their time at chairs and desks, the relationship between their anthropometric measurements and the physical design of their chairs and desks is therefore as essential as a correct workspace design feature [29]. School children may spend approximately 30% of their waking hours at school, much of that sitting [30].

A sustained flexed posture causes soft tissue stresses on the spine. In a child's early life, postural deviations are likely to be functional and fully reversible [31]. Children's bones are particularly soft during their school years; hence they can be easily deformed by long-term stretching [32]. Significant latissimus dorsi and trapezius activity, and the finding that erector spine was most active in the erect, upright position is of anatomical importance in analyzing sitting postural behavior [33]. These authors stated that further myography studies may be valuable in determining what features should be considered for the design and dimensions of school furniture (in conjunction with basic anthropometric requirements). Karvonen et al. (1962) supported a related view, recommending that school furniture design should permit changes in sitting posture. If, however, comfortable and correctly designed furniture was provided, there would be less incentive for children to make postural changes. As children's muscles tire more rapidly than adults' during static muscle work, introducing regular postural change is important [34].

Significant physical growth takes place during the school years; girls reach 65% of their stature at age 4, whereas boys reach 60% of their stature at age 4 [35]. The growth spurt occurs at an earlier age in girls than in boys, with girls reaching

95% of their stature at age 13, but boys not reaching the same percentage until age 15 [35]. According to Floyd and Ward (1969), the mean stature for secondary school boys is 174.5 cm, whereas for girls it is 163.1 cm. The implication of this is that a range of furniture sizes should be available to achieve a reasonable fit, with a recommendation that beyond age 14 one category of furniture size should not be recommended [33].

Students using flat desk top tend to slouch more on the table top while reading and writing. More of the trunk bending leads to more of the forward head posture of neck. Reading on flat desk require sharp bend in the cervical spine which can not be maintained for long. Furthermore, in this position the reading distance is larger than 25 to 35 cm (the height of the table must coincide with approximately the level of elbow). Consequently, children and adults always bend forward with curved spine over the table. In forward bent position of trunk and head considerable muscle force is needed. A prolonged continuous contraction causes lack of oxygen, accumulation of sour metabolites and intracellular shortage of potassium. Pain is the result which can lead to muscle spasm, which closes a vicious circle. Prolonged isometric contraction can even cause an inflammation process with fibrosing; the result is passive shortening of the muscle.

The data analysis shows that the flexion ranges are not affected in either of the group as maximum time spent by the students is in flexed position while reading and writing. But due to prolonged flexed posture in students there is adaptive shortening of these muscles which results is limitation in extension range of motion. The excessive load on trapezius studied in august 1984 while reading and writing (18) proved true in both the groups. The spasm in upper fibers of trapezius was more prominent in students using flat desk than in those using inclined desk. Thus, the neck pain was more reported in flat desk group.

The group A were using sled desk (as per described by Chanda Nelofer Khanam) while other group B were using table and chair separately. The study conducted, advises chair and table to be better over sled desk.Students realized the importance of feature that contribute to good furniture design. They preferred furniture height to be adjustable [27].

Tilted work surface reduces neck flexion and tension in the neck muscles. A 15° sloping tabletop was found to decrease neck angle by approximately 6°. Helps maintain more of erect spine, thus less of MSD.

CONCLUSION

We conclude from the study that the implementation of ergonomically designed adjustable inclined desk for the school students in their pre-adolescent age is beneficial over the traditional usage of flat desk. The desk height and the degree of inclination should be adjustable according to the need of the individual. This provides more erect and anatomical posture for the cervical spine. Hence, reducing the occurrence of musculoskeletal disorders related to neck in late adulthood. This also reduces the occurrence of neck pain due to sharp bent seen while reading and writing on flat desk.

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