INFLUENCE OF DESK DESIGN ON WRITING PERFORMANCE AMONG MIDDLE SCHOOL CHILDREN

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ABSTRACT

***BACKGROUND** : Handwriting is an important skill for school aged children. Handwriting is often judged and seen as reflection of an individual's intelligence and capabilities as illustrated by several studies in which lower marks are consistently assigned to children with poor handwriting and higher marks are given to those with legible handwriting despite similar content.* ***AIM:** To find out the influence of desk on writing performance among middle school children.* ***STUDY DESIGN:** Non-experimental study.* ***PROCEDURE:** Total of 50 middle school children between 10-13 years (both boys and girls) was included in the study based on inclusion and exclusion criteria. Anthropometric body dimension and furniture dimension for each individual was taken. Nordic Musculoskeletal Questionnaire was given to the subjects and made to fill it. Handwriting Proficiency Screening Questionnaire (HPSQ) was given to the teachers and they were asked to fill it.* ***RESULTS:** It was found that there is mismatch between children's body dimension and furniture dimension. It was also found that children with unsuitable furniture had handwriting difficulties and body aches.* ***CONCLUSION:** There was a statistically significant effect on writing performance and musculoskeletal discomfort among desk mismatch children.*

KEYWORDS: Ergonomics, unsuitability, furniture, handwriting performance, anthropometric measurements.

INTRODUCTION

Children used to spend at least 6 to 8 hours in school, mostly in sitting position [1]. They perhaps spend up to 3 to 4 hours of their class time in paper and pen activities [2]. A child's potential to bring out copious and readable writing is a major key for conveying, giving or exchanging information, and documenting the concepts besides academic development [3]. Mahatma Gandhi quoted as "I saw that bad handwriting should be regarded as a sign of an imperfect education"Childhood education is the period of time, where more concentration is required for the attainment of handwriting skills [4]. Readable handwriting comprises to be an effective skill for the child to evolve in middle school and problems in this area can impact the child's proficiency at work [4]. Proficiency is the quality of having great facility and adequacy at school task [5]. Children those who do not deliver proficient handwriting are defined by few authors as ''poor hand writers'' and by others as dysgrahic [6]. Handwriting is always evaluated and manifested as a child's intelligence and abilities as

documented by some studies in which low marks are systematically allotted to children with bad handwriting, and high marks are allotted to those with readable or neat handwriting [7&8].Handwriting difficulties interposes with the capability of the child to represent what he/she knows. The child having handwriting difficulties cannot finish assignments on correct time, as writing work is hard, so they try to finish only few words as possible [9].When the child tries to stress the mechanical facet of writing, the child cannot completely pay heed to the content of information [9]. In addition to readable and timing shortage, observations by clinicians have disclosed that children with dysgraphia erase frequently, moan more about fatigue and hand pain, and are reluctant to write and do their homework [10]. All of these signs may be considered to represent a category of physical and emotional well-being. The classroom is similar to other work environments because there is interplay of both "static work" and "force". Static work refers to the musculoskeletal exertion required to maintain or hold a certain position. For example, sitting, and keeping the head and torso upright requires static work; while force refers to the amount of tension generated in the muscles in order to move or keep the body in a particular posture. Hence the ergonomic requirements for educational chairs are the same as for work chairs [14&1]. Ergonomics aim is to fit the human capacity and requirement of the task [16 & 17]. In this study, the task is writing. To be effectual in encouraging competent handwriting accomplishment, ergonomic components ought to be advised [2]. The chief target of ergonomics is to improve human health, safety and execution. The correct position while sitting in the classroom can also impart enhanced confidence and vigilance level during classes. The designs of chairs and desks in the classroom are essential for good sitting posture [1].

Ergonomic design of chairs in classroom is closely tied to anthropometric features of the students population It is believed that there is a growing mismatch between desk design feature of the furniture used in the classroom and the anthropometric features of the students [23]

AIM OF THE STUDY: To find out the influence of desk on writing performance among middle school children.

NEED FOR THE STUDY: Written exams are very important as it decides the achievement or promotion in terms of grades or marks. In middle school growth spurt is more and differs with individual. But the chair and desk makings are quite same for all those in the class and different types of furnitures are available in different schools. So there aroused a doubt whether this variability may have an influence on performance of the students. There are many studies concentrating on the effectiveness of strengthening and improving the muscle grip, it is equally important to look after the desk design for better handwriting. Hence the need is to find out the influence of desk design on writing performance

METHODOLOGY

STUDY DESIGN : Non-Experimental

STUDY TYPE : Observational type

SAMPLING METHOD : Convenient sampling

SAMPLE SIZE : 50

STUDY SETTINGS : Chennai Middle School Triplicane and Otteri

INCLUSION CRITERIA:

Children attending a regular middle school

Age between 10-13 years

Both boys and girls were included in the study

EXCLUSION CRITERIA:

Developmental delay

Physical impairment of upper extremity and receiving treatment for the same

Neurological problem

Visual impairment

Children those who are receiving handwriting training

MATERIALS USED

Measurement tape,stadiometer,goniometer,pen and pencil.

PROCEDURE

Total of 50 middle school children (both boys and girls) were included in the study based on inclusion and exclusion criteria.Informed consent was obtained from the subject's school, parents and teachers. On the other hand, considering the importance of the ergonomic requirement for efficient design of the writing environment for the school children, anthropometric dimensions was measured. Permission to measure the dimensions of the furniture in each classroom was obtained from the correspondent.

INDIVIDUALSUBJECT'S ANTHROPOMETRIC DIMENTIONS

With reference to **Ghazzilla et al,** the following anthropometric dimensions were taken over a period of 10 minutes for each subjects; their shoes were removed and they wore light clothing:

HEIGHT: A perpendicular distance from the floor to the subject's head, while standing erect, and looking straight.

ELBOW HEIGHT: With the subject's elbow flexed 90 degrees, a perpendicular distance from the bottom of the tip of the elbow to his/her seated surface.

SHOULDER HEIGHT: A perpendicular distance from the top of the subject's shoulder at the acromion process to his/her seated surface.

UPPER ARM LENGTH: The difference between the elbow height and shoulder height

KNEE HEIGHT: With subject's knee flexed to 90 degrees in a seated position, a perpendicular distance from the resting surface of the foot to the top of the knee cap, just above the patella.

POPLITEAL HEIGHT: With subject sitting and the knee at 90 degrees of flexion, the distance from the foot resting surface to the popliteal space.

BUTTOCK-POPLITEAL HEIGHT: With subject's knee flexed at 90 degrees, the distance/length from the posterior surface of the buttock to the popliteal surface (thigh length

FURNITURE DIMENSIONS:

SEAT HEIGHT: The distance from the floor to the highest point on the front of the seat.

SEAT WIDTH: The distance from the back of the sitting surface of the seat to its front.

DESK HEIGHT: The distance from the floor to the top of the front edge of the desk.

DETERMINATION OF ERGONOMIC SUITABILITY OF FURNITURE:

According to **Parcells et al.,** rules anthropometric mismatches are the number and percentage of the students where the body match or mismatch with the furniture were calculated. A mismatch is defined as repugnance between furniture dimensions and the children's body dimension. The mismatch rules were followed in order to determine mismatch between certain body dimensions and their corresponding design parameter as listed below:

Elbow-Desk height mismatch: Acceptable desk height is determined by the equation, $hE = hEv + U [(1- \cos^{\theta}) + \cos^{\theta} (1-\cos \beta)]$.

Where hE is the vertical distance from the top of the desk to the subject's sitting surface. hS is the shoulder height, hEv is the elbow height, U = hS – hEv is the upper arm length, $^{\theta}$ = shoulder flexon, β = shoulder abduction. For flexion angles, the corresponding cosines are 1 (0 degrees) and 0.9063 (25 degrees) and for abduction angles, the corresponding cosines are 1 (o degrees) and 0.9397 (20 degrees).

-seat height mismatch: a mismatch is defined when the seat height is either >95% or <80% of the popliteal height.

Buttock popliteal-seat width mismatch: a mismatch is defined when the set width is either >95% or <80% of the popliteal height.

Knee- Desk height: a mismatch is defined as occurring when a desk is <2cm higher than the knee height.

In addition to anthropometric dimensions, two questionnaires were used in this study,they were .Nordic Musculoskeletal Questionnaire which was given to each subject and made them to answer it.and Handwriting proficiency screening questionnaire (HPSQ) which was given to the subjects teachers and asked them to fill it.

HPSQ consists of three main components;

(1) writing product legibility based on the teacher's as well as the subject's perception (item 1, 2, 10);

(2) performance time, including whether the child performed too slowly, whether the child tended to frequently erase or cross out things that he/she had written and whether the child needed to spend a lot of time looking back at the blackboard or the book while copying (items 3, 4, 9);

(3) indications of the subject's physical and emotional well being (items 5, 6, 7, 8).

On the basis of the teacher's observation and the general impression derived from the subject's writing performance in class, the teacher was asked to rate the degrees to which the behavior described in each items occurred (i.e., never, rarely, sometimes, often or always)

OUTCOME MEASURES:

Anthropometric dimensions

Handwriting Proficiency Screening Questionnaire (HPSQ)

Nordic Musculoskeletal Questionnaire (Nordic MSD

DATA ANALYSIS

Descriptive statistics of the minimum and maximum values, median, mean and standard deviation were used appropriately to summarize the data collected. The data collected were analyzed using Statistical Package for Social Sciences (SPSS, version 2)

TABLE 1 ANTHROPOMETRIC DIMENSIONS OF THE 50 MIDDLE SCHOOL

AGE								
	10 – 11Yrs				12 – 13Yrs			
Anthropometric Dimension	Minimum	Maximum	Median	Mean ± SD In cm	Minimum	Maximum	Median	Mean ± SD In cm
Elbow Height	9.00	14.00	11.00	11.00±1.123	8.00	20.00	12.00	11.73 ± 2.03
Popliteal Height	15.00	19.00	16.00	16.45±1.234	13.00	20.00	16.000	16.40±1.56
Buttock Popliteal Height	15.00	20.00	18.00	17.65±1.308	14.00	22.00	17.00	17.53±2.06
Knee_Height	17.00	21.50	18.90	18.81±1.219	15.50	22.50	18.50	18.65±1.81

CHILDREN CLASSIFIED BY AGE

The above table shows the mean value of elbow height, popliteal height, buttock popliteal height, knee height among 10-11 years and 12-13 years.The mean value of elbow height is 11cm among 10-11 years whereas, it is 11.73cm among 12-13 years, mean value of popliteal height is 16.45cm among 10-11 years whereas, it is 16.40cm among 12-13 years, mean value of buttock popliteal height is 17.65 among 10-11 years whereas, it is 17.53cm among 12-13 years and mean value of knee height is 18.81cm among 10-11 years whereas, it is 18.65cm among 12-13 years.

TABLE 2

FURNITURE DIMENSION (DESK HEIGHT,SEAT HEIGHT &SEAT WIDTH) ACCORDING TO THE AGE GROUP AMONG 50 MIDDLE SCHOOL CHILDREN.

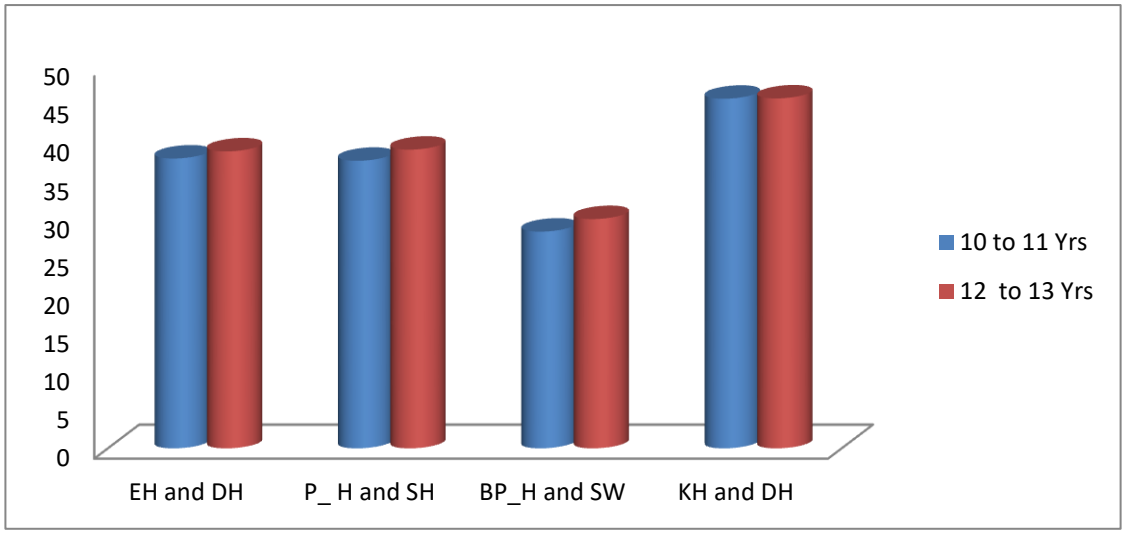
AGE								
	10 – 11				12 – 13			
Furniture Dimension	Minimum	Maximum	Median	Mean ± SD In cm	Minimum	Maximum	Median	Mean ± SD In cm
Desk Height	25.00	44.00	25.0	26.90±4.426	17.00	30.00	27.00	27.10±2.68
Seat Height	11.00	25.00	21.0	21.15±2.796	21.00	25.00	22.00	22.66±1.60
Seat Width	10.00	14.00	10.0	10.70±1.34	10.00	14.00	12.00	12.46±1.63

The above table shows the mean value of desk height, seat height, seat width between 10-11 years and 11-12 years.The mean value of desk height is 26.90cm among 10-11 years whereas, it is 27.10cm among 12-13 years, mean value of seat height is 21.15cm among 10-

11 years whereas, it is 22.66cm among 12-13 years and mean value of seat width is 10.70cm among 10-11 years whereas, it is 12.46cm among 12-13 years.

GRAPH 1

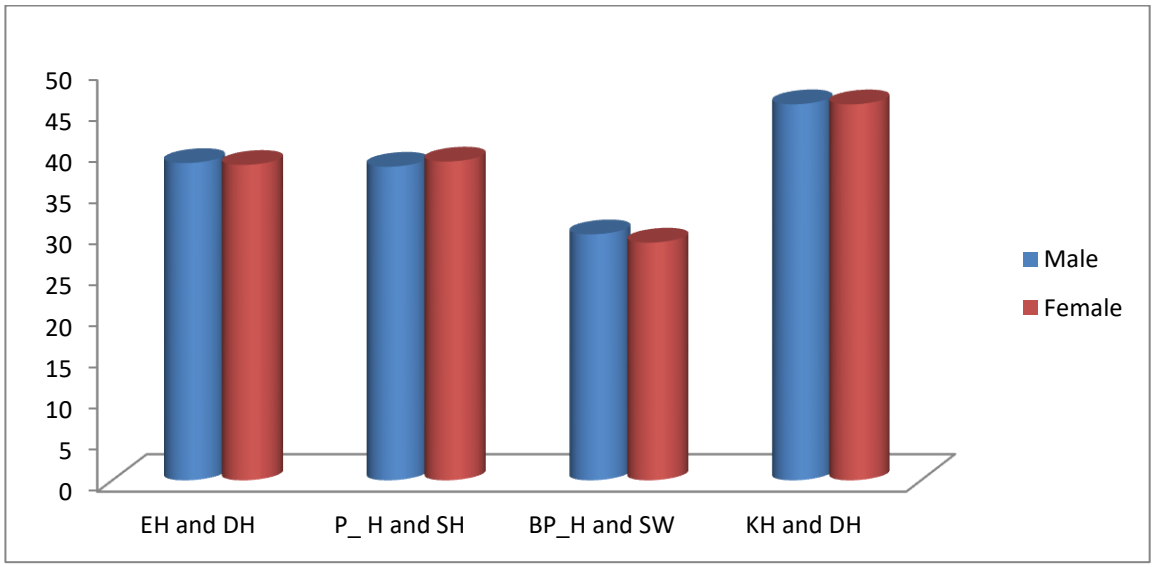
MISMATCH OF STUDENT BODY DIMENSIONS WITH SEAT AND WRITING SURFACE DIMENSIONS CLASSIFIED BY AGE.



EH= Elbow Height; DH= Desk Height; PH= Popliteal Height; SH= Seat Height; BPH= Buttock Popliteal Height; SW= Seat Width; KH= Knee Height.

GRAPH 2

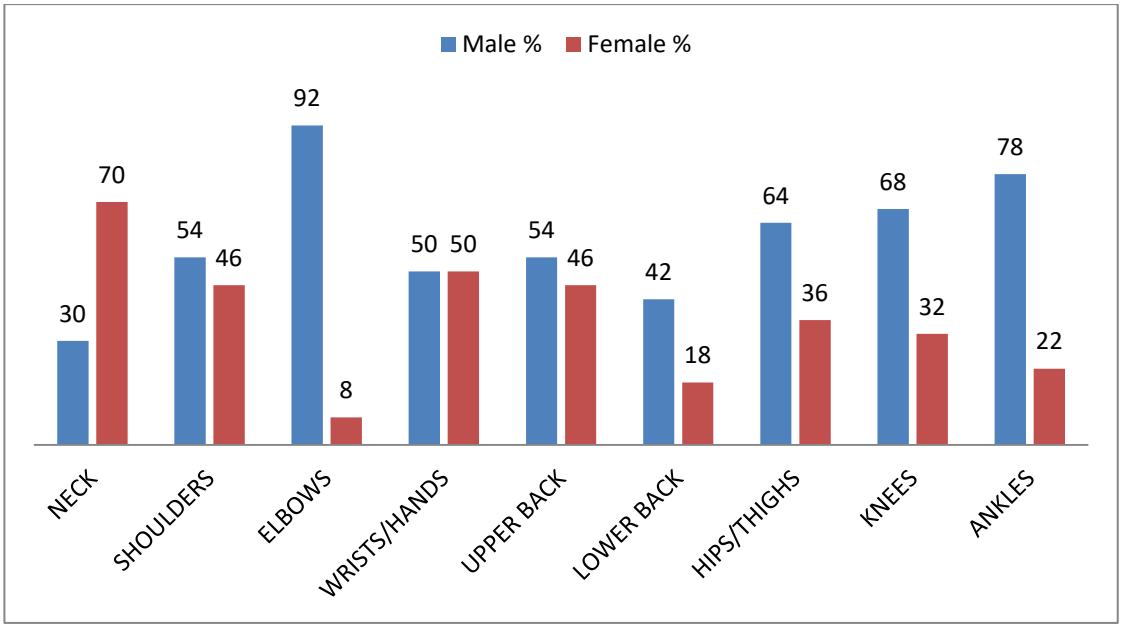
PERCENTAGE OF MISMATCH FOR THE STUDENTS CLASSIFIED BY GENDER



EH= Elbow Height; DH= Desk Height; PH= Popliteal Height; SH= Seat Height; BPH= Buttock Popliteal Height; SW= Seat Width; KH= Knee Height.

GRAPH 3

PERCENTAGE OF BOYS AND GIRLS REPORTING ON BODY ACHES WHILE WRITING AS SCORED BY NORDIC QUESTIONNAIRE



RESULTS

MISMATCH OF CHILDREN BODY DIMENSIONS WITH SEAT AND WRITING SURFACE DIMENSIONS ACCORDING TO AGE GROUPS:

Table 1and 2 and Graph 1 represents the mismatch of children's body dimension in relation with seat and writing surface dimension among 10-11 years and 12-13 years. Mismatches includes elbow height and desk height mismatch, popliteal and seat eight mismatch, buttock popliteal and seat width mismatch, knee and desk height mismatch.

Graph 1 shows the percentage of mismatches among 10-11 years and 12-13 years.

ELBOW-DESK HEGHT MISMATCH: The elbow-desk height mismatch was 40% for children between 10 to 11 years, and 42% for children between 12 to 13 years.POPLITEAL-SEAT HEIGHT MISMATCH: The popliteal-seat height mismatch was 40% for 10 to 11 years, and 44% for 12 to 13 years.BUTTOCK-POPLITEAL SEAT WIDTH MISMATCH: The buttock-popliteal seat width mismatch was 31% for 10 to 11 years, and 34% for 12 to 13 years.KNEE-DESK HEIGHT MISMATCH: The knee-desk height mismatch was 50 % for both the children between 10 to 11 years and 12 to 13 years.

MISMATCH OF CHILDREN BODY DIMENSIONS WITH SEAT AND WRITING SURFACE DIMENSIONS ACCORDING TO GENDER GROUPS:

Table 3and 4 and Graph 2 represents the mismatch of children's body dimension in relation with seat and writing surface dimension among boys and girls. Mismatches includes elbow height and desk height mismatch, popliteal and seat eight mismatch, buttock popliteal and seat width mismatch, knee and desk height mismatch.

Graph 2 shows the percentage of mismatches among boys and girls.

ELBOW-DESK HEGHT MISMATCH: The elbow-desk height mismatch was 41% for boys, and 41% for girls.POPLITEAL-SEAT HEIGHT MISMATCH: The popliteal-seat height mismatch was 42% for boys, and 43% for girls.BUTTOCK-POPLITEAL SEAT WIDTH MISMATCH: The buttock-popliteal seat width mismatch was 35% for boys, and 34% for

girls.KNEE-DESK HEIGHT MISMATCH: The knee-desk height mismatch was 48 % for both boys and girls.

HANDWRITING PROFICIENCY SCREENING QUESTIONNAIRE (HPSQ) RESULTS:

The main purpose of the survey questionnaire was to find out the handwriting performance among middle school children which is influenced by the desk design used in school. The respective teachers observed the children and answered the questionnaire. According to Table 5, the writing performance of the children are reported below:

No	Questions	Never 0	Rarely 1	Some-times 2	Often 3	Always 4
1.	Is the child's writing unreadable?					
	YES	3	22	13	6	6
2.	Is the child unsuccessful in reading his/her own handwriting?					
	YES	4	19	7	10	10
3.	Does the child does not have enough time to copy tasks from the blackboard?					
		0	13	22	13	2
4.	Does the child often erase while writing?					
	YES	1	10	19	19	1
5.	Does the child often feel he/she does not want to write?					
	YES	0	14	22	10	4
6.	Does the child not do his/her homework?					
	YES	0	5	19	14	12
7.	Does the child complain about pain while writing?					
	YES	0	2	14	21	13
8.	Does the child tire while writing?					
	YES	0	0	19	18	13
9.	Does the child need to look at the page/blackboard often when copying?					
	YES	0	4	25	21	0
10.	Is the child not satisfied with his/her handwriting?					
	YES	5	20	16	9	0

NORDIC MUSCULOSKELETAL QUESTIONNAIRE RESULTS:

The main purpose of Nordic questionnaire was to find out the musculoskeletal disorders among the middle school children that may occur due to the design of the desk used in school while writing. Table-6 shows the number of subjects participated and percentage of body aches for both boys and girls.

VARIABLES	**BOYS N (%)**	**FEMALES N (%)**
NECK	15(30.0)	35(70.0)
SHOULDERS	27(54.0)	23(46.0)
ELBOWS	46(92.0)	4(8.0)
WRISTS/HANDS	25(50.0)	25(50.0)
UPPER BACK	27(54.0)	23(46.0)
LOWER BACK	41(42.0)	9(18.0)
HIPS/THIGHS	32(64.0)	18(36.0)
KNEES	34(68.0)	16(32.0)
ANKLES	39(78.0)	11(22.0)
ALL	286	164

DISCUSSION

The main aim of this study is to find the advantageous effect of ergonomic desk design on writing performance among middle school children. This study focused on comparing the children's body dimensions and desk dimension they used.Handwriting is an essential skill for school children. Handwriting difficulties can have implications for a successful participation in academic and cultural activities, potentially leading to problems in academic execution and lowered self-pride. A number of correlative studies have identified the performance factors that are linked up with handwriting, namely, motor planning, eye-hand coordination, visual perception, visual motor integration, kinesthetic perception and in-hand manipulation. Only few studies had documented the effect of ergonomic desk design over handwriting performance. So this study was done to throw some light over the desk design on writing performance among middle aged school children.Skilled handwriting is a necessary activity for school aged children that allows them to write within a moderate time and to create a readable product through which thoughts and ideas can be communicated. Sitting is a dynamic task. It is not a static position even during a unmoving task like completing written work. When a child is seated at a desk, there are many variations in positioning. When a child is seated at a desk and trying to write, functional positioning is necessary. When addressing posture when writing, it is significant to consider the underlying reason. To address correct posture, commence at the pelvis. The pelvis renders a stable base of support whilst sitting. In succeeding proper positioning and tilt of the pelvis, the leg should be symmetrical and neutral so that the length of the thighs are subsidized by the chair. When the feet are resting flat on the floor, the thighs are furnished with appropriate weight distribution through the pelvis. Once the lower body is positioned befittingly, the upper body can be placed into a functional placement. Good upper body carriage while sitting follows pelvis symmetry.The child that inclines over to the side while writing is almost likely to dislodge their weight via the pelvis in a lateral tilt, rotating the thighs, and raising the feet. A drooped posture of the shoulders and upper back can draw the whole body down to the desk surface.Manipulation skills of the hands depend on the stability and proportion of the trunk in order to allow the child to ascend the pencil and paper. For the child who positions the elbow tucked in at their side, there may be inherent core weakness or pelvic/thigh positional

problems.For an individual to feel comfortable in sitting position, we aggregate three factors: the feature of the seat, the user's characteristics and the features of the task. The findings of this study shows that from the measurement of the children's body dimension and the classroom desks used shows a appreciable mismatch between the furniture and the users.From the results, Graph 1 and graph 2 we found that the popliteal and seat height mismatch was the highest mismatch with 85%, and elbow-desk height mismatch was second highest mismatch with 84%, whereas buttock popliteal-seat width mismatch was 69% and knee-desk height mismatch was 50% among 50 students. Students with this mismatches were reported with handwriting difficulties (Table 5) and body aches as shown in Graph 3.Anthropometry is regarded as the quantifiable measurement of the human body as well as deigns of the furniture used. Anthropometry readings are reproductive, as well as its objectives are with high specificity and sensitivity.The best school desk is one which is designed to afford comfort to the child and to allow effective school work at the same time. Furniture design plays a vital role in physical and mental welfare of the students. Improper seating arrangements lead to physical deformities and thus endanger the health of the students. If the desk is not suitable, curvature of the spine, contraction of the chest, roundness of the shoulders, and a confirmed stoop may result as physical injury. If the desk is not suitable, inability to sustained attention and concentration owing to lack of body comfort may result as mental problems.Improperly designed furniture, ill-fitted to the characteristic of a student can result in faster muscle fatigue, defective posture and the establishment of pathological states which could affect their performance in focusing in class. **Olsen et al.,** stated that ill-fitted design of classroom furniture has contributed to the high incidence of musculoskeletal disorders among school children.Furniture that is not suited to anthropometric measurements of a child, hours of intense sitting while writing, poor sitting posture are the main cause of the increase in musculoskeletal symptoms among the young. According to **Castellucci et al.,** seats that are too deep are unsuitable, as they cause compression of the popliteal fossa and lead to the adoption of faulty posture [11]. According to **Gouvali and Boudolos,** desks that are too tall were unsuitable, as they required children to flex their shoulders more than 25 degrees and abduct them more than 20 degrees in order to support their elbows, thereby resulting in quick onset of fatigue in the muscles of the upper limb [3].**Milanese and Grimmer** reported that there exists an optimal anthropometric/furniture dimension relationship, and deviations from that optimal relationship among a vast majority of the population will make the furniture unsuitable [17].**Amudson 2005,** founded that children who support their back in the chair and feet on the ground tend to write better [24].The fixed school furniture may have contributed for the instability of shoulder and trunk leading the children to employ more hand force variation and increased speed. **Tseng and Cermak 1993,** stated that this combination of elements tends to disrupt coordination affecting handwriting legibility negatively [11]Individual children can vary in size, shape or growth according to their age. Therefore before designing the desk design of the school, anthropometric dimensions must be taken into consideration or adjustable desk can be used. It is likely that the adjustable school furniture provides better conditions for the stabilization of shoulder and trunk. **Feder and Majnemer 2007,** indicated that ideal posture for the child to have better handwriting development entails sitting with feet flat on the floor and hips and low back supported against the chair back. The adjustable school desk gave exactly the opportunity for each child to adopt this posture [12]. **Rosnah Mohd. Yusuff,** documented that adjustable school furniture is important to furnish school settings with the appropriate environment for children to acquire and enhance handwriting skill much for the benefit of their overall educational development [1]. **Maria Antonia Goncalves and Pedro M. Arezes,** stated that children accommodated in dimensionally suitable furniture, have a better body posture, better handwriting and faster formation of letters which is an evidence of a positive correlation between ergonomic factors, such s seated posture and positioning and handwriting performance [8].Correct sitting posture for good handwriting includes:Feet flat on the floor, Thighs parallel to floor and knees at a 90 degree angle, Back up straight, inclined towards the desk and pivoted from the hips, Forearms resting on desk with elbows level with the desktop at 90 degrees, Paper stabilized with non-dominant hand, Neck and shoulders

relaxed, Paper tilted to the up to the right (if the right handed) or up to the left (if left handed).Child can be encouraged to get up and move during transition times to ensure that they don't become fatigued while also reducing the stress on their bodies.

CONCLUSION

This study concludes that the desk design influences the handwriting performance among middle school children. It was also concluded that the furniture dimension and children's body dimension is ergonomically unsuitable for most of the children's. Children with unsuitable furniture showed a difficulty in writing performance. This study recommends the adjustable school furniture, thus improving the handwriting skill thereby improving the academic performance of the children.

LIMITATIONS AND RECOMMENDATIONS

LIMITATIONS

The sample size was small

Body Mass Index was not taken in to account

Only two schools were included in the study

Gender distribution in both the groups was unequal

RECOMMENDATIONS

Larger sample size can be recommended

Future studies can be done comparing the fixed desk and adjustable desk design to be more effective Other outcome measures can be used

REFERENCES

1. Rosnah Mohd. Yusuff, Yoh Sun Ny and Faieza Abdul Aziz. Ergonomics evaluation of scho furniture design for primary school children in Malaysia.
2. Rosnah Mohd. Yusuff, Yoh Sun Ny and Faieza Abdul Aziz. Ergonomics evaluation of scho furniture design for primary school children in Malaysia.
3. I-hsuan Shen, Sue-may Kang, Ching-yi Wu. Comparing the effect of different design of desk with regard to motor accuracy in writing performance of students with cerebral palsy.
4. Chandan Kumar, Poonam Mehta, Sobika Rao. Effectiveness of physiotherapy for the handwriting problem of school going children.
5. Centre for child development. Child support.in Jhuitty.
6. Rosenblum, Sara. Handwriting performance, self reports and perceived self efficacy among children with dysgraphia. American Journal of Occupational therapy 2009 March.
7. Sasson R. Handwriting; A new perspective Cheltenham, UK: Stanley Thormes 1990.
8. Maria Kelley, Carolyn Phillips and Liz Persuad. Ergonomics in the classroom position for learning.
9. Phelps, J., Stempel L., and Speck, G. (1985). The childrens handwriting scale; a new diagnostic tool. Journal of education research. 79, 46-50.
10. Feder, Majnemer. Handwriting development, competency and intervention Review. Developmental medicine and child neurology 2007; 49: 312-317.
11. Rosenblum, Sara. Development, reliability, and validity of the Handwriting Proficiency Screening Questionnaire (HPSQ).. American Journal of Occupational Therapy 2008; 62; (298-307)
12. Feder, Majnemer. Handwriting development, competency and intervention Review. Developmental medicine and child neurology 2007; 49: 312-317.
13. Hammerschmidt, Sandra L. Teacher's survey on problems with handwriting: Referral, Evaluation, and Outcomes. American Journal of Occupational Therapy 2004.
14. Patron DD. Classroom ergonomics implications for health, safety and academic performance (webpage on the internet). Huntington Valley. PA; The free Library; 2009.
15. Occhipinti E. Colombini D, Molteni G, Grieco A. Criteria for the ergonomic evaluation of work chairs. Med Lav. 1993;84(4): 274-285.

16.Maria Kelley, Carolyn Phillips and Liz Persuad. Ergonomics in the classroom position for learning.
17.Smith, E.R (1989). Ergonomics of the occupational therapy. Ins Hertfelder and C.Guwin (Eds). Work in progress; Occupational therapy (PP.-127-155) Rock-Villed. MD. American Occupational Therapy Association.
18.Lefler K. Office chair: choosing the right ergonomic office chair (webpage on the internet). Deerfield, II : Spine-health; 2010.
19.Lane KE., Richardson MD. Human factors engineering and school furniture; a circular odyssey. Educ Facil Plan. 1993;31(3); 22-23.
20.Amick BC 3rd, Roberto MM. deRango K. et al. effect of office ergonomics interventions on reducing musculoskeletal symptoms. Spine (Phila Pa 1976). 2003;28(24); 2706-2711.
21.Alowayeh HN. Alshatti TA. Aljadi SH. Fares M. Alshamire MM. Alwazan SS. Prevalence. Characteristics and impacts of wrok-related musculoskeletal disorders: a survey among physical therapists in the state of Kuwait. BMC Musculoskeletal Disord. 2010: 11: 116.
22.Kahya E. The effects of job characteristics and working conditions on job performance. Int J Indust Ergon. 2007;37 (6); 515-523.
23.Negin Ozve Aminian and Fairuz I. Romli. Mismatch between anthropometric body dimensions and classroom furniture in Malaysian Universities.
24.Maria Antonia Goncalves, Pedro M. Arezes. Ergonomic design of classroom furniture for elementary schools.
25.Nse A Odunaiya, Dolapo D Owonuwa, Oluwafemi O Oguntibeju. Ergonomic suitability of educational furniture and possible health implications in a university setting

MASTER CHART-I

ANTHROPOMETRIC DIMENSIONS OF INDIVIDUAL CLASSIFIED BY AGE

AGE	HEIGHT	SH	EH	UAL	KH	PH	BPH
10	128	17	11.2	4.8	99.5	16.5	18
10	124	16.9	11.2	5.7	18	16	16
10	125	19	13.5	5.5	19	16.5	15
10	143	20	11	9	19.5	17.5	18
10	124	16.2	11.2	5	18	15	17.5
10	128	18	10	8	17.5	15	17
10	122	17	11.9	5.1	19	15	17
10	141	19	11.2	7.8	19.5	16.4	18
11	136	18	10	8	17.9	16.5	17.5
11	137	19	10.9	8.1	17.5	17	17.5
11	129	19	12	7	18	16	18
11	131	19.5	12	7.5	21	19	20
11	124	17	10.5	6.5	19	16	16
11	135	18.5	11	7.4	20	18	19
11	140	18.3	9.5	8.8	20	19	19.7
11	127	17	9	8	17.5	15	15.5
11	125	16.5	10	6.5	18	16	17.2
11	120	18	12	6	17	17	19
11	134	17.7	11.5	5.6	21.5	17	18
11	134	18.5	10	8.5	18.8	16	16.7

12	140	18	12	6	18	15.2	14
12	140	18.4	12.2	6.4	19	17.6	20.3
12	136	20	10.5	7.8	20	18	19
12	132	16.6	11.5	6.1	18.5	15.4	16.7
12	136	17	12.5	5.5	18.2	16.7	17.2
12	140	18.2	13	5.7	22.5	18	19
12	154	19.5	11.5	6.5	21	19	21
12	135	19	12	7.5	18	16	17.5
12	128	17.5	11.5	5.5	18	15	16
12	138	19	13	7.5	19.2	16	18
12	136	14.5	11.9	4.5	20.1	17.3	19
12	125	18.2	11	6.3	19	16	16.5
12	126	17	8	6	16	15	17.1
12	128	15.2	11	7.2	16	13	14
12	131	17	10	6	17.5	16	18
13	120	19	13.1	9	21	18	20
13	156	22	10	8.9	21	19	21
13	129	16	12	6	18.5	15	17
13	129	17.2	12.5	5.2	19.5	16	18.2
13	128	19	12.4	6.5	16	15.5	17
13	125	17.5	10.3	5.1	19	17.3	17
13	127	16	10	5.4	17.3	15	16.4
13	123	14	12	4	15.5	16.5	14.5
13	135	18.2	12	6.2	18.5	16.5	15
13	141	17	12.5	5	18	15.5	17
13	132	18	19.7	5.5	20	16	18
13	130	17.2	10.5	2.5	17.7	15.5	16
13	155	21	9	10.5	22.5	20	22
13	120	16.6	14	7.6	17	14	15.5
13	146	21	11	7	17	17.5	18.7

MASTER CHART-II

FURNITURE DIMENSION USED BY AGE GROUPS

AGE	DH	SH	SW

10	25	21	10
10	25	21	10
10	25	21	10
10	25	21	10
10	25	21	10
10	30	25	12
10	25	21	10
10	44	21	10
11	25	21	10
11	27	11	14
11	25	21	10
11	30	25	12
11	25	21	10
11	25	21	10
11	25	21	10
11	30	25	12
11	25	21	10
11	27	22	14
11	25	21	10
11	25	21	10
12	30	25	12
12	27	22	14
12	30	25	12
12	27	22	14
12	30	25	12
12	30	25	12
12	27	22	14
12	25	21	10
12	27	22	14
12	27	22	14
12	30	25	12
12	27	22	14
12	27	22	14
12	27	22	14
12	25	21	10

13	30	25	12
13	25	21	10
13	30	25	12
13	30	25	12
13	25	21	10
13	30	25	12
13	25	21	10
13	27	22	14
13	27	22	14
13	27	22	14
13	27	22	14
13	17	22	14
13	27	22	14
13	25	21	10
13	25	21	10

MASTER CHART-III

ANTHROPOMETRIC DIMENSIONS OF INDIVIDUAL CLASSIFIED BY GENDER

GENDER	HEIGHT	EH	SH	UAL	KH	PH	BPH
GIRL	128	17	11.2	4.8	99.5	16.5	18
GIRL	124	16.9	11.2	5.7	18	16	16
BOY	125	19	13.5	5.5	19	16.5	15
BOY	143	20	11	9	19.5	17.5	18
GIRL	124	16.2	11.2	5	18	15	17.5
GIRL	128	18	10	8	17.5	15	17
GIRL	122	17	11.9	5.1	19	15	17
BOY	141	19	11.2	7.8	19.5	16.4	18
BOY	136	18	10	8	17.9	16.5	17.5
BOY	137	19	10.9	8.1	17.5	17	17.5
GIRL	129	19	12	7	18	16	18
BOY	131	19.5	12	7.5	21	19	20
GIRL	124	17	10.5	6.5	19	16	16
GIRL	135	18.5	11	7.4	20	18	19
GIRL	140	18.3	9.5	8.8	20	19	19.7

BOY	127	17	9	8	17.5	15	15.5
GIRL	125	16.5	10	6.5	18	16	17.2
BOY	120	18	12	6	17	17	19
BOY	134	17.7	11.5	5.6	21.5	17	18
BOY	134	18.5	10	8.5	18.8	16	16.7
GIRL	140	18	12	6	18	15.2	14
BOY	140	18.4	12.2	6.4	19	17.6	20.3
GIRL	136	20	10.5	7.8	20	18	19
BOY	132	16.6	11.5	6.1	18.5	15.4	16.7
GIRL	136	17	12.5	5.5	18.2	16.7	17.2
GIRL	140	18.2	13	5.7	22.5	18	19
BOY	154	19.5	11.5	6.5	21	19	21
BOY	135	19	12	7.5	18	16	17.5
GIRL	128	17.5	11.5	5.5	18	15	16
GIRL	138	19	13	7.5	19.2	16	18
GIRL	136	14.5	11.9	4.5	20.1	17.3	19
BOY	125	18.2	11	6.3	19	16	16.5
GIRL	126	17	8	6	16	15	17.1
GIRL	128	15.2	11	7.2	16	13	14
GIRL	131	17	10	6	17.5	16	18
GIRL	120	19	13.1	9	21	18	20
BOY	156	22	10	8.9	21	19	21
GIRL	129	16	12	6	18.5	15	17
GIRL	129	17.2	12.5	5.2	19.5	16	18.2
GIRL	128	19	12.4	6.5	16	15.5	17
GIRL	125	17.5	10.3	5.1	19	17.3	17

BOY	127	16	10	5.4	17.3	15	16.4
BOY	123	14	12	4	15.5	16.5	14.5
BOY	135	18.2	12	6.2	18.5	16.5	15
BOY	141	17	12.5	5	18	15.5	17
GIRL	132	18	19.7	5.5	20	16	18
BOY	130	17.2	10.5	2.5	17.7	15.5	16
BOY	155	21	9	10.5	22.5	20	22
GIRL	120	16.6	14	7.6	17	14	15.5
GIRL	146	21	11	7	17	17.5	18.7

MASTER CHART-IV

FURNITURE DIMENSION USED BY GENDER GROUPS

GENDER	DH	SH	SW
GIRL	25	21	10
GIRL	25	21	10
BOY	25	21	10
BOY	25	21	10
GIRL	25	21	10
GIRL	30	25	12
GIRL	25	21	10
BOY	44	21	10
BOY	25	21	10
BOY	27	11	14
GIRL	25	21	10
BOY	30	25	12
GIRL	25	21	10
GIRL	25	21	10
GIRL	25	21	10
BOY	30	25	12
GIRL	25	21	10
BOY	27	22	14
BOY	25	21	10
BOY	25	21	10
GIRL	30	25	12

BOY	27	22	14
GIRL	30	25	12
BOY	27	22	14
GIRL	30	25	12
GIRL	30	25	12
BOY	27	22	14
BOY	25	21	10
GIRL	27	22	14
GIRL	27	22	14
GIRL	30	25	12
BOY	27	22	14
GIRL	27	22	14
GIRL	27	22	14
GIRL	25	21	10
GIRL	30	25	12
BOY	25	21	10
GIRL	30	25	12
GIRL	30	25	12
GIRL	25	21	10
GIRL	30	25	12
BOY	25	21	10
BOY	27	22	14
BOY	27	22	14
BOY	27	22	14
GIRL	27	22	14
BOY	17	22	14
BOY	27	22	14
GIRL	25	21	10
GIRL	25	21	10

MASTER CHART-V

NORDIC MUSCULOSKELETAL QUESTIONNAIRE FOR BOYS

NECK	SHOULDER	ELBOW	WRIST / HAND	UPPER BACK	LOWER BACK	HIPS/ THIGHS	KNEES	ANKLES

2	2	2	1	1	1	1	1	1
2	2	1	2	2	1	1	1	1
2	2	1	2	2	1	1	1	1
1	2	1	1	1	1	1	1	2
2	2	2	1	1	1	1	2	1
1	1	1	1	2	1	1	2	1
2	1	1	1	2	1	2	2	1
2	2	1	2	2	1	1	2	2
2	1	1	2	2	2	2	2	2
2	1	1	1	2	1	1	1	1
2	1	1	1	1	1	1	1	1
1	2	1	2	2	1	2	1	1
2	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	2	1	2	1	1	1	1	1
2	2	1	2	2	1	1	2	1
2	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1

MASTER CHART-VI

NORDIC MUSCULOSKELETAL QUESTIONNAIRE FOR GIRLS

NECK	SHOULDER	ELBOW	WRIST/ HAND	UPPER BACK	LOWER BACK	HIPS/ THIGHS	KNEES	ANKLES

2	1	1	2	1	2	2	2	2
1	2	1	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1
2	1	1	2	1	1	1	1	1
2	2	1	2	2	1	2	1	1
2	2	1	1	1	1	1	1	1
2	2	1	2	2	2	2	2	1
2	2	1	1	1	1	1	1	1
2	2	1	2	2	1	1	1	1
1	1	1	2	1	1	1	1	1
2	2	1	2	2	2	2	1	1
2	1	1	2	1	1	1	1	1
2	1	1	2	2	1	2	2	2
2	2	1	1	2	1	1	2	1
1	1	1	1	1	1	1	1	1
2	2	1	2	2	1	2	2	1
2	2	1	2	2	1	1	2	1
2	2	1	1	2	1	1	1	1
2	1	1	1	1	1	1	1	1
1	1	2	1	1	1	2	1	1
2	1	1	2	2	2	2	2	2
2	1	1	2	1	1	2	1	2
1	1	1	1	1	1	1	1	1
2	2	1	1	1	2	2	1	2
1	1	2	2	2	2	2	1	1
2	2	1	2	1	1	1	1	1
2	1	1	2	2	1	2	2	2
2	1	1	2	2	2	2	1	2