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The Effect of Poorly Designed School Furniture on Children's Head and Scapulae Postures: A Cross Sectional Design

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Abstract

The purpose: This study aimed toevaluate the effect of school furniture on the head and scapulae postures of school age children. **Methodology:** Two hundred normal subjects from both sexes participated in this study. Their age ranged from 7-9 years old. Recorded photographs analyzed by AutoCADprogram for posture assessment, user furniture and school furniture (desk and bench) dimensions were measured. Each furniture dimensions was tested according to ergonomics principles. **Results:**The results for this study showed that there was a mismatch between body dimensions of the subjects who participated in this study and the school furniture available for them. It also confirmed significant effects of the furniture dimensions on the head and scapulae posture variables.**Conclusion:** From the obtained results of this study, it could be concluded that there was significantimpacts of school furniture on the head and scapulae postures of these subjects.

Key wards:*classroom furniture, anthropometry, head, scapulae, posture.*

Introduction:

One of the main objectives of The Egyptian strategic plan 2030 was to develop new methods of treatment and disease prevention. So, this study aimed to evaluate the impacts of school furniture on the head and scapulae postures of school age children. These impacts were found significant in this study. Children spend from five to seven hour per day assuming sitting position in school life (1). There are different types of school furniture designs. Each one of these design should be meet the ergonomic principles to be healthier(2,3). The mismatching of educational furniture design contributes to the several musculoskeletal problems including muscle spasm, neck pain and

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incorrect posture(4-9).

In examinations directed in certain nations, furniture has been discovered to be excessively high for understudies. In Finland,the taller the young men, the more frequently report back agony. Exorbitantly little school furniture powers school studentsto sit in a kyphotic stance. Kyphosis has expanded in understudies in a long term follow-up where it has been discovered thatmore established youngsters willreport back agony more much of time than more youthful kids. Neck, shoulder and back agony are normal among younger students. Meetings have recorded an expansion in medical issues in younger students(10).The instruction of children in creating nations has long been respected as an imperative component of financial advancement. Routinely the furniture is of moo quality, has unforgiving creating surfaces, falls isolated quickly, and doesn't fit the youngsters; anyway it is modestly extreme and consumes an unequal amount of compelled educational spending plans(11). In this manner, in the desire to limit any potential future stance related medical conditions, the current examination was led to decide whether the classroom furniture would be coordinated with Global norms and subject's measurements. In addition, the study would examine the effect of poorly designed school furniture on the head and scapulae postures of these subjects.

PARTICIPATION AND METHODOLOGY

Study Design

This cross-sectional study was conducted in the primary public school during the period from March 2017 to April 2019. Informed consent was submitted by the parents of each child. Our procedures had No: P.T.REC/012/003029 that approved by the Institutional Ethical Committee Clearance of the Faculty of Physical Therapy at Cairo University. The registration number of our study was: NCT04758832 that was registered on Clinicaltrial.gov.

Participants

Two hundred normal children (121 males and 79 females) participated in this study. They were selected from primary public school, Cairo. They were selected according to the following criteria:1) Their age ranged from 7-9 years old, 2) had normal body mass index (ranged from 18.5 to 24.9 kg/ m^2), 3) The school furniture workstations used by all subjects were all of wooden flat desks and benches. We excluded from the study children who suffering from respiratory or heart problems which is confirmed by the school physician,not suffering from combined back deformity and deformity of upper or lower limb.

Randomization

Two hundred and fifty-seven normal children were evaluated for eligibility; thirty-five children

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were excluded because they failed to fulfill the inclusion criteria and sixteen parents refused to enrolled in this study. Therefore, Two hundred normal children were included in this study. A diagram of children's retention and randomization throughout the study is shown in fig (1).

Outcome measures:

Tape measurement:

It was used to determine the height of the subject in centimeters (cm)(12).

Weight scale:

It was used to determine the weight for every subject in kilograms (kg).

Body mass index (BMI):

BMI was calculated as the ratio of the subject's height (in meter) and weight (in kilogram) i.e. weight/ height^2. The normal subject's BMI value should range from 18.5 to 24.9 kg/ m^2, (13).

Photographic analysis:

Auto CAD program (version 2013) used to determine head and scapular postures(angles, displacement and elevation).

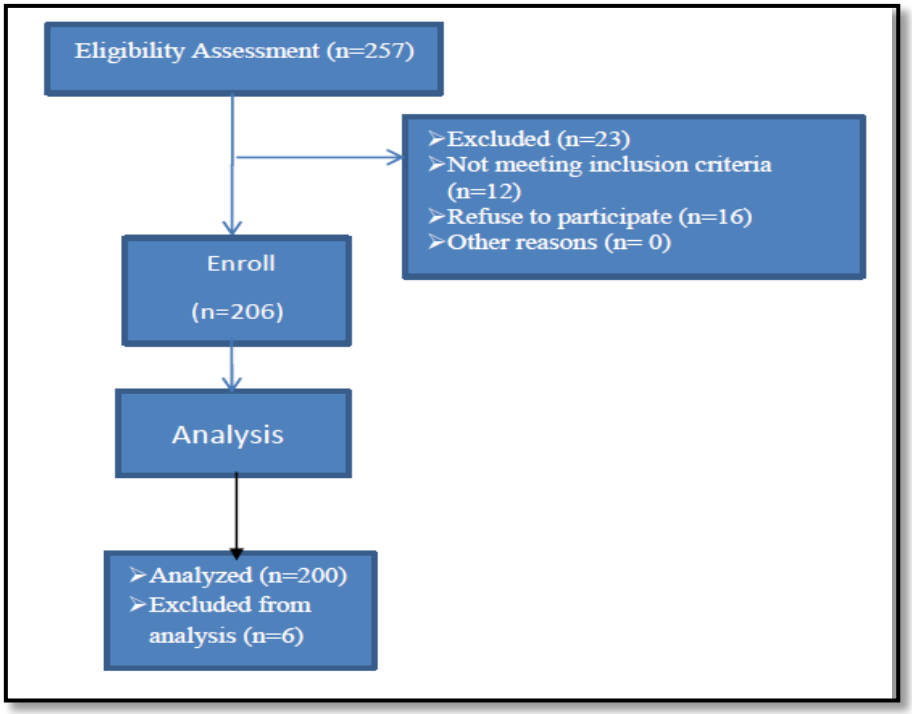

Figure (1): Flow chart.

Procedures

The approval was obtained from the concerned school authority. After parental permission, the tape measurement was installed on the wall by using pins. The subject's stature was determined as the vertical distance between the floor and the top of the head and measured with the subject standing erect against the wall and looking straight ahead, (12). He/she was asked to stand on a weight scale to determine his weight in kilograms. His/her BMI was calculated**.** The subject was asked to wear light cloths and the sheer spot with extended sticks were placed on define the

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anatomical land marks: lateral canthus of the eye, tragus of the ear, spinous process of C7, anterior border of the acromion and olecranon process, (14). All markers were not removed until the test was completed.The camera was placed on tripods of height 134.5 cm and at a distance of 2 meters lateral and perpendicular to the child and the school furniture. The tripods were secured in the correct position on the floor by using floor markers. Floor markers were also used to ensure the subject's right side was aligned perpendicular to the camera and to standardize the subject's placement (in standing and sitting position) and the distance to the school furniture (desk and bench). The recorded photographs were taken after one and half hour from the starting of the school day. These photographs were shot from the sagittal view and while the subject was asked to assume the following position:

- Standing in their relaxed normal posture at a mark on the floor, with the standardized instruction: “feet slightly apart, stand normally and relax, look straight ahead”,(14).
- Sitting on the school furniture with the standardized instruction: “knee and elbow bent at 90º, feet supported on the floor and look straight ahead”,(15).

Auto CAD analysis for recorded photographs:

The operator connected the landmarks by straight lines. The intersections joints between lines were measured and calculated automatically. It was as the following:

From standing position:

Two dimensional coordinates of each marker were used to determine the head and scapulae postures assessment including the distances and angles in figure (2), (14).

From sitting position:

- The user furniture dimensions were measured as mentioned in figure (3a), (15).
- Educational furniture dimensions (desk and bench) dimensions were measured as mentioned in figure (3b), (15).

Relationship between educational furniture dimensions and the user body dimensions:

- The educational furniture dimensions and the user furniture dimensions were used to define the range in which each furniture dimensions is considered appropriate. It was done according to the five ergonomics equations mentioned in figure (4),(15).

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Figure (2): The distances and angles measured from sagittal view.		
Distance/angle		Distance/angle definition
1	Head flexion angle (HFA)	Line of canthus to tragus with respect to vertical (measured from vertical above intersect).
2	Neck flexion angle (NFA)	Line of tragus to C7 with respect to vertical (measured from vertical above intersect).
3	Craniocervical angle (CCA)	Angle between line of canthus to tragus and line of tragus to C7 (measured anterior to intersect).
4	Head displacement (HED)	Horizontal distance between markers at C7 and tragus.
5	Scapula displacement (SCD)	Horizontal distance between markers at C7 and the anterior border of the acromion.
6	Scapula elevation (SCE)	Vertical distance between markers at C7 and the anterior border of the acromion.

Figure (3a): The user- furniture dimensions (sitting position).	
Item	Definition
Elbow seat height (EH)	Measured with the elbow flexed at 90°, as the vertical distance from the bottom of the tip of the elbow to the student's seated surface
Shoulder height (H)	Measured as the vertical distance from the top of the shoulder at the acromion process to the student's sitting surface.
Upper arm length (UAL)	Difference between the elbow height and shoulder height.
Knee height (KH)	Measured with knee flexed at 90°, as the vertical distance from the foot resting surface to be top of the knee cap, just above the patella.
Popliteal height (PH)	Measured with a 90°, knee flexion, from the foot resting surface to the popliteal space, which is the posterior surface of the knee
Buttock-popliteal length (thigh length) BPL	Measured with the knee flexed at 90°, as the distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal surface.

Fig (3a): Anthropometric dimensions measured: elbow-seat height (K); shoulder height (H); buttock-popliteal length (M); popliteal height (N); knee height (O).

Figure (3b): The educational furniture dimensions (sitting position).	
Item	Definition
Seat height (SH)	Measured as a distance from the floor to the highest point on the front of the seat.
Seat depth (STD)	Measured from the back of the sitting surface of the seat to its front.
Backrest height (BH)	The vertical distance from the desk seat to the top edge of backrest.
Desk–seat height (DH)	The vertical distance from the seat to the top of the front edge of the desk.
Under-surface of desk height (UDH)	The vertical distance from the floor to the bottom of the front edge of the shelf under the writing surface.

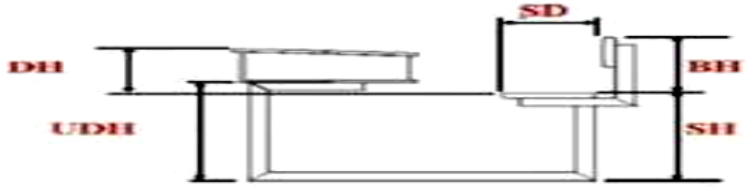

Fig (3b): Furniture dimensions (cm) showing the current SD = seat depth; BH = backrest height; SH = seat height; UDH = under-surface of desk height; DH = desk height.

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Figure (4): Relationship between educational furniture dimensions and the user body dimensions		
No	Relation	Ergonomics equation
1	Seat height to popliteal height	(N +2) cos 30°≤ SH < (N + 2) cos 5° Where SH is seat height and N is popliteal height.
2	Seat depth to the popliteal-buttock length	80%M≤ SD < 95%M Where SD is seat depth and M is popliteal–buttock length.
3	Backrest height	60% H≤ BH < 80% H Where BH is backrest height and H is shoulder height (scapula height).
4	Desk height	K + (N + 2) cos (30) ≤ DH < (N + 2) cos (5) + 0:8517K + 0:1483 H Where DH is desk height, K is elbow–seat height, N is popliteal height and H is shoulder height.
5	Under-surface of desk height	(O+ 2) + 2 ≤ UDH Where UDH is the under-surface of desk height and O is the knee height

Data analysis and statistical design:

The mean value and standard deviation were calculated for each variable measured during the study. The percentage of compatibility for each item of the educational furniture dimensions to the user furniture dimensions was calculated. The impact of school furniture on the posture of school age children was done by multiple correlation and regression.

Results

Descriptive data of the subjects:

The distribution of males and females was 60.5 % and 39.5%; respectively. The mean values ± standard deviations of the age, weight, stature, body mass index (BMI) and the subject's dimensions indicated were represented in table (1). The mean values ± standard deviations of head and scapulae posture assessment (angles and distances) for all subjects were represented in table (2). The mean values ± standard deviations of educational furniture dimensions were represented in table (3).

Table (1): The mean value of the user age, weight, stature, body mass index and	
Item	Mean ± standard deviation
Age (years)	7.45 ± 0.65
Weight (Kg)	29.38± 3.77
Stature (Cm)	120.64±7.745
Body mass index (BMI) in kg/m^2	20.14± 1.35
Elbow seat height (EH) in mm	63.43 ± 18.18
Shoulder height (H) in mm	164.98± 41.83
Upper arm length (UAL) in mm	101.38± 34.83
Knee height (KH) in mm	156.51± 46.54
Popliteal height (PH) in mm	116.24± 34.38
Buttock-popliteal length (thigh length) BPL in mm	127.60± 39.8

The percentage of compatibility for each item of the educational furniture dimensions to the user furniture dimensions.

The percentage of compatibility for each item of the educational furniture dimensions to the user furniture dimensions, table (4).

Table (2): The mean value of head and scapulae posture assessment (angles and distances) for all subjects.

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Item	Mean ± standard deviation
Head flexion angle (HFA)	72.32± 7.63
Neck flexion angle (NFA)	47.45± 7.44
Craniocervical angle (CCA)	154.45± 13.31
Head displacement (HED)	43.77± 19.39
Scapula displacement (SCD)	40.71± 19.39
Scapula elevation (SCE)	44.15± 20.03

Table (3): The mean value of school furniture dimensions (desks and benches) in mm.	
Item	Mean ± standard deviation
Seat height (SH)	120.27± 42.25
Seat depth (STD)	165.88± 57.19
Backrest height (BH)	141.24± 50.93
Desk–seat height (DH)	105.89± 35.60
Under-surface of desk height (UDH)	175.54± 55.42

Table (4): The mismatch and match percentages between the school furniture and the user furniture dimensions.

Item		Frequency	Percent (%)
Seat height to popliteal height	Mismatch	167	83.5
	Match	33	16.5
Seat depth to the popliteal- buttock length	Mismatch	180	90
	Match	20	10
Backrest height	Mismatch	125	62.5
	Match	75	37.5
Desk height	Mismatch	187	93.5
	Match	13	6.5
Under-surface of desk height	Mismatch	92	46
	Match	108	54

The relation of the compatibility of school furniture to the head and scapulae postures.

The Bivariate Correlations procedure computed Pearson- a parametric test, to test the relationship between variables with ordered categories and their significance levels. The correlations between head and scapulae postures and the compatibility of school furniture were represented in table (5).

Table (5): Correlation between head and scapulae postures and the compatibility of school furniture.

Item		The head and scapulae postures					
		HFA	NFA	CCA	HED	SCD	SCE
Seat height	Pearson Correlation	-0.222(*)	-0.095	-0.029	0.007	0.060	-0.061
	Sig. (2-tailed)	0.046	0.180	0.680	0.917	0.402	0.387
Seat depth	Pearson Correlation	0.029	-0.087	-0.052	0.054	0.162(*)	0.001
	Sig. (2-tailed)	0.682	0.221	0.468	0.444	0.022	0.991
Backrest height	Pearson Correlation	0.019	-0.094	-0.042	0.005	0.076	-0.045
	Sig. (2-tailed)	0.794	0.185	0.554	0.947	0.285	0.524
Desk–seat	Pearson Correlation	-0.048	-0.156(*)	-0.085	0.139	0.248(**)	-0.010

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height	Sig. (2-tailed)	0.500	0.028	0.234	0.052	0.000	0.886
Under-surface of desk height	Pearson Correlation	-0.005	-0.076	-0.031	0.014	0.078	-0.135(*)
	Sig. (2-tailed)	0.948	0.285	0.664	0.843	0.270	0.022
*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed).							
Head flexion angle (HFA), neck flexion angle (NFA), craniocervical angle (CCA), head displacement (HED), Scapular displacement (SCD) and scapular elevation (SCE).							

Discussion:

The present study was performed on two hundred normal children. Their age was ranged from seven to nine years old. The school furniture workstations utilized by all subjects were all of wooden level work areas and seats. The recorded photos taken from sagittal see whereas the subject was in standing and sitting positions were examination by AutoCAD program. The age of the subjects in the present study that ranged from seven to nine years old come in agreement with Bloomfield et al., (1994) who mentioned that development sprays occurring in nine to long term olds may cause extensive changes fit as a fiddle and estimations and affect muscle coziness and versatility, all of which may affect present in kids(16).Their body mass list that extended from 18.5 to 24.9 kg/ m2 come in assention with Pinto et al., (2006) who expressed that the corpulence is a vital figure related with musculoskeletal torment in subjects. Relative to their non-obesecomparative matured partners, stoutsubjects displayed essentially higher torment within the locomotorsystem. They in addition found a superior repeat of postural changes, for example, lumbar hyperlordosis, genu valgum and genu recurvatum in heavy subjects than in non-corpulent subjects(17).

It too comes in understanding with Kratenova et al., (2007) who specified that the most noteworthy event of destitute pose was found in underweight subjects. The foremost as often as possible abandons were jutting scapula, expanded lumbar lordosis and circular back (18).The results for this study showed that there was a crisscross between body measurements of the subjects who partook in this study and the school furniture accessible for them. It was seen that the school furniture seat heights were mismatch by 83.5%. The school furniture seat depths were mismatch by 90%. The school furniture backrests were mismatch by 62.5%. The school furniture desk heights were mismatch by 93.5%. The school furniture desk heights were mismatch by 46%. The results for this study also showed that there were significant relationships between school furniture dimensions and head and scapulae posture (distances and angles) variables.

These proportions of popliteal height and butt cheek popliteal length are needed to get it the impact of seat height and significance on posture. On the off chance that the seating surface is too tall, the underside of the thigh will be packed causing burden and imprisonment in blood dissemination. To make up for this, a sitting individual commonly moves his/her butt cheek

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forward on the seat arrange. This may bring about a hung, kyphotic posture because of need of back help. In development, the feet don't have real contact with the floor surface and body strength is crippled. Then again, on the off chance that the arrange surface is also moo, the knee flexion point will be close to nothing, the client's weight is traded to a little area at the ischial tuberosities, and there's a need of weight scattering over the back thighs (1, 19, 20).At the point when situate is also significant, the front edge of situate will press into the zone reasonable behind the knees, slicing off flow to the legs and feet. To diminish the burden, the person inside situate will slide forward yet will lose suitable lumbar and backrest back. Again, normally prone to bring about a hung, kyphotic stance with plan weight over and back to the ischial tuberosities. Also shallow arrange significance may make the customer have the vibe of tumbling off the front of the seat just as result in a need of back of the lower thighs (1, 21-23).A free zone between the rear of the lower part and the organize dish is beneficial to stimulate the proposed 80° flexion of the knees for emerging from the seat and for leg headways. Knee and elbow rest height are other than fundamental in thinking about stance. At the point when knee height beats the work area/table leeway, the patella or front thigh will strike the underside of the work district or table. This may lead the customer to develop and situate the legs forward. The feet by then require strength. If the elbow rest height is lower than the work zone or table surface, the working arm should be raised (21).If the elbow rest height is lower than the work zone or table surface, the working arm should be raised. To redress, shoulders should additionally be raised or took putting a push on the more significant back neck musculature to supply adjustment of the head present. If the elbow rest height outperforms that of the work area or table, it will result inside the customer bowing forward by spinal flexion, with the body weight being upheld by the arms. A kyphotic spinal posture with round shoulders will result. When performing deskwork, a bear flexion purpose of 25° and a bear abduction purpose of somewhere in the range of 15° and 20° is illustrate(21-23).

Conclusion

It can be concluded that the furniture of the school classroom did not meet the international standards and dimensions of the subject. There is bigrelation between these furniture and the head and scapulae postures.

Conflict of interest

No conflicts of interest have been declared by the author(s).

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In support of this study, no benefits or funds were obtained.

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