Effect of Seat Angle on the Load Moment of the Cervical Spine in Normal Individuals

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ABSTRACT

This study aims at finding the relationship between different seat angles and the load moments of the cervical spine of normal individuals. Thirty healthy male subjects aged between 18-24 years volunteered for the study. All subjects were photographed while they were sitting on a Dauphen chair with an adjustable seat angle and practicing a manual dexterity task. Six Photographs were taken perpendicularly from the sagittal view for each subject three for an ordinary (0 degree) seat angle and three for a 20 degrees forward inclined seat angle. Photographs were taken at the starting position before working, after ½ an hour and after one hour, respectively. Load moments were estimated from the photographs while the cervical and trunk range of motion (ROM) were measured by inclinometer and photography. Paired t-test was used to compare between the data findings. The study revealed that during sitting on a chair with a forward inclined seat angle, there was a significant decrease in the intensity of the load moments and on the displacement of the center of gravity (COG) of the head and the head and neck. The study also revealed that there was a significant decrease in the cervical and trunk ROM as estimated either by inclinometer or photography in case of sitting on an inclined forward seat. The study also indicated that photography is a valid method for measuring ROM. Moreover, the study revealed that there was no significant difference between the mean values of the cervical ROM and the eye sight of 6/6, 6/9 or 6/18.

Key words: Biomechanics, Ergonomics, Cervical spine, seat angle, Load moment.

INTRODUCTION

Familiar types of chairs and seats have long been known since Ancient Egyptians. The Ancient Egyptians used the wooden chairs as well as chairs made from ivory and metal. In this era, the interest was directed towards the appearance and beauty of the furniture rather than the ergonomics aspect. Recently, the chair presented a new challenge to those who perceived the scope of the new mechanics as well as of the new society[1]. The characteristics of an ideal chair such as the adjustable one, should allow adequate, natural, comfortable and flexible support and stability for body segments, as well as distribution of body weight and freedom of movement. A well-designed chair will affect posture, circulation, the amount of effort required to maintain posture, and the amount of strain on the spine[2]. Although Egypt has a significant sector of highly skilled manual workers, no study has been provided to address the criteria of an optimal working environment. Therefore, a pilot survey study was conducted on some of the artifact workers on the job using a simple questionnaire and a sequence of a photo-graphic pictures. It was observed that the workers showed tendancy to assume an deformed posture during work. This was confirmed by the fact that 80% of the surveyed subjects reported having pain in their upper extremities, cervical and lumbar regions. The chair, being a primary determinant of comfort (or discomfort) for most of the skilled artifact workers, has been chosen for this study.

As the chair design forces a certain posture of the body, the idial chair may be defined as that minimizing stresses upon joints of the body. Such stresses are built up in the form of torques which act at the joints. Torques are the result of forces acting at a distance. In the case of sitting, the most significant torque is that resulting from the weight of the body represented at the center of gravity (COG) on its moment arm. The center of gravity is an imaginary point representing the weight center of an object. It has been reported by (Dempster 1995) that each segment in the human body has its own center of gravity and the whole body has a collective COG[6,7]. The line of gravity (LOG) is an imaginary vertical line which passes through the COG of the body. For the purpose of stability the line of gravity should fall inside the base of support which is the area of contact of the body with the supporting surface[5].

The position of the COG changes according to the position and inclination of the body. The sitting posture which produces the best alignment of LOG and nearest curvature to the normal lumbar shape is one in which the trunk-thigh angle is about 115 degrees and the lumbar position of the spine is supported. In contrast, a right angle sitting-up position produces a great deal of spinal distortion. The main cause is the compressive weight of the upper part of the body which is harmful to the lower lumbar vertabrae. This is how discomfort and sometimes pain occurs as a person sits in a chair with a 90 degree backrest angle[8].

Furthermore, the curves of both the cervical and the thoracic regions are affected with time and cause a hump-back "kyphotic" posture, and extensive flexion deformity of the spine. This in turn, increases the load on the musculature supporting the head and produces fatigue in the neck and back[9]. The loading on the lumber spine differs according to types of sitting. There are three types of sitting; relaxed unsupported, erect, and supported sitting[8].

In relaxed unsupported sitting the intra-discal pressure increases to the maximum value 140% of the normal intra-discal pressure and if it is prolonged it will cause pain and discomfort[13]. In erect sitting, the backward tilting of the pelvis is reduced and the LOG becomes within its normal path and decreases the lever arm of the force exerted by the weight of the trunk. Therefore the torque on the lumbar spine will decrease and the corresponding muscular activity will also decrease[11,12]. In short, the intradiscal pressure decreases in the erect sitting[10]. In supported sitting, the load on the lumbar spine decreases significantly because the weight of the upper body is supported by the backrest especially at the lumbar region. The amount of decrease in the load imposed on the lumbar region and intradiscal pressure depends on the degree of inclination of backrest and presence of lumbar support. Chairs with 90 degrees backrest inclination without lumbar support produce maximum intradiscal pressure. Increasing the backrest inclination will decrease the intradiscal pressure. The best chair is one which has from 110 - 120 degrees backrest inclination with lumbar support of about 5 cm^2 in its contact area[8,13,14].

In order to reach the best design of the chair at which different kind of loads will be decreased, certain dimensions must be taken into consideration, namely, seat height, seat width, depth, and angle. In addition to backrest height and width, backrest angle, and arm-rest height. This anthropometric consideration differs according to types of chair. The easy chair is a chair which is preferred to relax the posture, and can be considered as a relaxing chair. The work chair is a suitable chair for subject during performing certain job. A multipurpose chair is a modern type of chairs which has been used nowadays in the big companies. It allows the subject to move surround his place and perform different tasks[3].

MATERIAL AND METHODS

Subjects:

Thirty healthy male subjects volunteered for the study. They were selected on the following bases; aged between (18-24 years) their height between 1.65-1.75 meters, with good eye sight, performing a job which requires manual dexterity.

Instrumentation:

The chair used in the study had an adjustable height ranging between 42-53 cm adjusted according to the subjects leg length. The seat enabled to incline forward 20 degrees below the horizontal level. Knee and foot support was a rest which was used for supporting the knees and the feet of the subject. It was used to prevent slippage of the subject forward while the seat angle was inclined forward.

Both the chair and the table which was used as a working desk for the study were placed close to the wall on which a graded pattern was adhered flat. The graded pattren was traced with vertical and horizontal equidistant lines forming squares of 5 by 5 cm length. This graded pattern was used as a calibrated background which could be seen on the photograph. Thus enabled the measurements of the variables used in the study. Keeping consistent repeated procedures when each subject was photographed and also with the subjects it was found that each 5 cm on the graded pattern were equal to 3.3 millimeters on the photograph of 10 x 15 cm in its size i.e. a reduction factor was 15.02%.

A canon 35 mm automatic camera with normal lens 50 mm was used to take pictures for each subject while sitting on the chair in front of the desk and performing a task of manual dexterity. The camera was mounted on a tripod which was always placed at the same location throughout the study. The tripod was 300 cm far from the graded background. Keeping the camera and tripod at this fixed distance insured the consistency of the sitting with each subject and between subjects recorded.

A 100 ASA colored Kodak film (36 exposures) with a size of 35 mm was used throughout the study. The photo was printed on a kodak textured colored paper size (10 x 15 cm).

Two inclinometers were attached to the subject. One inclinometer (O.B.) was wrapped around the head to measure the change of the range of motion of the head flexion in the sagittal plane during the procedure. The second inclinometer (PC 5057 biokinetic fluid-based inclinometer) was wrapped around the trunk by a strap to measure the change of the trunk range of motion (ROM) in the sagittal plane.

Procedure:

Preparation of the subjects:

The adhesive markers were stuck on the skin at specific sites; (1) at the atlantto-occipital junction, (2) at the tip of 7^{th} cervical spine, (3) at the level of 5^{th} thoracic vertebrae, (4) at a point just above the head of the clavicle which was exposed to the camera, (5) at the sternal junction, (6) at the small lip in the front of the ear opening over head of the mandible which represent the COG of the head and neck, (7) at a point 2 cm above and 1 cm in front of the COG of the head and neck, (8) at a point which was anterior to the mastoid process which represented the intersection of the perpendicular bisectors of two vectors; (one was in between occ-c_1 junction to the nose-upper lip junction and the other was the motion axes of occ-c_1 and C_7-T_1). These adhesive markers allowed measuring of different distances and angles to be measured on the photographs taken for each subject.

After the above subjects preparation, the subjects was instructed to erect on the chair while it was adjusted at ordinary seat angle with his hands over his thighs, looking in the front of him to a specific object at the same horizontal distance (4 meters) and located at the same height from the floor. Then, the subject was photographed perpendicularly from the lateral view. After that, the subject was given certain time to practice a task which required manual dexterity on the surface of the working desk. This task was in the form of giving the subject a piece of wood and a wood rasp and he tried to carve this piece of wood while sitting in the erect posture and performing the task. After half an hour the subject being in this position a picture was taken. After one hour of sitting performing the task as described before, another picture was taken for the subject with the aim of detecting any deviation which might occur in the body segments as a result of working in that length of time figure (1).

After the procedure of photographing the subject in the starting position, after half an hour and after one hour of performing manual dexterity, the subject was given a period of rest for fifteen minutes, then the seat angle of the chair was adjusted to be inclined downward. Then the subject was instructed to sit in the starting position and placed his hands again over his thighs. After half an hour later of performing manual task, another photograph was taken and after one hour the last photograph was taken. During each of the above sequence of picturing the subject, the reading of the two inclinometer were recorded.

Biomechanical calculation:

The photography was used for the determination of the head and neck position and also for the calculation of the load moments of the forces using mathematical calculation figure (2).

Fig. (1) : a- Working desk, b- Graded pattern, c- Dauphen chair

Firstly, the center of each marker was identified on the photo. Then a line was drawn from the center of the marker located at C_7 spinous process to the center of the second marker just above the head of the clavicle.

A mid way point of that line was detrmined (P_1) then a line was drawn from this midpoint to the line extending from the occipital-first cervical joint (occ-c_1 joint) to nose-upper lip junction to meet this line in a point (P_2).

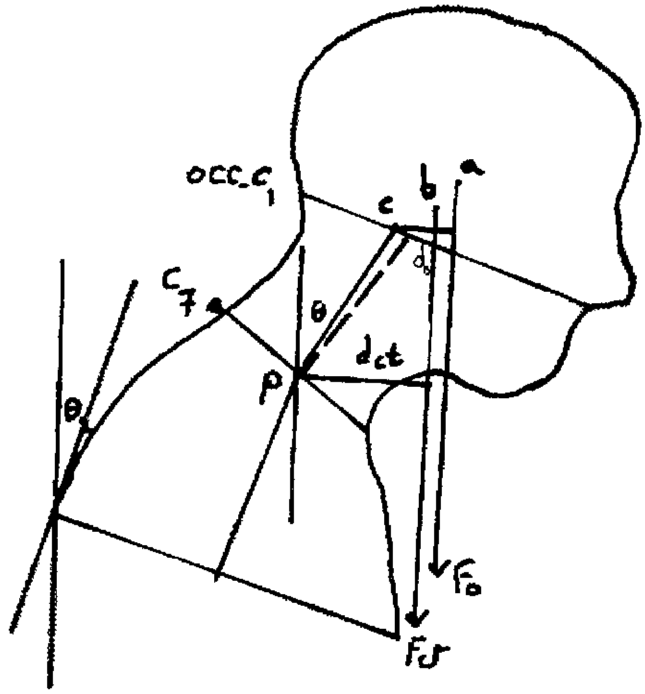

Fig. (2) : Schematic representation used for biomechanical calculation in the study. a = Point for COG of the head. b = Point for COG of the head and neck. c = Point represent axis of motion of the head. p = Point represent the axis of motion of the head and neck. d_o = Moment arm of the head. d_{ct} = Moment arm of the head and neck. F_o = Force induced by the body segment weight of the head. F_{ct} = Force induced by body segment weight of the head and neck. Φ1 = Cervical inclination. Φ2 = Trunk inclination.

According to published data Dempster the mass of the head alone is equal to 6.9% of the body weight with the COG located behind the sella turcica in the mid-sagittal plane. While the mass of the head and neck amounts to 7.9% of body weight with the COG in the sagittal plane is at the small lip in the front of the ear opening over the head of the mandible.

After obtaining the above data the load moment (M) was calculated by using static mechanical analysis as follows:

M = d x F

(**M**: Moment, **d**: Moment arm, **F**: Force)

$M_o = d_o \times F_o$ ________ (1)

M_o = Load moment of head only

d_o = Moment arm or a perpendicular distance from © to gravitational force of the head.

F_o = Force induced by the body segment weight of the head.

$M_{ct} = d_{ct} \times F_{ct}$ ________ (2)

M_{ct} = Load moment of the head and neck together.

d_{ct} = Moment arm from (p) to gravitational force of the head and neck.

F_{ct} = Force induced by body segment weight of the head and neck.

On the photograph, measurement of the cervical ROM was illustrated. For each picture, a line was drawn from the COG of the head and neck to the mid way point between the seventh cervical point and a point just above the head of the clavicle. The angle between that line and a vertical line was measured. For each subject, six angles were recorded, three for each seat angle.

The measurement of the trunk ROM could be illustrated on the photograph. A perpendicular line was drawn on the line extending from the fifth thoracic to the sternal junction. The angle measured was in between the tangential line at the 5th thoracic point which was parallel to the previous perpendicular line with the vertical line. Six angles were illustrated for each subject three for each seat angle.

ANALYSIS OF THE DATA

Data collection, presentation and analysis of the results were used, paired t-test of significance. The correlation coefficient are was used. The data were considered significant when p was less than 0.05.

RESULTS

The load moment of the head (Nm): Comparing the load moments obtained from the 30 healthy male subjects when they were sitting on the chair with an ordinary seat angle and then on a forward inclined seat angle, it was demonstrated that there were a significant decrease ($p < 0.003$) in the load moments of the head and the load moment of the head and neck ($p < 0.001$) when the subjects sat on a forward inclined seat angle after half an hour, as well as after one hour tables (1 and 2).

Table (1): Effect of change of seat angle on the load moment of the head (Nm) in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	1.1	1.84	2.01	0.88	1.47	1.7
Standard deviation	0.36	0.39	0.4	0.28	0.34	0.31
Paired t Test (t value)	-15.93 (p<0.001)		-2.73 (p<0.005)	-13.09 (p<0.001)		-4.84 (p<0.001)
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.	4.19 (p < 0.002)					
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.	6.77 (p < 0.001)					
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.	6.21 (p < 0.001)					

p : probability level

Table (2): Effect of change of seat angle on the load moment of the head and neck (Nm) in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	2.90	6.24	6.62	2.56	5.46	5.78
Standard deviation	1.06	1.44	1.21	0.96	1.40	1.16
Paired t Test (t value)	-14.04 (p<0.001)		-3.77 (p<0.003)	-11.87 (p<0.001)		-3.06 (p<0.002)
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.	4.16 (p < 0.003)					
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.	5.79 (p < 0.001)					
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.	7.66 (p < 0.001)					

p : probability level

Forward displacement of the COG of the head (mm): The results also demonstrate that sitting on a forward inclined seat minimize significantly ($p < 0.001$) the forward displacement of the COG of the head and forward displacement of the COG of the head and neck ($p < 0.001$) than sitting on ordinary seat tables (3 and 4).

Table (3): Effect of change of seat angle on the forward displacement of the COG of the head (mm) in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	1.53	2.60	2.85	1.25	2.08	2.40
Standard deviation	0.51	0.48	0.54	0.43	0.51	0.46
Paired t Test (t value)	-18.58 (p<0.001)		-2.81 (p<0.004)	-13.81 (p<0.001)		-4.83 (p<0.001)
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.	4.01 (p < 0.004)					
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.	7.00 (p < 0.001)					
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.	6.50 (p < 0.001)					

p : probability level

Table (4): Effect of change of seat angle on the forward displacement of the COG of the head and neck (mm) in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	3.65	7.75	8.22	3.20	6.75	7.12
Standard deviation	1.44	1.92	1.66	1.33	1.82	1.53
Paired t Test (t value)	-13.95 (p<0.001)	-3.04 (p<0.003)		-11.96 (p<0.001)	-2.71 (p<0.05)	
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.	4.06 (p < 0.015)					
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.	5.90 (p < 0.001)					
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.	7.82 (p < 0.001)					

p : probability level

Correlation between the measured load moment of the head and neck and the displacement of the COG of the head and neck has demonstrated that there was a significant correlation between the two variables. That indicates that an increase in the forward displacement of the COG of the head and neck was associated with an increase in the load moment to counteract the gravitational pull.

The cervical ROM (degrees) measured by either photography or inclinometer : Comparison between the values obtained by both techniques when the subjects were sitting on ordinary seat and sitting on forward inclined seat demonstrated that the cervical ROM was significantly ($p < 0.006$) less on the forward inclined seat than the ordinary seat angle. The analysis showed that both technics demonstrated a highly significant degree of correlation between the values obtained after half an hour and after one hour whether the subjects of the study were sitting on ordinary or forward inclined seat table (5).

The trunk ROM degrees measured by either photography or inclinometer: Statistical comparison between the ROM of the trunk when the subjects were sitting on ordinary seat and when they were sitting on forward inclined seat showed that in ordinary seat angle the trunk significantly bent more than sitting with the seat inclined forward table (6).

Correlation between the two methods used in measuring the trunk ROM showed that there was a significant correlation between the two measures when the subjects were sitting on ordinary seat. However, correlation between ROM measured by inclinometer and photography showed a low level of correlation between the two measuring methods particularly after one hour of sitting on a forward inclined seat.

Relationship between the cervical ROM at the starting position and subjects eye sight: Correlation between the cervical ROM and the eye sight of the 30 healthy male subjects showed a poor relationship between the two variables. The value of the correlation coefficient r was 0.33 when the subjects sat on ordinary seat and 0.18 when the subjects sat with forward inclined seat.

Table (5): Effect of change of seat angle on the ROM of the cervical spine (in degrees) measured by photography in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	17.03	52.33	55.60	17.03	44.93	47.53
Standard deviation	5.16	13.43	13.19	5.92	13.66	13.38
Paired t Test (t value)	-17.74 (p<0.001)	-4.20 (p<0.001)		-14.10 (p<0.001)		-3.38 (p<0.001)
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.				0.00 ($p < 0.000$)		
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.				3.83 ($p < 0.006$)		
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.				4.33 ($p < 0.002$)		

p : probability level

Table (6): Effect of change of seat angle on the trunk ROM (in degrees) measured by photography in relation to time in 30 healthy male subjects.

	Ordinary seat angle			Forward inclined seat angle		
	Starting position	After half an hour	After one hour	Starting position	After half an hour	After one hour
Mean	30.47	39.63	41.67	30.00	34.93	36.20
Standard deviation	5.72	6.85	7.13	6.54	7.70	6.35
Paired t Test (t value)	-12.50 (p<0.001)	-4.91 (p<0.001)		-6.33 (p<0.001)		-1.72 (p<0.04)
Paired t-test between the load moments at the starting position of sitting on ordinary seat and starting position on forward inclined seat.				0.72 ($p < 0.24$)		
Paired t-test between the load moments after half an hour of sitting on ordinary seat and on forward inclined seat.				4.60 ($p < 0.005$)		
Paired t-test between the load moments after one hour of sitting on ordinary seat and on forward inclined seat.				5.40 ($p < 0.001$)		

p : probability level

DISCUSSION

The specification of a work chair place an important role in maintaining a good sitting posture with minimum strain. One of these specification is the possibility of changing the seat angle in relation to the back support of the chair. The seat angle could be inclined forward or backward. The backward tilting seat would cause the subject to bend forward and curve the spine unnecessarily, so the seat angle for the work chair should be included forward[2,13].

This work was conducted to investigate the relationship between change of seat angle and the load moment of the cervical spine of normal individuals as well as the effect on the forward displacement of the COG of the cervical spine.

Results of the load moments of the head at "Occ-C_1" and the head and neck at "C_7-T_1" while sitting on an ordinary seat angle were compared with the load moments while sitting on a forward inclined seat angle in thirty healthy male subjects. It was observed that the load moments of the head and the head and neck were significantly lower when the subject was sitting on a forward inclined seat than sitting on the chair with an ordinary seat angle whether at the starting position, after half an hour and after one hour.

The results also showed that the forward displacement of the COG of the head and the head and neck was significantly less when sitting on a forward inclined seat angle than sitting on an ordinary seat angle.

The decrease observed in both, load moments and the forward displacement of the COG following sitting on a forward inclined seat may have occurred due to a modulation in the posture of the subjects. The inclination of the seat forward caused an increase in the anterior tilting of the pelvis which is associated with an increase in the lumbar lordosis. Calliet,[15] reported that any deviation of one part of the body towards one direction must be counterbalanced by another deviation of other part of the body in an opposite direction in order to maintain balance. Therefore any decrease or increase in the lordotic curve of the lumbar spine is counterbalanced directly by a change in the rest of the vertebral column. Thereby, an increase in the lumbar lordotic curve is associated with an increase in both dorsal kyphotic and cervical lordotic curves to ensure perfect effortless balance. This was in agreement with Ringdahl et al.,[16] who stated that neck position during sitting, reading, writing and manual working tasks is dependent on pelvic inclination in the sagittal plane.

Majeske and Buchanan,[17] stated that good sitting posture maintains the spinal curves in the erect position and reduce load which may be placed on the ligamentous structure of the lumbar region. Bennett et al.,[18] found that lumbar curvature was greater in Balans chair with forward inclined seat angle than in the staight back chair. As a consequence, the LOG moved nearer to the subject body causing a decrease in the moment arm of the head and the head and neck. That is supported by Link et al.,[19] who reported that the subjects had significantly more lumbar extension when they sat in the chair with forward inclinometer (Balans chair) than when they sat in an standard conventional chair (SCC). Since the load moment equals the moment arm multiplied by the weight of the segment, any decrease in the moment arm of either head or head and neck as a result of movement of LOG near to the subject, interpreted the decrease in the load moments of the head and the head and neck respectively during sitting on a chair with a forward inclined seat angle.

De Wall et al.,[20] reported that when the subject was working at a desk with a 10° degrees forward inclination, the load moments on the cervical spine decreased 35% and on the thoracic spine decreased to 95%. They inferred the results to movement of the trunk to more erect position and hence decreasing the moment arm of the LOG. In this study the significant increase of the load moments and the forward displacement of the COG of the head and the head and neck while sitting on either an ordinary seat angle or a forward inclined seat can be attributed to the effect of time on increasing the head flexion which may have resulted due to a progressive fatigue of the muscles. That led to increase the moment arm of the head and the head and neck respectively. The above was in agreement with Ringdahl et al.,[16] who concluded that the value of the load moments of the head when the whole neck was in flexion, was 1.2 times more than its value while the head was in the neutral position. Where as the load moment of the head and neck increased to 3.6 times when the head was in flexion position more than when it was in the neutral position.

The significant increase of the load moments and the forward displacement of the COG of the head and the head and neck with time can be inferred to fatigue of the muscles of the back and neck resulting from long duration of working in the same position. That means the weight of the head was not sufficiently counterbalanced by the muscular torque needed to keep the head in more erect position. Frankel and Nordin[8] who stated that the head represents first class of lever and the moment produced by the weight of the head anteriorly tends to make head flexion should be compensated by another torque produced by neck extensors posteriorly in order to keep the head balanced. If the neck extensors torque is not sufficient, the head will be easily moved forward by the effect of gravity and the weight of the head. Postural tension implies that the extensor muscles of the cervical spine must be in sustained isometric contraction to support the head in its position. As the weight of the head remains constant the muscle tension to counteract the increase in forward bending moment. This increase in tension is not only as a fatiguing factor but also acts as a compressive force on the soft tissues including the disc[10]. Forward bending moment = Backward bending moment "W x S = M x Y" where; W = Weight of the head, S = Distance of the head weight from the COG, Y = Distance of the spinal musculature from the COG, and M = Tension developed by musculature to sustain weight of the head.

Calliet,[15] postulated that the load moments could be balanced by the muscular forces, and tension of the passive connective tissue structures on the posterior aspect of the neck. Because the head was held statically, the tissues that prevent forward downward rotation must be the posterior musculature and the posterior ligamentous structures. These tissues act in a static manner. The posterior neck musculature acts in an isometric effort to diminish the stress upon the ligaments. De Wall, et al.,[20] reported that as the head bent forward, the force which the neck muscles have to produce to keep it in a balanced position must increase because during forward bending of the head, the horizontal distance between the COG of the head and the atlanto-occipital joint increases.

Schüldt[22] observed that when the whole spine was flexed in a sitting posture, it would give a higher level of static activity in several neck and shoulder muscles than when the posture was straight and the cervical spine was vertical. They also found that the static muscular load would be low during sitting with slightly backwards inclination of the thoraco-lumbar spine and vertical alignment of the cervical spine. Holmstom et al.,[14] concluded that the distribution of musculoskeletal problems, pain and discomfort occurring sometimes, as a result of long duration of working and poor work place design. They found that low back pain represents 72% of the workers complaints while neck pain 37%, knee pain 52%, right shoulder 37%, right hand 31%, left shoulder 29%, upper back 24%, right elbow 23%, hips 22%, feet 20%, left hand 19% and left elbow 15%.

Soderberg[11] evaluated the use of an anteriorly inclined seat in changing the magnitude of EMG activity produced at three levels of erector spine muscles of the back while the subjects performed a typing task for 15 minutes and the seat angle was adjusted to zero degree, 10 degrees and 20 degrees of anterior inclination. They found that EMG activity decreased as the inclination of the chair increased. That was not in agreement with Bennett et al.,[18] who found that there was no significant differences in EMG activity recorded for the back muscles during sitting on an office chair, a straight-back chair and a chair with a forward inclined seat angle.

Furthermore, the study also revealed that the posture was more upright when sitting on a chair with a forward inclined seat angle than sitting on a chair with an ordinary seat angle. That could be concluded from the significant decrease in both the cervical and trunk ROM measured either with the inclinometer or with the photos during practicing the task while the subjects were sitting on a chair with a forward inclined seat angle. The above results can be supported by the study which has been reported by De Wall, et al.,[20] who examined the effect of a disk with 10 degrees forward inclination on the sitting psture of the subjects while they were reading and writing. The position of the head in the sagittal plane was found to be 6 degrees more erect when working at a disk with 10 degrees inclination than when working at a flat desk. As well as, the position of the trunk was found to be 7 degrees more erect when working at an inclined desk than when working at a flat desk.

Frey and Tecklin[23], found that when subjects sat in the forward inclined chair and began writing at a desk, their lumbar curve approximated to their standing lumbar curve more than when they sat in an ordinary chair. They attributed the change in the lumbar curvature to the differences in chair design. As well as Majeske and Buchanan,[17] reported that maintaining a lumbar lordosis is necessary especially for those who spend much of their time sitting. That can be obtained through using a lumbar support pillow during sitting which is indicating for improving the alignment of the trunk.

Comparison between the ROM measured by photography and that measured by inclinometer showed that ROM measured by photography was significantly more than that measured by inclinometer. It was clearly observed that there was a significant increase of the mean value of the cervical and the trunk ROM in case of using photography in the measurement rather than using an inclinometer in the measurement of the ROM while the subjects were sitting on the chair either with an ordinary seat angle or with a forward inclined seat angle.

The amount of increasing was observed to be constant in the case of using photogrphy in the measurement. This result may be inferred to the method used for measuring the ROM. The cervical angle was measured on the photos between two lines. The first line was drawn from the COG of the head and neck to the mid way point between the seventh cervical point and a point just above the head of the clavicle, while the second line is a vertical line. whereas the angle drawn for trunk ROM was measured between two lines. The first line was perpendicular to the line extending from the fifth thoracic to the sternal junction while the second line is a vertical line. Analysis of the results of the cervical and the trunk ROM which were measured by photography and inclinometer showed a linear relationship between the two methods of measurements which ensures the validity of the photography technique.

Waddell and Newton,[24] found that the inclinometer is a reliable and valid method of measuring lumbar mobility. It is also quick and easy to be used particularly in clinical setting. Youdas et al.,[21] reported that measurements of the neck ROM can be obtained with various techniques, including the use of electrogoniometers bubble goniometers protractors, radiographs, hydrogoniometers, magnetic compasses, and computerized tomography. But photography was not mentioned as a kind of measuring the ROM in the area of studying the load moment and cervical and trunk ROM.

CONCLUSION

The study revealed that during sitting on a chair with a forward inclined seat angle there was a significant decrease in the intensity of the load moment and on the displacement of the COG of the head and of the head and neck. The study also revealed that there was a significant decrease in the cervical and trunk ROM measured either by inclinometer or photography in case of sitting on the chair while its seat angle was inclined forward. The study indicated that photography is a valid method for measuring ROM.

The use of a chair with a forward inclined seat angle is suggested to be favorable for sitting while performing a manual work because it appears to have a positive effect on posture. The degree of forward bending of the head decreased and therefore the forward displacement of the COG and the load moments which the cervical structure had to withstand also decreased. A reduction in the number of sick leaves and neck complaints could be expected. However, introducing such chairs into workplace where a lot of dexterity manual tasks is done would seem to be a beneficial idea. Moreover, the study revealed that photography is a reliable method for measuring the ROM.

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الملخص العربي

تحديد العلاقة بين التغيير فى زاوية المقعد وعزوم التحميل الواقع على الفقرات العنقية للأشخاص الأصحاء

يهدف هذا البحث إلى تحديد العلاقة بين التغيير فى زاوية المقعد وعزوم التحميل الواقع على الفقرات العنقية للأشخاص الأصحاء . تطوع ثلاثون شخصا تتراوح أعمارهم بين ١٨ – ٢٤ سنة لهذه الدراسة . تم تصوير جميع الأشخاص أثناء جلوسهم على كرسى 'دوفين' ذو زاوية متغيرة أثناء قيامهم بأعمال تتطلب دقة يدوية ، أخذت ستة صور فوتوغرافية عمودية لكل فرد (عند زاوية صفر ثلاثة صور ، وعند زاوية ٢٠° مائلة للأمام ثلاثة صور) ألتقطت الصور قبل بداية العمل بنصف ساعة . وبعد ساعة من بدء العمل تم حساب عزوم التحميل من الصور بينما تم حساب المدى الحركى للرقبة والجذع بواسطة أجهزة القياس انكلينومتر والتصوير . أوضحت الدراسة أنه أثناء الجلوس على المقعد المائل للأمام كان هناك نتائج ذات دلالة إحصائية لنقص عزوم التحميل وتحرك محور الجانبية للرأس والرقبة ، كذلك أوضحت الدراسة نقص واضح للمدى الحركى للفقرات العنقية والجذع كما تم قياسها بواسطة التصوير أو أجهزة القياس فى حالة الجلوس على مقعد مائل للأمام . أوضحت الدراسة أيضا أنه يمكن الاعتماد على التصوير كأداة فعالة لقياس المدى الحركى . وأخيرا أوضحت الدراسة أنه لم يكن هناك تغيير ذو دلالة إحصائية بين حركة الرقبة وقوة الابصار للأشخاص ٦/٦ ، ٦/٩ ، ٦/١٨ .