ASSESSMENT OF ERGONOMIC FACTORS AMONG NON-ACADEMIC STAFF OF SCHOOL OF ENVIRONMENTAL TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

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Implementing ergonomics in workplace improves health and safety among staff, increase job satisfaction of workers, thereby leading to increase work quality services and productivity. In a related development, ergonomics can also increase overall employees' morale, decrease workers compensation costs and decrease absenteeism and turnover among the workers. However, implementing ergonomic principles at work place has been low; hence this study assessed ergonomic related factors of workers within the School of Environmental Technology using physical measurement and personal observation of 10 non-academic staff. The 3 factors identified for assessment were anthropometric measurement (using measuring tape), light intensity measurement (using Lux meter) and quick exposure check (using checklist). The results of the anthropometric measurement assessment showed that only Hip width was found to match with current furniture for most workers, while other parameters were found to be highly mismatched. The results of quick exposure showed, that most workers have experienced moderate exposure levels for back (static and moving), shoulder/arm, wrist/hand and neck. Based on the lighting level at workstation of workers, there was an indication of inadequate lighting level. It can be concluded that based on the 3 ergonomic factors assessed, implementation level was low. Additional improvement to workers workstation is required coupled with long term planning of new chairs that are customized for workers need, ability to rest or lumber support with additional head support and adjustable table. This will enable the user to adjust the height of the table to ensure that his hand is able to wrest nicely on the table.

Keywords: Ergonomic, Anthropometric, Planning, Intensity, Workplace.

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INTRODUCTION

Ergonomics is the scientific study of human work. It considers the physical and mental capabilities and limits of the worker as he or she interacts with tools, equipment, work methods, tasks and the working environment. Ergonomics helps adapt the job to fit the person, rather than forcing the person to fit the job. Adapting the job to fit the worker can help reduce ergonomic stress and eliminate many of the potential ergonomic disorders. The objective of ergonomics is to adapt the job and workplace to the worker by designing tasks, work stations, tools, and equipment that are within the worker's physical capabilities and limitations (Shamsul *et al*., 2014).

According to E-Fact (2010), Office Ergonomics is the branch of ergonomics dealing specifically with the office environment. Historically, the office has been considered a relatively safe and healthy place to work and that the modern office environment presents an array of potential hazards that can be avoided by taking simple precautions (Shamsul *et al*., 2014). This concept according to Shamsul *et al.* (2014) is reflected in complaints of discomfort, anxiety, irritation and general job dissatisfaction and can be measured in terms of sick leave, absenteeism and job turnover. Accidents that occur in offices are frequently due to poorly designed office environments and improper office procedures and the rate of office accidents declines when office workers are informed of potential hazards and safe work practices (Shamsul & Mohammed, 2015). Shamsul and Mohammed (2015) recommended training regarding general safety precautions for work in an office reduces both the number and severity of accidents. Ergonomics: is the science of fitting jobs to people. Ergonomics encompasses the body of knowledge about physical abilities and limitations as well as other human characteristics that are relevant to job design (Office Health and Safety, 2002).

The main goal of office ergonomics is to reduce the incidence of musculoskeletal disorders (MSDs). From 1996 to 2004, the Workplace Safety and Insurance Board (WSIB, 2006) reported that MSDs accounted for nearly 42% of all lost time claims in Ontario. This statistic accounts for only lost time claims, which underestimates the true nature of the problem as many individuals continue to work with pain and discomfort.

By implementing office ergonomic methods, many MSD risk factors present in the office environment may be recognized and controlled, diminishing the risk of MSD injury. According to National Council for Occupational Safety and Health (NCOSH, 2007) Musculoskeletal disorders are major health and safety problems in many workplaces. In a poorly designed job, workers often have to reach or twist some part of their body over and over again. After a while, this can seriously hurt muscles, tendons and ligaments. These types of injuries are called musculoskeletal disorders (MSDs). Sometimes they are called cumulative trauma disorders, repetitive strain injuries, repetitive motion disorders, or overuse syndrome. All of these mean the same thing. They all are caused by poorly designed jobs and equipment (NCOSH, 2007).

Musculoskeletal disorders usually develop over time. They can cause constant pain and sometimes permanent damage. Musculoskeletal disorders can prevent workers from being able to do their jobs. According to Washington State Fund (WSF, 2009) workers' compensation claims that the single largest class of injury claims in the office is Work-related Musculoskeletal Disorders (WMSD's), which account for over 40% of all among office workers. These injuries result in medical and time loss costs of over $12 million per year to State Fund employers, and are responsible for over 70,000 lost work days per year. Due to the nature and severity of WMSD's, they account for more than their share of injury costs - about 60% of overall claim costs (WSF, 2009). The objective of the study is to establish ergonomic related factors of workers within school of environmental technology. Three factors were identified for assessment among the workers; those factors are anthropometric measurement, light intensity measurement and quick exposure check. Anthropometric measurements refer to furniture measurement. Furniture designed using ergonomic principles can improve performance and reduce workplace injury (Laypersons Guide, 2011). As contained in the Office Ergonomic Manual, (2011) the chair must fit you and be appropriate for your tasks, and sitting properly in a well-fitted chair helps to limit back strain and discomfort. The manual provide good features for an ergonomic chair as follow:

1. Adjustability
    a. Seat height range: Seat height should be adjustable to the height recommended for the worker(s) who will use it.
    b. Backrest: The backrest should be adjustable both vertically and in the frontward and backward direction.
2. Seat depth - Seat selection should be based on that which suits the tallest and the shortest users.
3. Adjust the seat height so your feet rest flat on the floor or use a supportive footrest.
    a. Sit upright in the chair with the lower back against the backrest and the shoulders touching the backrest.
    b. Thighs should be parallel to the floor and knees at about the same level as the hips (equal to or slightly lower).
    c. Back of knees should not come in direct contact with the edge of the seat pan. There should be 5.08-10.16 cm (2-3 fingers) between the edge of the seat and the back of the knee.
    d. Use a footrest when attempts to adjust your chair and the rest of the workstation fail to keep your feet on the ground.
    e. Ensure that you have some space (5-7 cm) between the top of your thighs and the underside of your workstation.
    f. Have enough space under your work surface so that you can pull yourself all the way up to the edge of the desk with room for your legs and knees to fit comfortably.
4. Check that the seat pan depth is such that the user can maintain contact with the backrest in the lumbar area and avoid increased pressure on the back of legs and behind the knees.
    a. Sit in the chair and push your hips back as far as they can go against the chair back.
5. Check that the adjustable arm rests do not impede access to the work station or arm movement. The arm rests should be removable and the distance between the arm rests should be adjustable.

a. Adjust the height and/or width of the armrests so they allow the user to rest arms at their sides and relax/drop their shoulders while keyboarding.
b. If the armrests are too high, they will elevate the shoulders which can cause stiffness or pain in the shoulders and neck.
c. Don't use the armrests to slouch.
d. If the armrests are too low, they promote slumping and leaning to one side.
e. Elbows and lower arms should rest lightly on armrests so as not to cause circulatory or nerve problems.
f. If your armrests are in the way, remove them.

6. Adjust the height of the backrest to support the natural inward curve of the lower back (100-119 degree reclined angle). The upper and lower back must be supported.
   a. A chair that maintains the normal alignment of the spine (S-curve) will relieve fatigue and discomfort

ANTHROPOMETRIC MEASUREMENT

Anthropometric measurement consists of measuring of the body part and also measuring the chair component. The matching between the workers and their workstation were assessed using the mismatch calculation. The formulation to determine the mismatch is show in Table 1.

Table 1: Mismatch Formula

Parameter	Measurement Equation
Popliteal height (PH) against seat height (SH)	$(PH + 3) \cos 30^{o} \leq SH \leq (PH + 3) \cos 5^{o}$
Buttock popliteal length (BPL) against seat depth (SD)	$0.8\ BPL \leq SD \leq 0.95\ BPL$
Hip width (HW) against seat width (SW)	$HW < SW$
Shoulder height (SH) against backrest height (BH)	$0.6\ SH \leq BH \leq 0.8\ SH$
Elbow height (EH) against table height (TH)	$EH + (PH + 2) \cos 30^{o} \leq TH < (PH + 3) \cos 5^{o} + 0.8517EH + 0.1483\ SH$

Source: US NIOSH, 2009

In anthropometric measurement two types of description were carried out. They are

1. The anthropometric description.

In anthropometric measurement there are 7 variable measurements in anthropometry which are categorized in to position of sitting. Anthropometric measurements were measured in sitting position. Details are described in Table 2

Table 2: Description of Anthropometric Measurement

Parameter	Method of Measurement
A. Sitting height	Vertical distance from a horizontal sitting surface to the vertex
B. Sitting shoulder	Vertical distance from a horizontal sitting surface to the acromion
C. Shoulder breadth	The lateral borders of the two Deltoid muscles
D. Hip breadth	Breadth of the body measured across the widest portion of the hips
E. Buttock to Popliteal length	Horizontal distance from the hollow of the knee to the rear most point of the buttock
F. Popliteal height	Vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee, bent at the right angles.
G. Sitting elbow height	Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at a right.

Source: US NIOSH, 2009

2. The furniture measurement description

The furniture was measured in four parameter consist of seat height, seat depth, seat width and backrest height using measuring tape. If the level of the furniture is adjustable, the height of the furniture should be levelled into the maximum height.

Details of the description of the furniture measurement are show in the Table 3

Table 3: Description of the Furniture Measurement

Parameter	Method of Measurement
A. Seat height	Measurement as the vertical distance from the highest point of the front of the seat floor.
B. Seat depth	Measure as the horizontal distance from back to front of the seat surface
C. Seat width	Measure as the horizontal distance from the outer left of the seat surface to the outer right.
D. Backrest height	Measure as the vertical distance from the highest point of the front of the back seat of the seat surface.
E. Desk height	Measure as the vertical distance from the floor to the top of the front edge of the desk.

Source: US NIOSH, 2009

LIGHT INTENSITY MEASUREMENT

Glare is a common problem with lighting in offices. It makes it difficult to see the computer screen and strains the eyes. Light intensity is measured in Lux and a good lighting in an office environment enables the staffs to see clearly and perform their work safely. Good lighting should enable employees to easily view their work and environment without the need to strain their eyes. Different activities require different levels and qualities of light (Ergonomic Guidelines, 2013). European Agency for Safety and Health at Work, (2000) stated that medical evidence indicates that using computers is not associated with permanent damage to the eyes but some workers may experience temporary visual fatigue. This can lead to impaired visual performance, headaches, and tired, red or sore eyes. These symptoms may be caused by concentrating on the screen for a long time, poor positioning of the computer, flickering screens, inadequate lighting, glare and refection, or poor legibility of paper or screen documents.

Recommended lightning level based on recommended average luminance level as shown in the Table 4

Table 4: Recommended lightning level based on average luminance level

Lightning for working interiors	**Level (Lux) on the working plane**
Infrequent reading and writing	200
General office, shops and stores, reading and writing	300 – 400
Drawing office	300 – 400
Restroom	150
Restaurant and Cafeteria	200
Kitchen	150 – 300
Lounge	150
Bathroom	150
Toilet	100
Bedroom	150
Classroom, Library	300 – 500
Shop, Supermarket, Department store	200 – 750
Museum and Gallery	300

Source: Malaysia Standard MS 1525:2007

Also, colour contour were used to determine the light intensity in each of the departmental office. Table 5 shows the colour contour

Table 5: Colour contour

Light intensity (Lux)	Colour Contour
<300	Yellow
301 – 500	Green
>500	Red

Source: Malaysia Standard MS 1525:2007

Quick Exposure Checklist (QEC)

Quick Exposure Check (QEC) involves conducting an assessment on workers that have direct experiences of the task. The Rubens Centre for Health and Medical Ergonomics (2013) defined QEC as assessing the changes in exposure to musculoskeletal risk factors of the back, shoulders and arms, hand and wrists, and neck before and after an ergonomic intervention. Quick Exposure Checklist is a method used to identify the relationship of posture used by employees with ergonomic problems. QEC assesses the exposure of the four body areas at greatest risk to the most important risk factors for work related musculoskeletal disorder (WMSDs).

Quick Exposure Checklist is based on the Lin and Buckle (1999) methods which require monitoring and feedback by employees in assessing postures performed by employees. This method contains 6 steps to determine the final score which are:

1. Observers Assessment
2. Working Assessment
3. Ergonomic Exposure Score Calculation
4. Determination of Response Category
5. Assessment by Ergonomic Observer
6. Interpreting result QEC score

Ergonomic assessment consists of four (4) assessments of the body areas which are:

a. **Back posture –** the assessment should be made at the moment when the back is most heavily loaded, for example, when lifting a box, the back is under highest loading when the person leans or reaches forward or bends down to pick the load.
b. **Shoulder and Arm –** the assessment should be based upon the position of the hands when the shoulder/arm is most heavily loaded during work. This may not necessarily be at the same time as when the exposure of the back is assessed.

c. **Wrist and Hand posture –** this posture is assessed during the task when the most awkward wrist posture is adopted. This may be the wrist flexion/extension, side bending (ulnar/radial deviation).
d. **Neck –** the neck posture is defined as excessively bent or twisted if the angle is greater than 20^o relative to the torso.

METHODS AND MATERIALS

The study was a criteria based study, the main criteria for the study were:

a. School of Environmental Technology Secretaries (6 from the Department and 4 from the Dean's Office) were the target using purposive sampling method.
b. The staff must be in the current post for at least One (1) year.
c. Every working day the staff must spend at least five (5) hours on his/her duty post.
d. Anthropometric measurement was carried out using measuring tape as stated under section 2.0
e. Lighting was measured using Digital Lux Meter (Model LX-1010BS). The measurement was done at 9am. A light mapping was developed for each workstation at each office in order to determine the lighting changes and compliance.
f. Quick Exposure Checklist was developed and used as stated under section 4.0

RESULT AND DISCUSSION

Table 5 is the average result of the anthropometric measurement of the 10 non-academic staffs selected for the study within the School of Environmental Technology.

Table 5: Average Anthropometric Measurement Result

Parameter	Length (cm)
Sitting Height	82
Sitting shoulder height	54.3
Shoulder breadth	45.6
Hip breadth	38
Buttock to popliteal length	43
Popliteal height	47
Sitting elbow height	69

Source: Researchers Analysis

Table 6 shows the average result of current furniture measurement at the ten (10) staff selected for the study with the non-academic staff of the school of environmental technology workstation.

Table 6: Average Current Furniture Measurement Result

Parameter	Length (cm)
Seat height	53
Seat depth	50
Seat width	52
Backrest height	53
Desk height	75.2

Source: Researchers Analysis

Analysis using Mismatch Formula

Using the Mismatch formula on Table 1 to analyse and determine the relationship between the anthropometric measurement of the staff and the furniture measurement of the staff, the following results in Table 7 were obtained from the mismatch analysis.

Table 7: Overall Mismatch

Parameter	Measurement Equation	Result
Popliteal height (PH) against Seat hight (SH)	$43.3 \leq 53 \leq 49.8$	High mismatch
Buttock popliteal (PHL) against Seat depth (SD)	$34.4 \leq 50 \leq 40.85$	High mismatch
Hip width (HW) against Seat width (SW)	$38 < 50$	Match
Shoulder height (SH) against backrest height (BH)	$32.58 \leq 53 \leq 43.4$	High mismatch
Elbow height (EH) against the table height (TH)	$111.4 \leq 75.2 < 116.6$	High mismatch

Source: Researchers analysis

Based on Table 7 above for overall mismatch, only the Hip width was found to match with current furniture for staffs while other parameters were found to be highly mismatched.

On the lighting at the workstation of the staff, most of their work areas indicated inadequate lighting (less than 300 lux). However, at the positions where the light sources were located in the offices, the areas were found to have adequate lighting. As regard to the Quick Exposure Checklist for the body areas, the problems that most staff faced are the back (when performing their task, their back is almost neutral but the maximum weight handle by them was heavy in between 11 and 20kg), shoulders and arms postures have placed at about chest high, wrist and hand is deviated and bent for 10 times per minute or less, and the neck is occasionally bent and twisted when performing work.

Table 8 refers to exposure category is used in determining the level of exposure of staff's body area

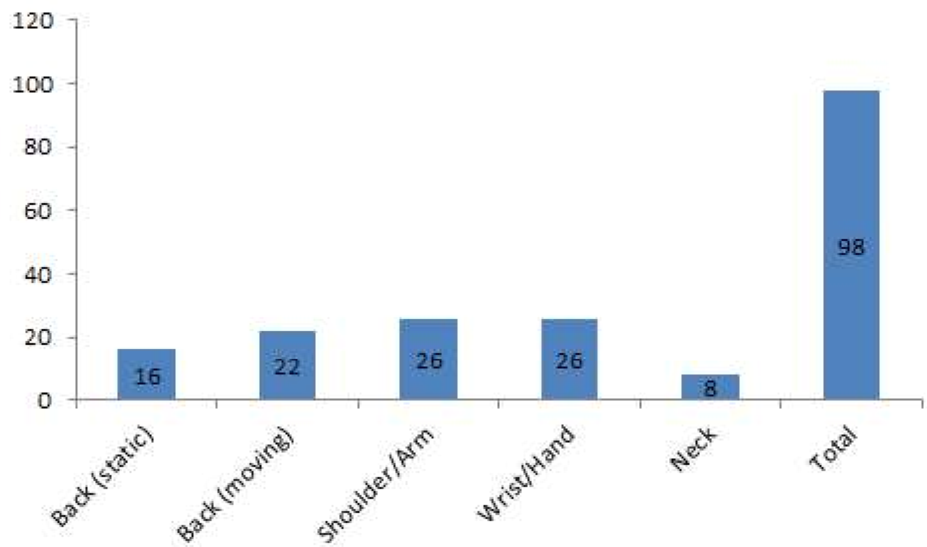
Table 8: Exposure Categories

Score	Exposure level			
	Low	Moderate	High	Very high
Back (static)	8 – 15	16 - 22	23 – 29	29 - 40
Back (moving)	10 – 20	21 - 30	31 – 40	41 – 56
Shoulder/Arm	10 – 20	21 - 30	31 – 40	41 - 48
Wrist/Hand	10 – 20	21 - 30	31 – 46	41 - 46
Neck	4 – 6	8 - 10	12 – 14	16 – 18

Source: US NIOSH, 2009.

The Figure 1 shows the average results of exposure for body area of the staff considered for the study

Figure 1: Average Exposure Score for Body Area.



The average results for exposure score shows that the staffs has experiences moderate exposure level for back (static and moving), shoulder/arm, wrist/hand and neck as indicated in Table 8 and shown in Figure 1.

However, the total average exposure score for body areas for the staffs is 98. Table 9 has to do with interpreting the result of Quick Exposure Checklist (QEC).

Table 9: Interpreting Result of QEC

If manual handling required by workers	
Sum of all scores	**Action suggested**
Less than 70	Acceptable
70 – 80	Investigate
89 – 123	Investigate further and change soon
Greater than 123	Investigate and change immediately
If manual handling is not required by workers	
Sum of all scores	**Action suggested**
Less than 65	Acceptable
65 – 81	Investigate further
82 – 113	Investigate further and change soon
Greater than 113	Investigate and change immediately

Source: US NIOSH, 2009.

Based on Table 9, the action suggested for the staff workstation is needed to be investigated further and change soon because the total exposure score were in range of 89 and 123 if required manual handling and 82 and 113 if manual handling is not required.

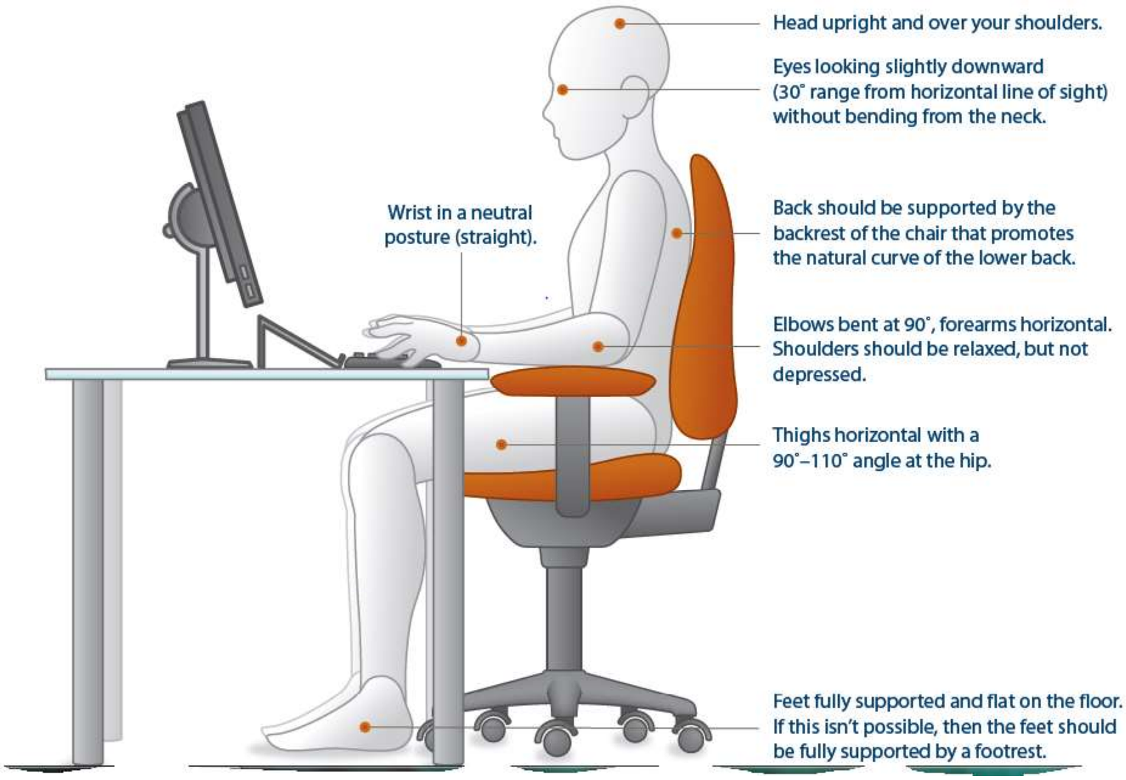
CONCLUSION AND RECOMMENDATIONS

Through assessing and interpreting the results of the three ergonomic factors consider in this study; the anthropometric measurement, the lighting measurement and the quick exposure checklist measurement (QEC), it can be concluded that majority of the staff (non-academic) of the school of environmental technology are at moderate risk of suffering from Musculoskeletal disorder (MSD) at their workstation.

Based on the above conclusion, the recommendation of the study can be divided into short term and long term planning. The short term planning consists of improvement to their workstation as shown in Figure 2.

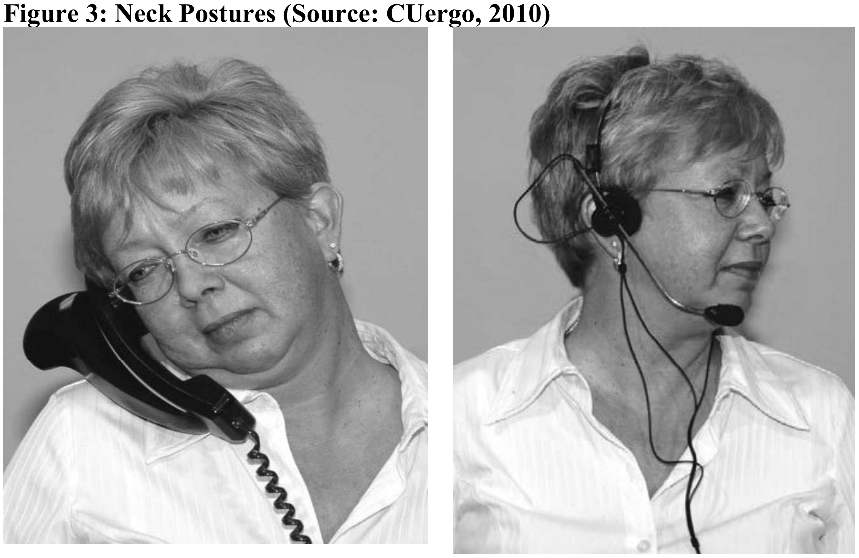
Also, the staff should use headset while working and answering a call, Figure 3 illustrates the best position on how to answer telephone call.

Figure 2: Improvements to workstation



(Source: CUergo, 2010)

Figure 3: Neck Postures (Source: CUergo, 2010)



A. **B.**

Picture A is an example of an awkward neck posture which occurs when multi-tasking while Picture B shows how awkward neck posture can be eliminated through the use of a telephone headset.

Long term recommendations: These include but not limited to:

a. New chair that is customized for their need including ability to rest on lumbar support with additional head support.
b. Adjustable table – this will enable the user to adjust the height of the table to ensure that his hand is able to wrest nicely on the table (without hanging).
c. Head set – this will eliminate the need of side bending of neck while on the telephone.

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