Ergonomics Assessment of Dentist Work Function and Suggested Improvements

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Received: 30 June 2020; Revised: 13October 2020; Accepted: 1December 2020; Published: 15 December 2020

ABSTRACT

Dentistry has been considered as a demanding profession. However, previous study asserted that they have a high frequency of and are prone to developing musculoskeletal disorder (MSD). This is due to the need of high concentration and precision in executing their tasks. The main purpose of this study is to analyze the working posture in dental clinic and suggest improvementsbased on the identified problems. A study has been done at the University Health Care (UHC) at the Universiti Teknologi Malaysia (UTM). Hazards identification, risk assessment and risk control (HIRARC) analysis was used to identify and asses the hazards which was then translated into a Pareto chart. Body discomfort survey (BDS) form was also used to identify which parts of the body that affected the dentist based on an interview. Subsequently, the posture of the dentist on the job has been observed and analyzed by using a rapid upper limb assessment (RULA) analysis. The final score on the existing posture was found to be 7, thereby needing further investigation and some specific changes to be made. Engineering analysis and design was also suggested in the study after going through an evaluation matrix via morphological chart and static analysis using CATIA software. The final score of the RULA analysis was 2which means that the proposed measures were deemed to produce an acceptable posture.

Keywords: *Ergonomics,musculoskeletal disorder,dentistry,working posture*

1.0 INTRODUCTION

The definition of ergonomics is to study the interaction between human and machine and to improve the performance of systems by improving the interaction [1]. According to DOSH (2018) [2], the effect of working posture, force exertion and task frequency reportedly has a positive relationship to upper limb musculoskeletal disorders (MSD)[3]. Precision and concentration are the demands of dentistry profession. Most dentists treat their patients in a sitting position.

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Several key risk factors can lead to injuries caused by poor ergonomics. On the other hand, by considering good ergonomics practice at workplace, in most cases resulted in improved quality and productivity and should create a safety culture [4-6].

2.0 LITERATURE REVIEW

A great deal of studies has been carried out on the dentists and dental students [7-12] revealing the fact that dentists have a high frequency and tendency to suffer from MSD since 1980s that resulted in muscle stiffness at the back, neck and shoulder[9-11]. MSD among dentists occurred because of prolonged sitting, repetitive movements and sustained hold posture for certain period of time before completing the treatments [13-16].

The works done in [7-8, 11-12, 17-18] suggested that there is a continual challenge faced by the health workers including the dentists to have a proper posture since many of them perform their duties in less than ideal positions and are working at any time in one place for a long period of time. Lower back and shoulder were the main parts of the body that contributed to the pain due to sedentary seated posture experienced by the dental professionals [7-8, 16], repetitive pinching motions and vibrations of instruments [11, 17, 19] that may ultimately lead to MSD [9]. However, most of the dentists ignored the symptoms because they think and assume that it is only a minor chronic disease [8, 15].

From the literature, it is proven that most of the respondents in many countries agreed to the fact that they experienced pains at the lower back and shoulder. There is a need to have awareness on a proper ergonomics postures in executing their routine tasks in order to reduce the risk of MSD[10, 15, 20]. Thus it is one of the aims of the study to identify or prove that the dentists in UTM are also having similar symptoms as reported by other dentists in many countries. Then,some control measures were suggested to reduce the risk of these hazards. There are only three dentists in UTM who are selected as the respondents, participating in the study and to also analyze their feedbacks.

3.0 METHODOLOGY

The methodology for the study is shown in Figure 1. Three methods/tools were used and implemented to identify and analyze the problems based on the followings:

1. Hazardsidentification risk assessment and risk control (HIRARC)analysis and *Pareto*chart
2. Use of body discomfort survey (BDS) form (interview)
3. Rapid upper limb assessment (RULA) analysis

In order to improve the outcome based on the identified problems, an engineering analysis wasperformed. The proposed design was developed after aconceptual design and an evaluation of the design based on a matrix using morphological chart have been carried out. The chosen design has gone through some improvements based on the dentist needs and engineering analysis (engineering static analysis using CATIA software).

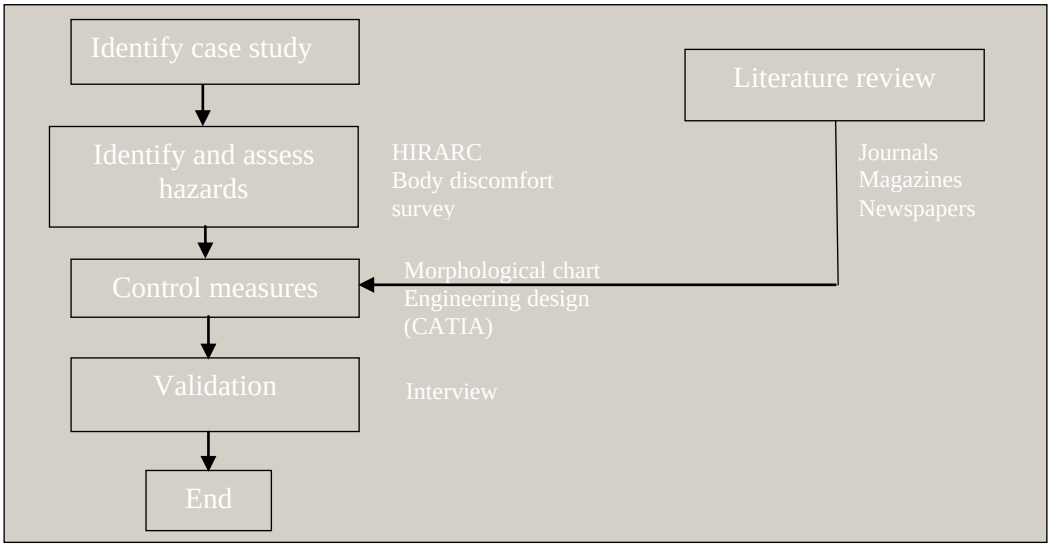

Figure 1: Methodology of study

4.0 PROBLEMS IDENTIFICATION

UTM Health Care (UHC) was selected to be the main subject of the case study. The workplace environment was systematically observed and all the three dentists were interviewed. The data was then analyzed using HIRARC analysis with referenceto Figures2 and 3 as examples and then converted into a *Pareto* chart as shown in Figure 4. It clearly illustrates that the highest hazard risk in the workplace is indeed the ergonomics factor. The hazard occurs almost every day depending on the numbers of patients and time taken for the dental treatment for a patient.

1. Hazard Identification				2. Risk Analysis				3. Risk Control
No.	Work Activity	Hazard	Which can Cause/Effect	Existing Risk Control (if any)	Likelihood (A)	Severity (B)	Risk (AxB)	Recommended Control Measures
1	Mixing dental materials using High Speed Mixer & Alginate Mixer	Mechanical – Vibration from instruments	May result in injury if the lid of the appliances is not closed and exposed to the hand	Perform work processes based on the Standard Operating Procedures	2	2	4	Existing Control Measures
2	Conduct dental treatment such as filling, scaling, minor oral surgery, extraction, endodontic treatment and prosthetic treatment using Dental Chair	Physical – Rotation of dental drill	Injuries due to burs handpiece	Use appropriate speed	2	2	4	Existing Control Measures
		Biology – Saliva and blood of patients	Cross infection	Use PPE such as gloves, mask, isolation gown, face shield	2	3	6	
		Physical – sharp tools and needles	Can cause accidental injection	Use tweezers when handling needle syringe				
			Wounded by sharp tools	Sharp equipment is thrown directly into a sharp equipment bin				

Figure 2: HIRARC analysis (Example 1)

1. Hazard Identification				2. Risk Analysis				3. Risk Control
No.	Work Activity	Hazard	Which can Cause/Effect	Existing Risk Control (if any)	Likelihood (A)	Severity (B)	Risk (AxB)	Recommended Control Measures
2	Conduct dental treatment such as filling, scaling, minor oral surgery, extraction, endodontic treatment and prosthetic treatment using Dental Chair	Ergonomic-Height chairs that do not fit the Dental Chair	Discomfort at the operator & cause back pain	Adjust the Chair and Dental Chair according to the correct body Posture	4	3	12	Existing Control Measures
		Physical-Electric	Potentially exposed to electric shock due to damage Dental Chair	Do Regular Maintenance	2	3	6	
3	The use of Dental x-ray	Physical-Radiation from Dental x-ray	Skin burns & Carcinogenic	Application of Lead Apron & application of badges by the patient by film Screen divider operator Lead	2	3	6	Existing Control Measures
				Do regular maintenance				

Figure 3: HIRARC analysis (Example 2)

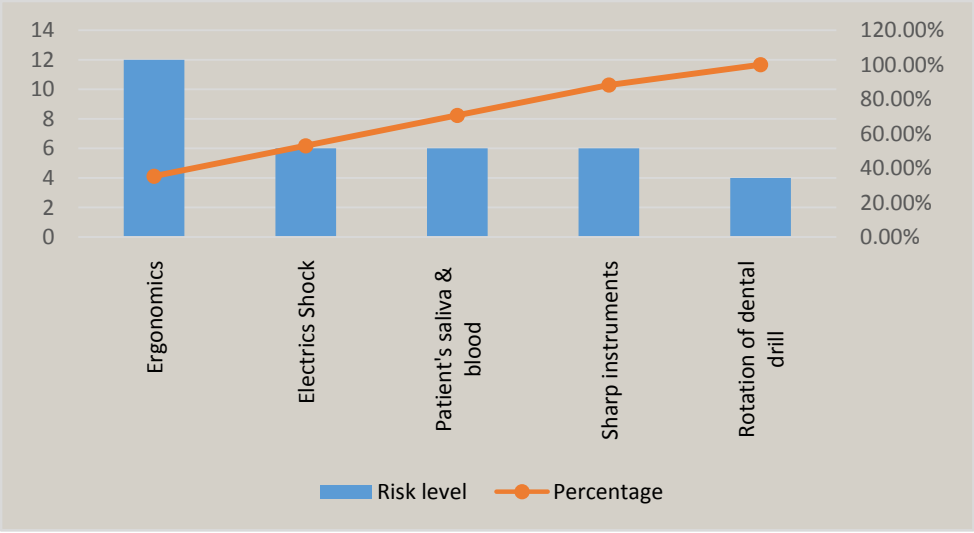

Figure 4: A *Pareto*chart showing the top five hazards at UHC, UTM

Then, an interview was done using the body discomfort survey (BDS) form. This is to identify the parts of the body that experience or show the main symptoms of pain during the working hours at the workplace. Table 1 illustrates the results of the survey.

Table 1: Results of respondents' feedback for the level of discomfort using BDS

Level of discomfort / Parts of body	1	2	3	4	5	6	7	8	9	10	Total
Neck								3			3
Left shoulder								3			3
Left elbow/forearm					3						3
Left wrist/hand							3				3

Left hip/thigh/buttock		1	1		1		3
Left knee		1	1	1			3
Left ankle/foot		1	2				3
Right shoulder					3		3
Right elbow/forearm			3				3
Upper back					3		3
Lower back						3	3
Right hand/wrist					2	1	3
Right hip/ thigh/buttock			1	1	1		3
Right knee		1	1		1		3
Right ankle/foot	2	1					3

The green indicator (Levels 1 - 3) shows the zone showing no pain. The yellow indicator (Level 4 - 7) indicates light pain to medium pain while the red indicator (Level 8 - 10) represents painful to very painful. The result shows that the dentists have the same experience of pain (red indicator) on neck, left shoulder and lower back.

Next, further observation/study was done on the posture of the dentists during the dental care operation. The RULA analysis wasemployed to analyze the posture as shown in Figure 5. It was taken during performing filling process that took about 20 to 30 minutes of operation. RULA requires theinvestigation on the degree of the body posture, load, sustained posture and repetitive motion. The results of RULA analysis indicated a final score value of 7 which means that it requires '*investigate and implementchange*'as depicted in Figure 6.

Figure 5: Filling process posture was chosen in the analysis

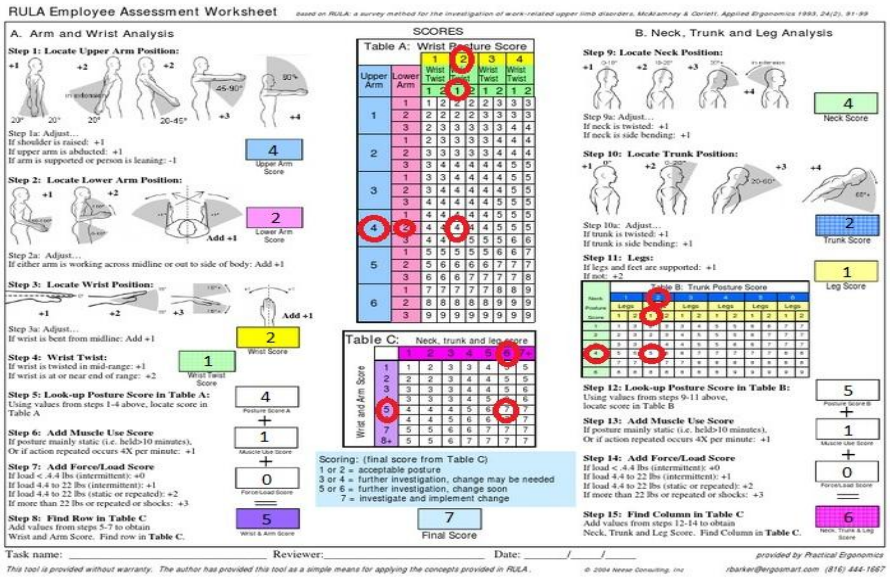

Figure 6: RULA analysis

5.0 DISCUSSION AND IMPROVEMENTS

Precision and concentration are the work demands that are normally practiced in the dentistry profession. From the HIRARC and *Pareto* analysis, the ergonomics issue is the top hazard problem identified. It typically occurred during the process of scaling, filling and tooth extraction. The dentists tend to lean their body forward in order to achieve better vision. They face the awkward posture such as bending, abduction hand and sustained posture; forceful exertion such as gripping, pinching; small continuous vibration, and eye fatigue is also a typical practiced procedure.

Control measures need to be proposed as the next stage in the study. The main criteria of the design should include some supports on hand and neck. This is based on the work observation (RULA analysis) and the symptoms (BDS analysis). The morphological chart was used to study some potential designs and product availability in the market as shown in Table 2. Then, the best combination of the alternative concepts was subsequently chosen.

Table 2: Morphological chart

PARTS	A	B	C	D
Neck Support				
Body Support				
Arm Support				
Concept	1	2	3	4

Next, the selected conceptual design was developed. It was chosen after completing the evaluation matrix as shown in Table 3. Even though the chosen concept has the highest score in the evaluation matrix, some modificationswere still needed in order to produce an effective design and good quality.

Table 3: The evaluation matrix

Criteria	**Weightage**	**Score/Point**							
		Concept 1		**Concept 2**		**Concept 3**		**Concept 4**	
Ease of handling	15	4	60	4	60	3	45	3	45
Ease of use	30	4	120	4	120	3	90	3	90
Durability	15	3	45	4	60	4	60	4	60
Maintenance	10	4	40	4	40	4	40	4	40
Portability	10	4	40	4	40	4	40	4	40
Cost	20	2	40	3	60	3	60	3	60
Total score	100	19	345	20	380	18	335	18	335
Rank		2		1		3		4	

The final design was then analyzed using an engineering analysis based on the engineering mechanics principle. A static analysis was performed by considering the loads on the specific parts of the dentist chair. The forces applied to the system were based on the following assumptions: body massis 80kg including the head with a massof 20kg and the lean force on the front body support is 200N. Figure 7 shows the static analysis done in CATIA software.

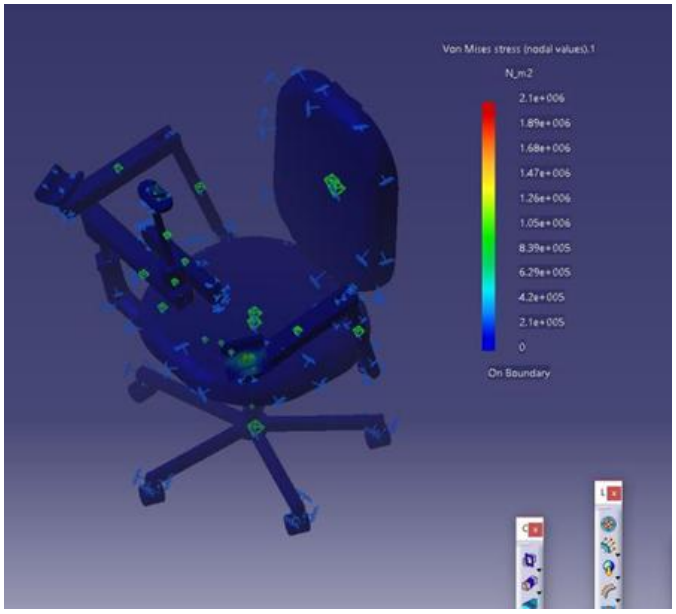

Figure 7: Static analysis of the final design in CATIA

In order to validate the suggested design, RULA analysis based on a certain body posture in CATIA software has been conducted assuming a manikin leaning forward at an angle of 27 degreesas depicted in Figure 7. All criteria used in the RULA worksheet have been implemented and analyzed. The score for each upper limb body part can be seen in Figure 8 and the final score is 2, implying that the posture was deemed acceptable.

(a) (b)

Figure 7: Final design showing the (a) front (b) side view

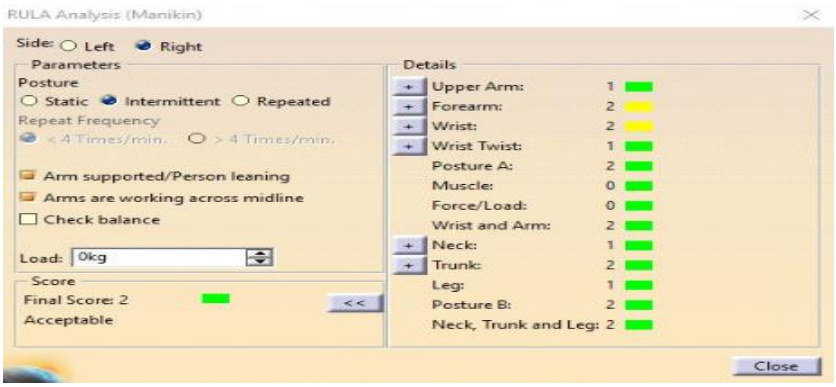

Figure 8: Improved RULA analysis

6.0 CONCLUSION

Dentists faced with ergonomics issues due to various awkward postures(sustained posture, bending and abduction hand), forceful exertion (gripping and pinching), small continuous vibration and eye fatigue. After some analyses of the study have been carried out, the control measures were accordingly suggested. It can be concluded that the objectives of this study to analyze and improve the dentists' working posture related to the individual and task in a dental clinic have been accomplished andsome control measures including a practical engineering design as an illustration has been proposed.

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