

Ergonomic working posture in dentistry: Importance of body and limb dimensions

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Objective: The aim of this study was to demonstrate the importance of body and limb dimensions in maintaining an ergonomic working posture with provided equipment in a group of undergraduate dental students at Mahidol University.

Materials and methods: 75 undergraduate dental students participated in this study. The participants were directed to sit in the upright position. Leg and arm measurements were performed. The leg measurements were used to evaluate the appropriateness of the limb dimensions to the dimensions of the dental chair. The dimensions of the body and upper extremities were used to calculate the visual distance. Descriptive statistics were used to analyze the data.

Results: Forty-three percent of the participants had leg dimensions not suitable for maintaining an ergonomic working posture. The calculated visual distances of the participants were over the recommended values.

Conclusions: Inappropriate body and limb dimensions in a group of undergraduate dental students at Mahidol university is observed. This impedes students from maintaining an ergonomic working posture on the provided equipment. Performing physical activity during working hours and the use of additional equipment is recommended to reduce the risk of work-related musculoskeletal disorders

Keywords: dental equipment, dimension, ergonomic, visual distance, work-related musculoskeletal disorders

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Introduction

There is increasing evidence of work-related musculoskeletal disorders (WMSDs) in dentists. The reasons responsible for this finding might be the nature of dental practice; repetitive working motions, absorption of force and vibration while providing treatment, and a non-ergonomic working posture. Consequently, WMSDs adversely affect dentist's work performance and quality of life [1-2].

Musculoskeletal disorders can occur at any time during a person's working life. It is evident that working in a non-ergonomic position for a long period of time causes WMSDs, including in dentists who worked for less than 5 years, which worsened

over time [3-5]. Improper leg and feet positioning while sitting causes varicose veins leading to muscle inflammation that results in swelling and leg muscle pain [6]. Inappropriate working posture also affects the upper body. Prolonged static awkward body flexion leads to muscle imbalance, ischemia, joint hypomobility, and spinal disk degeneration. Because a static posture requires the body's muscles to contract, it is not surprising that 80% of dentists report pain and neck, shoulder, and upper back muscle strain [1, 7-8].

To prevent poor posture-induced injuries, the Faculty of Dentistry, Mahidol University has added ergonomic education in the third year students' curriculum. However, a recent study demonstrated that dental students are at risk for developing WMSDs because they did not maintain

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an ergonomic working posture. Moreover, the education designed to increase their awareness of their posture did not impact their performance because there was no difference between the occurrence of ergonomic risk whether or not the individual reported to have ergonomic awareness [9].

It has been shown that injuries occur when a person performs tasks with their body segments out of their neutral range [10]. The aim of this study was to determine whether or not the undergraduate students had appropriate body and limb dimensions to maintain an ergonomically posture while providing treatment using the provided equipment at the Faculty. Ways to reduce the occupational hazards were also discussed.

Materials and methods

The research protocol and informed consent were reviewed and approved by the Mahidol University Institutional Review Board (COA.No. MU-DT/PY-IRB 2017/021.2303). The study was performed in the main clinic, of the Faculty of Dentistry, Mahidol University, Bangkok, Thailand.

The participants were given verbal instructions concerning the posture to be maintained. They were directed to sit upright with their Frankfort horizontal plane parallel to the floor. The participant's back should be perpendicular to their upper legs. The participants adjusted the position of their upper and lower leg until the upper leg was perpendicular to the lower leg and, if possible, place the soles of their feet flat on the floor. Four measurements were performed (Figure 1), i.e. (a) lower leg length (the distance between the soles of the feet and the knee), (b) upper leg length (the distance between the knee and buttock), (c) lower arm length (the distance between the center of the palm and elbow) and (d) the distance between the elbow and eye. The visual length

of each participant (e) was calculated using Pythagoras' theorem ($e^2=c^2+d^2$).

The dental chair dimensions (ACTUS 9000, J Morita Corp.) (Figure 2) and the recommended visual length (35–40 cm) were used as references to determine whether or not body and limb dimensions were appropriate to sit ergonomically [11].

The criteria for determining the inappropriateness of the body and limbs dimensions and visual length are presented in Table 1.

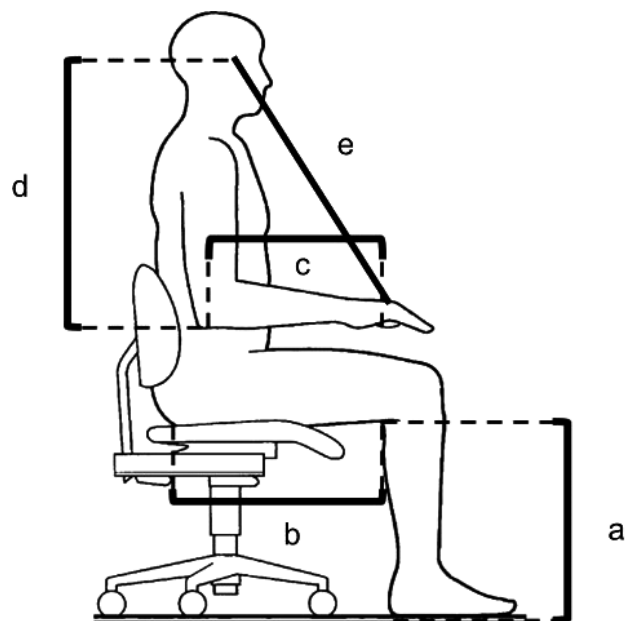


Figure 1 The positions used to measure the extremities. a) Lower leg length, b) Upper leg length, c) Lower arm length, d) Elbow-to-eye length, and e) Visual length ($e^2= c^2+d^2$).

Table 1 Inappropriate length criteria

Measurement	Inappropriate length (cm)
Lower leg	Less than 40, more than 52
Upper leg	Less than 38
Visual length ¹¹	Less than 35, more than 40

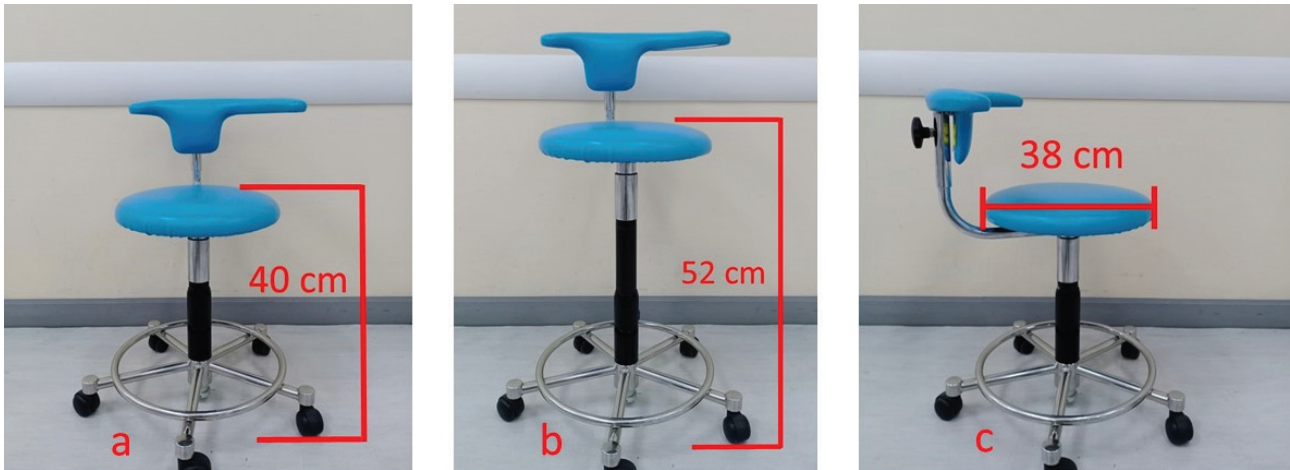


Figure 2 Dental chair dimensions a) The lowest adjusted position of the seat (40 cm), b) The highest adjusted position of the seat (52 cm), and c) The diameter of the saddle (38 cm)

The prevalence of inappropriate body and limb dimensions in the dental students is presented as a percentage.

34.6% of participants had inappropriate length of lower or upper leg and 9.3% had both. (Table 2) None of the students had an appropriate visual length (Table 3).

Results

Fifteen males and 60 females participated in this study. The average age was 22.46 ± 0.53 years old. Among the participants, 10.7% had an inappropriate lower leg length and 42.7% had an inappropriate upper leg length. We found that

Table 3 Visual length

Visual length (cm)	N (Persons)	%
35–40	0	0
<35 or >40	75	100
Total	75	100

Table 2 Upper and lower leg length

		Upper leg length (cm)		Total	
		≥38	<38		
Lower leg length (cm)	40–52	N (Persons)	42	25	67
		%	56	33.3	89.3
	<40 or >52	N (Persons)	1	7	8
		%	1.3	9.3	10.7
Total		Count	43	32	75
		%	57.3	42.7	100

Discussion

This study revealed that nearly half of the participating undergraduate dental students at Mahidol University did not have the proper body and limb dimensions to maintain an ergonomic working posture. We observed that the upper and lower leg dimensions of the participants were not compatible with the dimensions of the dental chair provided by the Faculty. To achieve an ergonomic posture, the individual must sit upright to allow the body weight to be transmitted along the vertebral axis to the dental chair base. The operator's lower back should contact the back-rest of the dental chair to gain lumbar support and a straight back position. The soles of the feet should lie flat on the floor and the angle between the upper and lower leg should be 90° – 110° to achieve body stability and facilitate transferring the body weight to the soles of the feet, which reduces lower back muscle compression [6, 12-14]. However, due to not maintaining this ergonomic posture, most subjects gradually experienced WMSDs [3, 5]. To maintain an ergonomic working position and prevent WMSDs from occurring, the operator's lower limb dimensions should be compatible with the dental chair dimensions [15]. Using Pythagoras's equation, all participants demonstrated a disproportionate lower arm length (palm-to-elbow) and elbow-to-eye distance that prevented them from having an eye-to-palm distance of 35–40 cm. The lack of an inappropriate eye-to-palm distance forces the operators to alter their posture to adequately view the operation field [6].

Because our results demonstrated that dental students at Mahidol University had difficulty in sitting ergonomically and effectively seeing when they worked using the provided equipment, we propose some solutions to alleviate these problems. If a participant's upper leg length is less than 38 cm, these students have to move their

buttocks forward to achieve a balanced-body-position; however, their back will not be against the back-rest. To reinforce keeping a straight back profile, the back-rest must be thick enough and properly shaped to provide lumbar support. Students with a lower leg length less than 40 cm or longer than 52 cm will have difficulty in keeping their upper leg parallel and positioning the soles of their feet on the floor. To avoid strain on their hamstring and gastrocnemius/soleus muscle in these situations, flat-soled shoes with an optimal thickness are recommended to keep their balance and maintain an ergonomic posture [12]. An unfavorable visual length causes neck muscle strain and excessive vertebral loading due to the student's bending their neck and back, which leads to musculoskeletal problems [16-18]. Using focal-length-adjustable eye-wear (Telescopes or Loupes) that are appropriate for each operator helps alleviate this problem [19]. Although it would construction of tailor-made equipment designed to fit each operator's body dimension is difficult to achieve, it should be considered [20, 21]. In addition to the above suggestions focusing on technology development and equipment modification, preventive ergonomic measures, including physical activity, aerobic movements and stretching can play an important role in relaxing and reducing the muscle tension caused by repetitive movements and poor posture [22]. Moreover, periodic rest during working hours and physical exercise have been recommended as protective measures [23].

To avoid WMSDs in the dental school, ergonomic assessment and analysis of the working condition along with recognizing specific behavioral changes for healthier working patterns should be implemented. Raising the awareness of the students who have not developed a WMSD can also play a crucial role in preventing a WMSD from occurring. Furthermore, during clinical practice

in the dental school, clinical instructors must encourage students to use an ergonomic posture while providing patient treatment. The above recommendations might prevent and control the non-ergonomic hazards and improve clinical performance for greater productivity.

Conclusion

Body and limb dimensions are important factors in maintaining an ergonomic posture while providing treatment using the equipment provided by the Faculty of Dentistry Mahidol University. Although ergonomic innovations are efficient, they might not be practical and cost-effective. Education, physical activity, and cognitive-behavioral modifications should be included in a daily self-care program to prevent or decrease WMSDs.

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