การศึกษาเปรียบเทียบตำแหน่งของศีรษะและต้นแขนขณะทำงานของนิสิตทันตแพทย์ที่ใช้และไม่ใช้อุปกรณ์การยศาสตร์เพื่อฝึกงานทางทันตกรรม

A COMPARATIVE STUDY ON POSITION OF HEAD AND UPPER ARM BETWEEN DENTAL STUDENTS WITH AND WITHOUT THE INTELLIGENT ERGONOMIC TRAINER SYSTEM DURING WORK

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บทคัดย่อ

การปฏิบัติงานทางทันตกรรมของนิสิตทันตแพทย์พบว่าเป็นสาเหตุของอาการเจ็บปวดบริเวณคอ บ่า ไหล่ หลัง ซึ่งเกิดจากการทำงานในท่าที่ไม่อยู่ในสมดุลเป็นเวลานาน ๆ ถึงแม้ว่าจะมีความรู้ทางการยศาสตร์มาช่วยเพื่อให้ทำงานในท่าทางที่เหมาะสมแต่ยังคงมีอาการเจ็บปวด ปัจจุบันจึงมีการนำเทคโนโลยีเข้ามาออกแบบอุปกรณ์เพื่อพัฒนาท่าทางให้อยู่ในสมดุล

วัตถุประสงค์ งานวิจัยนี้เป็นการพัฒนาอุปกรณ์การยศาสตร์เพื่อฝึกงานทางทันตกรรม (Intelligent Ergonomic Trainer: IET) จากความสามารถในการกำหนดตำแหน่งที่เหมาะสมในการทำงานของนิสิตทันตแพทย์โดยมีข้อมูลป้อนกลับขณะทำงานในท่าที่ไม่เหมาะสม โดยทำการเปรียบเทียบกับการชมภาพวีดีทัศน์การปฏิบัติงานย้อนหลัง

วัสดุอุปกรณ์และวิธีการ ผู้เข้าร่วมวิจัย จำนวน 32 คน แบ่งเป็น 2 กลุ่มๆ ละ 16 คน โดยใช้วิธีแบบสุ่ม ทั้งสองกลุ่มจะได้รับการฝึกท่าทางทั้งการใช้อุปกรณ์การยศาสตร์เพื่อฝึกงานทางทันตกรรมโดยมีข้อมูลป้อนกลับ และชมภาพวีดีทัศน์การปฏิบัติงานย้อนหลังในลำดับที่ต่างกันในขณะทำการอุดฟันกรามบนขวาซี่ที่หนึ่งในหุ่นจำลอง ครั้งละ 5 ซี่ ในวันแรกทำการบันทึกการเคลื่อนไหวจากการวัดมุมของศีรษะและต้นแขนของทั้ง 2 กลุ่ม เพื่อเป็นข้อมูลพื้นฐานจากนั้นทำการฝึกในวิธีที่ต่างกันในแต่ละกลุ่มในครั้งที่ 2 ครั้งที่ 3 ทำการทดสอบ และบันทึกการเคลื่อนไหวเพียงอย่างเดียวทั้งสองกลุ่ม ครั้งที่ 4 สลับวิธีการฝึกในแต่ละกลุ่ม ครั้งที่ 5 ทำการทดสอบ และบันทึกการเคลื่อนไหวเพียงอย่างเดียวทั้งสองกลุ่ม นำข้อมูลการเคลื่อนไหวของทั้ง 2 กลุ่ม ที่เป็นข้อมูลพื้นฐานเปรียบเทียบกับข้อมูลครั้งที่สามและครั้งหลังสุดโดยใช้สถิติ pair t-test

ผลการศึกษา กลุ่มนิสิตทันตแพทย์ที่มีการใช้อุปกรณ์การยศาสตร์โดยมีข้อมูลป้อนกลับเพื่อฝึกงานทางทันตกรรม และการชมภาพวีดีทัศน์ที่มีการบันทึกการเคลื่อนไหวย้อนหลังทั้งสองกลุ่มมีการพัฒนาท่าทางในการทำงานให้กลับมาอยู่ในช่วงการเคลื่อนไหวที่เหมาะสมอย่างมีนัยสำคัญทางสถิติ แต่ไม่มีความแตกต่างกันระหว่างทั้งสองกลุ่มในการสลับวิธีการฝึกตามลำดับ

สรุป อุปกรณ์การยศาสตร์เพื่อฝึกงานทางทันตกรรม และการชมภาพวีดีทัศน์ย้อนหลังช่วยพัฒนาท่าทางการทำงานที่เหมาะสมในนิสิตทันตแพทย์

คำสำคัญ: อุปกรณ์การยศาสตร์เพื่อฝึกงานทางทันตกรรม การให้ข้อมูลป้อนกลับชนิดเสียง การชมวีดีทัศน์ซ้ำ ความผิดปกติทางระบบโครงร่างและกล้ามเนื้อ

Abstract

Working posture of dental students can cause work related musculoskeletal disorders (WMSDs) in neck, shoulder and back areas. This was resulting from the repetitive improper posture. Although the dental ergonomics was applied to improve the posture, the pain still occurred. Therefore, in the present trend, the material design technology has been applied to the devices for improving the ergonomic posture.

Objective: The aim of this study was to develop the ergonomic devices to improve posture for dental students namely, Intelligent Ergonomic Trainer (IET) and compared with watching the video playback. IET had a capability to determine the proper position in dental practice and help correcting the work position by recording and warning when the dental students were not working in the appropriate posture by comparison with viewing of video after work.

Materials and Methods: The real time feedback IET program and video playback with no feedback IET program were applied to 32 dental students who randomly divided into 2 groups. Each group did 5 sessions of filling 5 upper right first molar typodont teeth per session. Both groups were applied both programs different sequence. The baseline data of angles of head and upper arm were collected on the first day from both groups for using IET program with each group were separated to complete their task (the real time feedback IET task and video playback with no feedback IET task). Then the second practice in different ways in each group in the second session. In the third time, both groups were tested and recorded only the movement assessment I data. In the fourth time, the participant in two groups were switched their task (the real time feedback IET task and video playback with no feedback IET task). Finally, the fifth time, both groups were tested and recorded the assessment II data. The data from the first, third, and fifth times were statistically analyzed using the pair t-test.

Results: The results showed that both IET programs with feedback and video playback was significantly improving the posture in dental students. However, there was no statistically significant difference between two groups when alternating the training programs.

Conclusion: Both IET programs with feedback and video playback can develop the proper posture for dental students.

Keywords: Intelligent Ergonomic Trainer, Real Time Feedback, Video Playback, Musculoskeletal Disorders

Introduction

Work-related musculoskeletal disorders (WMSDs) are one of the most common occupational disorders around the world, which can cause pain in neck, shoulder, arm, wrist and hands [1, 2]. Other from this in southern Thailand, Chowanadisai et al. [3] reported that the most occupational health problems were musculoskeletal pain. Hayes et al. [4] also reported in the systematic review that the prevalence of musculoskeletal pain is around 64 to 93 percent among dental professionals [3-5]. In addition, more than 70 percent of dental students in America have neck, shoulder and lower back pain in their third year of dental school [6]. There were classifications of work-related musculoskeletal disorders which grouped by symptoms. For example, Kromer's guidelines grouped the symptoms into 3 stages: Stage1 had local aches and tiredness during the working hour and usually abated overnight with days away from work, Stage 2 had symptoms of tenderness, swelling, numbness and pain which starts early in the work shift and not abate overnight, Stage 3 had symptoms persist at rest and during the night. This classification was cited by Thanathornwong et al. [7]. The risk factors of WMSDs included static and awkward posture, repetition, forceful exertion work practices, etc. In general, dental students do not have guidance on the correct head and upper arm postures and movement, thus they only follow the manual on how to handle instruments to perform dental procedures. In 2011, it was reported that the knowledge of ergonomics postural requirements and clinical application of the final-year undergraduate dental students were unsatisfactory [8]. And less than 20 percent of dental student were not aware of proper postures [9]. Since the proper posture may help reduce musculoskeletal pain, thus a dentist should realize the ergonomics requirements for dental posture. Many studies found that the distances in dental ergonomics including working height (the distance from head rest to the floor) and sitting height (the distance from the highest margin of dental chair to the floor) were 35-90 cm and 47-63 cm, respectively. The angles of head (left-right, flexion-extension), upper arm (flexion-extension, adduction-abduction) were 20-30, 10-20, 15-20 and 30-60 degrees, respectively [1, 10, 11, 12]. The methods of ergonomic assessment that had been developed for evaluate the risk factors causing the WMSDs could be grouped as observational methods, self-reporting methods and direct methods [13]. The observational methods included films, photographs or videotapes. The simpler observational techniques had been developed for systematically recording by an observer and record on pro-forma sheets [14]. The self-reporting methods had many methods. The most common type of this method was self-administered questionnaires. Diaries, interviews, self-evaluation of clips video of work task, web-based questionnaire and rapid upper limb assessment (RULA) were also included in this method [7, 12, 14, 15]. The direct methods had been developed using sensors that placed on subject for measurement of exposure. Examples of hand-held devices measured of the range of joint motion to electronic goniometers that recorded continuous movement, the three-dimensional co-ordinates of all body markers recorded in real time using dedicated computing systems [14]. Many studies had shown development of methods for the investigation of work-related upper limb disorders i.e. Rapid Upper Limb Assessment (RULA) (developed by McAtamney and Corlett) [12], Haptic Virtual Reality System (developed by Suebnukarn et al.) [16] and Intelligent Posture Trainer (developed by Thanathornwong) [17]. Rapid Upper Limb Assessment (RULA) was a survey method used for investigating the ergonomics in workplaces and reported the work-related upper limb disorders. This method was a quick assessment of the postures of the neck, trunk and upper limbs along with the muscle function and the external loads experienced by the body. There was the worksheet to assess the posture and the system was used for generating and indicate the level of intervention to reduced the risks of injury which depended on physical loading on the operator. The advantages of this method were easy to use and could identify the underlying factors relevant for intervention for tasks with high action scores. The limitations were that right and left hands had to be assessed separately and no available method could combine the scores [12]. In 2009, Gandavadi et al. [18] studied the postures assessment of dental students in the two seating conditions using RULA methodology and reported that dental students using a Bambach Saddle Seat were able to maintain an acceptable working posture during simulated dental treatment. This seating may reduce the development of work-related musculoskeletal disorders. In 2010, Suebnukarn et al. [16] developed Haptic Virtual Reality System for dental skill training and examined several kinds of kinematic information about the movement. The system is provided by the system supplement knowledge of results (KR) in dental skill acquisition. The trends in acquisition and retention sessions suggest that the augmented kinematic feedback can enhance the performance earlier in the skill acquisition and retention sessions.

In 2014, Thanathornwong [17] compared the positions of the upper back between dental students with and without the Intelligent Posture Trainer system during work. The data showed that the degrees of bending and tilting of the upper back in the group with feedback from the intelligent posture trainer group were significantly smaller when compared with the group with no-feedback. The system was developed for predicting work-related musculoskeletal disorders (WMSDs) among dental students. The results were obtained by crossing over trial scheduled for each sequence of working: receiving feedback or no-feedback from the system. The author concluded that the system can be used for predicting and preventing WMSDs which aids the correction of the extension of the neck and upper back in the y axis [7]. These studies are a foundation for the future work and provide some insight into WMSDs that commonly known to be occupational health hazards of dentist.

Objectives

This study aims to develop Intelligent Ergonomics Trainer program and assess the working posture of dental students and compare the results between Intelligent Ergonomics Trainer program (IET) with real time feedback and Intelligent Ergonomics Trainer program without feedback with video playback.

Methods

Material

1. Dental unit of Thai Dental Products® model AERO200 at dental clinic floor 8th, Faculty of Dentistry, Srinakharinwirot University, Thailand.
2. Airotor handpiece of NSK® model MACH-QDs
3. Straight bur of Kromet Dental Germany REF 835314012 Lot 647300 No 0.12
4. Typodont teeth no. 16
5. Examination set
6. Dentoform with head model
7. Camera and tripod
8. Intelligent Ergonomics Trainer (IET) (Figure 1).
9. Computer or tablet running Window 8 with installed SPSS program for statistical analysis and Intelligent Ergonomics Trainer program for collecting data.

Figure 1. Intelligent ergonomic trainer composed of software Intelligent ergonomic trainer in tablet or computer running Window 8, S1 was head sensor, S2 was upper arm sensor, S3 was chair sensor, S4 was head rest sensor.

IET System development

The prototype system was an integrated solution for recording the head and the upper arm movements of the dentists. The investigated movements included different angles and distances. The angles of head are measured from flexion and extension, and left and right lateral flexion of the head while the angles of upper arm are measure from flexion and extension, and adduction and abduction of the upper arm. Meanwhile, the angles were recorded during dental operations to assist in the proper angle placement of the head and the upper arm. The hardware development composed of development of sensors and wireless adaptor. The sensor consisted of 4 sensors which were two accelerometer sensors (MMA7361L) which had high sensitivity (800 mV/g at 1.5 g) and measured at up to ±6 g at head and upper arm (Figure 2).

(a) (b)

Figure 2. (a) accelerometer sensor model MMA7361L (b) head and upper arm sensor container

The other 2 sensors were ultrasonic sensors (Maxsonar) which had real-time auto calibration, ability for measurement from o cm up to 765 cm and reading up to every 100 mS at head rest and dental chair (Figure 3).

(a) (b) (c)

Figure 3. Ultrasonic sensors (a) ultrasonic sensor model MAXSONAR (b) head rest sensor container (c) dental chair sensor container

The wireless adaptor used in the hardware was the XBee® RF Module for wireless sensor networks. This module operated within ISM 2.4 GHz frequency band. The long-range data integrity in indoor were up to 30 m and receiver sensitivity were -92 dBm. It had FCC approval (USA) and manufactured under ISO 9001:2000 (Figure 4). The software was developed as shown in figure 5.

(a) (b) (c)

Figure 4. Wireless adaptor (a) wireless adaptor container (b) XBee® RF Module (c) XBee Module mounting interface

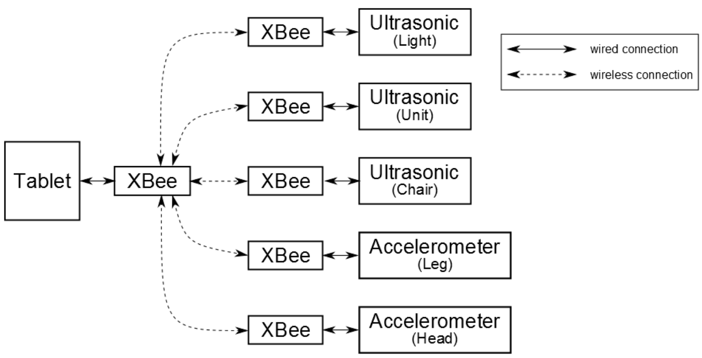


Figure 5. System overview

Participant

40 sixth year dental students who participated in this study were recruited from Faculty of Dentistry, Srinakharinwirot University, Thailand. All participants were age between 23-25 years old, had no history of head and neck injury, no congenital WMSDs and had Kromer's stage 0, 1, 2. The exclusion criteria were Kromer's stage 3 and cannot completed or pass the dental ergonomics and class I amalgam filling preparation test. This study was revised and approved by the committee on human right to human experimentation of the Faculty of Dentistry, Srinakharinwirot University, Bangkok, Thailand. No.10/2559.

Methods

In this study, a randomized control trial (RCT) design was conducted to compare the angle of head in left/right lateral flexion and flexion/extension as well as the angle of upper arm in adduction/abduction and flexion/extension of the participants. The choice of at least 16 participants per group was based on a two-tailed test, with α = .05 and the power ($1 - \beta$) of 0.80. After passing the criteria we had 32 dental students left and used lottery simple random sampling to equally separate students in 2 groups.

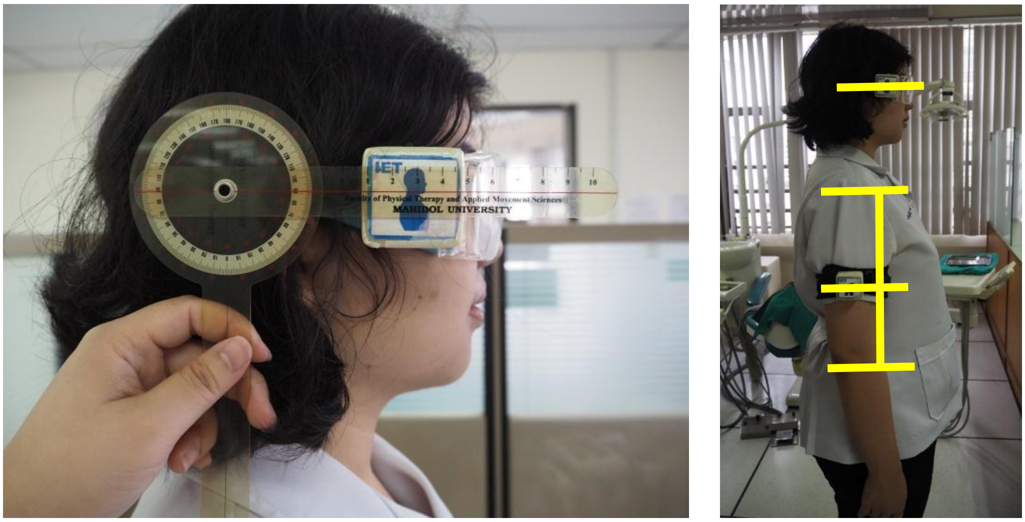
Collecting data

1. All participants were received a verbally explanation about the correct posture of ergonomics for dentist, briefly instructed on using the IET program (a real time feedback notification that alerted when the range of the angles were not in these range : the head left- right lateral flexion -30 to 30 degrees, head flexion-extension -20 to 20 degrees, upper arm adduction-abduction -30 to 30 degrees, flexion-extension -30 to 30 degrees) and the requirements of ideal class I cavity for amalgam filling preparation (the cavity outline extended from the mesial pit through the distal pit and prepared to 1.5 to 2 mm in depths on the upper right first molar blocks using indirect vision). Each participant was allowed to ask questions regarding the procedures from the investigators.

2. All participants did the questionnaire asked for demographic information, took the test on the knowledge assessment of dental ergonomics (the score is arranged between 0% and 100%) and the skill of ideal class I cavity for amalgam filling preparation by using the Intelligent Ergonomics Trainer (the score is arranged between 0 and 10).

3. The participants were equally divided into two groups by the lottery simple random sampling process. The first group was labeled as "AB" and the second group was labeled as "BA" correspondingly. Which "A" was the real time notification from IET program (Beeping sound) and "B" was the participants watched their own video playback after the task.

4. In every task used the same phantom head and had to set system and all sensors were calibrated when the posture of the dental students was in standing up straight, head back, looking straight ahead, eyes being parallel with the ground and arms being at sides of the body. Then, the angles and distance of sitting height and working height from the IET program and goniometer were checked for confirming data (Figure 6).



(a) (b)

Figure 6. Setting up and calibrating sensor (a) using goniometer for calibrating and checking angle (b) setting up the accelerometer sensor

5. The participants performed the 5 preparation sessions of the class I cavity for five days. Each day they required to do 5 teeth within 30 minutes (Figure 7).

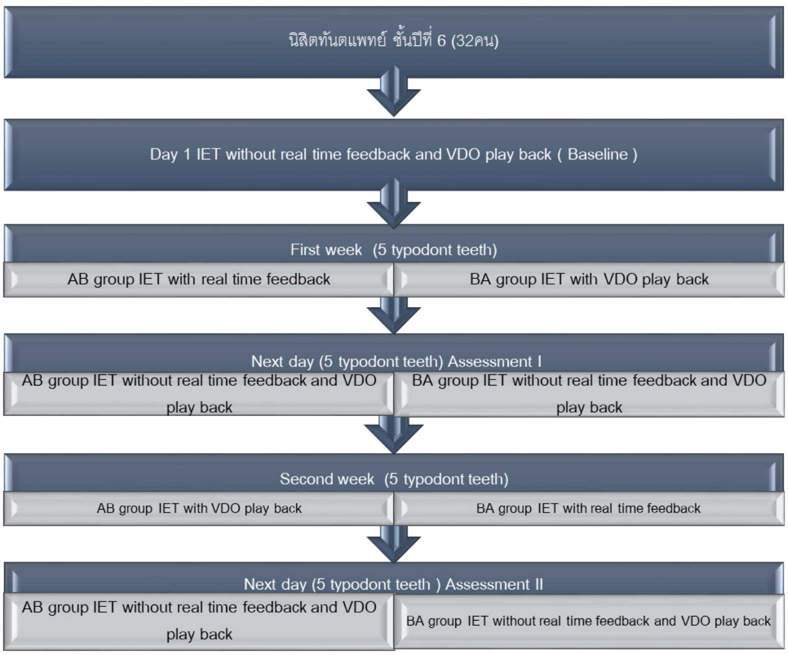


Figure 7. Flowchart through the trail

All the groups adjusted the position of sitting height and working height and then prepared class I cavity for amalgam filling preparation in 25 right upper first molar typodont teeth using IET program by the straight diamond bur (changed every 8 participants). All data were collected using IET program as shown in Figure 8.

Figure 8. Preparing operation for collected data using IET program

6. On the first day, each participant was set in the position of working and sitting posture (IET program calculated from height of each participants) and prepared 5 right upper first molar typodont teeth using IET program without the real time feedback (beeping sound). The video of dentists' postulate was recorded for the entire preparing session, but not with the task for baseline data.

7. For the next seven days, the group "AB" was set in the position of working and sitting posture from the IET program and prepared 5 right upper first molar typodont teeth using IET program with the real time feedback (beeping sound). The video of dentists' postulate was recorded for the entire preparing session, but not being watched after the task was done. Group "BA" was set in the position of working and sitting posture and prepared 5 right upper first molar typodont teeth using IET program without the real time feedback (beeping sound). The video of dentists' posture was recorded for the entire preparing session and watched the playback once the task is done.

8. In the next day, groups "AB" and "BA" were set in the position of working and sitting posture and prepared 5 right upper first molar typodont teeth using IET program without the real time feedback (beeping sound). The video was recorded for the entire preparing session, but not watched after when the task was done. This step was called assessment I (Assessment I assessed the mean value

of all angles in real time feedback method of AB group and video playback method of BA group.)

9. In the third week, the participants switched the task A to B and B to A. Therefore, "AB" group was set in the position of working and sitting posture and prepared 5 right upper first molar typodont teeth using IET program without the real time feedback (beeping sound). The video was recorded for the entire preparing session and being watched after when the task was done. Group "BA" was set in the position of working and sitting posture. Then, they prepared 5 right upper first molar typodont teeth using IET program with the real time feedback (beeping sound). The video was recorded for the entire preparing session, but not being watched after the task is done.

10. In the next day, group "AB" and "BA" were set in the position of working, sitting posture and prepared 5 right upper first molar typodont teeth using IET program without the real time feedback (beeping sound). The video was recorded for the entire preparing session, but not being watched after the last assessment. This step was called assessment II. (Assessment II assessed the mean value of all angles in real time feedback method of BA group and VIDEO playback method of AB group.)

11. After all the tasks were finished, the investigators delivered all the feedback and results of the posture of ergonomics to all participants.

12. The data used in this study were the angles of the head in the left/right lateral flexion and the flexion/extension, the angles of the upper arm in adduction/abduction and flexion/extension, and the sitting height and working height (cm). The mean values of the angles of the head and the upper arm in baseline, assessment I and assessment II from the IET program were compared using the pair t-test. The mean angles of group AB and group BA were compared using the independent t-test. Statistical difference was defined as having a value less than 0.05 ($p<0.05$).

Results

Thirty-two dental students were participated in this study. Several demographic parameters (Table 1) were recorded including age, gender, height and Kromer stage. The average age was 23.63+0.66 years old. The ratio of male and female was 1:3. The average height was 167.09+9.15 cm. The Kromer stage shown the WMSDs in participated was 86 percent. The results showed the comparing angles (degrees) of head in left/right lateral flexion and the flexion/extension, the angles of the upper arm in the adduction/abduction and the flexion/extension in the 50th percentile of baseline, assessment I and assessment II of the AB and BA groups in each participant. The results will be divided into two large categories; within the group of baselines, assessment I and assessment II, and between the group AB and group BA (Table 2-3). The sitting height and working height were in the period of 35-90 cm and 47-62 cm respectively.

Table 1: Demographic data

Variable	Categories	Group AB	Group BA	All participants
Age (years old)	-	23.69+0.70	23.56+0.63	23.63+0.66
Sex (people)	male	4	4	8
	female	12	12	24
Height (cm)	-	166.88±9.35	167.31±9.24	167.09±9.15
Kromer stage	No symptoms	2	2	5
	1	12	10	22
	2	3	3	6

Table 2: Comparing mean at 50th percentile and SD in all angle within the group of baselines,assessment I and assessment II.

Group	Angle	Baseline (degree)		Assessment I (degree)		Assessment II (degree)	
AB	Head Flex-extension	-48.19	0.00 *	-35.94	0.13 *	-30.5	0.00 *
	Mean (SD)	(8.74)		(2.14)		(2.20)	
BA	Head Flex-extension	-49.88	0.00 *	-35.56	0.24 *	27.75	0.00 *
	lateral flexion	(8.16)		(3.34)		(2.01)	
	Mean (SD)						
AB	Head right-left	-2.47		-4.25		-2.31	
	lateral flexion	(4.65)		(0.68)		(1.07)	
	Mean (SD)						
BA	Head right-left	-0.19		-1.94		-1.06	
	Mean (SD)	(4.93)		(0.64)		(0.94)	
AB	Upper arm ab-adduct	11.18	0.034 *	8.31		3.44	0.001*
	Mean (SD)	(3.97)		(1.48)		(1.95)	
BA	Upper arm ab-adduct	7.25		7.44		7.25	
	Mean (SD)	(4.67)		(2.00)		(2.20)	
AB	Upper arm flex-extension	-0.16	0.038 *	6.19		6.31	0.035*
	Mean (SD)	(10.63)		(1.97)		(2.26)	
BA	Upper arm flex-extension	-1.88	0.049 *	2.25		6.93	0.004*
	Mean (SD)	(8.91)		(2.23)		(2.28)	

* are the angles had significant difference by pair t test

Table 3: Comparing mean at 50th percentile and SD in all angle between the group AB and group BA.

Step	Angle	Group AB(degree)	Group BA(degree)	Significant value
Baseline	Head Flex-extension Mean (SD)	-49.19(8.74)	-49.88(8.16)	0.577
	Head right-left lateral flexion Mean (SD)	2.47(4.65)	-0.19(4.93)	0.188
	Upper arm ab-adduct Mean (SD)	11.81(3.97)	7.25(4.67)	0.624
	Upper arm flex-extension Mean (SD)	-0.16(10.63)	-1.88(8.91)	0.432
Assessment I	Head Flex-extension Mean (SD)	-35.94(2.14)	-35.56(3.34)	0.925
	Head right-left lateral flexion Mean (SD)	-4.25(0.68)	1.94(0.64)	0.019**
	Upper arm ab-adduct Mean (SD)	8.31(1.48)	7.44(2.00)	0.727
	Upper arm flex-extension Mean (SD)	6.19(1.97)	2.25(2.23)	0.210
Assessment II	Head Flex-extension Mean (SD)	-30.5(2.20)	27.75(2.01)	0.363
	Head right-left lateral flexion Mean (SD)	-2.31(1.07)	-1.06(0.94)	0.387
	Upper arm ab-adduct Mean (SD)	3.44(1.95)	7.25(2.20)	0.204
	Upper arm flex-extension Mean (SD)	6.31(2.26)	6.93(2.28)	0.847

** is the angle had significant difference by independent t test

In the first category, baseline and assessment I, assessment I and assessment II, and baseline and assessment II were analyzed accordingly. In the second category, data of group AB and group BA were also analyzed accordingly.

The results of group AB comparing baseline and assessment I were statistically different ($p < 0.05$) in the head flexion-extension, the upper arm abduction-adduction and the upper arm flexion-extension angles. A significant improvement of -48.19 to -35.94 degrees was seen for the head flexion-extension angles, 11.18 to 8.31 degrees were seen for the upper arm abduction-adduction angles. In the same way, in BA group, the results of comparing baseline and assessment I were statistically different ($p < 0.05$) in head flexion-extension and the upper arm flexion extension angles. A significant improvement of -49.88 to -35.56 degrees was seen for the head flexion-extension angles which based on the reference angle was -20 to 20 degrees.

The results of group AB comparing assessment I and assessment II were statistically different ($p < 0.05$) in the head flexion-extension angles. A significant improvement of -35.94 to -30.5 degrees was seen for the head flexion-extension angles (reference angle was -20 to 20 degrees). In the same way, BA group, the results of comparing assessment I and assessment II were statistically different ($p < 0.05$) in head flexion-extension angles. A significant improvement of -35.56 to -27.75 degrees was seen for the head flexion-extension angles

The results of group AB comparing baseline and assessment II were statistically different ($p < 0.05$) in the head flexion-extension the upper arm abduction-adduction and the upper arm flexion extension angles. A significant improvement of -48.19 to -30.50 degrees was seen for the head flexion-extension angles (reference angle was -20 to 20 degrees), 11.18 to 3.44 degrees was seen for the upper arm abduction-adduction angles (reference angle was -30 to 30 degrees). In the same way, BA group, the results of comparing baseline and assessment II were statistically different ($p < 0.05$) in head flexion-extension and the upper arm flexion extension angles. A significant improvement of -49.88 to -27.75 degrees was seen for the head flexion-extension angles (reference angle was -20 to 20 degrees) and -1.88 to 6.93 degrees for the upper arm flexion extension angles (reference angle was -30 to 30 degrees).

The means of group AB and group BA were also compared. In Baseline, there were no significant different in every angle. In Assessment, I, group AB and BA were significant different ($p < 0.05$) in the head right-left angles (BA group is better than AB group). On the contrary, in Assessment II, there were no significant different in every angle.

Conclusion and Discussion

This study investigated the posture of sixth year dental students from Srinakharinwirot University, Bangkok, Thailand. It was found that 86 percent of dental student participants had musculoskeletal pain. This finding is consistent with previous studies which reported more than 70 percent of American dental students having musculoskeletal pain [6]. Andrew et al. [19] reported that 97 percent of all dental personnel having musculoskeletal pain and 84.6 percent of undergraduate and postgraduate students suffered from WMSDs linked with clinical procedure and their training. The angle of head and upper arm measured in this study after using IET program in both group were in the ergonomics posture except the head (flexion-extension) angle which higher than normal posture (-20 to 20 degrees) [10].

The methods for assessment postures and risks of WMSDs in this study used self-reporting (video clip palyback) and direct method (IET program). The advantage of the video recording method was that dental students could recognize which part is in the wrong position. They could see the actual position in the video clip. The limitation of this method was that dental students could not realize the quantity of the task and could not adjust their position in real time which conform to the other study that the advantages of self-reporting methods were low cost with large samples size, but the disadvantages of self-reporting methods were low validity and low reliability [7, 14]. The advantage of the direct method was that dental student could notice that their position was not right immediately while performing dental tasks. The machine would not stop the beeping sound until the positions were adjusted. However, the disadvantage of this method was that a lot of sensors will be used during the test. It could be challenging for the dental students to distinguish which positions are wrong since the sensors were attached to both head and upper arms. Moreover, dental student could not see their own actual operating posture while performing the task. In the other studies reported the advantage of the direct methods was the ability to provide information in sufficient quality. However, some of these methods are not friendly with customers, highly skilled investigators, expensive and complicated [7, 14]. The comment from the dental students after the test was that they preferred group BA more as it offered the video of their operating posture before using the IET program with the real time feedback so that they could alter their posture effectively especially over the head areas. This result sorted with Suebnukarn et al. [16], who developed Haptic Virtual Reality System for dental skill training and examined several kinds of kinematic information about the movement. This system can enhance the performance earlier in the skill acquisition and retention sessions. Moreover, Thanathornwong et al. [7, 17, 20, 21] developed the system for predicting MSDs and improve dental ergonomics in many system (Intelligent Posture Trainer system, LabVIEW program, etc.) using accelerometers attached at face shield and back. In addition, inclinometer sensor attached at back was use for recording posture in LabVIEW program. These programs can improve many postures in ergonomic. However, as we can draw from previous work, the sensors sound should not be the same or adding vibrotactile feedback to improve training or using biofeedback with muscle activity. In many research experiments, biofeedback system was used for prominent component in examining the muscle activity in motor training and rehabilitation [21].

In 1992, Fleming and Mills classified the learning styles from the VARK model. The name comes from the first letters of the three learning styles described: visual, auditory, reading/writing and kinesthetic. Visual learners learn with their eyes seeing picture, graph or video. Auditory learners learn by listening all information e.g. verbal lecture and discussion. Reading/writing learners learn though the text taking their note. Kinesthetic learners learn though touching, exercise, hand-on and moving [22-24].

In 2014, Kahar et al. [24] evaluated the learning styles of dental students of VSPM's Dental College and Research Centre, Nagpur and found that 37 percent of students were unimodal while 47.22 percent of students preferred kinesthetic, 27.7 percent were auditory, 19.44 percent were read/write and 5.55 percent preferred visual type of learning style. Similarly, Asiry [23] reported the proportion of unimodal learners with 35.1 percent, 35.1 percent, 18.1 percent, and 11.7 percent of the students were kinesthetic, aural or auditory, visual and reading/writing, respectively. However, Busan [22], evaluated learning style of medical students. The distribution of learning style in VAK model was as following: 33 percent for visual, 26 percent for auditory, 14 percent for kinematic and Reading/Writing (R) learners, respectively which different from the other studies mentioned above. In this study, there were four styles of learning. The first and second ones were auditory and kinesthetic learning (IET program with real time feedback), the third one was visual learning (video clip) and the forth one was writing (Dental ergonomics test). All dental students are preferred the real time feedback if this study could resolve the problem in classifying the sound of sensors at head and upper arm.

The advantage of the video recording method was participants could recognize which part was the wrong position. They could see the actual position in the video clip. The limitations of this method were participants could not realize the quantity of the task and could not adjust their position in real time. The advantage of the direct method was participants could notice that their position was not right immediately while performing dental tasks. The machine would not stop the beeping sound until the positions were adjusted. However, the disadvantage of this method was that a lot of sensors will be used during the test. It could be challenging for the dental students to distinguish which positions are wrong since the sensors were attached to both head and upper arms. Moreover, participants could not see their own actual operating posture while performing the task. The comment from the participants after the test was that they preferred group BA more as it offered the video of their operating posture before using the IET program with the real time feedback so that they could alter their posture effectively especially over the head areas. This supported the last test of the assessment II as it pointed out that group BA had the head flexion and extension lower than group AB. Group BA with 27.74 degrees and group AB with 30.5 degrees).

The limitation of this study was the quality of tasks. The quality of class I amalgam filling preparation did not check after tasks because the study excluded the participants who had score of class I amalgam filling preparation skill below 70 percent.

To our knowledge, this is the first intervention trial using application of two methods for training posture though IET program among the dental students. Nowadays, the study grows its popularity to explore the training methods which evaluate quality and quantity of dental ergonomic posture, risk of WMSDs and promote quality of life for dental personnel. The future studies should include other parameters such as (a) larger sample size of dental students or dentists in other specialties (e.g. dental surgeons, and dental hygienists), (b) adding the different sound on different sensors, (c) obtaining the biofeedback with muscle activity examined with electromyography, and (d) training in different part of body or trying to use IET program system for daily training.

Studying the of the sixth-year dental student working posture at Faculty of Dentistry, Srinakarinwirot University leads us to the following conclusion: Using IET program with real time feedback and video clips playback significantly promoted the improvement of proper posture. However, there was no significant difference between the improvement of proper posture in students with and without IET program.

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