

## Original Article

# VDT Workstation: Comparison of Posture Computer Users with Musculoskeletal Symptoms Using EMG Sensor

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### **Abstract:**

**Introduction:** This paper proposes a “VDT Workstation” that proposed design methodology consist of an analytical base on design of workstation layout and task design can affect the physical and visual demands on people who work with computers. **Objective:** The VDT workstation consists of a computer table and a chair, including several adjustable components such as monitor shelf, keyboard shelf, mouse shelf, document holder, and chair seat. **Methods:** These workstation components can be adjusted in x-, y-, and z- coordinates. A decision support tool called CVOS (Centre VDT Operator System) is encoded in a C language. The experiment is based on an 8 bit arduino microcontroller, and the simulation is based on computer programming. **Results:** The results from a microcontroller are then transferred to the VDT workstation via a control system. VDT workstation components are then commanded to move to the locations defined by CVOS. **Conclusion:** An experiment that investigates the body posture and the hand movements of a VDT operator by comparing between the results from the manual adjustment and the CVOS assisted adjustment is also discussed.

**Keywords:** ● VDT workstation ● Adjustment settings ● Human computer interface ● Ergonomic engineering  
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## นิพนธ์ต้นฉบับ

### การทำงานบนโต๊ะกับคอมพิวเตอร์ (VDT Workstation):

### การเปรียบเทียบท่าทางการทำงานของผู้ใช้คอมพิวเตอร์ด้วยอาการของกล้ามเนื้อ และกระดูกโดยใช้เซ็นเซอร์แบบตรวจไฟฟ้ากล้ามเนื้อ (EMG)

เดชฤทธิ์ มณีธรรม

สาขาวิศวกรรมเมคคาทรอนิกส์ คณะครุศาสตร์อุตสาหกรรม มหาวิทยาลัยเทคโนโลยีราชมงคลธัญบุรี

#### บทคัดย่อ

**บทนำ** การทำงานบนโต๊ะกับคอมพิวเตอร์ (VDT Workstation) ที่เสนอวิธีการออกแบบประกอบด้วยพื้นฐานในการวิเคราะห์และการออกแบบรูปแบบ การทำงานบนโต๊ะทำงานและการออกแบบงานที่อาจส่งผลกระทบต่อทางกายภาพของคนทำงานกับเครื่องคอมพิวเตอร์เป็นเวลานานๆ **วัตถุประสงค์** การทำงานบนโต๊ะกับคอมพิวเตอร์ ประกอบด้วยโต๊ะคอมพิวเตอร์และเก้าอี้รวมถึงชิ้นส่วนที่สามารถปรับได้หลายอย่าง เช่น ชั้นวางจอภาพ ชั้นวางคีย์บอร์ด ชั้นวางเมาส์ ที่ใส่เอกสารและที่วางแก้ว **วิธีการ** การทำงานบนโต๊ะทำงานจะมีอุปกรณ์ต่างๆ ที่สามารถปรับได้ในทิศทางแกนเอ็กซ์ (x-axis) แกนแกนวาย (y-axis) และแกนแนวเซต (z-axis) โดยจะมีเครื่องมือหรือโปรแกรมที่สนับสนุนในการตัดสินใจที่เรียกว่า CVOS (Center VDT Operator System) โปรแกรมนี้จะเขียนด้วยภาษาซี (C Language) การทดสอบนี้จะใช้ไมโครคอนโทรลเลอร์อาดูอิโน (Arduino Microcontroller) ที่มีขนาด 8 บิต และการจำลองจะขึ้นอยู่กับเขียนโปรแกรมคอมพิวเตอร์ **ผลการศึกษา** ผลจากการใช้ไมโครคอนโทรลเลอร์ควบคุม จะสั่งงานหรือควบคุมการทำงานของโต๊ะทำงานกับคอมพิวเตอร์ ให้เคลื่อนที่ตามคำสั่งที่ตั้งไว้ด้วยโปรแกรม CVOS **สรุป** การทดลองโต๊ะทำงานกับคอมพิวเตอร์จะถูกปรับให้เหมาะสมกับท่าทางของร่างกายและการเคลื่อนไหวด้วยมือของผู้ปฏิบัติงานบนโต๊ะทำงาน การปรับการทำงานบนโต๊ะกับคอมพิวเตอร์สามารถปรับด้วยตนเองหรือปรับด้วยโปรแกรมด้วยตัวมันเองได้

**คำสำคัญ:** ● การทำงานบนโต๊ะกับคอมพิวเตอร์ ● การตั้งค่าการปรับ ● อินเทอร์เน็ตคอมพิวเตอร์กับมนุษย์  
● วิศวกรรมการยศาสตร์

**เวชสารแพทย์ทหารบก 2560;70:209-16.**

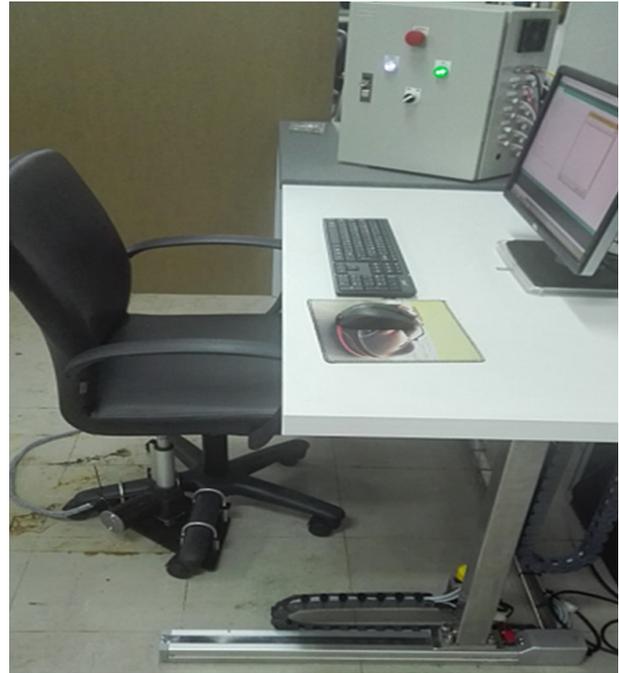
### Introduction

Nowadays, in terms of ergonomics, comfort integrates a sense of well-being with health and safety. There are other studies were performed to evaluate work posture and quantitatively of computer operations while working with the work posture. These researches have been focused on the development of new principles of the design of chairs and desks in the workplace<sup>1,3</sup> summarized from their research that between 50% and 90% of people who work at a computer screen have at least some symptoms. When you work at a computer, your eyes have to focus and refocus all the time. They move back and forth as you read. You may have to look down at papers and then back up to type. Your eyes react to changing images on the screen to create so your brain can process what you're seeing. All these jobs require a lot of effort from your eye muscles. And to make things worse, unlike a book or piece of paper, the screen adds contrast, flicker, and glare. They recommended that the adjustment of VDT workstation settings and the arrangement of computer accessories be considered concurrently, and with the consideration of user-related and task-related information. Later, Rurkhamet and Nanthavani<sup>2</sup> developed a rule-based algorithm to recommend the location of the monitor, document, keyboard, and mouse on a computer table base on computer task and the user's typing skill level. This paper discusses the design and construction of a "VDT Workstation" to supplement an application of a decision support system called CVOS (Centre VDT Operator System). Overall, the investigation focused to study the body posture and the hand movement of a VDT operator by comparing between Male and Female Computer users with Musculoskeletal Symptoms from the manual adjusting and the CVOS assisted adjustment is also discussed.

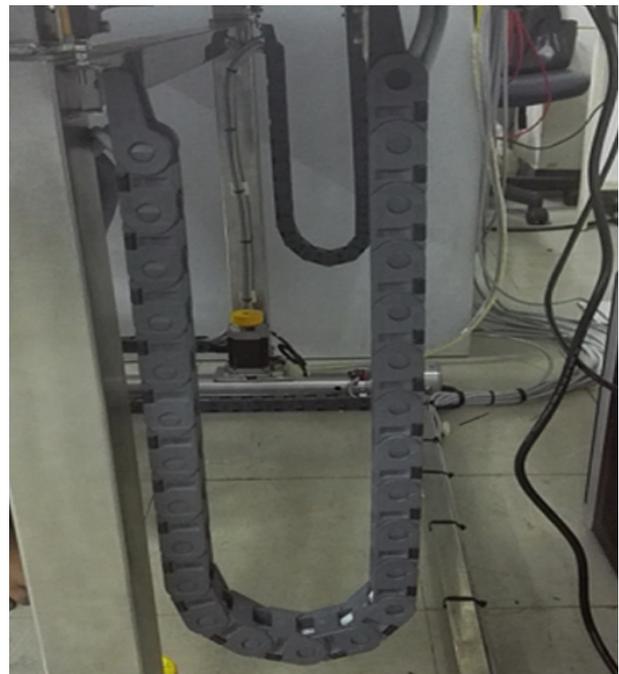
#### I. VDT Workstation Components

The term input device refers to all equipment used to enter or manipulate data in a computer. Four of the most commonly used input devices are the keyboard,

the mouse, the monitor, and the chair. The first four components are coupled with mechanisms that allow them to be adjusted through a control system, either automatically or manually. Stepper motors which drive screw shafts rotate guide units to move the adjustable components along the x - axis, y - axis, and z - axis.



A) Computer table base



B) Stepper motor

**Figure 1** VDT Workstation

### 1. Monitor Shelf

A monitor shelf is designed to be moveable along the three axes:  $x$  - axis (right-left),  $y$  - axis (in-out), and  $z$  - axis (up-down). The shelf stays on a double - rail structure that is connected to the workstation mainframe to support the weight of the computer monitor. The range of movement are as follows:

- $x$  - axis: 0 - 60 cm (from the center to the right)
- $y$  - axis 62 - 72 cm (measured from the VDT user's body to the center of the screen)
- $z$  - axis 65 - 95 cm (measured from the floor to the center of the screen)

### 2. Keyboard Shelf

A keyboard shelf also moves in all three axes. The movement directions are similar to those of the monitor shelf. The range of movement are as follows:

- $x$  - axis: 0 - 60 cm (from the center to the right)
- $y$  - axis 62 - 72 cm (measured from the VDT user's body to the center of the screen)
- $z$  - axis 65 - 95 cm (measured from the floor to the center of the screen)

### 3. Mouse Shelf

A mouse shelf is separated from the keyboard shelf to allow freedom in positioning a computer mouse. Similar to the monitor and keyboard shelves, it is moveable along the three axes through as assistance of two stepper motors. The range of movement are as follows:

- $x$  - axis: 0 - 9 cm (from the center to the right)
- $y$  - axis 16 - 38 cm (measured from the VDT user's body to the computer mouse)
- $z$  - axis 65 - 95 cm (measured from the floor to the computer mouse)

### 4. Chair Seat

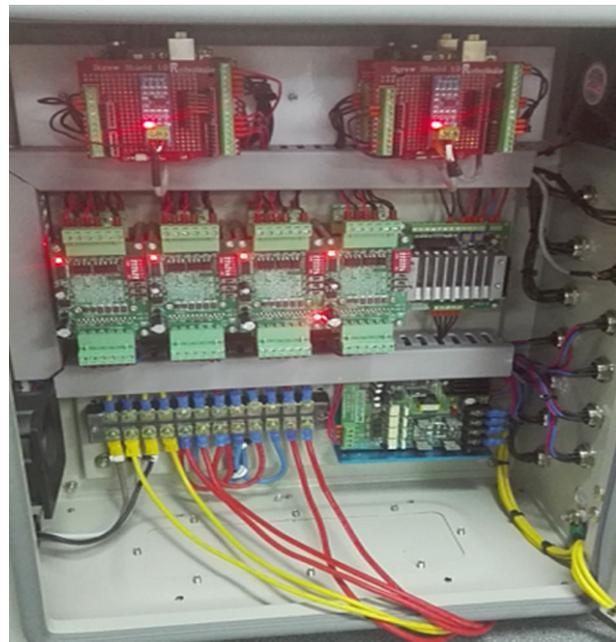
A chair seat is fixed with the mainframe of the VDT workstation and is not moveable. Its seat level height can be adjusted only along the  $z$  - axis using a stepper motor. The range of movement of a seat pan is as follows.

- $z$  - axis 40 - 52 cm (measured from the floor to the upper side of the seat pan)

## II. Control System

Generally, a control system is an integral part of a work cell or large complex of equipment having the purpose of controlling, monitoring, and analyzing a process or other equipment. The control system of a VDT workstation consists of the following units:

- 2 set of main board
- 12 sets of electronic stepper motor
- 2 sets of photoelectric sensor
- 1 set of LCD display
- 1 set of 16 button key pad (a 4 \* 4 matrix)
- 6 sets of potentiometer sensor



**Figure 2** Control System

## III. Microcontroller and Software Development

A microcontroller based control system has been developed and has been used to provide the satisfactory control of a VDT workstation. The evaluations of the characteristics for the purpose were obtained by using a microcontroller Arduino UNO to control the hardware. Adjustment and layout algorithm that are the essential

features of CVOS are encoded in a C language. An appropriate compiler is then used to translate the C program into relevant machine language. From its result, the twelve stepper motors are controlled in sequence to drive the screw shaft which, subsequently, move the concerned components. Figure 3 Shows the microcontroller control of the VDT workstation.

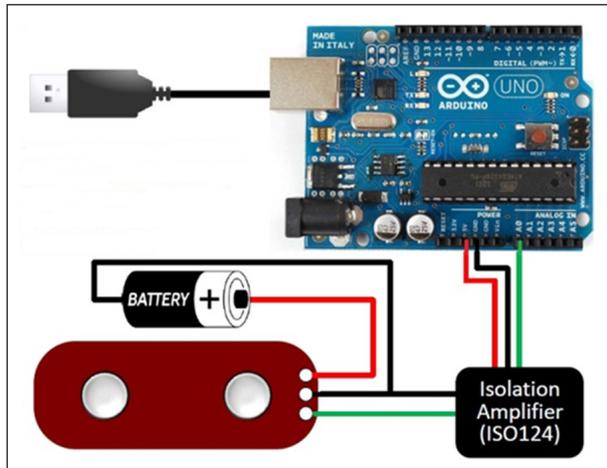


Figure 3 Microcontroller Control

Electromyography (EMG) studies have documented shoulder girdle muscle activation during common internal rotation (IR). The sit-stand workstation was evaluated with the use of musculoskeletal exposure measurements. (EMG) was recorded from two muscles of the middle and lower trapezius and biceps with a portable muscle sensor (AT-04-001) device with a video option.

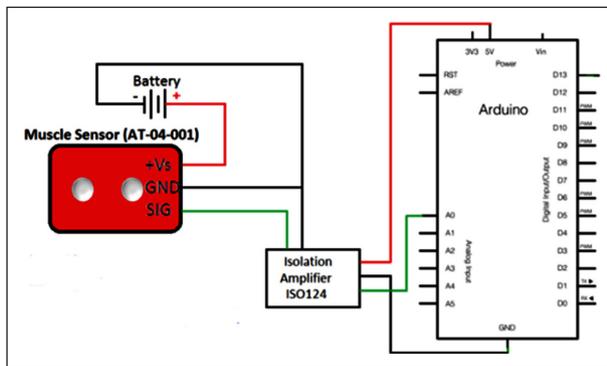


Figure 4 Arduino Microcontroller and EMG Schematics

Software modules were produced to run on the computer controller to evaluate the effectiveness of the control strategy. The PC delivers the signals to arduino microcontroller UNO via its parallel port. This simulator was created to test the performance of the controller and mechanical system integrated. It is a C Language code that sends data to control the VDT workstation and adjusted in x-, y-, and z- coordinates for support the body posture.

```
File Edit Sketch Tools Help
#include "DHT.h"
EMG dht;
void setup()
{
  Serial.begin(9600);
  Serial.println();
  Serial.println("Status\EMG(%) \EMG1(T) \ (B)");
  dht.setup(2);
}
void loop()
{
  delay(dht.getMinimumSamplingPeriod());
  float humidity = dht.getHumidity();
  float temperature = dht.getTemperature();
  Serial.print(dht.getStatusString());
  Serial.print("\t");
  Serial.print(EMG, 1);
  Serial.print("\t\t");
  Serial.print(EMG1, 1);|
```

Figure 5 Arduino Microcontroller Code

#### IV. Experiment and Results

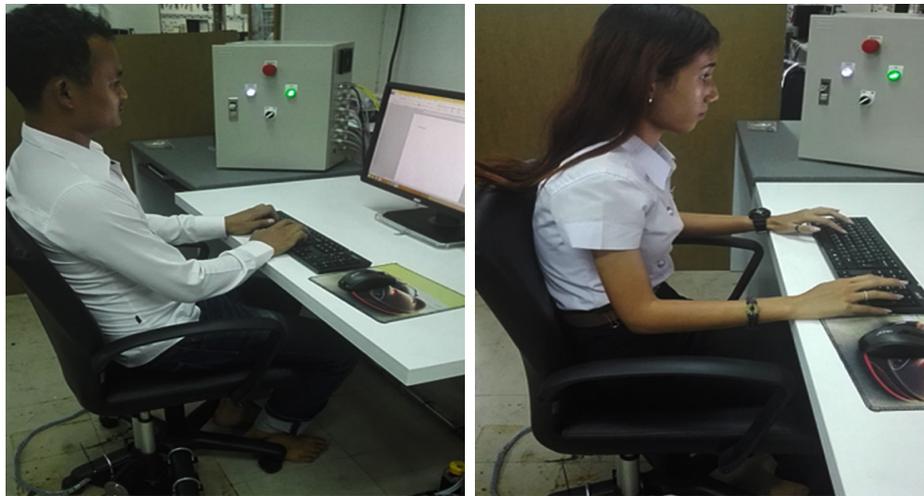
The validation of the VDT workstation was conducted. Eighteen students (9 males and 9 females) participated in the experiment. Their age and body height ranges were 20-22 years and 155-180 cm, respectively. Based on the results of the typing test, the subjects were categorized either as Thai language and English language (which lasted 30 minutes). Each subject had to perform the given VDT task to times, with at least apart between the two trials. In the trial, the subjects were asked to adjust the workstation and arrange computer accessories according to their preference. All adjustments were done manually using control buttons on a key pad of the controller to move selected adjustable components

to the desired positions. All the settings and accessory locations were recorded and reference points were measured. Additionally, all paired distances between input devices and those between display device were

measured and recorded prior to the test. A video camera was used to record the subject's hand movements. Figure 6. Shows the summary of the comparisons between the hand movements from male and female.

**Table 1** Comparisons between the hand movements from the two trials

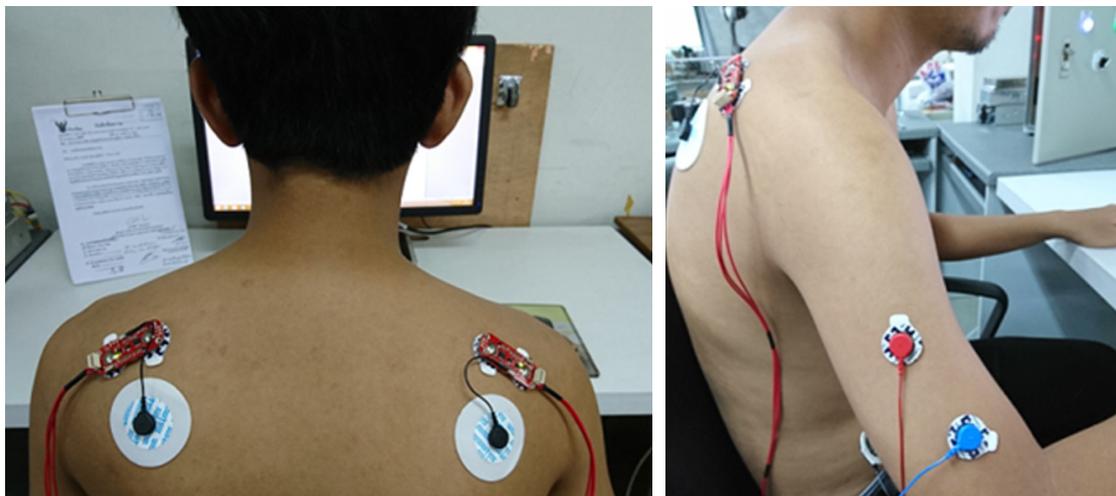
VDT task	Average hand movement (cm)		Average Difference (cm)	% Difference
	First trial	Second trial	(Second trial - First trial)	
Document Preparation				
- Thai language	1,378	301	-1,077	-78.15%
- English language	1,916	431	-1,485	-77.50%



A

B

**Figure 6** Body postures from male (A) and female (B)



Upper trapezius

Biceps brachii

**Figure 7** EMG Electrodes location on the muscle with male

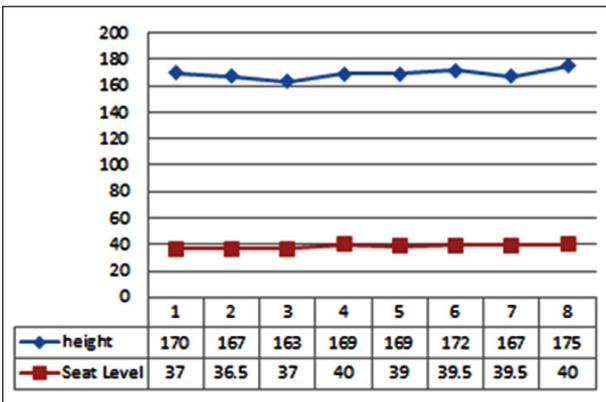


Upper trapezius

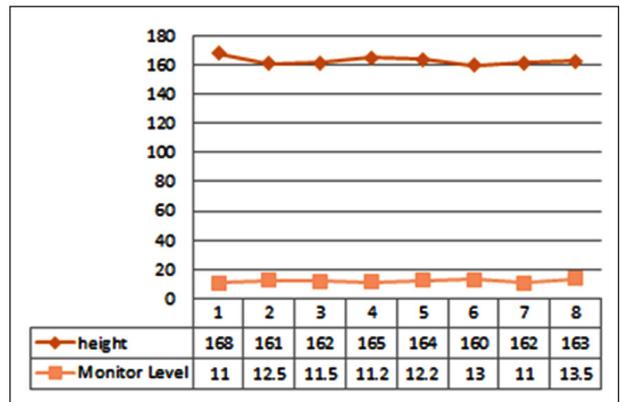


Biceps brachii

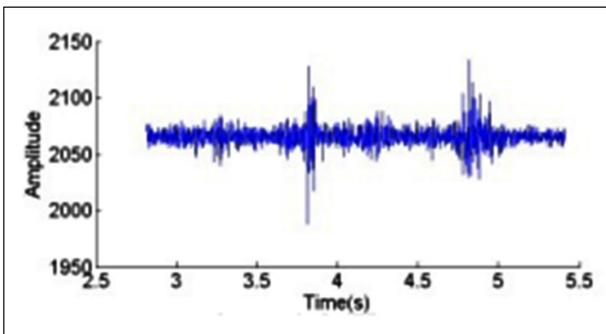
**Figure 8** EMG Electrodes location on the muscle with female



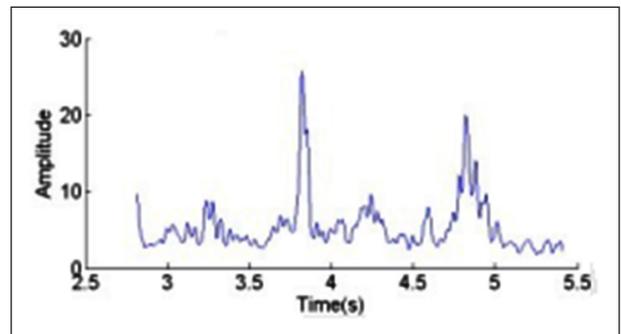
**Figure 9** Monitor level for Male



**Figure 10** Monitor level for Female

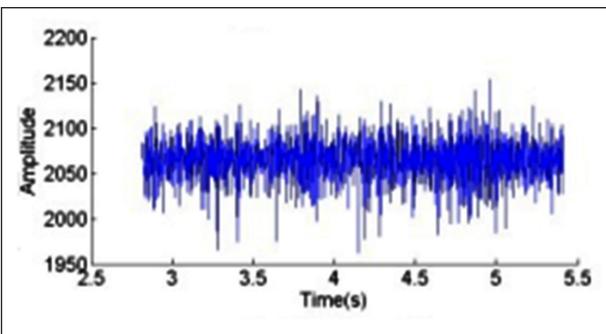


EMG

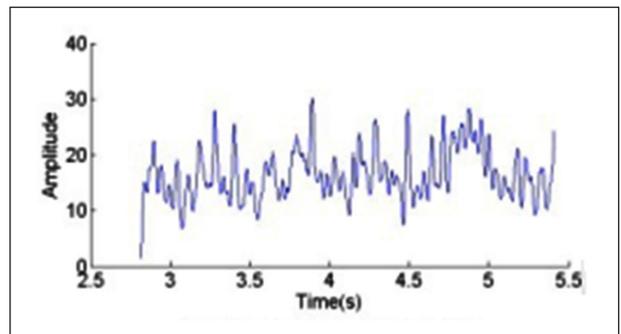


Muscle active

**Figure 11** An EMG signal showing hand movements (Male)



EMG



Muscle active

**Figure 12** An EMG signal showing hand movements (Female)

### Conclusions

The results showed that when adjusting the workstation and arranging computer accessories according to the recommendations from CVOS. The EMG signals were recorded through the bipolar arrangement with an inter - distance of 1-2 cm. Surface electrodes were placed on the skin to record the muscle activities of the left and right side upper trapezius. The hand movement were found to reduce significantly (at  $\alpha = 0.05$ ). The average hand movements when performing the document preparation with both languages such as English language and Thai language. The effect of typing changes on posture was analyzed in Figure 11 and Figure 12. (female can typing faster than male) If adjust screen height around  $12^\circ - 15^\circ$  degrees below the eye level then the neck muscle activities are significantly decreased in screen height. The decreasing the EMG activities of neck extensor muscle from posture reaction to decrease in height. The VDT work station is designed to automatically adjust its components base done the VDT user's physical data and task to be performed so that its adjustment settings and the layout of computer accessories ergonomically fit the VDT operator's body and facilitate the task that he/she has to perform. The VDT user can use a key pad on the controller to manually move the settings and layout to the desired locations or allow the VDT workstation to utilize rule - based algorithms of CVOS to adjust itself.

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