Development of the Ergonomic Wrist Posture Range for Indonesian in Typing Activity Using Electromyograph

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Abstract. Carpal Tunnel Syndrome (CTS) is one of the most common neuropathies which occurs due to repetitive activity of hand using non-neutral wrist posture whether in flexion, extension, or ulnar and radial. Even though this posture may be inevitable, however it should be confined in maximum range. Thus, this is very significant to develop the allowable of maximum deviation of wrist. Objective of this study is to determine the maximum range of wrist postures in such four motions with evaluating the muscle contraction at wrist. A case study applied is to type a manuscript using computer. Experimental study was conducted by using electromyograph to identify Maximum Voluntary Contraction (MVC) on Flexor Digitorum Superficialis (FDS) and Abductor Pollicis Brevis (APB). Ten healthy university students (5 females, 5 males) were participated with age between 20 to 23 years old. The statistical analysis was conducted to test the hypothesis. Result of this study shows that the suggested maximum wrist posture range is not greater than 30˚ extension, 20˚ flexion, 20˚ ulnar, and 20˚ radial, although the neutral posture of 0˚ was highly suggested. This guideline is proven to be valid for both male and female.

Keywords: Wrist posture, Typing, Electromyography, Flexor Digitorum Superficialis, Abductor Pollicis Brevis

1. Introduction
The use of personal computer (PC) is more and more widespread in recent decades for completing the task in a company [1]. In 2017, 13.7% of Indonesia population use personal computer and 22.52% use laptop and it increases gradually [2]. The main industrial activity done by using the PC is typing and adjustment the movement of cursor during the work day. These activities that is carried out frequently and repetitively will induce the risk of Musculoskeletal Disorders especially in upper extremity, including hand, wrist, and arm [3]. The disorder is also called the Carpal Tunnel Syndrome (CTS) which occurs as a result of the compressed median nerve attaching on the carpal tunnel at wrist [4-5]. These symptoms can disturb the ability to perform a task and potentially resulting in disability of hand [6-7]. Several studies have summarized that the well-known risks of work-related CTS is caused by forceful and repetitive movement [9], prolonged use of the hands and wrists [10], exposure to vibration [11] as well as non-neutral wrist posture [12]. For the last cause whether in flexion, extension, or ulnar and radial, it is always taken place excessively that is over a threshold of posture. This condition results in fatigue on muscle. Thus, this is crucial to know the maximum threshold of the wrist posture safely.
Electromyography (EMG) is one of electrodiagnosis techniques to record, analyze and display the muscle contraction [13-14]. This technique is valid to diagnose CTS by identifying the muscle contraction at wrist [15] such that it is reasonable to use this EMG. This study aims to define wrist posture maximum range in flexion, extension, and radial as well as ulnar by evaluating the muscle contraction at wrist.

2. Methods

Ten university students, consisting of five males and five females, were enrolled in this study. All participants are experienced in working on computer or portable computer for minimum 6 months [16], minimum fifteen hours as the median hours for computer use [17], and had no evidence of Carpal Tunnel Syndrome and musculoskeletal disorders conditions on upper extremity based on physical examination and medical history [14].

A within-subject design experiment was applied to all subjects by performing fifteen typing task, with five minutes duration of each task. The prior pilot study shows the significant difference in muscle activity for five minutes typing compared with one minute and three minutes typing. The participants were allowed to practice the typing for five minutes to become acclimated before the experiment began. The keyboard angle on each task were adjusted in order to achieve a desired wrist angle, with 10° of angle increment. The determined angles for extension were 40°, 30°, 20° and 10°, the determined angles for flexion were 40°, 30°, 20° and 10°, the determined angles for radial deviation were 30°, 20° and 10°, and the determined angles for ulnar deviation were 30°, 20° and 10°, and 0° for the natural posture as shown in figure 1. Goniometer is used to measure the desired angle. Flexion and extension measurement was conducted by centralizing the goniometer fulcrum on the lateral aspect of the wrist and aligning the goniometer distal arm towards the fifth metacarpal lateral plane. Ulnar and radial measurement was conducted by centralizing the goniometer fulcrum on the dorsal aspect of the wrist while the wrist in pronation position and align the goniometer distal arm towards the third metacarpal dorsal plane [18]. At the end of the experiment, the participants performed maximum static contraction against manual resistance for five seconds in kneeling position for obtaining Maximum Voluntary Contraction (MVC) value [19] [20]. During performing typing task, participants were not allowed to rest the hands or wrists on a surface in order to prevent palm contact pressure [12].

![Figure 1. Experimental Design](image)

The experiment apparatus consisted of two personal computers for display EMG signal data recorded by LabQuest 2 (Vernier Software and Technology, USA) and to display the typing task, EMG Sensor (Vernier Software and Technology, USA), and pre-gelled surface electrode as shown in figure 2. The standard workstation were given with 500mm – 1000mm monitor distance range [21] and the upright
position chair which gives horizontal thigh and vertical lower leg posture [22]. The software used to display the typing task was GS Typing Tutor version 2.96 (GrassSoftware).

Figure 2. Experimental Environment

The information regarding the experiment procedure were explained to the study participant and Phalen Test performed in order to diagnose the carpal tunnel syndrome indication [23]. The surface electrodes were attached afterwards in parallel to the muscle fibers with 2 cm distance between one electrode to another into the sterilized skin area, and one reference electrode on nearby but unaffected area [19]. *Flexor Digitorum Superficialis* (FDS) and *Abductor Pollicis Brevis* (APB) were two muscles used as the research object which innervated by median nerve, the only nerve passes through carpal tunnel [24] [25]. The location of attached surface electrodes on both muscles is illustrated in Figure 3. Electromyograph signal was sampled at 500Hz with high-pass and low-pass amplifier bandpass filter are set to 10Hz - 500Hz with 100ms Root Mean Square to smooth the signal and Maximum Voluntary Contraction applied to normalized the data [19].

Figure 3. FDS and APB Electrode Placement

3. Results and Discussion
The results of the experiment show that the muscle contraction increases along with the angle increment in flexion, extensions, ulnar and radial posture, and the lowest muscle contraction is in 0˚ position. A rank-based nonparametric test was performed to determine whether there was significant difference on one posture treatment with another. The probability value (*p* value) on Kruskal–Wallis test shows both the posture differences on *Flexor Digitorum Superficialis* (FDS) and *Abductor Pollicis Brevis* (APB)
muscles were significant \((p: 0.00)\). Figure 4 and 5 illustrate the average data of the normalized EMG signal shown with the percentage of Maximum Voluntary Contraction (%MVC) of these muscles. The %MVC of FDS muscle on 0° is 6.623%, on 10° extension is 13.181%, on 20° extension is 16.224%, on 30° extension is 24.267%, on 40° extension is 27.758%, on 10° flexion is 12.849%, on 20° flexion is 19.676%, on 30° flexion is 25.298%, on 40° flexion is 30.828%, on 10° ulnar is 12.255%, on 20° ulnar is 16.896%, on 30° ulnar is 20.707%, on 10° radial is 11.582%, on 20° radial is 15.308%, and on 30° radial is 23.465%.

*\(p > 0.05\) (not significant), **\(p < 0.05\) (significant)

**Figure 4.** %MVC of *Flexor Digitorum Superficialis* Muscle at different wrist postures; (1) Flexion and Extension, and (2) Ulnar and Radial

Mann Whitney U Test was conducted to compare differences between two postures whether in flexion, extension, ulnar, or radial. Figure 4 above shows the results of Mann Whitney U Test on *Flexor Digitorum Superficialis* muscle. There is a significant difference between wrist posture of 0° and 20° flexion, 0° and 30° flexion, 0° and 40° flexion, 10° flexion and 30° flexion, 10° flexion and 40° flexion, 20° flexion and 40° flexion, as well as 0° and 20° extension, 0° and 30° extension, 0° and 40° extension,
10° extension and 30° extension, 10° extension and 40° extension, 20° extension and 40° extension. On the other hand, there is significant difference between wrist posture of 0° and 10° radial, 0° and 20° radial, 0° and 30° radial, 10° radial and 30° radial, as well as 0° and 10° ulnar, 0° and 20° ulnar, also 0° and 30° ulnar, 10° ulnar and 30° ulnar.

Whereas the %MVC of APB muscle on 0° is 11.423%, on 10° extension is 14.612%, on 20° extension is 14.869%, on 30° extension is 21.725%, on 40° extension is 27.573%, on 10° flexion is 16.176%, on 20° flexion is 20.231%, on 30° flexion is 24.371%, on 40° flexion is 29.843%, on 10° ulnar is 17.002%, on 20° ulnar is 20.358%, on 30° ulnar is 23.197%, on 40° radial is 17.792%, on 20° radial is 23.280%, and on 30° radial is 25.793% as shown in figure 5.

The result shows that there is significant difference between wrist posture of 0° and 20° flexion, 0° and 30° flexion, 0° and 40° flexion, 10° flexion and 30° flexion, 10° flexion and 40° flexion, 20° flexion and 40° flexion, as well as 0° and 30° extension, 0° and 40° extension, 10° extension and 30° extension, 10° extension and 40° extension, 20° extension and 40° extension. On the other hand, there is significant

Figure 5. %MVC of Abductor Pollicis Brevis Muscle at different wrist postures; (1) Flexion and Extension, and (2) Ulnar and Radial
difference between wrist posture of 0˚ and 20˚ radial, 0˚ and 30˚ radial, 10˚ radial and 30˚ radial, as well as 0˚ and 20˚ ulnar, also 0˚ and 30˚ ulnar on Abductor Pollicis Brevis muscle.

The FDS muscle contraction on extension motion shows the significant difference at 20˚ angle increment (0˚ - 20˚) while in APB at 30˚ angle increment (0˚ - 30˚). The muscle contraction on 20˚ FDS extension is 16.224 %MVC, while in APB muscle of 30˚ extension is 21.725 %MVC. Since the %MVC value is still below 50-60 %MVC, it has not shown a major disturbance as muscle failure and blood circulation disruption [26] [13]. Based on the effort scale developed by [27], the %MVC value is still categorized as light to moderate effort. Thus, the extension wrist postures no greater than 30˚ is acceptable. On flexion motion, both FDS and APB muscle contraction show the significant difference on 20˚ of angle increment in flexion. The radial and ulnar posture on FDS muscle shows the significant difference on 10˚ angle increment for both radial and ulnar (0˚ - 10˚), and 20˚ angle increment on radial and ulnar for APB muscle (0˚ - 20˚). An adequate radial and ulnar maximum range is 20˚ since the %MVC value still in acceptable value. However, the sustained and prolonged muscle contraction will disclose the sign of muscle fatigue shown by the reduced conduction velocity of muscle fibres due to lack of energy source, and begins at 11%MVC [28]. Thus, the neutral posture is highly suggested to avoid muscle fatigue.

Some studies show that gender differences influence physical measurement, including body mass and height, blood pressure [29], and anthropometric size [30]. Based on the data obtained, the wrist muscle contraction on male tends to be greater than female had. However, the p value of non-parametric independent difference test shows no significant differences at between (FDS \( p = 0.221 \), APB \( p = 0.254 \)). Therefore, the threshold is possibly applied for both males and females.

4. Conclusion
Based on the experimental results, it is concluded that as the angle increment rises, there is an increase in wrist muscle contraction which leads to muscle fatigue. The suggested ergonomics wrist angle for typing is close to 0˚ as the neutral posture with considering the maximum range to avoid excessive muscle fatigue. The maximum range which needs to be avoided is no higher than 30˚ extension, 20˚ flexion, 20˚ ulnar, and 20˚ radial especially in prolonged use of computer.

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