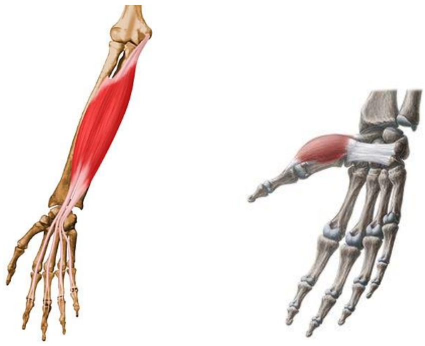
CHAPTER III

RESEARCH METHODOLOGY

3.1. Research Object

The object in this research is the wrist posture angle in flexion, extension, ulnar, and radial based on muscle contraction while doing typing activity. *Flexor Digitorum Superficialis* (FDS) and *Abductor Pollicis Brevis* (APB) are two muscles used as the variable which innervated by median nerve, the only nerve passes through carpal tunnel (Butler et al., 2005; Soewardi et al., 2005). FDS muscle are four out of nine tendons which pass through the carpal tunnel. The function is flexing the proximal interphalangeal joints of the four fingers as well as the metacarpophalangeal joints and wrist joint under continued action. Abductor Pollicis Brevis (APB) is a flat muscle located at the base of the thumb and has function to abduct the thumb and flex the metacarpophalangeal joint (Kim et al., 2009). Figure 3.1 illustrate the anatomy of *Flexor Digitorum Superficialis* and *Abductor Pollicis Brevis* muscle.



(1) (2)

Figure 3.1. (1) *Flexor Digitorum Superficialis*, and (2) *Abductor Pollicis Brevis*

3.2. Research Subject

The subject on this research consists of 14 university students (7 male, 7 female). The subject selection was based on demographic questionnaire criteria which described below:

1. Experienced in using computer or portable computer for minimum 6 months, which categorized as proficient in computer use (Kumar et al., 2013).
2. The median hours of computer and/or laptop use per week is 15 hours (Cook et al., 2004)
3. Subjects had no evidence of Carpal Tunnel Syndrome and neurological and musculoskeletal conditions on upper extremity based on physical examination and medical history (Roman-Liu & Bartuzi, 2013; Weiss et al., 1995).

3.3. Data Requirement

3.3.1. Primary Data

Primary data are data that obtained directly from the respondents which collected by the researcher. In this research, the primary data are obtained by having an experiment, to test whether the variables are effective or not, and to test the hypotheses that have been formulated. The data collection will be focused to the case-control design, where the respondents will conduct such activity with following the certain cases. Then, the data will be recorded by using Electromyography (EMG).

3.3.2. Secondary Data

Secondary data are data obtained by using the existing data, then the process of analysis will be performed and interpreted in accordance with the purpose of the study. The secondary data will be collected from indexed journals as well as textbooks.

3.4. Data Collection Method

In this research, the method used for collecting data is by distributing a demographic questionnaire, if the respondent meets the criteria, the respondent will be given a series of experiments in a standard adjusted workstation to perform typing activity. While doing the task, muscle activity is measured within a certain period and recorded using electromyography (EMG).

3.4.1. Research Apparatus

The research apparatus is the tools used to facilitate the data collection, processing and data analysis. The apparatus used in this study are as follows:

1. Data Collection Apparatus
    a. Personal computers
    Two sets of personal computers used for displaying typing task and display the EMG data.
    b. Lab Quest 2 and EMG Sensor (Vernier Software and Technology, USA)
    The EMG sensor will measure electrical signal produced during muscle contractions and the data will be collected with Lab Quest 2. This collecting data device will be connected to the personal computer which already installed with Logger Pro software to display the data.
    c. Pre-gelled electrode
    Silver/ Silver-chloride pre-gelled electrodes will be used in the experiment, which become the most often used surface electrodes for general use.
    d. Electrode Signal Gel
    A neurostimulation conductive gel to increase the moisture content and adhesion of the electrode pad.
    e. Alcohol pad
    Alcohol pad will be used at the beginning of electrode attachment procedure in order to clean and sterilize the skin area.
    f. Goniometer
    Goniometer were used to measure the wrist angle in flexion, extension, ulnar, and radial objectively.
    g. Marker
    The skin area will be marked by marker after it is measured with 2 cm distance.
    h. Angle determination tools (Keyboard slope)

Thin blocks and keyboard slope were used in order to set the slope of the keyboard to get the desired angle of the experiment.

i. 5 kg manual resistance tool

A manual resistance tool used for obtaining Maximum Voluntary Contraction value for both FDS and APB muscle.

2. Supporting Software

a. GS Typing Tutor version 2.96 (GrassSoftware)

The typing task in this study using GS Typing Tutor with typing test menu.

b. Microsoft Excel 2010 (Microsoft Office)

Questionnaire and EMG data recapitulation were recapped using Microsoft Excel as data processing software.

c. SPSS version 23 (IBM SPSS Software)

SPSS used to perform quantitative statistical analysis, in this study will be used for Kruskal-Wallis and Mann Whitney U test.

d. Logger Pro version 3.8.7 (Vernier Software and Technology, USA)

Logger Pro is a software to collect live-data, process, and read values graph based on the data recording.

3.4.2. Experiment Design

The wrist position which will be analyzed in the study are flexion, extension, radial, and ulnar, with 10 degree of increment. It is supported with the prior pilot study which shows the significant difference between 10 angles of increment compared with five angles of increment. The determined angles for extension are 40^o, 30^o, 20^o and 10^o, the determined angles for flexion are 40^o, 30^o, 20^o and 10^o, the determined angles for radial deviation are 30^o, 20^o and 10^o, and the determined angles for ulnar deviation are 40^o, 30^o, 20^o and 10^o, and 0^o for the natural posture. Flexion and extension measurement were 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 (Norkin & White, 2016). Figure 3.2 illustrates the angle determination between the experiments.

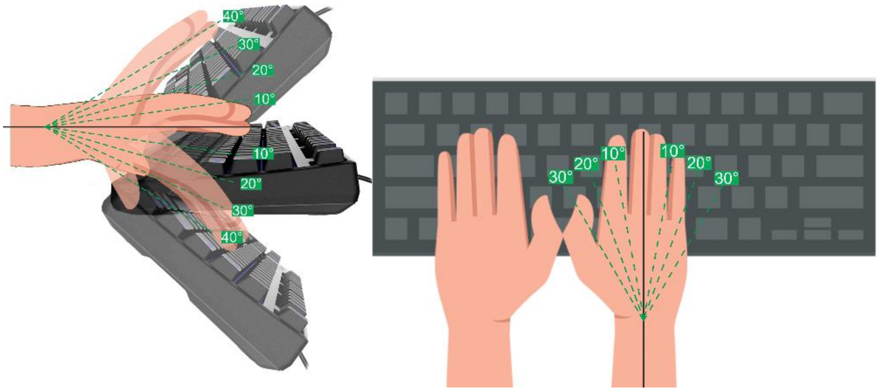


Figure 3.2. Experiment Angle Determination

The subject will perform the typing task given with typing software for 5 minutes (Rempel et al., 2008) for each angle, with the rest time of minimum two minutes for each experiment. The prior pilot study shows the significant difference in muscle activity for five minutes typing compared with one minute and three minutes typing (*p*: 0.021). The experiment environment was designed in standard workstation. The standard workstation was given with 500mm – 1000mm monitor distance range (HFES, 2001) and the upright position chair which gives horizontal thigh and vertical lower leg posture (Kroemer et al., 2001). Figure 3.3 illustrates the experiment layout.

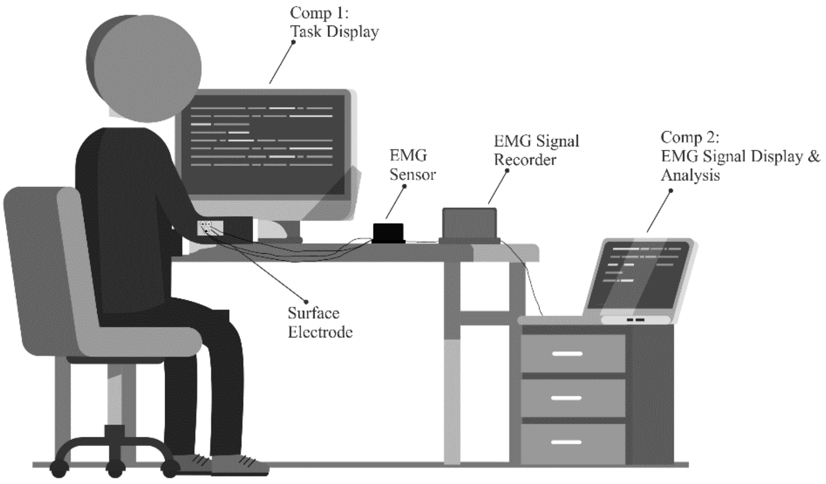


Figure 3.3. Experiment Layout

The subjects are needed to perform physical examination before doing the experiment in order to examine any Carpal Tunnel Syndrome indication from the subject. Phalen Test is one of the Carpal Tunnel Syndrome basic physical examination which has the sensitivity 85% and specificity of 89% compared with Hoffman-Tinnel Sign which has sensitivity and specificity of 67 and 68%, respectively (Bruske et al., 2002). The procedure of Phalen Test is by having the subject flex the hand and hold the dorsal side of both hands together and hold for one minute as the illustration on figure 3.4. At the end of the test, the subjects were asked whether they experience tingling in the thumb, index finger, middle finger, and the lateral half of the ring finger. The test is positive if the subject experience the tingling on the fingers mentioned above.

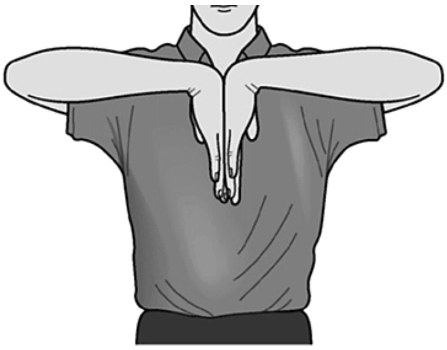
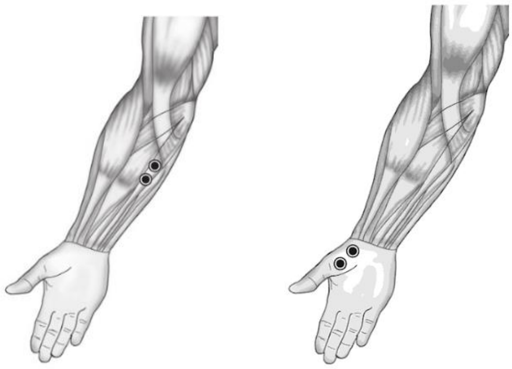


Figure 3.4. Phalen Test Illustration

The electrodes were attached in FDS and APB separately since the research apparatus is one-channel EMG. Since FDS originated from humeroulnar and radial head around lower arm, a study suggested to put two active electrodes which installed with a distance of 2 cm on the bulging muscle on lower arm near the elbow right after the subject move the muscle with fingers (Criswell, 2011). While the electrode attachment suggestion on APB is by attaching two electrodes at the center of the largest mound located below the thumb. Figure 3.5 shows the reference of electrode placement in both muscles. The procedures to attach the electrodes described in the following procedures (Konrad, 2005):

1. Clean the skin gently by rub the skin with 70% alcohol
2. Mark the skin at the point electrode will be attached with the distance of 2 cm between one electrode to another
3. Attach two electrodes parallel to the muscle fibers, and one reference electrode on nearby but unaffected area

4. Since the electrode to skin contacts need some time to reach an impedance condition, wait for three minutes before attach the cable to the electrode
5. Attach the cable to the electrode and connect the device



(1) (2)

Figure 3.5. Electrode Placement of (1) *Flexor Digitorum Superficialis*, and (2) *Abductor Pollicis Brevis*

The muscle activity signal will be recorded by using EMG 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 normalize the data. 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 (Konrad, 2005; Jepsen et al., 2009). The position on obtaining MVC shown in figure 3.6.

Figure 3.6. MVC Position

3.4.3. Experiment Task

The software used to display the typing task was GS Typing Tutor version 2.96 (GrassSoftware). The articles in the typing task represent the manuscript which usually read and typed by university students, which consists of subchapters in handbook, scientific articles, and journals. The study participants were asked to type the given manuscript by following the characters, capitals, and punctuations. The typing task will be stopped if the experiment time has run out. Figure 3.7 shows the typing task display in GS Typing Tutor.

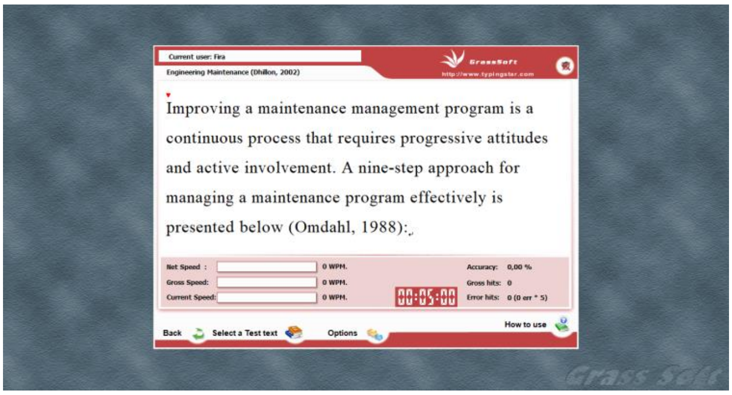


Figure 3.7. Typing Task Display

3.4.4. Experiment Procedures

The initial procedure is conducted to explain the purpose and objectives in this study as well as explain the information needed related with the experiments. Physical examination is performed in order to examine any Carpal Tunnel Syndrome indication from the subject by performing Phalen Test for one minute. Electrodes attached afterwards with following the procedures given at each muscle. Before the experiment begins, the subject asked to practice typing for five minutes in order to adjust the task. The data were collected for five minutes on each angle while the subject typing the manuscript given. The experiment will be repeated for another angle needed with the support of angle determination slope with resting time of two minutes each task. Goniometer was used in order to measure the certain angle inclination. In order to obtain the Maximum Voluntary Contraction, respondent needed to perform maximum movements that can be accomplished by *Flexor Digitorum Superficialis* and *Abductor Pollicis Brevis* muscles. After all procedures finished, the electrode will be detached.

3.5. Data Processing Method

Data processing done in this study is by observing the muscle activity that has been recorded by electromyography sensor. Logger Pro software provided the smoothed RMS signal which has been collected by filtering and rectifying process. The percentage of MVC being calculated to normalize the data and rescale it from microvolt to percentage (Konrad, 2005). The formula of calculating %MVC shown below (Bernard, 2012). The force unit is the data test, which will be divided by the MVC recorded at the end of the experiment.

$$\%MVC = 100\%\ x \frac{Force}{MVC} \tag{3.1}$$

3.6. Data Analysis Method

a. Kruskal-Wallis Assumption Test

The hypothesis used for the Kruskal-Wallis test in this study are:

1) *Flexor Digitorum Superficialis* muscle group data

H0 : There is no significant differences between experiment data on FDS muscle

H1 : There is a significant difference between experiment data on FDS muscle

2) *Abductor Pollicis Brevis* muscle group data

H0 : There is no significant differences between experiment data on APB muscle

H1 : There is a significant difference between experiment data on APB muscle

3) Work performance group data

H0 : There is no significant differences between WPM work performance

H1 : There is a significant difference between WPM work performance

The decision making is based on a hypothesis seen from the significance value. If significance value ≥ 0.05 then H0 is accepted which means that there is no significant difference. Otherwise, if the significance value is <0.05, H0 is rejected, which means that there is a significant difference between the test group data.

b. Mann Whitney U Test

The hypothesis used in the Mann Whitney test in this study are:

1) FDS muscle contraction on 0˚ neutral and 10˚ extension wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 10˚ extension

H1 : There is a significant difference between FDS muscle contraction on 0˚ neutral and 10˚ extension

2) FDS muscle contraction on 0˚ neutral and 20˚ extension wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 20˚ extension

H1 : There is a significant difference between FDS muscle contraction on 0˚ neutral and 20˚ extension

3) FDS muscle contraction on 0˚ neutral and 30˚ extension wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 30˚ extension

H1 : There is a significant difference between FDS muscle contraction on 0˚ neutral and 30˚ extension

4) FDS muscle contraction on 0˚ neutral and 40˚ extension wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 40˚ extension

H1 : There is a significant difference between FDS muscle contraction on 0˚ neutral and 40˚ extension

5) FDS muscle contraction on 0˚ neutral and 10˚ flexion wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 10˚ flexion

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 10˚ extension

6) FDS muscle contraction on 0˚ neutral and 20˚ flexion wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 20˚ flexion

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 20˚ extension

7) FDS muscle contraction on 0˚ neutral and 30˚ flexion wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 30˚ flexion

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 30˚ extension

8) FDS muscle contraction on 0˚ neutral and 40˚ flexion wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 40˚ flexion

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 40˚ extension

9) FDS muscle contraction on 0˚ neutral and 10˚ ulnar wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 10˚ ulnar

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 10˚ ulnar

10) FDS muscle contraction on 0˚ neutral and 20˚ ulnar wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 20˚ ulnar

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 20˚ ulnar

11) FDS muscle contraction on 0˚ neutral and 30˚ ulnar wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 30˚ ulnar

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 30˚ ulnar

12) FDS muscle contraction on 0˚ neutral and 10˚ radial wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 10˚ radial

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 10˚ radial

13) FDS muscle contraction on 0˚ neutral and 20˚ radial wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 20˚ radial

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 20˚ radial

14) FDS muscle contraction on 0˚ neutral and 30˚ radial wrist posture

H0 : There is no significant differences between FDS muscle contraction on 0˚ neutral and 30˚ radial

H1 : There is a flexion difference between FDS muscle contraction on 0˚ neutral and 30˚ radial

15) APB muscle contraction on 0˚ neutral and 10˚ extension wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 10˚ extension

H1 : There is a significant difference between APB muscle contraction on 0˚ neutral and 10˚ extension

16) APB muscle contraction on 0˚ neutral and 20˚ extension wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 20˚ extension

H1 : There is a significant difference between APB muscle contraction on 0˚ neutral and 20˚ extension

17) APB muscle contraction on 0˚ neutral and 30˚ extension wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 30˚ extension

H1 : There is a significant difference between APB muscle contraction on 0˚ neutral and 30˚ extension

18) APB muscle contraction on 0˚ neutral and 40˚ extension wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 40˚ extension

H1 : There is a significant difference between APB muscle contraction on 0˚ neutral and 40˚ extension

19) APB muscle contraction on 0˚ neutral and 10˚ flexion wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 10˚ flexion

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 10˚ extension

20) APB muscle contraction on 0˚ neutral and 20˚ flexion wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 20˚ flexion

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 20˚ extension

21) APB muscle contraction on 0˚ neutral and 30˚ flexion wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 30˚ flexion

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 30˚ extension

22) APB muscle contraction on 0˚ neutral and 40˚ flexion wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 40˚ flexion

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 40˚ extension

23) APB muscle contraction on 0˚ neutral and 10˚ ulnar wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 10˚ ulnar

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 10˚ ulnar

24) APB muscle contraction on 0˚ neutral and 20˚ ulnar wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 20˚ ulnar

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 20˚ ulnar

25) APB muscle contraction on 0˚ neutral and 30˚ ulnar wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 30˚ ulnar

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 30˚ ulnar

26) APB muscle contraction on 0˚ neutral and 10˚ radial wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 10˚ radial

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 10˚ radial

27) APB muscle contraction on 0˚ neutral and 20˚ radial wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 20˚ radial

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 20˚ radial

28) APB muscle contraction on 0˚ neutral and 30˚ radial wrist posture

H0 : There is no significant differences between APB muscle contraction on 0˚ neutral and 30˚ radial

H1 : There is a flexion difference between APB muscle contraction on 0˚ neutral and 30˚ radial

The decision making is based on a hypothesis seen from the significance value. If significance value ≥ 0.05 then H0 is accepted which means that there is no significant difference. Otherwise, if the significance value is <0.05, H0 is rejected, which means that there is a significant difference between the test group data.

3.7. Research Flowchart

Figure 3.8 below shows the research flowchart.

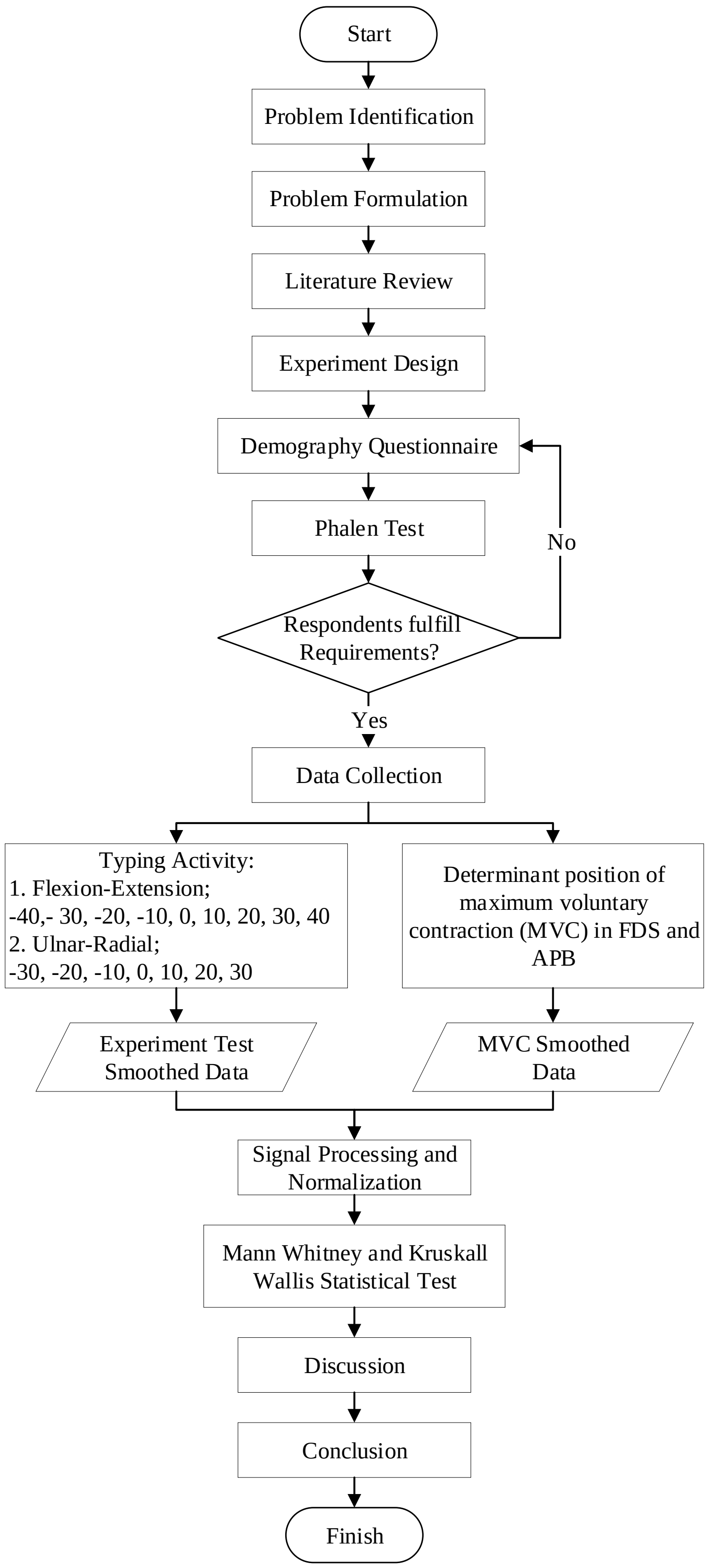


Figure 3.8. Research Flowchart

As seen in figure 3.8, the study is performed in several stages. The first one is identifying the existing problems. The increasing rate of personal computer usage, especially in typing activity, will produce inevitably excessive wrist posture deviation. A study shows that it has a correlation with the increasing risk of having Musculoskeletal Disorders. One of the most common MSDs in industries is Carpal Tunnel Syndrome (CTS). Literature study is done to obtain more information regarding the issues. Previous studies show that CTS could occur due to either excessive force, prolonged use, or non-neutral postures whether in flexion, extension, ulnar, and radial. It leads to determine the objectives of this study.

Designing the experiment is the next step in this study. Several benchmarks and pilot study were done in order to determine the angle increment in the experiment, duration of the experiment, as well as designing the experiment layout. A pilot study is carried out by identifying muscle activity contraction based on typing activity duration for one, three, and five minutes and the result shows the muscle activity in five minutes duration produce highest amplitude and muscle contraction. A study also conducted the similar experiments with the same duration (Rempel et al., 2011). Thus, the duration for one experiment is five minutes, with 2 minutes resting time in between. The total duration of the experiment is 120 minutes, while there will be two experiments because FDS muscle and APB muscle experiments will be conducted separately. The same pilot study also performed for 5 angle increments, 10 angle increments, 15 angle increments, and 20 angle increments to obtain the determined angle increment in the experiment. The result shows the higher muscle contraction as the angle increment getting further. However, five angles increment only shows very slight difference compared with other angle increment, and the wrist angle determination will potentially cause high deviation due to small angle difference. Thus, the study using 10 angles increment for the experiments.

The subject and object of the study also being determined. Demographic questionnaires were spread and physical examination (Phalen test) were done before the experiment in order to obtain the required study participants. There were fourteen healthy university students enrolled this study. The participants were asked to type the manuscript given while the muscle activity being recorded with EMG.

The raw EMG signal data were processed by Logger Pro software in order to obtain the smoothed signal. The experiment data of each angle will be normalized with MVC data of each subject to obtain %MVC data. This normalized data will be the input for the statistical analysis. A non-parametric statistical Kruskal Wallis test was performed to identify the difference between angle increments group data. This test was followed with Mann-Whitney U Test to compare differences between two data groups.

The result of both normalized EMG signal data and statistical test were discussed, and the researcher can make a conclusion based on the results as well as provide the recommendations needed for further research.