Factors in the comfort of a vertical mouse and the recommended for Indonesian user

L Iswara¹, D Prastitasari², A Nabil³, S B Perwira⁴ and T R Sahroni⁵*

Industrial Engineering Department, BINUS Graduate Program - Faculty of Engineering Bina Nusantara University, Jakarta, Indonesia 11480

Email: taufik@binus.edu

Abstract. In a traditional mouse, the design is usually made to position the arms and palms facing down so that the forearm muscles will be tenser, and posture or position is not ideal on the wrist which will be more at risk of disruption of the wrist nerve (median). The wrists carry out repetitive movements for long periods to type and hold the mouse which generally uses a combination of strength and repetition of movements of the fingers and hands over a long period. As a result of excessive use of these hands can be a trigger for the risk of Carpal Tunnel Syndrome (CTS). This syndrome occurs when the nerves in the wrist are squeezed or compressed, causing a condition that makes the fingers experience a tingling sensation, numbness, pain, or weakness. To avoid this problem, a vertical mouse is recommended to use. Vertical mouse factors include width, height, and button switch position. The aim of the research was to obtain information based on experiments of which factors most influence user convenience and the proposed design vertical mouse with a size suitable for Indonesian.

Keywords: comfort mouse, vertical mouse, Indonesia users

1. Introduction
The ergonomic mouse is specifically designed to minimize all forms of muscle tension and discomfort in the hands when using it. This typical mouse will fit the hand neutrally when being used.

People who work long hours on a computer oftentimes spend most of that time clutching an obedient mouse and other peripherals. Using a standard mouse, the slope of the palm and forearm against the horizontal is usually 0 degree or face down. By doing it daily with a standard flat mouse can cause wrist pain, and in the future, cause arthritis and nerve damage or Carpal Tunnel Syndrome (CTS). Use of a vertical mouse can be an alternative to minimize the potential symptoms of the syndrome [2].
The main advantages of using a vertical mouse are to keep the forearm and wrist position in a neutral position which can reduce muscle movement, keep the bottom of the wrist against the desk so that it can reduce pressure in that area, avoiding constant pressure on the median nerve which can cause symptoms of carpal tunnel syndrome (see Figure 1). With your hands in a shaking position, mouse operation is not with the wrist but with the forearm which will be very helpful for people with carpal tunnel syndrome or existing wrist strain.

A good vertical mouse not only helps prevent carpal tunnel syndrome, or certain hand muscle diseases but also can make people who already suffer from those diseases can still use a mouse without making their condition worse.

In the research, a design of experiment (DOE) method will be tested to obtain information on what factors are the main influence for the comfort of using a vertical mouse. An anthropometric data comparisons will also be performed to calculate the right size of the vertical mouse for Indonesian.

2. Methods
Design of experiment is a systematic method used to determine the relationship between factors that influence a process and the output of the process. In other words, it is used to find a causal relationship. With this information, the input process can be managed in such a way as to produce optimal output [7].

The design of experiment in the research is used to determine the impact of the factors of the mouse that most influence user comfort as an output response. It uses a two-level factorial design from three factors, those are the width of a mouse, the high of a mouse, and the button switch position of the mouse. Low- and high-level related factors are listed in Table 1.

Three factors tested with each of the two value levels produce eight combinations of models tested. The test is conducted by four people who rate the comfort level of each model, where the test is carried out using a mouse model of Styrofoam material. The results of experiments are in the form of ANOVA table that can tell the F-test value as a basis for the conclusion which factors have the most significant effect on the output response.

| Table 1. Mouse Factor and Associated Level |
|-------------------------------------------|
| Factor | Name     | Units | Low Level | High Level |
|--------|----------|-------|-----------|------------|
| A      | Width    | cm    | P5 = 16.3 | P50 = 17.5 |
| B      | Height   | cm    | P5 = 7.4  | P50 = 8.1  |
| C      | Button Position | position | front | side       |

Figure 1. Carpal Tunnel System (source: my.clevelandclinic.org)
Factor A (height) and factor B (width) use 2 levels based on anthropometric data of hand breadth and hand length with P5 (5\textsuperscript{th} percentiles) as low level and P50 (50\textsuperscript{th} percentiles) as high level.

The determination of the mouse size that is suitable for Indonesian adults will be done by calculating the proportionality between the size of the mouse with anthropometric data. Anthropometry is a systematic measurement of human body that can be used as tool that are useful for example for determining fit size and pressure power of computer input device. The shape and optimal size of an input computer device, such as mice, are most likely suitable and are comfortable in proportion to a person's stature. For example, mouse length and mouse height can be determined from the length and width of the person's hand. The place of the mouse buttons can be determined using the data of index finger length [6]. The normal distribution curve is generated based on the means and standard deviations of existing anthropometric data (Figure 2).

![Figure 2. Hands Length Anthropometric Data](image)

From the anthropometric data curve (Figure 2), it is found that the size of Indonesian hands can be grouped the same or not with the size of American hands. In addition, by looking at how large the hand size of Indonesian is tumbled inside the percentile of 5\textsuperscript{th} to 95\textsuperscript{th} of American hand size.

3. Result
Eight From the design of experiments method with three factors (A,B,C) and two levels in testing the factors that affect the comfort of the mouse can be detailed into eight test combinations and resulting responses as listed in Table 2.

| A  | B  | C  | R1 | R2 | R3 | R4 |
|----|----|----|----|----|----|----|
| -1 | -1 | -1 | 68 | 78 | 75 | 74 |
| 1  | -1 | -1 | 78 | 91 | 85 | 78 |
| -1 | 1  | -1 | 81 | 81 | 90 | 98 |
| 1  | 1  | -1 | 98 | 93 | 89 | 93 |
| -1 | 1  | 1  | 90 | 89 | 86 | 90 |
| 1  | 1  | 1  | 85 | 83 | 81 | 88 |
| -1 | 1  | 1  | 90 | 85 | 83 | 90 |
| 1  | 1  | 1  | 85 | 88 | 95 | 97 |
Based on the response data, it is processed using the ANOVA table without interaction factors observed, the following F-stat information is generated as listed in Table 3.

| Factor | SS     | df | MS         | F          | p-value     |
|--------|--------|----|------------|------------|-------------|
| A      | 108.7813 | 1  | 108.7813   | 3.154304   | 0.086596766 |
| B      | 427.7813 | 1  | 427.7813   | 12.40427   | 0.001489    |
| C      | 94.53125 | 1  | 94.53125   | 2.7411     | 0.108964342 |
| Err    | 965.625  | 28 | 34.48661   |            |             |
| Tot    | 1596.719 | 31 | 51.50706   |            |             |

The actual value of F for factor B is the highest, it is possible to conclude that factor B (height of the mouse) has a significant effect on the comfort of the mouse.

As shown in Figure 2, the mean data from the length of the Indonesian hand is out of range (P5 to P95) of the American anthropometric data, so it can be concluded that the size of Indonesian hands cannot be grouped the same as Americans.

Based on data anthropometric (Indonesian anthropometric data [10] and American anthropometric data [9]) and know size of the mouse that many in the American market, with proportional calculation can determine the vertical mouse size that matches the hands of Indonesians, as presented in Table 4.

| Length(cm) | Breadth(cm) | Length(cm) | Breadth(cm) |
|------------|-------------|------------|-------------|
| P95        | 21.06       | 18.9       | 8.8         |
| P50        | 19.33       | 17.6       | 8.1         |
| P5         | 17.87       | 16.3       | 7.4         |

Figure 3. Styrofoam Model Mouse
3.1. **Mouse length**

Work assumptions for length of mouse, refer to the standard length of mouse commercially available in USA are 9.9 cm that is based on the size accommodating 50th percentile males’ hands. So this can be concluded that mouse length should be 51% of hand length. From that proportional calculations, it can be recommended that a vertical mouse length for Indonesian refer to it is anthropometric P50 (50th percentile) is 9.0 cm.

3.2. **Mouse height**

Work assumptions for height of mouse, refer to the standard height of mouse commercially available in USA are 14.8 cm that is based on the size accommodating 50th percentile males’ hands. In addition, it can be concluded that mouse height should be 164% of hand breadth. By that proportional calculation, it can be recommended that a vertical mouse height for Indonesian refers to anthropometric P50 (50th percentile) is 13.2 cm, as shown in Figure 4.

![Figure 4. Comparison Chart of Mouse Size](image)

Based on the data that have been obtained than the design of the vertical mouse, it is recommended the design concept as shown in Figure 5.

![Figure 5. Front and Side Views](image)
4. Discussion
In further studies, other factors that can influence the comfort level such as the degree of the mouse slope and the number of activation forces on the mouse button can be tested. The slope of the mouse can determine comfort in the position of the forearm and wrist. The quantity of activation force on the mouse button produced is affected by the finger mass. Where according to ANSI and ISO recommends activation force on a computer input device is 0.5N to 1.5N [8].

Based on existing Indonesian anthropometric data, study appropriate mouse design for several age groups namely male or female adults, children age 14 to 11 years, children aged 6-10 years, and the smallest users under 6 years can be carried out to produce recommendations for the length, width, height, place of the buttons and the activation forces on the mouse for each group. Furthermore, the users met positive relation to the comfortable aspect while using the proposed design.

5. Conclusion
To find out the factors that affect the comfort of using a vertical mouse that is done by the design of experiment method for three factors and two level object tests which is then analyzed using the ANOVA table. Where from the results of experiments using four respondents for several combinations of factor levels obtained that the height factor of the mouse is the most influential on the comfort of the mouse.

The recommended mouse size for adults in Indonesia is produced using a proportional approach of size of the mouse on the market to anthropometric data. Here used as a reference is proportional data in the USA. And referring to the anthropometric data of Indonesian hands, it is concluded that the size of mouse for Indonesians is smaller than size of the mouse used by Americans.

References
[1] Tayyari F, Joseph T. Emanuel. 1993. Carpal tunnel syndrome: An ergonomic approach to it’s prevention.
[2] Keir P J, Bach J M, Remple D.. 1999. Effect of computer mouse design and task on carpal tunnel pressure.
[3] Gaudez C and Cail F. 2017. What’s the best computer mouse? A comparative study of wrist angles and carp extensor activity when using three mice.
[4] Jonsson P. 2009. Wrist and thumb joint postures and motions measurement using electrogoniosmetry and EMG.
[5] Li Z, Miao F, Yang Z, Chai P and Yang S. 2019. Factors affecting human hand grasp type in tomato fruit-picking: a statistical investigation for ergonomic development of harvesting robot. Comput. Electron. Agr. 157 90–97.
[6] Hughesa E F and ohnsona P W 2012 Children computer mouse use and anthropometry work 41 846-850.
[7] Sundararaja K, Design of Experiment – A Primer (isixsigma.com).
[8] Hwang S and Johnson P W.Computer input devices — race and gender: Is there a mismatch between anthropometry and input device design In: Proceedings of the Human Factors and Ergonomics Society 54th Annual Meeting (2010): 1130-1133.
[9] Gordon C C et al 1988 Anthropometric Survey of U.S. Personnel: Summary Statistics Interim Report. March 1989.
[10] Nurmianto E. Data Antropometri Orang Indonesia.