Ergonomics in Design, Vol. 47, 2022, 531–538
https://doi.org/10.54941/ahfe1001980

An Analysis on the Effects of Different Types of Keyboards on Users' Productivity and Hand Muscle Strain

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ABSTRACT

Musculoskeletal disorder (MSD) complaints are increasing as people are forced to do their daily tasks at home using computers, as evident with the limitations brought by the COVID-19 pandemic. The purpose of this study was to provide a comparative analysis on the efficacy of different types of keyboards in terms of typing speed, accuracy, and prevention of wrist/hand fatigue among keyboard operators to assist them in increasing work productivity and minimizing the risk of Carpal Tunnel Syndrome (CTS) or other hand injuries. To assess the pain level, typing speed, and accuracy, the participants were subjected to a 5-minute keyboard typing activity to test 4 different keyboards: standard, mechanical, foldable, and laptop. Through the Kruskal-Wallis H-Test, it has been found that mechanical keyboards are the optimal choice for all students and typing-related workers to increase their typing speed and accuracy and alleviate wrist/hand-related pain. Other than using a mechanical keyboard in the virtual workplace, it is also recommended that the users' hands move freely and be elevated above the wrist rest while typing to enhance the wrist's mobility.

Keywords: Keyboard design, Mechanical keyboard, Productivity, Ergonomics

INTRODUCTION

Carpal tunnel syndrome (CTS) is one of the most reported work-related musculoskeletal disorders due to posture-based issues and work-related factors (Necio et al. 2019; Shults et al 2020). Long hours of computer use give a higher risk of the upper extremity symptoms of work-related musculoskeletal disorders, evident with its high incident rates (Loh et al. 2018). Due to the prolonged computer use and working without breaks, young office workers have a relatively high prevalence of work-related wrist and hand issues, including clinically proven CTS (Feng et al. 2021). In addition, repetitive movements in keyboard typing harm people's wrist and hands due to the excessive pressure on the nerves (Wheeler, 2019). Thus, (De Putter et al. 2012) mentioned that hand and wrist related injuries are one of the most expensive injuries, constituting an average of US$740 million annually. Likewise, economic, and social pressures brought by musculoskeletal disorders among working-age population are immense that employers spend at least US$103,000 for every 100 employees annually. In the United States alone, 29% of the recorded injuries resulting from days of work attributed to work-related musculoskeletal disorders (Daneshmandi et al. 2017).

Keyboard design has shown to influence wrist and hand postures that affects median nerve deformation (Yeap et al. 2017). The abnormal flexion-extension posture of the wrist joint, repetitive movements throughout the day, and use of vibratory items were tagged as potential causes for the development of CTS (Bibi & Khan, 2019). Also, keyboard key spacing suggests comfortability and productivity based on the International Organization for Standardization (ISO). According to (Pereira et al. 2013), the optimal keyboard key spacing length lies between 17mm to 19mm, and touch typing may be a challenge for keyboard with key sizes less than 16 mm (Kim et al. 2014).

This paper investigates the effects of different keyboards on users' productivity and hand muscle strain. Specifically, this study identifies which keyboard produces most words with fewer typographical errors in each time frame and which keyboard has the slightest wrist and finger discomfort when typing. The results of this study will benefit the working people considering that office workers that use computers constitute a good percentage of Philippine labor (Philippine Statistics Authority, 2020). Moreover, the findings are expected to improve the keyboard design, which will enhance the task efficiencies of people and prevent the possibility of injuries.

METHODS

The researchers have collected the necessary data through actual data gathering from invited participants; however, due to the COVID-19 restrictions imposed in Metropolitan Manila, Philippines, only sixty-four participants have voluntarily participated in this study. The participants were provided with keyboards and asked to navigate the website application in the test conducted. The application includes a five-minute fixed timer and immediately starts when a person presses any key. With the test provided by the researchers, the test subjects were asked to type a random text as fast as possible without stopping for the allotted five minutes. After the typing test, the participants are required to answer a pain level questionnaire using a Likert scale from 1 (no pain) to 5 (worst possible pain). Moreover, typing speed and accuracy results were automatically shown on the application. Most employers solely recognize certification results from a 5-minute typing test (Meshulam, 2019).

During the data gathering, the participants were provided time to practice the touch-typing method, as all participants do not have a background of typing-related jobs or experiencing musculoskeletal disorders symptoms on their hands, wrists and shoulders (see Figure 1). The manual typing test was performed using a computer and a stopwatch; thus, a typing test application was utilized in the study. Furthermore, this paper used the pain scale to determine the pain level experienced by participants. It is a tool that physicians use to determine a patient's level of discomfort as it can be used during a hospital stay, a doctor's visit, physical activity, or post-surgery (Weatherspoon, 2018).

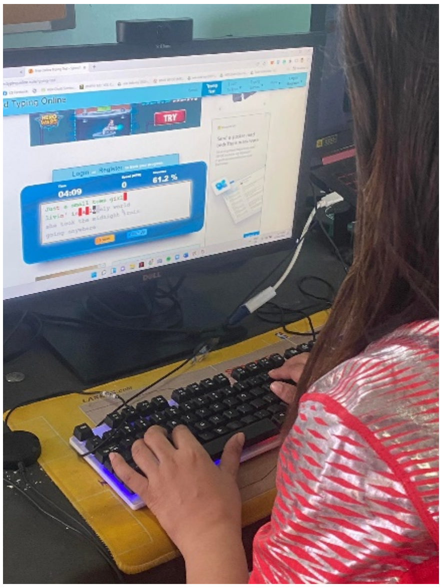

Figure 1: Picture of one participant doing the 5-minute typing test.

Table 1. Variables used in the study.

Types of tests	Independent Variable	Dependent Variables	Measurement Unit	Measurement Instrument
Pain Level	Type of Keyboard	Wrist/hand pain level	5-Point Likert Scale	Typing test application
Typing Speed	Type of Keyboard	Typing Speed	Words Per Minute (WPM)	Typing test application
Accuracy	Type of Keyboard	Typing Accuracy	Percentage of Accuracy (%)	Typing test application

The independent variable used is thept different keyboards commonly used in the Philippines. The dependent variables are pain level (ordinal), typing speed (continuous), and accuracy (continuous) (see Table 1). The researchers used a comparative research design to observe the impact caused by the independent variable on the dependent variables. Since the factors involved were continuous and ordinal, the Kruskal-Wallis H test was used. Kruskal-Wallis H test (also known as the one-way ANOVA on ranks) is a nonparametric rank-based test used to discover statistically significant differences among groups of independent variables comprised of continuous and ordinal dependent variables [Lund, 2020]. As the test was done using one-way ANOVA, the parametric analyses for 2 to 9 groups were done by each group containing more than 15 [Minitab, 2019]. In the experiment, four groups had four types of keyboards, each composed of 16 participants. Before starting the data gathering, all Kruskal-Wallis H test assumptions were met and further interpreted and analyzed using the SPSS 23 statistical software.

Table 2. Descriptive statistics of the study (N = 64).

Variable	N	Minimum	Maximum	Mean	Standard Deviation
Pain Level	64	1	5	2.83	1.432
Typing Speed	64	28.00	75.00	44.9688	11.66458
Typing Accuracy	64	91.00	99.00	96.0938	1.87480

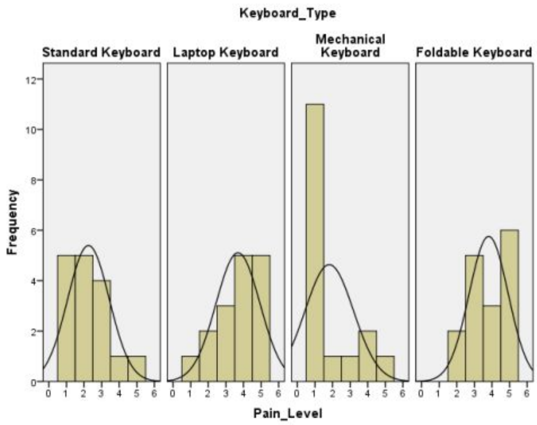

Figure 2: Histogram of pain level test.

RESULTS

The descriptive statistics shown in Table 2 show that the overall pain level mean is 2.83 with a standard deviation of 1.432. The overall typing speed mean is 44.9688, with a standard deviation of 11.66458. Lastly, the overall typing accuracy mean is 96.0938, with a standard deviation of 1.87480. The 64 respondents are grouped based on the 4 keyboard types (1 = Standard Keyboard, 2 = Laptop Keyboard, 3 = Mechanical Keyboard, 4 = Foldable Keyboard).

Based on Figure 2, the histogram of the pain level test showed the shape of distribution scores from all the keyboard types. Based on the normal curves presented, the forms are not similar across all the groups. With this, the Kruskal Wallis H-test cannot compare the median of the keyboard types; thus, the mean ranks will be compared.

Figure 3 presents the histogram of typing speed test and typing accuracy test, and it showed the distribution scores shape from all the keyboard types considered. The shapes are not similar for all the groups from the normal curves. Therefore, the Kruskal Wallis H-test cannot compare the median of the keyboard types, which is the same as above, the mean ranks will be compared.

Table 3 summarizes the hypotheses tests performed by the researchers, the test used its significance value, and the decision based on the results. In determining for the hypotheses to be concluded, the significance values (p-values) will be utilized (Kurata & Matias, 2018; Kurata et al., 2015). Based on the results, the typing speed test (p-value = 0.000), typing speed

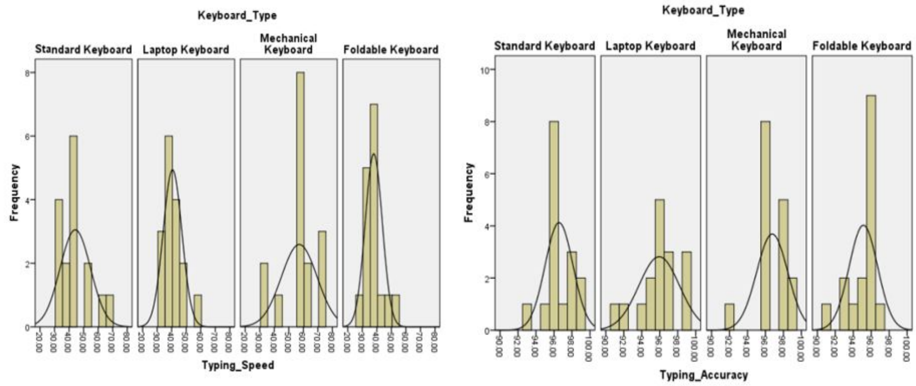

Figure 3: Histogram of typing speeding test and typing accuracy test.

Table 3. Hypotheses test summary.

Null Hypothesis	Test	Significance Value	Decision
The mean ranks of the groups in the Pain level Test are the same.	Independent Samples Kruskal Wallis-H test	0.000	Reject the null hypothesis
The mean ranks of the Pain Typing Speed Test groups are the same.	Independent Samples Kruskal Wallis-H test	0.000	Reject the null hypothesis
The mean ranks of the groups in the Typing Accuracy Test are the same.	Independent Samples Kruskal Wallis-H test	0.037	Reject the null hypothesis

test (p-value = 0.000), and the typing accuracy test (p-value = 0.037) all are less than the alpha level of 0.05. Thus, it is concluded that the mean ranks of the groups across the pain level test, typing speed test, and typing accuracy-test differ from one another.

The mean rank of the types of tests done to the keyboard types used is summarized in Table 4. It is evident on the results that the lowest mean rank in the pain level is the mechanical keyboard (mean rank = 19.47), followed by the standard keyboard (mean rank = 25.19), foldable keyboard (mean rank = 41.91), and laptop keyboard (mean rank = 43.44) as the highest. It determines that the participants experience the slightest pain level in using the mechanical keyboard.

Second, typing speed has been measured by the researchers. The mechanical keyboard garnered the highest mean rank with a value of 48.81, followed by the laptop keyboard, standard keyboard, and foldable keyboard with mean rank values of 31.63, 27.66, and 21.91, respectively. Hence, it is found out that most Filipinos can type faster using mechanical keyboards rather than other options available. Finally, the highest mean rank is

Table 4. Kruskal wallis H-test mean ranks for different keyboard type groups from pain level test, typing speed test, and typing accuracy test.

Type of Test	Keyboard Type	Mean Rank
Pain Level	Standard Keyboard	25.19
	Laptop Keyboard	43.44
	Mechanical Keyboard	19.47
	Foldable Keyboard	41.91
Typing Speed	Standard Keyboard	27.66
	Laptop Keyboard	31.63
	Mechanical Keyboard	48.81
	Foldable Keyboard	21.91
Typing Accuracy	Standard Keyboard	36.47
	Laptop Keyboard	31.81
	Mechanical Keyboard	39.31
	Foldable Keyboard	22.41

Figure 4: Proper hand and body posture while typing (Adapted from Muller, 2020).

the most optimal among the keyboards in determining the ideal typing accuracy. From the results, the mechanical keyboard garnered the highest mean rank (value = 39.31), followed by standard keyboard (value = 36.47), laptop keyboard (value = 31.81), and foldable keyboard (value = 22.41). Overall, it has been found that the mechanical keyboard is the optimum keyboard across the three criteria considered in the study.

CONCLUSION

This paper investigates the effects of different keyboards on users' productivity and hand muscle strain. Specifically, this study identifies which keyboard produces most words with fewer typographical errors in each time frame and which keyboard has the slightest wrist and finger discomfort when typing. Based on the results, the mechanical keyboard type is the most preferable among the four types of keyboards available and based on the criteria used (pain level, typing speed, and typing accuracy). This type of keyboard may pose an excellent substitute for the available ergonomic keyboards in the market based on the criteria considered.

Along with considering the use of the mechanical keyboard, the researchers also recommend that the hand and body postures be improved while users are using a computer keyboard. [Muller, 2020] highlighted the measurements that computer users must apply while working (see Figure 4). In addition, users' hand should move freely and be elevated above the wrist rest while typing to enhance the wrist's mobility. Frequent short breaks also help the users relax their hands and reduce the risk of having wrist injuries [Health and Safety Executive 2018]. Finally, it is advisable that one avoid resting their wrists on the desk, as this puts strain on an individual's tendons and reduces blood flow.

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