The Effects of Touch Screen Virtual Keyboard Key Sizes on Typing Performance, Typing Biomechanics and Muscle Activity

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Abstract. The goal of the present study was to determine whether different touch screen virtual keyboard key sizes affected typing productivity, typing forces, and muscle activity. In a repeated-measures laboratory experiment with 21 subjects, typing speed, accuracy, muscle activity, and typing forces were measured and compared between four different key sizes: 13x13, 16x16, 19x19, and 22x22 mm. The results showed that 13 mm keyboard had a 15% slower typing speed ($p < 0.0001$) and slightly higher static (10th %tile) shoulder muscle activity (2%, $p = 0.01$) as compared to the other keyboards with larger keys. The slower typing speed and slightly higher shoulder muscle activity indicated that 13 mm keyboard may be less optimal for touch typing compared to the larger key sizes.

Keywords: Virtual interface, typing forces, electromyography, typing speed, accuracy.

1 Introduction

As smart phones and tablet PCs have become increasingly prevalent, the touchscreen virtual keyboard has become a mainstream interface. From an ergonomics standpoint, touch screen virtual keyboards have a potential advantage in that key size and spacing between keys could be controlled by the device software and adjusted according to users' anthropometry. However, as tablet PCs gravitate towards smaller sizes for better portability, the key sizes on a virtual keyboard are often forced to be smaller than the existing standards for keyboard design [1-2].

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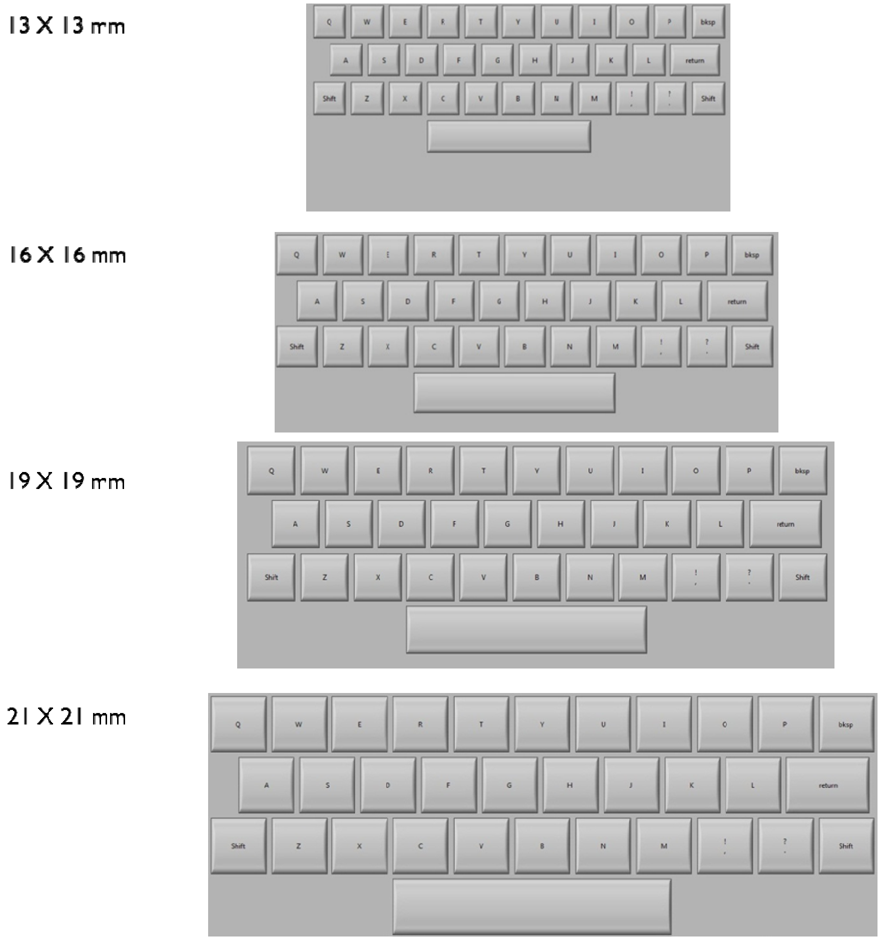

Fig. 1. Four different key sizes tested in the study

Virtual keyboard key sizes may affect typing performance and alter physical risk factors associated with computer-related musculoskeletal disorders (MSDs). Accordingly, an inappropriate key size may adversely affect typing productivity and cause awkward finger and/or wrist postures which can increase typing forces and/or muscle activity, which are well-known risk factors for MSDs [3-4]. Unfortunately, despite a few existing guidelines [1-2], no consistent recommendations for key sizes on touch screen virtual keyboards are available [5]. Therefore, it is important to understand how virtual keyboard key size may affect typing performance and physical exposures.

2 Methods

2.1 Subjects

A total of 21 subjects (12 male and 9 female) with an average age of 24.5 years (range 18-49 years) were recruited to participate in the study through e-mail solicitations. All subjects were experienced touch typists with no history of upper extremity musculoskeletal disorders and 19 subjects were right hand dominant. The experimental protocol was approved by the University's Human Subjects Committee and all subjects gave their written consent prior to their participation in the study.

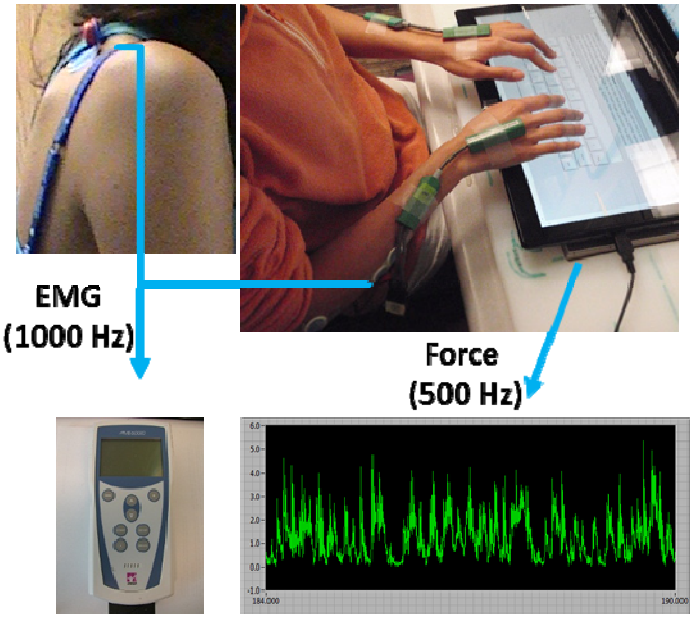

Fig. 2. Study set up

2.2 Experimental Design

In the repeated-measures laboratory experiment, subjects typed for two five-minute sessions on a touch screen virtual keyboard with the four following key sizes (shown in Fig. 1): 13×13 mm, 16×16 mm, 19×19 mm, and 22×22 mm (Width × Height mm). The gutter size surrounding the keys was kept at fixed size of 2.0 mm. The presentation of the key sizes was randomized to minimize potential confounding effects with order. During the typing sessions, typing productivity including typing speed (words per minute) and accuracy (% key correctly typed) were recorded. Using Electromyography (EMG), muscle activity was also recorded from the right extensor digitorum communis (EDC), flexor digitorum superficialis (FDS), and the right trapezius (TRAP) at a sample rate of 1000 Hz (Fig. 2). Lastly, typing forces were measured at 500 Hz by placing the devices on a 36 cm x 18 cm x 0.64 cm force platform mounted to a six-degree of freedom force/torque load cell (Mini40E, ATI Inc., USA).

2.3 Data Analysis

Statistical analysis was conducted in JMP (Version 9; SAS Institute Inc., USA). A *mixed model* with *restricted maximum likelihood estimation* (REML) was used to determine whether there were any differences in typing performance, typing force, and muscle activity between the different key sizes. Any statistical significance was followed by the *Tukey-Kramer* method to determine whether there were differences between the key sizes tested. All data are presented as mean and standard error; and significance was noted when Type I error was less than 0.10 or 0.05.

3 Results

3.1 Typing Performance

As shown in Table 1, net typing speed on 13 mm virtual keyboard (23.3 ± 1.0 WPM) was approximately 15% slower than the other virtual keyboards ($p < 0.0001$) while accuracy on 13 mm virtual key-board (92.3 ± 1.0 %) was 4.5% higher than the other virtual keyboards ($p = 0.004$).

3.2 Typing Forces

Due to technical difficulties, typing forces were calculated from 20 subjects (Table 1). The result showed that key sizes did not affect mean and peak typing forces; however, mean typing forces on 13 mm keyboard were slightly higher than the other keyboards ($p = 0.13$).

3.3 Muscle Activity

Due to technical difficulties, muscle activity data were recorded from 19 subjects. Static (10th %tile), median (50th %tile), and peak (90th %tile) muscle activity were compared between the different key sizes (Table 1). The results indicated that virtual key size had little effect on EDC and FDS muscle activity whereas static (10th %tile) TRAP muscle activity on 13 mm virtual keyboard was 2.5% higher as compared to 19 and 22 mm virtual keyboards ($p = 0.06$ and 0.06, respectively).

Table 1. Mean (SE) typing performance [n=21], typing forces [n=20], and muscle activity [n=19]. Rows with different superscripts indicate key sizes which are significantly different

			Keyboard				
			13 mm	16 mm	19 mm	22 mm	p-value
Performance	Typing speed (WPM)		23.3 (1.0)[a]	27.0 (1.0)[b]	27.0 (1.0)[b]	27.5 (1.0)[b]	< 0.0001
	Accuracy (%)		92.3 (1.0)[a]	90.3 (1.0)[b]	88.7 (1.0)[b]	88.9 (1.0)[b]	0.004
Typing force (N)	Mean		1.06 (0.06)	0.97 (0.06)	0.96 (0.06)	0.97 (0.06)	0.13
	Peak		2.12 (0.13)	2.11 (0.13)	2.18 (0.13)	2.20 (0.13)	0.69
Muscle activity (%MVC)	EDC	10th %tile	6.9 (0.5)	6.6 (0.5)	6.6 (0.5)	6.5 (0.5)	0.26
		50th %tile	11.0 (0.9)	11.0 (0.9)	11.0 (0.9)	10.9 (0.9)	0.99
		90th %tile	18.8 (2.4)	19.0 (2.2)	19.2 (2.2)	19.1 (2.1)	0.81
	FDS	10th %tile	2.3 (0.3)	2.2 (0.2)	2.3 (0.3)	2.3 (0.3)	0.57
		50th %tile	4.0 (0.4)	3.8 (0.3)	4.0 (0.4)	4.1 (0.5)	0.71
		90th %tile	13.4 (1.7)	13.7 (1.6)	15.3 (2.2)	14.9 (2.1)	0.19
	TRAP	10th %tile	12.6 (2.5)[a]	11.3 (2.2)[a,b]	9.9 (2.0)[b]	10.3 (2.1)[b]	0.01
		50th %tile	16.7 (3.2)	15.7 (2.9)	14.7 (2.6)	14.4 (2.8)	0.06
		90th %tile	21.9 (4.0)	21.6 (3.7)	21.1 (3.5)	19.7 (3.7)	0.16

4 Conclusion

The present study was conducted to determine whether different key sizes on a touch screen virtual keyboard affected typing productivity, typing biomechanics and muscle activity. The study findings suggested that 13 mm keyboard may be less optimal fir touch typing compared to the larger key sizes given slower typing speed and higher shoulder muscle activity. The slower typing speed with the 13 mm keyboard was somewhat counterbalanced with an increase in typing accuracy indicating there may be a speed and accuracy tradeoff starting somewhere around a virtual key size of 13 to 16 mm.

This study found that 13 mm keyboard had a slower typing speed as compared to the larger key sizes whereas there were no differences between the other keyboards. This finding was in-line with a previous study [6], which showed significant decrease in typing speed when key sizes of a conventional physical keyboard are smaller than 16 mm. Insufficient clearance between fingers due to smaller key sizes may have resulted in the decreased typing speed.

The results also found that static (10th %tile) shoulder muscle activity was slightly higher on 13 mm keyboard compared to the other larger key sizes. The smaller key sizes may have increased visual demand to locate keys on the virtual keyboard and consequently, resulted in higher shoulder muscle activity.

To sum up, the slower typing speed and slightly higher shoulder muscle activity indicated that 13 mm key size for virtual keyboard interface may be less preferable for touch typing compared to the larger key sizes.

References

1. ANSI/HFES 100-2007, Human Factors Engineering of Computer Workstations. Human Factors and Ergonomics Society. Santa Monica, CA, USA (2007)
2. ISO/TS 9241-411, Ergonomics of human-system interaction - Part 411: Evaluation methods for the design of physical input devices. International Organization for Standardization, Geneva, Switzerland (2012)
3. Armstrong, T.J., Foulke, J.A., Martin, B.J., Gerson, J., Rempel, D.M.: Investigation of applied forces in alphanumeric keyboard work. American Industrial Hygiene Association Journal 55(1), 30–35 (1994)
4. Rempel, D., Serina, E., Klinenberg, E., Martin, B.J., Armstrong, T.J., Foulke, J.A., et al.: The effect of keyboard keyswitch make force on applied force and finger flexor muscle activity. Ergonomics 40(8), 800–808 (1997)
5. Sesto, M.E., Irwin, C.B., Chen, K.B., Chourasia, A.O., Wiegmann, D.A.: Effect of Touch Screen Button Size and Spacing on Touch Characteristics of Users With and Without Disabilities. Human Factors 54(3), 425–436 (2012)
6. Yoshitake, R.: Relationship between key space and user performance on reduced keyboards. Applied Human Sciences 14(6), 287–292 (1995)