

# Relationship between Information and Communication Device Usage and Development of Hand Disorders

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## Abstract

This study examined the association between hand disorders and time spent using information and communication devices. The participants in this study, conducted between January 2017 and 2020, were 150 healthy university students. They were tested for carpal tunnel syndrome and De Quervain's tenosynovitis. Average daily device usage time was found to be  $5.76 \pm 3.00$  (1.9-16.2)h. Smartphones were used the most, followed by personal computers and gaming consoles. However, usage time did not vary significantly by device type. Intensive users were significantly more likely to have De Quervain's tenosynovitis ( $P < .001$ ), while non-intensive users were significantly less likely to have hand disorders ( $P < .001$ ) and less likely to have De Quervain's tenosynovitis. These results can form the basis of guidelines for the prevention of information and communication device overuse.

## Keywords

information and communications technology (ICT), hand disorders, De Quervain's disease, Eichhoff's test, receiver operating characteristic (ROC) curve

### What do we already know about this topic?

Excessive use of electronic devices is harmful to health.

### How does your research contribute to the field?

The results can aid in the development of relevant guidelines to prevent overuse of electronic devices.

### What are your research's implications toward theory, practice, or policy?

The results can contribute to preventive medicine.

## Introduction

In 2019, Japan's Ministry of Internal Affairs and Communications reported that with the proliferation of information and communications technology (ICT), ownership of ICT devices is increasing annually. The ministry defines 3 ICT device types: (1) ICT equipment, which includes personal computers (PCs), projectors, and digital cameras; (2) gaming hardware; and (3) telecommunications equipment, such as smartphones.<sup>1</sup>

According to the International Telecommunication Union Statistics,<sup>2</sup> just over 51% of the global population, or 4 billion people, were using the Internet by the end of 2019.<sup>3</sup> In 2018, the Massachusetts Institute of Technology stated that 95.7% of the population in Japan owned mobile devices, with 79.2% owning smartphones. These data also show a steady increase in time spent on the Internet; in 2019, 89.8% of people aged over 20 years, across 40 000 households,

spent 112 min daily using the Internet.<sup>1</sup> However, research has highlighted problems associated with using ICT devices.

When operating smartphones or gaming controllers, users risk repetitive strain injuries by repeatedly pressing their thumbs or using a combination of thumb/finger motions.<sup>4-6</sup> Several studies have reported a high rate of musculoskeletal disorders in young individuals, attributable to smartphone

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use.<sup>7-10</sup> Alosaimi et al<sup>4</sup> found that 650 university students (27.2% of their sample) used a smartphone for over 8 h daily (mean and standard deviation of  $6.65 \pm 4.3$  h). Woo et al<sup>11</sup> analyzed the use of smartphones or tablet computers, wherein people use their thumbs/fingers to manipulate the screen; it was found that these activities put excessive force on the median nerve, compressing it if these repetitive movements lasted for long periods. Additionally, on average, participants used electronic devices for more than 3 h daily and reported musculoskeletal complaints.<sup>12</sup> Baabdullah et al<sup>3</sup> found that this pain was positively correlated with the degree of smartphone use, with 66.4% of participants being smartphone addicts and 19.1% of those with pain testing positive on Finkelstein's test.

Although these reports offer valuable insights, they only explore the musculoskeletal effects of ICT device usage *vis-à-vis* a single hand disorder. It is, therefore, necessary to investigate the association of prolonged ICT device utilization with multiple hand disorders. Accordingly, this study examined the relationship between hand symptoms and the amount of time spent using electronic devices in healthy adults, as well as the cutoff value for positive hand symptoms.

## Methods

### Participants

The participants were healthy university students. Individuals undergoing treatment for cerebrovascular disease or neck pain complaints, or with a history of such conditions, were excluded.

### Design

This study, which employed a Cross-sectional study design, was conducted from January 2017 to 2020.

### Sample Size Calculation

Using  $G \times Power$  software, with an effect size of 0.3, significance level ( $P$ ) of .05, and a power level ( $1-\beta$ ) of 0.95, the necessary sample size was determined as 145.

### Variables

Four variables were measured: handedness (left- or right-handed), daily time spent using ICT devices (PCs, smartphones, and gaming consoles), presence of carpal tunnel syndrome, and presence of De Quervain's tenosynovitis. Carpal tunnel syndrome was determined using Phalen's test wherein the result was considered positive if participants experienced numbness/tingling in their median nerve after passively flexing their wrists for 1 min.<sup>13,14</sup> De Quervain's tenosynovitis was determined using Eichhoff's test, wherein

participants had to place their thumbs within their hands and clench their fists, with the examiner then bending the clenched hand ulnar-ward. If participants experienced pain, the result was considered positive.<sup>15-17</sup>

### Data Analysis

Participants were divided into those with a positive Phalen's test, those with a positive Eichhoff's test, those positive on either test, and those positive on both tests. Usage time was analyzed using Tukey's range test. Other variables were analyzed using a  $\chi^2$  test. The receiver operating characteristic (ROC) curve was constructed from the sensitivity and specificity of each hand symptom to the frequency of use of electronic devices. The cutoff values were examined using the least-squares method to find the nearest point from sensitivity 1.0 and specificity 1.0 and to find the point that maximized the Youden Index (sensitivity + specificity - 1). The significance level was set at less than 5%. All statistical analyses were performed with EZR Version 1.52 (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R version 4.02 (The R Foundation for Statistical Computing, Vienna, Austria). More precisely, it is a modified version of R Commander designed to add statistical functions frequently used in biostatistics.

### Ethical Considerations

The study was carried out after obtaining approval from the research ethics committee of the primary author's institution (approval no. 19-010), and all participants provided written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki. The participants were assigned arbitrary subject numbers so that no individual could be identified. The document matching individuals with their subject numbers was stored on a password-protected USB drive that remained locked in the principal investigator's laboratory. The data analysis file was stored on a different password-protected USB drive locked in the principal investigator's laboratory.

## Results

Originally, 150 healthy university students (76 females, 74 males) with an average age of  $22.5 \pm 2.4$  years were recruited. After excluding 2 participants because of a history of neck disorders, the data of 148 participants (72 males and 76 females) were analyzed. There were no sex biases in handedness. In total, 128 participants were right-handed and 20 were left-handed. There were no significant sex differences in hand dominance. Average device usage time was  $5.76 \pm 3.00$  (1.9-16.2) hours daily. Usage time across device types was as follows: smartphones were used the most, followed by PCs and gaming consoles. However, this trend was

**Table 1.** Average (Mean  $\pm$  Standard Deviation) Usage Time by Device (n = 148).

	Smartphone	Personal computer	Games console	F value	P value
Usage time (no. of hours)	3.10 $\pm$ 1.54	2.78 $\pm$ 1.10	2.71 $\pm$ 0.63	1.45	.24

**Table 2.** Presence of Hand Disorder (n = 148).

		Phalen's test	Eichhoff's test	Either test	Both tests	P value
Result	Positive	73	46	80	40	<.001
	Negative	75	75	68	108	
Sex	Male	34	20	38	21	.89
	Female	40	25	42	19	

not significant (Table 1). The negativity and positivity of the 4 items of Phalen's and Eichhoff's tests, 1 of Phalen's and Eichhoff's tests, and both of Phalen's and Eichhoff's tests for hand symptoms were summarized and found to be significant (Table 2). The 4 hand symptom categories and sex are shown in Table 2; however, the results were not significant.

Next, the relationship between A test positive, B test positive, one of the AB tests, and both AB tests positive and hand usage time was determined using the ROC curve for sensitivity, specificity, cutoff value, and area under the curve (Figures 1 and 2). In the A positive Phalen's test, the cutoff was 5.100, sensitivity was 0.667, specificity was 0.978, and area under the curve was 0.88 (95% confidence interval (CI): 0.83-0.93) (Figure 1a). In the A positive Eichhoff's test, the cutoff was 4.900, sensitivity was 0.840, specificity was 0.945, and area under the curve was 0.93 (95% CI: 0.89-0.97) (Figure 1b). In those positive on either test, the cutoff was 5.100, sensitivity was 0.926, specificity was 0.925, and area under the curve was 0.96 (95% CI: 0.93-0.99) (Figure 2a). In those positive on both tests, the cutoff was 5.100, sensitivity was 0.624, specificity was 0.974, and area under the curve was 0.88 (95% CI: 0.83-0.94) (Figure 2b).

## Discussion

This study found that intensive information and communication device users were more likely to be positive in either Phalen's test or in both Phalen's and Eichhoff's tests, similar to previous findings.<sup>18,19</sup> This implies that intensive ICT use is associated with hand disorders and that limiting ICT use reduces the risk of developing such disorders. However, as we did not have an indicator of the limitation required, we calculated the cutoff value. As a result, the cutoff values for tendonitis, neurological symptoms, and/or both of these symptoms were also obtained. In each case, the results were approximated from 4.9 to 5.1 h.

Multiple studies have examined handspan and grip, reporting that the former influences the latter among certain populations, suggesting an optimal hand size for grip.<sup>20,21</sup> Additionally, many studies have found that characteristic

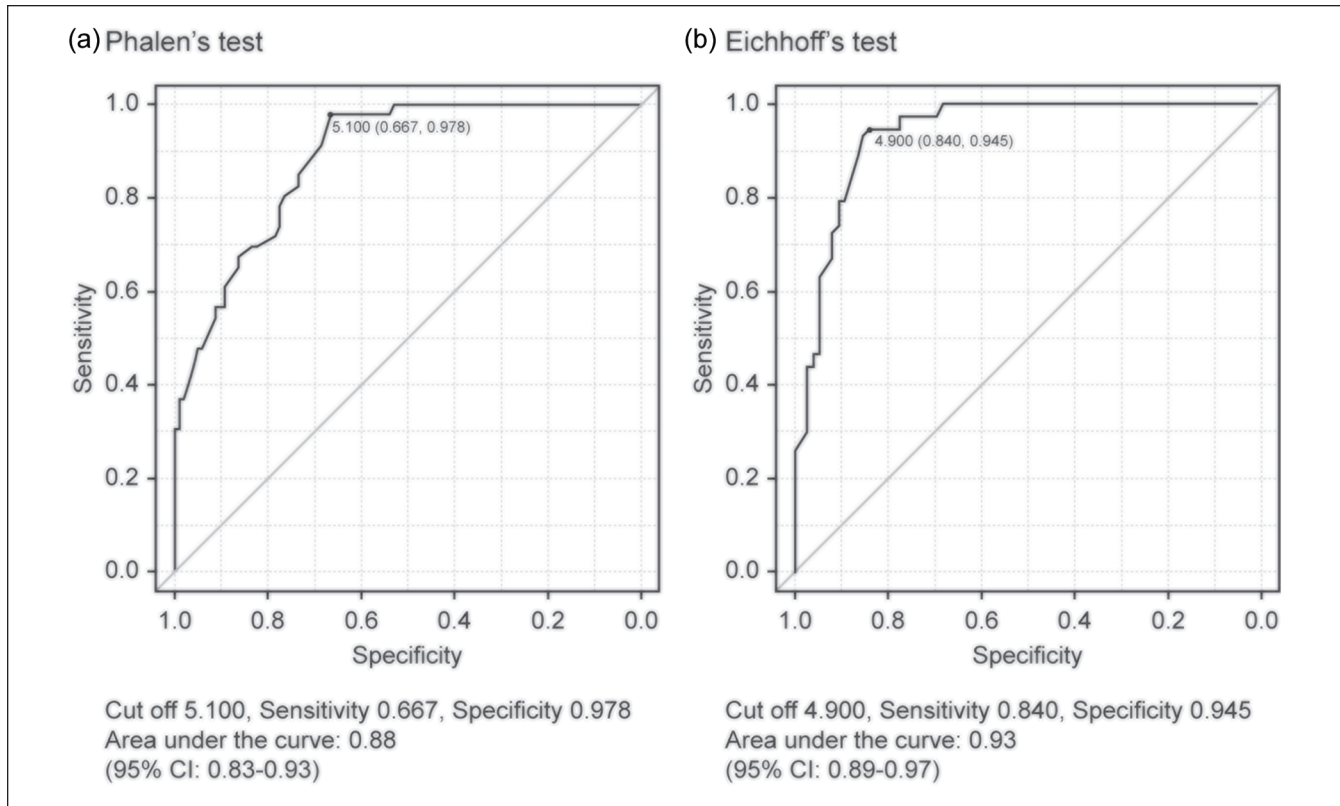
hand usage, whether at work or during activities like playing the piano, causes hand disorder symptoms and should be considered separately.<sup>22-24</sup>

As in Ruiz et al's<sup>21</sup> study, the hand movements we examined did not involve the intense, repetitive motions that employees perform during their jobs or those of piano players. Furthermore, no sex differences were observed in hand disorders. However, when using ICT devices, participants made repetitive thumb movements in a fixed posture. Thus, our results imply that long periods of repetitive motions increase the risk of developing hand disorders. When operating PCs, movements related to inputting for a long time and forcefully hitting keys while bending the wrist joint were observed, these are considered to be related to carpal tunnel syndrome. Additionally, when using iPads and smartphones, there were many movements which caused the wrist joint and the thumb to be in the shaku position, which is considered to be related to De Quervain's tenosynovitis.

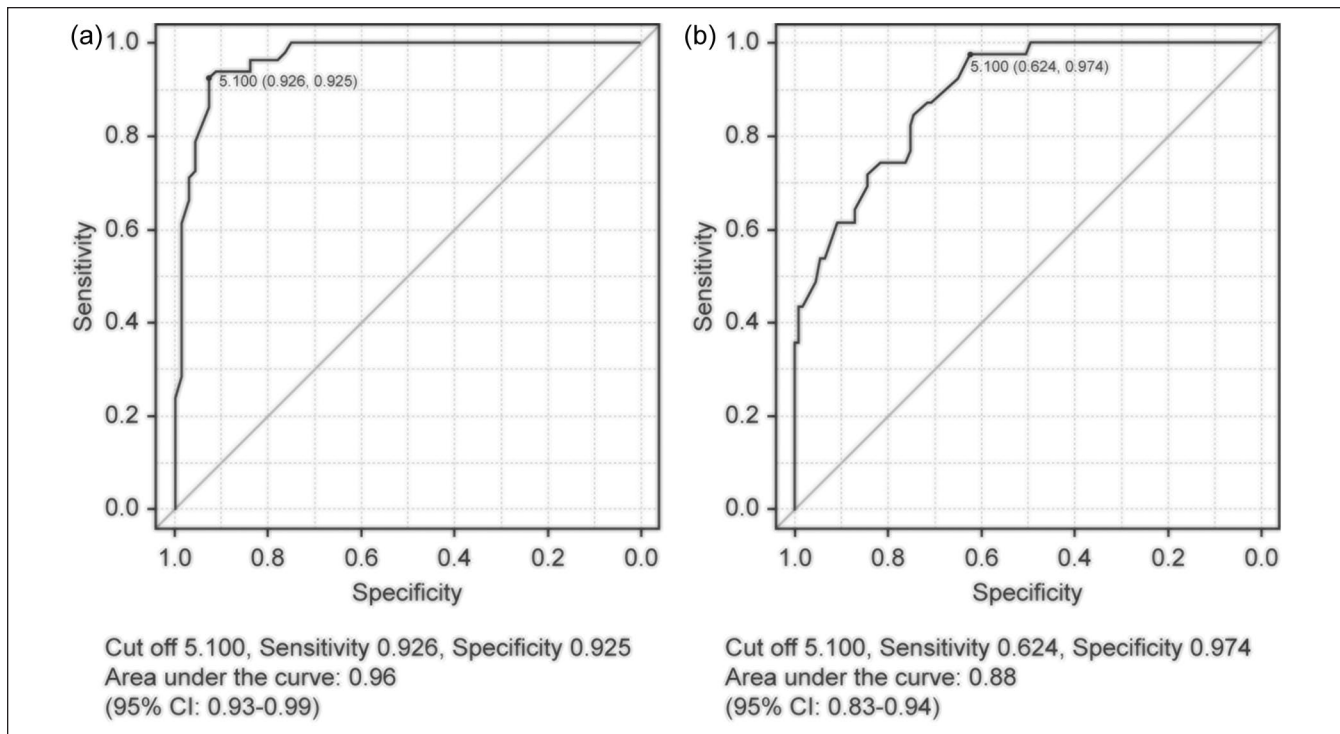
Accordingly, to prevent/mitigate hand disorders, future research should explore the specific motion patterns increasing the risk of these conditions and prevention methods for the same.

Individuals using ICT devices for over 5 h daily are more likely to develop hand disorders. This duration is an important indicator for protecting hand health. Our findings show that there is an association between intensive ICT use and hand health; thus, individuals should be encouraged to limit their ICT device utilization.

In Woo et al's<sup>18,19</sup> research, the participants were engineering students, many of whom had experienced carpal tunnel syndrome due to using PCs for long periods. However, in Baabdullah et al's<sup>3</sup> study, where the participants were smartphone users, many had experienced tendonitis. In the present study, the participants not only used smartphones in their daily lives, but also used different types of devices, such as tablets and PCs, in their classes. Further, the fact that they were typing in Japanese had an effect since it is more time-consuming than typing in other languages. Therefore, it was suspected that this could lead to developing symptoms of both carpal tunnel syndrome and tendonitis.



**Figure 1.** (a) Phalen's test and (b) Eichhoff's test positive (receiver operating characteristic curve, cutoff value, sensitivity, and specificity).



**Figure 2.** Positive on (a) either test and (b) both tests (receiver operating characteristic curve, cutoff value, sensitivity, and specificity).

The key finding of this study is that the cutoff times for symptoms of tendonitis and neurological symptoms were all around 5 h. However, a limitation is that only the total daily hand usage time was collected in the interview. The average duration of each session and other information was not collected. Future research should investigate average session duration and hand usage patterns and conduct interventions to improve hand symptoms.

## Conclusion

Intensive ICT users were significantly more likely to be positive in Phalen's test of hand disorders or in both Phalen's test and Eichhoff's test, showing an association between intensive ICT use and hand disorders. These results can form the basis of guidelines for the prevention of information and communication device overuse.

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## Author Contributions

KS and YS researched literature and conceived the study. YS was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. KS wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Unblinded Ethical Approval

All participants provided written informed consent. The study was approved by the Fuchinobe General Hospital Ethics Committee (Approval No. 20-001; Year of approval: March 3, 2020).

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