Wrist Motion in Computer Keyboard Typing

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The purpose of this study is to define how wrist motion is affected by different postures and supporting devices and to discover functional range of wrist motion for keyboard typing. The range of wrist motion (ROM) needed for fourteen experienced typists to type on a computer keyboard was measured by flexible and biaxial electrogoniometers. The most frequent wrist motion during typing was in extended and ulnarly deviated positions in both wrists. Range of wrist motion was similar in both wrists. The average ROM for keyboard typing with the typists' own posture was about 39° in flexion/extension (FEM) and 29° in radial/ulnar deviation (RUD) in both wrists. The range of wrist motion was significantly reduced to 30° in FEM and 27° in RUD with use of either wrist or forearm supporting devices, which suggests that these devices might help to relieve fatigue, discomfort, or pain during and/or after typing. Results of this study will be of interest to clinicians and helpful to those who are professionally or non-professionally involved in typing.

Key Words : Wrist Motion, Keyboard Typing, Electrogoniometers, Cumulative Trauma Syndrome, Overuse Syndrome

1. Introduction

Keyboard typing is an increasingly important skill as computers have become pervasive fixtures in most working and learning environments in our society.

Armstrong et al. (1981) and Pitner (1990) indicated that typing action is generally known to cause cumulative trauma syndrome or the so called "overuse syndrome". Specific injury in the wrist region related to keyboard typing has not been reported, but many keyboard users complain about wrist fatigue, discomfort or pain after typing. McPhee (1982) expected that more keyboard users will develop medical problems in the upper arm, shoulder or neck as more people use computers and start using them at an increasingly younger age.

Carey and Gallwey (2002) investigated the effects of wrist posture, pace and exertion on discomfort and they found that extreme flexion or combination of flexion and ulnar deviation resulted in higher discomfort than the other types of combined situation. In similar study, Nelson et al. (2000) reported that keyboard angles influenced on not only wrist motion, but also tendon excursion. From this study, a flat keyboards produce more wrist motion than keyboards with greater pitch and roll angles. To assess the biomechanical influence of keyboards design, tendon travel was chosen as a study parameter to evaluate commercially available keyboards design. Treaster and Marras (2000) also revealed that keyboard design can affect tendon travel which is highly related with the wrist motion.

Several researchers, Flanders and Soechting (1992) and Terzuolo and Viviani (1980) have reported on the motor pattern related to motion in the upper extremity during typing. Other resear-

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chers, Brumfield and Champoux (1984), Palmer et al. (1985) and Ryu et al. (1991) have reported on functional range of wrist motion during activities of daily living and Kang et al. (2003) developed anthropomorphic robot hand as a testbed for dextrous manipulation. However, in review of the literature, study that reported range of wrist motion (ROM) during keyboard typing was not found.

The purpose of this study was to measure the wrist motion required for keyboard typing and to investigate the effect on wrist motion of typing postures and the use of supporting devices, which may reduce stress on the wrist and help reduce the risk of potential overuse injuries.

2. Materials and Methods

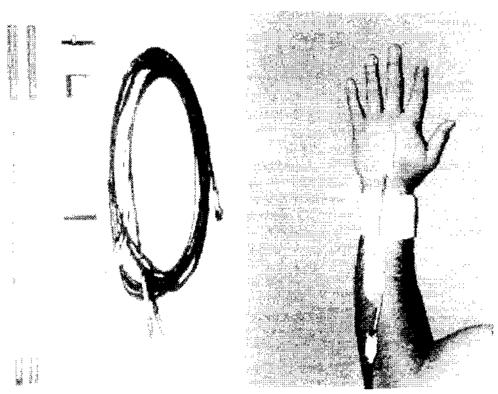
Fourteen experienced female typists with keyboard typing rates of more than 60 words per minute participated in the study. Average age was 43.6 years ranging from 22 to 55 years. All subjects but two were right hand dominant. Two subjects had a previous surgery for ganglion cyst removal from the wrist area.

All experiments were performed using a standard IBM PC computer keyboard. Subjects sat on a chair with seat and back height adjustments at a height adjustable keyboard table.

A biaxial and flexible wrist electrogoniometer (Penny and Giles, Blackwood NP2 2YD, UK) with an angle display unit and connecting wires measured wrist FEM and RUD simultaneously (Fig. 1(a)). The distal endblock of the goniometer was attached to the dorsal surface of the third metacarpus with double-sided adhesive tape (Fig. 1(b)). Single sided adhesive tape was laid over the top of the endblock to prevent detachment of the goniometer as suggested by the manufacturing company. A thermoplastic platform wrist brace was designed for mounting the proximal endblock to the distal radius to keep forearm rotation in neutral and prevent forearm pronation-supination from affecting the measurements. The reproducibility and reliability of goniometric data with or without the thermoplastic platform wrist brace were determined and

Table 1 Model selection was chosen from a typing textbook

There are numerous varieties of word processors on the market. Some have screens and are called CRTs. Others are blind processors, which do not have screens; operators must key documents without viewing what they're recording on the diskettes or magnetic tape. Some are standalones because a central processing unit is not connected to them. Some are connected to CPUs and operate in conjunction with terminals handling similar or different text.
Combining the newest types of word processors and data precessors has helped businesses realize the requirement of heavy paper flow. Businesses can merge information in word and figure forms by manipulating and changing formats electronically to speed up information flow.



(a) (b)

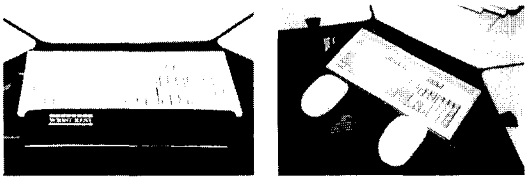
Fig. 1 (a) Penny and Giles 'M' Series twin-axis goniometer, angle display unit, and connector.
(b) Thermoplastic platform wrist brace as applied to the left wrist with a goniometer

Kihira et al. (1995) reported in previous studies. In this study, the neutral position of the wrist was defined as the long axis of the third metacarpal bone pointed to the center of radius head with the forearm in full supination.

Gregg (1989) published a well-known typing textbook and subjects were asked to type a selection from this typing textbook. The selection of about 250 words included confusing words, and was designed to take five minutes to type with three or fewer errors at a rate of 50 words a minute. The selection included all 26 letters of

Table 2 Description of the Standard Textbook Posture

1. Wrist up slightly off the front of the keyboard so that the fingers are free to move as we type
2. Arms hanging loosely at sides, forearm at the same angle as the keyboard
3. Shoulders level
4. Back straight with body leaning forward slightly
5. Feet apart, firmly braced on the floor, one foot ahead of the other
6. Height of the chair will be adjusted so that typist can address the keyboard with the wrist in neutral position



(a) (b)

Fig. 2 (a) Keyboard wrist rest from AliMed Inc. The height of the wrist rest matched the top of the space bar of our keyboard.
(b) Armrest from The Backcare Corp. Chicago, Illinois. position of the armrest was adjusted so the palmar side of both wrists aligned with the top of space bar

the alphabet (Table 1). Subjects, who were given warm-up time to get accustomed to the goniometer, were asked to type at their normal speed in the trials.

Four trials investigated the difference in ROM under different typing conditions. In the first trial, subjects were asked to type in the posture they used every day in their work place. In the second trial, subjects were asked to type in a standard typing posture recommended in the typing textbook (Table 2). In the third trial, a wrist rest (Keyboard Wrist Rest, AliMed' Inc.), which supports the wrists at the same height as the space bar of the keyboard, was used with the subject in standard posture (Fig. 2(a)). In the fourth trial, an forearm rest (The Backcare Corp. Chicago), which supports the forearm from the underside, was used with the subject in standard posture (Fig. 2(b)).

Goniometers were attached to both wrists of the

Fig. 3 Typist addressing the keyboard with the Penny and Giles "M" Series twin axis goniometer attached to her wrists

subjects and were calibrated before each series of trials (Fig. 3). Motion data were obtained every tenth of a second and recorded directly into IBM PCs computer using the LabTech Notebook software (Laboratory Technologies Corp).

Data were analyzed using the JMP computer program for the Apple Macintosh from SAS Institute Inc. The data were analyzed as a randomized complete block design with subjects serving as blocks and trials (1, 2, 3 and 4). The analysis of each variable was summarized by a F-test for the stages. P-value was set as 0.05 to determine statistical significance between trials. Turkey's Honestly Significant Difference Multiple Comparison Method identified significant differences between pairs of stage means.

3. Results

Averaged data of lower/upper limit wrist motion and range of wirst motion (ROM) required for typing with four different postures are summarized in Table 3 and Fig. 4. Wrist motions obtained in this study were described with respect to two planes, such as wrist flexion/extension (FEM) plane and wrist radial/ulnar deviation (RUD) plane. Positive values in wrist motion represented wrist extended position in FEM plane and ulnarly deviated position in RUD plane. The ROM was obtained by subtracting lower limit wrist motion from upper limit wrist motion.

In trial 1 with own posture, the wrist motion in both wrists ranged from 7.5° to 46.5° (=ROM 39°) in FEM and ranged from 5.5° to 34.5° (=ROM 29.5°) in RUD.

In Trial 2 with standard textbook posture, the wrist motion in both wrists ranged from 6.5° to 41.5° (=ROM 34.5°) in FEM and ranged from 70 to 34.5° (=ROM 27.5°) in RUD. The upper limit wrist motion and ROM for both wrists in FEM decreased by approximately 4.5~5.5° when compared to Trial 1. However, the statistical difference in upper limit wrist motion and ROM between Trials 1 and 2 was not significant.

Table 3 Wrist range of motion required in each trial

	FEM (degree)			RUD (degree)		
	Lower limit	Upper limit	ROM	lower limit	Upper limit	ROM
	Trial 1 : Own Posture					
Left	7	46	39	6	33	28
Right	8	47	39	5	36	31
	Trial 2 : Standard Textbook Posture					
Left	8	40	32	7	34	27
Right	5	42	37	7	35	28
	Trial 3 : Standard Posture with Wrist Rest					
Left	7	39	32*	9	36	27
Right	5	37*	32	3	32	29
	Trial 4 : Standard Posture with Forearm Wrist					
Left	13	41	28*	8	32	24
Right	10	39*	29*#	6	35	29

* : Significant difference compared to Trial 1, # : Significant difference compared to Trial 2. ROM : Range of Wrist Motion, FEM : Flexion/Extension, RUD : Radial/Unalr Deviation

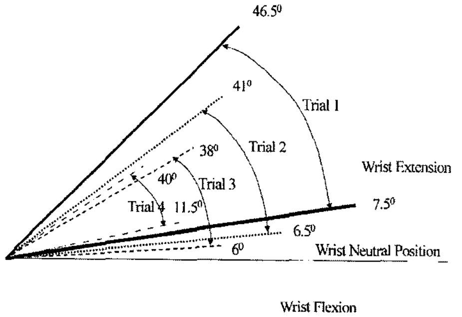


Fig. 4 Range of wrist motion including their lower/upper limits motion required for all trials

In Trial 3 with a wrist supporting device, the wrist motion in both wrists ranged from 6° to 38° (=ROM 32°) in FEM and ranged from 6° to 34° (=ROM 28°) in RUD. The ROM in FEM was statistically significantly lower than those in Trial 1. However, the ROM in RUD showed no statistically significant difference when compared to Trial 1.

In Trial 4 with a forearm supporting device, the wrist motion in both wrists ranged from 11.5° to 40° (=ROM 28.5°) in FEM and ranged from 7° to 33.5° (=ROM 26.5°) in RUD. The upper limit wrist motion in FEM and RUD decreased slightly by 6.5° and 1°, respectively, when compared to Trial 1. However, the ROM for both cases decreased greatly by 10.5° and 3°, respectively.

4. Discussion

This study demonstrated that typists used almost the same ROM in both wrists during keyboard typing and both wrists were maintained in extended and ulnarly deviated position during typing. It was also observed that the wrist was more ulnarly deviated in a less extended position during typing. When the wrist was in an more extended position, it was less ulnarly deviated. The wrist position most frequently used occurred almost in the middle of ROM (Fig. 5(a) and (b)).

When compared to Trial 1 (own posture), this study showed that standard textbook posture did not help reduce the ROM of typists statistically. However, the wrist support and forearm support devices decreased ROM by approximately 7°~10° in FEM. Statistical analysis revealed that these supporting devices help reduce the ROM signi-

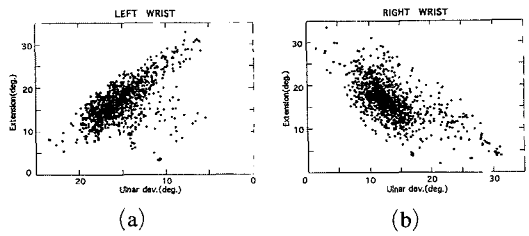


Fig. 5 Wrist position pattern during typing. (a) Left wrist, (b) Right wrist

ficantly. However, no significant difference in lower/upper limit wrist motion and ROM in RUD plane was observed in any of the four trials.

The results obtained in this study were not able to address the implication that reduced ROM could minimize the incidence of overuse injuries. However, ROM is directly and proportionally related to amount of excursion of the extrinsic tendon required to move the wrist. Therefore, the greater ROM required, the greater amount of tendon excursion is necessary, which may play a very important role in causing fatigue, discomfort or pain in the wrist, elbow, and shoulder over an extended period of time of typing. In addition, the hyper-extension along with greater ROM may accelerate the wrist pain as extensor may cause higher stress on tendons. However, how much a wrist supporting device can reduce the incidence of overuse injury associated with typing should be investigated in future studies. Also as a result of this study, lower/upper limit wrist motion and ROM data may help to provide surgeons with an objective basis on which to make decisions about appropriate treatment for typing related occupational overuse injury patients.

5. Conclusion

Range of wrist motion required for typing with own posture was approximately 40° of the extended position and 30° of the ulnarly deviated position in both wrists. Standard textbook posture did not help reduce the ROM of typists when compared to their own typing posture. However, ROM required for typing was significantly reduced when using wrist or forearm supporting devices. This results suggest that use of these wrist or forearm supporting devices may help typists relieve wrist fatigue, discomfort or pain after typing and further reduce potential of development of overuse injuries.

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