WHITE PAPER



A study of wrist angles when using portable ultrasound systems with a wrist supporting device

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INTRODUCTION & PURPOSE

It has been widely known that typing on a keyboard and using a mouse for extended periods of time can affect or exacerbate musculoskeletal disorders of forearms or CTS (carpal tunnel syndrome). Most studies related to this have reported that the flexion/extension angle of wrists and radial/ulnar deviation angle of wrists, as well as the pronation/supination angle of the forearms, can cause an increase in activity of extensor carpi ulnaris (ECU), muscle fatigue, and musculoskeletal disorders in forearms. There are also along with frequent reports of CTS incidence resulting from an increase of intracarpal canal pressure (ICCP). What kind of clinical impact will result from typing on a portable ultrasound system for diagnosing patients rather than on a standard computer?

Portable ultrasound systems are designed to have small footprints for easy carrying and immediate access for use in emergencies or surgeries, and they are designed to be similar to laptops in order to make them as small as possible. However, there are issues raised by researchers regarding such portable ultrasound systems. It is claimed that the disadvantages from such shapes include leaving the wrist or the forearm in the air without a wrist-supporting device, causing significant burdens on the wrist and forearm. This study aims to identify the impact of muscular fatigue on the forearm and the pressure to the carpal canal while using portable ultrasound systems by varying the wrist angle during use. It also aims to examine the usefulness of recently developed portable ultrasound systems by comparing these wrist angles when using portable ultrasound systems with a wrist supporting device (new model) and those without a support (conventional model).

Keyword; Ultrasonography, Wrist Angle, Supporting

SUBJECT & METHOD

This study was conducted with 10 male and 10 female subjects with an average age of 34.6 years (26-62 years of range) and no previous disorder or pain in their wrist and forearm. In order to minimize statistical errors, heights of chair and desk were set as 55 cm and 75 cm respectively and both wrist angles were measured. Additionally, the lengths of both hands (from the wrist joint to the end of the third finger) and forearms (from the wrist joint to the end of the ulnar olecranon) were measured. The ultrasound systems for this study were manufactured by a single supplier and included the conventional model, the E-CUBE INNO (ALPINION MEDICAL SYSTEMS Co., Ltd., Seoul, Korea) without a wrist supporting device and the new model, the E-CUBE i7 (ALPINION MEDICAL SYSTEMS Co., Ltd., Seoul, Korea), which does include a wrist supporting device. Both models are 6.5 cm thick (Fig. 1 and Fig. 2). For the statistical test [SPSS v20.0 (SPSS Inc., Chicago, Illinois, USA)], a paired t-test was employed to identify the significance of wrist angular differences with the portable ultrasound system using a wrist supporting device and then without the device, while Pearson correlation analysis was conducted on the lengths of the hands and forearms of all the subjects.



Fig. 1 Measurement methods





Fig. 2 Old and new models

RESULTS

All subjects were right-handed, with an average height of 169.5 ± 9.3 cm, average weight of 62.9 ± 14.9 kg, and average body mass index (BMI) of 21.6 ± 3.4 . The average length of the right hand was 7.8 ± 0.48 cm, while the average length of the left hand was 7.6 ± 0.56 cm. The average length of the right forearm was 26.8 ± 2.3 cm, while the left forearm was 26.3 ± 2.3 cm. The right wrist angle when using the ultrasound system without a wrist supporting device was -20.2 ± 2.3 degrees, and the left wrist angle when using the ultrasound system without 1.2\pm1.9 degrees, and the left wrist angle was 1.0 ± 1.8 degrees (Table 1).

Gender	Male: 10 subjects Female: 10 subjects
Age	Average 34.6 years
Height	169.5±9.3 cm
Weight	62.9±14.9 kg
Body Mass Index (BMI)	21.6±3.4 kg/m ²
Right-handed	20 subjects
Hand length	Right hand: 7.8±0.48 cm Left hand: 7.6±0.56 cm
Forearm length	Right hand: 26.8±2.3 cm Left hand: 26.3±2.3 cm
Wrist angle (Supporting device (-))	Right hand: -20.2±2.3 degrees Left hand: -20.0±2.1 degrees
Wrist angle (Supporting device (+))	Right hand: 1.2±1.9 degrees Left hand: 1.0±1.8 degrees

Table 1.Average measurements



The lengths of the right and left hands of the subjects turned out to increase proportionately to the lengths of right and left forearms, with correlation coefficients of 0.84 for the right and 0.81 for the left (Table 2).

Length (cm)	Right	Left
Hand length	7.8±0.48 cm	7.6±0.56 cm
Forearm length	26.8±2.3 cm	26.3±2.3 cm
(R)	0.842	0.814

Table 2. Pearson correlation analysis on forearm and hand lengths

The differences between the wrist angle on the conventional and new models were 21.5 ± 3.3 degrees (right) and 21.05 ± 3.0 degrees (left) in extension, which were statistically significant (p < 0.05, Table 3).

Angle (degree)	Right	Left	
Wrist angle (Supporting device (-))	- 20.2±2.3 degrees	- 20.0±2.1 degrees	
Wrist angle (Supporting device (+))	1.2±1.9 degrees	1.0±1.8 degrees	
Wrist angle changes	+ 21.5±3.3 degrees	+ 21.05±3.0 degrees	
P-value	P < 0.00001	P < 0.00001	
The result is significant at p < 0.05 (-) : Wrist flexion angle / (+) : Wrist extension angle			

Table 3. Paired T-test on wrist angle changes

DISCUSSION

When referring to precedent studies, and especially according to the one conducted by R. Werner, the intracarpal canal pressure (ICCP) increases by 1.6 mmHg when the wrist extension angle increases by 10 degrees, and it increases by 0.2 mmHg when the wrist flexion angle increases by 10 degrees. It reaches a minimum of 8.3-9.6 mmHg with the mid 0 degree. A study by N. D. Weiss found that intracarpal canal pressure (ICCP) mostly stays low from a wrist extension angle of 2 degrees up to a wrist flexion angle of 9 degrees (lowest at the mid 0 degree), while it is the lowest from 2 degrees of ulnar deviation up to 6 degrees of radial deviation. Also, a graph in the study by David M. Rempel shows that intracarpal canal pressure (ICCP) stays at its lowest level of 1.2 kPa with an extension angle/flexion angle of 0 (mid), which gives an approximate value of 9 mmHg for 1.2 kPa of pressure when the value is applied to the formula: 1 kPa = 7.5 mmHg(Fig. 3).



Fig. 3 David M. Graph from Rempel study (0 degree of extension/flexion \rightarrow 1.2 kPa ; Lowest)

This is the same as the lowest intracarpal canal pressure (ICCP) in the study by R. Werner (8.3-9.6 mmHg), leading to the conclusion that the lowest intracarpal canal pressure (ICCP) is about 9 mmHg from any study. Based on this conclusion, when the wrist angular values of both hands with conventional and new models for this study are applied to the formula, a change of 1.1 degrees in the average extension angle from the average flexion angle of 20 degrees results in decreased intracarpal canal pressure (9.4 \rightarrow 9.176 mmHg).

Average flexion angle of 20 degrees of both hands: 9 mmHg + (20 x 0.2/10) = 9.4 mmHg

Average extension angle of 1.1 degrees of both hands: 9 mmHg + $(1.1 \times 1.6/10) = 9.176$ mmHg

Also, a study by Guy G. Simoneau found that changes from a 12.8 degree extension angle to a flexion angle of 2.6 degrees resulted in a 2-3% decrease of EMG (electromyographic) activity in the ECU (extensor carpi ulnaris) and a 1-2% increase of EMG activity in the FCU (flexor carpi ulnaris). As an average flexion angle of 20 degrees is substituted for an average extension angle of 1 degree for this study, increased EMG activity for the ECU (extensor carpi ulnaris) and decreased EMG activity for the FCU (flexor carpi ulnaris) is indirectly observed. In the meantime, the limitations of this study include: not considering radial/ulnar deviation and pronation/ supination of the wrist, the fact that measurement of the wrist angles was taken only once leading to failure to represent the average, and the fact that the height of the desk and chair may have affected the measurements of wrist angles.



CONCLUSION

Wrist angles when using a portable ultrasound system with a wrist supporting device showed an average extension angle change of 21 degrees, leading to the lowest intracarpal canal pressure (ICCP) of the final extension angle (1 degree) which confirmed a numeric decrease in intracarpal canal pressure (9.4 \rightarrow 9.176 mmHg). The use of an ultrasound system with a wrist supporting device is expected to reduce the burden on the wrist and the forearm, along with reducing the CTS incidence rate as a result of decreased intracarpal canal pressure (ICCP).

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