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The effect of wrist rests and forearm support during keyboard and mouse use

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Abstract

Supporting the forearm on the work surface during keyboard operation may increase comfort, decrease muscular load of the neck and shoulders, and decrease the time spent in ulnar deviation. Wrist rests are used widely in the workplace and are more commonly being incorporated in keyboard design. The aim of this study was to examine the effect of wrist rest use on wrist posture during forearm support. A laboratory based, experimental study was conducted (subjects $n = 15$) to examine muscle activity and wrist postures during keyboard and mouse tasks in each of two conditions; wrist rest and no wrist rest. There were no significant differences for right wrist flexion/extension between use of a wrist rest and no wrist rest for keyboard or mouse use. Left wrist extension was significantly higher without a wrist rest than with a wrist rest during keyboard use (df = 14; $t = 2.95$; $p = 0.01$; $d = 0.38$). No differences with respect to use of a wrist rest were found for the left or right hand for ulnar deviation for keyboard or mouse use. There were no differences in muscle activity between the test conditions for keyboard use.

Relevance to industry

Wrist rests are used widely in the workplace and are more commonly being incorporated in keyboard design. Use of a wrist rest in conjunction with forearm support when using a conventional desk does not appear to have any impact on wrist posture or muscle activity during keyboard use.

Keywords: Wrist rests; Keyboard; Mouse; Wrist posture

1. Introduction

Computer use is widespread in the workplace and at home, with up to 25% of people reported to use a computer for more than 50% of their working day (Hjelm et al., 2000). Over the past decade, there has been a rapid increase in

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computer use, with worldwide personal computer shipments doubling from 25 million in 1990 to 57 million in 1995 (Feuerstein et al., 1997).

The relationship between computer use and musculoskeletal disorders of the neck and upper extremity has been well documented (Fahrbach and Chapman, 1990; Punnett and Bergqvist, 1997). The prevalence of symptoms associated with computer use has increased rapidly over the past decade (Karlqvist et al., 2002; Keogh et al., 2000). In the United States, the annual number of new cases of musculoskeletal disorders among office workers increased 10-fold between 1985 and 1990 (Fahrbach and Chapman, 1990).

Disorders related to computer use have been reported both in the distal and proximal upper extremity. In a review of 56 epidemiological studies related to computer use, Punnett and Bergqvist (1997), concluded that there was a direct causal relationship between computer keyboard use and hand/wrist disorders. An association was found between computer use and neck/shoulder disorders, although the association was not as strong as for the hand/wrist.

Use of a computer requires interaction between the user and the keyboard and/or other input devices such as a mouse or trackball and the computer monitor. Computer use may involve awkward postures, repetition, static load, and contact stress, all risk factors recognised as contributing to the development of musculoskeletal disorders (Bernard, 1997; Department of Labor & Industry, 1999; Amell and Kumar, 2000). Given the sizes of the structures involved, forceful exertions can occur during keyboard and mouse use (Amell and Kumar, 2000).

Awkward postures identified as risk factors during keyboard use include shoulder elevation, flexion and abduction, neck flexion or extension, wrist extension and ulnar deviation (Tittiranonda et al., 1999). Mouse use is associated with postures of shoulder forward flexion, abduction and external rotation, primarily due to the location of the mouse in a 'non-optimal position', i.e. not within the span of the shoulders (Karlqvist et al., 1996; Aaras et al., 1997; Cook and Kothiyal, 1998). In the distal upper extremity, mouse users are reported to adopt working postures of wrist extension, pronation and ulnar deviation (Karlqvist et al., 1994; Fernstrom and Ericson, 1997; Cook and Kothiyal, 1998; Burgess-Limerick et al., 1999).

Symptoms of the neck and proximal and distal upper extremities have been associated with the keyboard, which continues to be the most widely used data entry device. The continuous activation of muscles of the arms, shoulder girdle, neck and trunk to maintain a quasi-static position to allow the hands and arms to operate the keyboard has been proposed as one of the causal factors of neck/shoulder and arm/hand diagnoses (Bergqvist et al., 1995).

Despite this, the traditional recommendation for typists to 'hover or float' over the keyboard whilst keying, maintaining a neutral wrist posture without supporting the arms is still advocated and widely used (WorkCover, 2001). There is, however, increasing evidence that supporting the arms during keyboard and mouse use is a preferable working posture for most computer users (Aaras et al., 2001; Cook and Burgess-Limerick, 2001, 2002). The arms can be supported by either supporting the forearms or wrists.

1.1. Forearm support

The provision of forearm support during keyboard and mouse use has been demonstrated to reduce neck and shoulder muscle activity in both laboratory and field settings (Aaras et al., 1998, 2001; Cook and Burgess-Limerick, 2001, 2002; Woods et al., 2002). In the workplace, a reduction in musculoskeletal discomfort in the neck and shoulders (Aaras et al., 1998, 2001; Cook and Burgess-Limerick, 2002), and wrists and forearms (Cook and Burgess-Limerick, 2002) was reported following provision of forearm support. Forearm support has been also demonstrated to reduce extremes of ulnar deviation as well as time spent in extreme postures of ulnar deviation (Cook and Burgess-Limerick, 2001, 2002).

1.2. Wrist support

The load on the upper extremities can also be reduced by supporting the wrists on the work surface, or on wrist or palm rests. Wrist rests are used widely within the workplace, with many different types available. Wrist or palm rests which are separate to the keyboard are generally placed adjacent to the front edge of the keyboard (Bendix and Jessen, 1986; Parsons, 1991; Hedge and Powers, 1995). Many more recent keyboard designs incorporate an inbuilt palm rest or wrist rest. The primary aim of wrist rests is to place the wrists in a neutral flexion/extension posture while typing (Albin, 2000).

Although wrist rests are widely used, the literature on the use of wrist rests is limited, inconclusive, and contradictory. Wrist support (desktop, or when a wrist rest is used) has been reported to increase intracarpal tunnel pressure (Horie et al., 1993), but has also been reported to reduce wrist flexion/extension resulting in more neutral wrist postures (Albin, 1997). Cobb et al. (1995) report increases in carpal tunnel pressure in cadavers as a result of pressure on the palm arising from supporting the palm on in built keyboard wrist rests. Other authors have reported that wrist support may increase neck and shoulder muscle load (Hagberg and Wegman, 1987).

Horie et al. (1993) reported an increase in intracarpal tunnel pressure when the wrist was supported in comparison with the "floating" posture. The wrist was positioned at 30° extension in the Horie et al. (1993) study (Albin, 2000). This wrist posture is associated with an increase in intracarpal tunnel pressure, irrespective of the support provided. No other published research could be found to substantiate the claim that wrist rest use increases intracarpal tunnel pressure. Wrist rest users are reported to be at possible risk of tendon strain due to mechanical friction on the tendons that pass over the wrists to the fingers. This is reported to be due to the fingers reaching to the keyboard, rather than movement being generated by the whole arm.

The composition of wrist rests has been reported to have an effect on lateral deviation of the wrist, with softer wrist rests associated with greater deviation than firmer (Albin, 2000). It is reported that soft wrist rests result in people anchoring their wrists, resulting in lateral deviation or stretching the fingers to reach the keys. A recent laboratory study reported that use of a firm wrist rest in conjunction with forearm support resulted in a decrease in lateral deviation, with correspondingly low angles of wrist extension. In this case, participants were observed to anchor at the forearms rather than the wrists (Cook and Burgess-Limerick, 2001).

1.3. Mouse use

Use of the computer mouse is widespread with most software applications requiring movement of a screen cursor controlled via a pointing device. Computer mouse usage has been demonstrated to account for up to two-thirds of computer operation time, depending on the software used and the task performed (Karlqvist et al., 1994).

Mouse users have been observed to work with the arm unsupported, the shoulder abducted and externally rotated, with the arm in forward flexion (Franzblau et al., 1993; Karlqvist et al., 1994; Cooper and Straker, 1998; Aaras et al., 1997; Fernstrom and Ericson, 1997; Harvey and Peper, 1997; Cook and Kothiyal, 1998; Karlqvist et al., 1998; Cook et al., 2000). Arm abduction has previously been described as a risk factor for neck/shoulder musculoskeletal symptoms.

Supporting the forearm during mouse use has been demonstrated to reduce upper extremity load. Cooper and Straker (1998) reported a lower muscle load in the upper trapezius during mouse use in comparison with keyboard use. They attributed this to the forearm support adopted by the subjects when using the mouse. Although recommendations are made to support the arm during use of input devices such as the mouse (HFES, 2001), the benefits of forearm support on wrist postures had not been documented for mouse use at a conventional desk. A recent laboratory study examined the effect of 2 desk types and three methods of support on muscle activity and wrist postures during mouse use. Muscle activity was reported to be least when the arm was fully supported on the worksurface, with extreme wrist extension and radial deviation postures reported regardless of support (Woods et al., 2002).

Mouse use is reported to be associated with a higher prevalence of wrist symptoms (Cook et al., 2000). Mouse users are reported to adopt postures of ulnar deviation and wrist extension (Karlqvist et al., 1994, 1998; Fernstrom and Ericson, 1997; Burgess-Limerick et al., 1999), postures documented to be risk factors for distal upper extremity musculoskeletal disorders (Hunting et al., 1981; Hagberg et al., 1995).

The effect of mouse use in conjunction with forearm support on symptoms was reported by Aaras et al. (1998). The authors reported a significantly higher intensity of pain in the forearm and hand for the group of subjects who used a mouse for 31% of their work day in comparison with another group who used a mouse for a mean of 19% of their work day. This study did not examine the effect of forearm support on wrist posture or muscle activity during computer mouse use.

1.4. Summary

There appears to be evidence that supporting the forearm on the work surface may increase comfort and decrease muscular load of the neck and shoulders, and decrease the time spent in ulnar deviation, thereby being a beneficial working position for keyboard users. As wrist rests are used widely in the workplace and are more commonly being incorporated in keyboard design, the effect of wrist rest use on wrist posture during forearm support should be examined. The effect of wrist rests and forearm support on wrist posture during mouse use has not been established.

The aims of this study were:

1. To examine the effect of wrist rest use on wrist posture and neck/shoulder muscle activity during keyboard use with supported forearms and
2. To examine the effect of a wrist rest and forearm support on wrist posture and neck/shoulder muscle activity during computer mouse use.

2. Methods

2.1. Participants

Fifteen healthy female volunteer computer users (median age 24 years; range 18–55 years) participated in the study. All participants were 10 finger touch typists. Although one participant was left handed, all participants normally used the mouse with their right hand. Three wore glasses for computer use. The median hours of computer use per week was 15 (range 3–30).

2.2. Design and measures

2.2.1. Keyboard task

Participants completed a 15 min copy typing task in each of two conditions: (a) wrist rest; (b) no wrist rest. Testing order was randomised. Participants were given a 10 min break between the keyboard test positions.

2.2.2. Mouse task

Immediately following the keyboard task, a 2 min mouse task was performed. Subjects were asked to move the cursor from the left to the right of the screen, clicking on the last and first word of alternative lines of the typed text.

2.3. Experimental setup

An adjustable chair, adjustable height computer table and standard Microsoft keyboard and mouse were used. The desk used was a conventional straight edged desk. In both test positions, the worksurface height was adjusted so that the forearms, but not the elbow were supported, and there was no shoulder elevation or depression. The chair was adjusted to enable to feet to be placed flat on the ground. A firm wrist rest of the same height as the keyboard (20 mm) was positioned in front of and touching the keyboard for the wrist rest test position. During mouse use, the mouse was positioned adjacent to the keyboard, resulting in support of most of the forearm by the desktop.

2.4. Data collection

The following data were collected:

(i) *Wrist angles*: Biaxial electrogoniometers were used to collect wrist flexion/extension and radial/ulnar deviation angles (Biometrics Ltd, Gwent, UK).

(ii) *Muscle activity*: Electromyographic (EMG) activity of the upper trapezius and anterior deltoid was recorded bilaterally via a Flex-Comp/DSP system (Thought Technology Ltd., Montreal).

2.4.1. Electrogoniometry

Bilateral twin axis electrogoniometers (XM65 sensors) were used to measure wrist flexion/extension and ulnar/radial deviation. The goniometers were taped to the forearm using double-sided medical tape and adhesive tape. The goniometers were positioned while the participants were sitting, elbows at 90° with their wrist in neutral and forearms in pronation resting on the desk surface. Reference lines were drawn over anatomical landmarks to enable accurate positioning of the goniometers (Bucholz and Wellman, 1997; Biometrics, 1999). Left and right electrogoniometers were calibrated in a neutral position. Reference position (0° flexion and deviation) was defined as the wrist angles when the forearms were supported on the tabletop, elbows at 90°, forearms in pronation.

2.4.2. Keyboard

Four 30 s samples of kinematic data were collected at 0, 5, 10 and 15 min into the keyboard task. Data was filtered at 80 Hz, a sampling rate of 31 samples/s was used, with an averaging constant of 500 ms.

2.4.3. Mouse

Data was collected continuously throughout a 2 min task for each of the two test conditions.

Maximum and mean angles, standard deviations and 95% confidence intervals of the effect size statistic (*d*) were calculated for each participant for each trial for each angle. Paired *t*-tests were used to assess the probability of obtaining effects of the observed magnitude given a null hypothesis of zero effect.

2.4.4. Electromyography

Silver–silver chloride surface electrodes (Thought Technology Ltd., Montreal) were positioned over the horizontal fibers of middle trapezius, a quarter of the distance from the acromion to the seventh cervical vertebra. Electrodes were positioned 6 mm apart over the belly of anterior deltoid (Basmajian and De Luca, 1985). All electrodes remained in situ throughout and between the test periods.

Reference contractions were recorded (15 s) while the participant was seated, using the following positions: trapezius—arms held at 90° abduction in the coronal plane, elbows straight, forearm pronated, holding 1 kg weight; anterior deltoid—arms held at 90° shoulder flexion, forearms pronated, elbows straight holding 1 kg weight.

2.4.5. Data collection

The 30 s samples were taken at 0, 5, 10 and 15 min during keyboard use and continually during mouse use. Root-mean-square (RMS) values of raw EMG signals were calculated for each of the recorded epochs. A 20 Hz highpass filter eliminated low frequency artifact, such as movement and a 50 Hz notch filter eliminated mains noise. Electromyographic signals were sampled at a rate of 992 Hz. RMS values of raw EMG signals were calculated with an averaging constant of 65 ms, for each recorded sample. Mean RMS values were calculated for each task for each participant. These mean values were represented as a proportion of the reference contraction (%RC). Paired *t*-tests were applied to mean EMG values (%RC) for each task. 95% confidence intervals of the effect size statistic (*d*) were calculated.

3. Results

3.1. Electrogoniometry

3.1.1. Keyboard

3.1.1.1. Wrist extension. There were no significant differences for right wrist flexion/extension between use of a wrist rest and no wrist rest. Left wrist extension was significantly higher without a wrist rest than with a wrist rest (Table 1). There were no significant differences between the right and left hands for wrist extension.

3.1.1.2. Ulnar deviation. No differences with respect to use of a wrist rest were found for the left or right hand for ulnar deviation. Group mean ranges of ulnar deviation were less than 10°. There were however, significant differences between the right and left hands for both conditions. When using a wrist rest, mean right deviation was 3° compared with 9° for the left hand ($t = 3.54$, $p = 0.003$). Without the wrist rest, mean right deviation was 3° and left was 10° ($t = 3.28$, $p = 0.005$) (Table 2).

Only one person typed in a mean wrist position of more than 20° ulnar deviation. This was with the right hand when using the wrist rest.

3.1.1.3. Mouse. Mean wrist extension during mouse use was in the extreme range (>30°), whether or not a wrist rest was used. Mean ulnar deviation was less than 10°, with the maximum ulnar deviation less than 20°, whether or not a wrist rest was used.

There were no significant differences for wrist flexion/extension (Table 1) or deviation (Table 2) when wrist rest use was compared with no wrist rest. Mouse use resulted in significantly greater angles of wrist extension and ulnar deviation than keyboard use for all test positions (Table 3).

3.2. Electromyography

3.2.1. Keyboard and mouse use

There were no differences between the test positions due to wrist rest use for either trapezius or anterior deltoid during keyboard or mouse use. However, there were significant differences in right sided muscle activity when comparisons were made between mouse and keyboard use. Group mean right trapezius muscle activity during mouse use with a wrist rest was significantly less than during keyboard use (Table 4). Similar results were found when no wrist rest was used. There were similar findings between mouse and keyboard use for the right anterior deltoid with a wrist rest, and without a wrist rest (Table 4).

Table 1
Summary statistics for wrist flexion/extension

	Mean degrees flexion/extension (SD)		*d*	CI		*t*	*p*
	Wrist rest	No wrist rest		Lower	Upper		
Keyboard							
Right	22.6 (11.7)	25.7 (12.2)	0.23	−0.16	6.41	2.04	0.06
Left	19.3 (13)	22.5 (13.5)	0.38	0.88	5.57	2.95	0.01
Mouse							
Right	34.6 (7)	36.2 (6.4)	0.12	−0.99	4.21	1.34	0.20

Positive values indicate degrees extension, negative values indicate degrees flexion.

Table 2
Summary statistics (mean and SD) for ulnar deviation for the keyboard and mouse

	Mean degrees (SD) Radial-ulnar deviation		*d*	CI		*t*	*p*
	Wrist rest	No wrist rest		Lower	Upper		
Keyboard							
Right	2.86 (7.9)	2.96 (7.9)	−0.13	−0.16	6.41	2.04	0.06
Left	19.3 (13)	22.5 (7.9)	0.38	0.88	5.57	2.95	0.01
Mouse							
Right	34.6 (7)	36.2 (6.4)	0.12	−0.99	4.21	1.34	0.20

Positive values indicate degrees of ulnar deviation, negative values indicate degrees of radial deviation.

Table 3
t-Test analysis of differences between keyboard and mouse use for wrist angles

	Mean	SD	SEM	95% CI	*t*	*p*
Extension—wrist rest	11.7	9.6	2.5	6.4–17.1	4.7	0.000
Extension—no wrist rest	10.1	9.8	2.6	4.4–15.8	3.8	0.002
Deviation—wrist rest	7.5	7.8	2.0	3.1–11.8	3.7	0.002
Deviation—no wrist rest	9.1	8.7	2.3	4–14.2	3.9	0.002

Table 4
Summary data of electromyography for the keyboard and mouse use with and without a wrist rest are shown

	Mean (SD)		SEM	CI		*t*	*p*
	Wrist rest	No wrist rest		Lower	Upper		
Keyboard							
R trapezius	29.6 (20)	32.1 (21)	2.7	−8.3	3.2	−0.9	0.3
L trapezius	17.3 (19)	13.2 (14)	2.1	−0.5	8.7	1.9	0.8
R deltoid	12.6 (10)	15 (14)	1.5	−5.6	0.9	−1.6	0.1
L deltoid	7.1 (5)	7.5 (6)	0.6	−1.5	0.9	−0.6	0.6
Mouse							
R trap	13.2 (7)	19.1 (23)	6.4	−19.7	8.0	−0.9	0.4
L trap	10.3 (9)	8.6 (7)	1.6	−1.6	5.1	1.1	0.3
R deltoid	2.8 (3)	2.2 (2)	0.4	−0.3	1.4	1.3	0.2
L deltoid	3 (5)	1.7 (2)	0.9	−0.6	3.1	1.5	0.2

Mean, standard errors of group mean RMS values (root mean square) for muscle activity for keyboard and mouse use with and without a wrist rest are shown. Upper and lower 95% confidence intervals (CI) of effect size are tabulated as are the results of paired *t* tests (*t*) and level of significance (*p*), df = 13.

4. Discussion

This study examined the effect of wrist rest use in conjunction with forearm support for keyboard and mouse use. Minimal differences were found in muscle activity or wrist posture when a wrist rest was used for either keyboard or mouse use. The only significant finding was a decrease in mean left wrist extension when using a wrist rest during keyboard use. However, because the mean range of wrist extension bilaterally was between 19° and 24° extension, whether or not a wrist rest was used, the difference between the positions is unlikely to be clinically relevant.

The magnitude of wrist extension reported in the current study is consistent with previous findings in which the floating posture was studied during keyboard use (Serina et al., 1999; Chen et al., 1994). Wrist extension was greater than in a previous laboratory study on forearm support (Cook and Burgess-Limerick, 2001). In that study, a wrist rest was in situ for all test conditions, and wrist angles were measured using 2-D video analysis, utilising markers viewed by lateral cameras. The different methods used for measuring wrist extension (video analysis vs. electrogoniometer) do not enable comparisons to be made between the two studies. Electrogoniometers such as used in the current study are mounted on the dorsum of the hand/forearm over the 3rd metacarpal and midline of the wrist, resulting in extension angles taken from the middle of the hand (Serina et al., 1999). In 2-D video analysis, markers are placed over the head of the 5th metacarpal, the styloid process and the lateral epicondyle, resulting in angles taken from the medial border of the hand. Studies in which data has been collected using markers on the medial edge of the hand generally report lower ranges of extension (11–13°) than those using electrogoniometers (range 17–25°).

The use of forearm support with or without a wrist rest resulted in mean wrist angles of almost neutral ulnar deviation, much lower than the range of 11–25° previously reported for standard keyboard use (Chen et al., 1994; Serina et al., 1999). These findings were consistent with those for Cook and Burgess-Limerick (2001), where significantly less ulnar deviation and less time spent in extremes of ulnar deviation during keyboard use were associated with forearm support. Neutral postures during keyboard use are desirable as wrist positions of $2 \pm 6°$ ulnar deviation have been associated with the lowest carpal tunnel pressure (Weiss et al., 1995). Use of forearm support appears to have a positive effect by decreasing the amount of ulnar deviation during keyboard use, whether or not a wrist rest is used. This finding is consistent regardless of whether the measurement is made using video analysis or electrogoniometry.

The difference between the hands for ulnar deviation is consistent with previous findings (Simoneau and Marklin, 2001), although the mean deviation was much higher in that study (right mean 10.5°, left mean 15.9°). Possible reasons for differences between the hands during keyboard use may be due to the arrangement and usage of the keys or differences in text. As ulnar deviation in the current study was less than 10° bilaterally, these differences are unlikely to be clinically relevant.

There were no differences in muscle activity for either the trapezius or deltoid between the conditions for either keyboard or mouse use. The magnitude of group mean muscle activity (30% RVC for right trapezius) during keyboard use was consistent with previous findings of forearm support. Forearm or wrist support had been found to result in significantly less muscle activity than the floating posture (Cook and Burgess-Limerick, 2001). Consistent with previous findings (Cooper and Straker, 1998), trapezius muscle activity was lower during mouse than keyboard use, irrespective of whether or not a wrist rest was used. The previous differences had been attributed to the unloading of the neck musculature due to arm support during mouse use. These differences in this study were somewhat unexpected as forearm support was provided for both mouse and keyboard use.

No differences were found for muscle activity or wrist posture during mouse use, irrespective of wrist rest use. Group mean angles for wrist extension were higher in the current study than those previously reported in the literature (19–26°) (Jensen et al., 1998; Burgess-Limerick et al., 1999; Karlqvist et al., 1999; Bystrom et al., 2002). However, they were lower than those found by Woods et al. (2002) who reported mean wrist extension as 36° when the wrist was supported, 44° when the forearm was supported and 39° without support. It is difficult to determine whether the differences in wrist extension reported are related to the work station setup, due to the limited information on the workstation and mouse type provided in some studies (Jensen et al., 1998) and the variability of working postures adopted in others (Woods et al., 2002). Working posture did not appear to be controlled during the experiment conducted by Woods et al. (2002), with the distance between the mouse and the subject varying by up to 370 mm in one test condition. The photographs indicate that a variety of working postures was adopted within each test condition. Two studies reported that subjects were able to support their forearm on the work surface (Bystrom et al., 2002) with one of these studies also reporting the option for participants to use chair arms for forearm support (Karlqvist et al., 1999). As arm support was an option rather than a requirement in those studies, it is difficult to determine the effect of arm support on wrist postures. Keyboards were used in conjunction with pointing devices in all except one study (Burgess-Limerick et al., 1996). The position of the mouse with respect to the keyboard may also have an impact on wrist posture, however the lack of detail that can be provided in publications makes exact working postures used in other studies difficult to determine.

Mean and maximum angles of ulnar deviation during mouse use were lower than the previously reported 10–30° in the literature (Burgess-Limerick et al., 1999; Karlqvist et al., 1994; Jensen et al., 1998; Karlqvist et al., 1999). Interestingly, both of the studies in which forearm support was an option reported lower ranges of ulnar deviation, supporting the findings of this study, with Woods et al. (2002) reporting means of between 20° and 27° radial deviation regardless of desk type and arm support.

The findings regarding inter-individual differences during pointing device use were consistent with those found in the literature, especially for ulnar deviation, although the range of ulnar deviation was less than previously reported (Burgess-Limerick et al., 1999; Karlqvist et al., 1999; Bystrom et al., 2002).

4.1. Conclusions

There is evidence that provision of forearm support using a conventional straight edged desk is beneficial to both keyboard and mouse users, irrespective of whether or not a wrist rest is used. Upper extremity muscle load is decreased, as is lateral deviation of the wrist. Forearm support appears to have minimal effects on wrist extension during keyboard and mouse use.

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