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A Randomized Controlled Trial Evaluating an Alternative Mouse or Forearm Support on Change in Median and Ulnar Nerve Motor Latency at the Wrist

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Background *The purpose of this study was to determine the effects of an alternative mouse and/or a forearm support board on nerve function at the wrist among engineers.*
Methods *This randomized controlled intervention trial followed 206 engineers for 1 year. Distal motor latency (DML) at baseline and follow-up was conducted for the median and ulnar nerves at the right wrist.*
Results *One hundred fifty-four subjects agreed to a nerve conduction study at the beginning and end of the study period. Those who received the alternative mouse had a protective effect (OR = 0.47, 95% CI 0.22–0.98) on change in the right ulnar DML. There was no significant effect on the median nerve DML. The forearm support board had no significant effect on the median or ulnar nerve DML.*
Conclusions *In engineers who use a computer for more than 20 hr per week, an alternative mouse may have a protective effect for ulnar nerve function at the wrist. No protective effect of a forearm support board was found for the median nerve.* Am. J. Ind. Med. 52:304–310, 2009. © *2009 Wiley-Liss, Inc.*

KEY WORDS: RCT; carpal tunnel syndrome; entrapment neuropathy; median mononeuropathy; ulnar neuropathy; computer use; Guyon tunnel syndrome

INTRODUCTION

Several studies have demonstrated an increased risk of carpal tunnel syndrome with increasing hours of computer mouse use [Stevens et al., 2001; Andersen et al., 2003]. The risk factors associated with the conventional mouse are contact pressure on the palm, a pronated forearm posture, repeated or sustained pinching, wrist extension, or wrist deviation. These risk factors may increase compression of the median nerve and, therefore, increase the risk for carpal tunnel syndrome [Rempel et al., 1998, 1999; Keir et al., 1999]. The alternative mouse intervention we studied, which is used in a neutral forearm position instead of a pronated forearm, may reduce these risk factors and, therefore, reduce the risk for developing or aggravating a median nerve entrapment neuropathy at the wrist. The second intervention, a padded forearm support board, might reduce risk by decreasing contact pressure over the volar palm and wrist.

Similarly, the alternative mouse may reduce contact stress over the ulnar nerve by transferring the arm weight, when resting the wrist on a desk surface, from the volar surface of the wrist to the ulnar side of the hand. There have been no prospective or cross-sectional studies of the ulnar nerve at the wrist in computer users. Factors reported to be associated with ulnar neuropathy at the wrist (Guyon tunnel

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syndrome) include anatomic abnormalities, hypothenar hammer syndrome, or fractures of the wrist and hand [Haferkamp, 1998]. An increased occupational risk has been described with forceful activities in meat packers [Streib and Sun, 1984]. Bicyclists may also be at increased risk due to compressive force at the wrist [Akuthota et al., 2005].

Previously we presented findings from a 1-year randomized controlled trial on the effects of two computer workstation interventions (a large forearm support board and an alternative mouse) on upper extremity and neck incident musculoskeletal disorders and discomfort among 206 engineers [Conlon et al., 2008]. The forearm support board was associated with a significant reduction in right upper extremity discomfort and the alternative mouse had a protective, but non-significant ($P = 0.20$), effect on incident right upper extremity musculoskeletal disorders and right upper extremity discomfort. The current article presents the changes in median and ulnar nerve conduction latency at the wrist across the study period in the same subjects.

METHODS

Study Design and Subjects

This 1-year, randomized controlled trial was carried out from 2002 to 2003 at a large aerospace engineering firm in California. The study design was reviewed and approved by the UC San Francisco Committee on Human Research. Details of the study design have already been presented [Conlon et al., 2008]. To be eligible for the study, subjects had to report using a computer at work for at least 20 hr per week. However, as reported on the weekly surveys during the study, the actual computer use varied and was as low as 15 hr per week in some cases. Since one of the mouse interventions could only be used right-handed, only those who agreed to use their right hand for the mouse pointing device intervention were eligible for the study. Participants were randomized to receive one of four intervention combinations: (1) a conventional mouse only, (2) an alternative mouse only, (3) a conventional mouse plus a forearm support board, and (4) an alternative mouse plus a forearm support board (see Fig. 1).

Outcome Measures

On the day each subject received their workstation intervention they were asked if they would volunteer to undergo nerve conduction testing. The nerve conduction testing was performed using an automated electrophysiologic neurodiagnostic device (NC StatTM, Neurometrix, Inc., Waltham, MA) to measure the distal motor latency (DML) of the median and ulnar nerve at the right and left wrists. The device calculates the median or ulnar distal motor latency (calculated DMLs) and adjusts for skin temperature.

FIGURE 1. The study interventions were the padded forearm support board, the optical mouse (left; conventional) and the 3M mouse (right; alternative).

Details regarding the device and method of measurement have been reported previously [Conlon and Rempel, 2005]. As each subject exited the study, they were asked to undergo follow-up nerve conduction testing. Subjects exited the study at 1 year, or earlier, if they changed employment or they elected to discontinue use of a study intervention.

Data Analysis

The baseline DML for each nerve was subtracted from the final DML. An increase of greater than 0.10 ms over the study period was set as the threshold to identify participants as having an adverse prolongation of the DML. The choice of this threshold was based on setting a value well above the expected 0.02 ms/year increase with aging for the sensory median nerve latency [Tong et al., 2004]. Logistic regression methods were used to estimate the odds ratio for developing a prolonged DML for each nerve by intervention group. An odds ratio of less than 1.0 indicates that more participants in the intervention group improved compared to the control group. The control groups were the participants who were either not assigned the board (for the board analysis) or received the conventional mouse (for the alternative mouse analysis).

The covariates of age, gender, body mass index, and a psychosocial variable measuring job stress (effort-reward imbalance) were forced into all logistic regression models. Of the other 23 potential covariates that were considered, those covariates that were not evenly distributed among the intervention groups were individually examined for additional confounding in multivariate models that included the forced covariates. Potential covariates with a P-value of less than 0.50 in the univariate analysis were then tested in a combined model. Those variables with the highest P-value were sequentially eliminated from this combined model. The final model included only those variables with a P-value less than 0.10. Variables considered likely to influence changes in nerve conduction over the course of the study, and variables previously reported to be associated with carpal tunnel

syndrome were included in the univariate and multivariate analysis. These variables included a history of diabetes or thyroid disorders, pregnancy, post-menopausal status, current use of estrogens, hand dominance, preferred mousing hand, and time between initial and follow-up nerve testing.

The initial full models with interaction revealed that the interaction terms between interventions were not statistically significant. Therefore the subsequent models were simplified to compare those who received the alternative mouse (with and without the forearm support board) to those who received the conventional mouse, and, in a separate analysis, those who received the forearm support board (with and without the alternative mouse) to those who did not receive the board.

RESULTS

Of the 206 engineers who were in the randomized controlled trial, 154 agreed to have nerve conduction studies done at both the baseline and follow-up. The follow-up nerve conduction study was performed for the median nerve in 150 subjects and for the ulnar nerve in 151 subjects (Table I). Most of the follow-up studies were performed between 10 and 12 months after the intervention. The nerve conduction equipment failed to obtain a median nerve DML for four participants and an ulnar DML for three participants. Mean baseline ulnar DML was 2.59 ms (SD = 0.28) and mean baseline median DML was 3.70 (SD = 0.50). The overall number of participants, whose DML increased by more than 0.10 ms was 47 for the right median nerve and 68 for the right ulnar nerve.

The subjects who volunteered for nerve conduction testing (N = 154) did not differ in important ways from those who declined nerve testing at baseline (N = 52) on age, gender, mean pre-intervention right upper extremity discomfort, hours of work per week, hours of computer use at work per week, or body mass index (Table II). Table III presents the distribution of covariates between the intervention groups for the subjects (N = 154) who had nerve conduction testing at baseline. There were no important differences between intervention groups for these covariates. A split keyboard was used by 23 of the participants; however, there was no significant difference in the distribution of these keyboards between treatment groups (Chi-square test, $P = 0.76$).

The effects of each intervention on the ulnar and median nerve DMLs in comparison to the non-intervention group in the unadjusted and in the final adjusted logistic models are presented in Table IV. The only statistically significant finding was that the alternative mouse had a protective effect on the ulnar nerve DML in comparison to the conventional mouse, with the frequency of a 0.10 ms DML increase occurring half as often for the alternative mouse group (OR = 0.47, 95% CI 0.22–0.98, $P = 0.04$). There were no significant effects of either intervention on the right median nerve latency. No significant effects were found for either intervention on the left median or ulnar nerve latency.

The analysis was repeated treating the change in motor latency as a continuous variable using regression methods. The results of fully adjusted models indicated no significant effect of mouse or board on change in median nerve latency, but there was a trend for an effect of mouse and board on ulnar nerve latency (mouse: β-coefficient = −0.0625, $P = 0.19$; board: β-coefficient = 0.058, $P = 0.22$).

In addition to the linear regression analysis described above, a sensitivity analysis was performed for the logistic regression model by testing the effect of using different changes in latency thresholds, instead of 0.10 ms. For the effect of the alternative mouse on right ulnar nerve, a 0.05 ms threshold was associated with an OR of 0.59 (P-value = 0.14), while a threshold of 0.20 ms was associated with an OR of 0.52 (P-value = 0.10). The sensitivity analysis for the right median nerve and the board were little changed and remained non-significant.

TABLE I. Number of Subjects With Both Baseline and Follow-Up Nerve Conduction Studies, and the Time Between the Baseline and Follow-Up Test (N = 154)

	Right ulnar DML	Right median DML
Number of subjects		
Baseline	151	152
Follow-up	151	150
Time between studies		
1–3 months	16 (10.6%)	14 (9.3%)
4–6 months	11 (7.3%)	10 (6.7%)
7–9 months	9 (6.0%)	10 (6.7%)
10 or more	115 (76.2%)	116 (77.3%)
Total	151 (100.0%)	150 (100.0%)

DISCUSSION

In this randomized controlled trial among engineers who used a computer for more than 20 hr per week, the findings indicate that a mouse that requires a neutral forearm posture and reduces pronation may have a protective effect on the ulnar nerve at the wrist. There was no significant effect of the alternative mouse on change in median nerve latency. In our previous article of the same study, the symptoms and physical examination findings demonstrated that the alternative mouse was associated with a non-significant, protective effect on the incidence of right upper extremity musculoskeletal disorders (hazard ratio = 0.57, P-value = 0.20) [Conlon et al., 2008]. This mouse was also associated with a

TABLE II. Comparison of Nerve Test Participants to Non-Participants

Characteristic	Participants (n = 154), number (SD)	Non-participants (n = 52), number (SD)	*P*-value
Mean age (years)	42.8 (9.5)	42.9 (10.7)	0.81
Gender (% male)	73.0 (.04)	68.4 (.06)	0.40
Right upper extremity baseline discomfort (mean rating)[a]	1.72 (1.93)	1.76 (2.07)	0.79
Work hours (hr/week)	41.5 (3.5)	41.5 (3.6)	0.85
Computer use at work (hr/week)	28.6 (6.6)	29.8 (8.4)	0.26
Body mass index (kg/m^2)	26.8 (5.1)	26.2 (4.1)	0.40
Total months of computer use at >20 hr/week	216 (119)	216 (146)	0.95

[a]Discomfort range 0–10.

TABLE III. Characteristics of Participants by Intervention Group

	Interventions			
	Conventional mouse (n = 42), mean (SD) or %	Alternative mouse (n = 39), mean (SD) or %	Board plus conventional mouse (n = 40), mean (SD) or %	Board plus alternative mouse (n = 33), mean (SD) or %
Work history				
Job title				
Engineer	79%	83%	78%	67%
Leader	14%	10%	15%	18%
Manager	7%	8%	8%	15%
Seniority in months	203 (121)	216 (111)	223 (141)	239 (116)
Effort-reward imbalance score[a]	0.56 (0.18)	0.52 (0.19)	0.58 (0.31)	0.60 (0.24)
Split keyboard use (vs. standard)	12%	18%	13%	18%
Demographic characteristic				
Female gender	33%	18%	18%	27%
Age in years	41.0 (8.4)	42.9 (11.2)	42.7 (10.1)	46.4 (8.3)
Body mass index	27.2 (4.6)	26.6 (6.0)	26.8 (5.4)	26.7 (4.3)
Right-handed	86%	87%	87%	91%
Single	26%	23%	23%	26%
Ethnicity				
African American	4%	0%	0%	0%
Asian or Pacific Islander	14%	27%	15%	12%
Hispanic	12%	15%	10%	6%
White	67%	58%	70%	81%
Other	2%	0%	5%	0%
Current smoker	5%	0%	0%	9%
Activity hours per week (off of work)				
Hand intensive	15.4 (13.8)	14.9 (12.2)	13.5 (10.6)	14.3 (10.8)
Aerobic	1.32 (2.12)	1.84 (2.29)	2.43 (2.92)	2.42 (4.20)
Pre-intervention upper body discomfort scores				
Neck–shoulder	1.58 (1.97)	2.02 (1.91)	1.95 (2.32)	2.52 (2.45)
Right upper extremity	1.66 (1.71)	1.40 (1.76)	1.52 (1.60)	2.33 (2.60)
Left upper extremity	0.75 (1.20)	0.61 (0.92)	1.07 (1.80)	0.62 (0.95)

[a]Higher values indicate lower effort-reward imbalance.

TABLE IV. Crude and Adjusted Odds Ratios Evaluating the Effects of Interventions on Prolongation of the Distal Motor Latency for the Median and Ulnar Nerve at the Right and Left Wrist

	Intervention					
	Alternative mouse			Forearm support board		
	Odds ratio	95% CI	*P*-value	Odds ratio	95% CI	*P*-value
Right wrist						
Ulnar nerve						
Unadjusted model[a]	0.52	0.26–1.02	0.06	1.47	0.75–2.89	0.26
Adjusted model[b]	0.47	0.22–0.98	0.04	1.42	0.70–2.90	0.33
Median nerve						
Unadjusted model[a]	0.75	0.37–1.53	0.43	0.83	0.40–1.69	0.60
Adjusted model[c]	0.72	0.33–1.57	0.40	0.74	0.34–1.63	0.46
Left Wrist						
Ulnar nerve						
Unadjusted model[a]	0.84	0.42–1.66	0.61	0.61	0.30–1.20	0.16
Adjusted model[d]	0.84	0.41–1.74	0.64	0.64	0.31–1.35	0.24
Median nerve						
Unadjusted model[a]	1.02	0.51–2.03	0.99	1.41	0.70–2.83	0.34
Adjusted model[e]	0.76	0.34–1.68	0.50	1.39	0.65–2.98	0.39

[a]Crude or unadjusted model has forced age, gender, body mass index, and effort-reward imbalance.
[b]Forced age, gender, body mass index and effort-reward imbalance with addition of co-variates blood pressure medications, use of diabetes medications, and physical exhaustion.
[c]Forced age, gender, body mass index and effort-reward imbalance with addition of covariates oopherectomy, use of birth control pills, number of breaks per day, physical exhaustion, mental exhaustion and role limitations due to physical function.
[d]Forced age, gender, body mass index and effort-reward imbalance with addition of covariates, hours computer use per week at work, total aerobic activity in hours per week, hand dominance, mousing hand at baseline, blood pressure medication use, total upper extremity intensive work at home in hours per week, and pain medication use.
[e]Forced age, gender, body mass index and effort-reward imbalance with addition of covariates words per minute typing speed, total months working as an engineer at $>$20 hr of computer use per week at work, hand dominance, number of breaks per day, use of diabetes medications, hours of driving per week, and pain medication use.

non-significant, weakly protective effect for right upper extremity discomfort (β-coefficient $= -0.11$, $P = 0.50$). The subjects were not asked specific questions that could have been correlated to the nerve conduction findings, such as numbness, tingling, or burning in the median or ulnar nerve distribution in the hand.

The study is also interesting for the lack of benefit for the right or left median nerve with the use of the forearm support board. In our previous article, the group that received the forearm support board experienced a reduction of their right upper extremity discomfort (β-coefficient $= -0.35$, 95% CI $= -0.67$ to -0.03) in comparison to those who did not receive a forearm board. The improvement of right upper extremity symptoms with the forearm support is, therefore, unlikely to be due to changes in nerve function. Instead, the improvement of symptoms is more likely to be due to reduced discomfort associated with wrist or elbow tendonitis.

The findings of this study are consistent with prior studies that have shown a benefit with a neutral forearm posture mouse. Aaras et al. [1999, 2001, 2002], in a study of moderately symptomatic computer users at a telecommunications company, found that a neutral forearm posture mouse led to a reduction in pain severity for the wrist/hands, forearm, shoulder, and neck in comparison to a control group.

The regression analysis and sensitivity analyses described above did not statistically confirm the beneficial effect of the alternative mouse on the right ulnar nerve conduction. However, the findings of the regression analysis and the sensitivity analyses were in a similar direction and magnitude to the 0.10 ms threshold. Therefore, the strength of the association between the alternative mouse and the ulnar nerve latency at the right wrist is bolstered by the consistency and direction of the odds ratios and β-coefficient, but tempered by the lack of statistical significance with the sensitivity analysis and linear regression.

A potential concern with the alternative mouse was that during use the ulnar aspect of the hand and wrist rests on a hard surface on the mouse and this might cause ulnar nerve extraneural compression. The protective effect of the alternative mouse observed in our study should alleviate this concern.

Our results are more equivocal for the forearm support board. The results suggest an adverse effect on the ulnar nerve and a weakly beneficial effect on the median nerve

at the wrist; however, these results were not statistically significant. Our prior article reported that the forearm support board was protective for pain in the right distal upper extremity, but it was not protective against the development of incident right upper extremity musculoskeletal disorders.

The effects seen in prior studies of forearm support devices on upper body pain or musculoskeletal disorders have been mixed [Cook and Burgess-Limerick, 2004; Gerr et al., 2005]. In a 1-year randomized controlled trial of 182 customer service operators, Rempel et al. [2006] found beneficial effects of a forearm support board on incident neck–shoulder disorders as well as neck and right upper extremity pain scores. The forearm support board was different from the one used in our study, in that it was smaller and provided a horizontal support surface about 2.5 cm above the keyboard support surface. This elevated support surface would lead to less wrist extension than achieved with use of the support board in the current study.

Studies on risk factors for ulnar neuropathy at the wrist are scarce. In a study of unembalmed cadavers, Byl et al. [2002] measured strain on the ulnar nerve in the upper extremity during continuous movement and found that forearm pronation increased the strain and finger flexion decreased the strain. Wright et al. [2001] also demonstrated that the ulnar nerve at the wrist moved distally 4.4 mm with pronation and 3.7 mm with finger extension. Based on these findings, the alternative mouse in comparison to the control mouse would be expected to reduce strain on the ulnar nerve by reducing pronation and finger extension.

In a study of carpal tunnel pressure by Rempel et al. [1998], there was an increase in pressure with full supination of the forearm and the lowest pressure was at 45 degrees of pronation. However, the pressure at full pronation versus 0° rotation was approximately the same. Therefore, given that the alternative mouse in this study places the forearm at 0° of rotation, it may not be surprising that our study did not demonstrate a significant benefit for the median nerve in comparison to the full pronation of the control mouse. In the Byl and Rempel studies, flexing the fingers resulted in reduced carpal tunnel pressure and median nerve strain, respectively. Finger flexion is more likely with the alternative mouse used in this study.

Several limitations of the study deserve mention. The nerve conduction studies were not performed by traditional motor nerve conduction methods; however, there is good correlation between traditional nerve conduction studies and the NC Stat device used in this study for median nerve distal motor latencies [Leffler et al., 2000; Armstrong et al., 2008]. Conclusions about carpal tunnel syndrome and Guyon tunnel syndrome cannot be drawn, since subjects were not questioned about symptoms or examined for signs of peripheral neuropathy at the time of the follow-up testing. The 1-year duration of the study may have been insufficient time to see significant changes in median and ulnar nerve function. Thirteen subjects in the alternative mouse group and six subjects in the forearm support group terminated the use of their intervention during the first 2 months of the study due to problems with their intervention. Common subject complaints included difficulty using the alternative mouse for fine pointing tasks and difficulty accommodating the support board on the workstation due to insufficient office space. This early dropout may have led, for some subjects, to too short a duration of follow-up to expect a change in motor latency. However, no significant differences in dropout rates were observed between intervention groups. The alternative mouse used in this study required the use of the right hand. No subjects were eliminated or declined to participate in the study due to this requirement. Furthermore, ''hand dominance'' and ''left hand mouse use'' at baseline were included in the data analysis process but were eliminated during the step-wise elimination of variables. Therefore, it is not likely that the requirement to use the alternative mouse with the right hand biased the findings of the study.

Since ulnar neuropathy at the wrist is relatively uncommon in comparison to median neuropathy at the wrist, the protective effect on the ulnar nerve with the alternative mouse may be a minor benefit for computer users.

In conclusion, this study demonstrates a potential beneficial effect of an alternative mouse, which reduces pronation, in comparison to a conventional mouse, on ulnar nerve DML among engineers who use a computer for more than 20 hr per week. Computer users with ulnar neuritis may benefit from use of this alternative mouse. No benefit was demonstrated for the median nerve.

REFERENCES

Aaras A, Ro O, Thoresen M. 1999. Can a more neutral position of the forearm when operating a computer mouse reduce the pain level for visual display operators? A prospective epidemiological intervention study. Int J Hum Comput Interact 11:79–94.

Aaras A, Dainoff M, Ro O, Thoresen M. 2001. Can a more neutral position of the forearm when operating a computer mouse reduce the pain level for visual display operators? A prospective epidemiological intervention study. Part II. Int J Hum Comput Interact 13:13–40.

Aaras A, Dainoff M, Ro O, Thoresen M. 2002. Can a more neutral position of the forearm when operating a computer mouse reduce the pain level for visual display operators? A prospective epidemiological intervention study. Int J Ind Ergo 30:307–324.

Akuthota V, Plastaras C, Lindberg K, Tobey J, Press J, Garvan C. 2005. The effect of long-distance bicycling on ulnar and median nerves: An electrophysiologic evaluation of cyclist palsy. Am J Sports Med 33: 1224–1230.

Andersen JH, Thomsen JF, Overgaard E, Lassen CF, Brandt LP, Vilstrup I, Kryger AI, Mikkelsen S. 2003. Computer use and carpal tunnel syndrome: A 1-year follow-up study. JAMA 289:2963–2969.

Armstrong TA, Dale AM, Al-Lozi MT, Franzblau A, Evanoff BA. 2008. Median and ulnar nerve conduction studies at the wrist: Criterion

validity of the NC-stat automated device. J Occup Environ Med 50:758–764.

Byl C, Puttlitz C, Byl N, Lotz J, Topp K. 2002. Strain in the median and ulnar nerves during upper-extremity positioning. J Hand Surg 27A: 1032–1040.

Conlon C, Rempel D. 2005. Upper extremity mononeuropathy among engineers. J Occup Environ Med 47:1276–1284.

Conlon CF, Krause N, Rempel DM. 2008. A randomized controlled trial evaluating an alternative mouse and forearm support on upper body discomfort and musculoskeletal disorders among engineers. Occup Environ Med 65:311–318.

Cook C, Burgess-Limerick R. 2004. The effect of forearm support on musculoskeletal discomfort during call centre work. Appl Ergon 35: 337–342.

Gerr F, Marcus M, Monteilh C, Hannan L, Ortiz D, Kleinbaum D. 2005. A randomized controlled trial of postural interventions for prevention of musculoskeletal symptoms among computer users. Occup Environ Med 62:478–487.

Haferkamp H. 1998. Ulnar nerve compression of the wrist. Langenbecks Arch Chir Suppl Kongressbd 115:635–640.

Keir PJ, Bach J, Rempel D. 1999. Effects of computer mouse design and task on carpal tunnel pressure. Ergonomics 42(10):1350–1360.

Leffler CT, Gozani SN, Cros D. 2000. Median neuropathy at the wrist: Diagnostic utility of clinical findings and an automated electrodiagnostic device. J Occup Environ Med 42:398–409.

Rempel DM, Bach J, Gordon L, Tal R. 1998. Effects of forearm pronation/supination on carpal tunnel pressure. J Hand Surg 23(1):38–42.

Rempel D, Lundborg G, Dahlin L. 1999. Pathophysiology of nerve compression syndrome: Response of peripheral nerves to loading. J Bone Joint Surg 81-A(11):1600–1610.

Rempel DM, Krause N, Goldberg R, Benner D, Hudes M, Goldner GU. 2006. A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. Occup Environ Med 63:300–306.

Stevens JC, Witt JC, Benn ES, Weaver AL. 2001. The frequency of carpal tunnel syndrome in computer users at a medical facility. Neurology 56:1568–1570.

Streib EW, Sun SF. 1984. Distal ulnar neuropathy in meat packers. An occupational disease? J Occup Med 26:842–843.

Tong H, Werner R, Franzblau A. 2004. Effect of aging on sensory nerve conduction study parameters. Muscle Nerve 29:716–720.

Wright TW, Glowczewskie F, Cowin D, Wheeler DL. 2001. Ulnar nerve excursion and strain at the elbow and wrist associated with upper extremity motion. J Hand Surg 26A:655–662.