Hand Dominance Effect on Median and Ulnar Sensory Evoked Amplitude and Latency in Asymptomatic Workers

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Objective: To examine the relative effect of hand dominance on the median and ulnar sensory evoked responses and grip strength in active workers.

Design: A cross-sectional or survey design.

Setting: Workers from 4 different sites underwent on-site testing of the median and ulnar sensory nerves in both hands (antidromic stimulation, 14cm), and testing of bilateral grip strength.

Patients: 224 workers, asymptomatic of hand, wrist, or finger pain, numbness, or tingling; 87% were right handed.

Main Outcome Measures: Amplitude and latency of the median and ulnar sensory response and the grip strength of each hand.

Results: The amplitude of the median sensory response in the dominant hand was significantly lower in right handed individuals (34.6μV versus 38.8μV) but not in left handed workers (34.2μV versus 34.3μV). A similar relationship held for the ulnar evoked responses and the grip strength. Median and ulnar sensory latencies in right handed individuals did not differ side to side, whereas left handed workers had a slightly shorter latency on the left.

Conclusions: The left hand of a right handed worker may not be exposed to as much trauma, resulting in relative protection of the nerves in the hand and a higher amplitude of the left median and ulnar evoked response. Left handed individuals may be more likely to use both hands equally and thus expose the nerves in each hand to an equal amount of trauma, resulting in their sensory amplitudes being equivalent (and also equal to the dominant hand of a right handed individual).

THE ROLES of repetition, force, and posture in the development of carpal tunnel syndrome (CTS) are controversial. Because of many host specific factors, and because the quantification of hand-intense activities is cumbersome, the exact role of hand activity in relation to CTS is not known. Reinstein[1] demonstrated that CTS was more common in the dominant hand and suggested that the increased activity of the dominant hand was a contributing factor in the development of CTS. Kucera and Robins[2] demonstrated that the degree of hand dominance was related to the presence of upper extremity cumulative trauma disorders in the ipsilateral arm.

The effect of hand dominance on median and ulnar sensory evoked responses has not been widely studied.[3-12] A few studies in adults found that the amplitude of the right median sensory evoked response was smaller than that of the left, but the data were not stratified by right and left hand dominance.[3,11,12] Also, in most of these studies, the sample sizes were small and subjects were not recruited from an industrial setting. Nathan and coworkers[6] recruited subjects from an industrial population but only reported differences in the distal latencies. They found that children had equivalent median distal latencies in dominant versus nondominant hands, but in an older working population there was a trend for the latency in the dominant hand to increase compared with that in the nondominant hand.

We hypothesized that the dominant hand in an industrial worker would be exposed to more repetition, force, and awkward postures when compared with the nondominant hand; therefore, the amplitudes and distal latencies of the median and ulnar sensory nerve evoked responses would be smaller and longer, respectively, in the dominant hand of asymptomatic industrial workers.

METHODS

A cross-sectional screening research design was used to test the median and ulnar sensory evoked responses of industrial workers in four different settings within the midwest. The industrial sites included an automobile parts manufacturer, a furniture manufacturer, a paper container manufacturer, and the clerical staff of an insurance company. The data were collected as part of a larger study that selected specific jobs at each site based on the degree of repetition required for specific jobs. All workers at the identified jobs were invited to participate regardless of their tenure on the job. Among eligible workers at the four study sites, there was an average participation rate of 82%, with a range of 75% to 89%. All subjects signed a written consent form that was approved by our Institutional Review Board. Each subject completed a symptoms questionnaire as well as a self-report of hand dominance, tenure on the job, and medical history of diabetes or peripheral neuropathy.

Grip and pinch strength were collected in a subset of the workers (the automotive part manufacturer and the furniture manufacturer). Each hand was tested 3 times using a grip dynamometer[a] and pinch dynamometer.[b] Pinch testing was done using the force between the distal pad of the thumb and the radial edge of the proximal second digit. The average of the three trials was used for statistical analysis. The subject was given verbal encouragement with each trial. Circumferences of both index fingers were measured (in millimeters) for each subject.

Electrodiagnostic studies of the median and ulnar sensory nerve were conducted bilaterally using the techniques described by Kimura.[13] The tests were done using antidromic stimulation,

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a distance of 14cm, recording with ring electrodes at supramaximal stimulation. A standard interelectrode distance of 3cm was used. Hand temperature was recorded and the hand was warmed if the midpalmar temperature was below 32°C. All studies were performed on-site by a board-certified electromyographer and a certified electrodiagnostic technician on a TECA TD 20.[c] The peak latency and the amplitude (baseline to peak) were recorded for each sensory nerve.

Statistical analysis included *t* tests, using matched pairs, of the amplitude and latency differences of the dominant versus nondominant hand. The analysis was stratified by right and left hand dominant individuals. The analysis was run for the whole population and then stratified by each plant. Correlation coefficients between dominant and nondominant evoked potential measures were also run. Only individuals who were free of pain or other discomfort of the fingers, hand, or wrist were included in the analysis. A total of 224 workers met these criteria. The analysis was run using all workers and again with diabetic workers excluded.

RESULTS

Five hundred six persons were eligible for the field surveys, and 82% participated, of whom 224 reported no symptoms in the wrists, hands, or fingers. Of the 224 asymptomatic workers tested, 44% were men and the mean age was 36.1 ± 9.7 years. Eighty seven percent were right hand dominant. Mean tenure on the job was 8.7 ± 6.7 years with no significant difference between the left and right hand dominant workers. The index finger circumference of the left hand dominant workers showed no side to side difference (left = 68.5mm, right = 68.7mm, t = .82, p = .42), and the right hand dominant workers had a slight statistical difference with the right side being larger (right = 68.5mm, left = 68.2mm, t = 2.09, p = .04). The correlation between right and left index finger circumference had an r value of .95. Six subjects reported having diabetes, 5 right hand dominant and 1 left hand dominant worker. The analysis reported is for the entire population; the results did not change with the exclusion of diabetic workers.

The nerve conduction data are summarized in table 1. Within the right hand dominant workers, the median sensory amplitude is larger on the left (38.6μV compared with 34.6μV, $p < .001$). The same relationship holds for the ulnar sensory amplitude, but the side to side difference is smaller (34.4μV compared with 33.0μV, p = .02). The sensory latencies are virtually the same in both hands.

Among left hand dominant workers there is no difference from side to side for either the median or ulnar sensory amplitude. The latency of the left hand was statistically faster for both the median and ulnar sensory nerves but the actual differences were very small (0.2msec for the median latencies and 0.1msec for the ulnar latencies). The relationship among the median sensory amplitudes when stratified by hand dominance and again by right and left is demonstrated in figure 1. The left hand of a right hand dominant worker has a statistically significant higher median sensory amplitude, whereas the three other categories are equivalent. This relationship was consistent across all four sites although the mean amplitudes did vary from site to site, reflecting the divergent gender and age proportions among the sites. The age and gender of the combined population, when stratified by hand dominance, do not statistically differ. The left hand dominant group averaged 31.6 ± 8.3 years compared with 35.4 ± 10.4 years in the right hand dominant group.

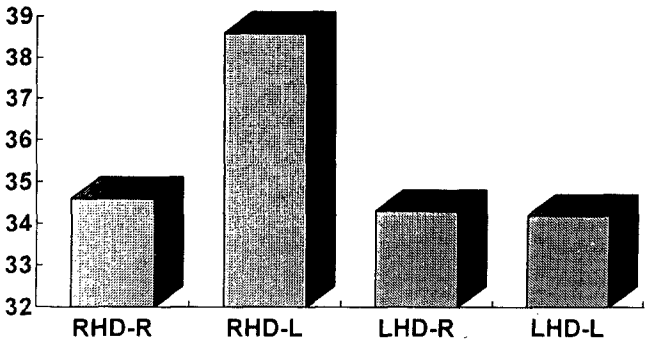

Fig 1. Median sensory evoked amplitudes (μV) when stratified by hand dominance and by right and left hands. RHD, right hand dominant (N = 194); LHD, left hand dominant (N = 30); R, right; L, left.

The small sample size of the left hand dominant workers does not allow a high enough statistical power to exclude the possibility that there is a real side to side difference in the values of the sensory evoked amplitudes, even though the values are not different in this sample. A sample size of approximately 175 left hand dominant workers would be necessary to determine a 4μV difference in amplitude in order to limit the possibility of a type II error or a false negative given α = .05 and 1-β = 0.8. The sample size would need to be significantly higher to detect a smaller difference in amplitude. The possibility of a type I error remains at p = .05.

Correlations between the right and left hand electrophysiological measures were high. The median amplitudes had a correlation coefficient of .83 ($p < .001$), while the ulnar amplitudes had an r value of .85 ($p < .001$). The median and ulnar peak latencies both had correlation coefficients of .83 ($p < .001$). The right and left grip strength was correlated with r = .96 ($p < .001$) while the pinch strength demonstrated an r = .93 ($p < .001$).

Table 2 summarizes the grip and pinch strength results that were collected on a subset of the workers. The grip and pinch strength were significantly higher in the right hand among right handed workers. Among left handed workers there was no difference in strength from side to side.

Table 1: Comparison of Right and Left Sensory Evoked Responses (Amplitude and Latency) Stratified by Hand Dominance

Hand Dominance	MS Amplitude (μV)	MS Latency (msec)	US Amplitude (μV)	US Latency (msec)
Right (n = 194)				
Right hand	34.6 ± 14.1	3.3 ± 0.52	33.0 ± 15.7	3.2 ± 0.32
Left hand	38.6 ± 15.1	3.3 ± 0.57	34.4 ± 15.9	3.2 ± 0.38
t, p	6.9, <0.001	1.43, .15	2.4, .02	1.4, .16
Left (n = 30)				
Right hand	34.3 ± 17.4	3.4 ± 0.66	29.3 ± 13.2	3.2 ± 0.32
Left hand	34.2 ± 15.2	3.3 ± 0.50	30.4 ± 12.0	3.1 ± 0.34
t, p	.05, .96	2.3, .03	0.7, .48	2.7, .01

Abbreviations: MS, median sensory; US, ulnar sensory.

Table 2: Comparison of Right and Left Grip and Pinch Strength Stratified by Hand Dominance

Hand Dominance	Grip Strength (kg)	Pinch Strength (kg)
Right (n = 70)		
Right hand	46.1 ± 13.6*	11.6 ± 3.0
Left hand	44.8 ± 14.2	11.3 ± 3.0
t, p	2.7, .009	1.9, .06
Left (n = 9)		
Right hand	52.4 ± 15.1	12.9 ± 2.3
Left hand	52.7 ± 16.6	12.5 ± 2.4
t, p	.25, .81	1.3, .24

All data are presented as the mean ± one standard deviation.

DISCUSSION

The results of this study are consistent with the contention that right handed individuals expose their dominant hand to greater trauma and thus place the median and ulnar nerves at risk of injury. We hypothesize that in these asymptomatic industrial and clerical workers, the left hand of the right hand dominant individual was relatively spared in terms of exposure to trauma and that this was reflected in a higher mean sensory amplitude. Our hypothesis that the same relationship would hold true in the worker who was left handed was not confirmed. The left handed worker seems to expose both hands to an equal amount of trauma and this is reflected in the reduced median sensory amplitudes in both hands. Although a larger sample size of left handed workers would be necessary to minimize the possibility of a type II error, this sample suggests that the median sensory evoked responses are equivalent. The median sensory evoked amplitudes in these left handed workers are equivalent to the median sensory amplitudes in the right hand of a right hand dominant individual (fig 1). This relationship of the sensory evoked amplitudes has never been reported previously, but our results do correlate closely with the reported grip strength of right and left handed workers.[14] Among right handed workers, the right hand is usually stronger, whereas left handed workers typically have equal strength in both hands. This was confirmed in our subsample of workers tested for grip and pinch strength. This relationship is similar to that found by Acheson and coworkers,[15] who studied the prevalence of osteoarthritis in the hands of 1,126 people. They documented that right hand dominant people had more arthritic changes, based on X-rays, in the right hand. However, left hand dominant people showed an equal distribution of arthritic changes in both hands. The results reported in this study of asymptomatic workers are consistent with these findings. It is not surprising that CTS and upper extremity cumulative trauma disorders in general have been found to be more common in the dominant hand.[1,2,16]

The definition of hand dominance can be expanded to determine the degree of hand dominance. The Edinburgh Handedness Inventory is a prime example of such a scale.[17] We used a self-reported determination that did not account for the degree of hand dominance. In general, however, right handed people are more likely to have a strong preference to perform all unilateral activities with the right hand, whereas left landed people tend to be more ambidextrous.[17] Additionally, we believe that left handed people may be placed frequently in situations in which the tool or instrument that they must use has been designed for a right handed person; consequently, left handed users are encouraged to accommodate the tool by using their right hand. These factors would help to explain our findings in this study and are consistent with the theory put forward by Kucera and Robins.[2] They demonstrated that the degree of hand dominance was related to the findings of cumulative trauma disorders. Left handed persons tended to have a lower degree of hand dominance, which may explain why we see different patterns of results for right and left handed workers in terms of their electrophysiological measures.

Some studies of normal individuals have not identified a difference between the right and left hand in terms of median or ulnar amplitude or conduction velocity.[4,5,8-10] Although our study did not have a specific control population, the other control populations reported in the literature did not show a significant side to side variation in terms of median and ulnar amplitude. One study found that the forearm conduction velocities of the median and ulnar nerves were more rapid in the dominant arm.[7] We believe that the industrial worker is exposed to greater local trauma compared with a nonindustrial based population and the median and ulnar nerves in the hand are at greater risk of injury. The actual difference in the sensory amplitudes was small but reached a convincing statistical significance. The difference in sensory amplitude is not important on an individual basis, but even a small difference in the sample mean suggests a trend that helps our understanding of the differential exposure to the hands among the working population. As electromyographers, a difference in sensory amplitude of $4\mu V$ is not clinically important, but to the epidemiologist, this difference in a population suggests a trend, and this is strengthened by finding of the same relationship at each of the testing sites. The subjects selected for this study were all asymptomatic, and the side to side difference suggests a difference in cumulative environmental exposure to each hand. Although this study did not analyze the degree of exposure of each hand to local trauma, it does lend support to the concept that cumulative trauma can contribute to impairment of the median and ulnar nerves and that this is primarily reflected in terms of decreased median and ulnar sensory amplitude even among asymptomatic workers. Right handed workers did have a statistically larger mean circumference of the right index finger compared with the left (0.3mm), but this small difference is unlikely to translate into enough electrical dampening to explain the differences in amplitude.

It has been well established that sensory amplitudes decline with age.[4-6,11] Whether this is due to loss of axons solely because of aging or whether this also is a reflection of cumulative trauma is not clear. In our study, the left handed group was slightly younger. This helps explain the higher grip strength in this group but statistically we would expect larger sensory amplitudes. However, we found that the amplitudes were smaller than in the nondominant hand of the right handed individuals. Falco and colleagues[5] demonstrated that the median nerve tends to lose more amplitude with progressing age than do other sensory nerves; this suggests that local trauma may play a significant role. We believe that the differential changes of the median and ulnar sensory evoked amplitudes between the dominant and nondominant hand, at least in right handed people, reflect the difference in the exposure to repetitive trauma.

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Suppliers

a. Jamar Hydraulic Hand Dynamometer; J.A. Preston Co., Jackson, MI 49203.
b. B & L Pinch Gauge; B & L Engineering, Santa Fe Spring, CA 90670.
c. TECA Inc., 3 Campus Drive, Pleasantville, NY 10570.