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# The Effect of Carpal Tunnel Release on Typing Performance

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## Abstract

**Purpose—**To describe the effect of carpal tunnel release (CTR) on typing performance.

**Methods—**Twenty-seven patients undergoing open CTR were studied prospectively. Patient demographics and clinical characteristics including nerve conduction studies, electromyography results, and duration of symptoms were collected. Preoperatively, and at 8 time points postoperatively ranging from 1 to 12 weeks, typing performance for an approximately 500 character paragraph was assessed via an online platform. The Michigan Hand Questionnaire (MHQ), and both the functional (BCTQ-F) and symptom severity (BCTQ-S) components of the Boston Carpal Tunnel Questionnaire were completed pre-operatively and at 1, 3, 6 and 12 weeks postoperatively. Repeated measures ANOVAs and follow-up dependent samples t-tests were used to analyze change in typing performance across sessions and linear regressions were used to assess relationships between typing performance and demographic and outcome measures. Typing speed was compared with MHQ, BCTQ-F and BCTQ-S using Pearson's correlation test

**Results—**Average typing speed decreased significantly from 49.7 ± 2.7 words-per-minute (WPM) preoperatively to 45.2 ± 3.1 WPM at 8–10 days postoperatively. The mean typing speed for the group exceeded the preoperative value between weeks 2 and 3, with continued improvement to 53.5 ± 3.5 WPM at 12 weeks following surgery. No clinical or demographic variables were associated with the rate of recovery nor with the magnitude of improvement after CTR. Each of the MHQ, BCTQ-F and BCTQ-S, demonstrated significant improvement from preoperative values over the 12-week period. MHQ and BCTQ-F scores correlated well with typing speed.

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**Conclusions—**On average typing speed returned to preoperative level between 2 and 3 weeks following CTR and typing speed showed improvement beyond preoperative level following surgery. MHQ and BCTQ-F correlate well with typing speed following CTR.

**Level of Evidence—**Prognosis IV

### Keywords

carpal tunnel syndrome; carpal tunnel surgery; typing performance; outcomes; keyboard use

## INTRODUCTION

Carpal tunnel syndrome (CTS) is one of the most commonly occurring hand disorders with an estimated prevalence of 3.7% (0.9–4.7%) in the US.[1] If non-operative treatments fail, it is often recommended that patients undergo carpal tunnel release (CTR), in which the transverse carpal ligament is divided surgically.

In an increasingly technological global society, computer use continues to rise, and along with it, the use of keyboard typing. In 2005, 55.5% of households in developed countries had a home computer; this was up to over 80% in 2015.[2] With keyboard use for both personal and professional pursuits widespread in modern society, it may be of interest to patients what impact CTR may have on their typing ability, particularly for those patients for whom typing comprises a major component of their occupation.

Currently there are no studies that evaluate the relationship between CTR and typing performance. Previous work has shown that anesthetizing the index finger leads to a 7- to 9-fold increase in typing errors for that digit.[3] Thus, it is reasonable to expect that there could be an impact on the typing performance of patients with either static or dynamic sensory alterations as a result of carpal tunnel syndrome. At present, however, this relationship is unknown, and having a better understanding of the effect of CTR on typing performance would provide clinicians with more accurate information with which to counsel their patients.

The purpose of this study was to investigate how long it takes for patients' typing proficiency to return to that of their pre-operative level when measured as a sustained effort for a period of 1–3 minutes, and what factors have an impact on the recovery of peak typing function. We additionally investigated whether patient reported outcomes as assessed by the Michigan Hand Questionnaire (MHQ) and the Boston Carpal Tunnel Questionnaire correlate with typing function.[4–6]

## METHODS

After obtaining institutional review board approval, patients were screened for inclusion in the study between April 1, 2013 and March 31, 2015.

Patients with signs and symptoms of either unilateral or bilateral CTS and with positive electrodiagnostic tests were considered for enrollment, although those who elected to undergo either simultaneous or staged bilateral CTR were excluded to maximize consistency in the 3 month post-operative data collection period. Those patients with bilateral symptoms but whose contralateral symptoms were deemed by the patient to be mild enough to be amenable to continued non-operative treatment were included. Based on the work by Salthouse et al showing that age and typing speed were not correlated for subjects between the ages of 20 and 70, we included patients aged 20 to 70 years.[7] Study inclusion additionally required that participants typed using both hands on the home row keys at a speed of at least 30 words per minute (WPM) as determined by an in-office screening examination. This screening examination consisted of typing a paragraph containing approximately 500 characters on a standard desktop computer utilizing a web-based interface developed by one of the authors (M.J.C.). The in-office screening allowed assessment of both the patients' typing ability, as well as the opportunity to familiarize them with the software used for the typing test prior to data acquisition. Exclusion criteria included an inability to read and speak English, those reporting typing less than once per week, a diagnosis of CTS without positive electrodiagnostic studies, a history of previous CTR in the affected extremity, and patients with ipsilateral neuropathies including cubital tunnel syndrome (diagnosed on the basis of history and physical examination) or diabetic neuropathy (diagnosed by patient's primary care physician, endocrinologist or neurologist). Patients with coexisting diagnoses of trigger finger, ganglion cyst, or lateral epicondylitis were initially excluded during the first 14 months of the study, however were permitted to participate during the final 10 months following a revised study protocol. This resulted in one patient with an ipsilateral dorsal carpal ganglion cyst which did not require operative treatment during the study period being included following the revised protocol.

## Patient sample

373 patients were evaluated for carpal tunnel syndrome during the study period of whom 64 met all of the inclusion criteria. Reasons for exclusion included: non-operative management (149), co-existing upper extremity pathology (132), outside the age limits (49), did not use all fingers to type (49), absent or normal electromyography test (38), previous carpal tunnel surgery (20), did not speak English (6) or did not have access to computer/internet at home (4). Some patients met multiple exclusion criteria. Of the 64 that met eligibility to take the typing screening exam, 15 did not meet the typing requirement and 11 declined participation leaving 38 that were ultimately enrolled in the study. Seven patients either did not end up going through with surgery or did not complete the typing tests and were removed from the study. Four patients underwent staged bilateral CTR and were excluded from the final analysis leaving 27 patients in the study cohort.

## Study protocol

Patients completed a preoperative typing examination prior to their surgery via the online platform. The patients were instructed to complete subsequent typing tests on the same computer on which they had performed the original test at 8–10 days, 2, 3, 4, 5, 6, 8 and 12 weeks post-operatively. Nine different typing tests of similar difficulty were administered at these intervals in random sequence and consisted of approximately 500 characters. Four of these paragraphs had been used in a previous study involving 971 subjects[7,8]. The test-retest reliability was found to be 0.97 ($p<0.05$) in these studies. The additional 6 paragraphs were selected from the same text and had similar readability statistics (appendix). Results of the typing test included WPM and accuracy. No letter appeared on screen for incorrect keystrokes; thus no "backspace" was utilized. Accuracy therefore was calculated as the number of correct letters on the first attempt divided by the total number of letters in the paragraph.

In addition, preoperatively and at the 8–10 day, 3, 6 and 12 week time points, patients completed the MHQ, BCTQ-F and BCTQ-S questionnaires via an online data collection service (REDCap).[9] To maximize data accrual, an automated email was sent to the patients 24–48 hours prior to the time when a typing test or questionnaire was to be completed. If the tests were not completed within 24 hours of the assigned time, a member of the research team called the patients to remind them to complete the typing test and/or questionnaires. This did result in slight variability in the time between surgery and completion of the typing tests and questionnaires. However, patients completed the assessments for each of the sessions within 24 hours of the specified time.

## Surgical Protocol

An open carpal tunnel release was performed in all patients. A sterile soft dressing was applied post-operatively and left in place until the patients were seen for their first follow up appointment 8–10 days following the procedure. Sutures were removed at that time. No splinting was employed and finger range of motion was allowed immediately post-operatively.

## Statistical Analysis

Repeated measures ANOVAs and planned comparison paired samples t-tests were used to analyze changes in typing speed and accuracy across sessions. A threshold of $p<.0.05$ was adopted for all statistical tests. A major question of interest was assessing within-subject changes in typing speed across sessions. A *post hoc* analysis was performed to estimate the power to detect within-subject changes by computing average within-subject standard deviations in typing speed from a published data-set of 800 typists who performed typing tests similar to those used in the present design.[8] The analysis showed we could detect within-subject differences in typing speed as small as 2.2 words per minute with adequate power ($\beta=0.8$) with 27 subjects.

Additionally, we conducted bivariate linear regressions relating the recovery rate of post-operative typing performance with the following patient characteristics as predictor variables: age, duration of symptoms, preoperative motor nerve conduction velocity and sensory nerve peak latency, and the presence of abductor pollicis brevis (APB) fibrillations on pre-operative electromyography. Workers' compensation claims and tobacco use were considered relevant analyses however due to low numbers in the experimental group (2 patients with workers' compensation claims and 1 patient with tobacco use), these analyses were not pursued. Patients with missing data on outcome measures were eliminated from the correlational analyses. This resulted in 26, 25 and 24 patients in the bivariate analyses of motor nerve conduction latency, sensory nerve conduction peak latency and presence of APB fibrillations respectively as shown in Table 1. For each set of regressions we used the following four dependent variables to estimate the rate of recovery in typing performance across postoperative sessions. First, recovery rate was estimated by the slope of a linear regression line of best fit for each patient's performance across all sessions. Second, recovery rate was estimated using the slope of a linear regression line of best fit with the first post-operative session excluded, as this session showed the most variability. Third, recovery rate was estimated using the difference in typing speed between the first and second post-operative sessions, which was the interval during which the greatest improvement between sessions was observed. Finally, recovery rate was estimated as the number of days to recover to baseline typing speed and was determined for each subject as the session in which each subject met or surpassed their preoperative typing speed. Subjects who did not meet this criterion were excluded from this portion of the analysis. We also conducted a separate set of regressions using a normalized measure of total improvement in typing performance as the dependent measure. The overall normalized change in typing performance for each subject was defined as the difference in WPM between the final post-operative typing test and the first pre-operative typing test, divided by the WPM for the pre-operative test as a baseline measure. A separate analysis was conducted to compare the patient reported outcomes MHQ, BCTQ-F and BCTQ-S with typing speed by session using Pearson's correlation test.

## RESULTS

Demographic information and clinical characteristics of the cohort appear in Table 1. Those patients who reported 4–6 hours of computer use per day as well as those who had measurable values for sensory nerve peak latency had a significantly higher average typing speed preoperatively. Otherwise no difference in preoperative typing speed was seen based on patient characteristics.

The overall performance for the group is displayed in Figure 1. Initially, there was a significant decrease in typing speed from 49.7 ± 2.7 preoperatively to 45.2 ± 3.1 WPM at the first postoperative typing test ($p<0.05$). However by 2 weeks, the average typing speed had nearly recovered to the preoperative level (49.2 ± 2.9 WPM) and by the final typing test, typing speed had improved to 53.5 ± 3.5 WPM, although this increased speed was not statistically significant when compared with the pre-operative typing assessment. Figure 2 shows the proportion of patients surpassing various thresholds of preoperative performance at each session. By 3 weeks, over half of subjects (56%) had surpassed their baseline performance and 85% and 93% performed above 95% and 90% of their baseline performance respectively. The effect of session on typing accuracy was not statistically significant, and mean accuracy ranged between 92–94% (Figure 3).

No significant associations were seen between patient characteristics and the rate of recovery with the use of any of the four methods described above in the Methods section. Likewise, no significant association was seen between patient factors and the overall normalized change in typing speed between the preoperative and final typing tests.

Each of the MHQ, BCTQ-F and BCTQ-S demonstrated significant improvement from preoperative measurements over the 12-week period. The results are displayed in Figures 4–6. Changes in MHQ ($r=0.90$, $p<0.05$) and BCTQ-F ($r=-0.97$, $p<0.05$) scores correlated well with post-operative changes in typing speed whereas BCTQ-S scores did not (r=−0.58, p=0.29).

## DISCUSSION

Keyboard use is widespread in modern society, with many people engaging in typing for both social and professional reasons.

We found a significant decrease in typing performance 8–10 days after however, the recovery from this point back to the patients' preoperative typing speed occurred between 2 and 3 weeks after surgery with mean typing speed for the group exceeding the preoperative performance at week 3. At this point over half of the participants had exceeded their preoperative performance in a post-operative typing test. From this point forward, there was continued recovery above and beyond the patients' preoperative typing performance suggesting that typing performance was impaired by CTS, although the difference between preoperative and final typing speed was not statistically significant. While this may have reflected a learning effect, this seems unlikely as the time spent on the 9 test paragraphs represents a relatively small amount of the overall typing in which the patients engaged. Over 87% of our patients reported greater than 2 hours of computer use per day normally.

In our study, no patient demographic or clinical factor was found to be associated with either the rate or magnitude of improvement in typing speed post-operatively. It is possible that these associations exist, and would be demonstrated in a larger sample, though the magnitude of the impact of these factors would be expected to be relatively small as our study was powered to detect a within-subject difference of greater than 2.2 wpm. Furthermore, the period of most rapid change in our study was within the first 2 weeks following surgery during which only 2 typing assessments were conducted. It is also possible that patterns in post-operative typing speed may be affected by patient factors during this time of rapid change which were not able to be detected with our sample due to our study design.

MHQ and BCTQ-F scores correlated well with typing speed, showing an initial worsening at the 8–10 day post-operative time point and then exceeding preoperative values at the 3 week time point with continued improvement thereafter. The BCTQ-S showed improvement throughout the study, including at the 8–10 day post-operative time point. These findings should be expected because the MHQ, BCTQ-F and typing performance are all functional measures, while the BCTQ-S is a measure of symptom severity, which recovers relatively rapidly after surgery. [4,10–12] This suggests that a post-operative typing assessment may not be required and either the MHQ or BCTQ-F may be used as surrogates for typing performance.

This study had a number of limitations. First, our patient population represents less than 10% of the patients initially screened. This was due in large part to patients not meeting study inclusion criteria, the largest proportion of which was due to non-operative management. Thus our results may not be generalizable to patients with CTS who are outside of the inclusion criteria of our study. This includes patients diagnosed with CTS based on clinical findings who have negative electrodiagnostic studies, as these patients were excluded from our study. The resulting sample was sufficiently small that we would not expect to be able to detect subtle differences in post-operative typing performance attributable to patient factors. However as discussed above, if these associations do in fact exist, we would expect them to be relatively small in magnitude. While no patients underwent staged bilateral carpal tunnel release in the study period, some patients did have bilateral CTS symptoms, but decided that only one side was symptomatic enough to warrant operative treatment. It is therefore possible for differences between the pre-operative and post-operative state of the non-operative hand and this might have had an impact on our observations. Further, while our study addresses maximal typing performance for a period of less than 4 minutes, it does not assess typing endurance, or subjective symptoms including pain experienced during typing activities, and therefore may not correspond with a patient’s ability to return to work, particularly if their work involves sustained typing for a substantial period of the day. The focus of our study, however, was on peak typing performance, not return to work. Typing speed was the metric as our primary outcome measure because we felt that measuring typing speed at maximal effort for a roughly 500 character paragraph would allow us to best isolate the processes associated with typing. Also, while patterns were present when the data was analyzed for the group as a whole, variability existed when individual patients were examined, and thus when counseling patients pre-operatively, it is not possible to make exact predictions regarding post-operative typing performance for an individual. Finally, while our online data accrual system allowed us to gather more datapoints than would have been practical with only in-office testing, we acknowledge that it is not possible to confirm that the patients themselves were actually the ones completing the typing tests nor to confirm that testing conditions were standardized for patients across sessions.

This study suggests that typing performance returns to preoperative levels for most patients between 2 and 3 weeks after carpal tunnel release surgery. It is also possible that patients’ carpal tunnel syndrome imparted a degree of impairment to their typing performance as their performance improved beyond baseline as their symptoms resolved, although further work is required to establish this relationship. Additional studies investigating typing endurance and patient symptoms could be useful to more reliably predict when patients will be able to return to work.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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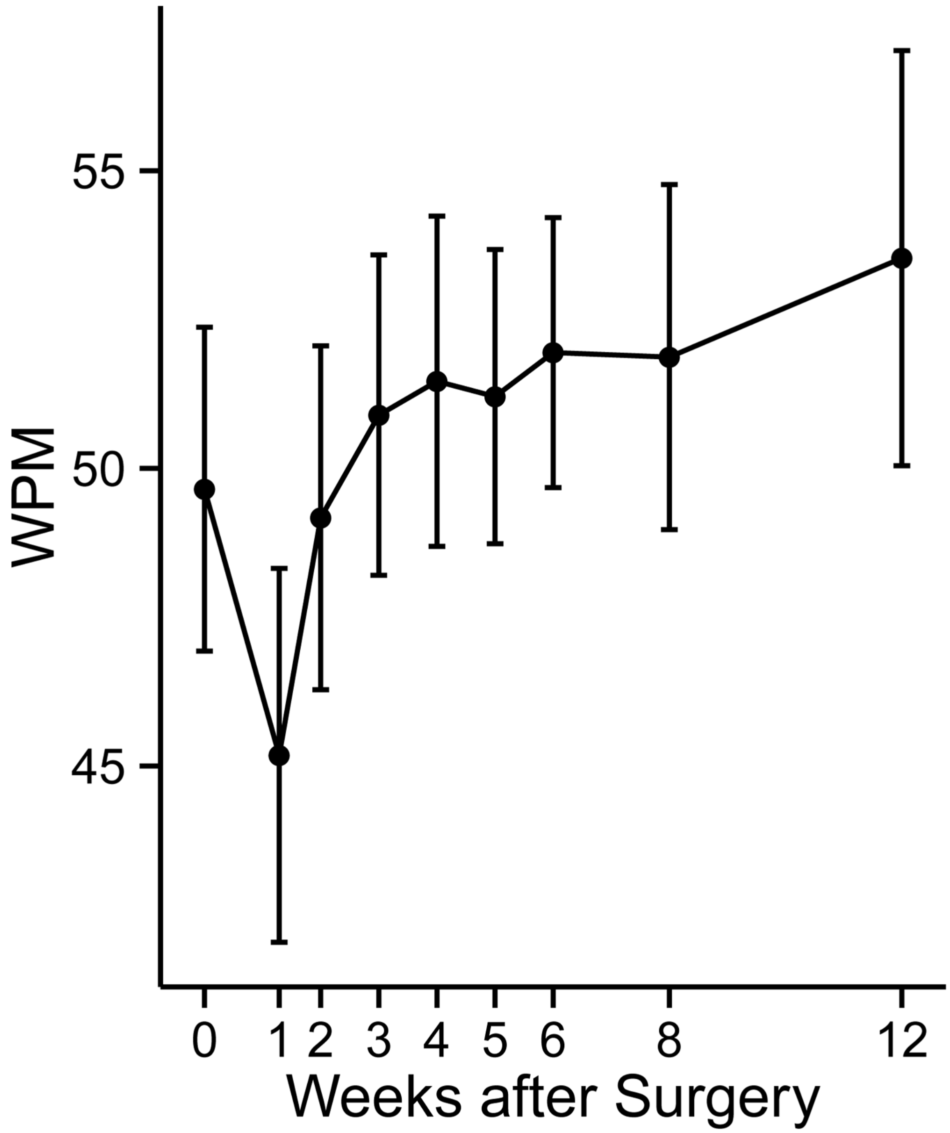


**Figure 1.**
Average typing speed for the cohort by session

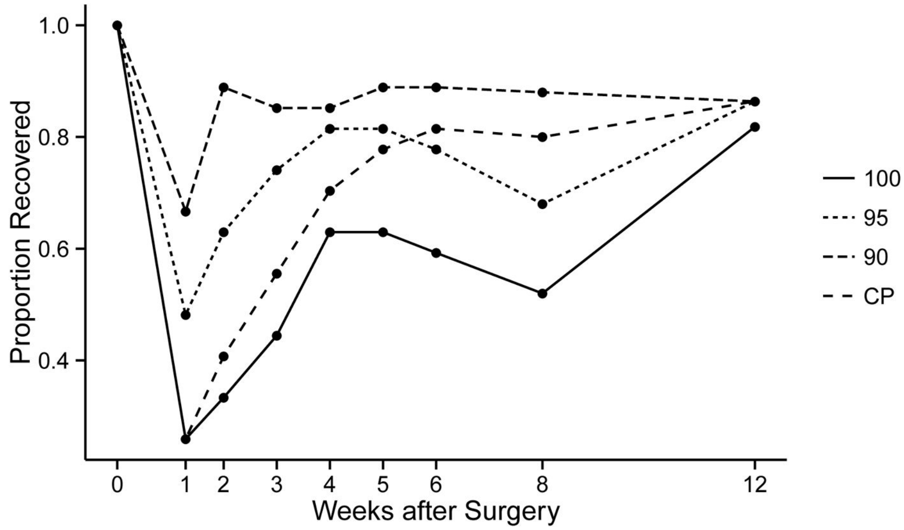


**Figure 2.**

CP represents the cumulative proportion of patients who have exceeded their baseline performance at any point since surgery. 100, 95 and 90 represent the proportion of patients exceeding 100%, 95% and 90% of their baseline performance for a given session.

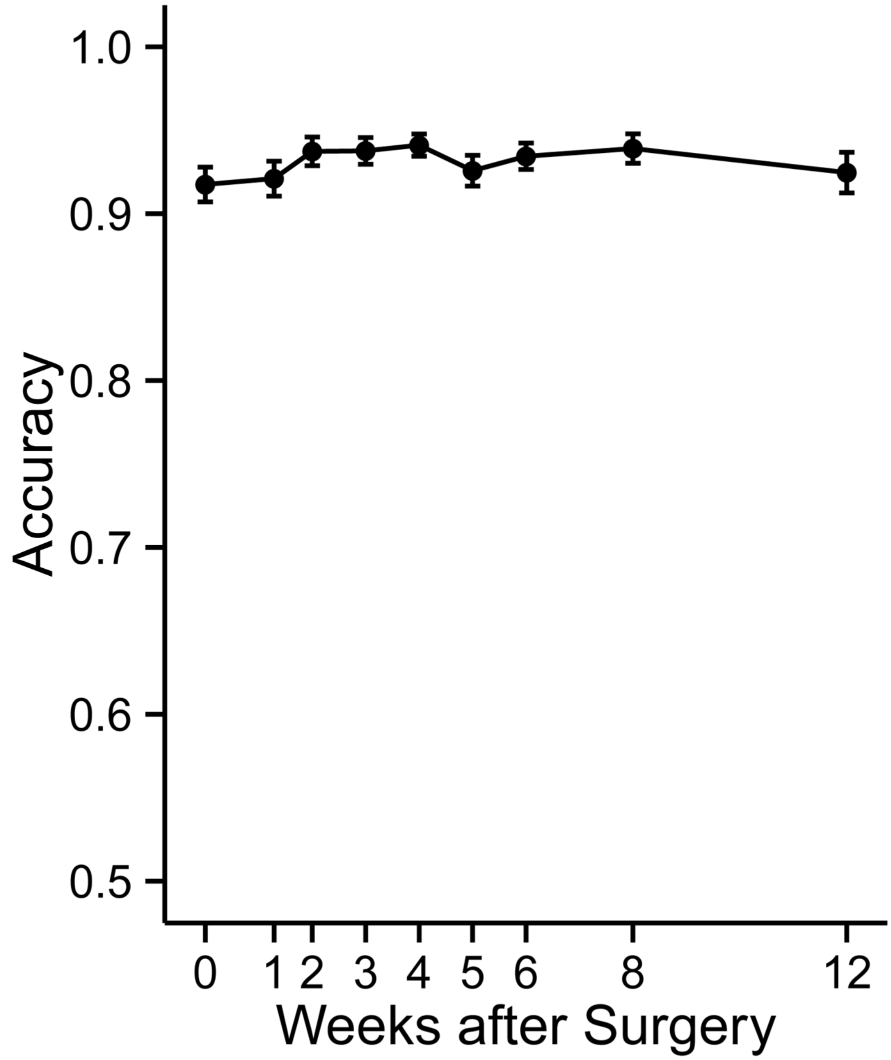


**Figure 3.**
Average typing accuracy for the cohort by session

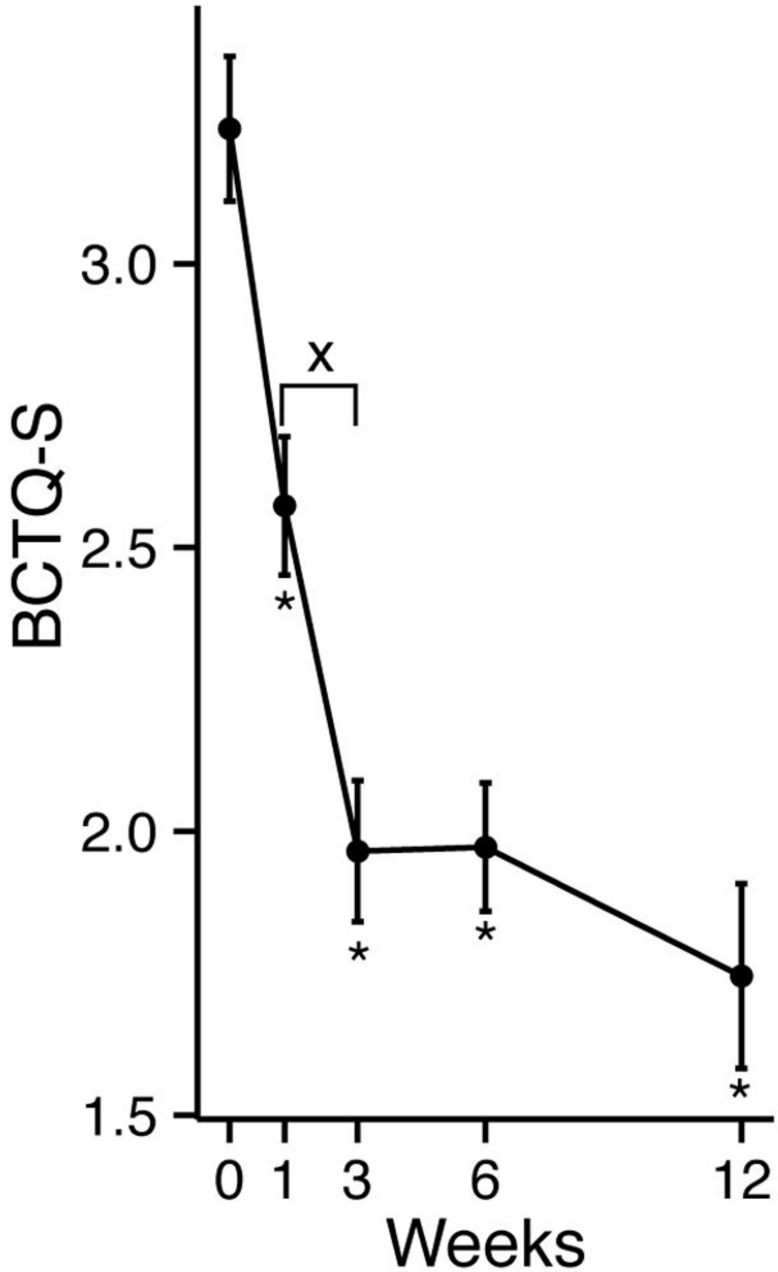


**Figure 4.**
Results of the Symptom Severity Component of the Boston Carpal Tunnel Questionnaire (BCTQ-S). Brackets with an "x" indicate statistical significance between consecutive tests. Asterisks indicate statistical significance as compared with the baseline value.

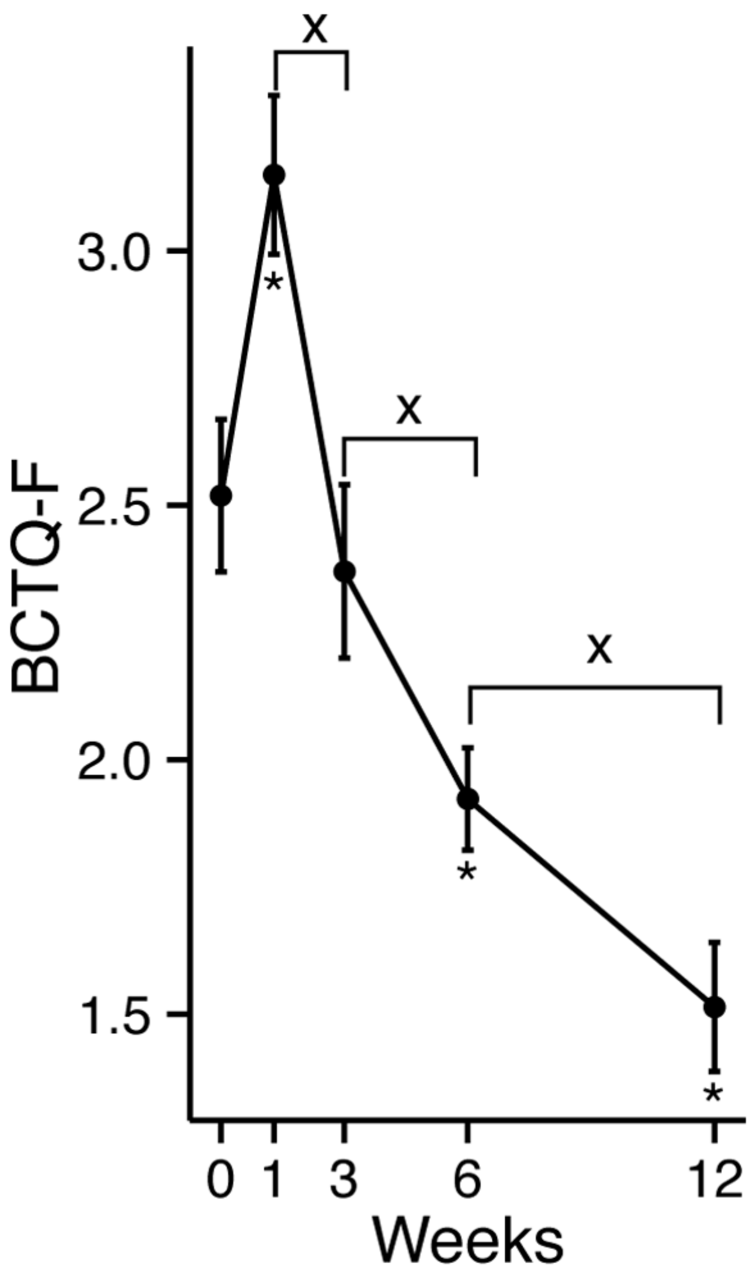


**Figure 5.**

Results of the Functional Component of the Boston Carpal Tunnel Questionnaire (BCTQ-F). Brackets with an "x" indicate statistical significance between consecutive tests. Asterisks indicate statistical significance as compared with the baseline value.

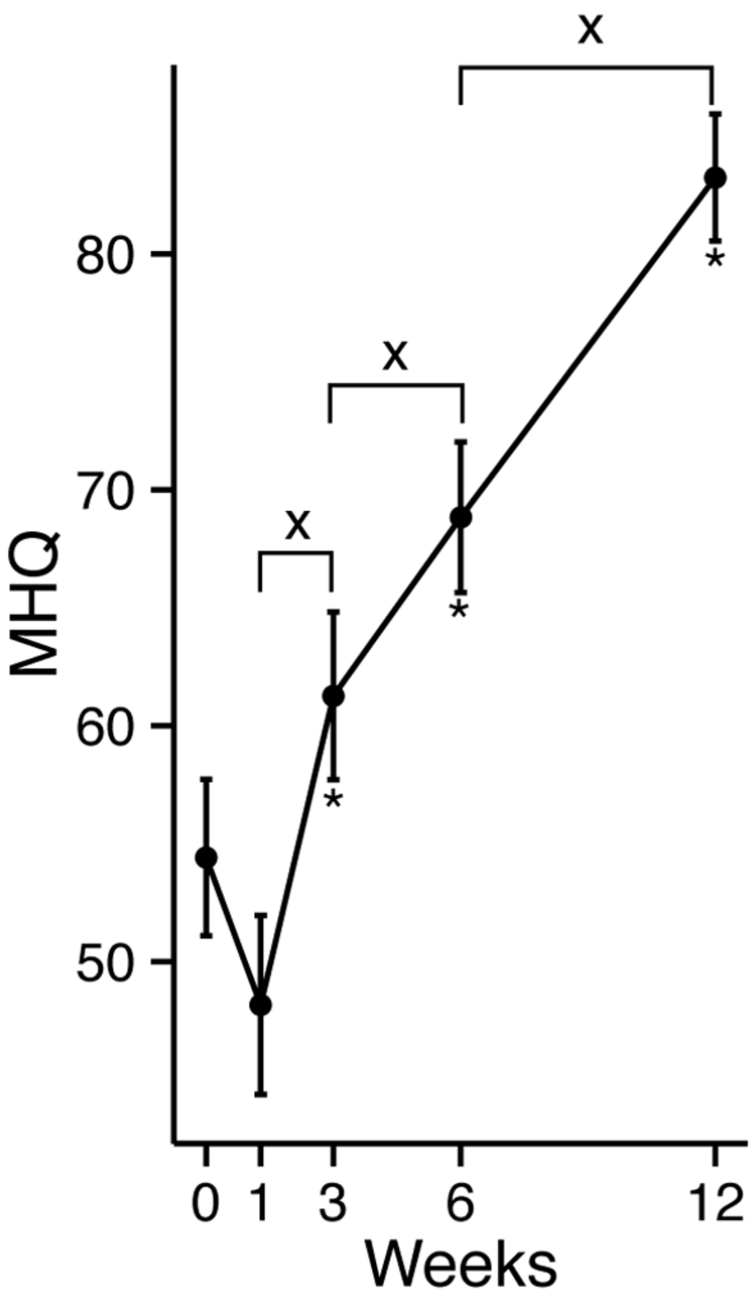


**Figure 6.**

Results of the Michigan Hand Outcomes Questionnaire (MHQ). Brackets with an "x" indicate statistical significance between consecutive tests. Asterisks indicate statistical significance as compared with the baseline value.

## Table 1

Demographic Data

| | | Baseline Average WPM (Standard Deviation) |
|---|---|---|
| Age (years) | 55 ± 8 | 50 (3) |
| Gender | | |
| Female | 24 (89 %) | 50 (14) |
| Male | 3 (11%) | 47 (18) |
| Tobacco Use | | |
| No | 26 (96%) | 50 (14) |
| Yes | 1 (4%) | 52 (NA) |
| Workers Compensation | | |
| No | 25 (93%) | 50 (15) |
| Yes | 2 (7%) | 52 (1) |
| Hand Dominance | | |
| Right | 26 (96%) | 50 (14) |
| Left | 1 (4%) | 37 (NA) |
| Operative Side | | |
| Dominant Hand | 18 (67%) | 47 (15) |
| Non-Dominant Hand | 9 (33%) | 55 (11) |
| Duration of Symptoms (Months) | | |
| <3 | 1 (4%) | 41 (NA) |
| 3–6 | 3 (11%) | 46 (12) |
| 6–12 | 5 (18%) | 56 (24) |
| > 12 | 18 (67%) | 49 (12) |
| Daily Computer Use (Hours) | | |
| < 4 | 9 (33%) | 41 (11) |
| 4–6 | 7 (26%) | 58 (18) |
| >6 | 11 (41%) | 51 (11) |
| Sensory Nerve Peak Latency | | |
| Obtainable | 20 (74%) | 52 (11) |
| Unobtainable | 5 (19%) | 37 (3) |
| Missing data | 2 (7%) | NA |
| Motor Nerve Conduction Latency (n=26) | | 50 (3) |
| Fibrillations in APB | | |
| Yes | 7 (26%) | 52 (10) |
| No | 17 (63%) | 46 (12) |
| Missing Data | 3 (11%) | NA |