Scholarly Article Critique

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Case & Diagnosis: Case #7, Carpal Tunnel Syndrome (CTS)

Title of Article: Effects of Carpal Tunnel Syndrome on Adaptation of Multi-Digit Forces to Object Weight for Whole-Hand Manipulation

1. **Article title information.**

Zhang, W., Johnston, J. A., Ross, M. A., Smith, A. A., Coakley, B. J., Gleason, E. A., Dueck, A. C., & Santello, M. (2011). Effects of carpal tunnel syndrome on adaptation of multi-digit forces to object weight for whole-hand manipulation. *PLoS ONE, 6*(11), e27715. doi:10.1371/journal.pone.0027715.

1. **Describe how this article is pertinent for your topic. Does it provide proof of a clinical concept? Does it explain a procedure that is needed for your topic? What are the implications for your topic?**

This article describes the implications of CTS on forces exerted during grasping tasks in terms of direction, magnitude and distribution of forces among digits. It compares these prehension characteristics for individuals with CTS against healthy controls to get a better idea of how whole-hand grasp is affected in CTS. Also, although it is not the primary focus, the article also helps to outline a number of characteristics (such as normal and tangential force/moment) that are important in studying prehension as well as providing an overview on previous results of prehension research in CTS. The results of the study will provide Stephanie with important expectations on the kinds of difficulties she may face if her hand/wrist issues do resolve into CTS. It will also provide her with some insight on the things she should try and avoid doing (grasping too hard or unevenly between fingers) which may come as a habit due to reduced sensory feedback in her lateral digits. Overall, I believe the article will serve to provide Stephanie with realistic expectations of CTS so that she can better prepare herself if her hand and wrist issues do worsen.

1. **Write a precis of the article, including:**
	1. **Purpose of the study**

The effect of decreased sensory feedback and motor control in the hands for individuals with CTS is well known. The study looked to determine how these deficits affect individuals with CTS in their ability to adapt multi-digit forces (object manipulation with whole hand) to varying objects. In particular, the researchers wanted to see if participants with CTS less accurately adjusted their force to object weight, exerted more force overall, and had an imbalance in the distribution of force across their digits to cause object rotation.

* 1. **Research design of the study**Although not explicitly stated, the researchers performed a quasi-experimental study with 13 participants (2 males, 11 females) that had CTS and 13 gender- and age-matched healthy volunteers, with the gender ratio being reflective of the distribution of those with CTS in the general population. The presence/absence of CTS in participants was confirmed using electrodiagnostic tests as well as the observation of clinical symptoms. Once inclusion to the study had been determined, the participants were asked to lift a grip device, with their fingers placed on force/torque transducers which can individually measure the force produced by each finger. The grip device could have its object weight adjusted to 445, 545, or 745 g. The participants were asked to lift each object weight 7 times consecutively. The order of the object weights was counterbalanced between the CTS participants and the same order was presented to their matched control. The participants were not told the weight they would be lifting but knew that the weight would remain constant for the 7 consecutive lifts.
	2. **Data collection and analysis**Data collection focused on measuring the total force exerted by the fingers in directions perpendicular (normal, F­G) and parallel (tangential, FT) to the sensors on the grip device. The researchers also calculated the moments (MNet) forces produced by the fingers and opposed by the thumb.

	The data was analyzed using a number of repeated measures ANOVAs including FG, within-trial FG varability, MNet on lift onset, against Weight and Trial number (1-7) as within-subject factors, and Group as the between-subject factor. The authors also focused more specifically on trials 2-7 for each weight, looking at the digit forces and variability within these trials. They used these trials to run a repeated measures ANOVA with Weight, Finger (not including the thumb) as within-subject and Group as between-subject factor. They looked at how these forces changed in the lifting process by performing a repeated measures ANOVA on Weight and Phase (lift onset and object hold) as within-subject and group as between-subject. A final ANOVA was performed on the variability of FG between trials at onset and hold for the different Weights, comparing between Groups. Lastly, a paired t-test was done on the average difference between lift onset forces and object hold forces between groups, to see how the forces changed within each trial.
	3. **Outcomes of the study**No participants had observed or reported difficulty with the task, though, some notable trends in grip characteristics were observed between the CTS and control group. For one, the CTS participants were still able to scale the forces between fingers somewhat appropriately, meaning that the index and ring finger exerted the most force while the pinky produced the least. However, the smaller two fingers (pinky and index) in CTS participants still exerted more force compared to the control group. It was also seen that the CTS group retained the ability to scale force to weight, meaning that the total applied force (FG) correlated appropriately with object weight. This suggests that there is still some sensory feedback occurring to help modulate the force exerted, though this feedback could be from forearm muscles or tendons. However, this scaling process was less precise with CTS, as total and maximal normal force only changed significantly for the heaviest condition and not between the two lower weights.

	Despite the ability to scale force between fingers and to varying weights one consistent difference in the CTS group was that the FG was excessive in relation to control in all digits. There was a tendency for the CTS group to overshoot the amount of force needed on object lift and then gradually decrease it on object hold, whereas controls more accurately estimated the amount of force needed for hold. This pattern in CTS participants may be reflective of a learned habit to produce excessive amount of force when lifting an object to compensate for decreased sensory feedback, as this would decrease the risk of the object slipping. The results also showed that on average, there were larger net moments on object lift in participants with CTS, again possibly due to decreased feedback or deficits in the intrinsic hand muscles that play an important part in fine motor regulation. This increased moment is reflective of decreased dexterity, which may have an impact on fine motor manipulation of objects.
	4. **Did the author explain why the work was important to, in relation to the work of other researchers?**

The authors highlighted past work looking at 2 finger grasp for CTS patients and expanded on it by measuring whole-hand grasping. This way, they were able to see how the behaviours from unaffected fingers (ring and pinky) changed in CTS patients. The researchers also built upon evidence of studies using people with median nerve compression (natural or induced) or anesthesia into the carpal tunnel, which also found an excessive amount of force being used by participants in these studies. All these findings serve to further support the theory that the excessive force is used to minimize risk of slipping given the lack of sensory feedback

* 1. **What are the conclusions?**The authors concluded that from a gross motor standpoint, the grasp of individuals with CTS was not greatly affected by the condition in relation to control participants. This is likely due to the residual sensory feedback that is unaffected by CTS. However, the whole-hand grasp was characterized by an excessive amount of finger force, a decreased sensitivity to change this force to differing weights, and a less stable object lift in terms of rotational movement. They posit that this may be due to decreased median nerve function, leading to a decreased ability to form sensorimotor “memories” of recurring motions.
	2. **If you found issues with the article, explain what your concerns are and how that will affect your reliance in the article as a source of good evidence for your topic.**

One issue I have with the article is the amount of statistical analyses the author’s ran on the data sets. Though there are many ways to characterize the grasp forces, running so many ANOVAs (on FG, within-trial FG varability, MNet, Mn, and Mtan on lift onset, etc.) creates the opportunity for one of the tests to show significant differences just by chance. The authors also further subdivided the data into means and standard deviations for trials 2-7 and performed analysis on this data set as well, further increasing the chance for false positives.

Another issue stems from the fact that the participants used in the study were not necessarily consistent in their progression of CTS. Determination of CTS in the study was based on increased distal sensory latency in the median nerve. This latency ranged from just over the provided norms to up to double the normal latency, representing various states of the progression of CTS for the participants. Therefore, more meaningful differences between the control and CTS group may have been masked by the inclusion of borderline cases.

Lastly, one big issue with the findings of the study is the lack of observed or predicted functional differences between the control and CTS group. As stated before, there were no reported or observed difficulties with the task from either group, differences arose in careful analysis of force data. The authors also did not attempt to frame their results in a more practical way, speculating on how this effected whole-hand grasp may influence daily occupations. Therefore, it is more difficult to translate the results into their impact on everyday scenarios for those with CTS, especially because a lot of the terms used by the authors are quite technical and not readily apparent in how they affect grip. This does not decreases the rigor of the study and I feel that informing those with CTS about differences in grip characteristics is important, but without a functional or practical application of the results I think it is harder for individuals with CTS to understand or remember the implications of the findings.