

Final Performance Report

Carpal Tunnel Pressure During Hand Maneuvers

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Publications

1. Rempel D, Manojlovic R, Levinsohn DG, Bloom T, Gordon L. The Effect of Wearing a Flexible Wrist Splint on Carpal Tunnel Pressure During Repetitive Hand Activity. *J of Hand Surgery*, 1994, 19A:106-109. 00218827
2. Rempel D. Musculoskeletal Loading and Carpal Tunnel Pressure. Chapter 9, pp 123-132, in **Repetitive Motion Disorders of the Upper Extremity**. S. L. Gordon, et al. (Editors). *Am Acad Orthopaedic Surgeons*, Rosemont, Illinois. 1995. 00241820
3. Weiss ND, Gordon L, Bloom T, So Y, Rempel DM. Wrist Position of Lowest Carpal Tunnel Pressure and Implications for Splint Design. *J of Bone Joint Surgery*, 1995, 77A:1695-1699. 00232973
4. Bach J, Engstrom J, Rempel D. Influence of thumb posture on carpal tunnel pressure. Annual Meeting of American Society of Biomechanics 1996, Atlanta.
5. Rempel D, Keir P, Smutz WP, Hargens A. Effects of static fingertip loading on carpal tunnel pressure. *J Orthop Research*, 1996 (in review).
6. Rempel D, Bach JM, Gordon L, So Y. Effects of forearm pronation/supination on carpal tunnel pressure. *J Hand Surg*, 1996 (in review).
7. Bach JM, Rempel DM. The effect of metacarpal and interphalangeal flexion on carpal tunnel pressure. 43rd Annual Meeting, Orthopaedic Research Society, 1997, San Francisco.
8. Rempel DM, Keir PJ, Bach JM. The dose-response relationship of wrist posture and carpal tunnel pressure. 43rd Annual Meeting, Orthopaedic Research Society, 1997, San Francisco.
9. Keir PJ, Bach JM, Rempel DM. Effects of finger posture on carpal tunnel pressure during wrist motion. *J Orthop Research* 1997 (in preparation).
10. Keir PJ, Bach JM, Rempel DM. Finger force and carpal tunnel pressure: Differences between pinching and pressing tasks. *Applied Ergonomics* 1997 (in preparation)

Significant Findings:

2. Postures of the wrist, thumb, finger, and forearm influence carpal tunnel pressure in complicated ways. For some joints and postures the direction and magnitude of effects are consistent across the healthy subjects tested (N=37). When tested in combinations most of the postures were found to have an interaction effect (e.g., wrist extension and finger flexion) although some did not (e.g., ulnar-radial deviation and finger flexion).

1. Static loading of the fingertip to forces of 6, 9, and 12 N significantly increased carpal tunnel pressure above a no load state (e.g., 0 N). The pressures remained elevated and constant as long as the load was present. The effect of loading on carpal tunnel pressure was independent of (and additional to) the effect of wrist posture.

3. Some of the relationships between carpal tunnel pressure and joint postures (e.g., forearm rotation, extension-flexion, ulnar-radial deviation) and fingertip load can be described by simple mathematical models. However, the specific equations should be used with caution because for some joints and postures the variability between subjects is high.

4. Carpal tunnel pressure during the performance of a repetitive task is influenced in a complicated manner by the pinch force applied during the task (e.g., moving cans) and the joint postures (e.g., keyboard work). For example, during typing the pressure rises above baseline and remains elevated for as long as typing continues. The magnitude of pressure increase is strongly influenced by wrist posture deviation from neutral.

Usefulness

1. The data on how postures influence pressure in the carpal tunnel can guide the design of hand intensive tasks, hand tools, and workstations. For example, the data support designing tasks so that the wrist is near neutral for task that require static wrist postures (e.g., keyboard work). The data also suggest new neutral postures for design (e.g., forearm rotation to 45 degrees) that differ from widely accepted neutral postures (e.g., 0 degrees forearm rotation). Likewise, the data identify postures to avoid for sustained hand tasks (e.g., forearm supination, finger extension).
2. The pinch force data demonstrate that relatively low levels of fingertip load (6N; 0.5 kg force) can rapidly increase carpal tunnel pressure to above 30 mmHg and that this pressure is maintained as long as force is applied. Therefore, in order to prevent sustained pressure elevations in the carpal tunnel the most effective intervention will be to limit the duration then the magnitude of applied fingertip load.
3. The data support varying hand postures throughout the work day and reducing static postures, especially those involving posture extremes or pinch force.

Meeting the Aims of the Grant

The original aims of the study were modified after year one to:

1. *Determine whether the relationships between CTP and elementary hand maneuvers are consistent between subjects and identify what those relationships are.*

The relationships between CTP and postures for each of the joints studied (e.g., wrist extension/flexion^{3,8,9}, ulnar/radial deviation^{3,8,9}, finger flexion^{6,7,9}, thumb position⁴, forearm rotation⁶) and for fingertip loading^{5,10} and loading type¹⁰ are presented in the attached publications. For all joints and loading there are consistent and significant relationships across subjects, but for some the variability between subjects is high (e.g., fingertip loading).

2. *Determine whether the CTP varies significantly within subjects performing typical work-related activities and identify the predictors of that variability.*

See Finding 4. The performance of a repetitive task almost always increases pressure above baseline and can increase pressure above 30 mmHg depending on pinch force and posture^{1,2}.

3. *Develop mathematical models that will predict CTP as a function of elementary hand motions.*

See Finding 3. The curve fit data and mathematical models presented in the attached publications satisfy this aim^{5,6,8,9,10}.