INTRODUCTION

A number of factors play a role in finger force production. Wrist position has been shown to be one of the most important regulators for grip and pinch strength capabilities (Kang et al., 1996; LaStayo & Hartzel, 1999). Most of the previous studies have concentrated on the influence of wrist postural changes on force output of a single finger (e.g., pinch), or the total force output of multiple fingers (e.g., grip). Very few studies looked at how force production capability of individual fingers is influenced by wrist position (Hazelton et al., 1975). In addition, previous attempts to evaluate the effect of wrist position on grip strength have concentrated on a few limited static wrist positions (Hazelton et al., 1975; Pryce, 1980).

The purpose of this study was to determine the influence of wrist position on individual finger forces and force sharing among individual fingers during functional tasks when subjects sustain maximum grip of an instrumented handle while voluntarily moving the wrist joint continuously. It was hypothesized that varying wrist position would lead to changes in (1) individual finger forces and total force production, and (2) the pattern of force sharing among individual fingers.

METHODS

Nine male college students volunteered to participate in the study. The subjects had no known trauma or neuropathy in the hand or upper extremity. A custom-made instrumented clay handle functioned as a grasping object. Four piezoelectric sensors were used to register force production of individual fingers. A two-axis electrogoniometer was taped over the dorsal side of the wrist to monitor the wrist joint position in the directions of flexion/extension motion (FEM) and radial/ulnar deviation (RUD). The task was to grasp the handle as hard as possible with varying wrist positions while maintaining maximum voluntary contraction (MVC). The subject was encouraged to explore all unconstrained wrist positions in the directions of FEM and RUD. Four channels of force data and 2 channels of goniometer data were collected simultaneously. In order to obtain finger forces at identical positions for different subjects, interpolation procedures were performed for the data of each subject. Individual finger forces, total force, and force sharing at 18 representative positions were selected for statistical analyses.

RESULTS AND DISCUSSION

Individual finger forces and total force, averaged across the 9 subjects are represented using linear gray-scale maps (Figure 1). The darkness of each map (i.e., relative magnitude of force) was dependent on wrist position. Individual finger force and total force showed
similar force change patterns. The peak individual forces and peak total force occurred at wrist position 20 degrees of extension and 5 degrees of ulnar deviation. At this position, the index, middle, ring, and little fingers produced 37.0, 37.5, 27.0, and 13.4 N, respectively, with a total force of 114.9 N. As the wrist deviated farther and farther away from this position, the forces generated by individual fingers and total force became less and less. In general, force generated in extension territory was higher than force generated in flexion territory. Moreover, finger forces vary more with wrist flexion than extension.

Two-way ANOVA (FE × RUD) performed on selected 18 wrist positions showed that individual finger forces and total force production was dependent on FEM and RUD (p < 0.001). No significant interaction between FEM and RUD was found for individual finger force or total force (p > 0.62). The effects of FEM and RUD on force sharing of individual fingers were different on different fingers. Among the selected positions, for example, the index finger force sharing was significantly affected by RUD (p < 0.001), but not by FEM (p = 0.47). When the wrist deviated from (0, 0) to a radial position at (0, 15), the force sharing of the index finger showed an increase from 31.0% to 42.6%, an absolute increase of 11.6%.

The utilization of the current results may assist hand rehabilitation, functional assessment, injury prevention, and ergonomic design.

REFERENCES

Hazelton, F. T. et al. (1975) *J Biomech* 8, 301-6
LaStayo, P. & Hartzel, J. (1999) *J Hand Ther* 12, 212-8;