

THE STATIC HUMAN PREHENSION: SYNERGY AND PRINCIPLE OF SUPERPOSITION

J.K. Shim, M.L. Latash, V.M. Zatsiorsky,
Department of Kinesiology, The Pennsylvania State University

OBJECTIVES: The main purpose of this study has been to identify the relationship between the mechanical variables enabling a stable human prehension and to confirm the principle of superposition in human. **METHODS:** Subjects (n=6) stabilized a 1.5 kg handle with five different external torques (-1.0 Nm, -0.5 Nm, 0 Nm, 0.5 Nm and 1.0 Nm). Under each torque, a subject performed 25 trials for 5 seconds each. Forces and moments exerted by the digit tips on the sensors attached to the handle were recorded. Principal component analysis and Pearson's coefficients of correlation with error correction were used to discover the relationships between variables. MANOVA was also used to find the subject specific performance characteristics and variable differences due to the torque conditions. **RESULTS:** Individual performance variables were organized in two null spaces (uncontrolled manifolds). Variables within a null space highly correlated with each other with the coefficients of correlation close to ± 1.0 while there was no correlation among variables from the other null space. Some of the observed phenomena could be predicted from static equilibrium equations. Other relations likely represent solutions preferred by the subjects. Among the latter were: (a) different locations of the clusters of data points reflecting the tangential forces in various tasks and in different subjects, (b) the lack of correlation between the total normal force and the moment that the force generates, and (c) a significant correlation between the thumb tangential force and the point of application of the normal resultant force of the fingers. **CONCLUSIONS:** The discovery of the two null spaces supports the principle of superposition for human prehension. We conclude that the prehension synergy is comprised of two sub-synergies realizing correspondingly the grasp control (preventing an object from slipping out of the hand) and the torque control (maintaining a desired object orientation).