# HAND POSTURE AND FORCE ESTIMATION USING SURFACE ELECTROMYOGRAPHY AND AN ARTIFICIAL NEURAL NETWORK

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**Introduction:** Work-related upper extremity disorders, such as carpal tunnel syndrome (CTS) remain a troubling and costly disease for both employers and workers. Recent prospective studies have identified dose-response relationships between various measures of hand force and carpal tunnel syndrome (Harris-Adamson et al, 2015). However, exposure assessment methods used to quantify hand force are limited in accuracy and ease of measurement. Prior studies have been done to classify the features extracted from the electromyography (EMG) with artificial neural networks (ANN), but relatively few studies have been performed to estimate hand posture and exertion forces at varying levels of force exertion, duty cycle and repetition rate. The primary purpose of this study was to develop a method for estimating hand posture (pinch versus grip) and hand exertion force forearm surface electromyography (sEMG) and neural networks.

**Methods:** Twelve people participated this experiment. Surface electromyography (sEMG) data was collected (Telemyo 2400 T, Noraxon, Scottsdale, Arizona); four electrodes were equally spaced distal to the elbow with the first sensor over the muscle belly of extensor digitorum and the next 3 forming a ring around the forearm. One additional sensor was placed over the abductor pollicis longus (APL). For calibration, subjects applied 25%, 50% and 75% of their maximum power grip and pinch force (digital dynamometer and pinch meter, Biometrics Ltd, Ladysmith USA) three times holding for 4 seconds per exertion with rest periods between. Next, subjects completed a variety of tasks that varied hand posture (pinch versus power grip), load (grip: 2Kg, 3.5Kg, 5Kg; pinch: 0.5Kg, 1Kg, 2Kg), duty cycle (20%, 80%) and repetition rate (12/min, 20/min). The sEMG data from the calibration were used to train the artificial neural network (ANN) to predict hand posture (pinch or grip) and hand exertion force above previously identified thresholds (1kg pinch; 4.5kg grip). The pre-trained ANN models (posture and hand exertion force) were applied to the task data and validate its accuracy.

**Results:** Posture prediction overall accuracy is 0.73±0.27, force level prediction accuracy is 0.75±0.19. The predicted posture accuracy of pinch (0.81 ±0.27) was higher than grip (0.65±0.27); prediction of force level at a lower repetition rate of 12/min (0.76±0.19) was better than the prediction of force level at the higher repetition rate (0.73±0.19). Similarly, prediction of force level was higher for lower duty cycle tasks (0.80±0.17) than higher ones (0.70±0.22).

**Conclusions:** Overall, hand posture and force prediction were possible using sEMG and ANNs, though predictions were better when tasks had lower repetition rates and duty cycle. Applying more sophisticated deep learning models may improve the accuracy of prediction.

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