

The Potential of Wearable Sensor Technology for EVA Glove Ergonomic Evaluation

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Question: What EVA work-related variables are affecting the hands to cause injury and can they be quantified?

Objectives: A feasibility pilot study to test for quantification methods for use in a pressurized EVA glove environment

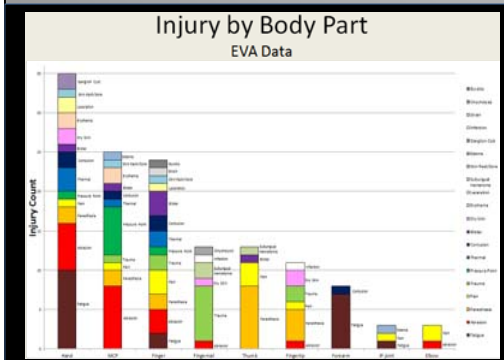
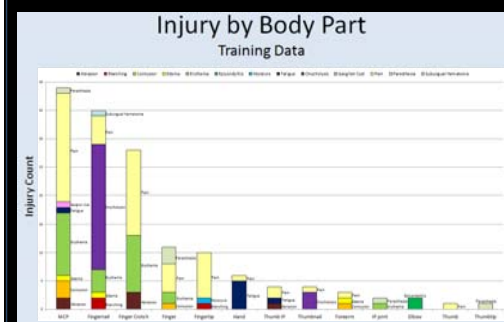
Injury Data

Prevalence

- 124 EVA flight related incidents
- 87 EVA training related incidents
- Over 57% of total astronaut upper extremity injuries (n=147) from EVA pool training (1998-2010) occurred to the hand metacarpophalangeal (MCP) joint (n=39), fingernail (n=35), or fingertip (n=10)
- 20% of crew have been injured during training
- 45% of crew have been injured during flight

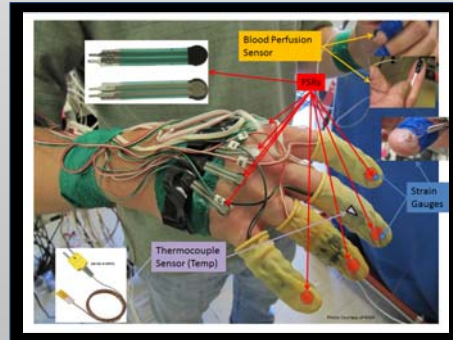
Potential Causes

- Poor glove-hand fit
- Glove related pressure points
- EVA related training and activities
- Pressurized EVA gloves



Method

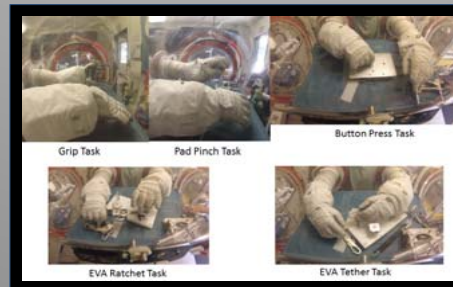
- 16 sensors were used to assess changes in forces (9 FSRs, 3 strain gauges), temperature (3), and finger pad blood perfusion (1) levels
- 2 male pilot test subjects performed static hand postures and dynamic strength tasks to assess sensor potentials



Glove Sensor Setup



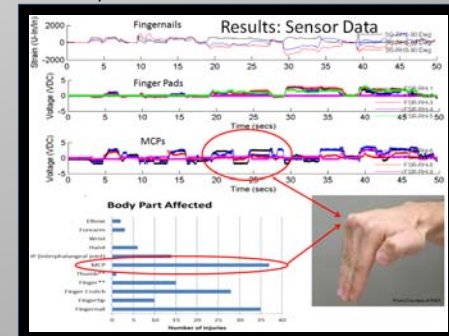
Static Tasks



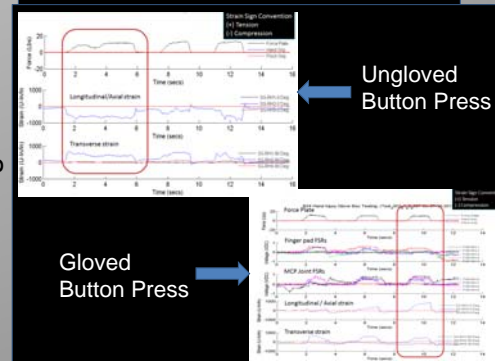
Dynamic Tasks

Results

- Fingernail strain gauge data revealed higher transverse tension/compression loads than longitudinal/axial ones
 - EVA glove usage influenced how fingernails deformed during tasks
- Finger pad perfusion levels were found to be influenced by both hand posture/task and the EVA glove
 - Blood perfusion levels in the capillaries would drop as finger pads deformed and would rush back in as they returned to a neutral state
- Fingertip temperatures in EVA glove were found to be cooler than hand dorsum and upper arm temperatures (7.5°F and 3.8°F)
 - All body location temperatures increased during testing with the hand dorsum locations being the warmest (avg. 95.6°F)



FSR Data



Strain Gauge Data

Future Work

- Consider sensors to assess moisture and pressure levels
- Consider wearable garment/glove integration
- Continue refining sensor types and testing methods
- Continue quantifying pressurized gloved environment to understand the cause – effect relationship of injury