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

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

Injury Data

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

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)

Injury by Body Part

Static Tasks

Dynamic Tasks

Glove Sensor Setup

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

Finger Pad Temperature

Glove Sensor Data

Strain Gauge Data

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