A Wearable Sensor to Mitigate Shoulder Injury in Astronauts

MADELINE BOUTWELL, MIKAELA ROOD, ANTHONY CAMPOS, JOSE CANELO, ALEXANDRA CHAPMAN, VIRIDIANA SILVA, STERLING WALKER, SHERI DRAGOO, NICHOLAS LEVINE and BRANDON RIGBY

Biomechanics Laboratory; School of Health Promotion & Kinesiology; Texas Woman's University; Denton, TX

Category: Undergraduate

Advisor / Mentor: Rigby, Brandon (brigby@twu.edu)

ABSTRACT

The prevalence of shoulder pain has been documented to be as high as 56% among astronauts who perform extravehicular activities (EVA) while training. The prevalence of shoulder injuries in astronauts required NASA to assemble a research team, called the Shoulder Tiger Team, nearly 20 years ago. In 2003, this team concluded that the majority of the shoulder injuries occur while the astronaut is wearing the hard upper torso unit (HUT) of their space suit during EVA training missions in the neutral buoyancy lab (NBL). These injuries typically carry-over to the actual mission, and required EVAs, which can negatively affect job performance duties performed by astronauts. We chose to create a warning system that is able to collect angular displacement data at the shoulder and, at a potentially dangerous range of motion, send tactile (vibrational) feedback to the astronaut. **PURPOSE**: To design a cost effective, wearable, tactile feedback sensor to help mitigate shoulder injury during EVA training. **METHODS**: A custom fitted, upper-body garment that contained a tactile feedback sensor capable of delivering a vibrational signal was originally designed in three-dimensional modeling software (Solidworks Premium 2018, Waltham, MA). The sensor and all associated components were integrated into a compression sleeve, which is personalized to each astronauts' anthropometrics. The components are removable and interchangeable for ease of maintenance. These components include a microcontroller, flex sensors, haptic motor driver, vibration mini motor discs, and battery. The sensor components were strategically placed at anatomical locations to maximize comfort and function: 1) anterior flex sensor: placed on the deltoid, extending from medial to lateral; 2) posterior flex sensor: extended from the lateral end of supraspinatus to the middle deltoid; 3) microcontroller: placed on the inferior angle of the scapular spine; 4) vibration motor discs: placed on the sternum and upper tricep, and; 5) haptic motor driver: placed directly superior to the vibration motor. **RESULTS**: In order to correlate range of motion with the resistance of the flex sensors, a goniometer was used to measure the range of motion of shoulder abduction and shoulder flexion while recording resistance data in the serial monitor. The mapped resistance value recorded at 90 degrees for shoulder joint flexion was approximately 57 kohms. The mapped resistance value recorded at 90 degrees for shoulder abduction was approximately 37 kohms. We also developed a protocol to improve the muscular endurance of the small upper back muscles and shoulder stabilizers. It is a 3-day strengthening program that will be complemented with the regular EVA mission training for each astronaut. **CONCLUSION**: Shoulder injuries are one of the most common issues affecting astronauts who undergo EVA training. A vibrational feedback sensor may mitigate the potentially harmful shoulder positions during this training.