LIFE IN SPACE DESIGN CHALLENGE
MUSCLE MAXIMUS
CARNEGIE MELLON UNIVERSITY

Problem Statement

Prolonged exposure to microgravity in space missions causes muscle atrophy. Astronauts lose almost 20 percent of their muscle mass due to this condition. To combat muscle degeneration, astronauts are required to exercise two and a half hours every day during their missions. But it still takes anywhere from a month to a year of physiotherapy for astronauts to gain mobility after returning to Earth. Furthermore, these special exercise machines occupy large areas within the space station. Since astronauts spend over 12 hours working each day, we think it would be beneficial to incorporate some sort of muscle training into their work. This device may not completely replace their entire two and a half hours of exercise a day, however it would potentially reduce their daily exercise time by at least an hour. While this may not seem like a lot of time, astronauts spend an average of six months for each ISS mission which equates to reducing around 180 hours of dedicated exercise time. In addition to reducing exercise time, this device can also significantly reduce the number of machines needed for exercise, freeing up more space in the ISS. While there have been exoskeletons made for physiotherapy purposes, these designs are often bulky and require a constant source of electricity. Our design, the Muscle Maximus, would be something astronauts could wear freely throughout the day without being limited by a power source.

Design Proposition

The Muscle Maximus targets four major muscle groups, the arms (biceps and triceps), the legs (quadriceps and hamstrings), the shoulders (deltoids and trapezius), and the back (spinalis). To provide a resistive force to these muscle groups, three types of mechanisms are used: a hinge, a ball and socket, and an elastic band.

Since the elbow and knee joints are only one degree of freedom each, a hinge is used to create the resistance. For the knee brace, one end is attached to the lower thigh area and the other to the upper calf with a Velcro band. On each side where the two parts come in contact is a container for a viscous fluid. As a person extends their legs, the fin turns in the viscous fluid causing a resistive force to the user's leg muscles. Similar to the knee brace, the elbow brace would be attached to the forearm and bicep and use the same type of mechanism to create resistance for the user.

While a hinge was used for single degree of freedom joints like the knee and elbow, it cannot be used for the shoulder because the shoulder has three degrees of freedom. Thus, a ball and socket support was created to imitate the shoulder joint. However, this ball and socket joint would be coated with a rough surface with high coefficients of friction, causing a high friction force when rubbed against each other. This will allow a person to engage more of their shoulder muscles when moving their arms during normal tasks.

While the knee, elbow and shoulder only have one point at which they can each move, the back consists of multiple vertebrae that can all move. An elastic band is therefore used to provide resistance to the back whenever it bends forward.

Carnegie Mellon University

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