Conservation of Energy during the Grip Cycle in Voluntary Opening and Voluntary Closing Systems

Authors: Alley, R. / Radocy, R. / Veatch, B.

Introduction

Cable driven technology has been the mainstay in the prosthetic industry since its inception. However, while new, increasingly advanced externally powered technologies have emerged and continue to evolve at a fairly rapid pace, cable driven technology has evolved much more slowly. To address entirety of the myriad reasons behind this are outside the scope of this paper; however, it is inarguable that the slow pace of development of cable-driven applications is at least partly due to lower reimbursement levels but also to the relative functional success that most avid wearers have enjoyed with regard to performance of their ADLs and other repetitive tasks using this simple yet effective technology.

Despite its overwhelming success, one of the recognized limitations of cable-driven systems is their reliance on gross body motion and harnessing for operation, resulting in increased discomfort, the potential for the onset of nerve entrapment syndrome and increased energy expenditure when compared to other technologies such as myoelectric control. A new enhancement to cable driven technology, the Sure-Lok, is designed to address these challenges by allowing the user to effectively lock the terminal device in an infinite number of positions, allowing for a reduced reliance on user-maintained cable tension, the chief source of discomfort, nerve issues and energy expenditure.

Method and Materials

Utilizing an HPxw4550 Work Station integrated with a National Instruments' cDAQ-9172 data acquisition system running LabVIEW software. The system collects data from a Measurement Specialties' ELPF Compact In-Line Tension Load Cell and a linear position transducer LX-PA-10 made by UniMeasure. The system collects simultaneous data on cable excursion and cable tension as the user executes one or more grasping cycles. From this we computed an effective average holding cable tension over the cycle while effecting grasp for an object of given weight, size, compliance, and orientation.

Subjects

Data regarding effective average holding cable tension over the grip cycle was collected from both a human subject and a bench testing apparatus using the system described above.

Results

When the Sure-Lok device was utilized during testing, it was noted that total time under which cable tension was generated by the user as measured at the harness was significantly decreased during the grip cycle using both a voluntary opening and voluntary closing terminal device.

Discussion

The results appear to substantiate the theory that the amount of user-generated cable tension in order to maintain grip will be reduced during utilization of a cable-locking device.

Conclusion

It can be inferred from cable-driven harness design that cable tension imparted to the harness results in a wearer's increased energy expenditure as he or she must exert an equal and opposite reaction to forces imparted by the pull of the cable if grip is to be maintained in VC applications and optimized in VO applications where less than maximum grip force is desired. Since total time under cable tension as well as total average cable tension experienced by the user were reduced during the grip cycle utilizing the Sure-Lok, it is ascertained that energy consumption by the user is was also reduced.