INTRODUCTION
Approximately one in every 160 Americans are currently living with an amputated limb. There are nearly 2 million people with a limb loss in the United States, with around 50,000 new amputations occurring each year. The sudden loss of a hand or arm causes the loss of fine, coordinated movements of the upper limb, reduced joint range of motion, tactile sensation, reduced proprioceptive feedback and aesthetic appearance, all which can be improved with the use of a prosthesis. Maintenance of joint range of motion, increasing upper-limb muscle strength, and gaining maximal functional independence are all crucial elements to ensure patient success with the prosthesis, making the training and rehabilitation phase significantly important. An effective training and rehabilitation program allows patients to return to their daily life duties at the most functional independence possible with the use of all prosthetic control capabilities. Since a successful training and rehabilitation program is essential, the need for advanced rehabilitation techniques is substantially high.

METHOD
Subjects: The patient population for this study included healthy individuals (n=5) and individuals with a unilateral transtibial or transradial amputation (n=10).

Apparatus: The Computer Assisted Rehabilitation Environment (CAREN) system (Motek Medical, Netherlands) was used to immerse patients into real life situations while providing real time visual feedback of their motion. CAREN is a multimodal system consisting of a 10-camera real time motion capture system (Vicon, Nexus, Englewood, CO), with a 6 degree of freedom hydraulic base with a double-belted instrumented treadmill and a 180-degree cylindrical screen projection system.

Procedures: Prior to participation, all subjects signed an informed consent. Specific anatomical measurements were taken and 40 reflective markers were placed at precise points on the subject. Each subject participated in two sessions, one with the use of virtual reality and one without. The order each subject completed the sessions was predetermined by a random generator. Each session lasted 1-2 hours, consisting of a series of range of motion (ROM) tasks, activities of daily living (ADL), and return to duty (RTD) tasks. When using the virtual reality, subjects were shown their real time avatar simultaneously with the individualized optimal motion for each task. Each task was completed three times.

Data Analysis: The motion-captured data of each subject were used to directly calculate the kinematic model’s joint angles from the measured XYZ marker positions on a frame-by-frame basis. The elbow, glenohumeral, and torso angle ROMs were all found. The joint angle ROMs were also calculated from optimal motion analysis data for a measure of comparison.

RESULTS
Greater improvements in movement and ROM were evident in subjects when using the virtual reality system verses non-virtual reality training. Improvements were assessed between each succeeding trial while using the virtual reality system and subject’s movement quickly became closer to the optimized goal motion showing movements to significantly improve.

DISCUSSION
Preliminary results suggests training and rehabilitation for upper limb prosthetic users are enhanced through improved movement and joint ROM when provided visual feedback of the subject’s real time avatar and an optimal goal motion model with the use of virtual reality.

CONCLUSION
The enhancement of upper limb prosthetic training and rehabilitation is especially beneficial to improve user’s movement, joint angle range of motion, and overall quality of life while greatly contributing to the state of science.

CLINICAL APPLICATIONS
With effective training and rehabilitation, prosthetic users are able to gain the maximal functional level of independence possible. This will be clinically significant to upper limb prosthetic training and rehabilitation programs by introducing an adaptable way to increase effectiveness and greatly impact the future of prosthetic users.

REFERENCES

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