The Functionality of the Bio-Mechanical Prosthetic Finger

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Study summarized by Naked Prosthetics

ABSTRACT

The purpose of this study was to examine the functionality of the Bio-Mechanical Prosthetic Finger (BPF/PIPDriver). The researchers administered various assessments to examine how the PIPDriver performed in comparison to the affected hand without the PIPDriver, as well as the unaffected hand. The following standardized assessments were administered: Minnesota Manual Dexterity Test, Jamar Hand Function Test, and Box and Blocks Test. The Disability of the Arm, Shoulder, and Hand (DASH) and two other questionnaires were also administered to examine the subject's ability to perform various activities. The results were analyzed to show the percent change between the three comparison groups of each assessment. The results indicated that the subject performed at a higher level of function while utilizing the PIPDriver.
Keywords: digit amputation, upper extremity prosthetics

INTRODUCTION:

Digital amputations are one of the most difficult amputations to fit for a prosthesis due to suspension challenges, proprioception loss, aesthetics, and patient discomfort. Digit amputations represent the largest number of amputations, but few prosthetic devices have been designed to suit the needs of digit amputees. Cosmetic silicone prostheses are made to resemble the patient's remaining fingers and hands, but they offer only limited functional ability. In 2008, the first myoelectric system for patients with partial hand or digital amputation was introduced. While the system attempts to mimic functions of the human hand, it is not suitable for harsh environments, and costs upwards of $100,000.

Body powered prosthetics were not appropriate for digit or partial hand amputations until recently. The Bio-Mechanical Prosthetic Finger (PIPDriver) helps to restore length, dexterity, and grip strength to patients with digit amputations. In addition to increasing function, the PIPDriver is designed as a protective and supportive mechanism for the residual digit. The PIPDriver operates from force generated by finger flexion and contain no electrical components. This allows the device to be worn in a variety of contexts, environments, and activities, which makes it practical for everyday use. The PIPDriver will continue to be operational and functional despite becoming wet or dirty. The combination of durability, versatility, and practicality makes the PIPDriver an excellent option for many amputees. The purpose of this study is to examine the functionality of the PIPDriver.

METHODS:

Student researchers at Alabama State University conducted research with standardized outcome measures to examine the functionality of the PIPDriver. In July of 2015, the researchers submitted the preliminary capstone proposal to the ASU Institutional Review Board and approval was granted in August of 2015.

The researchers located a current user of the PIPDriver through via convenience sampling, and contacted the subject to determine if he was interested in participating in this study. The appropriate documents were then signed by Naked Prosthetics (manufacturer) and the subject to address liability and obtain consent. The subject is a 28-year old male who currently wears two PIP driven devices (PIPDriver) on the third and fourth digits of his dominant, right hand. The subject is also missing the tip of his index finger on his right hand, but does not utilize a prosthetic device on this digit. His amputation occurred five years ago as a result of a work-related accident. He has utilized the PIPDriver for three years.

The subject completed all assessments both with and without wearing the prostheses. To minimize the learning curve, the subject first completed each assessment with his unaffected hand and without wearing his device. The subject then completed each

assessment again while wearing his devices. Upon completion of the assessments, the researchers utilized descriptive statistics to analyze the change in performance on each individual assessment. Through a qualitative analysis of an interview, two questionnaires, and one functional outcome measure, the researchers performed a thematic analysis to establish common themes identified by the subject.

RESULTS:

Minnesota Manual Dexterity Test

The Minnesota Manual Dexterity Test - Placing and Turning subtests were completed. For both subtests, the subject's time improved while wearing the PIPDriver. The subject showed an improvement of 0.64% for the Placing subtest, and an improvement of 8.48% in the Turning subtest.

Placing Subtest Time in Seconds

Hand	4 Trial Total	Average
Unaffected	299.61	74.93
Without PIPDriver	297.41	74.35
With PIPDRIVER	295.51	73.88

Turning Subtest Time in Seconds

Hand	4 Trial Total	Average
Without PIPDRIVER	234.01	58.50
With PIPDRIVER	215.72	53.93

Jamar Hand Function Test

Hand function was assessed using the Jamar Hand Function Test. The test consists of seven subtests, shown in the table below. The subject showed improvement while wearing the PIPDriver in five out of seven subtests.

Comparison of Subtests with and without PIPDriver

Subtest	No PIPDriver	With PIPDriver	Change (sec)	% Change
Writing	18.53	16.15	-2.38	-14.74%
Simulated Page Turning	4.5	4.75	0.25	5.26%
Small Common Objects	9.34	8.53	-0.81	-9.50%
Simulated Feeding	7.38	6.03	-1.35	-22.39%
Checkers	5.28	5.84	0.56	9.59%
Large Light Objects	5.16	4.57	-0.59	-12.91%
Large Heavy Objects	4.82	4.16	-0.66	-15.87%

Box and Blocks Test

Box & Blocks was performed by the subject with and without the PIPDriver prosthetics. This test evaluated gross manual dexterity, utilizing small wooden blocks and a wooden box with a partition. The subject placed 50 blocks without the PIPDriver, and 52 blocks with the PIPDriver, showing a 4% improvement. Norms for males age 25-29 are 85 blocks for the right hand.

Qualitative Analysis

The qualitative data were obtained through the use of one interview, one functional outcome measure, and two questionnaires. Common themes were identified as: grasping/holding/lifting, supporting/balancing, ADLs, sports/recreation, hobbies, and residual limb/phantom limb pain.

Subject identified grasping/holding/lifting as easier with the PIPDriver. He also identified supporting and balancing objects, such as his phone, as easier with the PIPDriver. Buttoning shirts, closing zippers, using scissors, and writing with a pencil were identified as equally difficult, with and without the PIPDriver. Subject reported he was able to participate in leisure activities, such as hunting and fishing, while wearing PIPDriver. The subject was able to better stabilize and grip a gun, fishing pole, and tackle, with the PIPDriver.

In addition, the subject reported phantom and residual limb pain in his residual digits. He reported an increased sensitivity at the amputation sites. While not wearing the devices, the subject experienced pain when his residual digits would impact objects or surfaces. The subject reported that the PIPDriver alleviated pain by protecting his residual digits.

DISCUSSION/CONCLUSION:
The goal of this study was to examine how well the PIPDriver performed on various standardized functional and non-functional assessments. Overall, the subject performed to a higher degree while utilizing the PIPDriver devices. This supports the claim that the PIPDriver reestablishes function to individuals following a digit amputation.

The subject gained a higher level of fine motor dexterity while utilizing his PIPDriver devices. Improvements were also noted during arm-hand dexterity tasks, and gripping tasks. The results of the Minnesota Manual Dexterity Test showed improvements in hand use related to fine motor dexterity, bilateral hand coordination, and gross manual dexterity. The results of the Jamar Hand Function Test showed improvements in functional hand use related to fine motor dexterity, gross manual dexterity, and grasp. These improvements were directly related to improvements in completion of daily tasks. The Box & Blocks Test showed improvements in tasks related to fine motor dexterity and gross manual dexterity.

The PIPDriver devices increased the length of the subject's residual digits. This extension allowed the subject to regain in-hand manipulation skills, which equated to that of the unaffected hand. The subject's results supported the Naked Prosthetics' claim that the PIPDriver helped to restore length, dexterity, and grip strength.

There were few aspects of the various assessment in which the subject failed to show improvement. This may be attributed to the glossy finish of the devices. While he could perform pincer grasp motions, he struggled utilizing a lateral grasp against the outer aspect of the PIPDriver. These tasks may have been more difficult due to the smoothness of the outer surface.

Based on the results of the various assessments, the PIPDriver serves as a viable option for digit amputees. Due to the active grip and motion that the PIPDriver provides, the subject has been able to maintain a career that involves manual labor. The subject stated that he was able to participate in many harsh-environment leisure activities without concern for damaging the devices. The subject reported that the device stayed securely in place, and he was not concerned about the device slipping off during daily tasks. Due to his indifference regarding the appearance of his amputation and prostheses, the subject has not experienced any psychological effects while wearing a device that does not match his skin tone.

CONCLUSION:
The purpose of this study was to examine the functionality of the PIPDriver. The subject wore two PIPDriver devices on fingers three and four on his dominant, right hand. The Minnesota Manual Dexterity Test, the Jamar Hand Function Test, and the Box & Blocks test all showed improvement in performance while wearing the PIPDriver vs not wearing it. Overall, the subject had an increase in performance on the assessments while utilizing the PIPDriver. The results of the study show that the PIPDriver is a viable option for digit amputations to restore function in daily tasks.

REFERENCES: (limited subset)
Dillingham, T., Mackenzie, E. Limb amputation and limb deficiency: Epidemiology and recent trends in the United States. *South Med J.* 2002; 95(8): 875-883.

Murphy, D., (2014). *Fundamentals of amputation care and prosthetics.* New York, NY: Demos Medical Publishing.

National Center for Health Statistics: US Department of Health and Human Services. *Current Estimates from the National Health Interview Survey,* (1994).