EFFECT OF MULTI-GRIP MYOELECTRIC HANDS ON DAILY ACTIVITIES, PAIN-RELATED DISABILITY AND PROSTHESIS USE COMPARED WITH SINGLE-GRIP PROSTHESES

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ABSTRACT

Objective: To evaluate the effect of multi-grip hands on performance of daily activities, pain-related disability and prosthesis use, in comparison to single-grip hands. Design: Single-case AB design. Patients: Nine adults with upper-limb loss participated. All had previous experience of single-grip myoelectric prostheses and were prescribed a prosthesis with multi-grip functions. Methods: To assess the changes in daily activities, pain-related disability and prosthesis use between single-grip and multi-grip prosthetic hands, the Canadian Occupational Performance Measure, Pain Disability Index, and prosthesis wearing time were measured at multiple occasions. Visual assessment of graphs and multi-level linear regression were used to assess changes in the outcome measures, adjusting for xx, yy, and zz. Results: At 6 months' follow-up self-perceived performance and satisfaction scores increased, prosthesis wearing time increased, and pain-related disability reduced in participants with musculoskeletal pain at baseline. On average, 8 of the 11 available grip types were used. Most useful were the power grip, tripod pinch and lateral pinch. Conclusion: The multi-grip hand appears to be associated with higher performance and satisfaction of individually chosen activities, increased prostheses use and lower pain-related disability. A durable single-grip hand may still be needed for heavier physical activities. With structured training a standard two-site electrode control system can be used to operate a multi-grip hand.

INTRODUCTION

It is well known that myoelectric prostheses are being used in varying degrees [1]. To improve the usability of prosthesis, myoelectric prosthetic hands have been developed with multiple grip functions. The multi-grip prostheses have the potential to facilitate fine motor skills and enable a natural movement pattern [2], which, over time, may reduce pain due to a reduction in compensatory movements, and avoidance of overuse of the contralateral limb. However, the impact of these hands on the users' daily life has been sparsely studied, and the results have been inconsistent. Both users and clinicians reported that many of the multi-grip functions are rarely used [3]. There are several possible reasons for this; notably that all functions in the multi-grip hand need to be mastered, which may take time, training and, inevitably, require higher cognitive load [4]. Another reason for not using the full potential of the multi-grip hand may be incomplete training [5,6]. With inadequate training the patients may use their multi-grip hand in the same way as they have used a single-grip prosthesis [7,8]. Questions arise as to whether extensive training in control skills and use of multi-grip functions will facilitate actual use of the prosthesis, and whether this will have an effect on prosthesis users' activity performance and pain-related disability.

AIM

The overall aim of this study was to evaluate the effect of multi-grip myoelectric prosthetic hands on the performance of daily activities, pain-related disability and prosthesis use, in comparison with single-grip myoelectric prosthetic hands. A secondary aim was to study the users' ability to learn and use the multi-grip hand functions with a standard 2-site control system.

METHOD

A single case AB-design was used.

Participants and procedure

Inclusion criteria were: age 18 years or older, upper limb loss due to amputation or reduction deficiency present at birth, being a previous user of a conventional myoelectric prosthesis (single-grip) and having had training in using it, and having currently being prescribed a multi-grip prosthetic hand. Nine patients (5 males/4 females) mean age 31,8 (range: 18-59) years with various causes of limb loss and various prosthesis wearing time (range: <1-15 hours /day) were prescribed a multi-grip hand during September 2017- September 2020 and included in the study. They were all fitted with a bebionic multi-grip hand from Ottobock, Vienna, Austria, and using 2-site direct control.

In the prescription procedure the patients identified activities that were hard to perform with their present conventional myoelectric hand. The activities required fine motor skills which the participants thought maybe could be easier to perform with a multi-grip prosthetic hand. Examples of activities were to hold a book, shake hands, use cell phone, carry shopping bags, dress children, cook, and use a keyboard.

The participants were assessed 3 times before fitting with their single-grip prosthesis for a base-line (Phase A). Thereafter, the intervention followed, including fitting a multi-grip hand and a period of training and follow-up (Phase B). They had 2 days of intensive training at the time of fitting the bionic hand, and further training at the follow ups after 2 weeks, 1, 2, 3 and 6 months after fitting. A total of 6 assessments were made with the multi-grip hand (bebionic).

Outcome measures

To assess the changes in daily activities, pain-related disability and prosthesis use between single-grip and multi-grip myoelectric prosthetic hands, the Canadian Occupational Performance Measure (COPM), Pain Disability Index (PDI), and prosthesis wearing time were measured at multiple time-points. A study specific questionnaire was also used at the 6 months follow up to investigate the usefulness and actual use of the available grip types.

The COPM is an interviewer administered assessment of individually selected problems in daily life activities. Patients define the 5 most important activities and score the quality and satisfaction with performance on a 1-10 scale where higher score indicates higher quality of performance or satisfaction with performance. The COPM scores were calculated according to the manual, with the sum of scores divided by the number of activities.

The effect on pain-related disability was measured with the PDI. This generic instrument measures the impact of prolonged pain on a person's ability to participate in essential life activities. The PDI is able to detect from low to high levels of pain-related disability on a 0–10 scale in 7 dimensions. The scores on all the dimensions are summed on a scale of 0–70, where a higher score indicates more obstacles in essential life activities due to pain.

The secondary aim, to study the users' ability to use the multi-grip hand functions, was assessed with a modified Southampton Hand Assessment Procedure (SHAP) and Assessment of Capacity for Myoelectric Control (ACMC). A modified SHAP was used to measure ability to switch between grips. The participants performed all tasks in the test in a sequence, and switched grip between each task. Time taken to complete all tasks was registered. The ACMC was used to see how well the participants learned to control and use the new prosthetic hand in daily activities. The ACMC is an observational based assessment with 22 items scored on a 0-4 scale of capacity for control of the prosthesis. Higher scores indicate higher ability. The ACMC raw scores were processed through the website resulting in an overall score ranging from 0-100.

Analyses

The changes in COPM, PDI, ACMC, and modified SHAP scores were assessed using both visual assessment of graphs [9] and multilevel linear regression models [10]. In the multilevel models, level 2 represented the individual and level 1 represented multiple measurement occasions from baseline to 6 months that were nested within level 2. Follow-up time was used as a categorical variable, with Phase A (baseline) as the reference. The coefficients indicate differences in scores between baseline and each follow-up occasion in Phase B, with adjustment for xx, yy and zz. Confidence intervals (CIs) not overlapping zero were considered to indicate a statistically significant difference.

RESULT

Performance of daily activities

The graphs present crude scores for occupational performance and satisfaction scores in COPM, both of which increased in all individuals after using the multi-grip hand (see Figure 1). Adjusted multilevel regression models showed that, after 3 months, quality of performance scores increased, by a mean of 3.9 points (95% CI=3.2–4.6) and satisfaction with performance scores increased by 4.9 points (CI=4.0–5.7) (see Table 1).

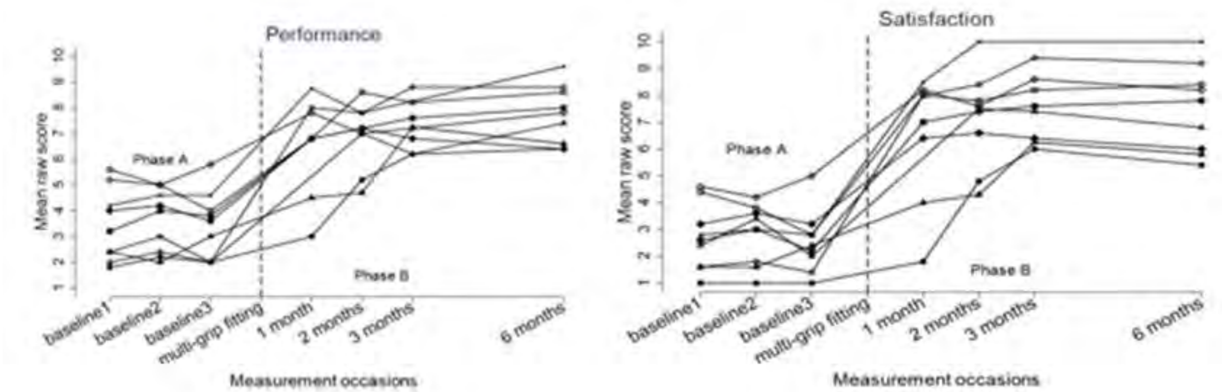

Figure 1: Visual assessment of graphs of quality of and satisfaction with performance, as measured with the Canadian Occupational Performance Measure (COPM). Performance= Quality of performance; Satisfaction= Satisfaction with performance. Raw scores range from 1 to 10, with 10 representing the best possible score. (Phase A=baseline with the single-grip hand, Phase B=follow-up after fitting the multi-grip hand.

Table 1. Coefficients, 95% confidence intervals and p-values using multilevel linear regression models for COPM, PDI, ACMC and modified SHAP scores, with adjustment for xx, yy and zz.

	Data collection time point	**COPM** Performance	**COPM** Satisfaction	**PDI**	**PDI (n=5)***	**ACMC**	**Modified SHAP** Light objects, seconds	**Modified SHAP** Heavy objects, seconds
		Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Phase A	Baseline	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Phase B	2 days	No data collected	No data collected	No data collected	No data collected	-18.5 (-24.5 to 12.4) p<0.001	26.3 (8.1 to 44.4) p=0.005	28.3 (12.2 to 44.3) p=0.001
	2 weeks	No data collected	No data collected	No data collected	No data collected	-12.4 (-18.4 to -6.5) p<0.001	7.7 (2.8 to 12.7) p=0.002	8.9 (-1.2 to 19.0) p=0.085
	1 month	3.0 (2.1, 3.8) p<0.001	3.8 (2.7, 4.9) p<0.001	-2.0 (-9.9 to 5.9) p=0.620	-4.6 (-18.1 to 8.9) p=0.504	-4.2 (-8.6 to 0.3) p=0.068	9.3 (2.9 to 15.8) p=0.004	12.1 (-3.1 to 27.4) p=0.119
	2 months	3.5 (2.9, 4.0) p<0.001	4.5 (3.6, 5.4) p<0.001	-4.0 (-10.8 to 2.8) p=0.249	-7.2 (-18.4 to 4.0) p=0.209	-4.8 (-9.5 to -0.2) p=0.042	5.0 (0.4 to 9.6) p=0.033	1.2 (-8.4 to 10.9) p=0.801
	3 months	3.9 (3.2, 4.6) p<0.001	4.9 (4.0, 5.7) p<0.001	-9.0 (-16.3 to -1.7) p=0.015	-14.4 (-23.0 to -5.8) p=0.001	-1.4 (-6.1 to 3.2) p=0.545	2.3 (-2.3 to 6.9) p=0.330	3.4 (-6.3 to 13.1) p=0.494
	6 months	4.3 (3.6, 4.9) p<0.001	4.8 (3.9, 5.7) p<0.001	-7.7 (-14.0 to -1.3) p=0.018	-13.8 (-21.8 to -5.8) p=0.001	-2.5 (-7.8 to 2.8) p=0.359	6.5 (-5.2 to 18.1) p=0.275	-3.7 (-13.4 to 6.0) p=0.454

*Includes only the 5 participants who reported pain-related disability in the Pain Disability Index at the baseline measurements.

Pain-related disability

Five participants reported that musculoskeletal pain was limiting their participation in essential life activities at baseline. This activity limitation generally declined after fitting a multi-grip hand. At the 6-month follow-up the number of participants reporting any pain-related disability had decreased from 5 to 2. In the adjusted multilevel analyses, focussing on the 5 participants who reported pain-related disability at baseline, it was found that, compared with baseline, their PDI mean score decreased significantly, by a mean of –14.4 (CI=–23.0 to –5.8) at the 3-month follow-up, and by –13.8 (CI=–21.8 to –5.8) at the 6-month follow-up (see Table 1)

Prosthesis use and perceived usefulness of multi-grip features

Participants increased their self-reported prosthesis wearing time after switching to a multi-grip hand, from a mean of 6.9 hours a day with single-grip hand to 8.8 h a day with the multi-grip hand at the 6-month follow-up. The median number of grip types used was 8 out of 11 (range 7–10). Grip types that were considered most useful and were used most were the power grip, tripod pinch and lateral pinch.

Prosthetic skill

Initially, when the participants were fitted a multi-grip hand, their skill in prosthesis control (ACMC scores) decreased compared with their baseline performance with the single-grip hand. After 3 months, the score of most of the participants increased to a level similar as with the single-grip hand. The time to perform the modified SHAP test became longer 2 days after fitting the multi-grip hand, compared with baseline with the single-grip hand. However, by the measurement after 2 weeks, it decreased to a similar level as with the single-grip hand. (Table 1)

CONCLUSION

The multi-grip myoelectric prosthetic hand has favourable effects on performance of, and satisfaction with, individually chosen activities, prostheses use and pain-related disability. A durable single-grip myoelectric prosthetic hand may still be needed for heavier physical activities. With structured training, a standard 2-site electrode control system can be used to operate a multi-grip myoelectric prosthetic hand, and many of the prosthetic functions are actually used.

REFERENCES

[1] EA. Biddiss and TT. Chau, “Upper limb prosthesis use and abandonment: a survey of the last 25 years.” Prosthetics and orthotics international, vol. 31(3), pp.236-57, 2007.

[2] Resnik L, Huang HH, Winslow A, Crouch DL, Zhang F & Wolk N. Evaluation of EMG pattern recognition for upper limb prosthesis control: a case study in comparison with direct myoelectric control. J Neuroeng Rehabil 2018; 15:1-13.

[3] Franzke AW, Kristoffersen MB, Bongers RM, Murgia A, Pobatsching B Unglaube F & van der Sluis CK. Users’ and therapists’ perceptions of myoelectric multi-function upper limb prostheses with conventional and pattern recognition control. PLoS One 2019

[4] Resnik LJ, Acluche F, Lieberman Klinger S. User experience of controlling the DEKA Arm with EMG pattern recognition. PLoS One 2018; 13: e0203987.

[5] Van Der Niet O, Bongers RM, Van Der Sluis CK. Functionality of i-LIMB and i-LIMB Pulse hands: Case report. J Rehabil Res Dev 2013; 50.

[6] Resnik L, Meucci MR, Lieberman-Klinger S, Fantini C, Kelty DL, Disla R & Sasson N. Advanced upper limb prosthetic devices: implications for upper limb prosthetic rehabilitation. Arch Phys Med Rehabil 2012; 93.4: 710–717.

[7] Roche AD, Vujaklija I, Amsuss S, et al. A Structured rehabilitation protocol for improved multifunctional prosthetic control: a case study. J Vis Exp 2015: e52968.

[8] Johnson SS and Mansfield E. Prosthetic training: upper limb. Phys Med Rehabil Clin N Am; 25: 133–151, 2014.

[9] Lobo MA, Moeyaert M, Cunha AB, et al. Single-case design, analysis, and quality assessment for intervention research. J Neurol Phys Ther; 41: 187, 2017.

[10] Baek EK, Moeyaert M, Petit-Bois M, et al. The use of multilevel analysis for integrating single-case experimental design results within a study and across studies. Neuropsychol Rehabil 2014; 24: 590–606.