USER-RELEVANT FACTORS THAT DETERMINE CHOICES FOR TYPE OF PROSTHESIS AND TYPE OF PROSTHESIS CONTROL

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ABSTRACT

Background: We recently provided a comprehensive overview of factors that could determine prosthesis choice for persons with major unilateral upper limb defects by performing a qualitative meta-synthesis of literature combined with results from a focus group among end-users. However, this overview did not contain any user experiences about pattern recognition (PR) control. Therefore, the aim of the current paper was to validate the overview for PR controlled prostheses.

Methods & Materials: A literature search, in which we searched for qualitative contributions about PR controlled prostheses from the users' perspective, was performed. The relevant text in the results sections of retrieved papers was extracted and entered into Atlas.ti for a qualitative analysis. The coding framework was based on the overview of our recent meta-synthesis and focus group study. The overview consists of six main themes ('physical', 'activities and participation', 'mental', 'social', 'rehabilitation, costs and prosthetist services', and 'prosthesis related factors') and 86 subthemes.

Results: Three articles were included. Out of the 43 subthemes that were mentioned in the data, 41 were already included in the coding framework. The subthemes 'intuitiveness' and 'calibration' were added (both within the main theme 'prosthesis related factors'). Furthermore, results showed that PR control was experienced as intuitive, but also as unreliable, difficult and requiring extensive training and high mental effort.

Conclusion: An up-to-date overview with factors that could affect prosthesis choice, which consists of six main themes and 88 subthemes, that was also applicable to the choice for PR controlled prostheses was created. The up-to-date overview may help persons with upper limb defects to identify factors that really matter for them when selecting a prosthesis. However, since only three studies were included and only a limited literature search was performed, more qualitative studies about user experiences with PR controlled prostheses are needed to further validate the results of this paper.

INTRODUCTION

Considering the high rejection rates of upper limb prostheses, it is important to determine which prosthesis characteristics best suit the preferences of a user [1]. Therefore, we recently performed a study in which we identified user opinions about factors determining prosthesis choice for persons with major unilateral upper limb defects [2]. The study existed of two parts: a qualitative meta-synthesis of the literature and a validation of those results in a focus group with end-users [2]. Based on these results a well-arranged overview of 86 factors that could affect prosthesis choice was created [2]. Potential prosthesis users can use the overview, provided by the clinician, to identify what really matters to them. Users and clinicians can discuss those factors and select a prosthesis that best fits the needs of the user. However, one of the limitations of this study was that we did not include any user experiences with pattern recognition (PR) controlled prostheses [2]. Since prostheses with PR control have recently become commercially available, it would be beneficial for clinical practice to extent the overview for PR controlled prostheses.

In contrast to direct control (DC), which uses electromyography (EMG) signals of two muscles to control opening and closing, PR control uses algorithms that learn to recognize patterns from EMG of six to eight muscles [3,4]. In PR control, switching between different modes of the prosthesis by using a trigger signal (e.g. co-contraction) is not needed anymore. The appropriate grip is automatically selected based on the recognition of associated EMG patterns. In this way PR control aims to provide more intuitive control of the prosthesis. However, also disadvantages of PR controlled prostheses have been reported: they seem to be unreliable and require extensive training [5]. The aim of this paper was to validate the overview of factors contributing to prosthesis choice for PR controlled prostheses [2].

METHODS & MATERIALS

Coding framework

Our recently performed study existed of two parts [2]. In the first part a qualitative meta-synthesis using a 'best-fit framework' approach was performed [2]. For this meta-synthesis a systematic search of literature was done, in which studies were considered eligible if they contained qualitative content about adults with major unilateral upper limb defects experienced in using commercially available prostheses. Out of 6247 articles, 19 were included. In the second part of this study, results of the meta-synthesis were validated with end-users in a focus group [2]. The focus group included 11 persons with an upper limb defect, of which three used a standard myoelectric hand, three a multi-articulated myoelectric hand, one a standard and a multi-articulated myoelectric hand, two a cosmetic/passive hand and two did not use any prosthesis. The result of the study was a well-arranged overview of factors that could determine prosthesis choice for persons with major unilateral upper limb defects [2]. The overview contained 86 subthemes that were divided into six main themes: 'physical', 'activities and participation', 'mental', 'social', 'rehabilitation, costs and prosthetist services' and 'prosthesis related factors' [2]. Since we aimed to extend this overview for PR controlled prostheses, we applied the coding system used to create this overview as a coding framework in the current paper [2].

Data collection and analysis

A literature search, in which we searched for studies reporting on qualitative contributions about PR controlled prostheses from the users' perspective, was performed (search date: 27-02-2020). PubMed was searched using the following search terms: 'prosthesis' AND 'upper limb' AND 'qualitative' AND 'pattern recognition'. Text was considered relevant if it was qualitative and described user experiences of persons with major unilateral upper limb defects with PR controlled prostheses. General information, such as participant demographics and analysis methods, were extracted and all relevant text in the results sections of the articles were extracted and entered into the Atlas.ti software. Relevant text included both quotes of participants and interpretations of the authors of the included studies. The data-extraction and analysis was performed by one coder (NK). If data did not fit within the existing themes and subthemes of the coding framework, new themes or subthemes were added. After a new theme or subtheme was added, the previously coded text was checked for the presence of this new theme or subtheme.

RESULTS

Study and participant characteristics

The electronic search resulted in three articles, which were included in this paper [5–7]. Those articles were not included in our recently performed meta-synthesis because in two studies non-commercially available prosthesis were used [5,7], in one study the focus on user opinions was not recognizable in the title or study aims [6], and one of the studies was published after the search we performed for the meta-synthesis [5]. A total of 24 adult participants were included in this synthesis (Table 1) [5,7]. In the study of Resnik et al. (2018) 12 adult participants used a PR controlled DEKA arm prototype in which the Coapt PR-control system was integrated with the DEKA-arm [7]. In the study of Franzke et al. (2019) four adult participants used a non-commercially available PR controlled prosthesis from Ottobock [5]. All 8 participants from the study of Hargrove et al. (2017) used a Boston digital elbow with a Motion Control wrist rotator and a single degree-of-freedom terminal device of their choice [6]. With exception of one participant, all participants were experienced with another prostheses [5–7].

Table 1: Summary of patient and study characteristics.

Study	**Sample size**	**Gender**	**Origin of limb loss**	**Level of limb loss**	**Type of PR prosthesis**	**Other prosthesis**	**Country (ISO-code)**	**Data collection technique**	**Data analysis**
Resnik et al. [7][A]	12	10 M; 2 F	1 CO 11 AA	10 TR; 2 TH[B]	3 EMG-PR-DEKA prototype 1; 6 EMG-PR-DEKA prototype 2; 3 both prototypes 1 and 2	11 personal prosthesis (type not specified); 1 none	USA	Open-ended questions in a survey and semi-structured interviews	Qualitative case series design with a constant comparison approach
Franzke et al. [5][C]	4	4 M	4 AA	4 TR	4 Michelangelo hands with non-commercially available PR control (Ottobock)	4 myoelectric prosthesis with DC control	AUT	Semi-structured interviews	Five-step framework approach
Hargrove et al. [6]	8	8 M	8 AA	8 TH[B]	8 Boston digital elbow with a motion control wrist rotator and a single degree-of-freedom terminal device of their choice[D]	8 myoelectric prosthesis (control type not specified)	USA	Open-ended question and an activities journal	Not clearly mentioned

[A] Study possibly also included persons with bilateral upper limb defects, however, this was not further described.
[B] All participants of those studies with limb loss at TH level also had TMR.
[C] Only participant demographics of the users with a PR controlled prostheses are shown in this table.
[D] Participants could choose between a powered split-hook (electric terminal device or electric Greifer terminal device) or a single degree-of-freedom hand.
ISO-code = country code assigned by the International Organisation for Standards; M = male; F = female; CO = congenital; AA = acquired amputation; TR = transradial; TH = transhumeral; TMR = targeted muscle reinnervation; EMG-PR-DEKA = a DEKA arm controlled by pattern recognition based on electromyography; DC = direct control; PR = pattern recognition control; USA = United States; AUT = Austria.

Findings

The data of current paper supported the six main themes of the coding framework. From the 86 subthemes of the coding framework, 41 were mentioned in the data. Most of these subthemes could be categorized within the main themes 'prosthesis related factors'. Two new subthemes were added to the coding framework. The first subtheme was 'calibration' (main theme: 'prosthesis related factors'), which was often experienced as inconsistent and unreliable. Since this issue was only mentioned in the study of Resnik et al. (2018), this might be explained by the prosthesis type with the PR control system that was used in this study [7]. Second, the subtheme 'intuitiveness' (main theme: 'prosthesis related factors') was added to the framework. PR was, if it worked well, often experienced as more intuitive compared to DC.

> *"Well, the PatRec [the pattern recognition control] surely is . . . with regard to how the control feels. . . more like it was before with the [intact] hand." – Quote of a participant* [5].

On the other hand, regarding the subthemes 'ease in controlling' and 'reliability' (main theme both: 'prosthesis related factors'), participants indicated that PR control was sometimes difficult and unreliable.

> *". . .moving my arm in any way confuses it, I think, to where it thinks that I'm asking it to change the grip and it does when I don't want it to." – Quote of a participant* [7].

Additionally, with regard to the subthemes 'prosthesis training' (main theme: 'rehabilitation, costs and prosthetist services') and 'mental effort needed to control' (main theme: 'mental'), participants said that extensive training and relatively high mental effort were needed for PR control.

> *". . .it takes a lot more thought and a lot more training I feel, to, and not just like strength training and stuff, but just thinking of what muscles or what movements you want to make" – Quote of a participant* [7].

“First of all, pattern recognition requires a lot of training before it works properly.” – Quote of a participant [5].

DISCUSSION

This paper examined whether the overview of all factors that could determine prosthesis choice, that was created in our recent study based on results of a meta-synthesis and focus group, was also applicable to PR controlled prostheses [2]. Therefore, three studies that contained qualitative contributions about user experiences with PR controlled prostheses were synthesized using the overview of our recent study as a coding framework [5,7]. The subthemes ‘calibration’ and intuitiveness’ were added to the framework. This resulted in an up-to-date overview, which consists of six main themes and 88 subthemes, that was also applicable for the choice of PR controlled prostheses. Since PR controlled prostheses are already on the market, this up-to-date overview could be used in clinical practice to inform clinicians and prosthesis users about factors that may matter when selecting a prosthesis.

Results suggest that PR control was often experienced as more intuitive, but also as difficult to control, unreliable and requiring extensive training and high mental effort to control. These matters should be discussed between potential prosthesis users and clinicians when considering a PR controlled prosthesis. However, it should be noted that not all participants included in the synthesis of this paper used a commercially available PR controlled prosthesis. In addition, the participants of included studies were from a quite homogeneous sample (e.g. mainly males with an acquired amputation). Possibly, a different, more heterogeneous group of participants might have different experiences with PR controlled prostheses, and perhaps might have required further adjustments of the coding framework. Furthermore, the participants with an upper limb defect at transhumeral level had undergone targeted muscle reinnervation (TMR) [6,7], and in the study of Resnik et al. (2018) it was unclear whether participants with bilateral upper limb defects were included too [7], which may have influenced our results. Another limitation of this paper was that a limited search with only a few search terms in one database was performed. For this reason, we may have missed relevant information.

To conclude, this paper provides the first step in the understanding of factors that could influence the choice for a PR controlled prosthesis. The overview with factors that could affect prosthesis choice controlled by DC was updated for the use of PR controlled prostheses. However, since only three studies were included and a limited literature search was performed in this paper, more qualitative studies about user experiences with commercially available PR controlled prostheses are needed to further validate the created overview. We think that the updated overview of all factors that affect prosthesis choice, may help persons with upper limb defects to identify factors that really matter for them. Ultimately, we hope that this will facilitate a better match between user and prosthesis, resulting in a decrease of prosthesis abandonment.

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