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Assessment of Clinical Requirements for a Novel Robotic Device for Upper-Limb Sensorimotor Rehabilitation After Stroke

Raphael Rätz, René M. Müri, and Laura Marchal-Crespo

Abstract In order to identify the clinical requirements for a novel upper-limb robotic device for sensorimotor neurorehabilitation, a survey with 33 participants (including physiotherapists, occupational therapists, speech therapists, nurses and physicians) was conducted. The results show that grasping, eating and personal hygiene are amongst the most important activities of daily living to be exercised. Hand/finger extension were reported as crucial movements. In serious games for neurorehabilitation, adjustable quantity of virtual objects as well as adjustable game difficulty are highly demanded features. The majority of the participants would like to spend less than 10 min for the setup of a robotic device.

1 Introduction

Although researchers and clinicians agree that a clinical-driven design approach is crucial for the successful development and acceptance of novel robotic devices, there is a deficiency of literature on clinical requirements for robotic devices in neurorehabilitation [1]. Even though reporting of identified requirements for novel devices would be critical for the general advancement of robotic neurorehabilitation, often, only user feedback on the final device is published.

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Preferred body positions for exercising upper and lower-limb movements in robotic systems, as well as preferences about adjustability of device parameters were identified in [2]. In [3], a large survey with 85 questions and 233 participants on design requirements for a robotic device for upper-limb rehabilitation was conducted. Requirements for the successful implementation of technology in stroke rehabilitation were established in [4] through literature research and interviews with therapists, while in [5], requirements for stroke rehabilitation technology were determined in interviews with patients.

Here, we present results from a survey conducted prior to the development of a novel robotic device for upper-limb sensorimotor rehabilitation with focus on forearm and hand functions. The goal was to analyse project-specific clinical needs to complement existing research.

2 Methods

A total of 33 participants (4 physicians, 1 nurse, 2 speech therapists, 1 neuropsychologist, 6 occupational therapists and 19 physiotherapists) from the University Hospital (Inselspital) Bern (26 respondents), and Reha Rheinfelden (Switzerland) answered 35 questions in an online survey.

After initial questions related to their professional experience, participants were instructed to list 3 activities of daily living (ADL) which they consider crucial to be exercised during stroke rehabilitation and sort them based on priority. Following, they had to judge the importance of practising various lower-arm and hand movements using five-point Likert-items. Potential elements to be employed in serious games were also evaluated. Participants were then asked to estimate the maximum time they would be willing to spend for the patient setup in a robotic device. Finally, they had to judge if they prefer a compact device with a low number of functionalities or a large device with more functionalities. They also had the possibility to express concerns about robotic-assisted neurorehabilitation and to leave a comment. The survey was anonymous, and all participants gave their consent to the usage of the data in scientific publications.

3 Results

The professional experience was found to be 5 years or less for 30.3%, between 5 and 20 years for 33.3% and more than 25 years for 36.4% of the participants.

Answers regarding the most important ADL were categorized according to a prior defined classification. The majority of the listed ADL could be attributed to the predefined categories, which confirmed the validity of the chosen classification (Fig. 1). Responses that did not fit this classification were grouped in the category “Other”. Out of the 33 respondents, 25 participants specified those activities categorized as

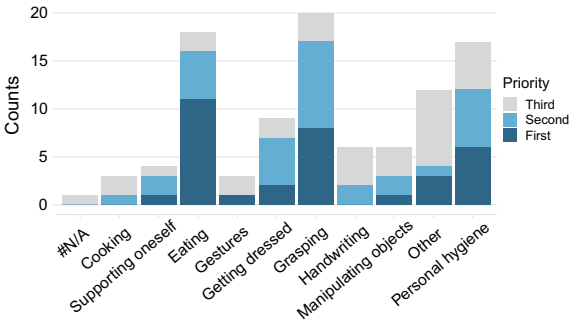

Fig. 1 Activities of daily living that should be trained in stroke rehabilitation and their given priority

"Eating", "Grasping" or "Personal hygiene" as first priority, whereof "Eating" was mentioned the most frequent with 11 responses. Including all three priorities (total of 99 answers), activities related to "Grasping" were mentioned at the highest count with with 20, followed by "Eating" with 18 and "Personal hygiene" with 17.

The training of extension movements (finger and elbow extension, dorsiflexion) was found to be of higher importance compared to practicing flexion movements (finger and elbow flexion, palmarflexion), as shown in Fig. 2. A Wilcoxon signed-rank test of the accumulated Likert-items showed a significant difference ($p = 0.0007$) between flexion and extension movements. Likewise, the training of wrist supination appears to be of higher priority compared to pronation ($p = 0.005$). Furthermore, based on the responses, exercising of independent thumb and index finger movements is more essential than independent movements of the middle, ring and little finger. Also, radial and ulnar abduction tend to be the least important movements to be practised.

When it comes to potential tasks in serious games for neurorehabilitation after stroke, adjustability of virtual object quantity and training difficulty are desired features (Fig. 3). A small number of objects by default as well as a colorful virtual environment were less appreciated by the respondents.

A setup time over 30 min was classified as outlier (4 subjects) because it was assumed that the question was misunderstood and confounded with the initial setup time after delivery of the device. Out of the remaining 29 participants, 25 specified a maximum setup time of 10 min or less. The median was found to be 5 min.

In regard to the size-functionality trade-off, no apparent tendency could be found as 14 subjects preferred a larger device with more functionalities and 18 subjects preferred a compact device with fewer functionalities while 1 respondent did not have an opinion.

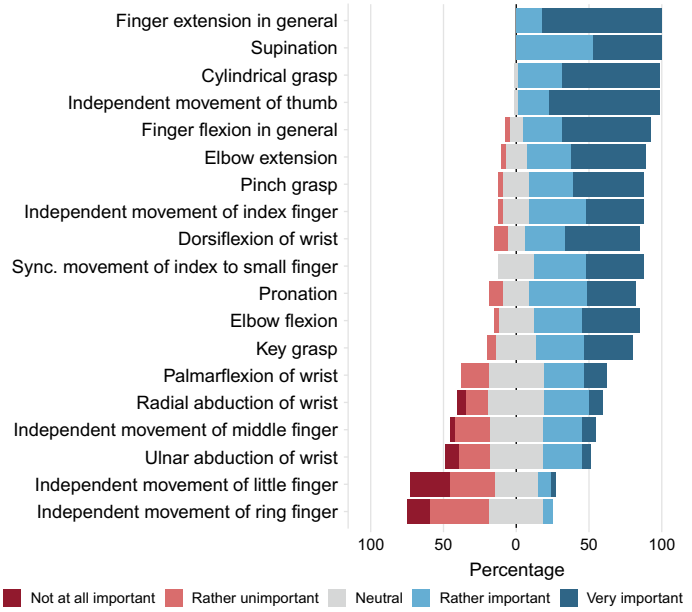

Fig. 2 Importance of different upper-limb movements in stroke rehabilitation

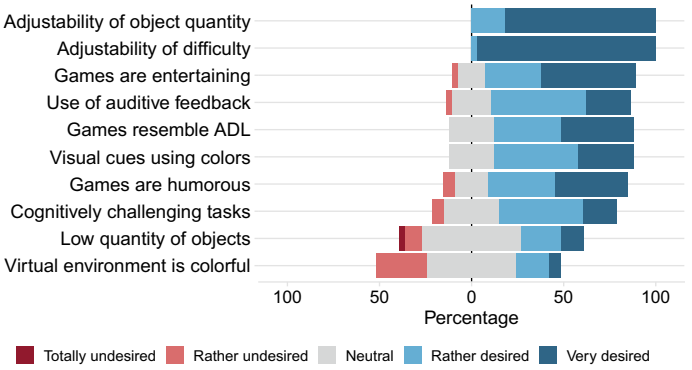

Fig. 3 Desired features for serious games in robotic stroke rehabilitation

4 Conclusion

The presented work complements precedent research by investigating the importance of practising specific upper-limb and hand movements as well as ADL in stroke rehabilitation from a point of view of clinical personnel. It was found that grasping is amongst the most important ADL to be exercised. Extension movements appear to be particularly important. Moreover, adjustability of difficulty and the quantity of virtual objects were identified as highly demanded features of serious games. The

maximum setup time specified by the participants for a robotic device indicates that a user-friendly design is a key factor for successful clinical integration. The results of this survey contribute to the formalization of clinical requirements for robotic upper-limb rehabilitation devices and serious games in virtual training environments.

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