

REQUIREMENTS FOR IMPLEMENTATION OF THERAPY DEVICES IN A TELE-REHABILITATION SOLUTION

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Abstract. Tele-rehabilitation provides advantages for the patient in terms of therapy success. Due to the use of digital therapy and training methods, motivation, adherence and outcomes can be fostered. Robotic or sensor-based devices, that could be used in this area (home setting), are still rare but are proved to be legit helpers in clinical, supervised setting. In the ongoing project REHA2030 we asked the question what requirements a therapy device for home usage must fulfill and what it takes to transfer devices from the clinical setting to the home setting. In the project, a Human Centered Design approach by means of workshops and focus groups was employed to gather requirements and develop solutions that fit the patients and therapists needs. On the basis of these requirements, we have developed a web-based therapist interface and an app-based patient interface. Both interfaces are designed to run tele-rehabilitation features like video calls, therapeutical exercises, serious games and activity monitoring. Furthermore, it is possible to enable sensor-based therapy with the training device Pablo (Tyromotion). We set up a concept on the processes it takes to deliver tailored therapy to patients, implementing the assessment of the hand force, that allows proper training with a serious game and monitoring of the rehabilitation progress. Further investigations with stroke patients will be necessary to obtain results that can be carried over to the actual target group.

Keywords: tele-rehabilitation, sensor-based therapy, human centered design

1 INTRODUCTION

Tele-rehabilitation is a promising way of improving the outcome after various illnesses due to technological progress [1]. Improvements in telecommunication make it possible to deploy experts regardless of the location of the patient. To support and expand rehabilitation, installing and using technical devices is a possibility in order to augment the progress of therapy and make it more measurable [2, 3]. Robot-assisted technology has been implemented in the research- and clinical setting, but the concept of combining tele-rehabilitation and technical-assisted therapy is a relatively novel approach in rehabilitation [4]. Home based technologies for rehabilitation are challenging to design and differ from the clinical use. In clinical settings, therapists use standardized approaches, with a focus on the patient's functional needs and recovery goals, to guide patients through therapy and to motivate them

to engage in rehabilitation therapy. The home-based therapies need additional consideration of a broader range of complex factors such as patient's home environment, technical know-how, social context and life experiences [5]. In view of these complex factors of home environment, technological support should be designed and applied to be operated by the patient him-/herself with the intention to achieve the rehabilitation goals as good as possible.

In the REHA2030 project, a service model and the complementary technical system to cover the whole (tele-) rehabilitation process has been developed. The technical system includes a multidisciplinary usage, one system for the patient covering different therapeutic interventions and allows an interoperability between different software and hardware solutions. The developed service model allows a flexible structure and frequency of therapy and exercise sessions on the patient's needs, comprising classical face-to-face, synchronous teletherapy and asynchronous training sessions. The therapist has the opportunity to supervise the rehabilitation via a web-based interface. In this interface the therapist can set up exercises, monitor data, document the therapy, perform therapy sessions face-to-face or via video calls and adjust therapy device settings. The patient can use the tele-rehabilitation system via an application on the tablet. If needed in the therapy process, the system enables the use of therapy devices and serious games [6]. The therapy devices are used in a home setting in REHA2030 with support of therapists, which gives the patient the possibility to exercise on his/her own with included therapeutically relevant instructions. A proof of concept of the service model and the test of the tele-rehabilitation system are planned in a real-life setting.

In this paper, general requirements for a hand-rehabilitation device for home usage, are presented. Furthermore, a concept on how a rehabilitation device intended for clinical usage can be used in a home-setting, are shown. For this concept, the sensor-based hand rehabilitation device Pablo (Tyromotion Austria) is used.

2 METHODS

The REHA2030 Project builds on a Human Centered Design (HCD) [7] approach, where future users and other relevant stakeholder were involved in the concept, design and iterative evaluation since the very beginning. To understand the users in their context of use and to gather the requirements, several workshops were held. In these workshops, the requirements for the core elements and core functions of the tele-rehabilitation system and the settings of the technical devices were determined together with physiotherapists, occupational therapists, speech therapists, physicians and rehabilitation experts. In order to include different perspectives, experts from rehabilitation institutions and therapists in Austria and Slovenia were involved. Patients were not included in the initial phases, since the focus was laid on the implementation of therapeutic devices, safety relevant and necessary functions such as docu-

mentation, communication, therapy structure, feasibility and activity monitoring. In an iterative manner, the requirements for the rehabilitation devices, therapist and patient interfaces were implemented in mockups and software concepts and discussed with experts in order to improve the system. Further investigations have been done to set up a concept to transfer the clinically used Pablo to a home-usage tele-rehabilitation system. The practical experiences from everyday clinical practice were considered in the design of the process of the unsupervised usage and combined with the suggestions of the experts with regard to the home use.

3 RESULTS

In the initial phase of the REHA2030 project, we identified the requirements of the implementation of a rehabilitation technology for home use. Therefore, six workshops were held in Slovenia and Austria, with 21 experts (therapists and physicians) from the inpatient rehabilitation and the self-occupied sector. In these workshops, general requirements for a hand rehabilitation device for stroke patients were assessed. An overview is given in Table 1.

Table 1. Requirements in a robotic device for home-usage in stroke rehabilitation

Therapy requirements	Device requirements	Process requirements
– Treatment of mild and moderate spasm	– Safety, handiness, ease of use for home usage, low-cost	– Usage in acute phase and later rehabilitation process
– Repetitive unsupervised training between therapeutic interventions	– Passive, active and active assistive mode	– Support in assessments
– Training of hand and finger strength	– Avoidance of compensatory movements	– Continuous measurement of range of motion and therapy progress
– Support of flexion, extension, fine motor skills	– Finger selectivity and support in pronation and supination	– Individual adjustable settings

A high potential was identified in the treatment of persons with mild or moderate spasm in the hand and fingers. To support these persons for better outcomes, high numbers of daily repetitions in training are needed. Important parameters for the device are safety certificates, small dimensions, handiness and ease of use. It is essential that compensatory movements are prevented, and active, passive and active assistive movements are foreseen and assessments as well as progress reports are implemented. The device should be able to be used in the acute phase (hospital) as well as in the later rehabilitation process. Another aim is, that despite the simple application, the patient's motivation for therapeutic practice is increased.

A prototype was developed within the consortium [8], but was not used for implementation in the tele-rehabilitation system due to safety-related regulations. Therefore, the Pablo handheld rehabilitation device from Tyromotion, was used in the project, as it is an already established, safety-certificated therapeutic device, meeting most of the requirements.

Furthermore, the Pablo is often used in neurological rehabilitation, therefore many therapists and even patients are familiar with the device. Amongst other measurements, the device can be used to record hand strength and transmit the results to the tele-rehabilitation system for activity monitoring and control of serious games.

One of the issues arising when patients use technical devices in an unsupervised setting is, that therapists are not present all the time, to set and adjust the parameters (in the case of Pablo it is mainly the force and serious game level) before, during and after an exercise. In addition, the question arose which setting options the patient should have. To overcome the challenge of setting the correct force in autonomous usage of a technology-assisted therapy at home, the gold standard of hand force measurement was transferred to a digital level. This standardized procedure was derived from occupational therapy and digitalized by using the Pablo. With this combination of an existing standardized procedure and the inputs from therapists, the attempt was made to create the setting options for the patients. The hand force measurement and the instructions according to the gold standard has been introduced in the patient interface and the graphic output has been optimized accordingly. Three maximum hand force measurements have to be made by the patient, whilst the maximum value of the three force measurements is used as a baseline to calculate the used force to control the serious games. Due to the outcomes of the expert workshops, it was recommended that therapists can set the force ratio (percentage of the maximum strength with which the game can be controlled), the duration and the level of the game. Therapists can adjust these parameters via the therapist interface, when changes are needed after a face-to-face session, video session or if the activity monitoring data indicates this. The force data that are collected during force initialization can be viewed in the activity monitoring to show the therapy progress. This means that these values can be used by patients and therapists, as a follow-up control. This, together with the scores in the serious games enables therapists, depending on the therapy goal, to challenge and encourage the patient as best as possible.

4 CONCLUSION

Clinical and home usage of therapeutic devices follow very diverse requirements. General requirements for a hand rehabilitation device were derived by therapists and rehabilitation experts and can be summarized in following points: easy to use, affordable, usage in home setting, settings should be made by therapists and patients and maximal individualization to the patient should be given. Finger selectivity and support of repetitive training should be provided and compensatory movements avoided.

A concept was proposed that shows a possible process and provides first results on how therapeutic devices that are initially intended for clinical, supervised usage can be transferred to home usage. The gained results about the implementation of the Pablo rehabilitation in a

tele-rehabilitation system, enables new possibilities in terms of individualized and tailor-made rehabilitation and therapy.

Further research will be conducted with a study including healthy participants for improving and evaluating the setting of the force-measurements and the controlling of the serious games. With the main target group, stroke patients and therapists, a field test is carried out in which the whole system will be tested in real tele-rehabilitation setting.

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