MARTHA - Master Therapy Assistant: Supporting the Recovery of Upper Limb Motor Function After Stroke with Digital Home Exercise Programs

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Abstract. This research aimed to develop a mobile application to support home exercise programs for persons after stroke. The study was conducted in three phases: understanding the needs, developing a prototype, and testing the application.

In the first phase, a survey with 52 physical and occupational therapists, and focus groups with 6 physical and occupational therapists were conducted to understand the needs of therapists regarding home exercise programs for persons after stroke. The second phase involved the development of the application by an interdisciplinary team following an agile software development approach. In the third phase the application's usability and feasibility was evaluated through a pilot study. The needs analysis highlighted the importance of individualized programs and adaptability in home exercise programs. 86.5% of the survey participants expressed interest in a mobile application for home exercise programs, with specific features like exercise videos, feedback mechanisms, and reminders. The usability, usefulness and satisfaction with the developed application, MARTHA, were tested in a pilot study involving 13 therapists and 18 patients and showed high scores for ease of use and learning. The study demonstrated the feasibility of using the mobile application MARTHA in supporting home exercise programs for persons after stroke. The application was found to be user-friendly and adaptable to individual needs. However, some participants raised the need for a more extensive variety of exercises, especially for patients with more severe limitations. Further development and testing are needed to address the concerns raised and to assess the long-term impact on patient outcomes.

Keywords: Home Exercise Program · Stroke · Rehabilitation · Mobile Application · mHealth · Telerehabilitation · Usability

1 Introduction

In 2019 12,2 million worldwide stroke incidents, resulting in the second-leading cause of death and 143 disability-adjusted life-years, were reported [1]. Poor health-related quality of life is, amongst others, associated with reduced upper limb function [2].

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Therefore, interventions supporting the recovery of upper limb function should be a core element of rehabilitation [3] and have been studied intensively in recent years [4–6]. International stroke rehabilitation guidelines recommend repetitive task training at a high intensity and home exercise programs (HEP) to enhance learning and recovery of upper limb function [7–11]. HEP have the potential to increase frequency and intensity of upper limb training, especially when rehabilitation resources are limited [7, 12].

The beneficial effects of HEP is not questioned [12], however adherence is highly variable and sometimes unsatisfactory: between 28% and 65% of respondents actually perform a recommended HEP [12, 13]. Mahmood et al. recently developed a Delphi consensus-based framework to support home-based exercise adherence after stroke, encompassing a comprehensive list of strategies in nine domains [14]. It contains, among others, strategies targeting at methods of exercise prescription, feedback and supervision, promotion of self-efficacy, motivational strategies, and reminder strategies.

Telerehabilitative approaches could support persons after stroke in order to perform and maintain a HEP and are recommended in guidelines [15, 16]. Systematic reviews conclude that telerehabilitative interventions are equivalent to a traditional exercise setting in stroke rehabilitation [17, 18]. Users (patients, relatives, and healthcare professionals) seem to be satisfied with telemedicine services and sufficient acceptance is shown [19, 20]. To increase the acceptance of telerehabilitative approaches, it is recommended to adapt them to the needs of the users. These needs include a simple and calm interface, receiving feedback, and the ability to set a goal and evaluate it [21]. Early involvement of potential users in the development of telerehabilitative interventions is strongly recommended and ensures user-centered development [22].

1.1 Aim

Based on current views of physical therapists (PTs) and occupational therapists (OTs) on HEP for persons after stroke (PS) (Phase 1), we developed a prototype application for a mobile tablet in order to support the realization of a HEP for PS (Phase 2). The final phase involved evaluating the usage, usability and recommendations for further development of the app by applying a mixed-methods approach (Phase 3).

2 Phase 1 – Needs Assessment

2.1 Methods

This phase employed a sequential explanatory mixed methods design [23]. The process began with a quantitative online survey, which was followed by an online focus group discussion. The participants were PTs or OTs working in Vienna (Austria). They had to have experience in working with PS in an outpatient setting and to provide informed consent for participation in the study. The online survey consisted of 34 questions, primarily of a closed or semi-open type, concluding with an open-ended question. It was conducted from January 28th to February 20th, 2020, and covered topics such as demographic data, HEP prescription behavior, HEP content, patient motivation for HEP, and interest, concerns, and specifications for a video-based mobile application for HEP.

The focus group was held online via video conferencing on March 19th, 2020. The semi-structured interview guideline was based on the results of the online survey. The focus group, which lasted an hour, was audio and video recorded and aimed to give a deeper insight into the same topics as covered in the survey.

Quantitative data of the survey were analyzed using descriptive statistics. The focus group transcripts and qualitative survey data were then thoroughly analyzed using thematic qualitative content analysis based on Kuckartz [24], using the software MAXQDA. Finally, quantitative and qualitative data were combined for a comprehensive analysis.

2.2 Results

Data analysis incorporated responses from 52 participants who completed the online survey. The participants were predominantly female (92% vs. 8% male). The professional background of the participants was almost evenly split, with 48% being OTs and 52% being PTs. The focus group included six therapists, four of whom were PTs and two were OTs. The gender distribution in the focus group was five females and one male.

Prescription Behavior of HEP. Regarding the prescription behavior of HEP, participants in the online survey reported prescribing HEP PS to varying degrees (see Fig. 1).

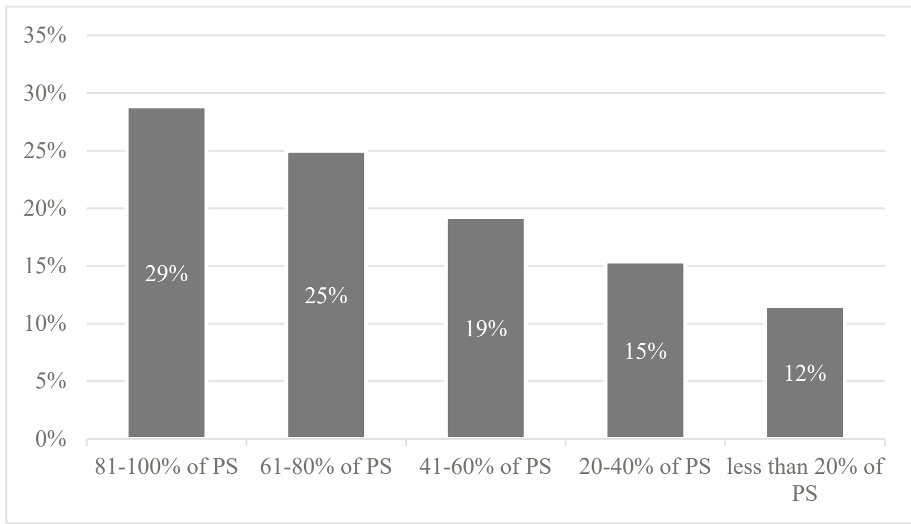

Fig. 1. Percentage of therapists (bars) prescribing HEP to different proportions of PS.

Reasons for not prescribing HEP included concerns about incorrect execution of the exercises, rejection by the PS, or a lack of time on the part of the therapists. In terms of instruction methods, 92.3% of therapists provided individual written instructions, 69.2% gave oral instructions, 17.3% used standardized paper-based instructions, and 15.4% utilized digital instructions such as videos or mobile applications. Most therapists

(72.6%) were satisfied with their chosen mode of instruction delivery, and 76.7% believed the PS were satisfied with it as well. The focus group participants reported that HEP was mostly provided in the form of individually written instructions, supplemented by hand-drawn pictures. PS involvement was facilitated by using the patients' own terminology and by having them document their exercises using their smartphones. In terms of the number of exercises prescribed, 59.6% of therapists typically prescribed three to four exercises per PS, 13% prescribed fewer, and 15.4% prescribed more. As for the frequency of the HEP, 40.4% of participants recommended once per week, 26.9% suggested several times per day, 21.2% recommended several times per week, while the rest did not specify a frequency. Frequency was individually tailored based on the PS's motivation, compliance, and physical or mental condition. The focus group participants also highlighted the importance of the timing of the HEP. This could involve a specific time of day or aligning the HEP with a specific daily activity to facilitate the integration of the HEP into the patient's routine.

Content of HEP. The content of the HEP was ranked by survey participants in terms of its importance for the rehabilitation progress. The ranking, from most to least important, was as follows: 1) Activities of daily living, 2) Tonus regulation, 3) Sensibility training, 4) Stability training, 5) Volitional motor activity in a specific plane, 6) Coordination training, 7) Strength training, 8) Improvement of passive range of motion, and 9) Endurance training. The focus group participants, however, did not specify particular exercises, emphasizing instead the importance of individualized programs and the need for adaptability. Nevertheless, they identified the following areas as most suitable for inclusion in a HEP: fine motor training, sensibility training, and integration of the affected arm into activities of daily living.

PS Motivation for HEP. The surveyed therapists rated the factors for PS motivation to carry out their HEP and found the perception of the actual rehabilitation progress, definition of a distinct goal to reach, PS involvement in exercise selection, feedback after HEP execution most important. Moreover, a digital reminder, informed relatives, monitoring by the therapist, view of progress, the relevance of the HEP for personal goals, hobbies, quality of life, a pleasant design of the HEP, a less demanding HEP, defining HEP as a part of daily productivity, and integrating HEP into daily living were mentioned to be important for increasing the motivation.

Video-Based Mobile Application for HEP. Most survey participants (86.5%) expressed interest in using a mobile application for prescribing and executing HEP, while 13.5% opposed it due to concerns about patients' tech-savviness, data privacy, or incorrect exercise execution. About 40.4% were open to using pre-made exercise videos, but others had reservations about exercise adaptability and potential misunderstanding of exercise execution.

The focus group participants suggested that exercise videos should include specific cues and should be adaptable by therapists. They also deemed it essential to have a feature for uploading individual videos. They outlined several criteria for pre-made exercise videos, including a neutral background, clearly defined initial body position, appropriate camera perspectives, detailed views, verbal instructions, and exercises for both sides of the body.

While 53.33% of surveyed therapists would use the app for communication between therapy sessions, others, including all focus group participants, declined due to concerns about maintaining professional boundaries, time constraints, lack of reimbursement, and data privacy. Those open to communication would use the app for sending HEP, text or voice messages, viewing HEP statistics, or video chatting.

Feedback for PS on HEP progress was preferred via individual text messages (40.4%), selected text modules (26.9%), or emojis (25%). The focus group suggested that feedback should be customizable, and that PS should be able to self-report feelings and to take notes. They also proposed features like checkboxes for HEP completion, a weekly HEP plan, progress statistics, goal visualization, and reminder notifications.

The design of the app should be simple, intuitive, and visually clear, with adequately sized text to enhance usability for the target group.

3 Phase 2 – Prototype

3.1 Methods

The application was developed by an interdisciplinary team comprising two PTs, one OT, and three software developers. Identified user needs (based on the survey and focus group phase 1 and literature) were articulated as user stories in the format: "As a therapist/PS, I want […], so that […]." Exercise videos, based on Impairment-Oriented Training [25] and results from phase 1, were created and supplemented with written instructions.

App Development. The development team followed an agile software development approach which was iterative and focused on delivering incremental improvements. The previously defined user stories were divided into smaller tasks and captured inside a product backlog. Furthermore, the development team used sprints, which are time-boxed iterations, to work on specific tasks. The sprint duration allowed the development team to focus on a specific set of user stories and deliver a working increment of the app within that timeframe. To manage their workflow, the team utilized a Kanban board, which visually represented different stages of work. Each task was represented as a card that moved across the board as it progressed through the stages.

At the beginning of each sprint, the entire team gathered to plan the sprint. They reviewed the user stories in the product backlog, selected the most important ones, and estimated the effort required for each story. Throughout the sprint, the team members collaborated and communicated regularly to ensure smooth progress. Regular stand-up meetings provided a platform for team members to discuss their work, any challenges faced, and plan for the week. To ensure code quality, the team employed code review techniques. After completing a user story or task, team members conducted code reviews, examining each other's code for potential issues, adherence to coding standards, and overall quality. At the end of each sprint, the team held a sprint review meeting to showcase the completed user stories to stakeholders, gather feedback, and ensure alignment with the product vision. Security was a paramount concern throughout the development process. The development team prioritized regular updates of core modules and libraries to ensure that the app remained up to date with the latest security patches and fixes. In addition, the team adhered to established software development principles to deliver

high-quality code [26]. By implementing coding standards and guidelines, they aimed to minimize the introduction of bugs and vulnerabilities, enhancing the overall reliability of the app. To ensure data privacy, collected data is stored securely in the app's internal storage, which is only accessible by the app itself. All data reports are stored encrypted, and password protected, preventing unauthorized access or manipulation. Saving the data locally on the device rather than relying on external servers minimizes the app's attack surface, reducing the risk of potential vulnerabilities or unauthorized access.

3.2 Results

The final product is an Android tablet application named "MARTHA" (Master Therapy Assistant). MARTHA, represented as an avatar, guides the PS through the individualized HEP. The application is used collaboratively by the therapist and PS during therapy sessions, and the PS continues to use it for HEP at home between therapy sessions. The following features have been implemented.

Home Screen. The home screen features a left-sided menu, progress statistics, a reminder for performing the HEP, an overview of goals, and a button to initiate the HEP (see Fig. 2).

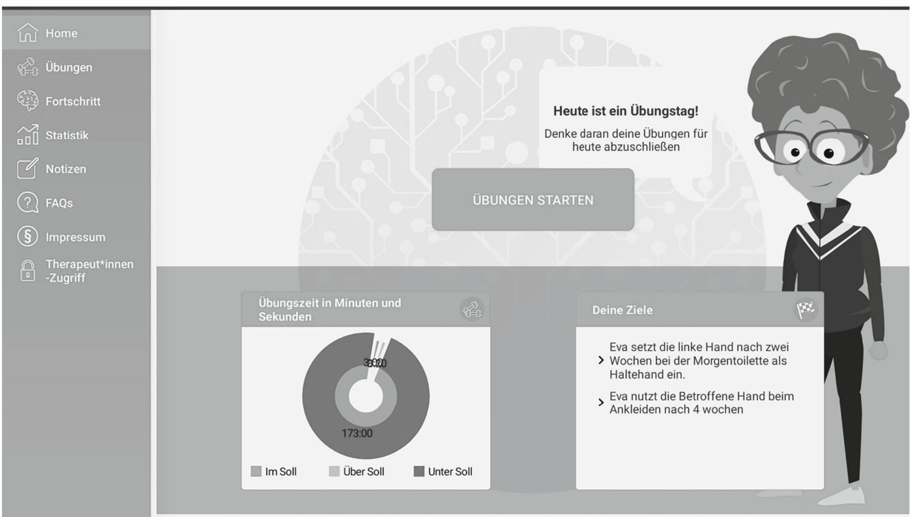

Fig. 2. Home screen of the app MARTHA.

Goal Setting and Evaluation. This section allows the PS and therapist to set one or more SMART (specific, measurable, achievable, realistic, terminated) therapy goals. The PS assesses the goal-achievement and satisfaction with this situation on a scale of 0 to 10. The therapist sets an evaluation period of two or four weeks, after which the system prompts the reassessment of the goal.

Exercise Videos. The application includes 36 videos and matching descriptions of upper limb exercises. These are categorized into grasping exercises, target-oriented exercises, object manipulation, and static/dynamic trunk exercises. Videos are available for both body sides. The therapist can select up to three relevant exercises that align with the therapy goals. Exercise frequency in terms of times per week, duration, and training cues have to be specified by the therapist as well.

Mood Assessment. The PS is prompted to assess her*his mood on a scale of 0 to 10 before and after each HEP session. Significant mood changes trigger a request which asks the PS to comment on her*his experience. These comments, which can include videos, photos, or audio recordings, can be viewed by the therapist in the next therapy session.

Progress Statistics. The home screen displays the total exercise minutes completed. In a separate statistics section of the app line graphs over time depict the goal and mood assessments. Any modifications to the exercise program are displayed as well.

Reminder and Additional Settings. Reminders for performing the HEP can be set according to the PS's needs and preferences, with or without an audio signal. Additional settings include the overall planned therapy duration and data export functions.

4 Phase 3 – Evaluation

4.1 Methods

This pilot study used a mixed-methods approach to evaluate the feasibility, usage, usability, acceptance, and satisfaction of the MARTHA application among PTs, OTs and PS.

Participants. PS inclusion criteria included being 18 years or older, having a diagnosis of ischemic or hemorrhagic stroke with resulting upper extremity impairment, undergoing occupational or physical therapy with a maximum of two sessions per week, and having the ability to use the affected upper limb for assistance. Exclusion criteria included another stroke event during the study period, hospitalization, injury of the affected upper limb, termination of occupational or physical therapy, or change of the therapist.

OTs and PTs needed to have a valid license to practice in Austria and a minimum of two years of experience in treating PS. They also needed to treat at least one PS who met the inclusion criteria and agreed to participate in the study.

The inclusion criteria were assessed by a study team member for OTs and PTs, and by the treating OT or PT for PS. Participants were recruited via professional networks and provided written informed consent.

Procedure. The study protocol was approved by the ethics committee of FH Campus Wien (EK-No. 4/2021). Before the intervention period, participating OTs and PTs received a detailed training on how to use the tablet and the MARTHA application. They were provided with the necessary hardware and software, a set of therapy material for specific exercises, and a manual with detailed instructions. Therapists were instructed

to use the MARTHA application within their usual therapy routine. MARTHA was to be used over a period of minimum four weeks to a maximum of three months. During therapy sessions, PS and therapists should use goal setting, goal evaluation, selection or modification of exercises, and discussions about notes taken by the PS. Between the therapy sessions, PS were encouraged to use MARTHA at home, in order to support their individual HEP.

Demographic data and technical affinity of the participants was collected using a questionnaire at the start of the study. To gather individual information about the feasibility, acceptability, and usability of MARTHA, therapists were asked to note their experiences in a user diary after each use of the application with the PS. The usability, ease of learning, and satisfaction with MARTHA was assessed using a self-translated version of the Usefulness, Satisfaction, and Ease of use Questionnaire (USE-questionnaire) [27]. To gain insight into how and how often the application was used and which features were accessed, usage data was exported from the tablets. Finally, focus group discussions and individual interviews with therapists and PS were conducted to discuss their experience with MARTHA into more detail.

Data Analysis. Demographic data, data from app usage, and data from the USE questionnaire were analyzed using descriptive statistics. Focus group discussions and individual interviews were analyzed together with qualitative data from the usage diaries using MAXQDA. The analysis process was based on the qualitative content analysis according to Sandelowski [28], using procedures from the structural analysis according to Mayring [29] and Kuckartz [24]. Throughout the analysis process, regular team discussions were held to ensure consistency and clarity.

4.2 Results

Participants. The study involved 13 therapists (9 OTs, 4 PTs) and 18 PS. The therapists, all female, ranged in age from 25 to 66 years (median 43 years). Eight of them had prior experience with technology-assisted therapy. The duration of their participation in the study varied from one to 13 weeks (median 7 weeks).

PS (11 males; 7 females) were between 41 and 84 years (median 64 years) old. Time since stroke varied from 5 to 185 months (median 59.5 months). Out of these, 13 had experiences with HEPs and 6 had experiences with technology-assisted therapy. Seventeen PS used technology (smartphone, tablet, or laptop) in their daily life. The duration of their participation in the study ranged from 1 to 13 weeks (median 6 weeks). Two PS discontinued their participation early, after one and three weeks respectively, due to lack of enjoyment and motivation. Available data of these two drop-outs was included in the results (Table 1).

Usage Data. Therapists prescribed using the app for a duration ranging from 12 to 66 days (median 29 days), using 29 out of the 36 available videos. The app was used by PS for a period between 21 and 94 days (median 46 days). On average, two therapy goals were set per PS, with a range of 1 to 7 goals. While most PS did not make any notes in MARTHA, five PS made between 1 to 5 notes, and one PS used this function 53 times. The feature to access statistics about goal achievement was used between 0

Table 1. Technical affinity of study participants.

	PS n = 18 median (min – max)	Therapists n = 13 median (min – max)
Self-rated interest in technology (1 = no interest, 4 = high interest)	3 (2–4)	3 (2–3)
Self-rated ease of learning of new technologies (1 = very easy, 4 = very hard)	2 (1–4)	2 (1–2)
Estimation of the potential of new technologies in therapy (1 = no potential at all, 4 = very high potential)	3 (2–4)	3 (2–4)

and 109 times (median 11). The function to export training details was used by only one therapist.

Usability. The evaluation of usability based on the USE questionnaire (best possible score = 7) resulted in a median score of 6 for the subscales of usefulness (range 4–7) and satisfaction (range 3–7), and 7 for ease of use (range 5–7) and ease of learning (range 6–7) among therapists. PS gave a median score of 5 points for usefulness (range 1–7) and satisfaction (range 1–7), 6 points for ease of use (range 1–7), and 7 points for ease of learning (range 1–7) (see Fig. 3).

Focus Groups and Interviews. Three focus groups were conducted with the therapists, two in-person and one online, lasting between 1 h 7 min to 1 h 48 min. Two therapists who couldn't attend the focus groups were individually interviewed in-person. Two focus groups (duration between 50 min and 1 h and 11 min) were conducted with each three PS. Ten PS couldn't come to the focus groups, therefore individual interviews in-person took place (duration between 18 and 43 min).

Feasibility. Therapists found it easy to learn and use the app due to the manual and initial instructions from the study team. Therapists and PS noted that due to the app's simplicity prior technical experience had little influence on its usage.

> *"Once ... go through everything once and then again […] I think, yes I can set that up for everybody now." (TH1, paragraph 116)*

> *"I didn't mind exercising with the tablet. […] that was the first time I had ever done anything like that. I never had anything to do with that." (PS 5, paragraph 71)*

The structured design facilitated therapeutic routine of setting a goal and applying focused exercises.

> *Having such a nice package for the home exercise program. […] these are the exercise days, we'll agree on them together, this is the exercise time, that's the goal behind it, and then we'll check again to see if you've achieved the goal. I find this a nice package that just runs smoothly. So I also have the feeling that I*

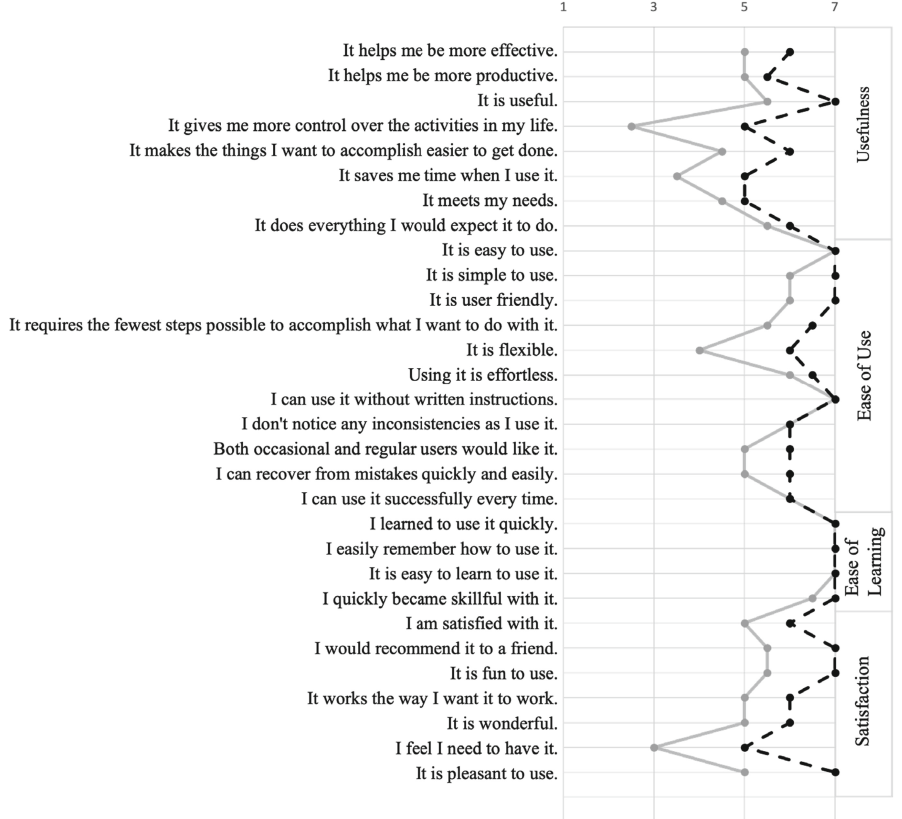

Fig. 3. Usability results according to the findings from the USE questionnaire. Grey, solid line: PS; Black, dashed line: Therapists.

> *don't have to worry about it, it runs even when I'm not there. You're not starting from scratch every time, "And have you practiced now or not?", or "What's the situation now?", and "Where are we at the moment?". This way, it's somehow more manageable for me and gives me a good feeling when I know, ah, they're practicing when I'm not there and we can really continue next time, we don't have to start all over again. (TH2, paragraph 74)*

Motivation. The motivation for therapists to participate in the study was mainly the interest in technical tools and to support therapy and HEP.

> *"I thought that this would motivate the patients to practice on their own. That it provides them with more structure and that they practice more regularly. And to observe this themselves." (TH1, paragraph 4)*

The primary motivational aspects of PS to participate in the study and using the app were personal interest, curiosity, and the hope for improvement. The application was perceived as a useful tool for routine exercises but did not specifically alter the

motivation to perform everyday HEP in all participants. PS were inconclusive if the app would support doing the HEP in the long term.

> *"Well, in itself, the tablet is the incentive to do the exercise." (PS 11, paragraph 85)*

Acceptance of specific features of the app. Therapists appreciated the provision of exercise videos and the opportunity to add individual ones. Although this procedure was time consuming. The visualization of exercise time was also welcomed. However, the design of the pie-chart for visualizing exercise time on the home screen was criticized for complexity. Although the opportunity of taking notes was hardly used by PS, therapists liked the idea. PS found the clear structure of the app supportive. The forced answering of the "How are you?" question and compulsory video watching though were reported as annoying.

> *"Well, I'm not very enthusiastic about these questions, but I thought it was good that they were there. But then I had to reflect on it and I don't like thinking about how it's going [...] But yeah, wasn't bad. I think some people will need it." (PS 10, paragraph. 72)*

The avatar, MARTHA, was appreciated by some, while others found it childish.

> *"[…]it was fun for me […]. I was already happy when the person appeared. With 'hooray, I'm happy and so on' ... And I always said, 'yes', and 'I'm happy too'. But she didn't hear me at all." (PS 17, paragraph 47)*

Similar to the therapists, PS liked the videos, and felt supported by them.

> *"The videos, exactly … because somehow, the persons who showed the exercises, they had so much fun, they seemed so cheerful." (PS 10, paragraph 160)*

For therapists as for PS having to define goals and evaluate these was welcomed, however this process was also perceived as complicated and sometimes too time consuming.

> *"For me, the goal was […] very much in focus. Because my patients are long-term patients. And then you do lose sight of this goal. […] where do we actually want to go specifically in the near future? This has become more present for me once again. Because these are such chronic, long-term patients, where a lot is about maintenance and so on. And to look at it again now, do we have a specific goal? And now we work towards that for a while. This has become very conscious to me with MARTHA and has been intensified." (TH 3, paragraph 32)*

App integration in therapy and daily routine. Integrating the app in daily routine was substantially influenced by being part of a research project. Therapists reported that the app was incorporated into therapeutic routines at the start and end of therapy sessions. Due to the scope of the therapy it seemed to be easier for OTs to argue to use the tablet than for PTs. Expectations within occupational therapy are that PS learn how to use things in everyday life, whereas physical therapy is associated with training.

Some therapists were surprised to see the integration of the app into daily routines, as PS exercised more during the study period.

"It was really cool to observe […] that he had much more motivation to practice on his own than usual. I've had him for about a year now, […] and he was always like, yes, when I come, he does it for me, but on his own (laughs) he didn't really enjoy it. Even though his wife was always very supportive […]. I called him again today and […] you could tell, he really enjoyed it, he said so himself and he also said after the first week, that he thinks it's great and he enjoys practicing with it. And then he really made more progress than usual, because he never... did anything at home voluntarily. That was really cool." (TH1, paragraph 10)

PS also stated that the app was integrated into both therapeutic and daily routines, however, the needs of PS were quite diverse: some required the support of the therapist in every session, while others used the app autonomously once a HEP was established.

"Only the evaluation was done with the therapist […] but everything else I did myself." (PS 13, paragraph 14)

Satisfaction with the app and related outcomes. Most therapists agreed that they would continue using the app in their daily routine, provided that the app was improved, specifically with respect to remote access. However, the selection of which PS could use it has to be done carefully and would be different based on their experience.

"We also usually address this, who do I have in front of me and what are the needs, what are the goals. And how does this patient work? How can she be motivated? What does she need to stay motivated, to stick with it? And there are those for whom I think this is really a good tool, and then there are those for whom this might be a tool, and then there are those for whom this might not be a tool at all. But I still need to have it at hand, because for many I could possibly provide a lot of support with it." (TH2, paragraph 296)

PS who have lower motivation, cognitive impairment and changing psychological status would not use the app appropriately. PS had limited expectations regarding the app's performance and outcome. The app was seen as a valuable tool, though PS were reluctant to pay for its use.

"As I said, if you look at it from the point of view: Am I motivated, do I need it at all - question mark? But if you are half-motivated, I think that's quite good and I think the program is relatively well structured. [...] So, I mean, if someone is not motivated, I don't think he will accept therapy" (PS 14, paragraph 30).

Technical Aspects. Technical issues concerning the hardware and the software hindered the usability. Especially the reminder function (for exercises and for evaluation for goal achievement) were not working reliably.

Recommendations for Further App Development. Therapists provided several recommendations, like adding audio explanations to videos, individualizing the avatar, and

adding a reward system. Concerning the videos it was suggested to add videos for PS on the upper or lower edge of upper-limb functional level and for the trunk. The ability to use the app with multiple patients simultaneously and remote access for the therapists were also suggested. PS suggested including a reward system, better visual aids to enhance motivation and larger font size. They also recommended improving charts for displaying exercise data and allowing the option to disable mandatory video watching. The need for a bigger exercise variety was also highlighted, especially for patients with more severe limitations.

5 Discussion

This study aimed to develop and evaluate a tablet application for HEP execution for PS, based on a needs analysis with OTs and PTs. The results indicate that the MARTHA application is feasible and usable for both therapists and PS and was generally positively received. However, the study also identified several areas for improvement.

The development of MARTHA was based on the needs of therapists and PS, which were identified in phase 1 of the study. The results of this phase are in line with previous research, which has highlighted the importance of individualized HEPs, the involvement of PS in the selection of exercises, and the need for feedback and reminders to increase motivation for HEP [14, 21].

The evaluation of MARTHA in phase 3 of the study showed that the application was generally well accepted by both therapists and PS. The usability of the application was rated highly by both groups, which is in line with previous research showing that tablet applications can be well accepted by patients [30]. However, the study also identified several areas for improvement. For example, some therapists reported that the process of adding individual videos was time-consuming, and some PS found the mandatory video watching to be annoying. These issues could potentially be addressed by adding a bigger number and variety of exercise videos. The application could also allow for more individuality. For example, the goal and mood query could be made adjustable rather than mandatory, and there could be an option to skip certain exercise videos if PS feel confident in performing the exercises. However, this presents a challenge as it could increase the complexity of the application and it would no longer be a simple tool. Further we conclude from the feedback, that the introduction of the therapists to the application might need to be more comprehensive, as it may be necessary to explain the theory behind the mood query, goal setting, the need to watch videos, etc., in more detail.

Despite the generally positive results, the study has several limitations. First, the sample size was relatively small, and the study was conducted in a single country, which may limit the generalizability of the results. Second, the study did not include a control group, so it is not possible to determine whether the observed improvements in HEP adherence and satisfaction were due to the use of MARTHA or other factors. The integration of MARTHA into the daily routine of therapists and PS might have been influenced by being part of a research project. Finally, the study did not measure the impact of MARTHA on clinical outcomes, such as functional improvement or quality of life.

In conclusion, this study shows that a tablet application for HEP for stroke patients, is feasible and usable, and is generally well accepted. However, further research is needed to improve the application and to evaluate its impact on clinical outcomes.

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