Usability of Remote Assessment of Exercise Capacity for Pulmonary Telerehabilitation Program

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Abstract. Pulmonary rehabilitation [PR] has been successfully carried out via telemedicine however initial patient assessment has been traditionally conducted in PR centers. The first step in PR is assessment of patient's exercise capacity which allows individualized prescription of safe and effective exercise program. With COVID-19 pandemics assessment of patients in PR centers has been limited resulting in significant reduction of patients undergoing life-saving PR. The goal of this pilot study was to introduce approaches for remote assessment of exercise capacity using videoconferencing platforms and provide initial usability assessment of this approach by conducing cognitive walkthrough testing. We developed a remote assessment system that supports comprehensive physical therapy assessment necessary for prescription of a personalized exercise program tailored to individual fitness level and limitations in gait and balance of the patient under evaluation. Usability was assessed by conducting cognitive walkthrough and system usability surveys. The usability inspection of the remote exercise assessment demonstrated overall high acceptance by all study participants. Our next steps in developing user-centered interface should include usability evaluation in different subgroups of patients with varying socio-economic background, different age groups, computer skills, literacy and numeracy.

Keywords. pulmonary rehabilitation, telemedicine, exercise capacity

1. Introduction

Pulmonary rehabilitation [PR] is one of few treatments of chronic lung conditions which has been shown to slow down the disease progression and improve clinical outcomes [1-3]. PR has been successfully carried out via telemedicine [2] however initial patient assessment has been traditionally conducted in PR centers. Home based patient assessments decreases the difficulties associated with travel to a PR assessment and has been shown to be effective [3-4]. The first step in PR is assessment of patient's exercise capacity which allows individualized prescription of safe and effective exercise program. With COVID-19 pandemics assessment of patients in PR centers has been limited resulting in significant reduction of patients undergoing life-saving PR. Remote assessment via telemedicine may limit the risks associated with face to face visits. Telemedicine remote assessments have been found to be effective for other

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conditions but have not been examined for exercise capacity evaluation [5] The goal of this pilot study is to introduce approaches for remote assessment of exercise capacity using videoconferencing platforms and provide initial usability assessment of this approach by conducing cognitive walkthrough testing.

2. Method

2.1. System Design

A system for remote exercise capacity assessment has been designed to support the connection between patients at home and rehabilitation providers including physical therapists (PT) at their office. This system utilizes secure videoconferencing platforms such as zoom or webex. The remote assessment system allows carry out comprehensive physical therapy assessment necessary for prescription of a personalized exercise program tailored to individual fitness level and limitations in gait and balance of the patient under evaluation.
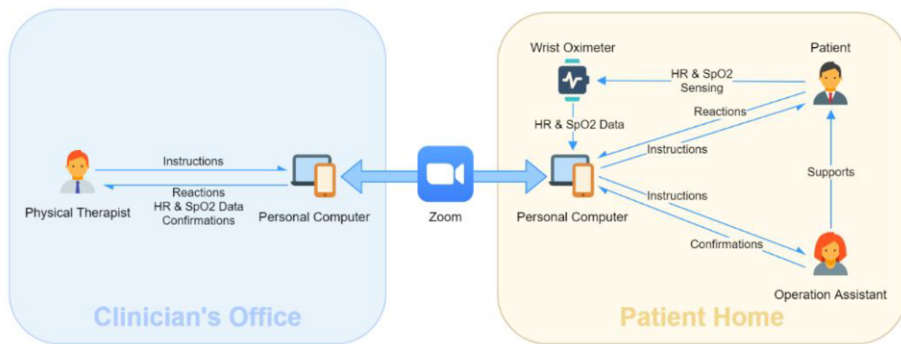

Figure 1. System design.

A system design of the remote assessment system is depicted in Figure 1. The system comprises: 1) personal computer with Zoom for PT; 2) personal computer with Zoom for a patient; 3) wrist oximeter and portable arm bike for a patient. The system supports three roles: 1) PTs who will assess patient fitness and prescribe exercises; 2) patients who will follow PT's instruction to be assessed; 3) operation assistant (OA) who will support the patient on both instructions and techniques during the assessment. The procedure is designed with minimal requirements for the participating parties. The OA will help with setting up the vital monitoring system in patient home and help the PT and patient to communicate via Zoom meeting. The PT can give the instructions and read the heart rate and SpO2 data through the system in real time. Thus, PT can also monitor patient's condition during the whole remote assessment via the system.

2.2. Study Design

Participants were given a packet of instructions and surveys to carry out a cognitive walkthrough of the system. Surveys consisted of standardized questions with answers

Table 1. Tasks performed by study participants during cognitive walkthrough.

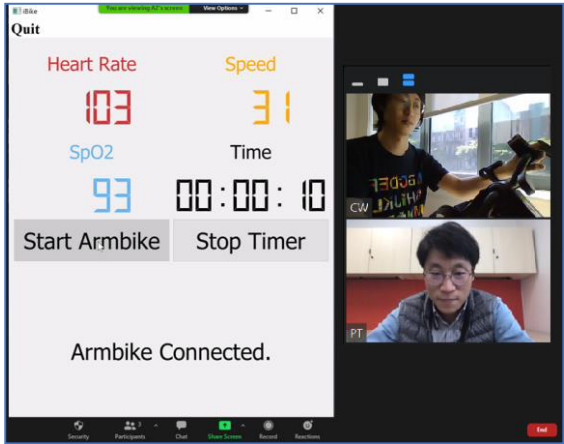| Task 1: login, enter the zoom meeting, and meet the meeting participants	
Steps	*Role*
1. Schedule and set up the Zoom meeting with both patient and physical therapist	OA
2. Join the Zoom meeting and check the setting with operation assistant	PT
3. Help patient to wear the wrist Oximeter and make sure the heart rate and SpO2 data can be read by physical therapist	OA, Patient
Task 2: five times sit to stand test	
Steps	*Role*
1. Introduce the purpose of the exercise test	PT
2. Explain the procedures of the exercise test	PT
3. Confirm the preparation of the exercise	OA, Patient
4. Perform sit to stand test.	OA, Patient
5. Monitor patient's reactions, heart rate, and SpO2 data during the exercise test.	PT
Task 3: prolong phonation test	
Steps	*Role*
1. Introduce the purpose of the exercise test.	PT
2. Explain the procedures of the exercise test.	PT
3. Confirm the preparation of the exercise	OA, Patient
4. Perform vital capacity test.	OA, Patient
5. Monitor patient's reactions, heart rate, and SpO2 data during the exercise test.	PT

Figure 2. System Interface.

Table 2. Participant profile.

	Mean (SD)			%
Age (years)	35.6 (13.3)			
	%			**%**
Gender		**ATM use**		
Female	40	Once a month or less		40
Male	60	Once a day		40
Race		Never		20
White	40	**Computer use at home**		
Asian	60	Once a day		100
Born in United States		**Computer use at work/school**		
No	80	Once a day		100
Yes	20	**English proficiency (self-reported)**		
Job		Good		60
Permanent	100	Excellent		40
Internet use		**Proficiency of using the internet**		
Once a day	100	Excellent		100

Table 3. Post-task survey

Questions asked after Each Task	Score Range	Sub Session
1. How difficult or easy was it to complete this task?	1, "Very Difficult," to 5, "Very Easy."	Task X.1
2. How satisfied are you with using this application/system to complete this task?	1, "Very Unsatisfied," to 5, "Very Satisfied."	Task X.2
3. How would you rate the amount of time it took to complete this task?	1, "Too Much Time," to 5, "Very Little Time."	Task X.3

Table 4. Results of patient testing of the remote tele-assessment system

Group	Session	Accomplished time (sec)		Exercise time (sec)		Sub Session	Score	
		Mean	SD	Mean	SD		Mean	SD
PT	Task 1	151.0	38.6			Task1.1	4.6	0.5
						Task1.2	5.0	0.0
						Task1.3	4.0	1.4
	Task 2	111.0	19.0			Task2.1	5.0	0.0
						Task2.2	4.6	0.5
						Task2.3	4.6	0.9
	Task 3	95.4	33.3			Task3.1	5.0	0.0
						Task3.2	4.8	0.4
						Task3.3	4.2	1.3
OA	Task 1	253.8	44.1			Task1.1	4.0	1.0
						Task1.2	4.0	1.0
						Task1.3	3.8	0.8
	Task 2	104.0	28.8			Task2.1	5.0	0.0
						Task2.2	4.2	1.1
						Task2.3	5.0	0.0
	Task 3	100.0	27.4			Task3.1	5.0	0.0
						Task3.2	4.2	1.1
						Task3.3	5.0	0.0
Patient	Task 1	271.0	33.2			Task1.1	5.0	0.0
						Task1.2	4.8	0.4
						Task1.3	4.4	1.3
	Task 2	107.8	22.2	15.4	2.3	Task2.1	5.0	5.0
						Task2.2	5.0	5.0
						Task2.3	4.8	0.4
	Task 3	95.2	32.8	23.1	13.5	Task3.1	4.4	0.4
						Task3.2	5.0	0.0
						Task3.3	4.8	0.4

PT: physical therapist, OA: operation assistant, Task Accomplished- PT: 100%, OR: 100%, Patient: 100%, Help needed- PT: 0%, OA: 0%

Table 5. Exit survey and System Usability scale

Items	Group	Mean	SD
The zoom is visually appealing[†]	PT	4.8	0.4
	OA	4.4	1.3
	Patient	4.6	0.9
The zoom is easy to navigate[†]	PT	4.4	0.9
	OA	3.8	1.1
System usability scale (0-100)	PT	86.0	16.5
	OA	88.0	6.9
	Patient	91.0	11.3

[†]1: strongly disagree – 5: strongly agree

arranged as Likert-type scales and additional written responses. Participants were instructed to perform three representative tasks while being timed. If participants needed additional help to complete a task, these requests were also noted. Each cognitive walkthrough experiment consisted of three participants representing PT, patient and OA. After completing each task, each participant was asked to grade that task on a scale of 1 (very difficult) to 5 (very easy) using a 3-item survey that included the following questions: 1) How difficult or easy was it to complete this task? 2) How satisfied are you with using this application/system to complete this task? 3) How would you rate the amount of time it took to complete this task? Once all tasks were completed, the participants were given an exit survey including the System Usability Scale (SUS). Data analysis has been carried out using IBM SPSS Statistics.

3. Results

The resulting user interface is depicted in Figure 2. Five cognitive walkthrough experiments have been completed by different teams including 3 participant each. Overall, 15 reports were generated and analyzed. The profiles of the 15 study participants are presented in Table 2. The usability analysis is presented in Tables 2-5. SUS scores ranged between 86 and 91 representing high usability of the system.

4. Conclusion

The usability inspection of the remote exercise assessment demonstrated overall high acceptance by all study participants. Our results are congruent with previous reports demonstrating significant potential of patient-centered digital health [7]. Our next steps in developing user-centered interface should include usability evaluation in different subgroups of patients with varying socio-economic background, different age groups, computer skills, literacy and numeracy.

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