14 Experiences of Clinicians Using Rehabilitation Robotics

Marcela Múnera, Maria J. Pinto-Bernal, Nathalie Zwickl, Angel Gil-Agudo, Patricio Barria, and Carlos A. Cifuentes

14.1 Introduction

While there is a consensus that it is essential to involve users in developing rehabilitation technology, there are few examples of how to do this, and no studies of which techniques are most effective [1]. In recent years, many useful robotic devices have been used in daily therapeutic life. The experience shows that the devices could not always be used successfully. Some impracticability factors such as being time-consuming, complicated usage, and though wearing, were the reason for the device's failure. There is a growing recognition that if medical devices are of real value, their users' need and capabilities must be considered [2]. In the case of rehabilitation robotics, "User" covers both the patients treated with a device, and the

M. Múnera · M. J. Pinto-Bernal · C. A. Cifuentes (✉)
Escuela Colombiana de Ingeniería Julio Garavito, Bogotá, Colombia
e-mail: marcela.munera@escuelaing.edu.co; maria.pinto@mail.escuelaing.edu.co; carlos.cifuentes@escuelaing.edu.co

N. Zwickl
Zürcher Hochschule für Angewandte Wissenschaften, ZHAW, Institut für Physiotherapie, Winterthur, Switzerland
e-mail: nathaliezwickl@hotmail.com

A. Gil-Agudo
Hospital Nacional de Parapléjicos, Finca De, Carr. de la Peraleda, S/N, Toledo, Spain
e-mail: amgila@sescam.jccm.es

P. Barria
Department of Electrical Engineering, University of Magallanes, Punta Arenas, Chile

Club de Leones Cruz del Sur Rehabilitation Center, Punta Arenas, Chile

Brain-Machine Interface Systems Lab Systems Engineering and Automation Department, Miguel, Hernández University of Elche UMH, Elche, Spain
e-mail: pbarria@rehabilitamos.org

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staff responsible for using the device to treat them [1]. This shows the importance of involving the clinicians and patients in the development process. In this chapter, the concept of the users' involvement in the development process is developed: the parameters assessed, the stages for this involvement, and the tools used. In the final sections, the application of these concepts is shown in three case studies.

14.2 Parameters Evaluated in the User's Input

In the development process [3, 4], the device's acceptance and practicability should be considered. Therefore, involving clinicians and patients who are the end- user group who will work with the device daily is essential. If the clinicians are not convinced about a device, its success could be significantly doubted [3, 5, 6]. Some reasons why the clinicians can reject the devices could be the difficulty and time of the donning/doffing of the devices, the complications in its handling, or if the device is triggering fear in the patient. Therefore, it is crucial to analyze social or physical robots' acceptability and practicability, more specifically [7]. In the following paragraphs, the key points of the clinicians' view for the application of robots in a daily therapeutic environment are presented.

14.2.1 Practicability

Practicability is a critical point for a clinician to use a physical device in their therapeutic sessions [7]. Practicability is the quality of being able to be done, or of being likely to be successful. Here, we describe this aspect through three important parameters found in the literature. First, we have to consider **specific target patient group considerations**. The clinician knows the target patient group which will use the device, and they know where specific problems may occur [3, 8]. The robotic device which helps physically is usually aimed at patients with neurological or muscular difficulties. Each target patient group might have specific needs and limitations [3, 4]. For example, a device targeted for patients who usually are in a wheelchair needs to be easily donned in a sitting position. Such limitations should be considered when designing the device, and the clinicians are a very reliable source for these design considerations [9]. For this parameter, in the case of social robotic in rehabilitation, the group should be analyzed with the clinicians' help. Different points should be clarified and considered, such as age (are the patients comfortable with using electronic devices?), weight (are the activities appropriate to the patients' weight group?), fatigue (are the patients motivated to have a certain level of activities?). Second, the devices should have **simple handling**. The clinicians are the end-users and should feel comfortable when working with the device. The usability of the device should be simple and should not have complicated and deep technical steps. Typically, the end-users are healthcare personnel without technical robotic knowledge [3, 8, 10]. Therefore, the possible technical adverse effect should be explained in a manual [9]. Third, the device should consider the **session process**

communication. The clinicians know how to explain the therapeutic session and the health-relevant problems in a patient-friendly language [3]. In each session, it is vital to create a safe and pleasant environment for the patient. Ideally, the patient should understand how the device works and what interactions with the device will happen. Having the process and interactions communicated to the patient helps the clinician achieve better compliance [6, 11]. In the use of social robots, patients have more direct contact with the robots. The clinicians' role is essential to communicate to the patients that they are not being treated solely by a robot but rather by a combination of human and machine. Having that communicated, the clinician is also influential in helping the patient to understand, cooperate with, interact with, and comply with the robot [3, 6, 11].

For physical robots, there is an additional parameter to take into account: **time**. The clinician knows the timeframe in which the device should be used and how long the donning/doffing should take to have a practical therapeutic session. They also know which steps are more time-consuming. Ideally, the device should be easy and not time-consuming to put on. The device donning should be straightforward with rather a small number of steps and the patient should not need to go through repetitive actions because this could cause the patient's loss of energy before the session starts [9].

14.2.2 Acceptability

Acceptance is defined as a phenomenon that reflects to what extent potential users are willing to use a specific system [12]. The difference between acceptance and acceptability is that acceptance is described as the respondent's attitudes, including their behavioral responses, after introducing a measure, and acceptability as the coming judgment before such future introduction [13]. Hence, acceptability is linked closely to usage, and acceptance will depend on how user needs are integrated into the system's development. Previous studies [14–17] showed that physiotherapists generally had a positive attitude to robotic devices' potential and a lack of knowledge about the systems currently being developed. Those studies indicated concerns about patient confidentiality and the cost and usability of robotic systems. For instance, a survey demonstrated which features of robotic devices physiotherapists considered to be desirable around the areas of safety, positioning, movement control, patient feedback, and display of and access to information [18]. As shown in the practicability, for the acceptability there are also different parameters for the physical robots and the social robots.

There are four critical parameters to define the acceptance of physical robots. First, the physical robot should cause **no harm**, which is a fundamental design principle. The clinicians have a good understanding of the human anatomy and the possible points of contact between the robotic device and the human body [3, 4]. Therefore, they can help understand specific implications of working with the device and potential harm points in the force transference. In this sense, an example of pressure points and the danger zones for skin integrity is shown in [9]. Second, the device should have a **Familiarization phase**. Clinicians know how long the patient needs to familiarize with the new device [8]. The goals of the use of the device as well as the limits of the device should also be clarified with the patients [3]. This would help to avoid future deception, insufficient compliance and disappointment. Third, the robotic device should **avoid fear**. Having a safe feeling along with a sense of comfort is desirable for the patients. With a proper knowledge of the device, clinicians should accurately use the device in their sessions [4, 11]. The role of the clinician is critical to provide the feeling of being safe and avoiding fear. Clinicians provide empathy due to the experience of handling patients with different diseases. Having a safe feeling during the therapy session is essential to achieve compliance. A patient who lacks information (e.g., how the assistive forces operate in a physical robot) starts to develop fear and will be rarely convinced to continue to work with the device [9]. The fourth parameter is **relevancy**. The clinician can decide if the device has relevance to the therapy. The device should help the clinician to achieve a better therapeutic result [3–5].

In the use of social robotics, it is crucial to clarify the **Role of the device** additionally. The clinician can discern the needs in therapy that can be helped by the device and how to implement it in the therapeutic environment. It should be clarified to the clinicians that the device is aimed to complement their role rather than replacing them [3]. For that, the clinician should understand how the social robot works, what its advantage is, and what its limits are [8, 10, 11]. In the category of social robots, the insecurity of the role of the clinicians is very high. Therefore, it is crucial to clarify the vital role of the clinicians next to the device. Generally, the robot can do a part of the clinician's work, which gives the clinician the liberty to perform other tasks [4, 11].

As the field of robotics develops, acceptance levels may rise, but physiotherapists, and rehabilitation in general, need to be in a position to make the best use of this by stepping out of established comfort zones. For this, they should recognize potential benefits to the patients and a broader assessment of cost/benefit that includes initial cost, storage, maintenance, training, and improved, efficient outcomes [19].

14.3 Stages for Clinical and Patient Input

Different tools have been used to collaborate between patients, the health staff, and the device's designers and developers. Those tools can help at different stages of the research in the use of new robotic devices. Figure 14.1 presents some of the inputs, those tools can offer in designing, implementing, and assessing a new robotic device.

14.3.1 Planning Stage

The study of the practicability of a device can be started in planning at the beginning of the project. From the beginning, a clinician can improve the device's

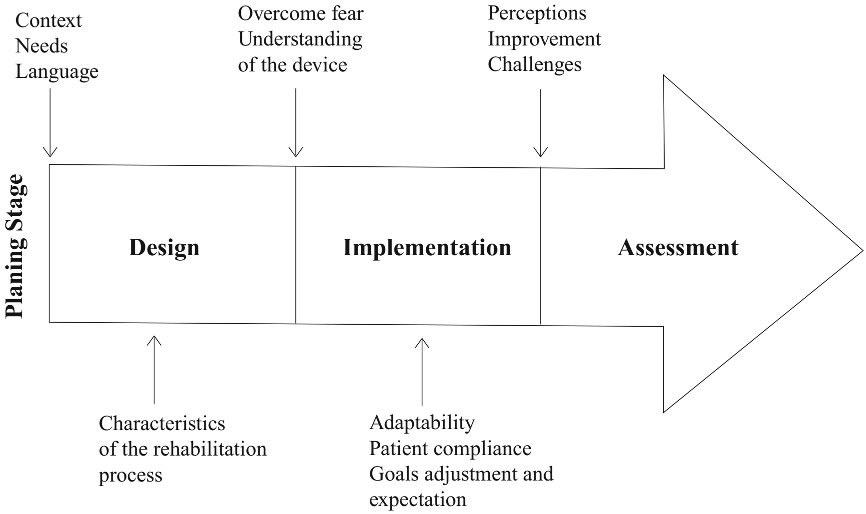

Fig. 14.1 Flow diagram of technology acceptance and perception: different aspects that can be obtained in the different stages of a study

practicability (e.g., make a wearable robot easier to donning and doffing the device). Working together with the engineers, they can save time through safe usefulness steps. The cooperation between clinicians and engineers can make the device more practical for clinicians and patients. Approaching the stakeholders during this stage can also give information about the context, specific needs, and specific language of the community.

14.3.2 During the Building Process

Involving clinicians in the planning and producing process support the building process and the stakeholder's integration. In this sense clinicians understand technical factors involved into the process, trade-offs, and limits. Engineers understand the clinical process and the challenges of handling patients. This approach also allows engineers to understand the clinical process and the challenges of handling patients. Moreover, a clinician involved in the building process can improve compliance with other clinicians. This factor will simplify and accelerate the implementation of the device in the therapy. Additionally, including clinicians in device design helps to overcome many clinicians' common fear, which is the job replacement. Concluding, clinicians will ideally tend to see their relationship with the new devices as cooperation rather than competition.

14.3.3 During the Implementation

The clinicians' role is crucial in providing a safe environment for patients when new devices are being implemented. Clinicians can better explain the device to the patient (e.g., how the forces work in a physical robot, and when wrong functioning is generated). The clinician can also define, together with the patient, reasonable goals and explain the devices. The role of the clinician is also vital in avoiding dangers. For example, in gait rehabilitation with robotic devices, the patient might get overly motivated, and therefore the risk of a fall might increase. Participants might lose their understanding of their physical limits during the interventions.

14.3.4 After the Implementation

After implementing a new device in a rehabilitation process, clinicians' and patients' opinions can be collected to view the community's perception of the device clearly. This can help to understand their idea of usefulness, difficulty, efficacy, and other parameters. Additionally, this can help the designers and engineers understand the challenges in using the device and the improvement possibilities. In the second section of this chapter, some tools are described. Those tools are divided into questionnaires, interviews, and focal groups. In the third section ,some specific examples in rehabilitation are presented. In those specific case studies, it is shown the use of those tools only at the beginning, only at the end, and at the beginning and the end of the process.

14.4 Perception Studies and Survey

Ergonomics and comfort are some of the most relevant aspects of user-machine interaction [20]. Those parameters are often measured using subjective scales. The idea of comfort for a robotic device in rehabilitation can be seen from different points of view. It can be related to the physical interface, its usefulness, and its safety among others. Additionally, the comfort can be related not only to the patient but also to the health staff that is part of the rehabilitation activity. Concerning the health staff, the comfort using the device can be related to how this device contributes to the therapy's development or can increase its difficulty. All those parameters can be grouped in the idea of acceptance and perception. This is usually obtained through qualitative data that is subjective, difficult to analyze consistently, and open to interpretation, but provides much richer information, explaining and giving context to the quantitative responses [1].

Some studies discuss the importance of balancing the device's functional requirements as defined by the potential users and the technical requirements from an engineering perspective. They also highlight the need for suitable strategies to gather information within a particular population to avoid problems associated with the trial of an unfamiliar device. They concluded that feedback from potential users is essential for device design [21].

In this section, a summary of different techniques to measure acceptance and perception will be developed. In this case, three methodologies will be explained (questionnaires, interviews, and focus groups). It seems probable that the most appropriate method and level of involvement to measure this perception will depend upon the nature of the device, stage of development, and the nature of the users involved [1].

14.4.1 Questionnaires

Standardized questionnaires have been proposed to provide a more reliable measure of people's perception [22]. These questionnaires have been standardized to have high reliability and validity measures, and they are compared based on their sensitivity degrees [23]. In this chapter, some questionnaires to use before the implementation of a robotic device (i.e., Knowledge, Attitude and Practice KAP questionnaire), during the intervention (i.e., Working Alliance Inventory WAI), and after the use of the robotic device (i.e., QUEST, UTAUT) are presented.

14.4.1.1 Knowledge, Attitude and Practice KAP

The Knowledge, Attitude, and Practice (KAP) questionnaire is a representative survey conducted on a particular population to identify the knowledge (K), attitudes (A), and practices (P) of a population on a specific topic [24]. In most KAP studies, data are gathered orally by an interviewer who uses a structured, predefined questions formatted in standardized questionnaires, making it a quantitative method that provides access to quantitative and qualitative information [24].

This questionnaire collects the data on the knowledge (i.e., what is known), attitudes (i.e., what is perceived), and practices (i.e., what is done) of a particular population [25]. In the first one, it is possible to measure the knowledge level regarding information acquired by a population and ensure that the tools used are appropriately suited to the people in question. In the attitudes, the gap between knowledge and practices is measured and shows the various restrictions people are bound. In the practices, the information about actual acts carried out by people in the situation, in their context, is measured [24].

KAP surveys are prevalent in health care because they provide helpful information and appear easy to design and execute [26]. KAP can be used before an intervention to reveal misconceptions or misunderstandings that may represent obstacles to the activities that would be implemented and potential barriers to behavior change [24]. It can also measure the impact of education programs [24] used at the beginning and the end, providing recommendations for implementing of future projects. KAP surveys burgeon when novel situations arise, such as the use of robotics in new clinical scenarios or during the COVID-19 pandemic, which has spawned several KAP studies in the population at large as well as in selected subpopulations, including health care workers [26].

Some reasons for conducting KAP Surveys are: (1) To identify the baseline knowledge, myths, misconceptions, attitudes, beliefs, and behaviors concerning a specific health-related topic, (2) To understand, analyze, and communicate about topics or situations of interest in the field, (3) To provide information on needs, issues, and barriers related to the development of effective, locally relevant public health interventions, and (4) To measure post-intervention changes, and thus, the effectiveness of intervention programs that were aimed at correcting and changing health-related knowledge, attitudes, behaviors, and practice.

Note that a KAP survey essentially records an "opinion" and is based on the "declarative" (i.e., statements). In other words, the KAP survey reveals what was said, but there may be considerable gaps between what is said and what is done [24]

14.4.1.2 Working Alliance Inventory (WAI)

The Working Alliance Inventory (WAI) is a method developed to evaluate some generic degree of success in counseling. This measurement by Hovarth et al. in 1989 is based on Bordin's pantheoretical tripartite conceptualization (i.e., bonds, tasks, and goals) [27]. In social robotics, it allows measuring the adaptation to the devices. These three subscales are assessed with a 36-item-self-report instrument. The *Bond* construct measures the degree to which the robot and the patient like and trust each other (e.g., "My relationship with the robot is important to me "); the *Task* construct evaluates the degree to which the robot and the patient agree on therapeutic tasks (e.g., "The things that the robot is asking to me do not make sense); and the *Goal* construct aimed to measure the degree to which the robot and the patient agree on the therapy goals (e.g., "The robot perceives accurately what my goals are").

This measurement has been analyzed and used in studies based on long-term interaction in social robotics, mainly based on the WAI proposed by Bickmore et al. in 2005 [28]. For example, to measure the robot interaction, the researchers use the WAI without the task construct in a study to measure the effects of anticipatory perceptual simulation on practiced human–robot tasks [29]. On the other hand, in Kidd et al. in 2008 [30], the interaction between the robot and the users in a long-term period scenario was measured. The researchers compare the WAI scores of a group who experienced the interaction with a relational robot with users who use a non-relational robot. The results show that the bond between the robot and the users was significantly better for the relational robot. Finally, Abdulrahman and Richards [31] modeled the therapeutic alliance using a user-aware embodied conversational agent that promotes treatment adherence. The researchers used the WAI to investigate the agent's influence on the adherence and therapeutic outcomes after 3 and 6 months of interaction.

14.4.1.3 Acceptance and Usability Assessment Based on UTAUT Test

Technology acceptance is commonly described as the favorable reception and ongoing use of newly introduced devices and systems [32]. Questionnaires used to assess this acceptance can be specific to an application or be universal. That means, they can be adapted to different forms of technology. For universal questionnaires, three criteria of ISO 9241-11 are the most taken into account: effectiveness, efficiency, and satisfaction [23].

The Unified Theory of Acceptance and Use of Technology (*UTAUT*) [33] was developed as an evolution to the Technology Acceptance Model (*TAM*) [34]. The TAM model is the basis for evaluating acceptance in different applications (e.g., e-commerce acceptance model (*EAM*), technology acceptance associated with mobile health devices [35]). However, the *TAM* has been criticized as it lacks precision and ignores influential factors such as the complexity of the technology, and user characteristics that are relevant on many applications [32]. The UTAUT model has been used in healthcare to evaluate of different devices and technologies, applications such as web-based devices and rehabilitation technologies [36]. This acceptance can be from the patients [37] or health care staff [38].

Based on the UTAUT and UTAUT2 models by [33, 39], and the questionnaire developed by Heerink et al. [40], an acceptance and usability questionnaire can be designed and adapted. Six categories are usually established in order to evaluate different perception constructs: Facilitating Conditions (*FC*), Performance and Attitude Expectancy (*PAE*), Effort expectancy and anxiety (*EEA*), Behavior Perception (*BP*), Trust (*TR*), and Attitude Towards Using Technology (*AT*). Each question is scored with a 5 points Likert scale (1 strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree). The **Facilitating conditions** define if the user has the necessary knowledge to use the system or have previously used similar systems. The **Performance and Attitude Expectancy** asks if the user finds the device helpful, compelling or if it increases the task's performance. The **Effort expectancy and anxiety** ask about the fear, difficulties, or learning necessary to use the system. The **Behavior Perception** defined the perception of the user about the communication and understandability of the device. The **Trust** can use questions such as, "I would trust the system if it gave me advice" or "I would follow the advice that the system gives me." Finally, the **Attitude Towards Using Technology** asks about attitudes such as the fun or interest in using the system.

In social robots, they seek to interact as humans do [41] and this represents a difference with other technologies. Therefore, the perception models need some adaptations to meet the social robotics needs [42–45]. Heerink et al. found that the UTAUT model did not indicate that social abilities contribute accepting a social robot [40]. This work presents an adapted version of the UTAUT model incorporating social aspects relevant to assess social robotic agents [46]. They described user acceptance as "the demonstrable willingness within a user group to employ technology for the tasks it is designed to support." This model integrates several constructs that enable to know social factors influenced by a social robot (e.g., anxiety, attitude, facilitating conditions, social influence, intention to use, perceive adaptability, perceived enjoyment, perceived ease of use, perceived sociability, and perceived usefulness) [14, 47].

14.4.1.4 QUEST

The user perception can also be assessed after an interaction employing a Quebec User Evaluation of Satisfaction with Assistive Technology *QUEST* test [48]. The

QUEST was designed as an outcome measurement instrument to evaluate a person's satisfaction with a wide range of assistive technology (AT). The original QUEST survey comprises 27 questions related to participants' satisfaction concerning the robotic device [49]. The user is asked to indicate the degree of importance they attribute to each of the satisfaction variables and then to rate their degree of satisfaction ranging from 1 (not satisfactory at all) to 5 (very satisfactory) [50]. Satisfaction is defined as a person's critical evaluation of several aspects of a device [48]. This definition is based on the principle that each variable's relative importance needs to be determined by the consumer to interpret the satisfaction data [51]. It was intended as a clinical and research instrument. As a clinical tool, the rating scale provides practitioners with a means of collecting satisfaction data to document AT's real-life benefits and justify these devices' needs for these devices. QUEST test, as a research tool, can compare satisfaction data with other outcome measures such as clinical results, quality of life, functional status, cost factors, and comfort. It can also compare satisfaction results obtained with different user groups, settings, and countries [48].

In the second version of this tool (QUEST 2.0), the instrument is divided into two domains based on the results of factor analysis [48,52]. Some items concerning satisfaction are related to the assistive technology device ("Device" domain), while other items are related to the assistive technology services in which the assistive device is delivered ("Services" domain) [50]. In the work of Demers et al. in 2002 concerning the QUEST, test–retest reliability was high, with intra-class correlation coefficients (ICCs) of 0.82, 0.82, and 0.91 for the "Device" and "Services" domains and the total scores, respectively [48]. The questionnaire is designed for either self-administration or interview [50]

This tool has been used to assess different assistive technologies like wheelchairs, exoskeletons, orthesis, among others [50, 51, 53, 54]. In Wearable devices, the questions concerning characteristics about the device are: dimensions, weight, adjustments, safety, durability, simplicity of use, comfort, and effectiveness [54]. Questions concerning the service are: service delivery, repairs/servicing, professional service, and follow-up services [51].

14.4.2 Interviews

A key aspect to the planning of a research project in rehabilitation robotics is patients and their families and health staff likely to use the system within their routine practice [1]. A user interview is a User eXperience (UX) research method during which a researcher asks one user questions about a topic of interest (e.g., use of a system, behaviors, and habits) to learn about that topic. This technique can be a quick and easy way to collect user data. Interviews can give insights into what users think about a new robotic device in a rehabilitation process. They can point out what people feel is essential in the process and what ideas for improvement they may have.

Interviews can be used alone or combined with questionnaires and observations [1]. For the questionnaires, the interviews can also be done before the design process to know the context, inform the population; or at the end of a usability test to collect verbal responses related to observed behaviors. When done at the end of a usability test, it is best to defer the interview until after the behavioral observation segment of the usability study. If the perception questions are asked before the participant tries to perform tasks with the proposed design, it can bias the user to pay special attention to whatever features or issues were asked about.

Interviews have been used to obtain general impressions about the benefits and barriers of using robotic therapy devices for in-home rehabilitation [55], the involvement of health staff and members of the public in the design stages of an upper-limb robotic device [1, 19, 56], to investigate and prioritize the needs concerning the personal mobility domains and their attitudes towards assistive robots [57], to ask clinical therapists their perspectives on robotic stroke rehabilitation [58], among others.

Usually, the data collected at the interviews are analyzed to obtain the more frequent themes and concerns of the population about a specific goal [55] and thematic content analysis by underlying recurrent topics [57]. For this analysis is vital to set a goal for the interview and avoid leading, closed, or vague questions [55].

Some studies show through interviews the health staff opinion concerning ways to improve the handling of the robot, additional features that they would like to see, existing features that they considered unnecessary or undesirable, the type of patients they would use the system with, the benefits (if any) that they saw in using the robot; and the barriers (if any) that may limit the use of the robot [56]. In some cases, interviews alone are not sufficient to meet all the work/task analysis needs. It is vitally important to observe users doing work in their natural settings, and to gather and document examples of that work for designers to gain a thorough understanding of potential users' work (including its surrounding context) which an intended application [59].

14.4.3 Focus Groups

The focus groups are a video- or audio-taped small group discussion that explores topics selected by the researcher and is typically timed to last no more than 2 h [60]. Unlike user interviews, which are one-on-one sessions, focus groups involve 6 to 9 users [61]. As a qualitative method for gathering data, focus groups bring together several participants to discuss: (1) a topic of mutual interest to themselves and the researcher or (2) issues and concerns about the features of a user interface [60]. This enables the project team to take the user's perspective and argue from the user's point of view [62]. Moreover, it can help researchers to assess user needs and feelings both before interface design and long after implementation [61].

Focus group participants are usually led through the discussion by a moderator, often the researcher [60]. For participants, the focus group session should feel free-flowing and relatively unstructured, but in reality, the moderator must follow a pre-planned script of specific issues and set goals for the type of information to be gathered [61]. The data collected from focus group sessions are typically analyzed qualitatively [60]. In interactive systems development, the proper role of focus groups is not to assess interaction styles or design usability but to discover what users want from the system [61].

Focus groups not only give us access to certain kinds of qualitative phenomena that are poorly studied with other methods but also represent an essential tool for breaking down narrow methodological barriers [60]. Focus groups can serve a variety of purposes related to rehabilitation programs. Among these are to (a) obtain general background information about a program (b) generate program ideas that can be subsequently tested, (c) diagnose program problem areas (d) gather information about clients' impressions about a program, and (e) learn how clients talk about the program or topic of interest [63]. However, the information of the focus groups should be complemented with other techniques due to the inaccurate data that can be produced because users may think they want one thing when they need another [61]. Within the realm of qualitative methods, focus groups have much to offer as an adjunct to other qualitative techniques, such as informant interviewing and participant observation [60].

In rehabilitation, focus groups can be used to empower its conventional programs [64]. This technique has been used in e-Health for stroke rehabilitation [65], with potential users of exoskeletons for Spinal Cord Injury [66], virtual reality training systems [67], and home-based stroke rehabilitation [68]. In some cases, through Focal groups, it has been found that the system's requirements between patients/informal caregivers and health professionals differed on several aspects [65]. Therefore, involving the perspectives of all end-users in the design process of Rehabilitation programs are needed to achieve a user-centered design [65].

In the field of social robotics, focus groups have been used to introduce *SAR* and discuss their questions and concerns associated with the technology [69], and to create new application within the community [70]. Some changes in opinion and perception are found in the participants once the robotic application has been explained and they had the opportunity to witness in situ demonstrations [69, 71].

14.5 Clinician's Experiences and Perception of Robotics

According to the previous section's perception studies and surveys already mentioned, this section presents three studies previously performed. These studies show different measurements used to evaluate the patient's and clinician's perception and experience with the technology and their results. The first study contemplates the patient's and clinician's perception before using technology. The second study evaluated only the patient's and clinician's acceptability after used the technology. Finally, the third study evaluated the patient's and clinician's perception and expectations before using technology and their acceptability.

14.5.1 Expectations of Healthcare Professionals for Robots During COVID-19

The study of Sierra et al. [72] presents the design and implementation of a perception questionnaire to assess healthcare providers' level of acceptance and education towards robotic solutions for the COVID-19 pandemic. In this work remarkably, several questionnaires were proposed to evaluate the perception of medical robotics, as well as of three types of robotics platforms for COVID-19 mitigation and control: (DIS) Disinfection and cleaning robots; (ASL) Assistance, Service, and Logistic robots; and (TEL) Telemedicine and Telepresence robots.

The researchers designed a qualitative survey to assess health professionals' concepts, ideas, perceptions, and attitudes toward robotics in managing the COVID-19 pandemic through the KAP questionnaire. As illustrated in Sect. 14.4.1.1, this questionnaire collects the data on the knowledge (i.e., what is known), attitudes (i.e., what is perceived), and practices (i.e., what is done) of a particular population [25]. It is essential to highlight, as mentioned in Sect. 14.4.1.1, several KAP surveys on COVID-19 have been reported in the literature. However, they aimed to assess the overall perception of COVID-19 in patients and survivors, and not to evaluate robotics perception for COVID-19 outbreak management [73–75]. Therefore, the survey was designed taking into account three sections, as follows:

- **The first part** was designed using knowledge-oriented questions. These questions measure the level of awareness and understanding healthcare professionals have regarding robotic tools for DIS, ASL, and TEL.
- **The second part** was designed using attitude-oriented questions. These questions measure how healthcare professionals feel about robotic tools for DIS, ASL, and TEL, as well as any preconceived ideas or beliefs they may have about this topic.
- **The third part** was designed using practice-oriented questions. These questions provide insight into how healthcare professionals apply their knowledge and attitudes regarding robotic tools for DIS, ASL, and TEL through their everyday actions.

Overall, yes or no questions were rated using 1 and −1 scores, respectively; the questions asking to rate experience, knowledge about a topic, and questions formulated as statements were evaluated using a 5-point Likert scale, converted to a scale from −2 to 2 points.[1]

Summarizing, 41 (20 women and 21 men, 35.39± 8.48 y.o) healthcare professionals (e.g., nurses, doctors, biomedical engineers, among others) satisfactorily accomplished the surveys, assessing three categories: DIS, ASL, and TEL robots. Participants were asked to virtually fill out the perception questionnaires using the

[1]The results of these surveys are available in the following link https://doi.org/10.6084/m9.figshare.13373741 [72].

Google Forms online tool. At the beginning of the form, participants were presented with the informed consent, which they read carefully and accept before proceeding with the form. Afterward participants were asked for demographic information about their profession and their work environment. Preceding the questionnaires, a brief description of each type of robot was presented (i.e., DIS, ASL, and TEL) to homogenize the definition of such devices among the participants. Then, the questionnaires were applied [72].

KAP results (see Fig. 14.2) related to the three questionnaire constructs (i.e., knowledge, attitude, and practice) revealed:

i. There is a positive level of knowledge about medical robotics in general for the surveyed population.
ii. Concerning robots for disinfection (DIS), assistance (ASL), and telemedicine (TEL), participants indicated that they have a low level of knowledge and experience with these types of robots.
iii. 82.9% of participants reported a positive attitude towards robots' usefulness and benefits in managing and controlling the COVID-19 pandemic.
iv. 65.8% of clinicians recommend using ASL robots in the pandemic.
v. Approximately 60% of the participants assumed a neutral position when asked if they considered a replacement.

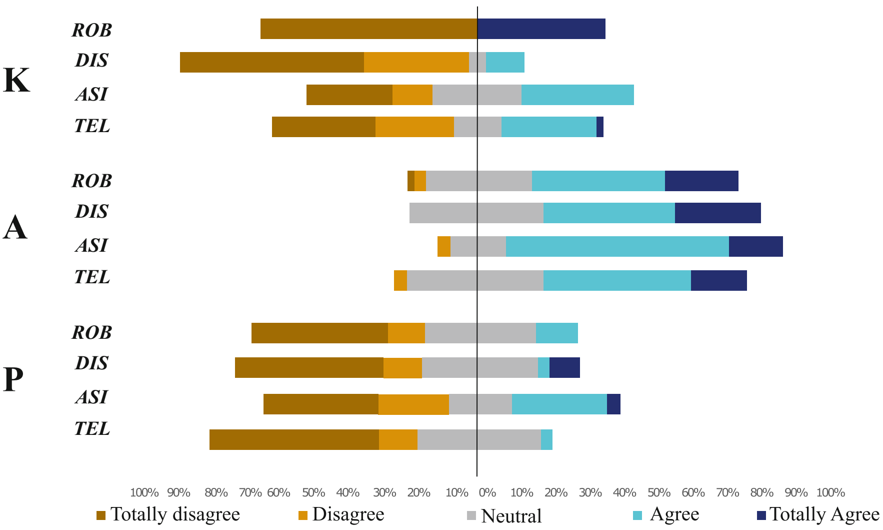

Fig. 14.2 Likert scale distribution for the KAP construct, K refers to knowledge, A to attitude and P to practice for the DIS, ASL, and TEL robots. At the same the results of general knowledge about robots, labeled ROBOT, are reported

The outcomes (i, ii, iii) showed that participants have a positive level of knowledge regarding medical robots in general. However, the clinicians' experience and knowledge regarding DIS, ASL, and TEL platforms are shallow. Consequently, the research suggested that the clinician's awareness and education have to be increased to understand these tools' opportunities, functions, and features [72]. Regarding the outcome (iv), i.e., the robot's role, clinicians prefer platforms capable of supporting logistic tasks, medication, and food delivery, and monitoring the environment. In the case of DIS and TEL platforms, a lower perception was presented. Hence, these technologies' efforts have to increase the clinicians' trust and develop comprehensive platforms capable of providing assistance and disinfection or teleoperation. Finally, concerning the result (v), this suggests that in the first instance, a familiarization stage is recommendable to increase healthcare personnel's trust and motivation as reported in the literature [76]. It is necessary to carry out education and awareness processes in the medical community [77], to strengthen the idea that robots can enhance and improve their work. However, they cannot replace healthcare professionals in fundamental activities. For instance, Coombs et al. [76] recommend performing a familiarization stage based on culture theory to understand individuals' social practices when interacting with the technology and their preferences within its usages. This culture theory will increase their motivation and trust towards technology, such as medical robotics.

14.5.2 Acceptance and Perception of Healthcare Staff in an Application of Social Robotics in Lokomat Therapy

In contrast to the study presented in the previous Sect. 14.5.1, this section presents the design and implementation of an acceptance questionnaire to assess patients and healthcare providers' level of acceptability after used a Social Assistive Robot (SAR) during Lokomat therapies. In this work by Raigoso et al. [78], before implemented the SAR during the therapies, a technology explanation was performed to inform the patients and clinicians about the possible robot's role during the rehabilitation procedure. Three robot assistance tasks were highlighted in this study: (1) clinicians support, e.g., the social robot give feedback to the patients about their cervical and thoracic posture; (2) patient's online monitoring; (3) corrections and motivations provided by the SAR. Overall, the robot was used to complement the therapist's tasks and motivate patients during therapy. It should be noted that, as mentioned in the previous section, several studies [79, 80] recommend this first step (i.e., technology explanation) to understand better the technology dimensions (i.e., the robot's limitations and capabilities tasks). Afterward, the researches designed and implemented a questionnaire based on The Almere Model adapted from the Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire [81]. As illustrated in Sect. 14.4.1.3, this questionnaire assesses the perception of the participants through different constructs (e.g., *Psychological factor* (PF), *Social perception* (SP), *Entertainment Level* (EL), *Effort's Expectations* (EE), *Performance Expectations* (PE), and *Facility Conditions* (FC)).

Table 14.1 Acceptance questionnaire for lokomat therapy users. Adapted from [78]

Construct	No.	Questions
PF	1	I think that the robot will give me confidence.
	2	Using the robot will generate stress.
	3	I think that the robot express emotions during the sessions will be uncomfortable.
	4	I think that the robot will increase the concentration during the therapy.
SP	1	I think that using the robot in rehabilitation could be more enjoyable.
	2	I think that the interaction with the robot would be nice.
	3	Using the robot will give me satisfaction.
EL	1	I think that the therapy could turn boring with the use of the robot.
	2	I think that I will enjoy more the therapy with the robot.
	3	I think that the robot company will make the therapy more enjoyable.
EE	1	Following the robot's instructions would be difficult.
	2	I think that using the robot would improve Lokomat therapy.
	3	I think that use the robot will be easy.
PE	1	I think that the robot will be helpful during the rehabilitation process.
	2	I think that use the robot will make the therapies faster.
	3	I think that the presence of the robot will affect the engagement in the therapy.
	4	I think that the use of the robot will motivate the patients to perform better the rehabilitation.
FC	1	I consider that the robot can be challenging to control.
	2	I consider that the robot could be adapted to any scenario.
	3	I would like the robot to reduce the workload I have during the rehabilitation procedure.

The survey used in [78] consisted of 40 questions based on the constructs above. The questions are divided into 36 closed questions, 32 items are evaluated through a 5-point Likert scale (i.e., 1: strongly disagree to 5: strongly agree), four dichotomous type questions answered with three scores (i.e., Yes, No, Maybe); and four open questions. It is essential to highlight that to avoid the bias in their results; the researches implemented for the closed questions, positive (e.g., "The therapy is more enjoyable if a robot participates in it") and negative formulation (e.g., "The therapy can be boring using the robot"). An illustration of the implemented questionnaire is shown in Table 14.1.

A total of 88 healthcare professionals and patients involved in physical rehabilitation procedures based on Lokomat therapies in two different countries (Colombia and Spain) satisfactorily accomplished the surveys online using the Google Forms online tool. UTAUT results (see Fig. 14.3) related to the six questionnaire constructs proposed in this questionnaire revealed that the robot's perception is primarily positive (PF, 63.92%; SP, 82.5%; EL, 73.29%, and PE, 67.17%). However, a negative perception was found in the Effort's Expectation and Facility Conditions constructs (EE, 51.14%; FE, 43.63%) [78]. These results are interesting because most patients and clinicians think robot usage can be tricky (e.g., ease of use,

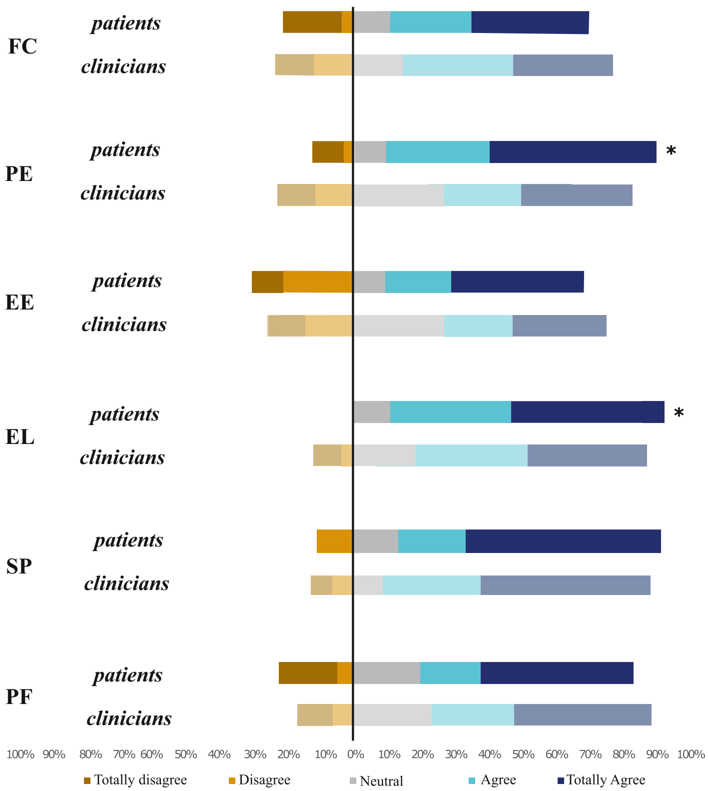

Fig. 14.3 Likert scale distribution for (FC), (PE), (EE), (EL), (SP), and (PF) construct of the acceptance and perception questionnaire applied to patients and clinicians. (*) Statistically significant differences between patients' and clinicians' groups

understand, and follow up the robot instructions, among others) considering the EE construct. In FC, the results show that the participants perceive that the robot role is exclusive for specific treatments and cannot be used in various tasks apart from the rehabilitation procedures [78]. This perception is expected as the robot's interaction is unknown for the users, suggesting that an introduction phase is needed to implement the robot in the future. In fact, in the literature, several studies [82, 83] recommend performing an initial stage where the participants could interact with the technology and understand it to increase the acceptance of the robot in the time.

Summarizing, the results are very encouraging as they highlight the positive perception of different kinds of participants (clinicians and patients) towards the robot in a physical rehabilitation scenario. More than 60% of the population evaluated accept the social robot in the PR with Lokomat. On the other hand, measuring the perception and acceptance in the first stage allows an initial perspective to the participants' needs and expectations. Moreover, the results also show that it is essential to perform a stage to present the robotic system's capabilities and introduce the technology (i.e., robustness and capabilities of the SAR system) to understand and integrate the system in the rehabilitation. The results allowed to build a social robotic interface to work with the patients. Results showed that the robot's support improves the patients' physiological progress by reducing their unhealthy spinal posture time, with positive acceptance. 65% of patients described the platform as helpful and secure [17].

14.5.3 Expectation vs. Reality: Attitudes Towards a Socially Assistive Robot

This section presents a user perception and acceptance questionnaire to assess the attitudes towards a socially assistive robot designed to support the outpatient phase of cardiac rehabilitation therapies.Casas et al. [47] designed and implemented a questionnaire based on the adapted version of the UTAUT model [33] for social robots to evaluate clinicians' and patients' perceptions before and after using a SAR during therapies. It is essential to emphasize that in the literature, there is some evidence [84–86] that the modified UTAUT is a reliable method to assess social acceptance, investigate users' reactions, and analyze the societal impact. In this context, this model has been successfully used in healthcare to evaluate various applications. For instance, acceptance of web-based aftercare devices [87], therapist acceptance of new technology for rehabilitation [5, 36], among others.

On the other hand, in Casas et al. similar to Raigoso et al presented in Sect. 14.5.2 participants had no previous experience with the robotic system. Hence, the researchers provided a technology explanation, i.e., participants were briefly contextualized about SAR systems, the benefits that they can provide, and the variables that are measured in this application, followed by the presentation of a video where the real cardiac scenario is displayed and the robot with its functionality can be appreciated [47]. The system used was comprised of a sensor interface, aiming to measure all relevant therapy variables such as cardiopulmonary parameters (e.g., heart rate and blood pressure), spatiotemporal parameters (e.g., speed, cadence, and step length), and exertion perception scale. Moreover, the robot behaviors were designed in three situations (motivation, warning, and emergency) to interact with the patient while monitoring its performance, and to communicate with the therapists if an event of emergency occurs during the therapy (e.g., heart rate over the maximum allowed level and dizziness) [47]. Afterward, to analyze patients' perception and attitudes towards incorporating this technology in clinical applications, such as cardiac rehabilitation, from both perspectives), two conditions were defined:

1. **Intervention condition:** Patients had a long-term interaction (more than 18 weeks) with the system and experienced the benefits and disadvantages.
2. **Control group**, where an interview was conducted for patients with no experience with the robot.

Besides, Casas et al. analyzed how clinicians are familiar with technology and the effects this might have on rehabilitation programs. Hence, a group of clinicians that work at the clinic in areas associated with cardiac rehabilitation were invited to participate in a focus group at the clinic. This focus group aimed to introduce SAR and discuss their questions and concerns about the technology [47].

Overall, the purpose of having three conditions in [47] was to contrast initial attitudes and expectations against a post-interaction period, to understand how the users can accept this technology more. Therefore, a total of participants performed the study, i.e., this questionnaire was administered to a group of 20 patients without experience with the robot (control group, male = 63.15%, female = 36.84%), eight patients (intervention group, male = 87.5%, female = 12.5%) who spent 18 weeks with the robot during therapy, and 15 clinicians (focus group, male = 6.66%, female = 93.33%, age 36.86 ± 8.78 years old, years of expertise years 11.13 ± 7.68) who work on the cardiac rehabilitation service.

Regarding the implemented UTAUT model in *Casas et al.* [47], it integrated several constructs (Usefulness (U), Utility and Advantages (U/A), Perceived Utility (PU), Safety (S), Perceived Trust (PT), Ease of Use (EU), Perceived Sociability (PS), and Social Presence (SP)), which provided insight into the social factors influenced by the SAR in cardiac rehabilitation scenarios. An example of the questionnaire used for the patients is illustrated in Table 14.2 and an example of the questionnaire implemented to the clinicians is in Table 14.3. The questions were based on a Likert scale. However, the questions were formulated only in a positive manner.

For the patient group (i.e., intervention and control condition), the UTAUT results (see Fig.14.4) allowed comparing the expectation and perception regarding a social robot's role in cardiac rehabilitation. Overall, the perception presented in both

Table 14.2 Perception questionnaire for patients. Adapted from [47]

Construct	No.	Questions
U	1	I consider that using robots it is a good tool to assist cardiac rehabilitation therapies.
	2	I consider that my interaction with the robot was comfortable.
	3	I am satisfied with the work that the robot did.
PU	1	I think that the use of the robot helps me to compromise to do a good job.
S	1	I consider it was easy to give information to the robot.
EU	1	I consider that the robot's instructions were clear.
PT	1	The robot made me confident.
	2	It gave me confidence that the robot guides my therapy.
PS	1	I find the robot pleasant to interact with.
	2	I think the robot is nice.
SP	1	When interacting with the robot I felt like I am talking to a real person.
	2	I can imagine the robot to be a living creature.
	3	I often think the robot is not a real person.

Table 14.3 Acceptance questionnaire for clinicians. Adapted from [47]

Construct	No.	Questions
U/A	1	I consider that using robots is a good tool to measure the HR and the BP during CR sessions.
	2	I consider that using robots it's a good tool to alert me if there is an abnormal heart rate.
	3	I consider that using robots can help me carry out my tasks faster.
	4	I consider that the verbal motivation given by the robot could help the patient to be more productive.
U	1	I might find the system easy to use.
	2	Learning to use the robot could be easy for me.
PU	1	I consider that using robots can bring benefits for the patients.
	2	I feel that the robot could replace me.
	3	I consider that using robots could aid me to evaluate the therapy better.
S	1	The robot would represent a risk to the patient's health.
PT	1	I would feel safe using the robot in the therapies.
	2	I would trust the robot to help me guide the therapy.
	3	I would be afraid to use a robot in therapy.
PS	1	I would like that the interaction between the patient and the robot can be pleasant.
	2	I would like the robot to act as a friendly companion.
	3	I would like to choose the program that the robot should perform during therapy.
SP	1	I consider that the interaction with the robot might feel like talking to a real person.
	2	I would consider good if the patient had the feeling that the robot will observe him in therapy.
	3	I consider patients would usually think that the robot is not a real person.

groups can be interpreted as positive; however, some categories showed differences between both conditions. For instance, the perceived trust (PT) is higher in the intervention group, than in the control group, which expressed low confidence in the robot. This is an expected reaction associated with the lack of experience and contact with the robot and suggested that the trust in the robot will influence the continuous use of the system in the future [88]. Moreover, the results showed for the utilitarian factor, which encloses ease of use (EU), perceived utility (PU), and usefulness (U), which are fundamental for the engagement in long-term relationships [88] differences between both conditions. Specifically, the following:

- **The (EU) construct** suggested that the intervention group perceives more ease of use than the control group; this is due to the time that these patients spent interacting with a robot where they had the opportunity to realize how complex the interaction with the robotic platform can be, in contrast to the patients in the control group who had limited knowledge of the system and its functionality, it is difficult to understand the complexity of the use of the platform.

- **The (PU) construct** showed a higher positive percentage in the intervention group than in the control group; although control patients perceive a high degree of utility, it can be evidenced that after the interaction, this expectation is overcome. This is because patients who had the opportunity to interact with the robot throughout the rehabilitation process expressed motivation and encouragement to perform better.
- **The (U) construct** was mainly focused on patients' perception of the system and its functionality (e.g., robot interventions, adaptability, manipulation, among others.). In this case, the same pattern as the previous categories was found. The intervention group attributes more usefulness to the system than the control group [47].

These results reflect the positive impact that the platform provided and the potential that it might have in future cardiac therapies. In general, the results of the utilitarian factor suggested the perception of the robot is better qualified for the group who interact with the robot more times as they are familiarized with it [14].

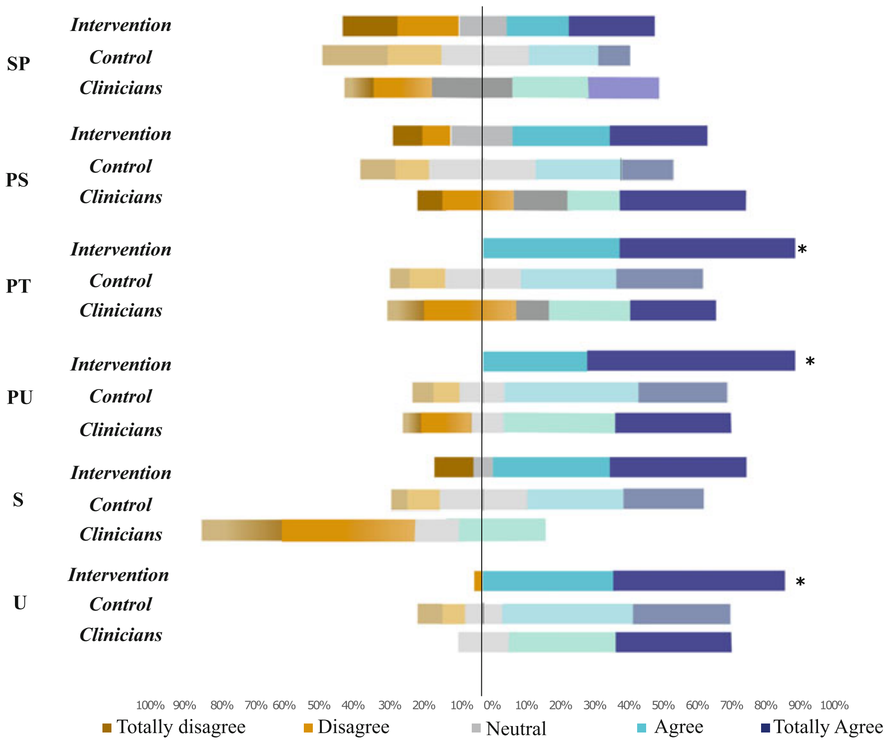

Fig. 14.4 Likert scale distribution for (SP), (PS), (PT), (PU), (S), and (U) construct of the acceptance and perception questionnaire applied to patients (i.e., control and intervention) and clinicians. (*) Statistically significant differences between patient groups

For the clinician group, the UTAUT results (see Fig.14.4) showed positive opinions regarding (U/A), (U), (PU), (PT), and (PS) categories, which means that clinicians think that the robot and the parameters measured are helpful and reliable in cardiac rehabilitation sessions [47]. The results reported:

- **The (S) construct** was scored negative; however, the research stated that it is due to the question formulation and that the results regarding this construct were positive as the clinicians did not consider the robot a risk for the patients.
- **The (SP) perception** showed a neutral response in general; this can be due to the robot's perception as a social agent before the focus group was performed. In this case, the responses related to this construct showed that clinicians think that the robot could not have social skills as the humans (e.g., emotion and living creature) due the robot is perceived like an object [47].

One of the essential aspects of these results was the clinician perception change, i.e., some clinicians perceived incorporating a social robot as a thread, as they regard the robot as a potential replacement. However, after the technology explication, the system's demonstrations and its objectives (e.g., the researchers emphasize that the robot must be considered as a tool that can improve its efficiency during therapy), the clinician's system perception turned into a positive one, where they showed interest and provided suggestions for the system improvements.

Summarizing, Casas et al. [47] demonstrated how the participants (patients and clinicians) present a lower expectation of the robot's usefulness, sociability, safety, and data reliability concerns before interacting with the SAR. However, after the technology explanation or after a considerable interaction time with the robotic platform, this expectation is overcome. Although there is a bias when people consider using this kind of technology, once they can become familiar with the social robot and interact for an adequate period, their attitudes and perception towards the SAR become more positive. The use of this interface has shown that patients felt more encouraged to perform physical activity and continue with the rehabilitation when they perceived that monitored and supervised by the system, demonstrating that it can be implemented as a reliable tool that would potentially leverage tasks carried out by health professionals [15].

14.6 Chapter Conclusions

Acceptance, perception, and the overall opinions of clinicians and patients can change how effectively a new device can be used in a clinical setting. Those concepts cover a series of different parameters for the community, like the ease of use, the time it adds to the therapy, and the physical and emotional comfort for the patient. Several techniques can be used to analyze these opinions and to quantify this qualitative information. Those techniques, like questionnaires, interviews, and focus groups, can be used before or during the design of the application, before or during the implementation of the device, or after for a post-treatment assessment.

The time of use of these techniques can give different information: the knowledge of the device before its application, the adaptability to its use, the challenges and improvement possibilities, among others. Finally, the case studies presented in this chapter show the overall positive perception of clinical staff and patients using robotics in the clinical process. It also showed some fears and challenges and how this can be overcome with the appropriate information about the application. This highlights the importance of the use of these techniques and the new opportunities for robotics in rehabilitation and clinical programs.

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