



Received: 07 November 2018
Accepted: 08 February 2019
First Published: 13 May 2019

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PHYSIOLOGY & REHABILITATION | RESEARCH ARTICLE

The perspective of rehabilitation health care professionals regarding the clinical utility of a body-environment proximity measurement device

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Abstract: Measuring the proximity of the body to the environment has the potential to provide rehabilitation health care professionals (RHCP) new, additional information to assess mobility. The aims of this study were to explore the opinions and needs of professionals to use a new device to measure such proximity, and to determine potential barriers and facilitators to implement it within the clinical setting. Four focus groups were conducted with 23 RHCP. The concept of a proximity measurement device in the early stages of development was introduced. A qualitative content analysis using a model of clinical utility as guidance for coding of the transcribed texts was used. Many potential uses were raised including: improving patient safety, motor learning, independence in tasks as gait, transfers and reaching tasks, saving time during assessment, improving follow-up with the client, data precision and objectivity to assess tasks. Barriers were related to still unclear relevance, effectiveness, the added

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This work was realized by an interdisciplinary team composed of experts in human locomotor control (B.J. McFadyen, K. Zabjek) interested in the development of clinical tools for the evaluation of mobility, health care professionals specialized in knowledge translation and best practice implementation in a clinic (M-E Lamontagne, E.L. Inness, G.Sirois), and a researcher (G. Edwards) who developed an expertise in designing and adapting new technologies for health applications. Emerging evidence has revealed that body-environment proximity is a key indicator of impaired mobility. However, it requires sophisticated equipment and expert interpretation to use it in the clinic. The manuscript focuses on understanding Therapist's perspectives of the clinical utility of a "Body-Environment Proximity Sensor System" which could provide additional information to assess mobility required for daily living. This is an important step to guide the prototype development of a new device and translate fundamental research into the development of a clinical tool.

PUBLIC INTEREST STATEMENT

The safe performance of daily activities requires a good control and adaptation of the body to environmental constraints, such as successful clearance when stepping over the obstacle. For people with acquired brain injury, this represented a substantial challenge. Presently, the clinical community has limited access to tools that will provide a measure of body-environment proximity. The present study is focused on understanding the needs and opinions of rehabilitation health care professionals (RHCP) to utilise a body-environment proximity measurement device and to determine barriers and facilitators to their clinical implementation. A focus group with RHCP was conducted and found that there was interest in such a measurement. In parallel, there is an interest to utilise this tool during interventions within a clinical setting, and to support autonomous function at home or in the community. The findings revealed the need to further include the RHCP within the design and development of clinical technologies.

value of such a device, and time required for use. The development of a turnkey device with support to facilitate its implementation was seen to be positive. These focus groups provided important information to further identify potential uses of such a device and to help to decrease barriers to its implementation.

Subjects: Biosensors; Assistive Technology; Physiotherapy

Keywords: proximity sensor focus group mobility technology development

1. Introduction

Mobility is the ability to move independently and safely from one point to another, and represents a fundamental part of daily living. It is a key element to the quality of life, social participation and maintaining independence (Patla & Shumway-Cook, 1999; Williams & Willmott, 2012). A rehabilitation health care professional's (rehabilitation professional or RHCP) capacity to assess key aspects of mobility is crucial to early diagnosis of impairments, the choice of appropriate interventions, and the evaluation of a patients' ability to re-integrate within the community and home. With evolving technology, there has been increasing interest and effort devoted to providing access to objective, efficient and reliable physical measures of mobility within clinical settings (Muro-de-la-Herran, García-Zapirain, & Méndez-Zorrilla, 2014; Shull, Jirattigalachote, Hunt, Cutkosky, & Delp, 2014). However, while mobility also includes the ability to modify and adapt gait to environmental constraints, such as obstacles, clinical measures usually focus on the individual with little consideration of their interaction with the environment (Huxham, Goldie, & Patla, 2001; Pardasaney et al., 2013).

Safe mobility is influenced by the way we process information from our environment and physically interact with it. Thus, the proximity of the body or its parts to the environment plays a key role in safe mobility, whether it is the whole body for circumventing obstacles (Vallis & McFadyen, 2003), or the foot trajectory to step over obstacles (Heijnen, Muir, & Rietdyk, 2012) or clear the ground (Lai, Taylor, & Begg, 2012). Furthermore, emerging evidence has revealed that such measures of body-environment proximity are key indicators of impaired mobility. For example, greater variability in minimum foot clearance is observed during gait in older fallers (Barrett et al., 2010), while this clearance is reduced in people with early Parkinson's disease, specifically when coupled with simultaneous cognitive tasks (Alcock, Galna, Lord, & Rochester, 2016). Also, people with stroke who fail an obstacle crossing task have a higher incidence of falls (Said, Galea, & Lythgo, 2013). In terms of dual-tasking, greater caution as revealed by higher obstacle clearance and slower gait is linked with cognitive impairment related to planning ability and visuospatial processing after traumatic brain injury (Cantin et al., 2007; Vallée et al., 2006), and attention in balance-impaired adults (Siu, Lugade, Chou, van Donkelaar, & Woollacott, 2008). Measures of body-environment proximity would thus have the potential to provide RHCPs with additional information to assess mobility required in daily living.

To date, measures of body-environment proximity require sophisticated equipment, technical support for data collection and expert interpretation making it difficult for RHCPs to use it in daily practice. However, with the progress in technology, new devices are being explored by different research teams to measure foot clearance over the ground with inertial (Santhiranayagam, Lai, Sparrow, & Begg, 2015), ultrasonic (Qi, Soh, Gunawan, & Low, 2015), or optical sensors (Kerr, Rafferty, Dall, Smit, & Barrie, 2010). Such instruments have the potential to provide body-environment proximity measurements within clinical and natural settings. However, such measurements are mainly focused on the height of the foot over the floor, and do not consider specific environmental constraints such as steps or obstacles or even proximity to walking aids (walker). The development of a device which could be used by RHCPs to measure both whole body and segmental proximity within complex environments

have the potential to enhance rehabilitation and represent an important step in further clinical measurement. However, it is crucial to first have the RHCPs' perspectives to better develop technology that is useful within the clinical setting.

As shown in Smart's analysis (Smart, 2006), previous work that has studied clinical utility has only considered clinical effectiveness and cost-effectiveness to introduce a new technology or technique in clinical practice. However, there are a broad variety of different facilitators and barriers that influence clinical uptake of new technology as well as the evolving health care setting. Professionals' needs and motivations, as well as the clinical context, influence their decision to use and adopt a new device (Liu et al., 2015). Factors related to how appropriate, accessible, practical and acceptable a device is, need to be considered (Smart, 2006). Thus, further research is required to evaluate the interaction between the user, possible tasks, the related environment and the device itself in relation to RHCPs' needs, in order to develop appropriate technology and improve its implementation within the clinical setting (Yen & Bakken, 2012). To date, no one to our knowledge has considered the RHCPs' perspective concerning the clinical utility of a device to measure body-environment proximity. Thus, the aims of this study were to explore the needs and opinions of RHCPs to use a body-environment proximity measurement device, and to determine the barriers and facilitators that may influence the implementation of such a device in the clinical setting.

2. Method

A qualitative method using focus groups was used to foster interactions between different RHCPs for a collaborative exploration of their perceptions regarding the use of a device to measure body-environment proximity. The current study was approved by the ethics committees of the integrated health care and social service of the national capital (CIUSSS-CN) in Quebec and of the University Health Network (UHN-TRI) in Toronto, Ontario. All participants provided informed written consent.

2.1. Participants

Four focus groups were conducted with RHCPs recruited from two rehabilitation settings in Toronto and Quebec City (Canada). Participants were included in this study if they were physical therapists, occupational therapists, physiatrists or residents in physical medicine and rehabilitation who were currently working in the physical assessment or treatment of individuals with musculoskeletal disorders, stroke, acquired brain injury, multiple sclerosis, amputation or spinal cord injury. They must also have had more than 2 years of experiences in physical rehabilitation. Four focus groups were conducted within the two rehabilitation settings. To facilitate meaningful discussion and to ensure the opportunity for each participant to contribute, a maximum of 10 participants were recruited for each focus group (Krueger & Casey, 2000). A purposive sampling technique was used to gain information from participants with a diversity of experiences in the area of interest (Wright & McKeever, 2000).

2.2. Procedure

An experienced facilitator, independent from the study investigators, moderated all four focus group sessions. For each focus group, the same discussion guide with open-ended questions was used to structure discussion (Table 1). Focus groups in Quebec City were carried out in French while those in Toronto were carried out in English. A member of the research team from each city was present at the respective focus group sessions. Their role was to present an overview of proximity sensor technology and to answer potential technical questions during the discussion. The presentation of the device was the same for all four groups. The device overview was presented in a way not to suggest detailed possible applications. During the first discussion within the group, the main ideas addressed by the RHCPs relative to the potential applications were written on a board visible to all participants. Similar ideas were then grouped together, and participants prioritized them by voting for the top two areas of clinical application which they felt were most meaningful to practice. The focus group ended with a discussion about barriers and facilitators. All discussions stopped when professionals had nothing more to add and were satisfied. Each focus group lasted approximately 2 hours and all discussions were recorded.

Table 1. Focus group outline

<p>1. Warm up:</p> <ul style="list-style-type: none">• To introduce each participant<ul style="list-style-type: none">○ <i>Question:</i> Introduce yourself, share with the group your clinical practice setting and describe your role within this practice setting.• To review of the study aims and explanation of the session procedure
<hr/> <p>2. Discussion 1:</p> <ul style="list-style-type: none">• To consider clinical importance of body-environment measurement within clinical practice.<ul style="list-style-type: none">○ <i>Question:</i> In what situation would information about an individual's proximity to their environment be clinically useful information? Do you think it is useful, if yes, why, and in which situation?
<hr/> <p>3. Presentation:</p> <ul style="list-style-type: none">• Overview of global functioning of the body-environment proximity technology. Time for any questions specific to the technology.
<hr/> <p>4. Discussion 2:</p> <ul style="list-style-type: none">• To consider the potential application of the technology to specific clinical problems.<ul style="list-style-type: none">○ <i>Questions:</i><ul style="list-style-type: none">○ What is your initial impression about this technology?○ How could you see this type of measurement technology being used in clinical practice? (<i>why? how? with whom? where?</i>)
<hr/> <p>5. Prioritizing exercise:</p> <ul style="list-style-type: none">• To focus next discussion on the most clinically meaningful use<ul style="list-style-type: none">○ <i>Instruction:</i> Reflecting on all the ideas that have been discussed, place your post-it notes beside the top 2 areas of clinical application that you feel would be most meaningful to practice.
<hr/> <p>6. Discussion 3:</p> <ul style="list-style-type: none">• To determine facilitators/barriers for future development of the technology specific to the most clinically meaningful use.<ul style="list-style-type: none">○ <i>Questions:</i><ul style="list-style-type: none">○ What would facilitate its uptake in clinical practice? (<i>In terms of technology, environment, individuals involved and implementation strategy.</i>)○ What would be a barrier to uptake? (<i>in terms of technology, environment, individuals involved and implementation strategy.</i>)

2.3. Data analysis

The focus groups were transcribed verbatim. All transcripts were anonymized and did not permit a link between the profile of the individual RHCP and their points raised in the focus group. However, the context of use was indicated by each clinician as well as the specific needs for the type of facility or targeted client. All transcripts were verified by the first author. Then, a qualitative content analysis with a directed approach (Hsieh & Shannon, 2005) was carried out using the multi-dimensional model of clinical utility developed by Smart (Smart, 2006) as guidance for initial coding of the transcribed texts. This analysis framework highlighted four components of the model of clinical utility that would influence RHCPs' judgement regarding the clinical utility of a device and their decisions to change their practice. The first component was the *appropriateness* of a device related to its effectiveness in relation to existing practice and consideration of its impact or disruption on treatment or work. The second component was the *accessibility* of the device in relation to economic considerations and practical issues of procurement. The third component was the *practicability* which establishes the link between the device, RHCPs' needs and their skills and capabilities. The last component was the *acceptability* of the device by stakeholders, which refers to moral, social, psychological and ethical concerns that may affect treatment, or preference about a device. An experienced research assistant and the first author read all the transcripts and initially independently coded the same one-third of the transcripts to check for differences and disagreements. Upon agreeing on a final coding procedure, the remaining transcripts were equally

assigned between them to finalize coding. The results were interpreted through discussions among all authors, which included a PhD student (also an occupational therapist), a physical therapist, a physiatrist, and three researchers with combined expertise in mobility, locomotor adaptation, technological development and interface design for health applications.

3. Results

3.1. Description of participants

A total of 23 rehabilitation health care professionals were recruited across the four sites. The number of participants varied from 3 to 8 in each of the four focus groups. Figure 1 provides demographic information including professional experience and experience with technology. Participants were predominantly female and either physical therapists or occupational therapists with more than five years of clinical experience who mostly worked in a rehabilitation hospital and had experience with technology for clinical practice or research.

3.2. Focus group results

Across the focus groups, several goals for a potential clinical application were raised. These applications covered three main areas for the use of a body-environment proximity measurement device: clinical assessment; rehabilitation intervention during formal therapy; and autonomous use by clients in day-to-day life (in a rehabilitation hospital or a client's home). Barriers and facilitators raised by RHCPs relative to the device's implementation depended on the different constraints associated with the task, the environment (e.g. rehabilitation hospital or clients' home), and the user (e.g. clinicians or clients with specific needs or who use the device by him/herself). Table 2 summarizes the potential uses raised by clinicians, with perceived benefit or limits depending on the context of use. Each of these potential uses within the context of the elements of the clinical utility model proposed by Smart (Smart, 2006) are detailed below.

3.2.1. Appropriateness

In the context of clinical assessment, potential uses raised by RHCP were to evaluate gait, posture, transfers, and balance or for upper limb assessment. These uses included the assessment of coordination, fluidity, precision and quality of movement. Main needs raised by RHCPs were to save time during both the evaluation and the interpretation of results. Specifically, a need to compare patients to normalized values was noted, and to have functional interpretations of body-environment proximity

Figure 1. Characteristics of participants and clinical services used.

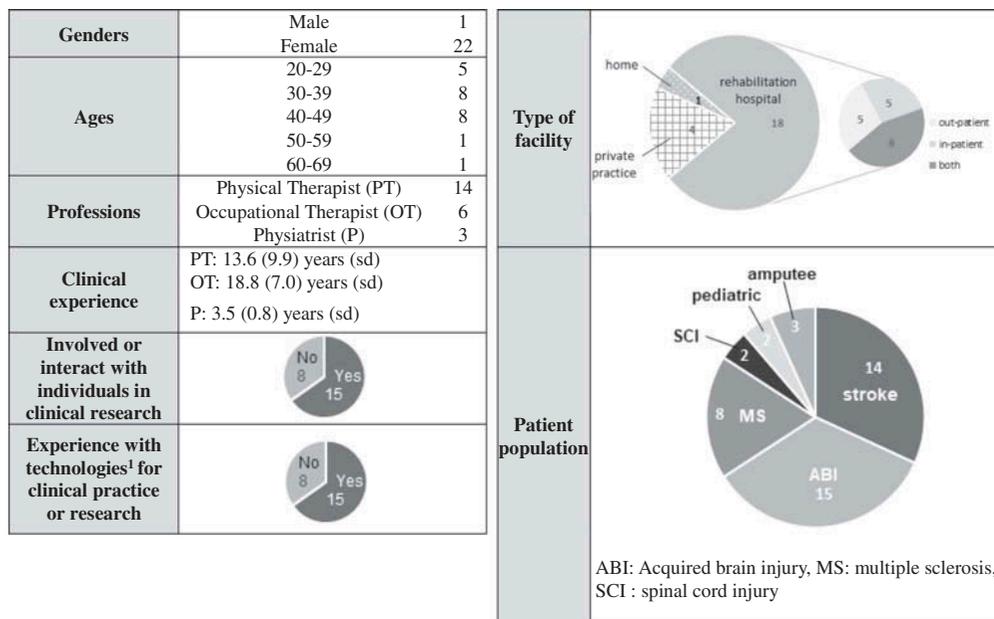


Table 2. Potential uses raised by clinicians with perceived benefits and limits

	Potential use	Perceived benefit	Perceived limits
Clinical assesment	Assess: <ul style="list-style-type: none"> • Gait • Posture, balance, pelvic obliquity • Risk of falls • Upper limb (coordination, fluidity, precision, quality movement) • Climb of stair • Transfers 	<ul style="list-style-type: none"> • Save time (during evaluation and interpretation) • Improve follow-up • Improve data precision and objectivity • Optimize evaluation (e.g. star excursion). 	<ul style="list-style-type: none"> • Added value overcurrent devices • Lack of perceived relevance or functional interest of the measure • No standardized data • Difficulty to assess compensating movements • Waste of time (installation)
Rehabilitation intervention	Give feedback during: <ul style="list-style-type: none"> • Transfers/stand up • Gait • Climb of stair • Use of prosthesis (upper/lower limb) • Handling 	<ul style="list-style-type: none"> • Improve motor learning • Help client to feel more independent • Make more sense for client • Reassure client • Give objective data of progress to RHCP and client 	<ul style="list-style-type: none"> • Redundant with verbal feedback of therapists • Waste of time (installation) • Limited measure (e.g. no angle nor centre of mass)
Autonomous use in day to day life	<ul style="list-style-type: none"> • Same that during rehabilitation intervention but during client day to day life. • Safe utilisation of wheelchair and walker • Safe mobility • Improve motivation during autonomous exercises (e.g. reaching). 	<ul style="list-style-type: none"> • Improve motor learning • Improve patient safety • Enhance learning experiences • Correct bad habits • Follow up outside of session 	<ul style="list-style-type: none"> • Capacity to detect relevant element • Battery lifetime • Client acceptance • Relevance for stroke with a patient with hemineglect or elderly

measurement to help them to understand the client’s impairment and its impact on daily life to guide therapy. Secondary needs were to improve the follow-up of the client as well as enhance data precision and objectivity. Some professionals thought that this technology could improve current clinical tests such as the Star Excursion (Gribble, Hertel, & Plisky, 2012), the Hop Test (Reid, Birmingham, Stratford, Alcock, & Giffin, 2007) and the Triple Hop Test (Bley et al., 2014) by saving time to measure, interpret, store and monitor one’s progression. These tests are already used by therapists with patients with musculoskeletal disorders and are based on repeated measures of the position of the patients’ foot during various tasks.

Some RHCP referred to direct measures of angles, centre of mass, or the position of one segment relative to another, which are currently used within the clinic, but without consideration of the proximity to the environment. Rehabilitation professionals explained that a body-environment measurement is not presently in use in clinical assessment. One barrier perceived by some RHCPs was the lack of added value of a new device relative to some actual interventions such as joint angle measurements for gait assessments. As one RHCP explained: *“I’m evaluating the gait pattern, but there are already programs where we can measure angles and I wonder what more this could bring to me”*. In this context of use, noted barriers for implementation of a body-environment proximity measures by some RHCPs were a lack of information and perceived relevance about the clinical significance and interpretation of the measure. For example, one RHCP noted that *“if the patient improved by 1 or 2 cm [over an obstacle], that doesn’t interest me. I want to know if he is autonomous”*.

Examples of potential functional interpretation that were stated as relevant were the assessment of the risk of falls during reaching or gait. In this way, some rehabilitation professionals thought the body-environment proximity device could evaluate and define boundaries for safe movement. For example, it could be possible to evaluate the maximum safe distance to reach an object, or the distance needed to stand up, and then use it during rehabilitation for training. One rehabilitation professional explained that it could be used “as *transfer training*. A cue [of proximity] would be *how far you need to bend forward in order to stand*”.

During rehabilitation intervention, the main goal of a body-environment proximity device would be to give feedback which informs the patient about the position of their limbs with regards to the environment in order to improve motor learning, provide reassurance, or help one feel more independent. Potential-specific applications identified included improving gait, reaching, body alignment and balance, or to walk up or down the stairs.

RHCPs talked about feedback to monitor different distances between body parts or with the environment. The distance between lower limbs was noted to improve the locomotor pattern of patients with a prosthesis or brain injury. As explained by one rehabilitation professional, “...you see a video of the limb with a picture which shows you that the limb isn't in a good position...it's visual...I find that says something clinically...”. Another distance of interest was between the upper limbs and an object which could help patients with a prosthesis to manipulate objects. As one rehabilitation professional explained, “my patient always wonders where his prosthetic hand is”. In addition, distances between the body centre or trunk and some environmental reference point to guide bending over and avoid overreaching or improve posture during the transfer from a seat or wheelchair was also noted. The distance between the trunk and an object, or between the trunk and the body to improve posture during manual handling was raised. Finally, the distance between lower limbs and stairs was noted as providing a possible way to reassure elderly people and reduce tripping and falls risks.

Regarding the use for rehabilitation intervention, for some rehabilitation professionals, a barrier for the implementation of a proximity measurement device was the lack of perceived added value compared to current practice, such as verbal feedback to guide a patient. On the other hand, some rehabilitation professionals indicated that validation of a new protocol with an explanation of its relevance would facilitate implementation.

There was a general consensus around the possibility of using the body-environment proximity measurement device in the day-to-day lives of patients to supplement therapy while outside of formal rehabilitation sessions, both within a rehabilitation hospital or at home. One main need linked to a potential use outlined for rehabilitation intervention was to provide earlier or more intensive training to improve autonomy and motor learning, and to correct for bad habits. Another main need noted for such an autonomous use was to provide feedback to improve patient safety. Indeed, rehabilitation professionals talked about prevalent and dangerous situations they observe but cannot control outside of therapy. For example, patients with hemineglect can injure their arms in the wheels of their wheelchair, collide with walls or obstacles, or walk too close to the street. One rehabilitation professional said as an example “you see all the time someone's hemiparetic arm is just hanging off their wheelchair or it gets caught in doorways”. Other situations concerned elderly persons, patients with amputation or brain injury who can fall when they walk too far away from their walker, get up from a chair or rollator with their feet incorrectly positioned, sit down on a chair or rollator from an unsafe distance, overreach to catch an object, or walk upstairs with their feet incorrectly positioned. The body-environment proximity measurement device was discussed as potentially providing a cue to alert the patient to increase or decrease the distance between their body and the object to avoid a dangerous situation. As explained by one rehabilitation professional, “we could put a sensor on the chair and when it rings, it means the patient can stand up because his foot is correctly positioned”.

There were mixed opinions, however, about the potential effectiveness of such a device for autonomous use. Main barriers identified were specific to patient capacity to use the device independently. For example, for patients with hemineglect or cognitive impairment due to dementia or in brain injuries, lack of awareness of their impairment was raised as an important barrier for the effectiveness of the device. Some of the rehabilitation professionals believed that patients with hemineglect may not be able to respond to the feedback provided by the device. For example, one rehabilitation professional wondered: *“Do they have enough awareness to change their posture? [...] I feel sort of negative about it”*. However, other rehabilitation professionals thought that it could be beneficial for patients’ security: *“Even if it doesn’t change their behaviour, it could give them enough time to process the fact that they’re getting too close to a wall and stop. It doesn’t mean that they’re just going to fix their inattention or neglect, but there might be less accidents”*. Furthermore, rehabilitation professionals thought it would not be helpful because some individuals, mainly elderly patients, will still take risks. For example, it was noted that *“Instead of asking someone to bring the walker, they stand up and then they risk falling”*. However, others were more positive: *“I think there are a lot of people for whom the device would be appropriate”*.

3.2.2. Accessibility

For all noted uses, the cost to the patient or rehabilitation institute was raised as an important potential barrier. Even if the sensors are low-cost, the need for accessory devices such as tablets, could also be a barrier. Rehabilitation professionals noted that accessories such as tablets are not necessarily available in the clinic: *“Ideally, it would all be done like through tablets, but the reality it is that we don’t have that technology here for us to use”*. Moreover, several tablets would need to be available in order to be accessible by more than one rehabilitation professional, which increases the cost barrier.

However, several facilitators were also noted. Evidence of improving patients’ security can override the cost barrier by justifying funding requests. In addition, a robust device, with easy replacement and maintenance, was judged as important for consideration during the development of such the device in order to facilitate its long-term use. Moreover, an application accessible via different devices, such as computers, phones and tablets, could be a facilitator to improve accessibility within a clinical department. Finally, the possibility to share data with other rehabilitation professionals, respecting patients’ confidentiality, was also a characteristic suggested by many rehabilitation professionals to facilitate the use of a body-proximity measurement device.

3.2.3. Practicability

Rehabilitation professionals explained that several technical characteristics need to be considered to implement such devices for all uses. Issues raised were related to the overall ability to be a turn-key, user-friendly device, with easy instructions and requiring brief training. It was also noted that it should be easy and quick to install. The physical characteristics that would facilitate this ease of use included the weight of the device (light), portability (wireless) and sustainability with a long battery life and quickly rechargeable. In addition, such a device was expected to be hygienic, easy to clean, secure, without interference with another medical device, durable and even waterproof (depending on the environment of use).

In terms of identified barriers to practicability, some rehabilitation professionals explained that modifying practice could, in its own right, also be a barrier. Thus, for all potential uses, training of RHCPs must be included in the implementation phase of the device within the clinic to facilitate its use. Indeed, as one rehabilitation professional explained: *“even for the best device, training the therapist is key.”* This training must be coupled with standardized procedures carried out across the larger rehabilitation team so that peer influence will facilitate and encourage use. As one rehabilitation professional explained: *“Sometimes we attend an educational session, but when we come back to the department, we don’t use it. We need to do it together. We need standardized procedures. A structured support system may also improve implementation.”*

Technical characteristics of the device need to respect several constraints relative to its use. For uses during clinical assessment or rehabilitation intervention, constraints are mainly linked to organizational issues. Time constraints appear as one of the most important barriers in the clinical setting. As one rehabilitation professional noted: *“if I need more than 10 minutes to install it, it’s impossible for me to use it”*. In relation to this constraint, rehabilitation professionals highlighted important characteristics to facilitate the use of the device. The device must be easily and efficiently installed and removed by the therapist, reusable with several patient profiles, and the interface must not require too much technical knowledge or a technician to reprogram it every time. For clinical assessment, it must be easily and consistently positioned on the patient from one evaluation to another to avoid bias, and the results of the evaluation must be quickly available and clearly presented in graphic form with standardized data to allow comparison.

For autonomous use, constraints were mainly linked to the environment as well as the patient’s impairment. Indeed, the size and the complexity of the daily environment were raised as potential barriers to the application and use of such a device. Thus, rehabilitation professionals raised a concern about the sensitivity and discrimination ability of sensors to detect relevant elements for patients’ safety and provide appropriate feedback. For example, one rehabilitation professional explained that if *“It rings when something gets close to his arm, but it mustn’t be his thorax for example. [...] It mustn’t ring every time he goes into another room or passes through a door frame”*. Thus, to facilitate the use of the device, feedback must be task-specific and sufficiently context sensitive to improve the patient’s safety. In addition, cognitive, motor or perceptual impairments would have to be considered in the design of a proximity measurement device. More specifically, the device must be easy to install, to switch on and off (e.g. easily accessible on/off button) and to be removed by the patient alone, even those with motor impairments such as hemiplegia. The interface must also be tailored to patient-specific impairments to provide appropriate, and customizable real-time feedback (e.g. audio, visual, haptic), with intensity and detection thresholds easily adjusted by therapists in a therapy session. Furthermore, older populations may need more support to learn how to use a technical device.

3.2.4. Acceptability

In the context of clinical assessment or for rehabilitation intervention, opinions about acceptability varied. Despite potential uses given by rehabilitation professionals, some of them did not think they would use such a device in their current practice. The main factors that influenced this point of view were related to those previously detailed, namely the lack of perceived relevance, the lack of time to use it, and the perceived difficulty to use the device. To this point, one rehabilitation professional noted that *« I just feel like I have better tools in my toolbox right now that aren’t necessarily tech-related for what we’ve already talked about. [...] Like even just being there. [...] And the verbal cue”*. The level of technology also appears to be a factor which can increase the perceived difficulty to use the device and/or its acceptability. However, for uses which meet their needs and their constraints, some rehabilitation professionals were more open to using it: *“[if the device could help us to do the Star Excursion test more efficiently] I will use it”*.

Moreover, to improve the autonomous use of the device by patients outside of therapy, most rehabilitation professionals agreed about the need to train their patients to use it during a few sessions first. In contrast to other contexts of use, rehabilitation professionals noted that it would be important to pay attention to patients’ acceptability of the device, and their motivation to use it, if they are to use it outside the therapy session. Some rehabilitation professionals were sceptical about the level of use without the rehabilitation professional available. One rehabilitation professional noted that *“when it comes to us asking people to wear something on their body outside of therapy, that almost never works”*. More specifically, some rehabilitation professionals believed that older patients are not interested in new technology. However, other rehabilitation professionals were more optimistic. Technical characteristics of the device, such as aesthetics and level of gaming of the device, were considered as facilitators to improve patient motivation. Motivating options such as providing scores or even graphs

to indicate progression, and positive feedback such as pleasant or customizable music were suggested. Moreover, motivated caregivers were considered an important facilitator to improve acceptability, whereas lack of support outside the clinical session was considered as a barrier.

4. Discussion

This study explored RHCPs' opinions and perceived needs for a measure of body proximity in relation to the environment. It also determined potential barriers and facilitating factors to implement a body environment proximity measurement device into the clinical setting. While the body-environment proximity measurement device was originally designed with clinical assessment in mind, the present focus groups enlarged the perspective of potential uses. RHCPs expressed potential applications related to clinical assessment, rehabilitation interventions and promoting patients' autonomy outside of clinical therapy. The main needs cited for such a device were to improve patient safety and improve motor learning in different tasks to help them to be more independent given the possibility to provide feedback to the patient. In terms of clinical assessment, rehabilitation professionals' main needs were to save time, improve the clinical assessment, with functional interpretations of results. Secondary needs were to improve the follow-up of the client, enhance data precision and objectivity. Rehabilitation professionals also expressed potential barriers and facilitators to implement the device mainly related to the perceived appropriateness of this measurement, and on the practicability of the future device. These findings will be discussed in relation to the literature. This discussion is organized using the elements of the Smart model (Smart, 2006). Table 3 summarizes technical and human elements that need to be considered and evaluated during the future development of the device, linked to RHCPs comments and the literature. Due to the early stage of development of the device, future studies will be required to provide guidance on indications or contraindications for clinical.

4.1. Appropriateness

Some applications for this technology have been previously explored. For example, improvement in motion and function of the neglected hand have already been demonstrated during bimanual activities in daily living with movement detection bracelets and visual and acoustic alarms (Trejo-Gabriel-Galan et al., 2016). Moreover, researchers have demonstrated that visual feedback of the vertical position of the foot during treadmill gait can enable young healthy participants to increase minimum toe clearance which is a good predictor of tripping risk (Begg, Tirosh, van der Straaten & Sparrow, 2012). It has also been noted that this feedback can help to change foot trajectory and reduce tripping probability in older adults as well as for one patient with stroke (Begg et al., 2014). Additionally, visual and auditory feedback are helpful to improve virtual obstacle crossing during gait on a treadmill with healthy subjects (Wellner, Schaufelberger, Zitzewitz, & Riener, 2008). Therefore, there is great potential for further investigations of augmented feedback training or feedback about body-environment proximity in day-to-day life, as raised by the clinicians. However, even if rehabilitation professionals proposed many uses, the appropriateness of the device to measure proximity was debated. For clinical assessment, the functional interpretation of proximity measurement was not clear to all RHCPs. For rehabilitation intervention or assessment, most rehabilitation professionals believed that this device would be redundant with their existing intervention and questioned the added value of the device with respect to other assessments or their own verbal feedback during a session. Further research is required to further elucidate the potential of proximity measurement to inform clinical decision-making. With respect to more autonomous use, some rehabilitation professionals raised the concern that some patients, for example those with hemineglect, who might not respond to feedback or have enough awareness to change a dangerous behaviour.

What the present critique on appropriateness by the focus groups underline is that there is a need to provide evidence-based relevance of the specific proximity measurement and the impact that such a device could have on existing rehabilitation or patients' autonomy. This evidence could support rehabilitation professionals' understanding of the potential added-value of such a new device. However, it was found that physiotherapists preferred to use verbal feedback in practice (van Vliet & Wulf, 2006), even though devices exist which can optimise type and schedule of feedback to

Table 3. Technical and human aspects needed to be considered or evaluated during future development

Use	Technical aspects			Human/organizational aspects
	Sensors' characteristic	Interface's characteristic	General characteristic of the device	
All context	<ul style="list-style-type: none"> • Easy and quick to install and take off • Wireless • Light, small • Usable with different clients 	<ul style="list-style-type: none"> • Mobile interface • Downloadable application 	<ul style="list-style-type: none"> • Turnkey system • Resistant • Low-cost • Sanitary and easy to clean • Good autonomy of the battery • Easy rechargeable • Waterproof (depending on environment) • Possibility to save data and share data with other professionals • Respect of confidentiality 	<ul style="list-style-type: none"> • Good utilisability of the device (in relation to user constraints, task and environment.) • Provide and explain evidence-based relevance of the measure and the device to the clinician (e.g. knowledge translation intervention) • Train RHCP • Support RHCP after training (e.g. champion).
For assessment	<ul style="list-style-type: none"> • Accurate • Reliable 	<ul style="list-style-type: none"> • Large screen • Clients profile recorded • Standardized, normalized data • Quick results • Clear results: graphs, pictures. • Results with functional interpretation 	<ul style="list-style-type: none"> • Save time in regard to other tools • Bring more information than other tools 	
Autonomous use/ rehabilitation intervention	<ul style="list-style-type: none"> • Easy to install and take off even with motor or cognitive impairment, without the therapist • Detect relevant information 	<ul style="list-style-type: none"> • Feedback customizable (audio, visual, haptic, number, intensity, threshold sensitivity.) • Real-time feedback • Feedback appropriate for the task, not too confusing • Progress graph • On/off button easily accessible (for autonomous use) 	<ul style="list-style-type: none"> • User-friendly even with motor or cognitive impairment for (autonomous use) • Motivating (progress graph, playful, positive feedback.) • Stylised, aesthetic 	<ul style="list-style-type: none"> • Good utilisability of the device for a patient with motor and/or cognitive impairment • Good acceptability of the device

enhance motor learning (Sigrist, Rauter, Riener, & Wolf, 2013). Thus, even if it is necessary to provide evidence-based relevance of a device, as seen above, it was not sufficient to change current practices. As shown by previous research, a lack of knowledge, or a poor performance expectancy perceived by therapists were barriers in the adoption of new devices or guidelines in clinical practice (Francke, Smit,

de Veer & Mistiaen, 2008; Hughes et al., 2014; Liu et al., 2015). Thus, as suggested by Levac et al. (2016), there is a need for better knowledge translation to decrease those barriers, with devices with proven usability (see the section below on practicability). In parallel, further research should focus on understanding the perceptions and needs of HCPs who intend to use the technology. This balanced approach has the potential to optimally integrate this technology into the clinical context.

Finally, time constraints are, as raised in this focus group study, a very important barrier to the implementation of any technology (Francke et al., 2008; Liu et al., 2015). Technical characteristics of the device must respect the constraints of the specific context to be at least as rapid to use as current tools (Cresswell & Sheikh, 2013), and to avoid disruptions to current practice.

4.2. Accessibility

The main component of accessibility raised by rehabilitation professionals was the cost of the device. The initial cost of a device often appears as a barrier to acquisition and implementation (Cresswell & Sheikh, 2013). No price of such a device was actually presented during the focus groups; however, the fact that a tablet may be necessary was seen as a cost constraint for some rehabilitation professionals. However, evidence to support that a new device increases the quality of care (as noted above with respect to facilitating appropriateness) and even decreases health care costs can have an influence over the impact of the initial cost of any device (Yarbrough & Smith, 2007). Thus, as also noted by some rehabilitation professionals, “low-cost” is relative in relation to the impact of the device on rehabilitation or patient security.

4.3. Practicability

Rehabilitation professionals cited different potential users, with the main user being either the rehabilitation professionals themselves (assessment or intervention) or the patient (autonomous use), and noted many technical characteristics deemed important in order to improve these uses. Those characteristics are consistent with the notion of usability defined by the International Organization for Standardization (ISO-9241-11) as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use”. Indeed, although knowledge and skills of rehabilitation professionals could be improved through research and knowledge translation, this alone does not guarantee a higher rate of use or intention to use a new technology if the device has a poorly perceived usability (Levac et al., 2016). Thus, during device development, rehabilitation professionals and patients should be included to assess the usability of the device and its interface for a given use. This evaluation must first take place in a laboratory, and then in a targeted environment, to gradually analyse the interaction between users’ constraints, the tasks and the environment (Yen & Bakken, 2012). As noted, by Cresswell and Sheikh (2013), the involvement of key stakeholders to test early prototypes can improve the use of the device. This evaluation of usability is crucial to develop a turnkey device and reduce implementation barriers.

Finally, as suggested in the focus groups, user training and support after training can facilitate the implementation of the proximity measuring device. As noted in other studies, organizational factors such as the presence of champion support or adjustment of workload during the introductory period of the technology can help to appropriately introduce a new device into a clinical setting and, thus, improve its use (Cresswell & Sheikh, 2013).

4.4. Acceptability

While there were few ethical, legal, social or psychological concerns raised about the effects of such a proximity measurement on practice, some rehabilitation professionals did wonder if the device would be accepted by patients and used in their absence. Some rehabilitation professionals expressed concern that older patients would not be interested in, or accept, new technology. While this common belief persists, many studies have demonstrated that this a misconception and that older adults do not reject all technologies. They adopt appropriate and easy to use technologies (Piper & Hollan, 2013), although sometimes it is in a slower and more selective way (Olson, O’Brien, Rogers, & Charness, 2011). Incongruity between the rehabilitation professionals’ perception of patient

acceptability of a new device, and the patients' real acceptability has been shown (Glegg et al., 2013). This underlines the fact that the involvement of patients', as suggested above, will also be important to assess their own acceptability during the development of the proximity measuring device.

According to both the Unified Theory of Acceptance and Use of Technology (Liu et al., 2015) and the Technology Adoption Model (Glegg et al., 2013), acceptance and use of technology are determined, respectively, by one's belief concerning how it will enhance performance and by perception of its usefulness and level of difficulty in using it. Thus, even if new technology itself may appear as a barrier to some rehabilitation professionals, the actual acceptability by therapists is not based on "new technology" per se, but influenced by their perceptions relative to the appropriateness and the practicability of the device as discussed above.

One key limitation of the current study is that these focus groups were confined to small groups of rehabilitation professionals and medical residents from North America only. However, including different governmental systems and cultures (French and English) provided some breadth in opinions. It should also be noted that these focus groups were based on the rehabilitation professionals' limited knowledge of the proposed proximity measurement device which was in a very early stage of development and is not yet available. However, within the early stage of development of a device, it is important to depict a wide variety of viewpoints, more representative of actual rehabilitation professionals' opinion. Thus, our focus groups provided several points for consideration during the development of the device. The clinician and client's profiles will be more deeply considered during the next phase of device development and evaluation. This helps verify if the device meets the requirement raised during the focus group for a given type of facility and a targeted client. Furthermore, rehabilitation professionals did not, in general, make a distinction between the device and the interface, aside from a few remarks about the interface as reported earlier, although this distinction will play a role in the development.

5. Conclusion

While the targeted proximity measurement device was originally designed for clinical assessment, the focus groups enlarged the perspective of potential uses including intervention and autonomous use. The needs and uses noted by rehabilitation professionals provided several potential ways to improve the proximity measurement device, thus increasing potential applications. The main comments by rehabilitation professionals highlighted the necessity to prove the appropriateness of the device, and to involve the user in the development and assessment of the device's effectiveness and usability within a given setting. The implication of the rehabilitation professionals in the development of the device offers the possibility to assess the evolution of its perceived relevance that is also a key factor to improve its implementation. Furthermore, an iterative involvement of rehabilitation professionals and patients to test future prototypes will be helpful to minimize barriers related to technology, human and organisational factors. The results obtained from these focus groups also have wider application to general development and implementation of technology in clinical practice.

Acknowledgements

The authors would like to thank Emilie Lacroix who moderated helped organize the focus groups, Véronique Gauthier who coded part of the results, and all rehabilitation health care professionals who participated in this study. We also thank the Institut de réadaptation de déficience physique de Québec and the Toronto-based University Health Network for allowing the participation of all rehabilitation professionals.

Funding

This work was supported by the Canadian Institute for Health Research and the Natural Sciences and Engineering Research Council of Canada [336687].

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Disclosure statement

The authors report no conflict of interest. This work was supported by combined funding of the Canadian Institutes of Health Research and the Natural Sciences and Engineering Research Council of Canada.

Citation information

Cite this article as: The perspective of rehabilitation health care professionals regarding the clinical utility of a body-environment proximity measurement device, Céline Faure, Elizabeth L. Inness, Marie-Eve Lamontagne, Geneviève Sirois, Geoffrey Edwards, Bradford J. McFadyen & Karl Zabjek, *Cogent Medicine* (2019), 6: 1605722.

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