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RESEARCH ARTICLE



"I think it was helpful but not as helpful as it could have been" - a qualitative study of the experiences and perspectives of using fitness apps among manual wheelchair users with spinal cord injury

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ABSTRACT

Purpose: To gain knowledge of the experiences and perceptions of using fitness apps by full-time wheelchair users with spinal cord injury (SCI) and to explore experiences and perceptions of using these apps in relation to barriers to and facilitators of physical activity (PA).

Materials and Methods: A qualitative design was employed. Semi-structured interviews were conducted with ten manual wheelchair users with SCI. Data were analysed using reflexive thematic analysis.

Results: Four themes were developed: 1) *App functionality and experience*, 2) *Enhancing motivation*, 3) *Precursors to engagement* and 4) *Knowledge gaps*. Experience and perception were strongly influenced by app design, particularly the presence or absence of features tailored for wheelchair users. Many apps incorporated the use of wearable or mountable sensors. Fitness apps were perceived to increase motivation, although, this had its limitations. Conversely, apps were reported to have limited influence on commonly reported barriers to PA. Furthermore, the data highlighted gaps in knowledge which created barriers to effective app use.

Conclusions: Fitness apps were perceived to increase motivation to engage in PA in manual wheelchair users with SCI. However, more needs to be done to further develop app features for wheelchair users with SCI and to address remaining barriers to engagement.

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KEYWORDS

Spinal cord injury; mHealth; physical activity; exercise; wheelchair

> IMPLICATIONS FOR REHABILITATION

- Fitness apps may provide additional motivation for manual wheelchair users with Spinal Cord Injury (SCI) to increase their levels of physical activity (PA).
- Fitness apps should be used in conjunction with other supports to enable these individuals to overcome additional barriers to PA.
- When recommending the use of fitness apps, health and fitness professionals need to consider the unique motivations of each client in order to select an app that best enhances their motivation.
- A collaborative approach needs to be taken by health and fitness professionals and individuals with SCI to create greater awareness of the benefits and limitations of apps and to advocate the need for more app features tailored for wheelchair users with SCI.

Introduction

Injury to the spinal cord can result in permanent paralysis and affect many systems of the body [1]. Damage to the cord at the level of the thoracic or lumbar spine can result in impaired movement of the lower limbs (paraplegia), while injury at the cervical spine can also impair movement to the upper limbs (tetraplegia) [2]. These impairments can create challenges in carrying out basic everyday tasks and many individuals with spinal cord injury (SCI) require the use of a wheelchair [3]. Unfortunately, these individuals are also at risk of developing secondary health complications such as reduced cardiovascular health, metabolic health and bone density [4–6]. Similarly, SCI often results in reduced resting metabolic rate and many individuals with SCI have difficulty maintaining a healthy weight [7]. Such complications have a significant impact on health economics [8] and can impact quality of life for these individuals [9].

Physical activity (PA) has been suggested as a means of reducing risk factors associated with secondary health conditions following SCI [10]. The findings of several recent systematic reviews [10,11], including meta-analytical data [12] suggest that for individuals with SCI, engagement in aerobic and resistance PA can improve waist circumference, insulin sensitivity, VO_{2peak} , muscle strength and overall risk of cardiovascular disease. Furthermore, PA has also been shown to improve mental health and life satisfaction amongst individuals with SCI [13–15]. However, it is often reported that many individuals with SCI do not achieve recommended levels of PA and experience unique barriers to engagement [16–20]. These include barriers relating to health, access to facilities and equipment, and psychological barriers such as feeling self-conscious or reduced self-efficacy [20–22].

There is a growing body of research focused on developing strategies to increase PA in individuals with SCI [23]. Nevertheless,

knowledge gaps remain in the current evidence base. For example, a large mixed-methods study ($n=347$) of individuals with SCI found that wheelchair users experienced different barriers to PA than those who were ambulant [24]. However, few studies have considered these populations separately when developing strategies to address barriers to PA [25]. Similarly, authors have argued that there is a need for greater use of technology to promote engagement in regular PA in individuals with SCI [26–28]. For example, a recent study by Gomes Costa et al. 2023 showed that exercise sessions provided *via* video conferencing software enabled wheelchair users with tetraplegia to meet and sustain recommended PA levels over a 7-month period [29]. Similarly, recent research has shown how mobile technology can be used to assess measures such as muscle strength in individuals with SCI, for the comfort of their own homes [30]. Furthermore, there has been a call for specific mobile health applications, which assists individuals to self-monitor their PA, set goals and provide instruction and education on how to engage in PA [26–28]. These technologies have been reported to increase accessibility of interventions and facilitate more sustained engagement in PA among wheelchair users [26,27,29].

Fitness applications, commonly known as “apps”, are an example of how technology can promote PA [31]. Fitness apps are programmes used *via* mobile phones or tablets which facilitate and encourage users to engage in PA. Some common features of fitness apps include provision of exercise programmes for users to follow, social platforms for viewing and sharing data on performed activity, while some apps can be used in combination with wearable devices such as heart rate monitors or motion detectors to provide real-time and recordable data relating to PA. Recent studies have reported positive results from the use of self-management apps specifically designed for individuals with SCI, which included features to help record PA [32–36]. Unfortunately, the apps used in these studies are still in their developmental stages and the majority of studies focused on apps which were introduced during inpatient rehabilitation [32,35,36]. Therefore, individuals with SCI living in the community are reliant on apps that are more readily available. However, the number of commercial fitness apps developed for wheelchair users, particularly wheelchair users with SCI, is limited [37,38].

Fitness apps may address some of the commonly reported barriers to PA, as they can be used at a time and location that conveniences the individual and are relatively cheap [39]. Furthermore, fitness apps often provide features designed to facilitate increased motivation and self-efficacy such as goal setting, feedback, reminders and the ability to share fitness data [39,40]. Therefore, fitness apps may be a valuable resource in improving the health and well-being of individuals with SCI. However, more research is needed to learn how fitness apps can assist individuals with SCI. Moreover, qualitative research would allow both academics and health professionals gain insight into the potential benefits and limitations of using fitness apps to address the barriers to and facilitators of PA for individuals with SCI. Therefore, this study aimed to use qualitative methods to answer the following research questions: 1) What are the experiences and perceptions of full-time wheelchair users with SCI of using fitness apps and 2) what are these individuals experiences and perceptions of fitness apps in the context their individual facilitators and barriers to PA?

Materials and methods

Design

A qualitative design was adopted using data collected from once-off, semi-structured interviews to generate themes [41]. This

method allows investigators to gain an in-depth understanding of the experiences and perspectives of patient populations [42]. The study was approved by the NRH Research Ethics Committee (NRH REC 2021_09_28) and EHS Research Ethics Committee at the University of Limerick (2021_09_11_EHS) and was reported in line with the COnsolidated criteria for REporting Qualitative research checklist (COREQ) [43].

Participants and recruitment

Purposive sampling was employed. To take part in the study individuals were required to be ≥ 18 year’s old, be able to speak fluent English, be living in the community, have a diagnosis of SCI and have at least one month’s experience of using a fitness app. This study defined a fitness app as “a programme that is used *via* a mobile phone or tablet to encourage or help people to engage in physical activity.” This definition included apps which function in combination with wearable technology such as heartrate monitors, motion detectors or smart watches. The study excluded individuals who were: 1) ambulant, 2) wheelchair users for reasons other than SCI or 3) unable to engage in PA due to co-morbidities such as severe cardiovascular or respiratory disease, severe arthritis or severe acute injury or illness.

Recruitment took place between January and April 2022. The study was advertised within the outpatient department of a large neurorehabilitation hospital, the National Rehabilitation Hospital (NRH), and *via* newsletters and social media of two national support groups, the Irish Wheelchair Association (IWA) and Spinal Injury Ireland (SII). Potential participants were encouraged to contact interviewer, CH, who provided further details and arranged a time and day for the interview. No gratuity was offered for participation. All participants who made contact were interviewed. Data analysis occurred simultaneously with the recruitment and interview process, therefore, recruitment continued until all investigators were in agreement that the data represented a rich collection of experiences and perspectives and that no further themes became evident. Thus, this sample achieved data saturation [44]. No participants dropped out or refused to allow their data be used for the study.

Data collection

Interviews were conducted using an online platform, Microsoft Teams (Version 1.5.00.5967). This method allowed participants to take part at a time, and in a location, that best suited them. It also eliminated costs and challenges associated with transport and potential risks posed by the Covid-19 pandemic. Participants had the choice to participate *via* telephone or video interview. Participants provided both written and verbal consent before commencing. Participants were informed that the interviews were being audio-recorded, how their data would be used and processed, and informed of their right to stop or withdraw from the study at any point.

An interview guide was used to introduce topics and provide open-ended questions to prompt in-depth conversation (see Appendix I). Participants were first asked about their own PA, followed by their experience and perceptions of the fitness apps which they had used. Participants were also asked to reflect on the barriers and facilitators that they had experienced when trying to engage in PA and then asked to consider if they experienced any similar or different barriers or facilitators when they used fitness apps. The guide was developed in line with evidenced based guidelines [45]. Questions were developed

following critical review of high quality qualitative studies relating to the barriers to and facilitators of PA among individuals with SCI (see [Appendix I](#)). Prompting questions about the features of apps were informed by recent studies systematic reviews of the efficacy and usability of fitness apps among the general public and individuals with disabilities (see [Appendix I](#)). The guide was further developed following piloting amongst a convenience sample of health and social care professionals, including one wheelchair user, working in the field of SCI. As the main investigators of this study were all female, researchers ensured that the guide was piloted amongst both males and females. Piloting was carried out by investigator, CH and was critically reviewed by all investigators.

Interviews lasted between 35 and 45 min and field notes were taken throughout. Participants were provided with opportunities to amend, clarify or elaborate on points made. Audio-recordings were transcribed verbatim. All interviews were conducted, and data transcribed by author, CH, a female physiotherapist and an MSc student working in the NRH, with 10 years' experience of working with individuals with neurological conditions. Participants were aware of this information early on in the recruitment process and that their data would be used for a Master's dissertation. Through her work in the NRH, some participants had known the interviewer prior to taking part, however, CH had never been directly involved in their treatment or care.

Data analysis

Data were analysed using a 6-phased approach for Reflexive Thematic Analysis (TA) [41,46]. Phase 1 involved reading and re-reading transcripts to gain an in-depth knowledge and sense of the data. Notes were taken documenting the investigator's initial thoughts and reflections. Codes were then generated separately by investigators CH and SH through open-coding using

an inductive, data-driven approach (Phase 2). This type of analysis is used in order to derive hypotheses from the data where little is known about a topic, therefore coding was not dictated by an agreed hypotheses or code book [39]. Coded data was then used to generate initial candidate themes (Phase 3), which were reviewed by both CH and SH and further reviewed and refined. Each theme was critically reviewed in the context of the whole data set, field notes and research questions (Phase 4). Mind Maps were employed to analyse and illustrate how candidate themes described the coded data and the relationships between themes [41]. [Figure 1](#) presents a map of the finalised themes and sub-themes. The fifth and sixth phases involved naming and defining these themes and writing the final report.

A critical-realist positionality was applied whereby investigators interpreted the data as being reflective of participants' true experiences, while acknowledging that their experiences and perspectives were also influenced by factors such as cultural, socio-economic, historical and political context [41]. An iterative approach was taken, whereby investigators (CH and SH) regularly reviewed and revised codes and themes to ensure that they appropriately captured the perceptions and experiences presented by the data. Coding was primarily conducted by CH using qualitative analysis software, NVivo (Version 12, QSR International Inc, MA, USA).

To optimise rigor, reference to the COREQ checklist was made throughout the study [43]. Codes and themes were reviewed and discussed between investigators CH and SH, a Senior Lecturer in Physiotherapy with experience of using these methods. In order to further maximise rigor, a reflexive diary was kept by CH during both the interview process and data analysis. The diary captured the interviewer's initial thoughts and reflections of the interview data and interactions with participants. It was also used to document CH's reflections on personal and professional experiences, opinions and biases. Investigators were able to use these

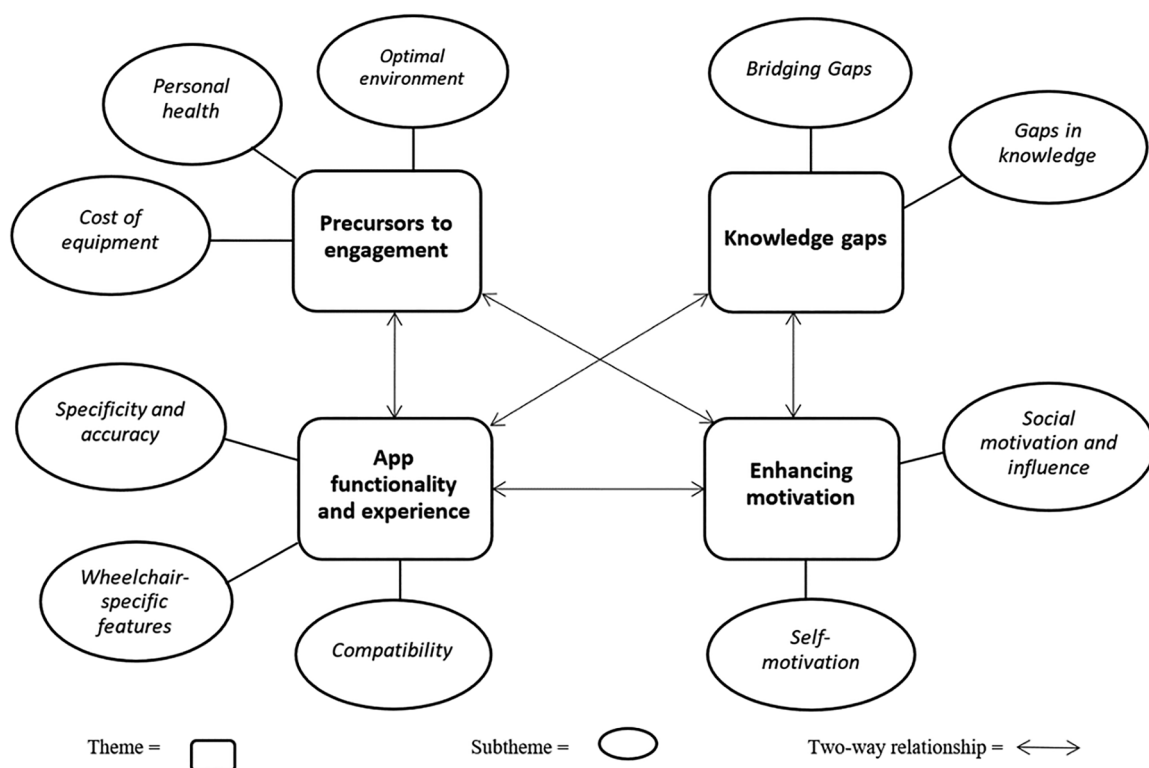


Figure 1. Map of finalised themes and subthemes.

Table 1. Demographic characteristics of participants.

Participant	Gender (Male/Female)	Time Since Injury	Level of Paralysis	Primarily manual chair or powerchair user	Apps used
1	Male	4 years	Tetraplegic	Manual	Apple Watch, Polar Beat, Wahoo, WHOOP
2	Male	3 years	Paraplegic	Manual	MapMyRun
3	Male	17 years	Tetraplegic	Manual	Apple Watch, MapMyRun, MyFitnessPal, Polar Beat
4	Male	20 years	Paraplegic	Manual	Apple Watch, MapMyRide, Strava
5	Male	30 years	Tetraplegic	Manual	Garmin Connect, Strava
6	Female	3 years	Tetraplegic	Manual	Apple Fitness, Fitbit
7	Female	26 years	Paraplegic	Manual	Apple Watch, Fitbit
8	Male	34 years	Tetraplegic	Manual	Apple Watch
9	Male	24 years	Tetraplegic	Manual	Apple Fitness, Strava
10	Male	16 years	Paraplegic	Manual	Garmin Connect, MyFitnessPal, Strava, Training Peaks, WHOOP, Zwift
Participant Age	Range: 27 – 48 years Mean Age: 36.4 years				

Table 2. Types of physical activities that participants engage in.

Participant	Activities Reported Engaging In
1	Gym, Handcycling, Home Workout, Pushing wheelchair outdoors
2	Gym, Home Workout, Pushing wheelchair outdoors, Wheelchair Basketball
3	Gym, Home Workout
4	Gym, Hand Cycling, Wheelchair Basketball, Wheelchair Racing
5	Home Workout, Wheelchair Racing, Wheelchair Rugby
6	Attends local Rehab Centre, Home Workout, Pushing wheelchair outdoors
7	Boxercise, Gym, Home Workout, Pushing wheelchair outdoors
8	Boccia, Home Workout, Wheelchair Rugby
9	Gym, Wheelchair Racing, Wheelchair Rugby
10	Hand Cycling, Home Workouts

reflections when finalising themes to ensure that the final themes provided a true representation of the data collected.

Results

Ten participants were interviewed. All 10 reported engaging in planned PA at least three times a week. All 10 participants reported that they were predominately manual wheelchair users, as opposed to powered mobility users. This included both home-based and community-based activities. Community-based PA included handcycling, wheelchair racing, wheelchair basketball, wheelchair rugby and attending local leisure facilities. Table 1 provides further details of demographic characteristics and Table 2 presents the physical activities that participants reported engaging in. Participants described using a variety of different apps, many of which combined the use of mobilise phones and mountable or wearable sensors. All eligible individuals who responded to the advertising campaign were interviewed.

Four themes were developed to capture participants' experiences and perceptions of fitness apps and how these relate to barriers to and facilitators of PA: 1) *App functionality and experience*, 2) *Enhancing motivation*, 3) *Precursors to engagement* and 4) *Knowledge gaps*. Subthemes were identified to provide more in-depth understanding of the meaning of each theme.

Theme 1: App functionality and experience

App usage and overall experience was dependent on app functionality. Three subthemes, *specificity and accuracy*, *compatibility* and *wheelchair-specific features*, describe how the features of app design influenced experience and perceptions.

Specificity and accuracy

The data revealed that, for all participants, a significant reason for choosing an app and overall perception of utility, was an app's ability to track specific measures that were meaningful to the participant. One participant expressed how being able to track her heartrate was particularly meaningful for her: "I definitely kept wearing it because I could keep an eye on my heart rate" (Participant 6). Whereas those who engaged in sports were drawn towards apps that provided sport-specific measures:

They display your speed, your time, average pace and a few bits of information that I needed. So that's why I kind of went with Garmin. (Participant 5)

Notability, all participants mentioned that being able to measure calorie expenditure was a significant reason for using an app. However, there was mixed opinions about how accurately the apps measured their calorie expenditure:

So for me, it really helps to be able to track a lot more accurately, you know, how many calories I've burnt and, you know, where I should be and that kind of stuff. (Participant 7)

So, if I was using the apps as a counting calorie, weight loss type of tool, I just don't think it gives you a realistic calorie burn for what I'm doing. (Participant 5)

In fact, participants' perception of how accurately an app could capture these measures was often highlighted as a reason for using, or ceasing to use, a particular app:

I played around with some apps. But uh, yeh, I think there was research done in, by somebody in [educational institute], whereby they trialed certain watches, eh, smartwatches and so on. And that the Apple Watch came out on top. It was the most accurate so that's why I use that for the gym and so on. (Participant 5)

In recent months I'm just less inclined to use it because I'm just not sure how accurate it is, you know? (Participant 2)

Compatibility

App usage and experience was also influenced by how compatible an app was with the equipment that they required for engaging in PA. For example, some ($n=5$) described how devices could be attached equipment such as hand cycles or sport chairs so that they could be used for sporting activities:

It's a bike tracker or one that you clip on a bike. It's the same on the race chair. (Participant 5)

Similarly, apps which required wearing a watch or band were reported to have limited usability, as it was seen as unfeasible to wear a watch or band for activities such as wheelchair racing,

which involves wearing gloves, and wheelchair rugby where the device could be damaged:

So, there are, uh, sort of barriers to using the app would be, if you had to wear a fitness band on your wrist or whatever. The sports I do, you need to wear gloves which cover your wrists anyway. So, you kind of take off your watch to, to glove up even if you had to wear one. (Participant 5)

But I don't know how easy that is because if you are pushing a rugby chair and you've got a watch on, it's very easy to damage that. There is nowhere to put a phone either. (Participant 9)

Wheelchair-specific features

All participants discussed the significance of features specially designed for wheelchair users. The inclusion of features such as measuring "pushes", or tailoring calorie expenditure for wheelchair users, was often reported as a reason for choosing a particular app:

Eh, just the feature on the Apple Watch is... I've looked around. It, like, it is the only smartwatch that does the calculation for a person who is pushing a wheelchair rather than walking. So that was, that was the biggest draw to an app that I have found as wheelchair user. (Participant 3)

Those who used apps which included such features ($n=7$) generally reported a positive experience. However, one participant questioned the accuracy of the features that he had used:

It doesn't take into account terrain and stuff like that... If you were jogging, like people aren't taking into account terrain or whatever, but terrain in a wheelchair is big difference. Eh, you know, path camber everything like that. So a lot of that isn't taken into account. So, I wonder how accurate it is, is the app when it says wheelchair use, you know? (Participant 2)

Nevertheless, all participants reported a scarcity of wheelchair-specific features and believed that these features would be significant for facilitating increased engagement in PA among wheelchair users:

Yeah, but obviously it would be great if there was...it would be a facilitator of, specifically for people, eh, who are in wheelchair situations, or like a lack of mobility situations. It would be a very useful tool for us all. (Participant 3)

Furthermore, wheelchair-specific features had an emotional impact on participants. The presence of these features created a sense of recognition and inclusion, whereas, a lack of wheelchair-specific features, or features targeted towards "able-bodied" individuals, such as notifications about step count, elicited a negative emotional response:

And, you know, just constantly being bombarded with the word 'steps', 'steps', 'steps', that could be very emotionally draining for someone that's still trying to come to terms with, you know, what's happened to them and how their life has changed. (Participant 7)

Theme 2: Enhancing motivation

Participants described how *self-motivation* and *social influence* were strong facilitators of PA. Participants discussed how fitness apps enhanced these sources and motivation, thus they reported that these apps facilitated increased engagement in PA. However, limitations were experienced in relation to enhancing social motivation.

Self-motivation

All participants described how a desire for self-improvement motivated them to engage in PA. For all participants, maintaining and

improving their health and weight were strong motivators which facilitated engagement. Many participants ($n=7$) were also motivated to improve their athletic performance. All participants described how using fitness apps to track their improvements further motivated them to increase their levels of PA. This perceived increase in PA was described in terms of increase in time spent engaging in PA, the intensity and/or the frequency in which activities were performed:

Seeing that I was improving helped and being able to see that I was doing more, or my heart rate was coming down and things like that helped. (Participant 6)

It kind of keeps me motivated. If I see my speed dipping, it kinda gets you to pick back up again. (Participant 5)

Similarly, participants reported that the apps helped to facilitate specific goals setting, which provided a focus for sessions and increased motivation:

So, what I do is, I look at my heart rate or my calories on the app. I would look at maybe what my average heart rate was, what my max heart rate was, and can I push beyond that? And that drives and motivates me. (Participant 1)

Social motivation and influence

For many participants, the influence of family, peers and role models both facilitated and motivated them to engage in PA. Similarly, social influence was frequently reported to be the main reason for using a particular app. Some participants used devices that were gifted to them ($n=3$), while others were influenced by fellow athletes or role models ($n=5$):

And I think the Strava aspect, a lot of the professional cyclists are on it, celebrities are on it. (Participant 10)

Similarly, participants used data from fitness apps to communicate with peers about PA. This was reported to increase engagement in PA and create a sense of comradery. For some, sharing fitness data was seen as a facilitator for engaging in PA as they viewed this as a way of inspiring others to increase their engagement. Similarly, for those motivated by competition, sharing and comparing data provided a means of facilitating this type of external motivation:

The wheelchair rugby ones at that time, because it was lockdown and I wasn't really doing much at the start, they did up a challenge to do 5k every day. So, in the end I was doing 10K, 12K. (Participant 9)

However, participants also remarked that the social motivation generated by fitness apps was limited. Although, many participants reported that they saw benefits in sharing fitness data, four participants did not share their data, while a further four only shared data with a limited number of individuals such as coaches or fellow athletes. Reasons for limiting data sharing included a sense that in-person interactions provided greater motivation, or that data was personal and no additional motivation could be facilitated by sharing this data with others ($n=4$):

When you asked me why I do it, I don't work out for anybody, I do it for me and I do it for my body. I don't do it to show off, "oh, I achieved this", or, "I've done that", or anything like that. (Participant 7 when asked why she doesn't share her fitness data)

Furthermore, half of participants described a scarcity of comparable data to compare their own data to. It was reported that differences in neurological impairment between individuals sharing data, differences in the type of routes and activities being recorded

and differences in equipment used to perform these activities, meant that data were often non-comparable. Thus, these participants believed that there was limited value in comparing fitness data:

As far as wheelchair-wise, there isn't too many other people to compare with, or to compete against. I suppose with the Strava one I know it's kind of, there are sectors you can compare with other guys on bikes in the same area and different things. Whereas the population, I suppose, isn't there. Like the routes I'm doing, I'm the only wheelchair doing them. So, there's no one else to compare with. (Participant 5)

Theme 3: Precursors to engagement

Although apps were perceived to enhance motivation, participants also discussed barriers to engaging in PA. Participants reported several barriers that limited engagement in PA which they believed could not be overcome by using apps. Furthermore, it was also highlighted that many of these barriers also limited their use of certain fitness apps. Therefore, participants discussed how these factors need to be considered before an individual with SCI tries using a fitness app. These factors, or *Precursors to Engagement* included *personal health*, *cost of equipment* and an *optimal environment*.

Personal health

All participants reported that health complications relating to their SCI could create barriers to engaging in PA. These include symptoms of pain, fatigue, spasticity and issues relating to the bladder and bowel. Participant 2 expressed that although using a fitness app encouraged him to push himself more when engaging in PA, when he was fatigued, he was unable to motivate himself to perform PA in the first instance:

And so it's hard sometimes to get the motivation when you're tired. Fatigue demotivates me, so put that down. And I do get fatigued quite easily.... (Participant 2)

More than half of participants mentioned how spasticity often limited their engagement in PA. Participants reported that unless these symptoms were well managed, using the fitness apps could not help them to overcome this barrier:

And spasticity can be huge too... as I drew the hammer curl up, the spasm hit me and nearly threw me out of the chair. And I got the attention of my coach and I just went, 'I'm done!', 'cause I was afraid. So, it didn't matter what app was there. (Participant 1 describing experiencing spasticity while in the gym)

Cost of equipment

Many participants described how certain apps could be used for activities such as handcycling or other adaptive sports. However, all participants acknowledge that the cost of exercise and sports equipment for wheelchair users can make these activities inaccessible. Therefore, the cost of equipment was not only perceived to be a barrier to engaging in certain physical activities. This was also perceived to be a barrier to using certain apps:

The cost of the equipment is, is astronomical. It's ridiculous! You know? That's the biggest barrier to entry, I think, is the cost of technology and equipment. (Participant 10)

Participant 7 articulated that, as many apps are designed to be used with specific exercise or sports equipment, unless individuals can afford the equipment, many apps become obsolete:

So, if you don't have access because of cost and finance to the equipment that the technology requires, that the fitness app requires, it's kind of a moot point. (Participant 7)

Optimal environment

The majority of participants reported requiring the assistance of another person to engage in many activities. Without this assistance, their ability to engage in PA was limited and the apps were of little use:

I need assistance being pushed off backwards, making sure that I'm in place and set up and then I can go... therefore when that is all set up, the apps become my best friend. If those boxes are ticked, the app comes into play. If those boxes aren't ticked, the app doesn't register for me. (Participant 1)

Similarly, factors such as bad weather, poor road conditions and inaccessible leisure facilities, were often highlighted as significant barriers to PA. Again, participants reported how they did not believe that the apps which they had used enabled them to overcome any of these barriers:

Probably not. Umm, it was more because of problems with accessibility and I don't think there was anything that the fitness app would have done. (Participant 6 speaking about why she did not attend her local gym)

Theme 4: Knowledge gaps

Participants portrayed a lack of knowledge amongst both individuals with SCI and professionals working in the fitness industry (*gaps in knowledge*). This created barriers to effective app use and engagement with fitness professionals. However, participants also suggested how apps could act as facilitators for gaining knowledge (*bridging gaps*).

Gaps in knowledge

Throughout the data, participants conveyed a lack of knowledge of the different apps and features available. Some participants ($n=5$) reported that this lack of knowledge may have limited their use of fitness apps and prevented them from capitalising on the potential benefits of these apps. However, almost all ($n=9$) described a desire to learn more about fitness apps and how these apps are being used by other wheelchair users:

But it's really learning more about the apps is the probably the biggest barrier for me. Just what they can do and not do and what I can get from them. (Participant 8)

Four participants discussed how data generated by apps designed for "able-bodied" individuals, often needed to be interpreted differently as a wheelchair user with SCI. These participants described how having a background knowledge of PA, and a knowledge of how SCI effects measures such as heart rate and calorie expenditure, allowed them to interpret app data more accurately. However, these participants believed that many individuals, particularly those new to living with a SCI, do not have the knowledge required to do this:

If I was a general, a wheelchair user with no fitness experience and [I was] looking at an app, eh, I'd be lost. It's only that I have a bit of fitness experience and fitness knowledge that I can navigate an app to suit my needs. (Participant 3)

Similarly, participants ($n=4$) reported that professionals, such as personal fitness trainers, can lack the appropriate knowledge of how to use and interpret data from apps when working with

clients with SCI. Participants expressed how this can create barriers to both engaging in PA and further engagement with fitness professionals:

...and then, you know, you go and sign up for a personal trainer. My concern there is that one, personal trainers aren't qualified to deal with people with special needs, uhm and special requirements, and two, is that personal trainer gonna understand the results of these? You know, is that gonna be then that conversation where are you are having to teach your personal trainer that your stats are going to be different to what they're used to seeing. And I think it overly complicates things to the point that people don't do it, if I'm completely honest. (Participant 7)

Bridging gaps

Participants also argued that fitness apps had the potential to bridge gaps in knowledge. This was discussed in two ways. Firstly, participants discussed how apps could be designed to provide information about ways of engaging in PA, thus facilitating increased in engagement in PA. For example, participants suggested that apps could provide information about accessible routes or activities, similar to how they already did for activities such as walking or running:

I think if there was an app that had a map or something of where all accessible walking routes or gyms or, you know, sports clubs, or things like that are, you know, that you could go...If they had something like that but for people with disabilities, it would be really useful to make them more involved, as well as, you know, getting more healthy, would be really useful. (Participant 6)

Secondly, participants discussed how two-way engagement between individuals with SCI and professionals could help to educate both parties about how SCI can effect PA and how to utilise fitness apps appropriately. It was believed that this could facilitate a more positive experience and better use of apps as well as facilitate increased PA:

I spoke with my coach in the beginning about what I was looking for and then he fed off of that and then he came up, he did his own research in what way he was going to challenge me. He actually started recommending apps to me... I think if you communicate with people in relation to what you're trying to achieve, they can come up with ways in allowing you to monitor that. Like we don't always have to have the answers as disabled people in relation to what works for us. (Participant 1)

Not like it's going to be Big Brother watching you, but I think that, with all the connectivity and all the data shared, I think these platforms are going to become very, very valuable for healthcare professionals in the future. (Participant 10)

Discussion

This study provides a unique insight into the experiences and perceptions of community dwelling wheelchair with SCI of using fitness apps. Not only does the present study provide insight into participants' overall experience and perceptions, it provides informs us on how participants perceive these apps in the context of barriers and facilitators of PA. All participants reported that they perceived that fitness apps increased their engagement in PA by facilitating additional motivation. The desire to improve health or athletic performance were strong motivators for engagement. Therefore, using fitness apps to objectively measure and track specific health and sport related measures facilitated self-motivation. For some, fitness apps also provided additional social motivation, as sharing of fitness data facilitated competition and comradery with other wheelchair users. However, not all

participants chose to share fitness data and some participants discussed how comparing fitness data with others, including others with SCI, had its limitations. Specifically, differences such as differences in neurological impairment and environmental factors were perceived to limit comparability and relatedness. Thus, using fitness apps to facilitate social motivation to engage in PA may not be effective for all wheelchair users with SCI.

Experience and perception were strongly influenced by app design, particularly the accuracy of apps, the ability to mount or wear devices while using wheelchair sports equipment and the presence or absence of features specifically tailored for wheelchair users. However, regardless of app design, this study suggests that fitness apps did not enable participants to overcome many of the barriers which still impact engagement in PA. These barriers include the cost of equipment and a lack of appropriate supports. Finally, this study also revealed a lack of knowledge among both wheelchair users with SCI and fitness professionals which can create confusion and further frustration. This includes a lack of knowledge of available apps and their features and features and how to appropriately use and interpret data recorded by fitness apps. This lack of knowledge was reported to create barriers between wheelchair users with SCI and fitness professionals and may limit effective app use.

By providing a means of measuring and evaluating PA, fitness apps were perceived to facilitate motivation to engage in PA. This is significant as recent meta-analytical data suggests that interventions which promote self-monitoring behaviour, increase the likelihood of bringing about sustainable increases in PA among individuals with SCI [25]. Nevertheless, some participants encountered challenges in measuring certain data. For example, participants were particularly interested in measuring calorie expenditure but doubts were raised about the accuracy of apps used in relation to this. Given that the energy demands of individuals with SCI vary compared to individuals without injury [47,48], it is possible that generic fitness apps may not provide accurate measurement of calorie expenditure for these individuals. However, there is currently a scarcity of high quality evidence relating to the use of fitness apps to measure calorie expenditure in this population [49]. Likewise, this study demonstrated how wheelchair-specific features, such as measuring "pushes", had a significant influence on participant experience and perception, including a positive emotional response to fitness apps. However, to the authors' knowledge, the Apple Watch is the currently the only commercially available app to include this feature.

Participants also highlighted the challenges of using apps for wheelchair sports. Like the Apple Watch, many fitness apps are used in combination with wrist-worn sensors. However, participants discussed how these can create challenges for wheelchair athletes, for example, when gloves are required to compete, or when there is a risk of devices becoming damaged or causing injury during sports. This is similar to the findings of one small ($n=6$) qualitative study where wheelchair rugby players with SCI raised these same concerns after trialling a wrist-worn activity tracker [50]. Moreover, these wheelchair rugby players also described how wearing the device created difficulties when transferring in and out of sports wheelchairs [50].

In the current study, concerns were raised that individuals with SCI lack the adequate knowledge to understand and interpret data presented by fitness apps. Similarly, participants conveyed a lack of awareness of the different fitness apps and features that are currently available. In a recent study by Hoevenaars et al. [32], participants ($n=14$) who trialled a fitness app for wheelchair users suggested that additional support from a coach to advise them on how to use the app, may have resulted in more effective use. However, as evidenced by the present study, many fitness

professionals also lack the knowledge required to provide such support. Nevertheless, participants in the present study argued that fitness apps could be designed and used as a resource for gaining knowledge. Similarly, recent qualitative findings suggest that health and fitness apps could be used as a “knowledge repository” [51] providing textual and visual information for both individuals and SCI and their carers [33,35,51,52]. Furthermore, wheelchair users, including those with SCI, have suggested that the social features of fitness apps could facilitate information sharing with other wheelchair users [33,52,53]. Thus, these features could help individuals gain information about PA in general or how to engage in specific activities. Given that lack of knowledge is consistently reported as being a barrier to PA for wheelchair users with SCI [21–23], fitness apps have the potential to become a critical resource for facilitating engagement.

In the current study, social features were discussed in relation to facilitating motivation. Previous systematic reviews of the literature relating to individuals with SCI [21,25] have emphasised the significance of social motivation in promoting and maintaining engagement in PA. In the present study, regardless of whether or not participants shared fitness data, all participants acknowledged that fitness apps have the potential to increase social motivation. Similarly, in recent high quality qualitative studies by Lai et al. [33] and Olsen et al. [53], it was found that individuals with disabilities perceived the social features of fitness apps to be significant in facilitating peer support. However, the findings of the present study revealed limitations to the potential of these apps to facilitate social motivation. Notably, the majority of participants chose to only share data with a very limited number of peers or did not share their data at all. This was evidenced by the experiences of a number of participants who tried using social platforms on fitness apps to compare data. Many of these individuals ceased using social features, citing there to be a lack of comparability between their data and that of others. This is significant as a study by Baretta et al. [54] found that “relatedness” was critical in enhancing social motivation when using fitness apps. This longitudinal mixed-methods study found that participants needed to be able to relate to others who shared their data in order to feel motivated by data sharing [54]. Therefore, in order to maximise the potential of these apps to facilitate social motivation, individuals with SCI must first be willing to share their fitness data with wider social networks.

Lastly, in recent years there has been a growth in the development of mobile apps and websites to support greater access to health information, assessment and interventions [29,30]. Although it is often reported and hypothesised that this type of technology may be effective for enabling individuals with disability and chronic disease to overcome barrier to engaging in PA [29,30,32,55,56], the experiences of participants in the present study highlighted that manual wheelchair users with SCI still face multiple barriers to engaging in PA. These barriers, such as financial restraints, restrictive environments and the need for more social support are highlighted in literature time and time again [20–25]. Therefore, although the use of mobile technology may be a step forward in helping to facilitate greater engagement in PA, more support may be needed to overcome barriers to engagement in order for this technology to be effective.

Strengths and limitations

To the authors’ knowledge this is the first study to investigate the experiences and perspectives of community dwelling wheelchair users with SCI of using fitness apps and how these relate

to barriers and facilitators of PA. Similarly, in order to maximise accuracy, participants were also given the opportunity to provide feedback on themes as they were being developed. Furthermore, investigators engaged in member checking, kept reflexive notes and used the COREQ checklist [43] to further maximise accuracy, rigor and transparency. Unlike many previous studies, the current study did not focus on just one app. This allowed for analysis of data relating to experiences and perceptions of a variety of different apps and design features. Likewise, the use of online communication platforms to conduct interviews facilitated collection of data from individuals living in diverse locations including a mixture of urban and rural areas. Furthermore, as the interviewer had several years of experience working with wheelchair users with SCI, she was able to develop a rapport with participants to elicit rich data.

However, this study also has a number of limitations. Firstly, all the participants in this study were manual chair users. Although it was not the aim of this study to exclude individuals who use powered mobility, unfortunately, the experiences and perspectives of powerchair users are not represented. Secondly, it should be noted that all individuals in this study were quite physically active, with all participants reporting engaging in planned PA sessions at least 3 times per week. Therefore, the results of this study may not be applicable to individuals who are sedentary or show low levels of motivation. Similarly, as self-reported levels of PA may not be reliable [47], without the triangulation of data with quantitative findings, this study cannot confirm the extent to which fitness apps effected PA levels. Lastly, as interviews were conducted using an online platform, it is assumed that all participants were relatively tech-savvy, which is likely to have influenced their experiences, perceptions, and openness to using new technologies.

Implications for future research

As the individuals in this study were relatively physically active, more research is needed to investigate the use of fitness apps among those who may encounter greater challenges overcoming barriers, such as those who are sedentary and powerchair users. Similarly, this study highlighted specific elements of app design which could be further developed to support PA among wheelchair users with SCI. These include 1) improving the accuracy of fitness apps for capturing PA levels of wheelchair users with SCI, 2) developing ways of making hardware more compatible with wheelchair activities and sports and 3) further developing apps to provide more recognition of wheelchair users, such as inclusion of wheelchair specific activities or social platforms. Furthermore, participants in this study experienced a lack of knowledge amongst fitness professionals about what apps and features are available and how to use these with clients who are wheelchair users with SCI. Similarly, participants perceived that individuals with SCI also lack this knowledge. As this study suggests that there is an appetite amongst these individuals to learn more about this type of technology, further qualitative research investigating the experiences and perceptions of health and fitness professionals are needed to determine how best to address this issue.

Conclusion

Gaining stakeholder’s perspectives is key in developing strategies to increase engagement in PA [57]. Overall, this study lays the

foundation for the use of this technology, which is relatively cheap and accessible, for improving the health and wellbeing of wheelchair users with SCI. This study illustrates the experiences perceptions of manual wheelchair users with SCI of using fitness apps to facilitate increased motivation to engage in PA. However, the findings highlight that significant barriers still need to be overcome for these individuals to engage in PA. Similarly, the current lack of widely available app features tailored for wheelchair users was found to be impacting user experience and perceptions of this technology. Moreover, the study reveals a lack of knowledge exists amongst wheelchair users with SCI of what apps and features are currently available and how to use and interpret fitness data. Therefore, this study highlights the need for researchers and health and fitness professionals to continue to employ strategies to reduce barriers to PA and to work with wheelchair users with SCI to further develop and promote app features that better meet their needs.

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