Including the Experiences of Physically Disabled Players in Mainstream Guidelines for Movement-Based Games

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Movement-based video games can provide engaging play experiences, and also have the potential to encourage physical activity. However, existing design guidelines for such games overwhelmingly focus on non-disabled players; in our work, we explore wheelchair users' perspectives on movement-based games as an enjoyable play activity. We created eight game concepts as discussion points for semi-structured interviews (N=6) with wheelchair users, and used Interpretative Phenomenological Analysis to understand their perspectives on physical activity and play. Themes focus on independent access, challenges in social settings, and the need for comprehensive adaptation. We also conducted an online survey (N=21) using the same game concepts, and thematic analysis highlighted the importance of adequate challenge, and considerations around multiplayer experiences. Based on these findings, we re-contextualize and expand guidelines for movement-based games previously established by Mueller and Isbister to include disabled players, and suggest design strategies that take into account their perspectives on play.

CCS Concepts: • **Applied computing → Computer games**.

Additional Key Words and Phrases: Accessibility, game design, movement-based games

1 INTRODUCTION

Movement-based video games offer opportunities for physically engaging play, and provide a wide range of potential benefits for players [15]. Previous work has explored such games in the context of physical disability through case studies; for example, casual extertion games (exergames) for manual wheelchair users [25], for young people with cerebral palsy [24] or to provide an opportunity for physically active play for young people using powered wheelchairs [18]. While these case studies exemplify how the design of movement-based games for physically disabled players can be approached in specific settings, structured synthesis of research findings into recommendations to guide the design of such systems remains limited in scope. For example, Mason et al. [36] provide design goals for playful technology that supports physical activity (PA) among wheelchair users, but does so at an abstract level. At the same time, existing guidelines that are more concrete and address the design of movement-based games, such as the widely cited and well-founded work by Mueller and Isbister [41], focus on the experience of non-disabled players (none of the examples described in [41] specifically address disabled players), and do not yet consider the impact that bodily difference may have on play experiences. Finally, a further body of work centres on guidelines for movement-based play as a therapeutic intervention for disabled players (e.g., [59]), prioritizing deficit-focused, medicalized views on disability, and health

outcomes, while omitting the potential of movement-based play to provide inherently valuable leisure experiences. This suggests that such guidelines do not sufficiently emphasize disabled players' right to engage in enriching physical play experiences, reflecting a common issue within HCI research that focuses on games for disabled people (also see [54]).

Hence, there remains a research gap with respect to the provision of actionable design recommendations for movement-based games that take into account disabled perspectives, while recognizing the value of movement-based play as an engaging form of leisure for physically disabled people. In our work, we address this gap through a mixed-methods exploration of wheelchair users' perspectives on games and physical activity, to derive recommendations for movement-based games that take into account perspectives of physically disabled players, and that can be leveraged to contextualize existing work on movement-based play.

Our work is guided by two main research questions (RQs): *How does physical disability need to be accounted for in movement-based games (RQ1), and how do guidelines for their design need to be adjusted to include physically disabled players (RQ2)?*

To address these questions, we conducted a two part study. We first created eight concepts for movement-based games for wheelchair users, which we used as conversation starters for semi-structured interviews with six participants. We analyzed this data using interpretative phenomenological analysis (IPA) [52], an approach that focuses on the lived experiences of participants. Themes focus on independent access to both games and physical activity, challenges that emerge when exercising in social settings, and the need for comprehensive adaptation of games to account for individual player needs. We supplement these findings with results of an online survey that received detailed responses from 21 wheelchair users, and was analyzed using thematic analysis [3]. We crafted themes which highlight the importance of adequate challenge and a focus on positive, engaging play experiences; for example, enabling players to be challenged according to individual preferences and limits. Findings further emphasise that movement-based play in social settings requires careful consideration, particularly when facilitated among strangers.

We then use these empirical findings to contextualize and expand the well known set of design guidelines for movement-based games compiled by Mueller and Isbister [41]. Our findings suggest that many of their guidelines remain relevant, with some aspects needing to be regarded as a mandatory requirement rather than a nice-to-have feature, e.g., *intending fatigue* or *dealing with ambiguity in movement execution*. Additionally, a small set of recommendations are no longer appropriate when including physically disabled players, e.g., seeking to *turn movement into a spectacle*, or need to be approached with nuance, e.g., when designing what Mueller and Isbister [41] call *social fun*.

Our paper makes the following three main contributions: (1) it provides an in-depth exploration of wheelchair users' perspectives on physical activity, games, and the combination thereof, (2) it contributes empirically-grounded recommendations that can help the work of researchers and designers wishing to create movement-based games that are inclusive of the experiences of physically disabled players, and (3) we highlight challenges and opportunities when integrating disabled people's preferences and needs into mainstream game design recommendations. Movement-based games offer physical activity in a playful setting, contributing to the diversification of physically engaging leisure activities. Ensuring their accessibility for physically disabled people not just in the context of specialized applications, but through design recommendations addressing mainstream projects facilitates a first step toward pathways of accounting for the needs of disabled and non-disabled players alike.

2 RELATED WORK

In this section we first summarize previous work examining movement-based games and play for physically disabled players, looking both at specific examples, and design recommendations focused on therapeutic outcomes. We then

proceed to describe works which propose design guidelines for creating enjoyable movement-based games for general (non-disabled) audiences, and conclude by outlining the gap between these two bodies of work, and how this motivates our research.

2.1 Examples of Movement-based Games for Physically Disabled Players

A number of previous studies have engaged with the creation of movement-based games and play for physically disabled people in particular settings, or with specific user groups. In this section, we present an overview of these case studies, highlighting design implications that were derived from them.

Several authors have described innovative interfaces for movement-based games, which support wheelchair users. For example, Astrowheelie [10] used an accelerometer to detect wheelchair movement in an arcade style exergame, and GAMEWheels [44] made use of a mechanical wheelchair mount so that players could control games through propulsion of their wheelchair [10]. Similarly, Malone et al. [33] compared versions of the Nintendo Wii Fit balance board and gaming mat with versions adapted for users with lower mobility, in order to evaluate them as input devices.

Sensors which are able to detect movement visually have also been explored. Eckert at al. [12] developed a gesture recognition interface to enable movement-impaired players to play commercial games, as did Szykman et al. [57]. Gerling et al. introduced Kinectwheels in [20], a toolkit for developers to build movement interfaces for wheelchair users using the Microsoft Kinect sensor: this was subsequently used by Hicks et al. [25] to build prototype games for children using wheelchairs. Attempts to build games for disabled players using standard ubiquitous platforms, such as mobile phones have also been made (e.g., Mason et. al [37]).

These works represent enabling technological solutions for movement-based wheelchair gaming, which comprise bespoke hardware and/or software; however, consideration also needs to be given to the *design* of movement-based games for disabled players. Some previous works have attempted to explore this design space, through specific case studies. For example, Hernandez et al. [23, 24] designed a series of mini-games for children with cerebral palsy, using recumbent bicycle interface, from which they drew guidelines for "fast-paced" games for these users. Gerling et al. [18] also used a participatory design approach to build prototype games for young wheelchair users, and their findings suggested that the varying needs of players required carefully differentiated game balancing at an individual level. Recently, Graf et al. presented iGym [22], a floor projection hockey game which enabled wheelchair players to play competitively with non-wheelchair players. Wheelchair players were presented with different levels of game adaptation, and reported that they were sometimes motivated by a desire for challenge, as well as balance, revealing distinct individual variations in preferences and approach to play.

Virtual reality (VR) interfaces are also often movement-based, and have attracted the attention of researchers concerned with players with limited mobility. For example, recent work by Gerling et al. [16] explored wheelchair-users perspectives on VR games through three prototypes, and highlighted design considerations around flexible, adaptive interfaces.

2.2 Design Guidelines for Movement-based Games for Physically Disabled Players

The case studies mentioned in the previous section, such as that by Hernandez et al. [24], do contribute design recommendations from their work. However, these are narrowly contextualised to specific user groups and settings: little work has attempted to discuss or reflect on these more widely, in order to construct general guidelines which are actionable by other game creators. Moreover, there is a tendency for researchers to "medicalize" movement-based games designed for players with limited mobility, and treat them primarily as therapeutic interventions rather than

as enjoyable leisure experiences. Such examples include the recommendations by Wiemeyer et al. [59], or Doyle et al. [11] who sought to enhance feedback to improve correct execution of exercises in a therapeutic movement game. This perspective is common, and extends to other user groups who are perceived as requiring clinical support, such as people with Parkinson's disease [38, 50], older adults [5, 30, 58], or patients recovering from stroke [27, 42]. Whilst such games may indeed provide therapeutic benefits, there is a wide-spread predisposition to see users through the lens of the patient, rather than as individuals who wish to enjoy play as a leisure experience. We seek to address this in our work by re-orientating movement-based games for disabled users towards the creation of enriching play experiences. With this objective in mind, we proceed to review general design recommendations for movement-based games.

2.3 General Design Recommendations for Movement-Based Games

Much of the work which addresses the design of movement-based games for general (non-disabled) audiences also takes the perspective of player well-being; for example, using health issues related to lack of physical activity as a primary motivation [2, 7, 8, 49]. Again, whilst this is undoubtedly a potentially important benefit of engaging with movement-based games (also referred to as *exergames* in this context), this perspective often draws the design focus towards physical exercise and health outcomes, rather than fun and engaging play.

For example, Bielik et al. [2] designed a mobile app to encourage physical activity, built around four design guidelines: personalised recommendations, progress tracking, informative feedback, and maintenance of motivation. Similarly, Consolvo et al. [8] evaluated a mobile app which allowed users to share their activity achievements with other users. They suggested guidelines which also emphasise feedback on activity levels and positive achievements, but also leverage social influence and support, and integration with users' lifestyles. Results presented by Chen et al. [7] suggest that framing a commercial exergame as a healthy activity (rather than a game activity) can increased player engagement, and Sinclair [49] suggested that maintaining a balance between the physical intensity of an exergame and the fitness of a player was important to maintain engagement, and introduced the concept of *dual flow*.

However, other authors have looked more towards *enjoyable* gameplay experience when considering the design of movement-based games. Most prominently, the well-cited design guidelines described by Mueller and Isbister [41] drew on their own research experience, and were refined in collaboration with experts from academia and industry. These guidelines are"general" in the sense that they do not consider sub-groups of players (such as people with limited mobility) and are intended to help designers craft engaging and entertaining play experiences.

Mueller and Isbister draw two broad categories of guidelines. The first, *Movement Requires Special Feedback*, comprises four guidelines: *Embrace Ambiguity*, *Celebrate Movement Articulation*, *Consider Cognitive Load*, and *Focus on the body*. The second category, *Movement Leads to Bodily Challenges*, comprises a further six: *intend fatigue*, *Exploit Risk*, *Map Imaginatively*, *Highlight Rhythm*, *Support Self-Expression*, and *Facilitate Social Fun*.

Aspects of Mueller and Isbister's guidelines echo previous work by Mueller [39, 41], and also resonate with other works which explore the design of engaging movement-based games. For example, Lyons [32] also highights the importance of feedback in the enjoyment of exergames, while Marshall et al. [34] discuss how to manage *exertion trajectories* through game narratives, emphasising social play. Recent work by Martin-Niedecken et al. [35] also discusses the importance of social connectedness, as well as different modes of feedback, including haptics, in the design of games to promote exercise. Recent work by Mueller et al. [13] has also considered how limited movement can be seen as a game mechanic for for non-disabled players, but this was not explored in the context of disability.

A recent review by Subramanian et al. [56] of design guidelines for movement-based games highlights the tension between designing for fun and for well-being (which they refer to as the "hedonic–utilitarian divide"), and also the lack of

an overarching systematic approach to the development of design guidelines by the research community. Consequently, they assert that a robust synthesis of guidelines proposed by different authors is not straightforward. However, from our perspective we consider that the guidelines proposed by Mueller and Isbister provide a primary reference point for the creation of *enjoyable* movement-based games, as they are drawn from multiple previous works by the authors, are detailed and expansive in scope, and are refined by feedback from experts in industry and academia.

However, like other works seeking to guide the development of enjoyable movement-based games, Mueller and Isbister's guidelines do not consider diversity amongst players' bodies, nor players who might have different needs and perspectives on physical play. Our work thus seeks to bridge the gap between these recommendations and the examples presented in sections 2.1 and 2.2, to provide supplementary considerations which can be used to guide the design of movement-based games which are accessible to disabled players and emphasise engaging, positive play experiences over therapeutic outcomes.

3 UNDERSTANDING MOTION-BASED PLAY IN THE CONTEXT OF PHYSICAL DISABILITY

In this section we present our two-part study which explores the perspectives of people with physical disability on movement-based games. We used a set of game concepts as conversation starters/prompts for both parts, and we begin by introducing these. We then proceed to describe the study procedures, results and analysis, followed by our key findings in Section 3.7.

3.1 Designing Game Concepts as Conversation Starters

Design concepts (e.g., paper prototypes) have been previously used to engage research participants in conversations about design requirements; in the case of games, they can foster exchange between designers and prospective players who are given a reference point for reflection [48]. In our project, we chose this approach as we did not want to assume that participants had extensive previous experience of playing movement-based games, and we wished to explore a broad range of relatable and accessible game ideas with them during interview.

The starting point for designing these concepts was a three hour ideation and design workshop with six designers, some of whom had previously designed accessible movement-based play. The aim of the workshop was to generate game ideas encompassing a wide variety of game mechanics, controls, and interactions suitable for physically disabled players. The resulting design ideas were then developed further using exertion cards [40], design goals for playful technology for wheelchair users [36], and Wizard of Oz prototyping to support rapid testing of game ideas [26]. To design movement-based play suitable in the context of wheelchair use, all player movement was based on a set of exercises for wheelchair users developed by rehabilitation experts [1]. Eight final concepts were selected and refined to ensure that they covered a breadth of game genres and levels of exercise integration. For each of the concepts, we created a short demonstration video, textual description of the game, and graphical representations of the game and physical player input. Demonstration videos include 20-60 seconds of mocked-up gameplay footage, accompanied by a video insert of a person performing the movements that would control the game (Figure 1). All these materials were integrated into a website that we used during the interviews and survey (Figure 2) to give participants a sense of the game concepts.

3.2 Example Game Concepts

Here, we describe two of the game concepts in more detail to give an overview of the nature of information shared with participants. For transparency, the remaining six concepts are included in the supplementary materials, covering

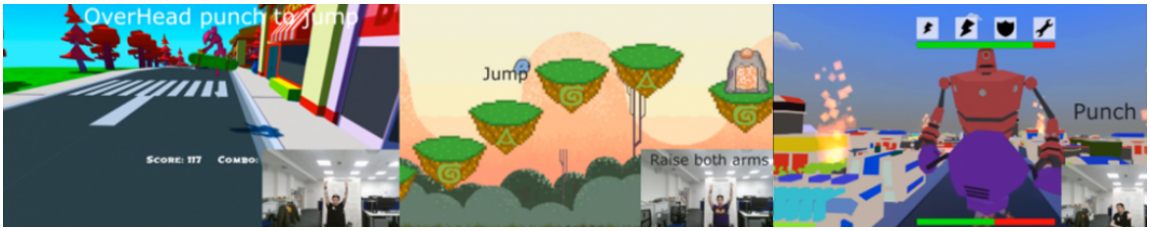

Fig. 1. Example design videos shown to participants

a broad range of genres and experiences including a strategic puzzle game, a platformer game, and a world-building game. Details for each game are included in the supplementary materials.

3.2.1 Concept 1: Kung Fu Skateboarding. **Gameplay:** Kung Fu skateboarding is a single-player endless runner game where the player controls a skateboarder who is constantly moving forward on a road filled with hazards. Core gameplay is similar to many "runner" games such as Templerun [55], but colliding with a hazard will not kill the player and instead momentarily slow them down. The goal of the game is to continue as long as possible while also trying to collect bonus items before time runs out. Additionally, the player can perform tricks while jumping over obstacles to achieve higher scores. Players will occasionally encounter special characters which engage them in mini games that require them to copy moves. The game ends when the player has run out of time.

Movement integration: The game uses several different gestures in combination with wheelchair movement for game control. To steer their avatar as they proceed through the level, the player must turn their wheelchair in either the right or left direction. The rest of the game is controlled via gestures: the avatar can be made to jump to avoid hazards in the level through side arm raises to initialize the jump, and then can extend the duration of the jump by performing overhead punches (see 3, 'Side arm raises'). While the avatar is in the air the player can also perform combos by raising their arm up in circles, punching the air, and stretching forward. These are based on the exercises 'Raised arm circles', 'Punches', and 'Dives' 3. During the mini game, the same gestures are used.

3.2.2 Concept 2: Beat Circle. **Gameplay:** Beat circle is a single-player rhythm game that creates a custom workout for the player using different songs. The game visualizes the audio spectrum of a song by changing the environment of the level. Gameplay is split into two phases: the *avoid* phase, and the *combo* phase. In the avoid phase, the player avoids bouncing objects while collecting power-ups (similar to Geometry Wars [9]) which give the player time in the combo phase. In the combo phase there are objects falling from the top of the screen, and the player is prompted to perform gestures to destroy them before they hit the ground. The objects are labelled with different instructions, for example, 'punch x 4', requiring the player to punch four times in order to destroy it. To increase the challenge, multiple objects can fall simultaneously, forcing players to prioritize. If an object objects reaches the bottom of the screen, the player loses time in this phase. The overall goal of the game is to finish songs while collecting power-ups, and remaining in the combo phase to score.

Movement integration: Beat Circle uses distinct input alphabets per phase. Side arm raises toggle between these modes. In the *avoid* phase, players hold out a hand and move it to dodge obstacles on screen. The *combo* phase prompts the players to perform a gestures based on 3, including 'Punches', 'Overhead punches', 'Raised arm circles', and 'Dives'.

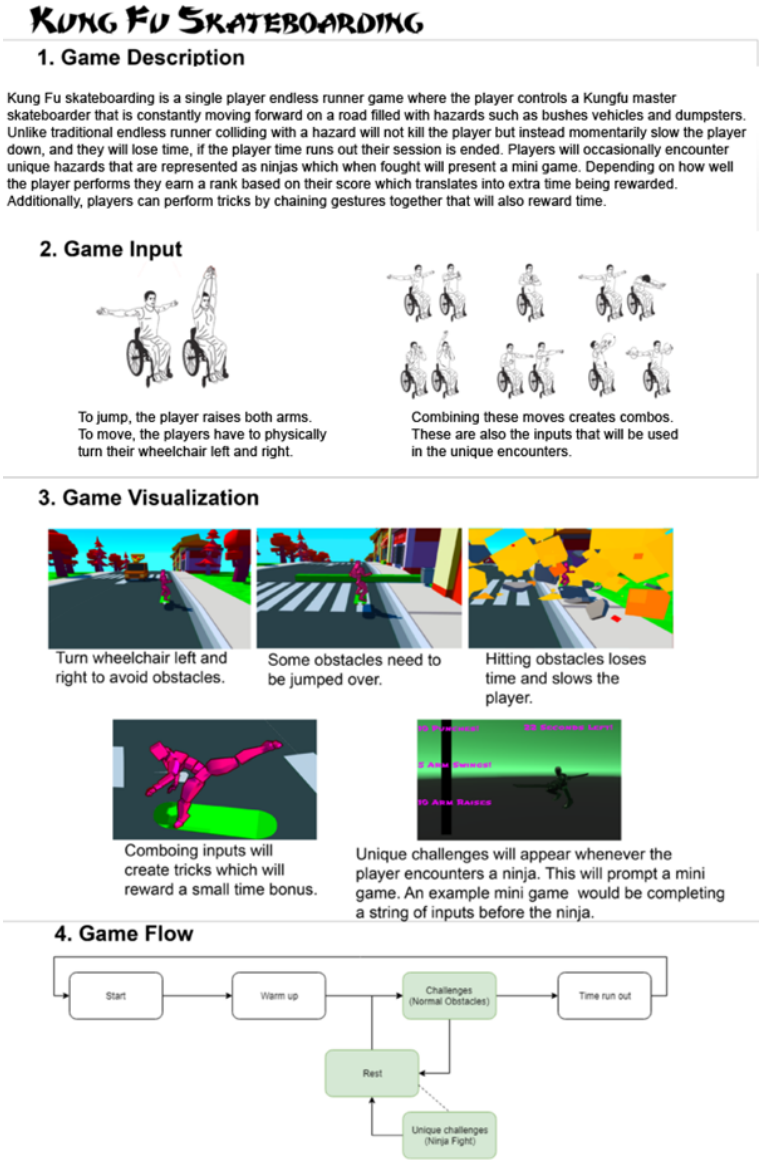

Fig. 2. Example segment from the website used to present our game concepts

3.2.3 Conversation Goals. The game concepts were designed with conversation goals in mind. For example, a conversation goal of Kung Fu Skateboarding was to encourage participants to reflect on the consequences of making mistakes in movement-based games (e.g., through loss of time when colliding with in-game objects). Additionally, Kung Fu Skateboarding requires the player to use their wheelchair as part of the control scheme, so that participants can reflect on the integration of assistive devices into game play. A conversation goal associated with Beat Circle was exercise intensity: the game encourages players to swap between light and moderate-intensity exercises, leaving room for

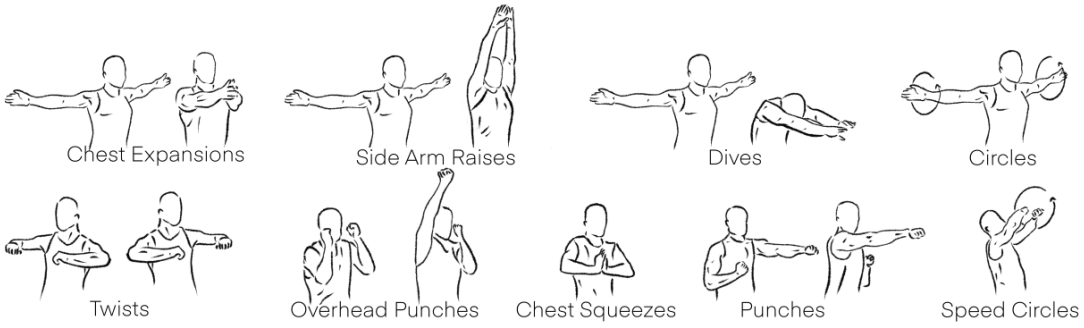

Fig. 3. Illustration of the NHS wheelchair exercises

reflection on the desired amount of effort required to engage with movement-based games, in the context of physical disability.

3.3 Part 1: Interviews

We designed semi-structured interviews around physical activity, gaming, and the game concepts. The goal of this step of our research was to provide an in-depth exploration of the perspectives of physically disabled people on movement-based games.

3.3.1 Procedure. Interviews were carried out in two steps, covering **(1) demographic information and individual backgrounds of participants** (including perspectives on physical activity, and experience with movement-based games), and **(2) reflections on physical activity and movement-based play** based on our game concepts (see Section 3.2). The first stage of each interview included questions on wheelchair use (e.g., reasons for use and duration), physical activity routines (e.g., *"Would you consider yourself physically active?"*, *"Do you exercise at home, outside, or in training facilities?"*), and gaming habits (e.g., *"What gaming systems do you use?"*, *"Have you played movement-based games before, and if so, which ones?"*). The second stage of the interviews introduced the game concepts one at a time, using a website (Figure 2), and each was followed by questions about the anticipated play experiences. On the website, participants were first shown a poster and a video of each design. To ensure that the participants shared our vision of each concept, they were asked to describe the game in their own words. Questions on the concept included general preferences (e.g., *"What did you think of the idea of this game?"*, *"Is there anything you particularly liked or disliked?"*, and explorations of specific parts of the concepts, e.g. what interaction paradigms would be suitable, how movement-based input would need to be adjusted, and whether features such as social aspects would be desirable. Questions on the game concepts were grounded in the design goals specified in [36]. At the end of this stage, participants were given opportunity to provide open-ended feedback.

We used local advertising and a number of social media channels (e.g., Facebook, Twitter and Instagram) to reach out to potential participants. At the beginning of each interview, participants were given information about the research, could ask questions, and were asked to provide informed consent. The research protocol was approved by <removed for review>. The average interview length was 108 minutes. Depending on participant preference, interviews were conducted in person (3), at a suitable location chosen by the participant, online via Discord (2), or by telephone (1).

3.3.2 Participants. Six participants (four male, two female, aged 19 to 61 years) agreed to take part in the interview stage, each with individual views on and experiences of physical activity and games. Here, we give an overview of their backgrounds to put their feedback in perspective. All names are replaced with pseudonyms.

Participant 1: Jack is a 33-year-old veteran and streamer who advocates for game accessibility. He shares a house with roommates in an urban area of <country removed for review>. He has a spinal cord injury which causes loss of lower body mobility, and also impacts his fine motor skills. Jack has used a wheelchair for six years, and is both physically active and an avid gamer. He plays wheelchair rugby and regularly works out. When playing games, he chooses the PC over console platforms for accessibility reasons, and also has an interest in VR. **Participant 2:** Simon is 29 years old, and together with his fiancée, he lives in an urban area of <country removed for review>. He has worked in the games industry and is currently a content creator for accessible gaming, creating video reviews of game accessibility features. Simon has Cerebral Palsy and has used a wheelchair for 27 years. He is physically active and participates in occupational therapy; he prefers to play games on the PC. **Participant 3:** Jess is a 19-year-old female, and works full time. She enjoys socializing, but highlights how living in both urban and rural areas comes with access barriers, pointing out that sometimes, *"it takes forever to get somewhere"*. Jess has been a part-time manual wheelchair user due to osteoarthritis for nine years. She currently is not physically active due to pain and the cost of participating in suitable activities, a situation which she is not happy with. While she does not consider herself a gamer, she does have an interest in games and enjoys playing when given the opportunity. **Participant 4:** Sarah is 26 years old and resides in an urban area with her mother, where she volunteers part-time at a local shop. She has Ehlers-Danlos syndrome, a condition that affects the connective tissue and affects her mobility. Sarah has used a wheelchair for a little over a year. She is physically active, and takes part in wheelchair basketball, yoga, weight watchers, and walking, but cannot access some activities because she does not drive. She uses technology to track her fitness goals. In terms of gaming, she plays on handheld consoles such as the Nintendo DS Lite, but also uses the Nintendo Wii Balance Board and the PC. She does not use consoles because she cannot use the controllers. **Participant 5:** Paul is a 21-year-old full-time student who lives in an urban area with friends. He has Scoliosis, and has full upper and low body function, but experiences pain with some motions, and has been using wheelchairs and canes as a form of pain management. Paul is physically active in his daily life (e.g., challenging himself to be faster while traveling back and forth from the university), with the wheelchair facilitating physical activity for him. However, he does not participate in sports activities because of accessibility-related concerns, and only does exercise for general health benefits. He regularly plays games on a wide variety of consoles including the Sony PS4, PS2 and the Microsoft Xbox 360, but also plays PC games, with the PC being his preferred platform. **Participant 6:** Bill is 61 years old and is retired, but regularly does voluntary work. He is a former Olympic wheelchair fencer, and has used a wheelchair for as long as he can remember following a spinal cord injury. He does not currently consider himself physically active due to a lack of suitable facilities. While he does not consider himself a gamer as he thinks they are a little past his time, he does occasionally play mobile games.

3.3.3 Data Analysis. Data were analyzed in accordance with interpretative phenomenological analysis (IPA) [51]. Our small participant pool is consistent with the idiographic nature of IPA, allowing us to focus on the individual and emphasise their unique personal experiences (A strength of IPA [53, p. 15]). Doing so creates rich and detailed descriptions of each participant, detailing what is important to them, and how those things are experienced, before identifying similarities across all participants [53]. Examples of where IPA have been used previously include Linder and Arvola [31], who used it to analyze participants' experiences with a start-up service that introduces them to the job

market,where it was particularly useful at the concept stage. Likewise Reid [47] used IPA to assess school children's engagement with a play experience.

Our analytical process involved several stages, following the procedure described by Smith [53]. Firstly, each interview was transcribed and read several times by the lead researcher to gain familiarity and a complete understanding of the content. Secondly, initial important points were recorded on each transcription. Lastly, data was explored systematically to identify themes across all transcripts. The lead researcher conducted the initial analytic process; however, to ensure the credibility of the analysis and to minimise bias, a co-author audited and agreed on the final hierarchical structure of themes, and collaboratively approved the verbatim extracts, agreeing upon the final themes.

3.4 Interview Results

Analysis led to four superordinate themes: (1) Independence and Physical Activity, (2) The Push and Pull of Social Settings, (3) Full Access Requires Individual Rather than General Adaptation, and (4) Leveraging Games to Shift Focus From Real World to Play. To our surprise, much of the discussion focused on physical activity and movement rather than play, highlighting the delicate role of physical activity in the context of physical disability. Here, we discuss the main themes, illustrating them with participant quotes and examples that directly relate to the game concepts, and highlight relevance of our findings for the design of movement-based games.

3.4.1 Theme 1: Independence and Physical Activity. Across participants, appropriate access to activities was highly important, and influenced whether people would consider taking part in an activity, which they sometimes preferred to do on their own. This was not just limited to physical activity, but also extended to participants' engagement with games. For example, Simon explained: *"The reason I don't do it [physical activity] is because I'm on my own, my carer comes in the morning and the night and I'm with my fiancée or whatever most of the day so to get into the pool and get changed to exercise you need someone there, so I like to be as independent as possible and that's probably why I don't exercise and do that stuff in my own time. [...] With gaming I can just have my PC set up on sleep and roll up to it and use it and we are good to go."* In this extract, Simon highlights how his dependency on others influences what activities he engages in, and clearly outlines the value of independent access in the context of gaming. Interestingly, Jack touched upon the same phenomenon, his desire for independence influencing his gaming decisions and acting as a barrier to engagement: *"One of the reasons I don't play [movement-based games] is it involves a lot of set up depending on what game you want to play."*

Whilst we we encountered many instances in which participants strove to preserve their independence when engaging in activities, participants also highlighted how they worked together with others, for example through rehabilitation programs or support from partners, family and friends, to access physical activity (PA). Here, many participants reflected on how their lives were interwoven with that of family, friends, and carers. In contrast, participants reported actively avoiding undesired offers of help, or situations in which they would unintentionally depend on the help of others. For example, Paul details that *"if the building has accessibility but it requires someone to operate the lift for you, you don't feel very independent, you don't want to feel as if people are going out of their way."* Bill expressed similar experiences by avoiding going to previously unvisited gyms as he do not want gym goers to *"pity"* him and offer support. Likewise, Paul mentioned purposefully wearing headphones to avoid people offering help as he wants to succeed independently. Along these lines, we observed instances where participants were willing to take risks to participate in activities on their own. For example, Jess described that she liked going for bike rides, but that there was a chance she would become stranded miles from home because her *"muscles will cramp up making it impossible to*

return home". Likewise, Sarah engaged in active tasks that she had been advised to avoid: *"I used to do it all the time [be physically active], why should I stop now?"* These experiences demonstrate that participants generally recognized the role of interdependence in their lives, but appreciated being able to participate in activities on their own, or on their own terms.

With respect to our game concepts, we want to note here that the theme extends beyond gameplay to the general setup of the game and hardware that is required to play, drawing out an additional point of attention for designers that has previously been highlighted by research on game accessibility for people with limited mobility (e.g., [17]).

3.4.2 Theme 2: The Push and Pull of Social Relationships and Settings. This theme encompasses participants' perspectives on social relationships and social settings in which both physical activity and games can take place. In particular, participants highlighted awareness of performative aspects of physical activity and playing games on a social stage, and difficulties that surround (expected) participant performance and its relationship with their experience of physical disability.

With respect to physical activity, participants highlighted how social relationships could both be contributors and barriers to participation. For example, Paul pointed out that he *"didn't want to be nagged"* by his family, and that this experience created an adverse interest in exercising. Conversely, Sarah explained that as a result of the negative perceptions of others telling her that she *"can't do stuff"*, she wanted to prove them wrong and pushed herself to exercise. Likewise, participants highlighted a need for more realistic perspectives on wheelchair use and PA, with Paul pointing out that *"the main problem is like most wheelchair users in <country removed for review>, they're told by doctors [...] this is kind of the end, like once you're in a wheelchair that's sort of the of it [physical activity] [...] so it's difficult to find a large enough group"*. This dynamic was a common recurrence throughout, with participants explaining how negative interactions with others altered their perspectives on and access to PA.

In terms of engaging with games, participants thought that playing in social settings would require careful consideration. In particular, they made a distinction between co-located play with people they already knew, and engaging in online competition with strangers. For example, Simon pointed out that he avoids voice communication with other players because *"I don't like getting called out. There can be a lot of rage like you can make a mistake and die first [...] and people might not know you're disabled, like you die on an easy part where everyone lived. [...] I don't want to have to explain myself."* Jess and Sarah share a similar perspective on online gaming. They avoid playing with strangers as they feel like their disability would impact their performance in comparison with non-disabled players, and they would not want to be criticised by others. On the other hand, participants gave details of positive social gaming experiences. Some participants did express an interest in playing games with friends as they are *"more considerate"* (Paul). However, participants also pointed out that some types of social play would be more suitable than others. In particular, local multiplayer modes were seen as an opportunity to socialize with friends and to engage in physical activity if designed for movement-based games. Likewise, participants highlighted the potential for asynchronous multiplayer, both with respect to player roles and indication of competition: *"So in Tell-Tale games, they say at the end of the chapter '66 percent of people made this decision', and you can compare yourself so if you're climbing Everest you can give them options to go this way, or tie yourself to this tree, so this influences PA that the person does [...]."* (Simon) - *"Like Facebook games...it will come up on your feed showing you how well others have done, giving people a challenge, like global challenges so that's involving others, but it doesn't really affect you."* (Sarah).

Some of our game concepts included references to multiplayer modes; however, While reflecting on them, some participants made specific suggestions for social play features which could connect them with close friends and family.

For example, Jack suggested creating "party games", while Simon, talking about Kung Fu Skateboarding, suggested "I could play with my fiancé see who lasts the longest and you can get pickups to slow each other or little things in the streets you can collect like red shells". Sarah and Paul also made suggestions for online play modes which could connect them with wider online communities indirectly, avoiding the possibility of negative comments about performance, such as "global challenges. So that's involving others but doesn't directly affect you" (Paul).

3.4.3 Theme 3: Full Access Requires Individual Rather than General Adaptation. This theme summarizes participant experiences that address access barriers despite adaptation, highlighting the relevance of adjusting activities to the needs of individuals, and suggesting that general adaptation may lower superficial access barriers, but is not enough to involve everyone in the longer term.

With respect to physical activity, participants pointed out that although many activities were labelled as accessible, they may still be inaccessible for individuals. Here, Paul pointed out that *"There are some that say they are accessible like wheelchair basketball, but it's not because it hurts my spine"*. Jack detailed a similar experience when engaging in physical activity, pointing out that *"I only don't have a bit of wrists and no finger movement so I was able to do you know all shoulder exercises, but then like when it came to weight lifting, things that I need my hands for, I found different ways to adapt with that."* This highlights the difference between general access to an activity (i.e., taking part in physical activity), and access to the full experience (i.e., having the opportunity of completing all exercises in an engaging way).

Likewise, fully accessing games remained challenging, with the need for individual adaptation spanning both game interfaces and game mechanics. In the context of movement-based play, Sarah inspected our game concepts and pointed out that while she could generally access these games, actions such as *"lift your arms over your head"* would be challenging and at times impossible to complete. Reflecting on movement-based games more widely, Jack focused on the role of the controller and stated that *"independent finger movement or grasping movement"* that many movement-based systems still require would be an accessibility issue. Likewise, when engaging with Virtual Reality games that require movement-based controls, Simon explained that that he *"couldn't hold the controllers, but could use my head to dodge and I could get someone to use the controller"*, suggesting that creative problem solving was required to fully access movement-based game interfaces, once more highlighting the role of interdependence. In this context, participants underlined the value of full adaptation, i.e., *"customization to a different input"* through re-mapping of controls to an interface (or movement) that would be more suitable.

With respect to adaptation of game mechanics, participants pointed out the relevance of difficulty settings and game pacing. For example, Paul welcomed the ability to cycle through difficulty settings as this enabled him to play less strenuously if he was *"having a bad back day"*. However, participants also reflected on the emotional burden of having to select difficulty settings, suggesting that *"having to manually say easy, medium, hard [...] can be a bit sad in a way"* (Jess), and they feel that the game *"rubs it in your face like fuck you"* (Simon). Reflecting on our game concepts, participants discussed how to implicitly customize difficulty, for example by choosing game characters associated with specific levels of difficulty, or the introduction of calibration routines that adjust in-game challenge to player ability. Regarding elements that could be the focus of adaptation, Jack highlighted the importance of being to adjust reaction times as *"my body isn't translating that fast"*, Paul flagged up sudden movement as an accessibility barrier, and Simon reflected on the general benefit of appropriate game pacing for accessibility.

3.4.4 Theme 4: Leveraging Games to Shift Focus From Real World to Play. This theme focuses on participants' desire to leverage games to motivate them in physical activity, using play as a means of masking unpleasant elements of activity by adding an extra layer that would help distract from exertion and pain.

This perspective is rooted in the shared experience of physical activity in the context of therapy and rehabilitation, which participants describe as a challenging, at times boring, and often painful activity. Many participants highlighted that pain often remains in the foreground of their mind when engaging in activity, with Paul indicating that playing a movement-based game could mask that he is doing exercise, and allowing his attention to shift from his pain to the game. With respect to engagement, we also observed instances of boredom, e.g., Sarah pointing out that when *"they tell you to stand on your toes and slowly lower, you are bored out of your mind"*. Here, Jess explained that games were a *"fun way to get me moving [...] it wasn't like going to the gym, it was fun"*.

Here, participants highlighted the importance of movement-based games offering engaging and immersive experiences first, and incorporating physical activity second. Drawing on serious games, Paul pointed out how *"[some games] are very obviously teaching you math"*, and do not effectively mask the serious purpose of the game. Similar concerns were raised with respect to serious games specifically addressing wheelchair users, with Paul pointing out that *"I think that an issue that a lot of wheelchair users have with games, because obviously there aren't many they seem a bit hand-holdy sort of alienated in a way, it feels very specifically designed for wheelchair users while someone in a wheelchair could use it, when it's simple it seems obvious that it's for someone in a wheelchair"*. Along these lines, Jack suggests that games need to offer enough challenge to draw him in, and also points out how unsuitable interfaces break immersion.

Finally, participants highlighted the role of games as a means of escaping reality, and removing focus from their personal situation by switching it to the content of the game. For example, Simon suggests that the *"game is there for me to escape and forget what I'm doing [...] it allows me not to be reminded of what I look like"*. This suggests that a contributor to the enjoyment of play is the potential of games to shift player attention away from their own bodies, allowing them to immerse themselves in an alternative setting.

Participants highlighted features of some of our game concepts which were aligned with this theme, masking elements of exercise with engaging mechanics. For example, regarding our concept game Scavengers, Paul remarked, "with this [Scavengers] you are doing the exercises because it is a fun thing to do. Also, the actions you are doing seem more relevant to what's going on on the screen." Similarly, when talking about Kung Fu skateboarding and scavengers Simon stated "you don't think about doing these activities when you're playing the game like collecting these pizzas or fighting robots, so it becomes one more robot, one more robot, and you don't even realise you've done PA". Music and music interaction i.e., games being controlled by music was a highlighted mechanic that participants expressed would be good to see in other concepts such as making an endless runner controlled by music. Simon described "Ye there are some cool things you could do with music so in the skateboarding game music intensifies so there could be more cars on the road, and it becomes less … things to dodge if the music is slow"(Simon). While Jack expressed that "I like involvement of music well music in any game is gonna create some physical interaction with the player … with fast music your gonna be involved but with chill your gonna be less involved" (Jack).

3.5 Part 2: Online Survey

We followed up on the interviews through an online survey that included participation from a broader group of respondents in an effort to avoid missing important user groups in our work (see [31] for a criticism of IPA). The survey reflected interview topics, addressing physical activity, physical disability, and games, and was likewise structured around the game concepts (see Section 3.2).

3.5.1 Survey Description and Procedure. The online survey first provided basic information on the study and asked participants to provide informed consent. Afterwards, participants were invited to provide demographic information

including gaming preferences and their participation in physical activity, with statements such as *"I would consider myself physically active"* rated on 5-point Likert scales, with one being high. They were then presented with the game concepts in randomized order (see Section 3.2 for an example; all designs are provided in the supplementary materials), and asked to report their perspectives on the concepts. Additionally, participants were invited to reflect on all concepts in a final section of the survey. The survey was implemented using Qualtrics; the research protocol was approved by the <removed for anonymous review> ethics board. The survey was distributed via Facebook, Twitter and Instagram.

3.5.2 Respondents. Twenty-one people responded to the questionnaire (12 female, 8 male, 1 other; age range 18-64; all from Western societies including Europe, North America and Australia). Sixteen respondents were active wheelchair users (predominantly manual active chairs), and length of use ranged from less than six months to more than ten years, varying between continuous and occasional use. Participants reported medium to high perceived levels of PA (M=1.95, SD=0.84), with a strong emphasis on PA participation for health benefits (M=1.85, SD=1.08). Interestingly, not everyone enjoyed PA (M=2.47, SD=1.17). Participants reported a wide array of activities they take part in, such as basketball, archery, boxing, swimming and hand cycling. Engagement with games was relatively high (M=1.9, SD=0.97), with the majority of participants playing between 7-12 hours per week. Engagement with movement based or exertion games was lower (M=2.9, SD=1.37). Example of movement-based games participants had previously played include Beat Saber [14], Pokémon Go [43], and games on the Nintendo Wii and Switch consoles. Overall, participants reported a high interest in exploring movement-based games to support PA (M=1.28, SD=0.45).

3.5.3 Data Analysis. Qualitative data were analyzed using inductive thematic analysis [3, 4]. First the data was studied by the main researcher before important features of the data were coded. These codes were then examined and themes were identified. The themes were then reviewed and refined with the 5th author before being further defined by all authors. In line with the reflexive approach, data were coded by the main researcher. The main researcher is a young, white, heterosexual, CIS gendered male, with no disabilities from [Removed for anonymity]. A Gamer, a doctoral candidate and a XR developer, having an interest both design and development, and in accessibility from both a theoretical and an empathetical standpoint. They wouldn't consider myself an overly physical active individual but do play movement based games regularly and would consider them a form of PA. . Themes that were crafted were reviewed and discussed within the research team. In total, 183 data points were coded, applying 18 final codes which were refined into three overarching themes. Quantitative data (see above) were processed using SPSS.

3.6 Online Survey Results

Here, we present the main themes that were crafted during analysis. They focus on (1) The Central Role of Adaptation to Ensure Access and Adequate Challenge, (2) Social Play Needs to be Designed Carefully, and (3) Prioritizing Play over Physical Activity.

3.6.1 Theme 1: The Central Role of Adaptation to Ensure Access and Adequate Challenge. This theme summarizes respondents' comments on the potential of adaptation to provide levels of both accessibility and challenge that align with their personal situations and preferences for PA. Here, the theme of adaptation provided nuanced insights, focusing on the need for adaptive interfaces and interaction paradigms, while exploring the potential of adaptive game mechanics to deliver tailored play experiences. With respect to interfaces and interaction paradigms for movement-based games, many respondents highlighted that the movements afforded by our proposed concepts - which focused on upper-body movement - *"seemed achievable"*. However, we also observed instances where respondents highlighted concerns, e.g.,

with one person stating that *"It looks like my arm would ache and I would struggle to keep it out like that for a long time."* This reflects interview findings that suggest that individual adaptation is an integral step towards physically disabled players fully accessing movement-based play, and highlights that even when disability is taken into account at the time of system design, adjustments may increase accessibility for many, but still not include everyone. In terms of in-game challenge and game mechanics, we also observed individual preferences and needs. With respect to physical effort, some respondents stated that they would like to be challenged more, e.g., one respondent pointed out that *"I am very physically active, and it looks a tad to slow for me"*, and another stated that *"it didn't appear to be very cardio"* and *"Doesn't look very action packed"*. At the same time, respondents saw some benefit in the relative simplicity of the game concepts, for example, commenting that *"as long as the movements aren't too complex, I think this will allow people of different abilities"*, and suggesting that *"now I don't need to customise as much it's not as big a problem [Simple mechanics]"*. Hence, there exists a tension between accessibility for broad groups of players, and ensuring that every individual player is challenged according to their preferences and abilities.

3.6.2 Theme 2: Social Play Needs to be Designed Carefully. This theme highlights that respondents considered playing with others a source of engagement, but were likewise aware of instances in which careful design considerations would need to be made to ensure that instances of social play remained a positive experience. With respect to the benefits of social play, respondents suggested that *"Social engagement is always nice"*, and that *"Everything is funnier with friends"*. With respect to the game concepts, they suggested they would like to *"maybe play with [others] every now and then"*, and that Kung Fu Skateboarding *"Would be a good multiplayer game"*. Additionally, respondents highlighted the benefits for people who found it difficult to leave the house, *"[social play] is a good thing, some disabled people probably feel more isolated than your average person, particularly if they are stuck in the house a lot"*. However, this was contrasted by individual preferences for solitary play, e.g., *"I do like playing with other people but it's not always a need for me as I mostly play a lot of single player games"*, which was related to independence, with one respondent pointing out that when playing alone, *"I don't have to rely on others"*. Likewise, participants expressed a need that disclosure of disability and competition should be taken into careful consideration, with one respondent pointing out that *"I strongly dislike this form of inspiration. THEY had MS, but THEY still climbed a mountain [...] well good for them. People should not be encouraged to compare them-selves to others"*. Therefore, we conclude that social movement-based play may engage some players, but deter others, and designers need to carefully consider their target audience and deployment context.

3.6.3 Theme 3: Prioritizing Play Over Physical Activity. This final theme was constructed to highlight respondents' preference for movement-based games that prioritize player engagement and the provision of positive playful experiences over those that foreground physical activity. Respondents expressed a distinct desire to have fun and take part in a positive experience, stating that they wanted to play a *"game that's a game and not an exercise routine"*, with one participant detailing that they *"think the exercise element of the game [...] to a certain extent should be hidden, as we can work out a lot longer if we don't focus on the physical activity itself that we are doing, which really good gameplay should take care of"*. Other respondents were in agreement with that perspective, e.g., *"Most important is that I don't think of it as only exercise"*, and *"As a gamer, I find the gaming aspect most important"*, highlighting the relevance of positive player engagement, e.g., *"I won't play a game that isn't fun"*. Here, some respondents viewed their own enjoyment and engaging in exercise as opposites, which was also reflected in perspectives on our game concepts, with those that foregrounded physical activity receiving more negative feedback.

3.7 Summary of Key Findings

The key findings from our two-step research process highlight three main elements that need to be accounted for when designing movement-based games for physically disabled players. (1) Both interviews and online survey underline the importance of **meaningful, individual adaptation** that allows players to adjust interaction paradigms and in-game challenges to their needs. For example, players might struggle with specific movements and giving them an opportunity to replace them with more suitable ones would ensure game accessibility. Likewise, participants highlighted how good adaptation would ensure adequate challenge, i.e., pushing each player according to their individual limits. (2) Our results show that **social play is not universally positive**, with disabled people recounting instances of being physically active that were stigmatizing rather than empowering. Hence, social aspects of movement-based play need to be designed with care. (3) Participants broadly highlighted that **movement-based games need to be engaging first, and physically challenging second**, suggesting that they would like to see play prioritized over exertion, and that this approach offers the opportunity of masking physical activity which is sometimes perceived as uncomfortable.

4 A REVISED SET OF GUIDELINES FOR MOVEMENT-BASED GAMES FOR PHYSICALLY DISABLED PLAYERS

On the basis of our work, we now discuss implications for the design of movement-based games for physically disabled players. We draw from our findings to review and contextualize the set of guidelines provided by Mueller and Isbister [41]. We organize this section around the existing guidelines split into two categories, (1) movement requires special feedback, and (2) movement leads to bodily challenges. For each guideline, we include our own commentary as to how they do or do not address the needs and preferences of physically disabled people, and how they need to be interpreted in the context of physical disability.

4.1 Set 1: Movement Requires Special Feedback

Within this category, Mueller and Isbister [41] summarize recommendations that inform researchers and designers about how players engage with movement-based games, and provide insights into how to achieve an engaging player experience.

4.1.1 Guideline 1: Embrace Ambiguity. "Instead of fighting the ambiguity of movement [in execution and sensor data], embrace it." [41, p. 2193] Our results show that heterogeneity in movement execution is particularly relevant for disabled players, not just in terms of articulation of one particular movement, but also with respect to an individual's ability to produce a specific movement that is expected by the game. Additionally, prior research has demonstrated that sensor precision is poor for disabled people [29]. Therefore, **we recommend that this guideline is given particularly close attention when designing for physically disabled people.**

4.1.2 Guideline 2: Celebrate Movement Articulation. "Celebrate how well players articulate movement, and the joy of movement, by giving feedback on movement quality moment-to-moment." [41, p. 2194] Our findings highlight the heterogeneity of player abilities, and while movement articulation should be articulated, this needs to be done in the context of the specific player and not on the basis of pre-defined performance thresholds. Hence, when designing for physically disabled players, **this guideline needs to be applied with nuance, paying special attention to the way that movement quality is assessed.**

4.1.3 Guideline 3: Consider the Cognitive Load of Movement. *"Moving can demand a lot of mental attention, creating high 'cognitive load', especially when learning new moves. Don't overload players with too much feedback."* [41, p. 2194] Our data suggests that this guideline is also relevant for physically disabled players, e.g., we observed instances of participants highlighting slower translation of movement by their body. Therefore, **we recommend to fully embrace this guideline.**

4.1.4 Guideline 4: Focus on the Body. *"Focus on the body, not just the screen, when designing player feedback."* [41, p. 2195] Our results directly contradict the recommendation to draw audience or player focus to their bodies: the physically disabled people who took part in our research neither appreciated when others watched them engage in physical activity, nor did they want to be aware of their own bodies while playing. Therefore, we recommend to **not place additional emphasis on player bodies when designing for physically disabled persons.**

The challenging role of social settings is also picked up in the context of the corresponding guideline (section 4.2.6), and in the discussion (section 5.1) we provide critical reflection on the push and pull of social settings in the context of disability.

4.2 Set 2: Movement Leads to Bodily Challenges

This category of guidelines specifically focus on the implications of movement-based play for player bodies [41].

4.2.1 Guideline 1: Intend Fatigue. *"If you use fatigue as a game challenge, make it intentional rather than incidental."* [41, p. 2195] Our results fully support this guideline, and add further nuance: when designing for physically disabled players, designers need to be aware that some players may experience fatigue quickly, and that it may also extend to pain. At the same time, our data support the notion that players want to be challenged and push themselves, suggesting that designing for the absence of fatigue is not a viable strategy. Hence, we recommend that **designers carefully playtest the level of fatigue caused by their game, and reflect on potential exclusionary consequences for certain groups of players.**

4.2.2 Guideline 2: Exploit Risk. *"Exploit physical risk sensibly."* [41, p. 2195] Our results suggest that many disabled players are at risk of experiencing pain during physical activity, shifting the original focus from risk that is inherent in constrained indoor environments (e.g., bumping into furniture) to the risk that specific game mechanics may pose to the bodies of individual players. At the same time, the thrill of risk (see [41, p. 2195]) will appeal to certain players, with some participants in our work taking part in high-contact and genuinely risky sports such as Rugby. We therefore argue that designers should **embrace and extend this guideline, carefully reflecting on risk for players with physical disability to identify appropriate game mechanics, but not pre-emptively avoiding risk altogether.**

4.2.3 Guideline 3: Map Imaginatively. *"Map movements in imaginative ways."* [41, p. 2196] For games that do not require realism, the original guideline suggests to map movements in ways that amplify player input, or make possible actions that cannot be done in real life. Our results support this notion in the sense that movement-based games can replace movements not possible for disabled players. However, our findings contradict the second element of this guideline, i.e., that it should not be applied in case of simulation (e.g., sports simulations). For physically disabled players, this would lead to the reproduction of access barriers experienced in the real world. Therefore, we recommend to **not just map imaginatively, but to map accessibly, prioritizing adequate player access to gameplay over movement realism.**

4.2.4 Guideline 4: Highlight Rhythm. "Help players identify rhythm int heir movements." [41, p. 2196] Our results strongly support this guideline, suggesting that music was a key factor that participant perceived as motivating and engaging in movement-based play. We thus conclude that **designers should fully embrace this guideline.**

4.2.5 Guideline 5: Support Self-Expression. "Support players in expressing themselves using their bodies." [41, p. 2197] This guideline highlights the importance of self-expression, and recommends to give players leeway in performing different movements that all lead to a similar outcome within the game [41, p. 2197]. In the context of physical disability, this is particularly important as not all players will be able to perform specific movements (e.g., engaging in two-handed vs. one-handed input). Hence, **this guideline is highly relevant, not just as a means of improving player experience, but to ensure basic access.** It should be applied meticulously and with attention to access barriers associated with certain movements (e.g., requiring players to move both arms, or including mandatory locomotion).

4.2.6 Guideline 6: Facilitate Social Fun. "Facilitate social fun by making movement a social experience." [41, p. 2197] Our results suggests that the notion of social fun needs to be carefully addressed. While the authors suggest to turn the game into *"a spectacle others enjoy watching"* [41, p. 2197], physically disabled participants reported that being physically active in the presence of others was uncomfortable exactly because of being viewed as said spectacle (e.g., by strangers in the gym), an aspect that is well-researched in the context of traditional physical activity (e.g., see [45]). However, participants did point out that they would be interested in playing together with family and friends. In conclusion, we reject the initial call of the authors to *"make the game a spectacle"* [41, p. 2197], instead **prioritizing players' comfort zones and facilitating optional social fun that does not turn disability into a spectacle.**

5 DISCUSSION

In this paper, we explored physically disabled players' perspectives on movement-based games through interviews and an online survey, with the goal of contextualizing an existing guidelines for the design of movement-based games - the set proposed by Mueller and Isbister [41] - according to their insights. With respect to the two research questions that we raised, we therefore conclude the following.

RQ1: How does physical disability need to be accounted for in movement-based games? Our results suggest that physical disability primarily needs to be accounted for in movement-based games through inclusion of opportunities for players to adapt games to their individual needs. This includes adaptation of interaction paradigms to maintain game accessibility (e.g., replacement of movements that are not feasible), and adaptation of game mechanics (e.g., adjusting for player performance over time). Here, our results show that players want to be challenged *adequately*, which implies that for some players, physical challenge needs to be reduced, while it has to be increased for others. Likewise, our findings suggest that certain game features (e.g., options for social play or strong emphasis on physical activity rather than on play) may not be universally engaging for physically disabled players, and that tedious setup routines of many hardware solutions to support movement-based play continue to pose a barrier to play, suggesting - many years after the release of the first movement-based gaming systems - we still need lightweight solutions that facilitate independent system setup.

RQ2: How do guidelines for their design need to be adjusted to include physically disabled players? Our work suggests that existing design guidelines for movement-based games - in our case, those by Mueller and Isbister [41] - generally address features of movement-based games relevant to physically disabled players, but that they do not not account for the experiences of physically disabled players in their nuances (as they are largely based on the perspectives of non-disabled people). Hence, there is a need to carefully contextualize existing design recommendations.

In particular, we observed instances where feedback from our participants directly contradicted design advice (e.g., focusing on players' bodies and turning games into a 'spectacle' - see section 4.2.6), and recommendations that were thought to improve the player experience of non-disabled players that would be a fundamental access requirement for disabled players (e.g., allowing players to substitute movements - see section 4.2.5).

In the remainder of this section, we will discuss implications of these findings for the design of movement-based games, and we will reflect on the inclusion of accessibility considerations in mainstream game design recommendations.

5.1 Designing Movement-Based Games for Physically Disabled Players: Reflections on Adaptation and Social Play

On a general level, our results suggest that people with physical disability see potential in movement-based games as a means of providing physical activity while addressing some of its unappealing elements. However, for games to be accessible, we illustrate that **adaptation is one of the key factors for disabled people to be able to participate in play**, which is in line with previous findings on movement-based game interfaces for disabled persons (e.g., see [28], [16]). In order to achieve flexible designs, a number of design considerations need to be made, for example with respect to input mapping and the overall structure of gameplay, i.e., how players are challenged throughout. Here, more flexible interaction paradigms and adaptive game mechanics (e.g., leveraging dynamic difficulty adjustment to adjust bodily challenge [46]) may offer a first step toward adaptive movement-based games. However, given the heterogeneity of preferences and needs that participants reported in our work, this approach needs to be explored with care, examining to which extent it can replace individual adaptation, how algorithms would need to be adapted, and which groups of players would still be excluded from play. Additionally, **social elements of play were a controversial topic**, contradicting previous findings summarized in mainstream recommendations for movement-based play (see section 4.2.6), and those specifically addressing playful physical activity for wheelchair users [36]. Our findings suggest that negative perspectives toward movement-based play particularly in public settings are a result of stigma that physically disabled people experience when engaging in physical activity (e.g., see [21]). While one might argue that games could serve as a vehicle to *reduce stigma* in this setting, we argue that it is important to put engaging experiences for disabled players first, and therefore recommend that designers carefully weigh the risks and benefits that social forms of play hold for the play experiences of physically disabled people.

5.2 Including Accessibility Considerations in Mainstream Design Recommendations

In the past, accessibility guidelines have frequently been maintained outside of the body of mainstream game design considerations. Here, our work serves as an example of how accessibility considerations can be integrated in existing game design recommendations, offering the opportunity of considering the experiences of disabled players alongside those of non-disabled players. This supports the idea of **turning accessibility into an ongoing rather than a post-hoc design consideration** [19]. However, this comes with the challenge of updating and revising existing recommendations, which are often based on non-disabled experiences (e.g., the guidelines used in our work [41] neither explicitly nor implicitly - for example, by choice of games used to illustrate guidelines - reflect on the role of disability). Here, one risk is that by grounding one's work in guidelines created for non-disabled players, core issues relevant to disabled players are overlooked. In our process, we counteracted this potential pitfall by starting from the (anticipated or recalled) play experiences of physically disabled players, and contextualizing the guidelines on this basis, rather than grounding our questions in the existing guidelines in an effort to directly review them. Likewise, our results suggest that disabled and non-disabled players may have conflicting preferences and needs with respect to

core design choices (e.g., viewing movement-based play as a performance for others to observe). This highlights that **guidelines incorporating both disabled and non-disabled perspectives can be a starting point for design, but that conflicts and challenges remain for designers to be resolved in the process**. By contrasting our findings the existing set of guidelines, our work makes explicit where normative assumptions are made about moving human bodies, and draw the attention of designers to these instances. It can further help highlight the difference between fundamental access challenges, and aspects that would contribute to player experience, supporting the prioritization of designs that are inclusive of and engaging for the broadest possible group of players. Ultimately, the integration of accessibility considerations into mainstream game design recommendations is another step toward the creation of games that do not specifically address disabled players, something which aligns with previous research on the preferences of disabled players (e.g., see [6]), and is also reflected in our data with participants suggesting an interest in movement-based games in general, but not so much in play experiences that are specifically targeting disabled players.

6 LIMITATIONS AND FUTURE WORK

Our work needs to be interpreted in the light of a number of limitations. Most importantly, the interview and survey stages of our research focused on wheelchair users; we did not include other groups of disabled people, e.g., individuals with limited upper-body mobility, or persons using other kinds of assistive devices. Likewise, our game concepts are somewhat limited in terms of movement integration, and there are other approaches (e.g., location-based games) that were not explored. Here, future work can build on our findings to further examine relevance of design guidelines. Likewise, we only worked with game concepts rather than fully implemented prototypes during the interview stage. To further ground our reflections on movement-based game guidelines for physically disabled players, we recommend implementing and evaluating case studies of accessible movement-based games to further validate our findings. With respect to examining design guidelines, we decided to focus on those by Mueller and Isbister [41] as the most prominent example that would allow us to create focus in our work, but of course there are other pieces of work in this space (see section 2.3) that should be reviewed. Finally, we only address physical disability in our work, and do not yet include other disabled people, e.g., persons with sensory disabilities or neurodivergent people. Here, we see potential for further reflection on how different groups of people engage with movement-based games, and which elements of play help or hinder positive and engaging play experiences.

7 CONCLUSION

Movement-based games offer an opportunity for physical activity, and our work makes a contribution toward ensuring accessibility of such systems for disabled players, not just on the level of basic system access, but also in terms of engaging play experiences. Based on a mixed-methods enquiry combining semi-structured interviews with an online survey, we highlight how existing recommendations for the design of movement-based games for non-disabled players need to be adjusted to also take into account the needs and preferences of physically disabled players. Here, our work serves as a first step toward identifying game features and mechanics that need to be designed with more nuance when wishing to include physically disabled players in mainstream movement-based play (e.g., offering modes of play that allow players to avoid directing uncomfortable focus onto the body, be it from the perspective of themselves, co-players or bystanders), which is crucial if researchers and designers are to create movement-based games that accommodate players with a range of bodies and gaming preferences.

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