Enhancing Physical Activity: Autistic Perspectives on Co-Designing Applications

by

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A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

In partial fulfilment of the requirements of the degree of

MASTER OF ARTS

Department of Psychology

University of Manitoba

Winnipeg

Abstract

People with Autism Spectrum Disorder (ASD) often do not engage in the recommended levels of physical activity compared to their neurotypical peers. Although these patterns are more pronounced in adolescence and adulthood most of the research has focused on the experiences of children. Using Interpretive Phenomenological Analysis and co-design methodology, the current study explored the experiences of adolescents and adults (N = 4) by conducting a series of workshops and asking participants about their physical activity engagement. It also introduced two physical activity applications, Move Improve and Exercise Buddy and asked participants to provide feedback and general guidance about what app features they found useful. Participants were also asked to share their experiences being part of a co-design study. The primary goals of this research were to elucidate the experiences of individuals on the spectrum when using apps designed to improve physical activity. Given the unique methodology employed, it also aimed to understand autistic perspectives on codesign research methods. Finally, the research intended to explore barriers and facilitators of physical activity from those on the spectrum. Findings from the current study highlighted the need for app customization features and detailed research outlines to facilitate both app engagement and research participation.

Keywords: Autism Spectrum Disorder (ASD), Physical Activity (physical activity), Apps, Co-design

Co-designing Physical Activity Applications for Individuals with Autism Spectrum Disorder

Introduction

Autism Spectrum Disorder (ASD) is developmental disorder characterized by difficulty with social interaction and communication as well as repetitive behaviours, notably restricted interests and sensory challenges (American Psychiatric Association, 2013; DSM-5-TR, 2022). Prevalence rates of ASD have increased steadily over the last few decades due to increased awareness, reporting, and improved diagnostic processes including adult diagnoses (Matson & LoVullo 2009; Russel et al., 2022). Consequently, there has been an increase in ASD related research (Kim, 2021). Historically focused on etiology, more recent studies have shifted to translational research centered around enhancing the lives of those with ASD (Matson & LoVullo 2009; Singh et al., 2009).

While an overwhelming amount of ASD research has neglected the experiences of adults and focused on early childhood and adolescence, particularly programming as well as managing social, emotional, and behavioral deficits (Graff et al., 2013; Kim, 2021; Zhu et al., 2021). The research on these age groups offers insights into the challenges and experiences of adults with ASD. For example, children with ASD often struggle with gross motor movements because of delayed motor development and poor posture (Abu-Dahab et al., 2013; Bhat et al., 2011; Dewey et al., 2007) and are less proficient in balance and coordination compared to atypical peers (Somogyi et al., 2016; Travers et al., 2013). These challenges, in combination with the social aspects required of many sports programs, mean that children and young adults with ASD are often not meeting the recommended physical activity guidelines and are more likely to be

sedentary compared to typically developing peers (Healy et al., 2018; Nichols et al., 2019). These findings mirror those of adults with ASD who also tend to be less physically active than peers, have higher rates of obesity, poorer cardiovascular health, and various other health-related challenges (Croen et al., 2015; Zheng et al., 2017).

Physical Activity and ASD

Physical Activity is a recommended, safe, and cost-effective method of combatting the consequences of a sedentary lifestyle. Its benefits include improved well-being and quality of life (Bhat et al., 2011). Specifically, physical activity interventions have demonstrated improvements in motor performance, physical activity levels, language development, social interactions, mood, sleep, and cognitive development (Brand et al., 2015; Ferreira et al., 2018; Healy et al., 2018; Yanardag et al., 2013). However, participation in physical activity remains low for people with ASD for several reasons (Dieringer et al. 2017; Nichols et al., 2018). First, many individuals with ASD struggle with physical literacy, which comprises of the knowledge, skills, motivation, and confidence to engage in physical activity (Durden-Myers et al., 2018).

Secondly, in relation to skills, teaching the skills needed for physical activity can be challenging for parents, teachers, and therapists due to difficulty motivating and retaining the focus of learners with ASD (Dieringer et al., 2017). Further, physical activity becomes harder as children with ASD get older due to a widening gap in skills compared to typical-developing peers and sports becoming more competitive (Raitakari et al., 1994; Shields & Synnot., 2016). As a result, inactive children are likely to maintain a sedentary lifestyle as adults (Raitakari et al., 1994; Shields & Synnot., 2016). The use of technology has expanded in recent decades and various technological innovations have been developed to address some of these issues (Porayska-Pomsta., 2012).

A review of the extant literature shows that there are a range of barriers that hinder physical activity engagement and facilitators that promote physical activity for individuals with ASD (Nichols et al., 2019; Shields et al., 2011). One of the first steps towards understanding physical activity levels and engagement involves exploring these barriers and facilitators because to increase participation there must be some understanding of why people do not participate in physical activity in the first place (Shields et al., 2011).

ASD and Physical Activity Facilitators

Physical activity facilitators that have been identified include desire to be fit, enjoyment of physical activity, skill practice, family support, peer involvement, skilled staff, accessible facilities in proximity, structured programs, social interaction, and small or individual programs that were non-competitive (Shields et al., 2011; Shields & Synnot., 2016). Technological supports such as Fitbits have also been identified as facilitators to physical activity (Lalonde et al., 2014; Savage et al., 2022).

Shields et al. (2011) note that traditionally there has been a greater emphasis placed on the barriers rather than the facilitators. The authors suggest that less emphasis should be placed on barriers as some of those are inexorable and focus should be on facilitators instead as these can inform practice and policies (Shields et al., 2011). In addition, understanding facilitators is particularly important when leveraging the power of technology.

ASD and Physical Activity Barriers

Shields and Synnot (2016) found that the barriers experienced depend on whose perspective you take, and like much of the work in other areas of ASD, the focus has been on children. As a result, the perspectives of children, their parents and caregivers (Gurkan & Kocak., 2020; Nichols et al., 2019), teachers, activity instructors and physiotherapists have been

solicited (Shields et al., 2012). The reasons behind reduced participation of physical activity in individuals with ASD are complicated and multifaceted, evidenced by children and young adults identifying more personal level barriers and parents identifying more systematic or program level barriers such as inadequate programs or poor policy (Shields & Synnot, 2016). Additional identified physical activity barriers include supervision difficulties (Healy et al., 2018), time constraints, behavioral problems, motor skill deficits, lack of experts and peer partners, lack of transport, poor facilities, negative attitudes of staff, preference for other activities, lack of programs, costs, fear, and inadequate knowledge about physical activity (Healy et al., 2018; Shields et al., 2011; Shields & Synnot., 2016). Furthermore, many individuals with ASD struggle with physical literacy, which comprises the knowledge, skills, motivation, and confidence to engage in physical activity (Durden-Myers et al., 2018).

Many traditional in-person physical activity programs have issues with scalability and sustainability due to requirements of specialized settings, equipment, and personnel (Healy et al., 2018). Another disadvantage of these programs is that, like most interventions in ASD research, they target children and adolescents, ignoring the needs of adults, particularly older adults. Additionally, the Covid-19 pandemic highlighted the need for individuals to be proactive about their own physical activity rather than have complete reliance on programs. Technology has been used as a tool to endorse and increase physical activity for people with ASD and can be viewed as a direct solution to some of the barriers previously mentioned (Porayska-Pomsta., 2012).

Physical Activity Facilitators and Barriers: Gaps in the Literature

Only a few studies have examined both barriers and facilitators to physical activity from the perspective of adolescents and adults with ASD. The studies that have looked at physical activity levels have grouped together individuals with a wide range of intellectual disabilities or

have focused on comorbidities or specific medical conditions (Shields et al., 2011). Of note the Covid-19 pandemic has impacted many lives and we have yet to explore in depth what ways this has affected the inactivity and physical activity levels of individuals with ASD.

Technology Use

Technology in the ASD field is continually and rapidly advancing (deLeyer-Tiarks et al., 2023; Porayska-Pomsta., 2012) with many positive results. For example, applications (apps) are cost effective compared to specialized programs and readily available on mobile devices and tablets negating the need for travel and transportation arrangements. Lalonde et al., (2022) demonstrated that a treatment program that involved teaching young adults with ASD to self-monitor their walking goals using exercise technology was successful. It is, however, vital to assess the functionality and adaptability of products being developed (Parsons & Cobbs., 2011). It has been argued that research tends to focus on the potential of technology rather than its effectiveness when in some cases technological innovations lack ecological validity (i.e., how well research findings translate to real world situations (Bossavit & Parsons., 2018; Parsons & Cobbs., 2011). In a review of commercially available apps for individuals with ASD, Kim et al., (2018) noted that there were no scholarly references providing information for this population, meaning only a few apps had been systematically tested and focus is on feasibility rather than efficacy. App developers need to question if apps are beneficial for their intended users, and if users are engaged and motivated to continue using a particular product. One of the most efficient ways to answer those questions and avoid user abandonment is to proactively engage intended users in the design process before official product or app release (Parsons & Cobbs., 2011). The risk of user abandonment for assistive technologies by people with ASD is significantly lower with user-involvement in the design process (Francis et al., 2019).

Applications for ASD

There are between 2.2 and 3.5 million apps available for Android and iOS users, of these hundreds target ASD (Kim et al., 2018). Consistent with ASD research, a disproportionate number focus on the needs of children (Kim et al., 2018) and most are designed to teach and strengthen social, academic, and activities of daily living (Grynszpan et al., 2014). A review of applications offered on apple products (ipods, ipads, and iphones) for individuals (including adults) with developmental disabilities and particularly ASD found that they could be grouped into five categories: academic, communication, employment, leisure, and transitioning skills (Kagohara et al., 2013). It can be assumed that applications offered by android devices also fall into these major categories. Interventions and applications are so focused on the targeting these five domains that they have almost ignored other aspects of the wellbeing of the autistic community.

Physical Activity Apps and ASD

There is another category of apps that focus on the health of people with ASD. However, it pales in comparison to the other categories in terms of available apps and content offered. Physical activity is an essential part of health and most (physical) health apps are designed to offer the same repetitive functions of allowing users to monitor their BMI, weight, height, medications, eating, calorie and water intake, sleep, mood, steps taken, and remember doctor appointments.

There are a few apps designed specifically to enhance physical activity in individuals with ASD, and others such as Pokémon Go, that have affected physical activity indirectly (Wingenbach et al., 2022). Some physical activity apps, such as Move Improve and Exercise Buddy (see Tables 1 and 2), were designed specifically for people with ASD and focus on

building motor skill competence by breaking down skills necessary to engage in various types of physical activity. These apps address concerns caused by poor physical literacy and include visual learning, an effective method of teaching individuals with ASD new skills (Bennett., 2017; Gies., 2012). Additionally, these apps, particularly Move Improve, are designed to be used with a peer. Physical activity interventions for adolescents found parental involvement to be beneficial, suggesting involvement of family, friends, or anyone close to the individual can have the same effect (Healy et al., 2018). Previous research conducted on these apps concentrated on their physical activity outcomes and found they were beneficial to users (Bennett., 2017; Rafiei et al., 2021). In this study, I gathered information directly from people with ASD to identify strengths and weaknesses of the features and functionality for Move Improve and Exercise Buddy.

Pokémon Go

Pokémon Go, a mobile game that uses augmented reality and geocaching requires players, called Pokémon trainers, to physically move around to catch fictional characters called Pokémon. It is the most well-known app, attracting 65 million users within one week of being released (Serino et al., 2016). Because it targets the walking behavior of Pokémon go trainers, several studies have examined its influence on physical activity and found that users increased their physical activity levels particularly if they had sedentary lifestyles prior to app use (Althoff et al., 2016; Nigg et al., 2016). These increased levels of physical activity were true across gender, weight, and prior physical activity levels but were more pronounced among younger users (Althoff et al., 2016). Ma et al. (2018) found that the increased physical activity benefits of Pokémon Go were short-term. In contrast to other studies their sample included more adult users,

suggesting that despite its popularity it may not be engaging for adults, particularly older adults (Ma et al., 2018).

Although most studies (Althoff et al., 2016; Ma et al., 2018; Nigg et al., 2016) that have examined the effects of Pokémon Go have focused on the physical activity benefits on the general population there are some implications for individuals with ASD. For example, findings that the app was particularly helpful to users who had sedentary lifestyles before using it (Althoff et al., 2016) suggest that Pokémon Go may have benefitted the autistic community. However, research and blogs about Pokémon Go and ASD have focused on social interaction, anxiety reduction and perceived life satisfaction rather the physical activity benefits of this app (Organization for Autism Research, 2016; Wingenbach & Zana, 2022).

Move Improve

Move Improve is a video modelling platform available on smart phones and tablets that delivers learning opportunities and is designed to enhance skill performance (L. Katz, personal communication, March 18, 2021). It enables the giving and receiving of feedback through peer-to-peer interactions by breaking physical skills into simple components and learners can use a structured approach to discussing and assessing performance (Thacker et al., 2021). A model video and a component list are provided for each skill. One peer creates a video recording of the other peer performing the skill. Then, together they evaluate the performance and gain insights into how to improve. They can then reverse roles. Each component has three possible ratings (yes, partial, no) to indicate whether the movement has been performed correctly, parts of it have been performed correctly, or when it has not been performed correctly (Hillis et al., 2022). Past research participants reported enjoying the ability to see themselves performing various movements (Thacker et al., 2021). Move Improve users can choose from a variety of skills in a

range of categories such as injury prevention, basic gymnastics, specific sports (such as volleyball essentials), and fundamental movement skills such as learning to kick. Previous research suggests this app is user friendly and enjoyable to use, and it requires no previous sports knowledge (Thacker et al., 2021). Additionally, based on observation, course instructors of students who used the app noted how quickly they seemed to be learning the physical activity skill components (Rafiei et al., 2021).

Exercise Buddy

Exercise Buddy was designed to mitigate the communication and social challenges that might prevent individuals with ASD from engaging in physical activity by communicating exercise, gross motor skills, and physical activity using familiar structured teaching systems through integration of visual support and visual modeling (D. Geslak, personal communication, March 21, 2021). Exercise Buddy incorporates components of behavioral-based techniques such as visual scheduling (first/then) and reinforcement through audio feedback, for example the app tells users to “keep it up” (Bassette et al., 2020). It was also intended to be a tool for providing physical activity training techniques to parents and teachers of children with ASD, with over 180 exercise videos, varying in length and complexity, so that users can benefit from it even if they have had no experience teaching physical activity (Bittner et al., 2018). Previous research with adolescents and young adults demonstrated that Exercise Buddy was valuable for users by increasing their ability to perform physical activity skills independently (Bassette et al., 2018).

Research Approaches

Research with individuals with disabilities falls into three main categories: non-participatory, participation via proxy, and full participation (Frauenberger et al, 2012). Traditionally the most common approach was non-participatory research driven by theory, where

the perspectives of experts in the field and those with prior experience of the condition were considered without inclusion of those affected by the disability (Frauenberger et al., 2012; Robb et al., 2021). Recently, the other two approaches are emerging as commonly used methodology (Robb et al., 2021). Participation by proxy is a method that has been used extensively as it draws on the perspectives of those with intimate knowledge of the research population such as parents, teachers, and caregivers (Frauenberger et al, 2012). Full participation, in contrast to what the name implies, refers to any level of involvement that allows the population of interest to have an impact on any of the outcomes (Frauenberger et al, 2012). There are a variety of terms used to denote participant involvement in research including: user-centered design, participatory co-design, informant design, design-thinking, and emancipatory design (Fabri & Satterfield, 2019; Robb et al., 2021).

Co-design and Participatory Research

Co-design and participatory design are often used interchangeably to describe a specialized approach in which the users of a product are consulted in the design process (Benton et al., 2012; Fabri & Satterfield, 2019). A well-planned co-design is one that distributes power among all members of the research team, which includes participants and recognizes that participants are experts in their lived experience (Fabri & Satterfield, 2019; Robb et al., 2021). Research emphasis has highlighted the need for researchers and developers to adopt this method due to understanding the importance of an efficient design process as users can give feedback before a product is finalized (Robb et al., 2021). Additionally, it fosters inclusive research practices (Robb et al., 2021). Bossavit and Parsons (2018) found that adolescents with ASD who did not participate in co-designing a game gave the same favorable ratings as the adolescents with ASD who had participated in the co-design process. Their findings highlight that the

benefits of co-design extend beyond the needs and preferences of those directly involved in the design process and can be generalized to target (Bossavit and Parsons, 2018). There is also evidence of the benefits of co-design with autistic children, adolescents and adults enjoying the co-design experience because they found it interesting and engaging and the process made them feel valued, safe, and that they contributed in meaningful ways to a product intended for them (Benton et al., 2012; Zhu et al., 2018; Zhu et al., 2022).

However, experts have acknowledged the potential challenges that traditional co-design methods may pose when applied to an autistic population for both research participants and researchers; therefore, co-design methods may need additional considerations and modifications to allow individuals with ASD to maximize their participation (Francis et al., 2009). One modification used by researchers is the inclusion of an assistive/assistant peer, someone of the participants' choice, in the co-design process (Francis et al., 2009; Zhu et al., 2022). Studies with children and adolescents typically include a parent or caregiver but have also included teachers, physical education teachers, special program facilitators, speech language pathologists and physiotherapists (Boster & McCarthy., 2018; Shields et al., 2021). The heterogeneity of ASD dictates that individuals have varying social and communication challenges and may require assistance from those familiar with them to participate (Fabri & Satterfield., 2019). Despite limited research with adults, child literature suggests that adults may also benefit from a partner. There has been a greater emphasis on the need for research collaboration with all stakeholders but as a relatively new method there needs to be better understanding of what constitutes good co-design practice for people with ASD so that the benefits of technology can be leveraged to enhance their lives (Francis et al., 2009; Robb et al., 2021).

Purpose

The primary purpose of this study is to provide app developers with feedback and guidance directly from people with ASD about the utility of features and functions so future apps are engaging and user friendly. For the past few years, experts have been recommending that intervention designs should consider expansion to more members of the autistic community, not just young children, and advocate for direct involvement of people on the spectrum in research about them (Graetz., 2010; Gerhardt & Lainer., 2011). With the widespread use of technology, it is also important to assess the merits of innovations being promoted, specifically when apps claim to enhance the physical activity engagement of people with ASD (Parsons & Cobbs., 2011). Additionally, results may also provide researchers with insights about how to design appropriate and inclusive co-design studies with individuals with ASD as there is limited guidance on how researchers can plan effective co-design studies with this population.

Secondly, the current thesis aims to determine the barriers and facilitators of physical activity from the perspectives of older adolescents and adults with ASD. The challenges of physical activity for these individuals are well documented from a physical health perspective; however, it is important to explore the issues from the viewpoint of those directly impacted (Croen et al., 2015; Zheng et al., 2017).

Method

Study Design

This qualitative thesis is anchored in co-design and participatory research. This approach holds potential to provide an appropriate method for people with ASD to contribute to research, particularly given the tendency for autism researchers to gather information from caregivers rather than people on the spectrum themselves (Shields & Synnot, 2016). These approaches are

designed to engage participants directly in research to ensure diverse and marginalized perspectives are reflected in research. Additionally, researchers aim to be neutral observers in the process, which is conducted using focus groups.

The data for the current thesis was part of a larger Social Sciences and Humanities Research Council (SSHRC) funded study. Two semi-structured workshops in which participants had an opportunity to share their physical activity, app use and co-design participation experiences were conducted. Discussions were guided by open-ended questions surrounding barriers and facilitators, experiences using MI and EB, as well as insights about the co-design process in general (see procedures below for more information on specific steps).

The study employed Interpretive Phenomenological Analysis for both data collection and analysis. Interpretive Phenomenological Analysis is a qualitative analysis approach that focuses on exploring lived experiences and views participants as experts in the phenomenon being studied (Hefferon et al., 2006; Smith et al., 2009). It allows researchers to work with highly specific samples to answer broad research questions but also provides information about nuanced topics (Hefferon et al., 2006; Noon, 2018; Smith et al., 2009). Interpretive Phenomenological Analysis is an iterative process that involves reviewing data multiple times to identify themes and subthemes (Noon, 2018). Interpretive Phenomenological Analysis was used to interpret the data because the focus is gathering insights from participants on the barriers and facilitators that impact their physical activity to understand their experiences using apps and being part of a co-design study. Given the exploratory aim of this thesis to better understand physical activity and research participation from the perspectives of individuals with ASD, this is an appropriate method to conceptualize perspectives as it focuses on individual experiences.

Participants

In line with recommendations for efficient co-designs involving people with ASD (Francis et al., 2009), four pairs of participants, with each pair consisting of one person over the age of sixteen with ASD and their assistive peer, participated in the study (N = 8). The participants with ASD (see Table 3) ranged in age from 16 to 27 years (M = 21.50), while the communication partners' ages ranged from 44 to 66 years (M = 55).

Recruitment

Recruitment posters were circulated in Calgary, through Autism Asperger's Friendship Society (AAFS), and Sinneave Family Foundation (See Appendix A). One pair of participants were known to a member of the research team and recruited through convenience sampling. Convenience sampling is a method of sampling where research participants are included in a research study due to easy accessibility (Jager, Putnick, & Bornstein, 2017).

Table 3

Participant Table

ID	Age	Gender	Weekly Physical Activity	Communication Partner
Lauren	18	Female	Once a week	Erin
AA	16	Female	>3x per week	Nancy
Nick	25	Male	>3x per week	Pamela
Benjimjam	27	Male	Not Applicable	Z

Materials

Researchers brought eight paper copies of consent forms (see Appendix B). Several pens were brought for participants to complete the consent forms and demographics questionnaire and

take notes. Additionally, four iPads preinstalled with Move Improve and Exercise Buddy were available for participants to use during the workshops. Notepads and pens were also used for supplemental note-taking by both co-facilitators during the workshops. Questions about barriers and facilitators to physical activity, experiences using the apps and the workshops in general were asked (See Appendix C). An iPad was used to audio record workshops using the Zoom. An audio-recording device (Phillips VoiceTracer DVT1250) was used as a backup recording device. Honorariums were distributed to each participant at the start of each workshop in the form of a preselected gift card worth $30 each. Participants parking costs and lunch costs were also covered by the study.

Data Collection Procedures

A team of expert researchers in Psychology, Kinesiology, Sport Science and Education met to discuss the proposed workshops in order to finalize the outline and content of workshops, timeline, scheduling, focus group discussions, app selections, and potential participant homework. The workshops, which lasted 2 – 4 hours, were run by two facilitators (a research expert in Kinesiology and a graduate student with experience in autism). Experts in the team familiar with qualitative research reviewed proposed workshop plans to ensure content validity. To provide time for review prior to data collection, each participant was provided with an overview of the study via email and consent forms detailing the aims of the study, the number of and length of each workshop and the activities involved in each workshop. At the beginning of the second workshop, participants reviewed a mind map to ensure facilitators had accurately captured their responses from the first workshop (See Appendix D). Consistent with the literature, participants were emailed potential questions a week prior to the second workshop (Shields & Synnot., 2016).

Additionally, participants provided logbooks via email to track app use and document their reflections. Each logbook had a table which asked participants to fill out the name of the app, date, time, how long (they used each app), their reflections, and feelings. Logbooks instructions were as follows:

> We would like you to write down your reflections and feelings directly after you have used the tool. Remember, there are no rights and wrongs – we are interested in your experiences of using the tool. If you want to use more space, please continue on the back of the sheet. Thank you for your participation.

Analysis

Data Analytic Strategies

Following recommendations by Smith et al. (2009) on conducting Interpretive Phenomenological Analysis, data analysis included six stages, namely: 1) reading and rereading, 2) initial noting, 3) developing emergent themes, 4) searching for connections across emergent themes, 5) moving to the next case, and 6) looking for patterns across cases. This process involved the workshop facilitators and other members of the research team reading and re-reading transcripts to identify all the themes until no new themes emerged (i.e., saturation). Once all the themes are identified and coded, connected themes were grouped together to create a hierarchy of themes and subthemes by the co-design facilitators and research assistants (Noon, 2018).

Credibility

Credibility, which refers to the level of trustworthiness of results, is thought of as reliability in quantitative research (Tracy, 2010). A credible research design is one that measures what the researchers proposed that it would measure and allows readers to feel that they trust the

findings enough to make decisions based on it (Tracy, 2010). In this study, credibility will be accomplished using multivocality and member reflections (Tracy, 2010).

Multivocality

Multivocality involves including multiple varied voices in the research and includes intense collaboration with participants (Tracy, 2010). In the present study, multivocality was implemented during the focus group discussions and prior to the coding phase. Additionally, it will also be implemented in the coding phase. During the focus groups both the participants with ASD and their communication partner were given opportunities to share their experiences. After each workshop, a summary of the discussions in the mind map format was emailed to participants for their feedback to ensure views and experiences were captured accurately (member reflections). To ensure multivocality and avoid bias in the coding phase, both co-facilitators and other members of the research team were involved in the process of interpretation and analysis of the transcripts to identify emerging themes. Themes were identified based on common agreement between researchers and a careful justification process. More specifically, each coder independently read the transcripts and generated initial themes. Next coders met together to review each other's themes and identify consistent and inconsistent codes. When coders disagreed on codes, they discussed the reasons why they categorized a particular sentence the way they did. At times it was necessary to identify more appropriate codes that captured their interpretation of excerpts.

Member Reflections

Member reflections involve soliciting input from research participants during the study (Tracy, 2010). In this study participants filled out logbooks detailing their experiences using the app and thoughts about both Move Improve and Exercise Buddy. They were also given an opportunity to respond to the mind maps to clarify their thoughts, add to their initial insights, and

confirm that the researchers had accurately understood their experiences. This reflection process allows participants to agree, disagree, react to, or find problems with the interpretation of the data (Tracy, 2010). Before the second workshop, participants were emailed the proposed workshop questions and asked for their feedback about whether the questions were appropriate.

Qualitative Rigour

In qualitative research, rigour is concerned with providing thorough accounts of a study including justifications for decisions during the research process (Wu et al., 2016). It includes selecting an appropriate sample, using relevant interviews, recordings, and data analysis procedures (Tracy, 2010). In this study, purposeful sampling of a small and homogenous group of participants facilitated rigour. Additionally, members of the research team with expertise in qualitative data analysis provided direct support to facilitators by overseeing the analysis procedures.

Sincerity

Sincerity means that the research is marked by honesty and transparency of author's biases, goals and methodology (Tracy, 2010). Part of sincerity is transparency through the research process, which is also known as auditing. This was conducted in this study with facilitators keeping audit trails.[1] This involved taking and keeping detailed notes about the research process, including keeping track of emails that were sent during the research planning process and taking notes of what was discussed in planning meetings. Additionally, it involved taking notes during the workshops, debriefing after the workshops, and meeting with members of the research team to further debrief. This process of sincerity allowed facilitators to discuss ideas

[1] Hard copies of the audit trail data are securely stored in a locked filing cabinet within the research office, accessible only to authorized members of the research team.

they may have overlooked during the workshops and make appropriate adjustments. For example, during the first workshop facilitators stood at the front of the room while participants sat around the table. During a debriefing meeting, the research team discussed how these positions could inadvertently create a power imbalance. As a result, the facilitators set up the technology for the second workshop so that both participants and facilitators sat around the table. An additional adjustment included facilitators emailing potential research questions to participants before the second workshop, despite not doing this before the first workshop.

Worthy Topic

This aspect of qualitative research emphasizes the need for research that is timely and significant (Tracy, 2010). The current study addresses this in several ways. First, given the impact of modernization on sedentary lifestyles, this study adds to the ongoing research in physical activity that looks at ways to combat the harmful effects of limited physical activity (Croen et al., 2015). Additionally, a recent shift in product (app) development is the importance thinking about app development it is important for product users to be included in the research process. Developers may use the results of this study to design new apps or make changes in their current apps to better reflect their users' needs. Second, from a research perspective, we are shifting away from researchers holding all the power when autistic people are experts in their lived experience (Fabri & Satterfield, 2019). Indeed, the participants alluded to the importance of the neurodiversity movement bringing increased awareness to those on the spectrum; this research seeks to contribute to making the world a more inclusive space with research a study that highlights the voices and focuses on experiences of adolescents and adults with ASD.

Ethical

There are various forms of ethics established by research governing bodies. For example, procedural ethics for this study was ensured by obtaining ethics approval from both the University of Calgary and the University of Manitoba research ethics boards. This meant that I was required to detail the procedures I would use to safeguard study data including storage and sharing of data.

Equally important, this study prioritized relational ethics in the ways facilitators interacted with research participants, beginning at recruitment and continuing throughout the study. For example, facilitators contacted and communicated with research participants in ways that were most comfortable for the participant, whether over zoom, phone or text. Opportunities were provided for participant pairs to review the study details and address any additional questions or concerns. At the start of each workshop participants were welcomed and reminded that they were in a "safe space" meaning could participate in any way that felt most comfortable to them and that they could get up and move or take breaks as they needed. Participants commented that they appreciated the emphasis on inclusivity shared at the beginning of each workshop.

Findings

To explore the objectives of this study, recordings from each workshop were transcribed and analyzed together with information from participant logbooks and notes from the workshops. Firstly, research aimed to elucidate the experiences of individuals with autism when using apps designed to improve physical activity. Further, given the unique methodology employed, it aimed to understand autistic perspectives on codesign research methods. Finally, it intended to

provide understanding on perceived barriers and facilitators to physical activity for those on the spectrum.

The following observations are provided to facilitate understanding about the context of participation across the two workshops. At the beginning of the first workshop, participants were given the option to choose pseudonyms, their name choices are reflected in the findings. Participants appeared engaged in the workshops and participated to varying degrees. Some participants contributed more than others and were happy to elaborate on their thoughts while others gave brief responses. There was significantly more participation during the second workshop, with the discussions taking more of a conversational style. For example, during the second workshop participants interacted more with each other. They were seen to build on each other's ideas, sometimes interrupting each other, but often clarifying experiences and suggestions that were confusing or different from their own. Participants also asked other participants to speak up during the second workshop, further demonstrating their interest in what was being shared by other participants. In contrast, most conversations between participants in the first workshop were within participant pairs.

When participants returned from the lunch break after the second workshop, they spent several minutes talking to each other and workshop facilitators about their general interests. One participant who made art, shared pictures of her art with the group. Additionally, at the end of the final workshop all participants stayed for 20 to 40 minutes talking to each other and workshop facilitators, suggesting good relational ethics and rapport had been established.

While most participants seem generally comfortable in the group setting, one participant, AA, went for multiple walks and listened to music on her headphones for a significant amount of time during the workshops. Her communication partner shared that she thought she was

overwhelmed because her autism diagnosis was recent, and it was her first time spending time with other autistic people in a group setting. However, AA frequently engaged with other participants when they discussed topics of interest to her. She also demonstrated initiative by helping her communication partner set up her app profile when she was having difficulties. Further, her communication partner reached out between workshops to confirm dates, times and the honorarium for the second workshop, mentioning AA was asking about it. Consequently, it seems that while this participant might have had some initial reservations, they developed some interest and enthusiasm over time.

Additionally, information from participant logbooks, question sheets and notes were used to supplement workshops discussions. Three of the four participants pairs completed logbooks, with the last pair jotting their experiences in a notebook. According to the information provided by the logbooks, some participants used both apps for 5 minutes once [Nancy and AA], Nick used them for 3 – 5 minutes on several different occasions, and Benjimjam used Exercise Buddy for 10 – 20 minutes five times. Erin and Lauren did not document how long they had used each app. Transcripts were viewed holistically and findings from data analysis revealed four overlapping superordinate themes and several subthemes (see Table 4).

Table 4

Table of Themes

Superordinate Themes	Subthemes
Emotions and Motivation	• Enjoyment • Ambivalence • Anxiety and Frustration
Evidence-Based Instructional Design	• Direct Instruction

	• Learning Goals • Customization and Personalization
Advocacy	• Ableist Assumptions • Squeaky Wheel • Symbolism and Representation • Accessibility
Tensions	• Physical Literacy vs Physical Activity • Developer Intent vs User Need • Challenge vs Obsession

Emotions and Motivation

While not directly asked about emotions or motivation during the workshops, the responses provided often reflected emotional experiences. Thus, emotions appeared to play a significant role in the participants' practices of physical activity in general and influenced their experiences using Move Improve and Exercise Buddy apps. Emotions appeared to impact both the frequency of app use and the level of engagement with the apps and the co-design process. The following subthemes illustrate these experiences.

Enjoyment

Most participants spoke of engaging in types of physical activity that they enjoyed with their enjoyment serving as a facilitator for physical activity engagement. One pair shared "If you enjoy it, then its motivating...certain sports but not every sport, so it depends on if you enjoy it, that's your motivation." Consequently, more enjoyment appeared related to both increased participation and a willingness to try more varied activities. Conversely, lack of enjoyment of aspects of activities also arose within this theme.

The availability of similar age peers also contributed to participants' enjoyment of physical activity. One pair of participants discussed social difficulties caused by living in a community away from friends. Lauren's communication partner, Erin, shared:

> I find another reason why my daughter isn't so active is because she doesn't really want to do it with me her mother and she doesn't have anybody else to do it with, so I find that if like when she had a good friend, they would often go for a walks together or swimming together so I think having a peer to do it with because she goes to school in Calgary, lots more of her friends are in Calgary and I find that I think if there was a peer in [town] with her like I do know that, there's more physical activity, so I think it's a reason why it can be low- just because she doesn't want to do it with me.

Erin later also added "She does most of her activities with her sisters and she doesn't like being with her sisters." Both Lauren and her communication partner laughed after this statement, appearing to agree with it.

Conversely, lack of enjoyment served as a barrier to physical activity for some participants. Pamela explained "I mean everyone has their days where they just binge watch something on Netflix instead." Nick acknowledged "I just don't like being active, I would rather be sedentary." While several participants shared that they did not enjoy engaging in physical activity, they noted appreciating the benefits, such as improved mental health (e.g., "I think it improves the mood, it's a mood improver [Erin about Lauren]" and "It's positive on her...improves her self-esteem [Nancy about AA]"), sleeping well ("It helps her go to sleep" [Nancy about AA]), increased focused, as well as physical benefits ("To stay strong and in shape [Benjimjam]). "

Ambivalence

All participants shared that physical activity was important to them but often included statements that revealed ambivalent attitudes. Nick explained "I don't really care for it, but I have to (be physically active)" and Erin shared "I enjoy physical activity but I'm not crazy crazy about it." Pamela explained "I know people that like literally exercise three or four hours a day and I do not do that." Likewise, Nancy shared "Yeah, I know (exercise) is important, I do value it...I just struggle with the motivation and confidence like when I was younger.

Lauren reported engaging in various types of physical activity including hiking and swimming, during the summer said she engaged in those activities "because I'm forced," with her communication partner agreeing:

> I drag her a lot. I'm like, 'come on you're coming swimming' or 'come on you're going on a hike'. So yeah, it's me, it's me dragging.... but I find that it's umm, it's a lot of grumbling to get out there but once we're there, there's enjoyment. So, there's a lot of grumbling to get on that hike but then once we're on the hike she enjoys the hike.

Similarly, some participants displayed ambivalent attitudes towards the apps. For example, they expressed a desire for their direct feedback to be shared with app developers, asking "Are you sending them the records? [Z]." They also seemed happy to give detailed responses as well as share elements they did enjoy. However, there was a pointedly long silence followed by a firm "absolutely not! [Nick]" when asked by workshop facilitators if they would continue to use the apps for the rest of the two-month subscription period. After the silence and probing from communication partners, one participant, Lauren indicated she would "maybe" use the Exercise Buddy app "if it ever came down to that." She later added "it could be like a lazy winter thing, if you don't feel like going outside." Other participants shared similar feelings with Aurora sharing

telling her communication partner, Nancy, that she found the apps "boring" and with the group that she would not use the apps in the future because she "doesn't like apps that tell her what to do." Consequently, while participants appeared to like being involved in the study and using the apps from time to time, their feedback indicated a lack of interest in continued use.

Anxiety and Frustration

Participants expressed feelings of anxiety and frustration related to various aspects of physical activity and app use. This was expressed by both participants on the spectrum and communication partners. When speaking about "recording of self and movement" Pamela shared "One of the other things was the anxiety that it would create, so, I was like, I didn't find that option was feasible." Nick summarized his general experience using one of the apps "It was just confusing and frustrating to use, just made me more anxious" and preferred the other app because it "was not frustrating to use… using the app didn't feel like a chore."

Workshop Anxiety and Frustration. In addition to responses gathered directly about apps, some participants shared information between sessions informally. For example, after the lunch break during the first workshop one pair of participants expressed interest in touring the University of Calgary campus. During the tour, Lauren shared that waiting for her turn to answer the question was anxiety inducing for her and she would prefer if the questions were asked randomly and to the group as a whole rather than moving in order of seating arrangement.

Participants also seemed to experience feelings of frustration in response to parts of the co-design process during the first workshop. As compared to the open frustration they expressed regarding the apps, participants appeared sensitive to the feelings of the workshop facilitators were gentler in their critiques of the workshops, suggesting good rapport had been established. For example, Nancy shared "The first one was a little slow. I felt, I wondered if it was interactive

enough...I don't know how it would be different if that was a nice safe way to do it or if you want more interaction exercises today." Z agreed, noting: Yeah, I was expecting, first of all, I was expecting that we would be doing physical exercise."

Other participants reported that the first workshop was overwhelming, particularly regarding the number of questions asked by the facilitators. Pamela, Nick's communication partner noted it would have been helpful to have a "brain break" because:

> It was a lot all at once with all of the questions and information and I think... I think that interaction probably would have because I mean that (brain) storming portion of the team, right? Getting that interaction probably would have been quicker. I found a lot of the questions very repetitive, and I know Talking with Nick afterwards, he starts to tune out when the same question is asked too many times. It's like, I've already answered that question.

Several communication partners expressed the same sentiment regarding the number of questions, with Z noting "Yeah, it's asked slightly differently, but the answer would be the same," and Erin sharing "Yeah, I agree with you" and Nick adding "It's like the same thing. Same thing, just different wording." Additionally, one participant pair, Nick and Pamela, typed out the following suggestions on their previously emailed sheet of potential questions:

> Make the questions smaller and more specific. Narrow the scope of questions. The broader the question, the harder it is to answer, and it can become overwhelming. Instead of: What did you like about this app? Try: What did you like about the colour coding? What did you think about the videos? Instead of: What did you enjoy about this process? Try: Were the sessions the right length, was the presentation material clear and interesting, were the

facilitators knowledgeable and engaged? Keep the question repetition down as that drove frustration at answering the same question multiple times.

Their note reinforced the frustration participants experienced during the first workshop and provided strategies for future workshops to be improved.

Evidence Based Instructional Design

The creation of instructional materials and instructional process are important for effective learning. Good instructional design involves consideration of how individuals learn and a systematic selection process of what materials and methods are most beneficial for effective learning. There are many elements to evidence based instructional design, including direct instruction and clearly identified and achievable learning goals are often regarded as critical components (Mitchell et al., 2020). Instructional design is an important component of app development, as technological apps, such as the ones included in the study, are teaching (and learning) tools.

When discussing their experiences using the apps app and features and functions that they found helpful, participant feedback indicated that they desired more elements of effective instructional design. In fact, many participants discussed features that the literature supports as evidence-based teaching practices particularly relevant to people with autism. These are discussed in the following section.

Direct Instruction

Participants made many comments, reflecting aspects of the apps they used being unclear or providing insufficient instruction. While they did not explicitly mention direct instruction, all participant pairs alluded to failure in "giving that proper instruction [Pamela]" across both apps, both in terms of availability and quality. For example, Nick shared how the

"lack of audio instruction" on the Move Improve app contributed to it being his less preferred app. Pamela, Nick's communication partner, elaborated on why the lack of audio presented was problematic:

> One of the things that Nicholas brought up, is the lack of audio instruction. So, it was just a visual on the video, so without understanding what needed to happen he may be observing the top half of the person, and everything's happening in the bottom half of this person, and he doesn't know because here's no instruction.

Nick also suggested that while Exercise Buddy did have audio instruction, it needed more "or at least better instruction. Sometimes, there just isn't enough instruction for what needs to be done." Z agreed, noting both apps needed "more instruction."

Participants also critiqued the quality of videos indicating the videos did not provide adequate scaffolding for individuals learning new skills or performing skills they have not performed in a while. Noting that the videos were too short "often times the video ended before they had gone through the full instructions [Pamela]." Z also shared:

> The videos were few seconds long and in the first however many seconds, we're getting ready to do it and it was only the last few seconds actually doing it and that wasn't necessarily enough...then I had to demonstrate for him, like the video was not good enough.

On their notes about the apps, Nancy and AA wrote about Exercise Buddy "video too short, slow to get going, ended too soon to capture a clear learning of the skill." In their discussions in the workshops Nancy reiterated their point that they thought the videos ended too soon to have a "really have an effect...or learning impact."

Pamela summarized the general sentiment about the app instructions sharing:

> Again, back to what Nicholas and Sandra had said about the minimum instruction. Like oftentimes the video ended before they had gone through the full instructions. Where did you need to put it? Your foot. How did you meet the position of your body? It wasn't very clear. I mean it was very clear that the app was, appeared to be a very supplemental to one-on-one instruction, not necessarily an individual starter or an individual app. So that would, I would give that as feedback that if it's something that you want an individual to use, it needs to be better for me.

Participants also appeared confused with some of the instructional inconsistencies in the apps "Like some of them had a lot of videos and some of them had none or very few, why? Do you know? [Z]." Erin and Lauren shared similar thoughts in their notebook "more videos – finish adding videos for ALL exercises. Ones with videos are great." Participants also agreed that not having any videos at all was a barrier for engaging in some of the movements "You didn't know what you were supposed to do. It was just the name of it and nothing [Z]"

It was apparent that participants appreciated videos but disliked the inconsistent availability of videos. Additionally, consistent, predictable format seemed very important to participants.

Learning Goals

Learning goals explicitly describe the intended purposes and desired achievements of a particular program. They include identifying the knowledge, skills, and capacities an individual should achieve and are important for accessing individual progress. In their discussions about the lack of progressional opportunities, participants implied that the apps in the current study lacked clear learning objectives as "there was no progression [Pamela]".

This desire for linear progression makes sense, as many autistic individuals have expressed difficulty with big picture thinking (Nason, 2016). Including clear and explicit

structure and instructions within the apps can help participants better understand the purpose of the activities (i.e., why am I doing this), situating physical activity skills within the larger context.

Pamela also shared:

> I thought that the content was not arranged in a way that would promote a healthy progression of activities. Teaching stretching, then fundamentals before moving on to anything more complex or more difficult, right? So, there was not really that ability or capability to label. You know, levels.

She later explained that she did not think the activities and exercises were "laid out in a straightforward kind of way to support linear thinkers" so they could "connect this or that" but were instead "all or nothing in one bucket." Nick expressed similar concerns that there were "no clear indication of difficulty of movement or exercises." Related to linear thinking, Lauren expressed a strong desire to know the purpose of what she was doing:

> Yeah, like I always like when I do stuff, I like to see that there's like a point to it or reason why I'm doing it...I always like I always have a checklist. Like I always like to see the end of something or see a reason why I'm doing it. So, like if I do this exercise, I'll improve my posture. If I do this exercise, I'll strengthen my arms. Like a point to it, because sometimes I do stuff, you know, kind of like what it's like why am I doing this? What's the point of it? What does it do?

Participants also demonstrated a desire to make progress and track growth in their physical activity endeavors, in a similar way to learners achieving learning goals. For example, Lauren suggested that the apps could be improved by adding checklists "where if you finish one activity another one could come out" or "a chart where you have some sort of ability to chart

your progress or something visual, I guess. You can look at what you've done, or you've done it so many times."

Agreeing with other participants about the lack of learning goals, Erin shared:

> Maybe, teaching something like there's a program, I don't know, what is that, couch to 5K? Where you start, okay, today we're going to walk a block, and then we're going to walk two blocks, and then we're going to walk three, and then we're going to walk four. I might try jogging or walking. You know what I'm saying? Maybe something that was going upward and can teach you how to eventually maybe run.

Additionally, participants suggested that the self-assessment components of the apps may not be as helpful as having a knowledgeable expert identify areas for improvement. For example, regarding self-recording, they expressed challenges with either "hyperfocus" or not being able to see themselves accurately. Taken together, their comments implied that the apps would be more appealing to potential users if they included clear learning objectives and a clear presentation of the progression through skills for each movement or exercise.

Within the theme of instructional design, Participants also provided information that indirectly critiqued the learning goals of each workshop. While they understood the general purpose of the study, they expressed frustration at some aspects of the co-design process. Several participants also discussed needing to know all the details involved in an activity. Nancy and Aurora wrote down on their sheet for future workshops "Have an outline for the whole workshops, each one – given @ beginning of the 1st session."

Customization

Customization refers to users' capability/potential to change aspects (e.g., setting, features) of the app to better suit their needs, allowing them greater control over their experience.

Conversely, personalization refers to the interface and product decisions a developer makes to increase the appeal of an app to a particular group. During both workshops, participants appeared to use both terms to refer to their desire to be able to select various functions to make the app more accessible and enhance their experience (i.e., customization).

Participants expressed different preferences and suggestions for (customization) modifications. Their discussions about preferences ranged from cosmetic nonfunctional features like being able to add their picture on their profile ("She wants to have her own picture. She likes that a lot. [Erin]" "Yeah, like snapchat [Lauren]") to how the apps presented instructions ("It would be nice to turn off the text to speech narrator as its quite annoying and distracting [Nick]."

In discussing physical activity preferences, some participants suggested it might be beneficial to have predesigned workouts rather than looking at individual exercises. However, because they liked the slow-motion feature available on Move Improve videos but preferred the range of activities on Exercise Buddy participants indicated they would have preferred combined features from both apps rather than trying to utilize features from both at the same time. Pamela suggested "A customization, we can put one thing from here and one thing from here and create it because otherwise you're navigating from different menus and scrolling."

Participants discussed ways in which apps needed to have more of a motivational component "like interactive rewards or positive comments [Nancy]." They simultaneously acknowledged this feature needed to be done "without creating a stressor [Erin]." For Lauren, having a phone reminder with the ability to ignore would be sufficient as she explained "I ignore lots of things on my phone" but for others just the knowledge that they had a reminder was a stressor that would "just cause anxiety [Nick]" demonstrating how crucial customization functions are.

Further one participant pair, Nick and Pamela, listed the “complete lack of personalization capabilities” as barriers towards app use. However, although they critiqued this aspect of the apps, they also acknowledged that it holds the most potential for user engagement:

> I think again the personalization is where you're going to be able to tweak it to get it to where someone is on the spectrum going to be more comfortable with it. They don't. They don't. And please correct me if I'm wrong, but my understanding is nobody wants to be pulled aside and identified as different. Because it's... It's not that they're different. They want the sounds a little lower, they want the colours a little more subtle, and they want instructions more clear. You know, pattern more linear, right? I like it too. I'm an analyst. I like everything spelled out. I mean, I think that a lot of it is interchangeable, regardless of whether you're a neurodiverse or not, right? It's that personalization is really going to be where it's going to peoples...[Pamela]

Other participants joined her saying “That’s a really good point” and murmuring in agreement before she could complete her thought.

Conversely, users critiqued personalization attempts by the developers to create a specifically ‘autistic’ app. Pamela explained:

> I don't know any group, regardless of what they are, who wants to be spotlighted. So, with increasing neurodiversity awareness, with regards to these applications, I think that not necessarily having to build the app for only individuals on the spectrum, but building the app where there are specifications or personalizations that will make it more favourable for individuals with ASD or neurodiversity. So, volume, colours, all that kind of stuff.

In summary, participants seem to indicate that it would be better to design apps that provide a variety of options (i.e., sounds, colours, instructions) allowing each user to select features that best support their needs and preferences rather than the developer making decisions about what an autistic app should look like, despite good intentions.

Advocacy

While discussions throughout the workshops often reflected individual perspectives, participants often mentioned issues related to advocacy for other people with ASD. Their comments, primarily initiated by communication partners, indicated that their views about MoveImprove and ExerciseBuddy apps reflected both their experiences using the apps but also extended beyond the participants in the study to other potential users. While many of the comments related to this theme were initiated by the communication partner, autistic participants had opportunities to respond to what was said. The relationship dynamics noted by workshop facilitators was one in which autistic participants were comfortable disagreeing or emphasizing points made by their communication partners and vice versa.

Further, all communication partners often clarified differences in opinions between within their pairs with statements such as “She likes it, and I don't. It's too busy for me, it gives me a headache.” They also checked in with comments such as “We liked that its...I’ll just maybe speak for both of us, if that's okay? Unless you want to add or change anything?” or “Would it be kinda fair to say...?” or “One of the things, if you’re okay with me saying this...”

Ableist Assumptions

Participants noted that they felt the apps were teaching skills to individuals with no prior physical activity experience:

> So, they (developers) want to just focus on the basic skills. And then people are good at learning them and performing them, they are good, better in life doing more complex skills...so, that's assuming that they're not active maybe. So, it's assuming that if you're not active, then you start with the basic skills [Nancy].

Additionally, participants noted that some of the apps seemed to be geared towards young children. Nancy shared: “And then the fundamental movement skills, again because they're younger people, I don't think we would identify with that personally, that might be a barrier, that is not as relevant.” This concern was also noted by Z “To Move Improve, who is it geared to? Like it's geared, is it geared to children and to seniors? Because that's what it is here. Like, doesn't appear to be clear for this age-group...” Pamela noted, “There was none of that (warming up or stretching). It was very, very, very junior level, super elementary level with those workouts.”

In the second workshop participants alluded to how nuanced developing appropriate apps could be. Z acknowledged that Move Improve and Exercise Buddy developers were trying to hit “different cognitive levels”, but she felt the apps were “too low.” Pamela also expressed concern that the apps seemed to “differentiate to the point of alienation” and were “simplifying something to the point that its childish.” She added that “it maybe be simple enough for an individual who struggles with sensory input but it's too childish, it's insulting.” Nick agreed, adding “It’s insulting to be patronized.” It should be noted that Nick’s overall opinion about the apps was they added “an unnecessary level of complexity” to physical activity and he would “rather go for a walk instead.”

Squeaky Wheel

In their discussions about the co-design experience, participants suggested opportunities to participate in research studies reduced as they got older. One pair shared that they had been involved in "lots of studies but not for a long time. When he was little, we did more... but not as much anymore [Z]." Several participants mentioned concerns about the suitability of the apps throughout the workshops. Z shared that she had read about "a little bit about Exercise Buddy" and while it was clear they had consulted professionals she "wondered if they consulted with adults on the spectrum [Z]." Other participants responded to her comment with murmurs of approval.

Participants also appreciated the opportunity to voice their opinions on a product that might directly impact them. Pamela shared:

> It's nice to have somebody ask us instead of us having to constantly be the squeaky wheel to say this is what's needed, and this is what's the problem. And actually, if somebody comes to us and says what do you need? Like, it's nice....means somebody's looking for that answer instead of us constantly having to bang somebody over the head to bring that awareness.

Further, participants independently asked about future opportunities to participate in similar studies: "Also, if there's a way to sign up for more workshops, that would be great." Their interest in research participation extended beyond the objectives of this study "Is there a way to sign up for university studies, psychology studies, or whatever department?" suggesting a desire to continue in their external and self-advocacy roles, even those not directly related to physical activity.

Symbolism and Representation

During the introduction of the ExerciseBuddy app, one autistic participant expressed concern about the app logo "Do the devs of this app realize that the use of a puzzle piece is actually quite offensive to those on the spectrum?...It implies we have something missing at birth [Nick]." Another participant had the same concerns and shared with the group "Yeah, I wondered if it was made awhile ago. In the autism community the puzzle piece is no longer a symbol they identify with [Nancy]."

Additionally, all the participants commented on the models performing the various physical skills, with one participant mentioning "I don't know what else I like, but I did like the real people." While appreciative of the "real people", most participants expressed a desire to have more representative models rather than children and older adults. One participant on the spectrum began his explanation of why he did not like the app by saying "Firstly, its geared towards senior citizens and that's not, I'm not part of the targeted demographic, I don't think any of us are [Nick]." These thoughts were shared by both autistic participants and communication partners. It appeared that not seeing representative peers made participants feel that the apps "were not geared to the audience for the purposes of this study [Z]."

Accessibility

Participants discussed issues related to accessibility of the apps, with some of the issues more focused on socio-economic factors. Nick pointed out that Move Improve was "only usable when connected to Wi-Fi so usability outside the home is decreased" serving as barrier for people without access to Wi-Fi. Erin and Lauren also shared that they would have preferred to use the apps on their phones, after learning that the apps were tablets or iPads were needed to access full functionality of the apps: "Today's kids...like they're always on the phone. [Pamela]."

Pamela highlighted another accessibility issue, commenting about the audio quality:

> I was just looking at the notes, the narration. I don't know if anybody else saw this but the text to speech narrator was a lot louder than the videos, so I found the sound disparity was significant and I know it bothered me so I can just imagine someone who has any kind of sound sensitivity how it would be for them.

Z also shared that individuals "who have any kind of barrier to motor coordination" may have difficulty implementing the video instructions, indicating that although they focused on basic skills, some of the apps do not account for various abilities.

Tensions

In their discussions, participants also revealed several conflicting narratives that related to the apps, their experiences using the apps and physical activity in general.

Physical Literacy vs Physical Activity

In relation to previously discussed ableist assumptions, participants noted that both apps emphasized the basic skill component of physical literacy. In their discussions, they highlighted how the Move Improve and Exercise Buddy apps could be more appealing if they focused on activities rather than individual skills. Nancy shared:

> Maybe, something relevant or maybe more an activity rather than a particular type of movement, like it's very broken down into the movements, hop, skip, gallop, but maybe if it was framed as an activity...is that maybe a goal later on?

Further, comments made about tracking progress and including motivators in apps (see above), suggest that apps would be more beneficial if they target all the components of physical literacy such as confidence and motivation rather than just the basic skills.

Developer Intent vs User Need

The distinction between physical literacy and physical activity needs highlighted the gap between the developer intent and the user needs. This was evident across both apps with participants questioning the purpose of various features and functions. Participants expressed doubts about the relevancy and effectiveness of self-recording and peer feedback functions. One communication partner commented:

> I don't know if they would see themselves. Like, sometimes, I show them, like I was saying to Makenna, okay, you see this is how they're doing it. She's like: "well, that's how I am doing it!" And I'm like, no, you're not doing it that way. And, then she says: "Yes, I am". And I don't know if they can just see or not see the difference.

Other participants echoed this sentiment "Because if you're recording for yourself and you don't know what are you doing, I guess will not be helpful" but also added "So, (recording) might be beneficial if it's like a paired part-like tutorial or if using this app to support it, that you're helping with skill-building. I'm not sure it'd be good for the individual themselves but perhaps a trainer... [Pamela]." Concerns about the effectiveness of recordings were voiced even after a workshop facilitator affiliated with the University of Calgary explained that the developer's rationale for recording movement skills when using MoveImprove was to increase self-awareness.

In addition, several participants expressed discomfort at the thought of the recording component of the apps. Pamela noted "just having been exposed to individuals with ASD, having to record themselves and compare that, because it would be one small thing is wrong, and now I'm wrong, and I'm not going to try it..."

Erin interrupted “That was a big no for us too. (Lauren) Does not like to be recorded does not like to watch self.” Lauren clarified that although she was fine with “selfies and taking pictures and what all” she just did not “like being recording on video.” Nick responded that he could “empathize with that.”

One pair of participants had no concerns about being recorded but reiterated concerns about relevancy “About the recording, I would just add, yeah, so for Benjimjam, it's not a problem to be recorded. But I don't know that there would be any purpose to it.” The communication partner noted that “I don’t think it will be helpful” and responded “For some people” when a workshop facilitator explained protentional benefits.

Challenge vs Obsession/ All or Nothing

Participants indicated that the apps lacked progressional or reward features that may be beneficial for motivation. However, they noted that while these features might be useful, they can also serve as a barrier to physical activity. During the first workshop one participant shared:

> I also find that, something we used to struggle with a little is to try and find the motivation where it doesn’t become like an obsession. Like we’ve tried sometimes to motivate Lauren and we’d say okay here’s a Fitbit or something. We’d like you to try and walk 10,000 steps a day kind of thing and it become, it can become a stressor and because it, and a little bit of an OCD thing where I have to hit that, right? So, we found that when she had it, she liked it, but it became a pressure and then it can become too much, so now she doesn’t. We bought her an apple watch last year and she didn’t want it because it's a pressure of having to walk, she doesn’t want that pressure of I have to walk every day...I find that can be a difficulty to create the motivation to exercise but not that

> it's so much that it's a stressor...and because sometimes there can be a little bit of an obsessiveness.

Lauren later confirmed that she stopped using her Fitbit because having to complete her walking goals “felt like a chore” and that experience had discouraged her from using technological supports to engage in physical activity. Another pair of participants, Nick and Pamela, shared a similar experience:

> I encouraged Nick to get a Fitbit as well and he was absolutely against it. And I think a lot of it, we had really good conversations about it. Throughout him growing up if there was, if he didn’t feel he could be successful 100 percent before he started it, he wasn’t going to it and I think with the Fitbit the struggle was if he didn’t think he was able to reach a goal or whatever, he wanted nothing to do with it. It’s way too much pressure [Pamela].

In the second workshop, when participants discussed potential progress monitors features in apps, they contextualized barriers with discussions from the previous workshop noting “Well, it's similar to recording. Right, you're being tested. So again, if I'm not 100% successful, I'm not gonna do it [Pamela].” AA’s communication partner confirmed that she was also unwilling to continue activities that she could not be completely successful in.

Discussion

The primary purpose of this study was to engage individuals with autism to provide app developers with guidance directly from people with ASD about the utility of features and functions of physical activity apps. Additionally, the researchers in this study aimed to provide insights about how to design appropriate and inclusive co-design studies with autistic individuals

as there is limited guidance on how researchers can plan effective co-design studies with this population. Finally, the researchers aspired to determine barriers and facilitators of physical activity from the perspectives of older adolescents and adults with ASD. The research objectives were addressed using two workshops guided by an Interpretive Phenomenological Approach. Findings also reflect experiences shared in participant logbooks, notes and informal situations (i.e., university tour). Four key themes emerged from the data analysis 1) Emotions and Motivation 2) Evidence-Based Instructional Design 3) Tensions and 4) Advocacy.

Application Feedback and General Guidance

Participants provided thorough and constructive feedback about their experiences using Move Improve and Exercise Buddy apps. Participant responses also reflected guidance that may be beneficial for all app developers. Participants' discussion indicated that they are more likely to use an app if they feel they are part of the intended audience, even at face value. The apps presented in the current study featured pictures of senior citizens and younger children which created confusion and inadvertently conveyed to participants that the product was not developed for them.

Participant concerns about the apps emphasized the need for evidence-based instructional design when developing apps. Their comments about the lack of “proper instruction” and progression are consistent with literature that suggests autistic learners value explicit and systematic instruction (Mitchell et al., 2020; Nason, 2016). Participants also indicated that apps needed to clearly organized and easy to navigate especially for “linear thinkers.”

They noted that instructions needed to be clear, direct and convey the relevancy of the various skills and exercises. Additionally, participants shared that physical activity engagement would be more motivating if apps provided clear learning goals that allowed users to monitor

their progress. They also indicated a preference for apps following progressional opportunities, such as providing participants with stretching exercises before physical activity, consistent with literature on best practice for learners with autism (Nason, 2016).

All participants agreed that more customization features on Move Improve and Exercise Buddy apps would have made them more user friendly. They noted that with the growing number of apps being developed, they would be more drawn to an app they can customize. For example, participants identified the possible need for internal motivators in the app but noted that these motivators could also be a stressor depending on the individual, highlighting the need for customization. Further, participants highlighted how this need for customization considers the heterogeneity of ASD, with people learning differently and having different sensory sensitivities (Fabri & Satterfield., 2019). Their responses conveyed the importance of a universal design approach that incorporate the needs and preferences of all users (Persson et al., 2015).

Despite developer well-meaning intent to enhance physical activity by teaching fundamental movement skills, participants noted that the apps in the current study were “boring” and “too low.” Their feedback suggests that physical activity app developers should target other elements of physical literacy such as motivation and confidence, rather than just knowledge (i.e., physical skills). Overall, participants comments highlighted the need for developers to consult target populations when designing apps to ensure their intentions match the needs of potential users.

Codesign Feedback and General Guidance

Participants also shared their experiences being involved in a co-design study. Overall, participants had a positive experience and appeared to be enthusiastic about having the opportunity to “do something that will benefit a lot of people.” Participants seemed mindful of

the workshop facilitators' feelings and framed feedback about the workshop positively. Despite this, they provided constructive feedback that can be applied to future co-design studies to make them more effective.

For example, participants noted there was a lot of information shared and questions asked particularly during the first workshop which was overwhelming. They also pointed out that some of the questions were repetitive which led to feelings of frustration and "tuning out." They suggested questions be simplified and targeted rather than large open-ended. They also indicated that having an outline of the workshops, detailing content and length, at the beginning of each workshop would be helpful. It appeared that providing participants with possible questions at the beginning of the second workshop facilitated communication, with most participants coming to the workshops with notes that they could refer to.

Barriers and Facilitators

Finally, this study looked at barriers and facilitators. Many barriers and facilitators that were the same as those identified by past literature. Participants in this study shared that mood, motivation, personal injuries, health concerns, seasonal and social challenges were all barriers to physical engagement (Healy et al., 2018; Shields et al., 2011). On the other hand, they identified enjoyment, better sleep, and physical and mental health benefits as facilitators. Consistent with past literature, barriers and facilitators varied based on individual reporting them and more personal rather than systematic and environmental were mentioned (Shields & Synnot, 2016). However, in contrast to existing literature the barriers and facilitators mentioned by communication partners did not always reflect the barriers of autistic participants, highlighting the importance of asking individuals about their experiences rather than experts or research proxies (Shields & Synnot, 2016).

Implications

The findings from this study have several implications for MoveImprove and Exercise Buddy app developers, app developers in general, and researchers. Participants in this study indicated that they would be more interested in the apps if they included "real people" and members of the target demographic rather than pictures and videos of children or seniors. They also indicated that they were confused by inconsistent features such as videos for some movements but not others, suggesting that the apps need to be updated to ensure video instruction is available for all the skills. Some participants expressed discomfort at having to film themselves, which suggests that it will be beneficial for MoveImprove and Exercise Buddy app developers to consider alternative ways for app users to receive feedback and monitor their progress.

Participants provided feedback that offers valuable recommendations and guidance for all app developers. Their comments indicated that direct instruction and clearly defined learning goals are desirable features in apps intended to improve physical activity skills. They also preferred skills to be progressional and organized in a way that provides some indication of difficulty. Most importantly, it appears that while many developers focus on personalizing apps for autistic users, participants indicated that they would prefer to have the ability to customize app features rather than have separate apps.

Finally, this study had several implications for researchers as they pursue collaborative research approaches with the autistic population. It is important for researchers to pursue collaborative research opportunities in ways that enhance participation engagement. However, it is important to do so without overwhelming participants with information and questions. Researchers should ensure they avoid repetitive questions and narrow the scope of questions so

that participants are motivated to give detailed and specific answers. Providing autistic participants with outlines of research involvement and possible research questions appears to be an effective way to increase research engagement for autistic individuals.

Strengths

There were several key strengths of this study. Firstly, based on the current shift in research to acknowledge people on the spectrum as experts of their lived experience and incorporate more effective technological supports, it provides crucial feedback and guidance for researchers in multiple areas that have previously been neglected (Graff et al., 2013). Additionally, it supports the small but growing body of research that focuses primarily on adults and adolescents, rather than children. Further, as more people turn towards technological support and apps, it is important to have an efficient design process, so app developers know what features and functions end users would like incorporated in the design.

Secondly, the recruitment sample of this study was a significant strength for several reasons. First, given the historic exclusion of girls and women in autistic literature, it was incredibly insightful to have two female participants involved in the study (D'Mello et al., 2022). Second, given the diversity and heterogeneity of ASD, having participants with a range of attitudes towards physical activity (ranging from "I would rather be sedentary" to "I like it") and who engaged in physical activity for multiple reasons was beneficial because it captured a range of perspectives, meaning that the feedback reflected a wider range of people on the spectrum rather than just those who are enthusiastic or averse towards physical activity.

Finally, the rapport built with workshop facilitators and among participants was another source of strength. It allowed participants to share their honest opinions about the apps which included detailed suggestions for modifications, including feedback that one of the apps should

be “scrapped and designed from the ground up [Nick].” It also facilitated constructive criticism about co-design studies with tangible guidance about how they can be modified to be less “overwhelming” and more accessible and engaging for adolescents and adults on the spectrum.

Limitations

The findings of this study need to be understood considering limitations. First, it did not collect any quantitative data that could determine how long individuals used the apps for. Three out of four participant pairs filled out their logbooks and those that did indicated they used the app anywhere between 20 minutes daily to 3 minutes four times between the four workshops. However, there were no measures in place to verify their app usage. Similarly, there were a range of options available in both apps and different participants may have used certain features more extensively than others, limiting their feedback and recommendations.

Secondly, the current study did not collect any information to verify autism diagnosis or severity of symptoms or account for comorbid diagnoses. Autistic recruited participants in the study had high verbal skills and given the correlation of verbal skills to cognitive function it can be assumed that most participants recruited in the study did not have a comorbid intellectual disability. Consequently, the views expressed by these participants that the apps presented oversimplification of movements and exercises may not be reflected of other adolescents and adults on the spectrum with comorbid diagnoses. Therefore, findings need to be generalized to other autistic people with caution.

Future Directions

The findings of this study provided important insights about app development and co-design research methodology that are worth further exploration by future researchers, particularly given the widespread use of technological supports and increased emphasis on inclusive and collaborative research. Considering the large number of apps available for users, it

is recommended that future studies to include verifiable measures of app use (what features were used and for how long) by each participant as well as physical literacy outcomes so that researchers can determine if the apps are achieving their intended goals. Consequently, future studies will need to be much longer than the two-week period provided in the current study.

Along with quantitative information provided about app use, future research should include measures to verify autism diagnosis and additional diagnoses that may impact app use and co-design participation. Considering the high comorbidity of ASD and the heterogeneity of those on the spectrum, it is important for future research to have a sample population that is representative of the abilities and functioning of all autistic people.

While rapport was established quickly in the current study, it is recommended that future researchers allocate time within the study design to build rapport to ensure that participants are comfortable sharing their perspectives and interacting, particularly if information is being shared in a group setting. In relation to rapport building and participant comfortability, it may be beneficial for future studies interested in adolescent and adult perspectives to focus on one demographic rather combining them in the same workshop setting (i.e., have separate workshops for adolescents and separate workshops for adults). Although participants in the current study were overwhelmed by the volume and repetitive nature of the questions, they were not directly asked about their communication partners. Future co-design studies hold promise to reveal insights about the use of communication partners by directly addressing what benefits and challenges autistic participants experience by having communication partners.

Conclusion

The findings of this study summarize the experiences of autistic individuals use of two applications – Move Improve and Exercise Buddy to provide app developers with direct

feedback about the utility of features and functions so future apps are engaging and user friendly. Participants shared that they are drawn to apps that appear targeted for them, offer customization options, and provide evidence-based instructional design features such as direct instruction, clear learning goals, consistent structure supplemented with video instruction. The findings also provided guidance on planning effective co-design studies with this population. Insights included, providing outlines of workshops and asking targeted questions about specific aspects of the phenomenon being studied. Finally, this study examined the barriers and facilitators of physical activity from the perspectives of older adolescents and adults with ASD, an often-neglected population.

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Appendix A

Participant Recruitment Poster, Phase 2

UNIVERSITY OF CALGARY
SPORT TECHNOLOGY RESEARCH LABORATORY

Autism Aspergers Friendship Society of Calgary

PARTICIPANTS NEEDED FOR RESEARCH PROJECT

Using Technology to Enhance Physical Literacy, Peer Interaction, Self-efficacy, Self-perception, Social skills, and Adventure-seeking in Individuals with Autism Spectrum Disorder

We are looking for autistic participants between the ages of 16 - 40 and their communication peer (roommate/parent/sibling)- a person who attends workshops with the participants to facilitate the involvement engagement- and to take part in this study involving the development and usability testing of a novel resource to support physical activity, peer interaction, social skills development, and adventure-seeking in individuals with autism.

In this co-design project, you will be asked to contribute on how to improve app design using your feedback, input, and perspective. The app aims to improve physical activity, enjoyment, social connection, and motivation related to being physically active. In maximum four workshops, each last for 3-4 hour over a two-month period, you will be involved in discussions and examine video and technology tools together with four other autistic individuals and their communication peer. You will help us find, develop, or modify a tool that can be used to improve social communication, learn physical skills, and encourage physical activity engagement.

To thank you for your time, you will receive $30 gift cards for each session. Lunch will be provided in case we do four workshops in two days. And we will cover the cost of parking at the University. You will not be reimbursed for any other out-of-pocket expenses.

There are no foreseeable risks as a result of participation in this study and your identity will be kept confidential in any reports or research arising from this project.

Your participation will provide a valuable contribution to finding/creating an important resource for individuals with ASD.

For more information, or to volunteer in this study, please contact:

Dr. Homa Rafiei Milajerdi, Post Doc — homa.mialjerdi@ucalgary.ca

or

Dr. Larry Katz, Professor
403-220-3418
katz@ucalgary.ca

Sports Technology Research Laboratory
This study has been reviewed by and received ethics clearance by the Conjoint Health Research Ethics Board (CHREB), University of Calgary. Under the Protocol # Ethics ID: REB20-0007

Appendix B

UNIVERSITY OF CALGARY

CONSENT TO PARTICIPATE IN RESEARCH

TITLE: Using Technology to Enhance Physical Literacy, Peer Interaction, Self-efficacy, Self-perception, Social skills, and Adventure-seeking in Individuals with Autism Spectrum Disorder (ASD) - Phase 2 co-design-Step 2

SPONSOR: Sport Technology Research Laboratory

FUNDER: Mitacs and Autism Asperger Friendship Society
INVESTIGATORS: Dr. Larry Katz, Professor

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INTRODUCTION

Dr. Larry Katz, and associates from the Faculty of Kinesiology at the University of Calgary are conducting a research study.

INTRODUCTION

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Take the time to read this carefully and to understand any accompanying information. You will receive a copy of this form for your records.

You were identified as a possible participant in this study because you are an individual between 16 and 40 years old with ASD, independent in physical activities of daily living and able to read and speak English. Your participation in this research study is voluntary.

Enhancing physically activity and social interactions with people in daily life activities is important in order to improve their quality of life. The focus of this project is on how technology can be used by people with ASD and how it can impact on social communication, self-confidence, learning new physical activity, and trying new experiences.

WHY IS THIS STUDY BEING DONE?

In this project, we work collaboratively together in groups and with peers and assistive roommate/parent/sibling to discuss ideas about what you need to stay active and healthy, improve communication, and what kinds of technology might be of use to you in accomplishing those goals. With your help, we hope to find, modify or design a new resource that can be used by those with ASD to improve communication, learn new physical skills, and increase engagement in physical activity.

HOW MANY PEOPLE WILL TAKE PART IN THIS STUDY?

A maximum of 10 persons (5 pairs) will participate in this workshop.

WHAT WILL HAPPEN IF I TAKE PART IN THIS STUDY?

If you volunteer to participate in this study, the researchers will ask you to participate in a number of workshops (maximum four workshops within two months) in which you, together with your parent/guardian and three other individuals with ASD and their parents or guardians, will:

- Participate in discussion groups about experiences and ideas of technological support for improving your social and communication skills and learning new physical skills and trying new activities.
- Use tools during the workshops focusing on physical activities and social interactions and be asked to talk about your thoughts with regard to using the tools.
- The workshops will be held at the Faculty of Kinesiology, University of Calgary.
- You will be reimbursed for the parking fees at the University of Calgary.
- The workshops will be video recorded.
- You will be given logbooks to fill out due to utilizing the applications.
- A mind map of the discussions during workshops will be send out to you for confirmation.
- Transcripts of the workshops will be sent out to you for confirmation.
- You will be asked to choose a Pseudonym for yourself to be printed on the publications.
- We are providing lunch as part of the sessions.

HOW LONG WILL I BE IN THIS STUDY?

Participation will be a maximum of 12 hours. Each workshop (maximum 4) will last about 3-4 hours and all sessions will be completed within two months.

ARE THERE ANY POTENTIAL RISKS OR DISCOMFORTS THAT I CAN EXPECT FROM THIS STUDY?

- When trying the different tools that involve engaging in physical activity, there is a potential risk of injury. However, the risks are no more than one would normally be expected from participating in non-contact physical activities. A Kinesiologist will be participating in the workshops to monitor activities and provide support if needed.
- For those with ASD, social interactions may cause some discomfort, but a facilitator will be there to monitor the situation and provide support if needed.

ARE THERE ANY POTENTIAL BENEFITS IF I PARTICIPATE?

Participation may not offer any direct benefits although participating in the study could imply an increased awareness of how you perform movements of daily living. Participation will give you insights into issues of social communication and new technologies. You will be part of an effort to develop new tools, and you will get the opportunity to try new activities and new technologies.

CAN I STOP BEING IN THE STUDY?

Yes. Involvement in this study is completely voluntary. You are free to withdraw from participation in this study at any time without any consequence by simply writing a letter to researchers indicating as such. Tell the researchers if you are thinking about stopping or decide to stop and they will help you.

WITHDRAWAL OF STUDY DATA

If you decide to withdraw from the study, your data will be withdrawn at your request for up to 1 month after completing all the sessions without any consequence.

WILL I BE PAID FOR PARTICIPATING OR DO I HAVE TO PAY FOR ANYTHING?

You will not be paid for your participation in this research study. An incentive will be given to participants. The incentives include gift cards (to places like Sport Check) in amounts between $10-$30 depending upon the time commitment. In addition, parking fee and lunch will be provided for the participants. Lunch will be provided, and we will cover the cost of parking at the University. You will not be reimbursed for any other out-of-pocket expenses.

WILL INFORMATION ABOUT ME AND MY PARTICIPATION BE KEPT CONFIDENTIAL?

The researchers will do their best to make sure that your private information is kept confidential. Information about you will be handled as confidentially as possible, but there is always the potential for an unintended breach of privacy. The research team will handle data according to the Data Management Plan as outlined below:

- All identifiable information about you will be replaced with a code. A master list linking the code and your identifiable information will be kept separate from the research data.

- All research data and records will be stored electronically on a secure network with password protection.
- Video recordings of performances using the resources will be erased immediately when the device is returned to the research team. Video recordings of the workshops will be erased once the research is published.

HOW LONG WILL INFORMATION FROM THE STUDY BE KEPT?

All research data will be saved 15 years from date project is closed according to the University of Calgary's Data Retention Policy. Participant names and contact information will then be deleted by the Principal Investigator and all other research data will be retained. Any future use of this research data is required to undergo review by a Research Ethics Board.

IF I SUFFER A RESEARCH-RELATED INJURY, WILL I BE COMPENSATED?

In the event that you suffer from an injury as a result of participating in this research, no compensation will be provided to you by the Sports Technology Research Lab at the University of Calgary or the Researchers or Autism Asperger Friendship Society (AAFS). However, you still have all your legal rights. Nothing said in this consent form alters your right to seek damages.

WHOM MAY I CONTACT IF I HAVE QUESTIONS ABOUT THIS STUDY?

The Research Team:

You may contact Dr. Larry Katz at 403-220-3418 or Dr. Homa Rafiei Milajerdi at 587-966-0556 with any questions or concerns about the research or your participation in this study.

Conjoint Health Research Ethics Board (CHREB):

If you have any questions concerning your rights as a possible participant in this research, please contact the Chair, Conjoint Health Research Ethics Board, University of Calgary at 403-220-7990.

HOW CAN I FIND OUT ABOUT THE STUDY RESULTS?

The results from the study will be made available to you on request.

WHAT ARE MY RIGHTS IF I TAKE PART IN THIS STUDY?

Taking part in this study is your choice. You can choose whether or not you want to participate. Whatever decision you make, there will be no penalty to you.

- You have a right to have all of your questions answered before deciding whether to take part.
- If you decide to take part, you may leave the study at any time.
-

HOW DO I INDICATE MY AGREEMENT TO PARTICIPATE?

Your signature on this form indicates that you have understood to your satisfaction the information regarding your participation in the research project and agree to take part in the study. In no way does this waive your legal rights nor release the investigators or involved institutions from their legal and professional responsibilities.

SIGNATURE OF STUDY PARTICIPANT

*

_____
Name of Participant

_____ _____
Signature of Participant Date

SIGNATURE OF PERSON OBTAINING CONSENT

_____ _____
Name of Person Obtaining Consent Contact Number

_____ _____
Signature of Person Obtaining Consent Date

SIGNATURE OF THE WITNESS

_____
Name of Witness

_____ _____
Signature of Witness Date

A signed copy of this consent form has been given to you to keep for your records and reference.

Appendix C

Focus Group Questions and Prompts

Barriers and Facilitators	Applications	Co-design Process
1.What barriers do you face when engaging in physical activity? 2.What challenges do you experience? 3.What barriers do you face that prevent you from getting as much physical activity as you would like? 4.What barriers have you faced that prevent you from being physically active? 5.What prevents you from being physically active? 6.Do you engage in physical activity? Why? Why not? 7.What facilitators/factors help you engage in physical activity? 8.What facilitators/factors have helped you stay physically active?	1. What did you like about this app? 2. What did you dislike about this app? 3. How would you make this app better? 4. How would you improve/change this app?	1.What did you enjoy about this process? Why? 2. What did you like about this process? Why? 3. What did you dislike about this process? Why? 4. What would you recommend for future co-design studies? 5. What would you add to future co-design studies? 6. What would you remove from future co-design studies? 7. Is there anything else you would like us to know?

Appendix D


Themes of the first workshop- October 23rd, 2022
Workout habits
House chores: planting, sweeping, laundry, snow shoveling
Medium intensity: walking, hiking, swimming, snowshoeing, dog walking
High intensity: gymnastics, volleyball, badminton, skating
Benefits of physical activity
Shifting focus from work or school
Mental health
Mood enhancement
Self-care
Feeling self-confident and positive toward self
Promoting sleep
Physical health
Improving lung capacity and breathing quality
Strong body
Facilitators of physical activity
Planning ahead, having notice about the physical activity
Listening to music
Having incentives (money, food)
Group activities
A good friend
Close family members
Using technology (Fit Bit, apple watch, Wii, Kinect)
Having an accountability
Barriers of physical activity
Not being flexible toward changes in program
Long distance
Health condition
Pain of joint problems
Limited range of motion
Side effects of medicine
Dizziness
Lack of motivation and persistence
Having checklist for completing tasks
Time limitations
Busy school days
Late evening physical activity may prevent a good sleep
COVID
Group activities
Competition
Different skill level from others
Expensive facilities and programs
Lack of knowledge of correct movement patterns
Applications and tools for physical activity
Apple watch (monitoring sleep, heartbeat, stress)
Wii and Kinect
miro

Table 1

MoveImprove	
Purpose	To teach fundamental physical skills
Features	Video modelling, Written List of movement components, Peer to peer feedback
Functions	Visual Instruction
Devices	Phones, Tablets
Physical Activity Skills	Catch, Dribble, Gallop, Hop, Kick, Leap, Overhand Throw, Hollow Body Roll, Run, Side Gallop, Skip, Standing Jump, Two-Hand Overhead Throw, Underhand Roll, Underhand Strike, Underhand Throw

Table 2

Exercise Buddy	
Purpose	To enhance exercise success
Features	Video modelling, Workout Customization, Coach's Workouts, Save Workouts, Track and Report Workout Data, Add a personal profile, Ability to bookmark favourite exercises and add new exercises, Work Out History, First- Then, Learning about body systems
Functions	Visual Instruction, Slow Motion, Audio Instruction, Pictures
Devices and Connectivity	Tablet and Wi-fi
Physical Activity Skills	Abdominal Strength, Motor Coordination, Posture, Body Image, Dynamic Flexibility, Fitness Room, Sensory, Yoga, Sports Skills, Cardiovascular Fitness