Research Article

Feasibility of a virtual service delivery model to support physical activity engagement during the COVID-19 pandemic for those with spinal cord injury

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Background: The current pandemic has reduced access to safe, monitored physical activity (PA) programs for persons with spinal cord injury (SCI). The use of telerehabilitation has the potential for continuing activity engagement without risking virus exposure. The present study evaluates the feasibility and efficacy of an online group-based PA program for persons with SCI.

Methods: This preliminary pre–post study delivered an online group-based PA program to persons with SCI. The program consisted of 1-hour sessions twice weekly for six weeks. Online PA satisfaction questionnaires were assessed at post-treatment. Psychosocial subscales from the NeuroQOL-SF were assessed.

Results: Participants were adult females between 3 and 32 years post-injury, 1 tetraplegic and 3 paraplegics ($n = 4$). All participants were highly satisfied with the online instruction, overall content, and videoconferencing platform. Participants stated that the online program was beneficial for their overall physical and psychosocial wellbeing. The program resulted in improvement in anxiety and satisfaction with social roles and activities.

Conclusion: The current pilot study demonstrates the acceptability and limited efficacy of an online PA program for those with SCI. The program resulted in improved overall perceived wellbeing and satisfaction with social roles and activities. These results have important implications for the clinical implementation of online PA programs in a hospital and community setting.

Keywords: Spinal cord injury, Online services, Physical activity, COVID-19 pandemic

Introduction

COVID-19 has rapidly become a pandemic emergency, distressing health systems in each affected country. Rehabilitation services are also affected by this epidemic with current patients undergoing outpatient rehabilitation no longer able to access services including physical and occupational rehabilitation therapies. Lack of physical activity can contribute to a multitude of secondary complications including worsening of physiological and psychosocial health among those with spinal cord injury (SCI). Current SCI Physical Activity Guidelines recommend a minimum of 20 min of aerobic activity and strength-training activities (*i.e.* 3 sets of 10 reps) twice a week.[1] However, persons with SCI have often been characterized as living sedentary lifestyles due to less physical activity participation, with few people meeting recommended guidelines and many reporting minimal or no physical activity participation whatsoever.[2,3] A Canadian study found only 12% of adults with SCI meet the recommended intensity of these guidelines[4]. Physical activity can have numerous benefits for individuals living with SCI, ranging from enhanced health through prevention of

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secondary health complications to improved subjective well-being.[2,3] There have also been studies showing a positive relationship between physical activity and subjective well-being with an emphasis on depression and life satisfaction.[5] Additionally, regular engagement in physical activity has been linked to lifetime cost savings due to fewer hospitalizations and less reliance on assistive care.[6]

Even under optimal circumstances, persons with SCI face several barriers (e.g. functional; psychological; architectural) that limit their engagement in physical activity.[7] Some of the most prevalent barriers experienced include transportation, physical access, and time barriers to community-based physical activity programs.[8,9] Unfortunately, during the COVID-19 pandemic, persons with SCI experience additional barriers as they are unable to attend fitness centers due to closures and limited access to health care services.[10] Additionally, access to specialized professionals to learn appropriate home-based exercises is limited.[10] A recent survey identified reduced access to adaptive exercise equipment and physical distancing protocols as factors associated with poorer mental and physical health for this population throughout the pandemic.[11] Specifically, individuals reported several psychosocial concerns such as reduced social connectedness (72.5%); increased feelings of depression/anxiety (60%); worsened attitude (42.5%); decreased mental outlook (35%); and reduced emotional wellbeing (32.5%) due to reduced access to physical activity services.[11] The barriers associated with the COVID-19 pandemic result in several negative health outcomes indicating a need for adapted online physical activity programs that may promote regular and personally modified physical activity for populations with chronic neurological conditions.[10] The use of telerehabilitation has the potential for continuing rehabilitation remotely without the risk of virus exposure. Studies have recommended the use of online programs to be leveraged to accelerate the dissemination of health services to the vast numbers of people impacted by the COVID-19 pandemic.[12]

Although several community-based online physical activity programs exist across Canada, e.g. Neurosask Active and Connected (https://rehabscience.usask.ca/neurosask/), there is a lack of research evidence on the acceptability and feasibility of these synchronous group-based programs among those with SCI. Previous studies have examined the use of telehealth for promoting physical activity through use of motivational and counseling strategies.[4,13,14] Only two studies were found to promote physical activity through synchronous programming.[15,16] Costa and colleagues[15] reported promising findings to support the feasibility of synchronous group-based programming over asynchronously delivered tele-exercises that were administered in a one-to-one format. In an earlier study, Lai and colleagues[16] delivered one-to-one tele-exercise sessions to persons with SCI three times a week over eight weeks.

These synchronous one-to-one sessions may help promote activity engagement, but may not be able to harness a sense of connectedness potentially provided by group-based programs. As a key component of long-term engagement with physical activity is the development of social networks, programs that foster group-based strategies may be beneficial[8]. Additionally, group-based programs that incorporate time for socialization may help to overcome feelings of isolation experienced during the COVID-19 pandemic. The current study aims to evaluate the feasibility and limited efficacy of an online group PA program designed specifically for persons with SCI. It was hypothesized that improvement in symptoms of depression and anxiety will be seen among participants post intervention.

Methods

Phase 1 – program development

This virtual physical activity program was designed with the intention of providing adapted aerobic and strength training exercises for persons with SCI via videoconferencing software. With knowledge of exercise program development as a certified personal trainer, the program instructor developed a regime based off boxing-style exercises for the virtual physical activity program. This included a routine primarily focused on upper-body exercises. The program instructor also has 32 years lived experience with an SCI which informed the development of adapted exercises for the target population. The initial exercise program was reviewed by members of the research team (*i.e.* researchers; physicians; clinicians) to address any concerns with the program design. Feedback from the team informed the development of a resource for safety planning, highlighting of red flags and identification of risks and/or potential adverse events. Additionally, spotters were identified as a crucial element to the program to ensure the safety of all participants. Their role included the observation and recording of any health emergencies or technological issues and demonstrating modifications of adapted exercises (e.g. showing an exercise with leg function). Spotters were research staff members supervised by the fitness instructor. Once the program was developed, it was pilot tested with the research team on the

hospital's videoconferencing platform (Cisco WebEx, Milpitas, California). Technology-based concerns such as lag of video on slower internet speeds, compatibility of specific browsers, and the number of participants able to join without streaming disruption was evaluated. Technology based guidelines were developed by the IT staff member to ensure resolution if these concerns occurred. Additionally, as the program was delivered through the hospital platform, concerns related to participant privacy were addressed.

Phase 2 – pilot and analysis

Study design and ethics

The current feasibility study employed a single group pre–post design. The study received ethics approval obtained from Western University's Research Ethics Board.

Recruitment and screening

Inclusion criteria were the following: 18 years or older; sustained an SCI; living in the community; at least one upper limb function permitting arm movement against gravity. Exclusion criteria included inpatients, no physician approval, and unable to meet any of the inclusion criteria. The Physical Activity Readiness Questionnaire (Par-Q) was conducted to assess the ability of a participant to safely engage in the program.[17] Participants that met inclusion criteria completed the informed consent electronically via REDCap surveys.

Intervention

Prior to the start of the program, each participant received an individualized pre-session consisting of an initial assessment with the program instructor, a spotter, and an IT professional in their homes through the WebEx platform. The assessment addressed the following: participant's severity of injury; level of physical functioning and fitness levels; safety, including awareness of red flags (e.g. autonomic dysreflexia); a course of action in the event of an injury or emergency; an overview of each exercise with an explanation of technique and rationale for the movement; relevant exercise modifications; introduction to the WebEx platform; and troubleshooting any technological issues.

The online fitness sessions provided participants with 60-minute sessions, twice weekly for six weeks. The exercise was broken down into a 10-minute warmup, 25 min of aerobic and strength-training exercises, and 10 min of cool-down and stretching, followed by 15 min of peer social interaction. The 15 min of peer social interaction involved informal group discussions moderated by the fitness instructor. The exercise portion of the program was comprised of 10 consecutive upper-body boxing style movements that were performed for 30 s each. The program was designed to be modified to meet the physical ability, fitness level, and goals of each participant. Leg movements were added for participants with lower limb function. Resistance was added with the use of home-made resistance weights (*i.e.* soup cans, rice-filled socks, wrist weights) for those that had a high level of fitness or strength. The participants were encouraged to complete as many repetitions as possible over a 5-minute period. This was referred to as a single "round". After each round, there was a 1-minute rest, stretch and hydration period. Participants were led through four rounds, making up a total 25 min of exercise time. At appropriate intervals during the physical activity sessions, the instructor asked participants to rate his/her rate of perceived exertion (RPE) based on the Borg Rating of Perceived Exertion Borg scale (*i.e.* rating on a scale from 1 to 10)[18], to ensure that participants were exercising at an appropriate level of exertion. The instructor engaged participants to achieve a RPE of at least three or above in order to align with CPG recommendations for moderate intensity exercise.[1] Adverse events were captured weekly.

Outcome measures

The primary outcome of feasibility was assessed using the following constructs: the success of participant recruitment; engagement; retention; and satisfaction.[19] Participant engagement was measured by attendance in sessions and completion of the program. The completeness of data was evaluated by examining the number of participants who completed post-treatment and 3-month follow-up measures. Acceptability and satisfaction were measured using Participant Satisfaction Survey. The Participant Satisfaction Survey is a questionnaire assessing participant satisfaction throughout the duration of the program asking about the participant experience through six subdomains (*i.e.* Live, Online Physical Activity Program Satisfaction; Access; Instruction; Content; User interface; Perceived Benefits). The satisfaction survey was adapted from the System and Use Survey developed by Canada Health Infoway[20]. Assessment of group interaction was evaluated using the Physical Activity Group Environment Questionnaire. The questionnaire consists of 22 items which assess feelings about participant's personal involvement with the physical activity group and the physical activity group as a whole. Each item is scored from 1 to 9, indicating level of disagreement, with 1 representing "extremely disagree"

and 9 representing "extremely agree". Both the Participation Satisfaction Survey and the Physical Activity Group Environment Questionnaire were assessed post-treatment.

Secondary outcome measures to evaluate limited efficacy included the Quality of Life in Neurological Disorders short-form (NeuroQoL-SF). The NeuroQoL-SF is a measurement system that assesses physical, mental, and social wellbeing among those with neurological conditions. The current study used the following short-form item banks: depression, anxiety, fatigue, sleep disturbance, and satisfaction with social roles and activities. Scores on the NeuroQoL-SF are calculated by converting the raw score into a T-score using the automatic REDCap scoring service. Higher scores indicate worse functioning while lower scores indicate better functioning. NeuroQoL-SF has been shown to have high internal consistency ($\alpha = 0.85–0.97$).[21]

NeuroQoL-SF item banks were completed by participants at pre-and post-intervention, and at 3-month follow-up to assess limited efficacy through REDCap surveys. REDCap libraries were used to conduct auto-scoring and T-score conversions.

Analysis

Analysis was conducted using SPSS Version 26.0.[22] (IBM Corp., 2019). Descriptive statistics were provided for participant demographics, PA satisfaction questionnaires, Physical Activity Group Environment Questionnaire, and secondary outcomes of the NeuroQol item banks. Cohen's d was calculated for secondary outcomes of the NeuroQoL item banks from baseline to post-treatment and baseline to follow-up.

Results

Participant demographics

Participant's demographic and clinical characteristics are presented in Table 1. All four participants were Caucasian women who identified as female and sustained a traumatic injury.

Feasibility

Six individuals applied to be participants in this program. Of these, four (67%) individuals completed consent and enrolled in the program. Two participants did not meet inclusion criteria due to secondary complications. Recruitment occurred over a two-week period. Overall, there was a 100% attendance rate for all sessions. High retention rates were found, with all four participants completing the program, post-measures, and 3-month follow-up measures.

Satisfaction

All participants reported high satisfaction with the virtual physical activity program in general; they all reported that they would continue participating and would recommend this program to others (Table 2). All participants did report that they were more likely to attend the classes because they were accessible online (Table 2).

All participants stated that they were highly or moderately satisfied with their access to the online exercise program (Table 3). Two participants (50%) moderately disagreed to having access to fitness programs that met their physical activity needs before this program, whereas all participants agreed (strongly and moderately) that 45 min was an appropriate amount of time for the physical activity sessions.

All participants were highly satisfied with the class instruction and believed the instructor was knowledgeable in their content area, an effective leader in the physical activity class, and maintained good control of the class (Table 4). Furthermore, all participants either moderately or strongly agreed with other aspects associated with instruction as outlined in Table 4.

Participants were also highly satisfied with the overall content of the exercise classes (Table 5) as well as finding it interesting and applicable to their physical activity needs.

The satisfaction ratings around videoconferencing and other study technology was mixed. Three

Table 1 Participant demographics.

Age (years)	Highest level of education	Location	Time since injury (years)	Severity of injury	Level of injury	Spine level of injury
70	Some university	Town or village	13	Incomplete	Paraplegia	Thoracic
62	College certificate or diploma	Large city	18	Incomplete	Tetraplegia	Cervical
56	University undergraduate degree	Large city	32	Complete	Paraplegia	Thoracic
38	High school diploma	Large city	18	Incomplete	Paraplegia	Thoracic

Table 2 General participant satisfaction.

Variable	N = 4
How satisfied were you with the online exercise classes?	4 highly satisfied.
I would like to continue participating in the online exercise classes.	4 strongly agree.
I would recommend this program to others.	4 strongly agree.
I found I was more likely to attend the classes due to the convenience of them being online.	4 strongly agree.

participants were satisfied with the videoconferencing of the online class and one participant was moderately dissatisfied (Table 6). The participant dissatisfied with the technology reported concerns related to slow video and freezing video on the hospital-based WebEx platform. Not concerns with audio during the session was reported. In addition, two participants were moderately satisfied with the function of the technology, and the other two participants were not satisfied with the function of the technology.

All participants were highly satisfied with the effect that the online exercise program had on their health and general well-being as well as their physical and psychological health (Table 7). Three participants reported that they will continue to engage in the physical activity exercises that they learned during the online exercise class whereas one reported that they would not. All participants reported that they would like to continue to use the study technologies in their home, if possible.

Table 3 Participant satisfaction with access to exercise program.

Variable	N = 4
In general, how satisfied were you with your access to the online exercise program?	3 highly satisfied. 1 moderately satisfied.
Before the online exercise program, I had access to fitness programming that met my physical activity needs.	1 strongly agree. 1 moderately agree. 2 moderately disagree.
The online exercise program provided me access to fitness programming I would not otherwise have.	3 strongly agree. 1 moderately agree.
Before participating in the online exercise program, I engaged in physical activity on a regular basis (*i.e.* 30 min or more at least 3 days per week).	1 strongly agree. 1 moderately agree. 2 strongly disagree.
I found that the online exercise program twice a week was adequate.	1 strongly agree. 2 moderately agree. 1 moderately disagree.
I found that 45 min was an appropriate amount of time for a physical activity session.	3 strongly agree. 1 moderately agree.

Table 4 Participant satisfaction with instruction.

Variable	N = 4
In general, how satisfied were you with the online exercise class instruction?	4 highly satisfied.
My instructor was knowledgeable in their content area.	4 strongly agree.
My instructor was an effective leader in a physical activity class.	4 strongly agree.
My instructor maintained good control of the exercise class.	4 strongly agree.
Having a live instructor aided in my ability to do moves correctly and safely.	3 strongly agree. 1 moderately agree.
The instructor explained why the individual exercises were beneficial.	2 strongly agree. 2 moderately agree.
I found the instruction easy to follow.	4 strongly agree.
I found it helpful to follow a specific instructor based on my physical capabilities.	3 strongly agree. 1 moderately agree.
The instructors cueing skills (the ability to explain moves ahead of time) were helpful in keeping up with the class.	3 strongly agree. 1 moderately agree.

Group physical activity

Participants reported high levels of agreement related to the group based physical activity program (Table 8). Items with the highest level of agreement included, *"This physical activity group provides me with a good opportunity to improve in areas of fitness I consider important" (mean=8.50), "I like the program of physical activities done in this group" (mean=8.50), "I enjoy new exercises done in this physical activity group" (mean=8.50), "In terms of the social experiences in my life, this physical activity group is very important" (mean=8.50), "This physical activity group provides me with good opportunities to improve my personal*

Table 5 Participant satisfaction with content.

Variable	N = 4
In general, how satisfied were you with the overall content of the online exercise class?	4 highly satisfied.
I found the content of the online exercise class interesting.	4 strongly agree.
I found the content of the online exercise class applicable to my physical activity needs.	4 strongly agree.
I found I was able to keep up without overexerting myself.	3 strongly agree. 1 moderately agree.
I felt the structure of the class made it more enjoyable (*i.e.* warm up, aerobics, cool-down).	4 strongly agree.

Table 6 Participant satisfaction with videoconferencing.

Variable	N = 4
In general, how satisfied were you with using videoconferencing for the online exercise class?	3 highly satisfied. 1 moderately dissatisfied.
I found the videoconferencing technology easy to use.	2 strongly agree. 2 moderately agree.
I was satisfied with the function of the technology.	2 moderately agree. 2 moderately disagree.
The screens provided by the videoconferencing software seemed well-suited to the exercise class.	1 strongly agree. 3 moderately agree.
I found videoconferencing with the instructor helpful in performing the physical activity exercises.	2 strongly agree. 2 moderately agree.
I believe videoconferencing assisted the instructor in properly managing the seated exercise class.	1 strongly agree. 3 moderately agree.

fitness" (mean=8.75), and "Members of our physical activity group often socialize during exercise time" (mean = 8.75). *Items with lower levels of agreement included, "Our group is united in its beliefs about the benefits of the physical activities offered in this program." (mean=6.75), "Our group is in agreement about the program of physical activities that should be offered" (mean=6.75), "Members of our physical activity group would likely spend time together if the program were to end" (mean=6.67), "Members of our group sometimes socialize together outside of activity time"* (mean = 6.25).

Table 7 Participant perceived benefits.

Variable	N = 4
In general, how satisfied were you with the effect of the online exercise program on your health and general well-being?	4 highly satisfied.
I believe that the online exercise class had a positive effect on my physical health.	4 strongly agree.
I believe that the online exercise class had a positive effect on my psychological health.	4 strongly agree.
I found that the online exercise class resulted in fewer health complications (e.g. pain, pressure sores, fatigue, infections, etc.).	2 strongly agree. 2 moderately agree.
I will continue to engage in the physical activity exercises I learned in during the online exercise class.	2 strongly agree. 1 moderately agree. 1 moderately disagree.
I now have a better understanding of the kinds of exercises suited for my capabilities.	2 strongly agree. 1 moderately agree. 1 moderately disagree.
If possible, I would continue to use the study technologies in my home.	3 strongly agree. 1 moderately agree.

Table 8 Physical Activity Group Environment Questionnaire.

Variable	Mean	SD
I like the amount of physical activity I get in this program.	8.25	.96
This physical activity group is an important social unit for me.	8.00	1.16
I enjoy social interactions within this physical activity group.	8.00	1.16
This physical activity group provides me with a good opportunity to improve in areas of fitness I consider important.	8.50	1.00
I like meeting the people who come to this physical activity group.	8.25	.96
I am happy with the intensity of the physical activity in this program.	7.75	.96
I like the program of physical activities done in this group.	8.50	.58
If this program were to end, I would miss my contact with the other participants.	8.00	.82
I enjoy new exercises done in this physical activity group.	8.50	.58
In terms of the social experiences in my life, this physical activity group is very important.	8.50	1.00
This physical activity group provides me with good opportunities to improve my personal fitness.	8.75	.50
The social interactions I have in this physical activity group are important to me.	8.00	1.41
Members of our physical activity group often socialize during exercise time.	8.75	.50
Our group is united in its beliefs about the benefits of the physical activities offered in this program.	6.75	2.06
Members of our physical activity group would likely spend time together if the program were to end.	6.67	4.04
Our group is in agreement about the program of physical activities that should be offered.	6.75	2.06
Members of our group are satisfied with the intensity of physical activity in this program.	8.25	.96
Members of our group sometimes socialize together outside of activity time.	6.25	3.77
We spend time socializing with each other before or after our activity sessions.	8.25	.96
Members of our group enjoy helping if work needs to be done to prepare for activity sessions.	7.75	2.06
We encourage each other in order to get the most out of the program.	8.00	1.16

Secondary outcomes: neuroqol

Moderate to large effect sizes were seen on measures of depression ($d = 0.67$), anxiety ($d = 2.39$), and satisfaction with social roles and activities ($d = 0.43$) from baseline to post-intervention. Improvements in anxiety scores ($d = 2.02$) and satisfaction with social roles and activities ($d = 0.52$) were maintained at follow-up. Table 9 provides an overview of changes in outcomes from baseline, post-treatment, and three month follow-up.

Adverse effects

Shortness of breath and pain were adverse events reported by participants. Shortness of breath was reported by one participant after the exercise class for weeks 1 –4. During the first exercise class, shortness of breath impacted this participant by causing her to "need to take a small couple seconds to catch up". Similarly, this participant was "challenged to keep up" during the second week of exercise classes. During the third week of exercise courses, this participant only experienced shortness of breath during "the beginning while blood pressure catches up" and during the fourth week, found herself to be "challenged at times when using 1 lb weights". The onset of pain was reported by two participants after the first week of exercise; neuropathic foot pain and shoulder tightness/ upper back knots. Shoulder pain was also reported by one participant after week five; however, it was specified that the pain was not due to the exercise class. The same participant who reported experiencing shortness of breath and shoulder pain also reported positive changes in her ability to perform activities of daily living after weeks 3 - 6 of the exercise classes. After weeks 3 through 5, she reported benefits of it being easier to wheel up hills and slopes and after week 6, she reported having improved strength.

Discussion

The COVID-19 pandemic has contributed to rapid, widespread implementation of virtual platforms for service delivery of hospital-based programs, including online physical activity programs. Despite this, there is very little scientific literature describing group online physical activity programming for persons with SCI or similar conditions, including perceived feasibility and acceptability of the program. This study demonstrated that the virtual delivery of a hospital-based SCI physical activity program was feasible and acceptable; as indicated through high rates of recruitment (67%), engagement in each session (100%), and retention (100%). These results are consistent with previous studies evaluating online physical activity programs among those with SCI,[14,16] and other disability populations.[23,24]

Participants reported high levels of satisfaction and acceptability with the overall program and videoconferencing platform. In terms of access to the program, one participant felt that twice weekly sessions were not adequate for their needs. However, the number of sessions beyond the minimal recommendations may not significantly impact outcomes. Michie and colleagues[25] reported no relationship between effect sizes of outcomes such as self-monitoring and intensity among various physical activity interventions. Previous online programs targeting those with SCI were less intense, with once weekly sessions over four weeks, and were found to have similar levels of satisfaction.[14,16] The current program was developed to align with recommendations for the minimal level of activity engagement for those with SCI,[1] which may not meet the needs of those who desire a more intense program. Thus, including the minimal number of sessions to align with clinical practice guidelines in the core program would benefit most individuals; additional programing could be added for those interested in greater engagement.

The benefits of physical activity post SCI are well established.[1,5,26] All participants reported that the exercise program resulted in improvement in their physical and psychological health. Additionally, participants reported that the program resulted in fewer secondary complications, such as pain and fatigue. Consistent with previous findings,[5,27] the current study found large effects of the intervention on anxiety post-intervention and at three-month follow-up. In contrast to previous studies, moderate effects on symptoms of depression were seen post-intervention and these were not maintained at follow-up.[5] This may be explained by the low levels of depressive symptoms at baseline among participants. Improvement in satisfaction with

Table 9 Secondary outcomes – means of Neuro-QOL outcomes of interest and Cohen'd for baseline to post-intervention and baseline to follow-up.

	Mean (standard deviation)			Cohen's d	
	Baseline	Post-intervention	3-month follow up	Baseline to Post-intervention	Baseline to 3-month follow up
Depression	45.20 (2.00)	46.66 (2.68)	43.50 (6.86)	0.67	0.29
Anxiety	50.50 (5.86)	39.03 (4.56)	39.83 (5.95)	2.39	2.02
Fatigue	40.37 (5.07)	41.03 (4.56)	41.97 (6.35)	0.15	0.31
Satisfaction with social roles and activities	46.43 (3.22)	45.20 (3.12)	45.00 (2.91)	0.43	0.52
Sleep Disturbance	51.90 (6.20)	53.83 (8.38)	48.50 (10.76)	0.28	0.39

social roles and activities was seen post-intervention and was maintained at a 3-month follow-up. As many individuals experience greater feelings of isolation during the pandemic,[10] this finding has important implications for the acceptability of online programs to connect individuals during the pandemic. Additionally, these results demonstrate that virtual programs which allocate time for social interactions may help develop social connectedness among people that may experience geographical and physical barriers to in person physical activity programs. Social interactions amongst participants may also serve as motivation for continued engagement.[28]

Previous studies have shown that personal factors such as sex (*i.e.* females), older age, higher injury severity, and tetraplegia are correlated with decreased likelihood that an individual will meet the activity recommendations of best practice guidelines.[1,29] The current virtual physical activity program was effective in engaging these subgroups of individuals. A possible explanation for this may be that the current study incorporated strategies to overcome barriers to engagement. Among those with SCI, barriers to engagement includes expensive exercise equipment, inaccessible facilities, lack of transport, health concerns, and perceiving exercise as difficult.[30,31] Through the online delivery of the program, many barriers including inaccessible facilities and lack of transport were overcome. Alternatives to expensive equipment such as water bottles and rice bags were incorporated to provide resistance to those able. Additionally, during the initial assessment phase of the study, particular attention was placed on ensuring participants were able to address any health concerns with the fitness instructor. Education on red flags and steps to take in case of adverse events were provided in the one-on-one session. Furthermore, in order to ensure participants were capable of all the exercises, individual one on one instruction was provided with modifications based on an individual's needs.

Limitations

The current study was small and meant to be an initial step towards implementing the program into an outpatient rehabilitation or community-based fitness setting. The study's small sample size limits it's generalizability for a larger population. Thus, the results from the study should be interpreted with caution as larger trials are warranted to confirm its findings. Since this was not a controlled study, the results were limited to a preliminary indication of feasibility and efficacy. The outcome analysis should be evaluated with caution; however, the results are consistent with previous findings that have shown improvement in psychosocial outcomes with increased group based physical activity. Additionally, as the study was conducted during the pandemic, access to services and/or social interaction were dynamic. Thus, changes in outcomes may be due to the dynamic nature of the system rather than the program itself. Individuals that developed the program were also involved in recruitment and program delivery. This may have potentially led to biases in the positive results. It is unknown whether having a previous relationship with participants influenced participants level of acceptance on the program and platform. The researchers did not evaluate the impact of having the program led by a person with lived experience on participant engagement. Evaluation of participants' perceived acceptability of a program led by a person with lived experience compared to those without may be warranted for developing future programs and scaling up to a larger population. As the current study was conducted through a hospital-based outpatient program, it was limited in the use of the videoconferencing software approved by hospital IT department. Evaluation of other videoconferencing software may be warranted for greater ease of use and acceptability by participants. The study is also limited by its short follow-up period of three months; information on long-term continued participation is lacking. Outcomes were collected through subjective means and may have response bias associated with it. Questions related to intensity of exercise (moderate or strenuous) were not examined; thus, future studies should evaluate intensity in order to ensure adherence to guidelines are met. Furthermore, capturing physiological outcomes through user friendly devices such as accelerometers or heart rate monitors may provide more objective measures of activity engagement.

Clinical implications

Despite the limitations presented above, the current study has important clinical implications for the development and delivery of virtual physical activity programs for those with SCI. A virtual exercise program increases the availability of accessible services and minimizes physical and environmental barriers to activity participation for this population. This is especially true during the COVID-19 pandemic, when there are additional barriers in terms of services available and the need to minimize potential risk of exposure to the virus. The program has the capability for customization and adaption to the participants needs; ability to

monitor participants and provide feedback; and the ability to reach a larger population. Of note, given the emerging availability of online programs, rehabilitation providers might be advised to introduce and promote these programs to their patients during inpatient stays. This would have the benefit of assisting the person to gain the awareness and skills to access these resources after they have been discharged in to the community – often with less than adequate accessible physical activity services.

The current study incorporated several considerations when implementing the virtual program. Concerns related to safety and perceived difficulty can be addressed through pre-session consultation and screening with the participants. In the current program, initial sessions offered information on safety planning, personalized assessment of an individual's ability, and guidance on exercise movements. This allowed participants to be better informed of their abilities and develop risk plans thereby reducing their health concerns related to safety in activity engagement. Additionally, each session included spotters to help participants appropriately engage in the program without hurting themselves. As a greater number of participants form the group, it may be necessary to include more spotters.

Providing technical support and guidance on the online platform on an individual basis allowed participants to be more familiar with the software. Incorporating a brief period at the end of the session for social interaction may help to develop motivation and a sense of connectedness among participants. Despite the advantages of the online program, barriers related to access to appropriate technologies (*i.e.* laptop, phone, tablet) and a reliable internet connection may be present. As mentioned previously, due to limitations to the availability of videoconferencing software available to researchers in the hospital setting, some participants experienced concerns related to quality of the video transmission. Thus, it may be important to trial different videoconferencing software to help overcome some of these technical concerns. Additionally, it's important for researchers and clinicians to work with local community organizations and help advocate for these devices for those that may be in a lower-socioeconomic status.

Future directions

The current study provides a framework for on-going virtual physical activity programming among those with SCI. Future programs may benefit from a more holistic approach such as embedding behavioral change strategies to enhance participation and long-term maintenance. A previous meta-analysis examining physical activity interventions among those with disabilities found that incorporating behavioral interventions resulted in larger effect sizes in increasing levels of physical activity at home or in the community than those that did not.[32] Thus, future programs may consider the inclusion of physical activity coaches, peers and/or exercise specialists, to further develop behavior change. The current research team is developing an enhanced program which embeds online cognitive behavioral therapy and physical activity programming for a more multidisciplinary approach. Additionally, use of more objective measures such as accelerometers and heart rate monitors may provide a more accurate measure of activity engagement and intensity. Future studies may also want to incorporate use of various monitoring strategies throughout the program. Programs embedded with monitoring and feedback from other individuals were reported to have higher effect sizes that those that did not.[32] However, having an individual monitor engagement may not be sustainable in all settings. Thus, self-monitoring strategies such as apps or gamification may be used to promote sustainable programs. Research evidence suggests that use of self-monitoring strategies are more effective in increasing levels of physical activity at home or in the community than those that do not.[32] To ensure the development of sustainable programs, partnerships with community organizations to help ensure community engagement and funding may be warranted. The Telerehabilitation Toolkit may be an important tool to provide a framework for implementing the program in an outpatient or community setting (https://kite-uhn.com/tools/tr-telerehab-toolkit).

Conclusion

In conclusion, the current study demonstrated that virtual physical activity programs have promise for promoting activity engagement and perceived emotional wellbeing among those with spinal cord injury. They have the potential to overcome barriers to access services during the COVID-19 pandemic; but also to improve access to programming in the future for those with geographic and mobility barriers. The program was found to be acceptable and participants reported increases in perceived health benefits. Implementation of virtual programming may help to transform service delivery models that benefit those not able to access current services.

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