Potential Benefits of a Novel Home-Based Exercise Program for Inactive Older Adults: An Exploratory Case Study

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Abstract

Background

This study proposed a 3-week home exercise program using a square-stepping exercise (SSE) to explore if it could address common barriers and enhance enablers of regular exercise among older adults.

Methods

Using embedded mixed methods, 10 inactive older adults over the age of 65 completed the proposed program in conjunction with follow-up interviews. Participants were deemed inactive if they took less than 10,000 steps/day over one week. Their physical activity was tracked at home with a pedometer.

Results

Barriers reached during the proposed program were being uncomfortable in a fitness facility and body image. The proposed program enhanced enablers such as the use of home equipment and easy access. The average total steps/day increased by 27% ($p=0.02$) and moderate-intensity was reached by 80% of participants when performing the SSE.

Conclusion

The exercise program addressed the common barriers to exercise and could increase the physical activity level of inactive older adults especially for those intimidated by a fitness facility setting and those concerned with their body image.

Background

The proportion of the world's population over 60 years is predicted to almost double between 2015 and 2050 as older adults will outnumber young children due to population aging (1). Most countries are aiming to increase the number of older adults who remain in an independent living situation. In order to remain independent older adults, need to stay physically active. Thus, exercise is a suitable option to reach this goal since it reduces the risk of chronic conditions, frailty, hospital stays, and mortality (2). Adults 65 years or older are recommended to do at least 150 minutes of moderate-intensity to vigorous-intensity aerobic physical activity (3). Moderate intensity is typically the minimum intensity recommended during aerobic exercise by many international and national agencies to optimize health and functional benefits (3, 4). Unfortunately, less than 15% of older adults meet the recommendations when exercise is measured objectively (5).

Previous research has identified several barriers and enablers to regularly engaging in physical activities. Such barriers to exercise have included lack of time (6), pain/injury (7–10), and lack of motivation (8, 9). Conversely, some enablers identified in previous research have included perception of health benefits (8–12), social support (8–11), and enjoyment/fun (8–11, 13). Home-based exercise can help encourage

lifestyle changes that may mitigate the majority of barriers to regular physical activity (14). In an attempt to increase physical activity, it was concluded that encouraging lifestyle changes may benefit those with increased cardiovascular risk (14). In order to be effective, they suggested that various lifestyle approaches such as home-based exercise need professional encouragement from healthcare or exercise professional.

Home-based exercise offers the opportunity to complete exercise every day using a flexible schedule at a low cost (15). Square-Stepping Exercise (SSE) is an example of a home-based aerobic exercise (16). Shigematsu and Okura (17) developed this exercise in Japan and it was deemed suitable for home-based exercise (18). The SSE is performed on a thin felt mat that is two meters in length and divided into small squares. It is an unobtrusive piece of equipment to be used in the home. The SSE would pose a dualistic function as it combines a cognitive aspect (memory task) with physical activity.

In general, taking multidirectional steps in a pattern was shown to enhance motor learning, balance, and memory that could potentially prevent falls (19). It was suggested that SSE is safe and acceptable especially for lower-body functional fitness and it may be recommended to older adults due to its low cost and effectiveness (20). Research has shown that the SSE is effective in strength and balance training (20) and can improve cognitive impairment as a result of changing stepping patterns (20). The exercise is also more effective than walking programs in reducing fall risk factors (21). Despite these results, the intensity reached while performing the SSE in 10-minutes bouts is unknown.

After reviewing the literature on how to combat adverse consequences from physical inactivity, it was determined that this home-based SSE program would promote accessible physical activity outside of fitness facilities. When considering the impacts of health and physical activity in tandem with the needs of the aging population, suitable options for moderate-intensity exercise were needed. A stepping program like the SSE could be modified to fit different purposes, settings, and populations (19). This study aimed to employ a single case study design to determine if a home-based exercise program for inactive older adults would help overcome barriers and stimulate enablers for regular physical activity following the World Health Organization (WHO) recommendations at the recommended intensity. The primary research question was: Can SSE overcome baseline barriers to exercise or stimulate enablers? The secondary research question was: Can SSE increase physical activity level and reach the recommended intensity?

Methods

This study used a case study methodological approach. Case study research is defined as “a qualitative approach that explores real-life, contemporary bounded system (a case) or multiple bounded system (cases) over time, through a detailed, in-depth data collection using multiple sources of information” (22 p96). The use of data from multiple sources aid in identifying case themes and descriptions (22). Thus, case studies seek to answer the “How” and “Why” (23).

The intent of a case study can be viewed in three different variations: single case study design, collective or multiple case study, and intrinsic case study (22). For the purpose of this research, a single instrumental case study was employed. A single instrumental case study focuses on a question by selecting a bounded case to describe the topic being reviewed (22). Specific procedures for conducting case study research have been identified by Stake (24) and Yin (23) and further explained by Creswell and Poth (22):

1. Determining if the research problem is appropriate for using a case study approach;
2. Identifying the focus of the study and select a case or cases;
3. Developing techniques using multiple sources for extensive data collection;
4. Specifying the analysis approach for developing case description(s); and,
5. Reporting the interpreted meaning of the case through using case assertions. (pp. 100-101)

The single case study design was used to focus on a home-based exercise program for inactive older adults to help overcome barriers and stimulate enablers for regular physical activity.

By taking this methodological approach, embedded mixed methods were used for the data collection process as this research employed multiple sources of data collection. More specifically, Ivankova and Creswell (25) described embedded mixed methods as one data set providing a supportive and secondary role in a study based primarily on the other type of data. This is useful to intertwine the quantitative data with a qualitative methodology while answering the research questions.

Participants

This project was approved by a Research Ethics Board. Purposeful and convenience sampling was used to identify information-rich cases that provide information about issues of central importance (26). Therefore, the selected sample was purposefully inactive older adults. As well, the geographical location of the study attracted many participants that had post-secondary education and high-income levels, which was convenient for the researchers. Each sample group selected for this research contributed data to answer the research questions.

Inclusion criteria for the participants were the following:

- Age 65-80;
- Not receiving any kind of home care services (formal or informal);
- Being cleared to exercise using the Get Active Questionnaire (27);
- Resting heart rate <99 and blood pressure <160/90; and
- Average total steps/day <10,000 measured over seven days via a pedometer (Steps Count, StepRX) (28).

Exercise Program Design

The goal of the participants in the exercise program was to accumulate ≥150-minutes of the SSE in 10-minute bouts per week. Even though resistance training is also recommended since it can help improve the decline in muscular function seen in older adults, the focus of this research thesis was whether older adults could increase their physical activity with SSE. All exercise sessions began with the SSE warm-up with participants performing 5 sequences before their 10-minute bout. An SSE sequence included forward, backward, lateral, and oblique steps, however, only one SSE pattern was used for all aerobic activity (see Figure 1).

An SSE mat, provided to each participant, which was 200 × 100 cm divided into 32 small squares (25 × 25 cm) two meters in length. Typically, the SSE was completed in groups where participants travelled forward on the mat and circled around the mat to complete additional sequences. Participants in this research were asked to complete the sequences as they preferred or were most comfortable with. For example, participants could choose to go back and forth or circle back to the starting point. The study participants were asked to position the mat close to a wall for support. The cost of the SSE mats were less than $5.00 CDN each.

During the data collection process, the researcher gathered with participants four times and all visits took place in a setting that mimicked a home setting where the only requirement was a flat floor. Beyond the in-person visits, the study participants were responsible for completing the remaining part of the program at home. Below is a description of measures completed over four visits.

Visit One (60-minutes)

Participants read and signed a consent form to participate and allowed the researcher to publish patient information. Then, they performed tests to determine baseline data. Resting Heart Rate (RHR) and Blood Pressure (BP) was measured using an automatic blood pressure cuff (Omron, blood pressure monitor, Kyoto, Japan) for safety purposes. Height and body weight were measured using a stadiometer (Seca, stadiometer, Hamburg Germany). The Four Senior Fitness Tests (SFT) used were the 2-minute step test (endurance), 8 foot up and go (agility), and squat to chair (lower body strength), and arm curl (upper body strength). A description of the tests is within the Senior Fitness Test Manual by Rikli and Jones (29). The unipedal test was used to measure balance. Participants self-reported a level of importance (e.g., 1: not very important to 10: very important) on 25 barriers to exercise with a maximum score of 250 made through the Canadian Society for Exercise Physiology (CSEP) (27). Participants answered additional demographic questions regarding their ethnicity, level of education obtained, age, gender, and personal income. Participants were also given a Step RX pedometer (Steps Count, StepRX, Ontario, Canada) to measure total steps and total time spent at Moderate to Vigorous Physical Activity (MVPA). The threshold for MVPA was 100 steps or above per minute (30) with a minimum of four consecutive days of wear-time to be considered as a valid measure (31).

Visit Two (45-minutes)

Before starting the program, participants returned the Step RX pedometer. The laboratory staff confirmed their eligibility criteria. During the visit, participants were given an SSE mat to bring home and practice the home-based exercise program. Although the SSE session was 10-minutes, it might have varied a bit based on the number of questions asked by the participant.

Visit Three (45-minutes)

Before the last week of the program, the session of the SSE was 10-minutes. Fewer questions were asked as research staff wanted to observe how participants performed the exercises after completing the program for 2-weeks. Participants were given a Step RX pedometer again. This device was worn again on the hip for a minimum of four consecutive days during which the participants had access to a SSE mat.

Visit Four (90-minutes)

Participants returned the Step RX pedometer and completed a 10-minute SSE session. Heart rate (HR) was registered via the HR sensor (Polar H7, Woodbury, New York, USA). To estimate the exercise intensity, HR reserve (HRR) was calculated by (max HR-resting HR) *.40 + resting HR; max HR was calculated by 220-age. The average HR while performing the SSE was recorded during minutes 5 to 10. To reach moderate intensity, 40% of HRR had to be achieved (32). No feedback from the staff was made. Then, participants completed a 30-60-minute interview to understand their experience with the home-based exercise program.

Interview Process

After completing the SSE during the fourth visit, each participant was involved in a 30 to 60-minute interview. Interviews were done face-to-face. Semi-structured interviews with open-ended questions were used to allow participants to respond freely, provide descriptions, and understand participant perceptions in more detail (33). A total of 14 open-ended questions were asked (see Additional File 1 for the interview guide). By taking this approach, new ideas emerged to gain a deeper understanding of the participant's experience. The general area of questions posed related to personal experiences of becoming more physically active with the program. All interviews were audio-recorded and transcribed with participant permission. Participant's names were changed to ensure confidentiality. Data saturation is often used to determine when to end conducting interviews (34). This point was reached when a minimum of 10 participants was sampled.

Data Analysis

The analysis employed the framework method that interpreted the quantitative and qualitative results through five stages (35). The framework method developed by Ritchie and Lewis was used to analyse data for a matrix output (35). The method originated in large-scale social policy research but has become more popular in health research (36). The analysis was shown to be suitable for both qualitative and quantitative researchers and provided a spreadsheet format and clear steps to follow for qualitative exploration (36). However, caution was recommended as data sets should cover similar topics and be

overseen by an experienced researcher. The matrix output offered interconnected data for charting quantitative and qualitative data which included rows (cases), columns (codes), and 'cells' that summarized this data.

Quantitative data analysis consisted of gathering measurements on baseline characteristics and the changes during the program. The Wilcoxon Signed Ranks Test was used to quantify the change pre-post on continuous variables. To analyze the qualitative interviews, Miles and Huberman's five-step process was used (37). The stages used were:

1. Familiarization - listen
2. Thematic identification – use of Leximancer 4.0 to emerge themes
3. Indexing or coding - trustworthiness of the data analysis process
4. Charting - use of QSR NVivo 12
5. Mapping and interpretation - verbal insight towards quantitative outcomes

Results

Quantitative data

Demographic and characteristic information on participants is presented in Table 1 and 2.

The sample included 10 participants, of whom were 60% female. The average age was 71 years with an average body mass index (BMI) of 30 kg/m^2. All participants completed high school at least; four participants obtained a university degree. Five participants had personal incomes above $35,000/year. Physical function measurements showed that most participants were above average compared to age-sex norms based on the Senior Fitness tests (29).

Participants self-reported a level of importance (1-10) on 25 barriers to exercise with a maximum score of 250 (Table 3).

The most important barriers included: lack of motivation (6.2), lack of energy (4.8), other priorities (4.7), uncomfortable or intimidated in a fitness facility (4.7), lack of exercise programs suitable for my level (4.7), keep talking myself out of it (4.3), and how I see my body (4.3). Most of the participants increased physical activity when last week of the program and baseline were compared. The average total steps/day increased by 27% from 5878 to 7495-steps/day (p=0.02), but no difference was observed in daily MVPA. Figure 2 presents the average HRR for each participant when supervised performing 10-minutes of the SSE at week 3. A total of 8 of 10 participants reached moderate intensity.

Qualitative data

After the framework analysis, five barriers and five enablers for cases were represented in the program based on several common references. Table 4 and 5 presents perceived barriers and enablers to the

proposed program. Actual transcribed quotations are included in these tables. Interestingly, the most important barrier was lack of motivation which may have been modified by participants during the program. Participant 1 noted, “10-minutes is easy, when I first started it felt a little difficult, in the beginning, some days I was at 10-minutes then I increased it to 15 to 20-minutes and 10-minutes, in fact, started to become easy [Achievable Goal].” Participant 8 added, “It is nice, you don’t really need any special equipment. In the hall there’s a treadmill and a bike, at home, I keep my eye on that. But you can just stand up to the wall and do it… [Home equipment].” Finally, Participant 5 stated, “The fact that the program is all set up and it’s not difficult to do on your own [Convenience].”

The simplicity of the program presented a non-daunting task that facilitated participants’ adherence to exercise regardless of the perceived lack of motivation. It was simple to do and could be done anywhere in a short amount of time. The provided home equipment, such as the SSE mat, was also convenient and provided at no cost. Acquiring equipment at no cost or of little cost can have a dramatic effect on physical activity. However, it is important to note that some cases (e.g., Participant 2, Participant 3) thought the SSE mat required a certain level of concentration described as too much focus needed to perform the exercise.

Table 6 provided the framework matrix highlighting cases with high and low average total steps/day with qualitative results. The matrix summarized the connections of self-reported barriers, senior fitness, pre-post average total steps/day, intensity, and themes sorted by row. The first two rows offered a unique representation of cases with the lowest average total steps/day; the last two rows represented cases that reached >10,000-steps. From the first row, Participant 8 had a low average total steps/day and discussed some limitations that were experienced:

Just on the mat, things that came to my mind, just don’t overdo it. Yes, keep a rhythm, but you don’t have to go fast. I think it was going around and around. I was getting dizzy at the end.

As well, Participant 2 had a low average total steps/day and had difficulty balancing. They also perceived a barrier total of 118/250 based on the level of importance. Participant 2 elaborated on a negative previous experience in their 50’s while playing soccer when they tore some tendons in their knee:

I do a lot of work at the computer and read books a lot. We live in the country, I want to spend more time outside, but the bugs are a problem. We have a treadmill at home to have me do exercise, if I’m listening to a food radio program or watching TV programs. I have a lot of reasons I come up with for not doing exercise. That’s why I wanted to come here to be more active in the home without involving much equipment.

To reduce data, the framework matrix summarized information on Participant 2 and 8 (low average steps/day) and Participant 4 and 5 (>10,000 steps/day) to compare, contrast, and search for patterns.

Discussion

This study aimed to determine the effect of a home-based exercise program for inactive older adults to influence current barriers and stimulate enablers for regular physical activity at the recommended intensity. As well, it evaluated a novel home-based exercise program for inactive older adults. This study showed that the proposed program targeted some barriers and enablers and could lead to greater exercise at moderate intensity. However, as with any exercise program, it could be more suited for some than others. Our results showed that inactive older adults who benefited from this program are those intimidated by a fitness facility setting and concerned with their body image.

Barriers

This study demonstrated that some main barriers commonly reported by older adults such as lack of time, pain/injury, lack of social support, poor health/illness, and lack of knowledge (7–9,12) were not observed to be of high importance in the sample when self-reporting perceived barriers to exercise at the baseline. This could be in part related to the baseline characteristics since most of the participants were highly functional, highly educated, and financially comfortable. However, five barriers with the highest level of importance reported through the baseline questionnaire (i.e., lack of motivation, lack of energy, other priorities, uncomfortable or intimidated in a fitness facility, lack of exercise programs suitable for my level, keep talking myself out of it, and how I see my body) mostly changed during this home-exercise program as reported in the interviews.

Motivation to exercise could be linked to other barriers; for example, the perception of lack of time was often related to a lack of motivation to exercise (38). A lack of time was reported by the participants of this study. The perception of a lack of time and a lack of motivation are both modifiable (38). Motivation is dependent on self-discipline when trying to adhere to an exercise program (9). However, motivation is a multi-dimensional construct suggesting that a host of barriers could be linked to not feeling like exercising. There are many reported barriers in the literature; however, none of the exercise programs in the literature addressed all barriers. Home-based exercises as proposed in this study did not address all barriers but addressed some important ones. This is known as ‘responders’ to show not everybody will respond the way anticipated (39).

Barriers reported at baseline were not always reported in the interviews. This showed that perceived barriers are dynamic and depend on the program characteristics. Participants who performed this home-based exercise program did not experience constraints with accessibility and feeling uncomfortable in a fitness facility. The participants reported barriers to exercise at baseline and even if the program addressed some of these, participants identified other barriers after the program. This phenomenon can be explained by the fact that habits and behaviour patterns change (40). As a result, finding the perfect exercise program to overcome barriers might change over time and from one person to the other. Therefore, the tested exercise program seemingly addressed some barriers identified in the literature as perceived at baseline and could be useful depending on the situation. For example, this program was considered by some when it was raining or hot outside.

Enablers

Effective exercise programs for older adults can stimulate exercise enablers such as the perception of health benefits, social support, and enjoyment/fun (8–13). For example, one of the enablers found in the interviews was increasing fitness which often related to wanting to improve health (8). Through the course of this program, most participants performed the program at moderate intensity and increased average steps/day, which is known to lead to an increase in fitness.

Framework Matrix

Most participants completed the SSE and reached moderate intensity when supervised. However, based on the interviews, this program may not be suitable for adults age 75 and older as they reported more barriers to keep intensity required because of a lack of energy or motivation. This is consistent with some barriers in the literature suggested for this demographic (8). Interestingly, participants with a higher BMI were seen as capable to complete the home-based exercise program. Lastly, those who were more active, even if considered inactive at baseline, reported fewer barriers.

Physical Activity Level

The number of steps that increased to the recommended level of 7000 steps/day for older adults could be due to the high baseline of the participants' functional abilities and the short-term program (28). It is important to note that this short-term program resulted in acute effects and long-term effects of any program normally decline over time. Long-term follow-up of these participants would be important to see the true value of physical activity levels.

Even if the total number of steps increased significantly during the program, the number of minutes spent at moderate to vigorous intensity did not significantly increase. This is surprising since eight out of ten participants reached moderate intensity while exercising with us during the last week of the program. This could be explained by the fact that they were supervised when the intensity was measured and not at home. The literature supported that the intensity is greater when supervised (41). This can explain the difference between moderate intensity at home with a pedometer (>100 steps per minute) compared to a heart rate monitor (>40% of HRR) used during supervision. Some have reported that the number of steps/minute should be greater than 100 to be considered moderate intensity. 120 steps per minute was suggested (42,43).

Limitations

This study is not without limitations such as a small sample size for increasing physical activity. The SSE was also not tracked at home, so it is impossible to understand the contribution of this part of the program. Participants seemingly enjoyed the visits with the research staff present, so this could have developed a bias encouraging participation and increased adherence to the program. This study used the framework method for analysis which was overseen by an experienced researcher; however, the framework method required similar research objectives. The majority of participants had post-secondary education and high-income which is not the norm for the target population. This could have been caused

by the location of data collection, the university setting, or the strategy used to attract participants (e.g., internet). The demographics of the sample may have been an underlining foundation of the themes that emerged for barriers at baseline, barriers overcame during the program, and stimulated enablers.

Impact/conclusion

The results showed that the SSE program increased the physical activity level of older adults considered inactive, overcame barriers, and stimulated enablers to exercise within the sample. Regardless of body weight, older adults younger than 75 years with greater physical function seemed to be more likely to benefit the most from this program. Older inactive adults who were uncomfortable in a fitness facility or those who do not have a great perception of their body image could also benefit from the proposed program. As older adults begin to remain inactive longer and possibly at home longer, this home-based exercise program could be beneficial. Possibilities are endless when you consider the amount of time one might spend at home that would allow for a greater opportunity to encourage aging in place (i.e., health, social support, and services to live safely and independently) or rather aging in home.

Abbreviations

WHO: World Health Organization

SSE: Square-Stepping Exercise

CSEP: Canadian Society for Exercise Physiology

RHR: Resting Heart Rate

BP: Blood Pressure

SFT: Senior Fitness Test

MVPA: Moderate to Vigorous Physical Activity

HR: Heart rate

BMI: Body mass index

HRR: HR reserve

Declarations

Ethics Approval and Consent to Participate

Approval number of the Research Ethics Board of the University of New Brunswick is 2019/057. Participants read and signed a consent form to participate and allowed the researcher to

publish patient information.

Consent for Publication

Written informed consent for publication was obtained.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contribution

ML made substantial contributions to the conception, design of the work, the acquisition, analysis, and interpretation of data. ML draft and revised the work, approved the submitted version, and agreed to be personally accountable for the author's own contributions.

JE made substantial contributions to the conception, design of the work, the acquisition, analysis, and interpretation of data. JE draft and revised the work, approved the submitted version, and agreed to be personally accountable for the author's own contributions.

DB made substantial contributions to the conception, design of the work, the acquisition, analysis, and interpretation of data. DB draft and revised the work, approved the submitted version, and agreed to be personally accountable for the author's own contributions.

JM made substantial contributions to the conception and interpretation of data. JM also draft and revised the work, approved the submitted version, and agreed to be personally accountable for the author's own contributions.

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Tables

Table 1

Demographic Information on Participants

Characteristics	Mean	1	2	3	4	5	6	7	8	9	10
Age (years)	M (72) F (70)	66	74	76	70	67	76	68	75	65	71
Sex	M (40%)	M	M	M	M	F	F	F	F	F	F
Education Level	U (40%)	HS	U	U	HS	U	U	D	D	HS	D
Personal Income ($)	-	3	4	5	2	5	5	1	2	0	4

Sex: M: Male; F: Female

Education Level HS: High School; D: Diploma; U: University.

Personal incomes: 0: Less than 20000; 1:20,000 to 34,999; 2: 35,000 to 49,999; 3: 50,000 to 74,999; 4 75,000 to 99,999; 5 N/A

Table 2

Baseline Information about Participants

-	Mean	1	2	3	4	5	6	7	8	9	10
BMI (kg/m^2)	31.0	32.8	30.4	28.6	32.1	28.4	33.1	31.0	34.1	29.9	26.8
Physical function											
2-min Step Test (steps)	99 (60)	129 (90)	71 (25)	186 (90)	97 (75)	118 (90)	121 (90)	84 (50)	73 (50)	45 (10)	63 (25)
Chair Stand Test (reps)	16 (60)	19 (90)	9 (10)	20 (90)	25 (90)	22 (90)	21 (90)	16 (75)	9 (25)	10 (25)	8 (10)
8 foot up and go (feet)	6.4 (45)	5.6 (25)	8.4 (10)	5.1 (75)	5.1 (50)	4.9 (75)	5.8 (75)	4.78 (75)	7.85 (25)	9.19 (10)	7.36 (25)
Arm curl (reps)	16 (55)	23 (90)	14 (25)	21 (90)	20 (70)	14 (50)	24 (90)	17 (75)	9 (25)	12 (25)	7 (10)
One leg stance open eyes (seconds)	15.1	15	3	28	14	25	5	45	2	6	45

BMI: Body Mass Index

Physical function scores shown as the score and percentile for sex and age norms (Rikli & Jones 2013).

Table 3

Participant's Perceived Physical Activity Barriers to Exercise

Barrier level (1-10; 10 being very important)	Mean	1	2	3	4	5	6	7	8	9	10
1- Past negative experience	2.5	1	8	1	1	1	1	1	8	1	2
2- Lack of time	3.1	1	1	1	1	7	1	1	6	10	2
3- Not a priority	4.7	1	7	1	1	2	1	8	9	10	7
4- Costs	3.1	1	1	1	1	8	1	1	5	10	2
5- Lack of energy	4.8	1	8	1	5	2	3	4	8	10	6
6- Lack of knowledge	3.6	1	3	1	7	2	1	1	9	5	6
7- Lack of motivation	6.2	3	8	6	1	9	9	10	5	5	6
8- Lack of skill	3.8	2	3	1	3	4	3	6	5	5	6
9- Uncomfortable in a fitness facility	4.7	1	10	1	1	2	1	8	9	10	4
10 -Fear of injury	3.3	1	7	1	1	2	1	1	6	10	3
11- Fear of making an existing condition worse	3.8	1	6	1	1	5	1	4	6	10	3
12- How I see my body	4.3	1	2	7	4	2	3	10	8	3	3
13- Failure to reach goals in past attempts	3.8	1	9	1	2	2	2	1	4	10	6
14- Know that I cannot achieve my goals	2.2	1	1	1	2	2	3	6	3	1	2
15- Lack of access to opportunities	3.7	1	10	1	6	2	1	10	3	1	2
16- Keep talking myself out of it	4.3	2	5	1	1	8	8	10	2	1	5
17- Lack of safe places	1.3	1	1	1	1	2	1	1	2	1	2
18- Lack of childcare	1.1	1	1	1	1	1	1	1	1	1	2
19- Lack of partner	1.8	1	1	7	1	1	1	1	2	1	2
20- Lack of suitable programs	4.7	1	10	1	2	9	1	10	7	1	5
21- Lack of support from others	2.8	1	1	4	2	9	1	1	6	1	2
22- Lack of transportation	1.4	1	3	1	1	1	1	1	2	1	2
23- Hard to keep intensity required	3.5	1	10	1	10	1	3	1	2	1	5

24- Peer pressure	1.4	1	1	1	1	1	3	1	2	1	2
25- Other	1.5	1	1	6	1	1	1	1	1	1	1
Barriers total _/250	81	29	118	50	58	86	53	100	121	111	88

Table 4

Case Examples of Barriers Experienced by Participants

Barrier	Definition	Keywords	Quote	Cases	References
Hard to keep intensity required	Fitness related limitations during exercise program.	fitness, balance, ageing, or fatigue	Case2: We live in the country, I want to spend more time outside, but bugs are a problem, the ground is a problem as well. I have a poor sense of balance, I don't really enjoy walking, and I'm always looking at the ground. Case1: Well its difficult, it takes a lot of concentration because you have to look down where you want to put your feet. I tried to look up but I had to look down at the boxes…	6	16
Lack of time	Conflicts regarding exercise schedule.	too busy, prioritizing activities, unorganized, or travel	Case4: See, well, I never reached the total goal [≥150-minutes]. I got 90-minutes because I did it once a day. Case2: With difficulty, I had to fit it in my days, day by day I would think ahead, I did it after breakfast and after lunch.	6	16
Pain	Mild pain during the exercise program.	knee joints, lower back, shoulder joints, leg, or foot	Case1: Every time I did the steps for a few minutes I would feel a little pain in the knees as I continued it seemed to go away, my back, lumbar spine gives some pain, occasionally sometimes when I hit the ground and I would feel it in my back. Case9: I had a difficult time the first week because I did have day surgery on my legs so I had a healing process	6	16
Unsuitable program	Dislikes in specific areas of the exercise program.	boring, repetitive, no incentive, no social interaction, too much space.	Case3: Specifically, I don't like the home-steps program it's not for me and it's too boring just the short distance and rotation… Case6: They were simple exercises with the exception of one that I found difficult and that was the triceps exercise and that was only because my back was hurting…	6	15
Negative previous experience	Recalls a negative previous experience	torn tendons in knee, cancer, or injuries from falling	Case3: As I told you I busted my ACL tendon. When you do that then you can walk or you can fall, and that's what actually happened…	5	6

	Case2: When I was 50, I did soccer, but my experience was not good, I tore some tendons in my knee really badly.

Note. **Each quote is an example of a case where the barrier is experienced**

Table 5

Case Examples of Enablers Experienced by Participants

Barrier	Definition	Keywords	Quote	Cases	References
Achievable goal	Shorter durations became more realistic.	easy/simple to follow, shorter durations	Case1: 10-minutes is easy, when I first started it felt a little difficult, then I increased it to 15 to 20 and 10-minutes in fact started to become easy. Case6: Not really, once you keep going you just kind of gain momentum… I always do more than 10-minutes.	10	58
Home equipment	Supplied equipment helped physical activity.	helpfulness, convenience, value, flexibility, or no associated costs	Case4: You go to a restaurant now and half the people are on their iPhone, they might as well stay home. Case8: It is nice, you don't really need any special equipment. In the hall there's a treadmill and a bike, at home, I keep my eye on that. But you can just stand up to the wall and do it…	10	42
Convenience	Staying home to complete exercise was convenient.	suitable at home, no cost, own time, simple, no transportation, no gym, no specific attire, weather, short duration.	Case9: Yes, it's convenient, and I have the space to put the mat down and I have windows on both sides of my mini home to get the breeze, so I don't get hot because when I get hot, I feel faint. Case5: The fact that the program is all set up and it's not difficult to do on your own.	10	32
Fitness	Physical fitness was important	too inactive, afraid to fall, sedentary, maintaining activity, health benefit/quality of life, stay home longer.	Case6: Yes, well I realize that I was not doing any exercise, like zero, I knew better but like many people they may have a rational thought about it, but they might not do anything about it. Case2: Weight. My regular routine is	10	23

			sedentary, I do a lot of work at the computer and read books a lot.		
Preferred home exercise	Prefers exercising at home.	personal space, secure, without communication, indoors, easier to get started, lacking access to facilities	Case9: Yes, so I don't have any neighbours beside me, I have a sister in law and my sister are in senior's apartment and you can hear the doors opening and closing. Case4: I like doing it at home, I wouldn't go to a gym, I never been to one in my life, I get out and I do a lot around the yard and the house where I live now…	9	36

Note. **Each quote is an example of a case where the barrier is experienced**

Table 6

Framework Matrix for Barriers and Enablers

Case #	Self-reported barriers	Senior fitness	Pre-post	Intensity	Themes
Case 2 **Age 74** **BMI 30.4** **Male**	Uncomfortable in fitness facility, Access to opportunities, Suitable programs, Hard to keep intensity	Endurance: 25 Lower strength: 10 Agility: 10 Upper strength: 25 Balance: 3sec	3403-3674	23%	Prefers home exercise [enabler]: I don't like changing in front of people, I can't balance and can't get my clothes on. I don't want people watching that… I have had unpleasant experience with changing with people watching and me exercising. Hard to keep intensity [barrier]: It's hard, it's really boring, I was just counting, boring, easier if I had a radio program on, I organized it around radio programs, then it was easy. It's mentally hard when nothing is playing.
Case 8 **Age 75** **BMI 34.1** **Female**	Not a priority, Knowledge, Uncomfortable in fitness facility	Endurance: 50 Lower strength: 25 Agility: 25 Upper strength: 24 Balance: 2sec	5412-4008	9%	Home equipment [enabler]: the materials I used were just great! I didn't have to buy anything new… Hard to keep intensity [barrier]: Too much at once. If I just cut down and do 5-minutes and got do my exercises and maybe a week or two later, I add a minute and I can work up to 10-minutes.
Case 4 **Age 70** **BMI 32.1** **Male**	Hard to keep intensity, Knowledge, Access to opportunities,	Endurance: 75 Lower strength: 90 Agility: 50 Upper strength: 70 Balance: 14sec	7129-10952	79%	Prefers home exercise [enabler]: I like doing it at home, I wouldn't go to a gym, I never been to one in my life, I get out and I do a lot around the yard and the house… Lack of time [barrier]: If the work hadn't had come up it wouldn't had been a big deal… this would've been fun.
Case 5 **Age 67** **BMI 33.1**	Social support, Suitable programs, Motivation, Cost,	Endurance: 90 Lower strength: 90	6921-10688	54%	Convenience [enabler]: The fact that the program is all set up and it's not difficult to do on your own… we've got the thing [SSE mat], we have time, we have Alexis [AI device] for a timer… we had a backpack with a weight in it…

Female	Self-talk	Agility: 75 Upper strength: 50 Balance: 25sec	Pain [barrier]: When I was younger, I use to go to the gym all the time, step classes etc, but now you know bad knees and feet or back and now you don't do those kinds.

Note. **Intensity reaching MVPA at 40-85%**

Figures

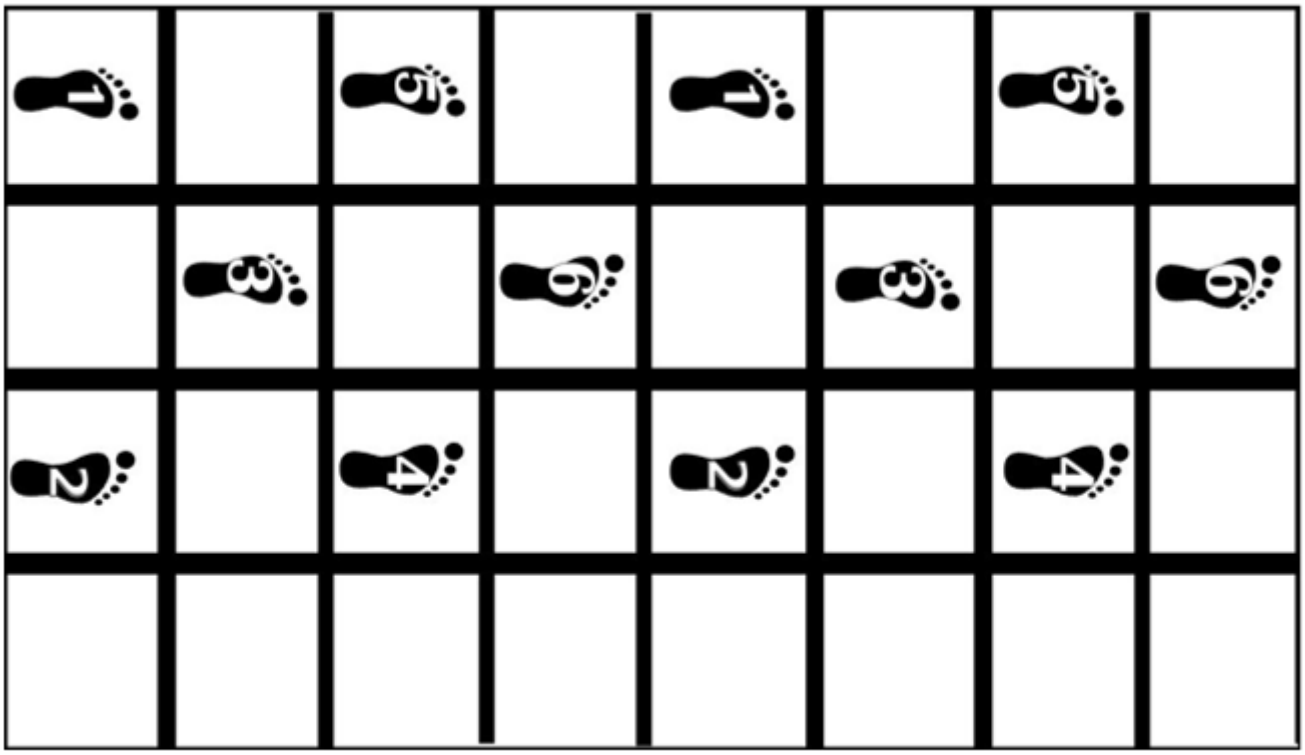

Figure 1

Square-stepping Exercise Pattern Used for the SSE

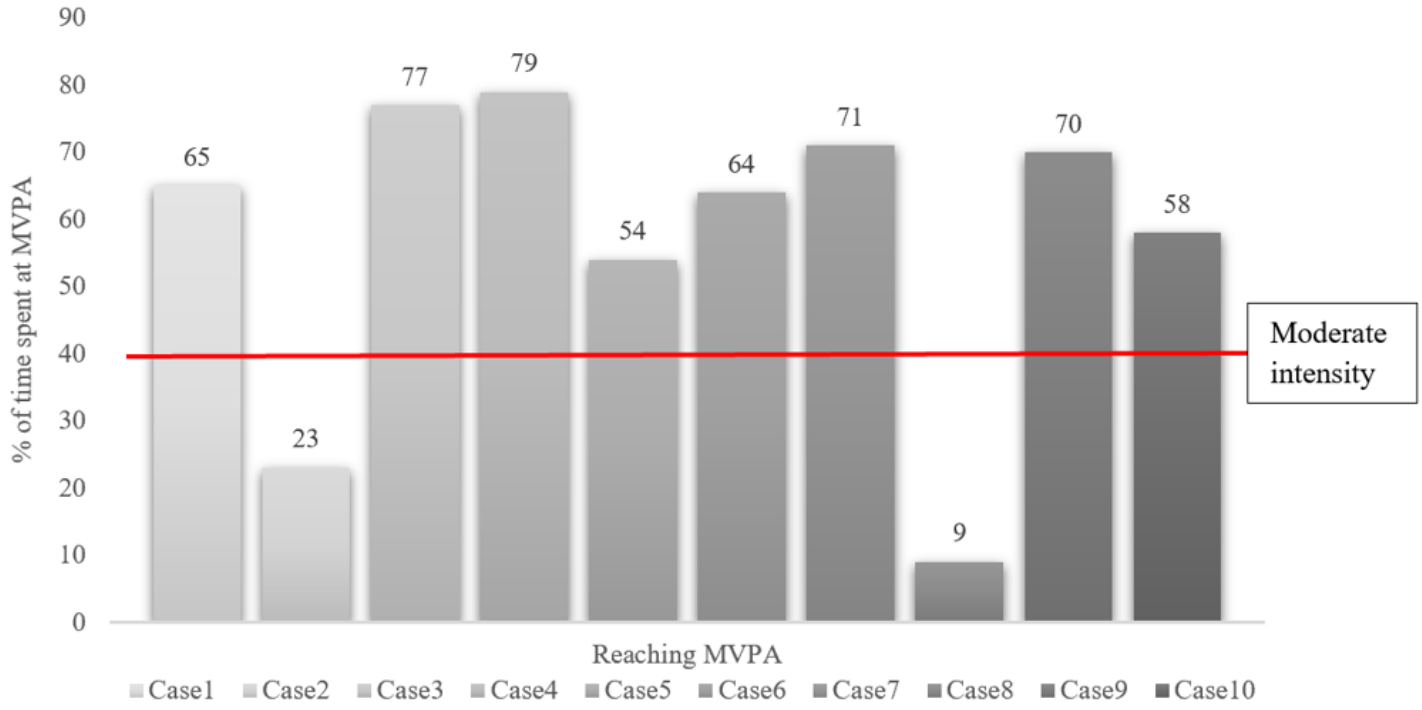

Figure 2

Average HRR Percent Recorded from Minute 5-10 During a 10-Minute Bout of SSE

Supplementary Files

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- AdditionalFile1.pdf