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ORIGINAL ARTICLE

"This is my home-based exercise": exploring environmental influences on home-based exercise participation in oncology

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Abstract

Purpose Home-based exercise interventions offer many health benefits; however, the environments that constitute home-based exercise are not well-understood. The purpose of this study was to explore what constitutes the "home" for cancer survivors engaging in home-based exercise and identify factors of the environment that may impact exercise participation.

Methods We conducted a qualitative exploratory study of cancer survivors receiving a home-based exercise prescription to manage their cancer-related impairments. Semi-structured interviews included photo elicitation to actively involve participants in the interview process and provide opportunities to visually "observe" environments utilized for home-based exercise.

Results Sixteen participants were interviewed (n = 11 women, median age = 53.5, range = 26–74 years) and three themes emerged: (1) reasons for participating in a home-based exercise program; (2) physical environmental influences and preferences; and (3) social environmental influences and preferences. The ability to self-manage exercise and accommodate competing demands, having access to exercise facilities, feeling comfortable exercising without qualified supervision, and a desire for autonomy were reasons home-based exercise programs were preferred. Participants reported that the physical environment influenced their experience with home-based exercise and sub-themes related to a dynamic environment, indoor and outdoor characteristics, and aesthetics were identified. The social environment, with sub-themes associated with the presence of people, social climate, exercise modeling, connection, and exercise support, also related to exercise behavior.

Conclusion The findings highlight the influence of the physical and social environment on exercise prescription engagement. They further indicate the need for exercise professionals to consider the environment for exercise when delivering home-based exercise interventions.

Keywords Physical activity · Exercise · Qualitative · Photo elicitation · Cancer survivor

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Introduction

The strong evidence underlying the health benefits of exercise for people with cancer has supported the development of cancer-specific exercise guidelines [1]. The American College of Sports Medicine (ACSM) recommends that people with cancer engage in a minimum of 30 min of moderate intensity aerobic exercise three times per week and resistance exercise twice per week [1]. Most people with cancer are not meeting these evidence-based guidelines [2, 3], and thus, strategies to support exercise for this population have become a priority in cancer survivorship research.

For many cancer survivors, the home has been described as the preferred setting for exercise [4]. Preferences for "home-

based exercise" typically include removed costs and travel to an exercise facility, and the flexibility to accommodate competing commitments [4]. For researchers and clinicians, home-based exercise interventions may be advantageous because of increased scalability, and reduced operating and infrastructure costs [5, 6]. Notwithstanding these perceived favorable features, the description and meaning of "home-based exercise" is not standardized [7], and there is high variability in where participants may exercise (e.g., places of residence, outdoor community, and/or local fitness centers) [8]. Furthermore, details such as living spaces amenable to exercise, condominium gyms, and neighborhood walkability are rarely captured in the home-based exercise literature [8]. Ultimately, while two participants with similar health conditions may be prescribed home-based exercise, their environments may differ markedly in ways that impact their experience and adherence.

Several systematic reviews have demonstrated significant positive associations between features of the neighborhood built environment (e.g., access to parks, fitness facilities, bike paths) and exercise in the general population [9–11]. Similarly, the perceived proximity to retail shops and green spaces has been associated with meeting exercise guidelines among cancer survivors [12]. Factors of the social environment such as having an exercise partner, and divisions of responsibilities within the home have also been suggested to influence exercise participation [13–15]. Collectively, personal, environmental, and social factors influence exercise participation, yet there is high intra-individual variability. Combined with the lack of clarity on how cancer survivors describe and engage in home-based exercise, there is a need to better understand the home environment and the perceived impact on exercise participation. The purpose of this study was to explore participants' home-based exercise experiences to identify the ways their environments may impact exercise behavior.

Methods

Study design

We conducted a qualitative, exploratory study, to capture participants' home-based settings and their influence on exercise participation. This study refers to the Ecological Theory, which suggests that environments provide a range of opportunities or deterrents that influence health behaviors [16, 17]. In the context of home-based exercise, this provided a unique theoretical lens to exploring the complexity and diversity of environments available or amenable for home-based exercise. We applied Ecological Theory to understand the meaning of "home-based" exercise and the advantages and disadvantages posed by home-based settings.

Sampling

Following research ethics board approval, patients enrolled in the Cancer Rehabilitation and Exercise (CaRE) program at the Princess Margaret Cancer Centre were recruited to participate in the study. Written informed consent was obtained from all participants. The CaRE program includes a facility-based stream (CaRE@ELLICSR) and a home-based stream (CaRE@Home), both designed to support people with cancer in managing cancer-related impairments. Patients are referred to one of the CaRE streams based on their need for in-person supervision and personal preferences. CaRE@ELLICSR consists of weekly 1-h in-person group exercise classes followed by 1-h self-management skills education delivered by a rehabilitation expert for 8 weeks. Patients in the CaRE@Home program are provided with an exercise prescription to be completed independently without supervision or survivorship education. In both CaRE streams, participants receive an in-person initial assessment and exercise prescription by a Registered Kinesiologist (RKin) and attend in-person follow-up assessments at 2, 5, and 8 months to monitor progress and receive programming adaptations.

Given the study's aim to understand experiences of home-based exercise programing, participants were recruited from the CaRE@Home stream. Maximum variation purposive sampling was used to identify participants who were able to provide diversity in insights related to the research questions [18]. We sought to sample participants with diversity in (i) gender; (ii) household income (i.e., above and below the median income of their region); and (iii) location of exercise (i.e., at home or private/public fitness facility). Gender is important to consider because of the division of household labor between men and women [19], as well as gender-based differences in barriers to home-based exercise [14]. Diversity in household income was thought to provide insight into differences in housing and living conditions [20] that may influence home-based exercise participation. Lastly, diversity in exercise location was thought to inform a more comprehensive understanding of home-based settings.

Data collection

Demographic and disease information

Self-reported demographic information was collected from CaRE program records and neighborhood income was extracted using 2016 Canadian census data by postal code. Additional disease information (e.g., cancer type) was collected via electronic patient records.

Semi-structured interviews

Experiences and perspectives of the "home" environment for exercise were collected using photo elicitation semi-structured interviews [21, 22]. Photo elicitation refers to the concept of incorporating photographs into research interviews. Participants were provided with a prompt to guide the photo elicitation activity that asked them to imagine they were going to showcase a photographic exhibition entitled *This is My Home-Based Exercise*, an exhibition that would display home-based exercise from their unique perspective. Participants used their own devices to capture any number of photographs that they felt represented their home-based exercise experience, which could also include photographs from online websites. They were asked to capture their photographs within two weeks of consenting to participate in the study. Following completion of this activity, an interview was scheduled at their preferred time. They were also asked to upload their photographs to a secure online hospital file transfer system prior to their interview using a unique and dedicated portal link created for each participant.

Interviews were guided by participants' photographs and an interview guide (Supplementary File 1) to probe for different aspects of the environment for exercise. All of the interviews were conducted by a RKin (C.L.) who has 4 years of experience working in cancer rehabilitation and exercise, is involved in the delivery of exercise for patients in the CaRE program, and was trained in qualitative interviewing. The interviewer was not involved in the clinical care of the study participants.

Data analysis

Data collection and analyses were performed simultaneously in an inductive manner. Interviews were transcribed verbatim and transcripts were entered into NVivo (version 11) to assist in data management. While the photographs were used to elicit the interview data and provide a visual representation of this information, the photographs were not analyzed. This study followed a step-by-step approach to constant comparative analysis (i.e., comparison within a single interview, and comparison between interviews) [23]. Each individual transcript was read and re-read to become familiar with the interview and underwent a process of open coding. Codes within a single interview were compared to inform adjustments to the code descriptions and reflect the diversity of discussions surrounding a particular code. Fragments of information from different interviews that had been given the same code were then compared. New codes emerged in this part of the analysis, and previously identified codes were further refined. This process produced an inventory of characteristics of each theme, which served to describe the phenomenon of interest (i.e., home-based exercise).

Several strategies were used to ensure trustworthiness [24]. Data analysis was conducted with a second coder (CP), who coded four transcripts. Meetings were conducted between coders to clarify the emerging codes and patterns. These meetings provided opportunities to discuss the varied interpretations of the data and allow for a provision of a more complex and nuanced understanding of the data. These discussions ensured that the fragments of information from the interviews were provided with the appropriate codes. This study also incorporated the use of multivocality by including multiple and varied experiences of participants in the reporting of the findings. Lastly, the analytic process encompassed reflexivity through memoing, allowing the primary coder to continuously monitor how their own position may affect the research process and outcome.

Results

Participant characteristics

Twenty-six participants enrolled in the CaRE@Home program consented to participate in this study. Of these, sixteen completed the photo elicitation activity and semi-structured interview between December 2018 and June 2019. Reasons for non-participation in the photo elicitation interviews included family emergency (n = 2); busy with other tasks (n = 1); and uncomfortable with taking photographs (n = 1). The remaining six participants did not provide a reason for non-participation. The demographic information from the sixteen participants are summarized in Table 1. The majority of participants were female (n = 11), had been diagnosed with breast cancer (n = 5) or leukemia (n = 4), and were living in a detached or semi-detached house (n = 9). The majority of participants (n = 12) conducted the interview over the phone, with the remaining conducting their interview at the study site (n = 4). Participants provided 2–16 photographs each for a total of 109 photographs, the majority of which were original photographs taken by the participants with a few online photographs of the public fitness facilities they attended. The mean duration of the interviews was 58 min (range = 44–76 min).

Qualitative findings

Three overarching themes emerged from the data. These include (1) reasons for participating in a home-based exercise program; (2) physical environmental influences and preferences; and (3) social environmental influences and preferences. Each theme is described in detail below.

- Theme 1: reasons for participating in a home-based exercise program

Table 1 Participant demographics and characteristics (n = 16)

Characteristic	Median (range)
Age (year)	53.5 (26–74)
Neighborhood household income (dollars)	96,864 (46,797–134,144)
Distance to the CaRE Program (kilometers)	7.6 (1.01–77.6)
	Frequency (%)
Gender	
Female	11 (69)
Male	5 (31)
Cancer type	
Breast	5 (31)
Leukemia	4 (25)
Sarcoma	2 (13)
Lymphoma or myeloma	2 (13)
Gastrointestinal	1 (6)
Genitourinary	1 (6)
Gynecologic	1 (6)
Ethnicity	
White	11 (69)
East Asian	3 (19)
Black	1 (6)
Mixed heritage	1 (6)
Marital status	
Married or common-law	9 (56)
Single	7 (44)
Education	
College/university	9 (56)
Graduate or professional degree	3 (19)
Prefer not to answer	4 (25)
Work status	
Working	6 (37)
Not working	10 (63)
Annual household income	
Greater than $75,000	5 (31)
Less than $75,000	1 (6)
Prefer not to answer	10 (63)
Housing type	
Detached or semi-detached	9 (56)
Condominium	3 (19)
Apartment	3 (19)
Townhouse	1 (6)

This theme describes participants' preferences for home-based exercise and encompasses five sub-themes: (1) self-management; (2) managing competing demands; (3) exercise experience and knowledge; (4) access to exercise facilities; and (5) autonomy. Most participants discussed the ability for home-based exercise to alleviate barriers to routine exercise participation such as work, household, and social responsibilities. Additionally, many discussed the benefits of being able to choose when and where to exercise, and expected more autonomy and control with home-based exercise. Participants' own experience with exercise often related to their level of comfort and safety with unsupervised exercise and provided some with the confidence to self-regulate their exercise prescription. Lastly, some participants emphasized that having access to exercise facilities influenced their preferences for a home-based program. A more fulsome description of each of these sub-themes along with illustrative quotes is summarized in Table 2.

- Theme 2: physical environmental influences and preferences

Participants described and took photographs of key components of the physical environment that influenced exercise participation. Photographs included different areas within places of residence (e.g., living rooms, kitchens, hallways) and fitness facilities (e.g., yoga studio, aerobic or resistance exercise areas), exercise equipment, and outdoor spaces such as parks. Examples of participant-produced photographs are depicted in Fig. 1. This theme encompasses four sub-themes: (1) dynamic environment; (2) indoor features and characteristics; (3) outdoor features and characteristics; and (4) aesthetics of exercise space. Each of these sub-themes is described below and representative quotes for each sub-theme are depicted in Table 3.

Many participants described the importance of dynamic environment(s), whereby they were able to make changes to where they exercised or changes within their environment(s) to facilitate exercise. These changes included, but were not limited to, purchasing exercise equipment, modifying elements of the environment (e.g., furniture configuration and space), and/or diversifying the environments in which exercise took place. Changes to the environment were spurred by efforts to render the space more amenable to exercise. Many participants also discussed preferences and motivations around exercising in environments that were visually appealing, often characterized by the presence of natural lighting and opportunity for outdoor scenery.

Each of the participants noted that exercise participation was influenced by a variety of indoor characteristics. Participants discussed the importance of having optimal space to complete the exercise prescription. For some, a lack of space was a barrier to performing exercises as prescribed (e.g., inadequate wall space to complete a wall squat) and led a few participants to seek out a fitness facility in the community. The availability of secure and supportive features, as well as even and non-slip flooring, provided a majority of participants with a sense of safety and comfort during exercise, particularly those exercising within their place of

Table 2 Sub-themes for reasons for participating in a home-based exercise program

Sub-theme	Description	Example
Self-management	Provides an opportunity to self-manage the exercise prescription, including when, how, and where it is completed.	P1 (Female, age 29, ovarian cancer): "I think the flexibility of how and where [exercise is] being done, and then also the time aspect." P4 (Female, age 41, breast cancer): "I chose the CaRE@Home program because I can [exercise] at any time without necessarily planning it. I can do it in my jeans if I wanted to and just drop down into a plank. I don't have to plan the 30 minutes either."
Managing competing demands	Provides an opportunity to accommodate other responsibilities and priorities such as medical appointments, job and household responsibilities, and maintaining social interactions.	P7 (Female, age 48, breast cancer): "Just going back to work and juggling a lot of things. I thought it would be better to just do it at home versus going down every week [to ELLICSR] for appointments. I already had a bunch of appointments so the group class would have been one more thing on my plate." P10 (Male, age 55, leukemia): "Your spouse has spent months driving to the hospital, so it's nice to get back [home] and see that your spouse gets a break from all the care they provided. There are also the normal social interactions in your job, in your community, and your church that are important to maintain."
Exercise experience and knowledge	Participants felt comfortable and safe exercising without supervision from a qualified exercise professional due to level of experience and knowledge with exercise.	P2 (Male, age 26, sarcoma): "I didn't need week to week specific instruction because I was already familiar with all of the exercises that I was prescribed." P14 (Female, age 33, leukemia): "Before I got cancer, I really enjoyed exercise. It was something that I got into a little later in life. I think that if I haven't had that change from before, I might have felt a little bit more intimidated by the idea of home-based exercise."
Access to exercise facilities	Participants already had access to a facility for exercise (e.g., public gym, condo gym, community program).	P6 (Female, age 58, lymphoma): "Some people might see my gym and think this is different than home-based exercise because it's a gym, but this gym is actually in my home. So, [choosing home-based] definitely depends on where people live." P12 (Female, age 39, breast cancer): "I think it's great to have this community centre near my home. I wouldn't be able to do these exercises if I didn't have this gym. Some people have equipment or machines at home, but I don't."
Autonomy	Provides an opportunity to be independent and have control over their exercise, including the environment where exercise takes place.	P10 (Male, age 55, leukemia): "This gives you some motivation to work independently which I think is important. Doing it at home gives you ownership of what you're doing. You're also in your own space and it's in an environment you control." P14 (Female, age 33, leukemia): "I take a lot of pride and comfort in being in my home. It's been a real relief to me throughout the course of my treatment at the times that I've been able to transition back here and not be at the hospital. It's a sign of a certain level of independence."

residence. In-home features that were important to consider for exercise included the utility of chairs, handrails, stairs, bannisters, newel posts, mirrors, and doors. These features allowed participants exercising within their place of residence to support themselves and maintain balance, monitor and maintain correct form, and correctly anchor and position resistance bands.

Many participants described an appreciation for equipment that was compatible with the level of function or impairments they were experiencing, such as the use of a treadmill instead of walking outdoors due to reduced balance and concerns about uneven surfaces. Additionally, utilizing a space with access to electronic screens (e.g., television, tablet) to follow exercise videos and receive real-time guidance facilitated exercise engagement. The majority of participants also described the benefits of being able to complete the prescribed exercise in a single area within their place of residence, as this would offer a convenient and engaging experience with exercise.

Most of the participants also discussed the influence of features of the outdoor physical environment. Nearby green

Table 3 Sub-themes for physical environmental influences and preferences

Sub-theme	Description	Example
Dynamic environment	Facilitators of having more than one location to choose for exercise, and any changes made within an environment to facilitate exercise.	P3 (Female, age 69, leukemia): "I do my exercises at the gym, but if I can't move that day because I'm too fatigued or my blood counts are low, then I do my exercises at home. For walking, besides the boardwalk, I go to different parks to have something different and make exercise interesting." P11 (Male, age 74, multiple myeloma): "As I worked into the whole program and tried a few different things, I was able to fine-tune where I was doing my exercises. It's reached a point where I don't have to move a whole lot of stuff to set up my area at home."
Indoor features and characteristics	Aspects of the physical environment within a setting for exercise that influenced exercise participation. Features include: 1) proximity of areas; 2) space; 3) exercise equipment; 4) feedback and monitoring (electronic screens mirrors); and 5) secure and supportive (furniture, bannisters).	P7 (Female, age 48, breast cancer): "Sometimes moving around the house is a barrier. It just breaks your momentum a little bit and then it's easier to say, 'I won't do that one today'. If you just had everything at hand in one space, you can go from one exercise to the other and it would be more streamlined. P11 (Male, age 74, multiple myeloma): "Balance is a bit of a problem so having a solid chair to hold onto is important. It's the right height, it's solid, and it's comfortable. I also have big bannisters on the stairs and stuff. I think the house is very good for what I need in terms of feeling safe because of my mobility issues."
Outdoor features and characteristics	Aspects of the outdoor physical environment that influenced exercise participation. Features include: 1) green spaces; 2) public pathways and bike lanes; and 3) density of business establishments.	P6 (Female, age 58, lymphoma): "Half of my route to work has bike lanes. I prefer to bike along streets with bike lanes and streets that are wide and free from potholes, because I feel safer and can go a little faster." P14 (Female, age 33, leukemia): "The park is actually right at the end of my street. It's easy for me do some walking in the park and get home in a short amount of time. That is wonderful because I'm more interested in areas with flowers and trees."
Aesthetics of exercise space	Preferences and motivations for exercising in environments that were visually appealing, including natural light and outdoor scenery.	P8 (Female, age 56, sarcoma): "A lot of it has to do with a nice surrounding. I will generally run down a longer route to a park and through old houses" P9 (Male, age 64, pancreatic cancer): "My home isn't my preferred place to exercise. Maybe it's because I'm doing my exercises in a hallway whereas when I'm at the gym, I've got a wall of windows and natural light and just enjoy it more."

spaces were preferred by many participants and offered a convenient and positive alternative to exercising indoors. The availability of public pathways such as bike lanes and walking trails was also important considerations for the convenience and safety of exercise outdoors. Furthermore, a few participants described the benefits of residing near various types of business establishments, as they could incorporate walking for exercise into their daily routines.

- Theme 3: social environmental influences and preferences

Participants described key components of the social environment that influenced exercise participation. Participants took photographs of private or heavily trafficked spaces within facilities, places of residence, and outdoors, as well as areas where they felt a sense of connection. Examples of photographs are depicted in Fig. 2. This theme encompasses five subthemes: (1) presence of people; (2) social climate; (3) exercise modeling; (4) connection; and (5) exercise support and guidance. Each of these sub-themes is described below and illustrative quotes for each sub-theme are depicted in Table 4.

Many participants discussed the influence of the volume of people in a setting where exercise was performed. For some, exercising around others provided a more enjoyable environment and indicated a need to avoid isolating environments after treatment. For others, private settings were preferred in order to avoid potential negative thoughts from individuals using a given space. This reflected their discussions surrounding the importance of the prevailing attitudes among individuals within a setting. Positive interactions with other members in a setting created an encouraging and accepting environment for exercise. Additionally, many participants commented on the added

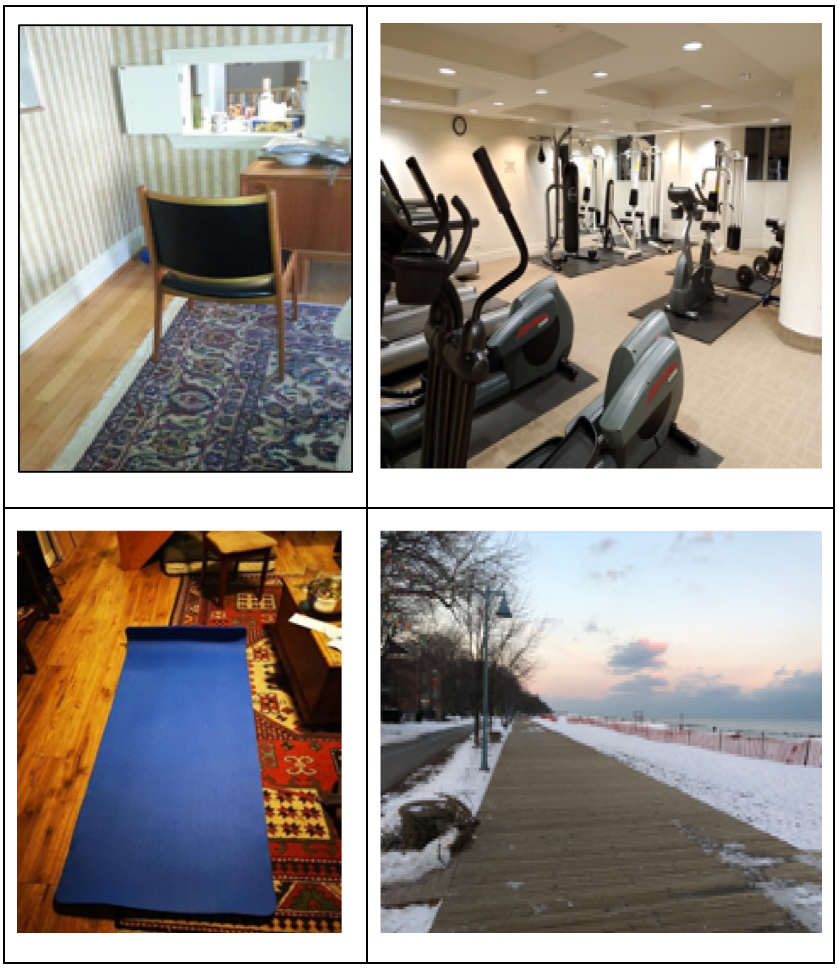

Fig. 1 Examples of participant-produced photographs representing the physical environment

motivation from seeing others exercise. However, the influence of interpersonal modeling was complex and not always positive. At times, modeling negatively impacted self-efficacy and discouraged exercise through negative comparisons with others. For instance, a few participants described public facilities as intimidating environments because they were reminded of their physical impairments when exercising alongside seemingly fit individuals.

The majority of participants described motivations for exercising in an environment they had a connection to. A familiar environment provided a space for exercise that was detached from negative memories of the cancer experience, such as exercising at home around family instead of a hospital. The theme of connection was also characterized by positive experiences with exercise that arose from a sense of community. This included returning to local facilities they had previously utilized and developing relationships with other members, which fostered continued exercise engagement.

Lastly, most of the participants discussed the importance of receiving support from others in order to manage exercise around competing demands. This included receiving support for childcare and household responsibilities. However, when this support was not available, some participants had difficulties prioritizing and finding the time to exercise, particularly women. Supports were also characterized by the ability to receive guidance while completing an exercise prescription. The level and type of guidance provided to participants varied and provided some participants with the self-assurance that they were completing the prescribed exercise correctly, as well as motivation for sustained exercise behaviour.

Discussion

This study provides a foundational understanding of the diversity of the "home" context for home-based exercise, and the related factors that influence home-based exercise engagement for people with cancer. Factors such as the availability of floor and wall space, secure and supportive features to maintain balance during exercise and correctly anchor resistance bands, and encouraging and supportive social environments were considered favorable features to shaping a safe and motivating setting for exercise participation.

Table 4 Sub-themes for social environmental influences and preferences

Sub-theme	Description	Example
Presence of people	The influence of the volume of people in a setting where exercise was performed. This includes advantages and disadvantages of private and isolating environments or being around others.	P9 (Male, age 64, pancreatic cancer): "There's a small gym in my building that I used to go to before my operation. I was the only person there. […] Through the process of being at home and recovering, I spent a great deal of time in bed and alone. I go to the gym to see people and get my mind off of me for a moment." P2 (Male, age 26, sarcoma): "I like this because it's a private space. It's not highly trafficked and I won't be worried about anyone's opinions of me. I would've been really embarrassed exercising in a place where there was a bunch of strangers around."
Social climate	The influence of the prevailing mood and attitudes of individuals in a setting where exercise was performed.	P9 (Male, age 64 pancreatic cancer): "I prefer going mid-morning with the retiree group during the week. […] They're like-minded and the same stage of life. It's a safe and comfortable setting because it's close to my home and has like-minded patrons." P13 (Female, age 58, breast cancer): "At home, my husband has been very supportive and makes sure I have what I need. He knows I have to exercise, he's supportive, and he doesn't laugh at me or anything when I'm doing my exercises."
Exercise modeling	The influence of the experience, knowledge, and participation in exercise by other individuals in an environment (e.g., family members, friends, and other individuals exercising in a given setting).	P7 (Female, age 48, breast cancer): "My partner exercises at a gym, and that motivates me. It makes it a little bit easier to get up and exercise when someone else is doing it." P1 (Female, age 29, ovarian cancer): "When I start to get tired, I look around at what other people are doing at the gym and it inspires me to push through. […] I guess the one limitation for me at the beginning of the program was that since I wasn't feeling very strong, seeing people that were so fit and capable at the gym was almost a bit discouraging because I felt like I didn't really fit in."
Connection	Participant preferences and motivations for exercising in an environment they felt attached and accustomed to. This includes familiarity of a setting and sense of community.	P3 (Female, age 69, leukemia): "I have gone to the [health club] for years, so I know a lot of people. It's kind of like knowing your neighbors. In all this time, our kids have grown up, they may be married, some of us have grandchildren." P13 (Female, age 58, breast cancer): "I was used to exercising at home. My home is also very much a haven. My husband and I have made it to what we like. […] It's been a very important place for me not just for exercise. It's a haven for me from the world."
Exercise support and guidance	Types of supports related to the social environment that influenced exercise participation and experience. Includes receiving guidance and encouragement for exercise from others and ability to receiving support to prioritize exercise around other competing demands.	P3 (Female, age 69, leukemia): "My husband has been a motivator and an important part of my exercise. It's the companionship and often the extra motivation to walk a bit further or telling me that I'm getting really winded and should slow down." P15 (Female, age 52, leukemia): I'm trying to prioritize better and I don't always do that well. I don't feel like I have support for this home-based exercise program. I mean I do have other people in the house who do housework as well, but it hasn't really increased since I've started the program. There's no real change.

Overall, the findings are consistent with previous research suggesting that cancer survivors may experience difficulties creating an area for exercise in their homes due to the physical environment [25]. Furthermore, similar to research on the prevention of at-home falls and maintenance of independence in adults [26, 27], this study highlights the potential role of the evaluation and modification of the home environment to facilitate optimal and safe exercise for people with cancer (e.g., changes to the areas and features used, arrangement of furniture, obtaining new equipment). Such considerations are rarely discussed in published home-based exercise studies [8].

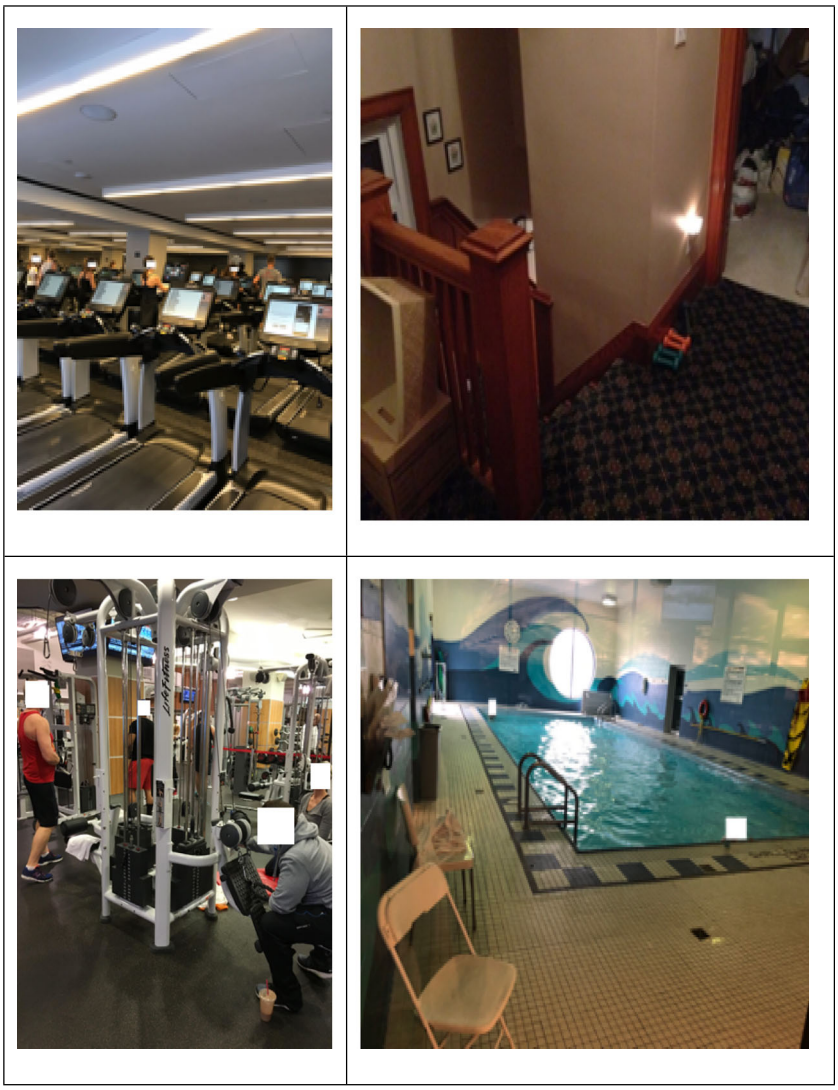

Fig. 2 Examples of participant-produced photographs representing the social environment

Public facilities are not typically described as potential sites for home-based exercise in the research literature; however, these types of settings allowed some participants to overcome barriers associated with the at-home physical environment such as limited access to space, equipment, and mirrors. However, for others, fitness facilities posed more social barriers to exercise. This was largely due to the less private nature of these environments and feelings of inadequacy relative to their physical capacity prior to their cancer diagnosis. Places of residence offered more privacy for participants who felt uncomfortable exercising around others due to negative self-perceptions. This is consistent with previous qualitative findings on the social barriers to exercising in a public facility [28, 29]. Given the variability for preferences and experiences associated with environments for exercise, researchers and providers should be aware of the need to personalize exercise based on discussions about advantages and barriers characterizing particular exercise locations.

Social support were considered highly influential to participants' experiences with exercise, consistent with a systematic review demonstrating positive associations between social support and physical activity participation [30]. Moreover, neighborhoods characterized by greater levels of walkability have demonstrated higher levels of social capital by supporting social connectedness and involvement in local communities [31, 32]. In the cancer context, the ability for environments to promote positive social interactions and connections can be significant because of the difficulties with social adjustment after treatment [33, 34] including meeting social obligations and reduced social activity [35, 36]. Social support also shaped experiences with home-based exercise by providing opportunities to prioritize exercise and manage competing demands. The findings of this study suggest that a gendered impact on receiving support for household responsibilities may exist. Further research investigating the impact of gender on home-based exercise participation is warranted

given the extensive literature suggesting the home is often experienced as a site of work for women [19].

This study suggests that not accounting for environmental resources can compromise the overall quality of care patients receive during a home-based exercise program. Oncology care providers should consider the nature of in-home and community features available to participants for exercise in order to address the complexity of safety needs and environmental resources available from person to person. Currently, there is no tool available to guide oncology care providers in prescribing exercise that is suited to the home environment. A sample checklist was developed based on the findings from this study (Supplementary File 2) to assist qualified exercise professionals in designing exercise prescriptions that manage the diversity and complexity of environmental resources for home-based exercise. A checklist conducted during assessments about where and how amenable the environment is for exercise may initiate important discussions that can minimize relatively minor barriers to routine exercise before they undermine program engagement.

A notable strength of this study was the use of photo elicitation. The use of photo elicitation interviews has been suggested to challenge potential pre-conceived biases of the interviewer, and has been regarded as an effective approach to support qualitative interviews by actively and consciously involving participants in the research process [21, 37]. Photo elicitation gave participants the necessary time to reflect on their personal understanding of home-based exercise, and the artistic means through which to articulate the potential complexity of the "home" environment. Several strategies were used to maintain the quality of the telephone-based photo elicitation interviews and mitigate potential influences on participant responses resulting from the lack of personal interaction. For instance, the interviewer numbered all of the photographs prior to the interview and reminded participants which photograph was being discussed throughout the interview. Additionally, extra time was provided between participant responses in order to mitigate any potential interruptions and allow participants to collect their thoughts.

There are also limitations that warrant mention. First, ten consenting participants did not complete the photo elicitation activity and interview. Future studies should incorporate multiple researcher-participant contacts throughout the phototaking process in order to build rapport and normalize the activity [21]. Second, many participants did not report their annual household income and of those that did, the majority reported an income level above the regional median threshold. Furthermore, the median income by neighborhood was also well-above the regional median income, and the sample was highly educated. Many participants in this study had access to exercise facilities, and were able to accommodate large pieces of exercise equipment within their place of residence or purchase equipment to facilitate exercise. The findings of this study may not reflect the experiences of cancer survivors residing in economically disadvantaged neighborhoods, where disparities in environmental resources such as walkability, perceived safety, and exercise facilities may be apparent [38]. Third, participants in this study were almost exclusively residing in urban and suburban areas. This is an important consideration given evidence suggesting differences in environmental factors influencing exercise participation between urban and rural settings [39]. Fourth, the diversity of cancer types in this sample is worth noting given that different cancer types may require various different treatments and result in different adverse effects experienced by participants. The results presented should be interpreted in the context of the participant sample. Finally, we acknowledge that our checklist was not rigorously developed or validated; rather, it serves as a starting point for further discussions and research since there is no existing tool.

Conclusion

This study provides a foundational understanding of the diverse representations of the "home" environment for home-based exercise among people with cancer. Our findings suggest that home-based exercise may be facilitated by environments that support the adoption and maintenance of exercise. The findings of this study provide health professionals with several factors of the physical and social environment that may need to be considered when delivering home-based exercise interventions.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the University Health Network Research Ethics Board (#18-5421).

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