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ORIGINAL ARTICLE

Factors predicting gains in moderate-to-vigorous physical activity in prostate cancer survivors on androgen deprivation therapy

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Abstract

Background Whether individual, environmental, and psychosocial factors predict changes in moderate-to-vigorous physical activity (MVPA) is poorly addressed in prostate cancer (PC) survivors undergoing androgen deprivation therapy (ADT).
Purpose This secondary analysis of a randomized controlled trial examined changes in MVPA following a supervised personal training (PT), supervised group-based (GROUP) program, or a home-based, smartphone-assisted exercise (HOME) intervention in PC survivors on ADT and explored individual, environmental, and psychosocial predictors of MVPA.
Methods PC survivors on ADT underwent aerobic and resistance training for 6 months via PT, GROUP, or HOME. MVPA was captured via accelerometers and the Godin Leisure-Time Exercise Questionnaire. Changes in MVPA between groups were assessed using linear regression. The following predictors of MVPA were examined using Spearman correlations: the Neighborhood Environment Walkability Scale (NEWS); the Planning, Attitudes, and Behaviours (PAB) scale; the Relatedness to Others in Physical Activity Scale (ROPAS); and individual factors at baseline.
Results Participants ($n = 37$) were 69.4 ± 6.5 years old and 78.4% were on ADT for ≥ 3 months. Changes in accelerometry-based bouts and MVPA as well as self-reported MVPA did not differ between groups at 6 months. The Aesthetics domain of the NEWS questionnaire at baseline was the strongest predictor of positive MVPA changes ($r = .66$). Attitude ($r = .64$), planning ($r = .57$), and motivation ($r = .50$) at baseline were also predictive of engaging in higher MVPA throughout the intervention.
Conclusion Changes in objective MVPA were modest. Additional emphasis on specific psychosocial and individual factors is important to inform theory-based interventions that can foster PA behavior change in PC survivors on ADT.
Registration # NCT02046837.

Keywords Physical activity · Behavior change · Environmental predictors · Androgen deprivation · Prostate cancer

Introduction

Prostate cancer (PC) is the second most common cancer to affect men, with an average age at diagnosis of 66 years [1]. With early detection and improved treatments, the 5-year

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survival for PC in North America is ~ 95% [2]. Given these high rates of survival, it is important to address survivor needs, particularly in PC survivors receiving androgen deprivation therapy (ADT). ADT has numerous adverse side effects including fatigue, decreased musculoskeletal and cardiorespiratory fitness, loss of sexual functioning, negative mood, body composition changes, and reduced quality of life (QOL) [3]. These side effects are common in PC survivors given that up to 50% will undergo ADT at some point in their disease management [4].

Physical activity (PA) and structured exercise interventions are effective strategies to counteract many of the physical and psychological side effects of ADT [5, 6]. Despite the health benefits of PA and exercise, the extent to which PC survivors on ADT adopt an active lifestyle may be contingent upon health-related and psychosocial factors. A scoping review in PC survivors suggests that structured group exercise is the most common facilitator of PA, whereas treatment-related adverse effects and lack of time are two of the most common factors that undermine a physically active lifestyle [7]. Psychosocial factors have also been shown to predict higher PA in PC survivors [8, 9]; however, few studies have examined whether psychosocial factors are predictive of PA in patients undergoing ADT [8], limiting the understanding of specific psychosocial factors that are required to be addressed when using exercise as a supportive care intervention. Inclusion of understudied yet theoretically relevant factors is important to further elucidate PA behavior of PC survivors on ADT, and subsequently identify strategies that can optimize PA within exercise interventions. For example, community-related factors, such as the built and natural environment, can positively or negatively influence PA behavior in older adults [10, 11]; however, McGowan et al. found no associations between built environment and PA levels in PC survivors [12]. Whether these factors are predictive of PA in PC survivors on ADT is poorly understood due to the scarcity of evidence.

The aims of this study were to (i) to assess the effects of different exercise delivery modes on MVPA and (ii) explore individual, environmental, and psychosocial predictors of higher accelerometry-based and self-reported moderate-to-vigorous PA (MVPA) in PC survivors on ADT following 6 months of aerobic and resistance training.

Methods

Study design

This is a secondary analysis of a randomized phase II non-inferiority trial that recruited patients from two Canadian academic tertiary-care centers — the Princess Margaret Cancer Centre (Toronto, ON) and the Tom Baker Cancer Centre (Calgary, AB). Ethics approval was obtained at both institutions and all participants provided written informed consent. The trial was registered at clinicaltrials.gov (Registration # NCT02046837). A detailed trial protocol and a report of the primary outcomes have been previously published [13, 14]. The study protocol and procedures are briefly summarized below.

Participants

Eligible participants were diagnosed with histologically confirmed PC of any stage; starting or continuing ADT for at least 6 months (or who remained biochemically castrate after stopping ADT); able to communicate in English; and living in proximity to a study center. Participants were excluded if they were already engaging in 150 minutes (min) of MVPA per week, or who had a condition that would interfere with their ability to engage in PA.

Intervention

Participants were randomized equally to a 6-month exercise intervention delivered via personal training (PT), supervised group-based (GROUP) training, or home-based (HOME) training. All training programs were prescribed using the FITT principle: Frequency, Intensity, Time, and Type and were individualized based on baseline fitness assessment results. All participants were prescribed 4–5 days per week of mixed modality exercise, incorporating aerobic, resistance, and flexibility training. The target time and relative workload (target heart rate 60–70% of heart rate reserve) were consistent across all intervention groups. Exercise intensity was monitored throughout the intervention using the 10-point Rating of Perceived Exertion (RPE) scale [15], with participants instructed to maintain their intensity level between an RPE of 3 and 6 during exercise sessions. HR monitors (Polar, NY, USA) were used at 3-week intervals in each intervention arm to ensure that participants reached their target heart rate range, providing calibration with the 3–6 rating on the RPE scale. Exercise progression was individualized and monitored by a Certified Exercise Physiologist/Registered Kinesiologist (CEP/RKin) in the PT and GROUP intervention arms or a health coach in the HOME arm. Every 3 weeks, the intensity level during the exercise sessions (both aerobic and resistance) was used as an indicator of whether the participant was ready to progress, and intensity levels were adjusted as required to ensure that participants continued to work within their target heart rate range. All participants received a study manual outlining exercise techniques and reinforcing safety principles.

Each program also included an education component that consisted of discussing 12 topics focusing on common issues facing new exercisers. These topics were reviewed with participants during their supervised sessions (by the CEP/RKin) or during weekly phone calls with the health coach.

Personal training

The PT group completed 3 sessions per week in an equipped gym space and was prescribed 1–2 additional days per week of independent (home-based) exercise. Each session consisted of aerobic training (15–30 min), resistance training (with a focus on major muscle groups, 15–20 min), and flexibility training (5–10 min of static stretching at the end of each session). All participants were provided with resistance bands to support and encourage the completion of 1–2 days of independent resistance exercise. The details of their exercise sessions were documented on standardized forms (PA logs).

Supervised group-based training

GROUP participants had an identical exercise prescription to the PT group described above. However, instead of being delivered in a 1:1 personal training format, the program was delivered in a small-group format (4–6 individuals per group), supervised by a CEP/RKin, in the same gym area but at separate times from PT sessions.

Home-based training

HOME participants performed the same exercise volume as PT and GROUP, and received resistance bands, a stability ball, an exercise mat, a HR monitor, and a smartphone with a 6-month pre-paid plan and customized software to connect with a health coach. HOME participants communicated weekly with the health coach via the smartphone to review weekly exercise sessions, receive exercise-related guidance and assistance with smartphone application issues. Health coaches also instructed the participants to use the provided HR monitors to evaluate intensity (every 3 weeks). The Connected Wellness Platform (NexJ Systems Inc., Toronto, ON) was used as the application to enable participants to input health information, levels of symptoms, and exercise routines. This application also enabled progress tracking over time. In addition to the smartphone app, exercise was documented on standardized PA logs identical to PT and GROUP.

Physical activity

PA was measured at baseline and 6 months (post-intervention) via self-report and accelerometry. Self-reported PA was measured using the Godin Leisure-Time Exercise Questionnaire (GLTEQ) [16]. Weekly MVPA minutes were calculated as [(total strenuous × 2) + total moderate]. PA was measured objectively using the Actigraph GT3X (Pensacola, FL) worn for a 7-day period while awake at baseline and post-intervention. Accelerometer data were extracted in 60-s epochs. Data were screened using standard methods for (i) at least 4 days of valid data, including (ii) at least 10 h of wear time per day, and (iii) non-wear time assessed as periods of time with no movement (0 counts per minute) for more than 1 h at a time. Accelerometer data were examined as time spent in MVPA during the week, which is calculated as an activity > 1952 counts per minute [17], and the average number of continuous bouts of MVPA > 10 min per day.

Individual, environmental, and psychosocial predictors of changes in MVPA

Clinical stage, Gleason score, and body mass index (BMI) were examined as potential individual predictors of changes in MVPA throughout the study. Participants were asked to complete three questionnaires at baseline to examine whether psychosocial factors were predictive of MVPA changes from baseline to 6 months.

Psychosocial factors were examined using a social ecological framework [18], taking into consideration multiple levels of influence on PA levels. More specifically, the Neighborhood Environment Walkability Scale (NEWS): Short Form was used to examine the role of environmental factors in determining PA behavior [19]. The NEWS has been used in prior exercise oncology work [20, 21] and has demonstrated validity [19, 22].

To assess whether psychosocial factors were predictive of increases in MVPA we used the Related to Others Physical Activity (ROPAS) [23] and Planning, Attitudes, & Barriers (PAB) Scale [24]. Both the ROPAS and PAB measure theoretically driven determinants of PA that have been found to be significant in prior work in oncology [25].

Statistical analysis

To examine the effect of the different exercise delivery modes on accelerometry-based and self-reported MVPA, we used linear regression with study arm and the baseline value of the outcome as predictors. In analyses exploring potential individual, environmental, and psychosocial predictors of MVPA changes, study arms were combined to improve statistical power. To address issues of non-normality in this small sample, we used the Kruskal-Wallis test in a sensitivity analysis. To understand differences at baseline between those who met current PA guidelines (i.e., 90 min of MVPA) and those who did not, based on self-reported MVPA, participant characteristics were compared using *t*-tests or Wilcoxon rank-sum tests for continuous and chi-squared tests for categorical variables. Spearman correlations were used to estimate associations between individual, environmental, and psychosocial variables and changes from baseline to 6 months in MVPA. Only participants who had MVPA data at baseline and post-intervention (6 months) were included in the analyses. Given the exploratory nature of the study and the modest sample size, we focused on the magnitude of correlation coefficients rather than formal statistical significance to identify the most relevant factors.

Results

A total of 53 participants were enrolled in the primary study [14], of whom 37 had available data on objective ($n = 14$) or self-reported ($n = 37$) MVPA at both baseline and 6 months. The participants who were included in the analysis were 69.4 years (± 6.5) on ADT for ≥ 3 months (78.4%) and diagnosed with clinical stage T1-2 (51.4%) or T3 (48.6%) (Table 1).

Table 2 lists the changes in accelerometry-based (including bouts) and self-reported MVPA following 6 months of PT, GROUP, or HOME. No differences were found on accelerometry-based minutes and bouts of MVPA including self-reported MVPA (Table 2).

Clinical stage, Gleason score, and BMI were not predictive of accelerometry-based or self-reported MVPA (data not shown). Figure 1 lists the Spearman correlations between psychosocial predictors of objective and self-reported MVPA. A moderate correlation was found between the

Table 1 Characteristics of study participants at baseline

Characteristic	Level	Overall ($n = 37$)	≥ 90 min ($n = 21$)	< 90 min ($n = 16$)	p
Age (years), mean (SD)		69.4 (6.5)	67.5 (6.7)	71.9 (5.4)	0.040
Education (%)	No	12 (32.4)	5 (23.8)	7 (43.8)	0.353
Completed university/college	Yes	25 (67.6)	16 (76.2)	9 (56.2)	
Number of comorbidities, median [IQR]		2.0 [1.0, 4.0]	2.0 [1.0, 4.0]	3.0 [1.0, 3.5]	0.863
Clinical stage (%)	T1–T2	19 (51.4)	9 (42.9)	10 (62.5)	0.394
	T3	18 (48.6)	12 (57.1)	6 (37.5)	
Gleason grade (%)	6–7	19 (52.8)	13 (65.0)	6 (37.5)	0.191
	8–10	17 (47.2)	7 (35.0)	10 (62.5)	
Indication for ADT (%)	Adjuvant	18 (48.6)	12 (57.1)	6 (37.5)	0.394
	Other	19 (51.4)	9 (42.9)	10 (62.5)	
Prior ADT duration (%)	< 3 months	8 (21.6)	5 (23.8)	3 (18.8)	1.000
	≥ 3 months	29 (78.4)	16 (76.2)	13 (81.2)	
BMI baseline, median [IQR]		28.2 [24.4, 30.8]	29.6 [25.9, 31.1]	26.0 [22.6, 29.8]	0.053
GLTEQ MVPA (min) baseline, mean (SD)		67.5 (148.0)	99.0 (191.2)	28.1 (42.6)	0.156
Accelerometry MVPA (min) baseline, mean (SD)		147.3 (108.4)	115.7 (88.1)	184.2 (121.5)	0.109
Planning, Attitudes, & Barriers (PAB) Scale					
Attitude, mean (SD)		35.1 (4.0)	35.8 (3.7)	34.4 (4.4)	0.300
Motivation, mean (SD)		37.0 (3.8)	37.8 (2.3)	36.1 (4.9)	0.166
Planning, mean (SD)		42.5 (8.5)	44.2 (8.6)	40.4 (8.2)	0.189
Total barriers, mean (SD)		68.3 (26.4)	67.0 (22.2)	69.8 (31.4)	0.763
Related to Others Physical Activity (ROPAS scale) Total, mean (SD)		21.5 (10.4)	21.8 (10.5)	21.1 (10.7)	0.846
Neighborhood Environment Walkability Scale (NEWS) Short Form					
Residential density, mean (SD)		301 (146)	327 (157)	268 (126)	0.224
Proximity to non-residential land uses (e.g., restaurants, retail stores), mean (SD)		3.3 (0.9)	3.4 (0.9)	3.1 (0.8)	0.225
Ease of access to non-residential uses, mean (SD)		3.2 (1.1)	3.2 (1.2)	3.2 (1.0)	0.936
Street connectivity, mean (SD)		3.1 (0.8)	3.0 (1.0)	3.3 (0.5)	0.224
Walking/cycling facilities (e.g., sidewalks, pedestrian/bike trails), mean (SD)		3.2 (0.5)	3.2 (0.6)	3.2 (0.4)	0.864
Aesthetics, mean (SD)		3.3 (0.4)	3.3 (0.4)	3.2 (0.4)	0.384
Pedestrian traffic safety, mean (SD)		2.4 (0.5)	2.5 (0.5)	2.4 (0.6)	0.653
Crime safety, mean (SD)		1.3 (0.4)	1.2 (0.4)	1.4 (0.5)	0.359

ADT androgen deprivation therapy, *BMI* body mass index, *FACT-P* Functional Assessment of Cancer Therapy—Prostate, *FACT-G* Functional Assessment of Cancer Therapy—General, *GLTEQ* Godin Leisure-Time Exercise Questionnaire, *IQR* interquartile range, *MVPA* moderate-to-vigorous- physical activity, *SD* standard deviation

Table 2 Changes in accelerometry-based and self-reported MVPA after 6 months of aerobic and resistance training delivered via PT, GROUP, or HOME

Outcomes by study arms	Baseline Mean (SD)	6 months Mean (SD)	Mean change (SD)	*p*-Value for change*
Accelerometry bouts ($n=14$)				
PT	4.0 (3.8)	4.2 (3.1)	0.2 (2.7)	0.94
GROUP	3.0 (3.4)	3.4 (4.5)	0.4 (1.8)	
HOME	7.3 (7.1)	7.0 (2.7)	−0.3 (7.6)	
Accelerometry MVPA ($n=14$)				
PT	171 (160)	161 (90)	−10 (88)	0.58
GROUP	150 (92)	139 (104)	−11 (43)	
HOME	209 (151)	171 (71)	−38 (195)	
Self-reported MVPA ($n=37$)				
PT	71 (127)	211 (177)	140 (161)	0.46
GROUP	53 (60)	129 (254)	76 (230)	
HOME	73 (125)	88 (85)	14 (205)	

Outcome analysis is based on the mean changes throughout the intervention. Thus, the mean and SD were reported despite that SD was higher than the mean values as shown in Table 2

*The results from the Kruskal-Wallis test were not materially different from the linear regression (data not shown)

PT supervised personal training, *GROUP* supervised group-based training, *HOME* home-based training, *MVPA* moderate-to-vigorous physical activity, *SD* standard deviation

Planning domain of the PAB scale at baseline and changes in bouts via accelerometry ($r=0.61$). The strongest baseline predictor of greater changes in accelerometry-based MVPA was *aesthetics* from the NEWS questionnaire ($r=0.66$). *Attitude* ($r=0.64$), *planning* ($r=0.57$), and *motivation* ($r=0.50$) were also correlated with higher MVPA levels from baseline to 6 months.

Discussion

This secondary analysis of a Phase II trial [14] aimed to assess the effects of different exercise delivery modes on MVPA over a 6-month intervention of aerobic and resistance training in PC survivors on ADT, and to identify individual, environmental, and psychosocial factors at baseline that would predict increases in MVPA throughout the study period.

We found that changes in accelerometry-based bouts and minutes of MVPA as well as self-reported MVPA did not significantly differ between PT, GROUP, and HOME, and overall, objective MVPA did not increase in any of the study groups. Previous work in PC survivors demonstrated that self-reported MVPA tended to increase from baseline to post-intervention (only vigorous PA was statistically significant), whereas MVPA measured by accelerometer did not change following 12 weeks of exercise training [26]. Collectively, these results suggest that participants may perceive higher levels of PA post-intervention (i.e., over-reporting) [27], or that accelerometers may not capture all activities, particularly resistance training (i.e., under-capturing) [28, 29]. In addition to participation in structured group-based exercise [7], other factors may support PA behavior in PC survivors on ADT. We demonstrated that environmental and psychosocial factors at baseline were positively correlated with increases in MVPA. However, individual factors at baseline, including age, clinical stage, Gleason score, and BMI, were not predictive of higher MVPA throughout the intervention.

Despite several studies examining potential facilitators and barriers of PA in PC survivors [7], only a few have included psychosocial factors [8, 9]. In a cross-sectional study by Keogh and colleagues [8], the Theory of Planned Behavior model was used to determine the role of subjective norm, attitudes about PA, and self-efficacy in predicting PA behavior in PC survivors on ADT. This study showed that attitudes towards PA and perceived behavioral control were indicative of participants' intention to be physically active and actual PA, respectively [8]. In line with these findings, Hunt-Shanks et al. [9] found that 57% of exercise intention was explained by attitudes, subjective norm, and perceived behavioral control in PC survivors who were receiving different treatments. Our study corroborates the notion that attitudes towards PA, in addition to planning, and motivation may predict actual PA behavior of PC survivors on ADT [30]. A novel aspect of our study is the incorporation of natural environmental factors that may foster or hinder a physically active lifestyle in neighborhoods. Of the eight environmental/neighborhood characteristics of the NEWS questionnaire [19] and other psychosocial predictors, neighborhood aesthetics was the strongest predictor of objective MVPA in our cohort. Aesthetics includes street elements such as sidewalks, trees/plants, lighting, and storefronts. Our results are novel in older survivors with PC on ADT and strengthen existing literature on the role of neighborhood-related factors in fostering PA behavior in older adults [31, 32]. Despite our small sample, our findings may be used to further future research on the role of the environment on PA levels in older individuals living with and beyond cancer.

A major limitation of this study is the small sample size and the discrepancy in the proportion of participants with available accelerometry-based versus those with self-reported MVPA. Our comparisons are thus likely underpowered, suggesting that these results should be interpreted with caution. Additionally, our small sample precluded us from examining the importance of predictors within each study arm and might have impacted the effect sizes of predictors within the entire cohort. Another limitation is the exclusion of patients (by design) who were not living in proximity to a study center. Data from patients living in rural areas might have provided additional and/or different insights on environmental factors (e.g., more natural/

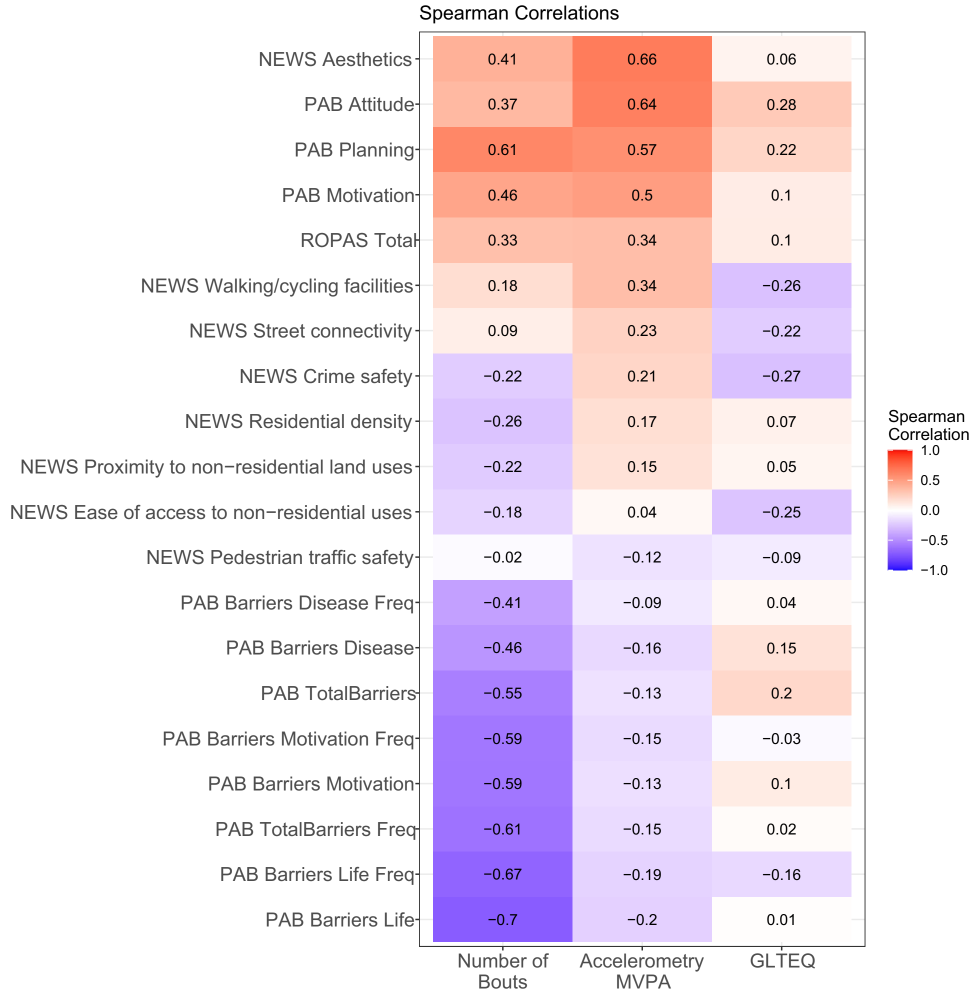

Fig. 1 Spearman correlations between psychosocial factors and changes in MVPA. For accelerometry data ($n = 14$), correlations with absolute value > 0.37 have $p < 0.10$, correlations with absolute value > 0.46 have $p < 0.05$, and correlations with absolute value > 0.63 have $p < 0.01$. For GLTEQ data ($n = 37$), correlations with absolute value > 0.22 have $p < 0.10$ and correlations with absolute value > 0.28 have $p < 0.05$

green and open landscape with less traffic/noise as opposed to dense urban areas) influencing MVPA. Our study included a relatively young cohort of men on ADT. Whether these findings are generalizable to older men (75 + years) on ADT warrants further research.

Our study, however, also exhibits several strengths. First, despite the small sample, assessing the impact of 3 different exercise delivery modes on MVPA behavior is novel in PC survivors on ADT. Second, we examined several potential predictors of MVPA that are understudied, particularly in PC survivors. Third, PA was assessed using both subjective and objective measures, enhancing the understanding of the role of exercise delivery modes and psychosocial factors in predicting MVPA.

Conclusion

Based on these preliminary results, additional research on whether specific factors predict adherence differently based on type of exercise program would be important. Future work should also utilize hybrid implementation-effectiveness trials to build best evidence into best practice and deepen our understanding of factors impacting behavior change, making exercise oncology resources more widely available to support PA for PC survivors.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Heather Leach, Sara Durbano, Daniel Santa Mina, Catherine Sabiston, Efthymios Papadopoulos, Nicole Culos-Reed, Shabbir Alibhai, and George Tomlinson. The first draft of the manuscript was written by Efthymios Papadopoulos, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability De-identified data will be available from the corresponding author upon reasonable request.

Code availability Not applicable.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the institutional review boards of the University Health Network and the Tom Baker Cancer Centre.

Consent to participate Informed consent was obtained from all participants included in the study.

Consent for publication Patients signed informed consent regarding publishing their data.

Conflict of interest The authors declare no competing interests.

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