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BRIEF REPORT

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The promoting physical activity in regional and remote cancer survivors (PPARCS) trial: Physical activity maintenance

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Abstract

Introduction: The study examined whether increased physical activity (PA) in nonmetropolitan cancer survivors was maintained 12 weeks following the PPARCS intervention.

Methods: PA outcomes were assessed using an accelerometer at baseline, end of the intervention, and at 24 weeks. Linear mixed models were used to examine between-group changes in PA outcomes.

Results: The increased moderate-to-vigorous PA (MVPA) following intervention was maintained with significantly higher MVPA in the intervention group at 24 weeks (vs. controls) compared to baseline nett change of 52.5 min/week (95% CI 11.0–94.0.4).

Clinical Trial Registration: ACTRN12618001743257.

Conclusions: Distance-based interventions using wearables and health coaching may produce MVPA maintenance amongst nonmetropolitan cancer survivors.

KEYWORDS
behavior change, exercise, health disparities, oncology, wearable technology

1 | INTRODUCTION

The PPARCS (*P*romoting *P*hysical *A*ctivity in *R*egional and Remote *C*ancer *S*urvivors) trial explored the efficacy of a wearable (the Fitbit Charge 2™), in conjunction with telephone-health coaching in an entirely distance-based intervention to increase MVPA in Australian breast and colorectal cancer survivors residing in nonmetropolitan* areas. The PPARCS intervention significantly increased MVPA with a between-group net difference in MVPA of 50 min/week favoring the intervention group.[1]

The primary objective of the present study was to determine whether group differences in MVPA observed at week-12 were still evident 12-week postintervention (week-24). Secondary aims were to explore within-group changes between T1 and T3, and T2 and T3 for MVPA, light PA, and sedentary behavior.

2 | MATERIALS AND METHODS

The trial was a multicenter randomized controlled trial conducted across five Australian states (New South Wales, Victoria, Western Australia, South Australia, and Tasmania). The study was approved by the St. John of God Hospital Human Research Ethics Committee (Reference #1201) and registered (ACTRN12618001743257). Written informed consent was obtained from participants prior to enrolment. An overview of PPARCS methods has been published.[2] A brief summary of methods relating to the present the study are outlined below.

2.1 | Assessments

Participants† were mailed the study questionnaire, an ActiGraph GTX9 accelerometer (ActiGraph, Pensacola, FL, USA), written accelerometer instructions, and a reply-paid satchel at T3 (12 weeks following T2).

2.2 | Outcome measures

The ActiGraph GT9X accelerometer was used to ascertain min/week of MVPA. Participants wore the accelerometer on their right hip for all waking hours across 7-consecutive days at each assessment. Wear-time had to exceed 10 h/day for at least 5 days and contain no excessive counts (>20 000) to be considered valid, with nonwear-time defined as at least 60-consecutive min of 0 counts. Data were processed using 60-s epochs. Daily accelerometer logs were completed by participants for cross-checking of data. Freedson cut points[3] were adopted as follows: light (100 to <1952 cpm), moderate (1952–5724 cpm), and MVPA (1952+ cpm). Total duration of MVPA was examined as both weekly time accumulated (min/week) and time in bouts of at least 10 consecutive minutes (MV10; min/week) using a modified 10+ min bouts/week minus 2-min hesitation.

2.3 | Sedentary behavior

Sedentary behavior was defined by accelerometer activity counts of <100 cpm for ≥20 min. The accelerometer log and heatmaps assisted in differentiating sedentary time from nonwear-time.

2.4 | Statistical methods

Linear mixed models were used to model the relationship between outcome measures and the fixed effect of arm, time (T1, T2, and T3), and the interaction of arm by time. The models included random intercepts for individuals to account for the correlation within person. All available data were included on an as randomized basis. Approximate Wald $\chi 2$ tests based on model standard errors were used to statistically compare pairwise between-group nett differences and within-group differences to 0 (i.e., no difference).

Sensitivity analysis included (a) adjusting the models for sex, cancer type, minutes of wear-time, age,

*Nonmetropolitan denotes outside of major cities. Remoteness was measured according to the accessibility/remoteness index of Australia and the Australian Statistical Geography Standard, which define five statistical areas: major cities, inner regional (IR), outer regional (OR), remote (R), and very remote (VR). For international comparison, approximately 28% of Australians reside in regional and remote areas.

†Participants included adult breast cancer and CRC survivors who had completed active cancer treatment in the 5 years prior to recruitment.

comorbidity, and remoteness (inner regional vs. other); and (b) subgroup analyses that involved refitting the models for Completers (participants that completed T3), Adherers (participants that received ≥4 health coaching sessions) and insufficiently active participants (those that recorded <150 min/week MVPA at T1).

Model residuals were used to visually assess heteroscedasticity and normality. Standard errors for MV10 were bootstrapped (1000 repetitions), clustering on participant, because this outcome deviated from these assumptions. Data were analyzed using Stata v17 (StataCorp.) and $p < 0.05$ was considered sufficient evidence to infer an effect.

3 | RESULTS

A total of 87 participants were randomized to intervention ($n = 43$) and control ($n = 44$) groups. Demographic characteristics were similar across groups at baseline (Table S1). Sixty-nine participants (79%) remained in the trial at T3. Those who remained at T3 did not differ from those who did not by age, sex, baseline MVPA, cancer type, or months since diagnosis.

Observed means for ActiGraph outcomes and wear-time variables across all timepoints (T1–T3) are displayed in Table S2. Valid Actigraph wear-days were high with 100%, 95.9%, and 98.5% of participants meeting this criterion at T1, T2, and T3, respectively (only three participants at T2 and 1 at T3 had insufficient valid wear days). There were no differences between the groups for valid wear-days except at T2, with higher wear-days in the intervention group (6.9 vs. 6.6) compared to controls ($p = 0.041$). All participants had valid wear-time with an average of 844 (SD 63.9), 853 (SD 71.0), and 851 (SD 61.3) minutes/day at T1–T3, respectively, with no differences between groups.

The nett change in MVPA at T3 was 52.5 min/week (95% CI 11.0–94.0, $p = 0.013$), with the intervention group showing increased MVPA from T1 to T3 of approximately 68 min/week (see Table 1). There was also a nett increase in MVPA bouts (i.e., MVPA bouts of ≥10 min) of 30 min/week (95% CI 1.2–60.8) favoring the intervention group ($p = 0.059$). There was no evidence for a nett change in any other secondary measure (see Table 1). Further, there was no clear evidence of a nett change in any outcome between T2 and T3, nor of any within group difference, for MVPA or the secondary outcomes (see Table 2).

Adjusted models did not produce substantial variation in the estimated nett mean differences for any outcome measure, for either the T3 versus T1 or T3 versus T2 comparisons. For example, the nett change in MVPA ranged between 50.5 and 53.1 min/week from T1 to T3 (see Tables S3 and S4). Subgroup analyses according to PA status at baseline and protocol adherence also did not produce substantially different results (Table S5).

4 | DISCUSSION

Our trial is one of the first to examine the short-term maintenance of PA following participation in a distance-based intervention, using wearables and telephone health coaching in nonmetropolitan breast cancer and CRC survivors. The significant increase in MVPA observed at week-12[1] in the intervention group was still evident at 24 weeks, with a significant between-group nett difference of 52.5 min/week of MVPA favoring the intervention group between baseline and 24 weeks. The improvement of 67.7 mins/week of MVPA following participation in the PPARCS intervention is likely to be clinically meaningful for reductions in all-cause mortality. This is because post-diagnosis PA of ~80 mins/week MVPA reduces all-cause mortality by about 22% in cancer survivors and twice this (i.e., meeting the PA guidelines) yields a 43% reduction.[4]

Less than a quarter of studies have examined post-intervention maintenance of PA in cancer survivors and, of those that have, just 22% of interventions were effective in promoting PA maintenance.[5] Research limited to PA maintenance in nonmetropolitan cancer survivors is scarce with no evidence for exercise maintenance at follow-up in the handful of previous studies.[6] Relatively little is known about the effective maintenance of PA in cancer survivors.

It is difficult to discern the active techniques that facilitate PA maintenance in cancer survivors because interventions that are effective often use similar content and behavior change techniques (BCTs) as those that are ineffective (e.g., goal setting, self-monitoring of behavior, problem solving, and instruction on how to perform a behavior).[7] However, ineffective interventions are less likely to include action planning, goal setting (behavior), graded tasks, social support, or a supervised element.[7]

Remotely delivered interventions using wearables such as PPARCS are attractive because they integrate BCTs that demonstrate promise in the maintenance of PA (e.g., self-monitoring of behavior and feedback on performance), tend to be of a lower-intensity (i.e., less contact time), and thus are more scalable. Remotely-delivered PA interventions using wearables also align with survivor preferences for monitoring/accountability as a source of motivation[8,9] and exercise preferences for walking[10,11] and unsupervised PA.[12]

Previous research using smart wearables in conjunction with health coaching[13] or group sessions[14] have demonstrated preliminary maintenance of MVPA, albeit

TABLE 1 MVPA and secondary Actigraph activity outcome comparisons between T3 (24 weeks) and T1 (Baseline): Estimated between arm (Wearable change (T3-T1) – Control change (T3–T1)) nett difference and within arm (T3–T1) mean differences (95% CI).

		Between-arm comparison			Within-arm comparison			Within-arm comparison		
		Wearable change (T3–T1) – control change (T3–T1)			Wearable change (T3–T1)			Control change (T3–T1)		
Actigraph outcomes		**Nett mean difference**	**95% CI**	***p*[1]**	**Mean difference**	**95% CI**	***p*[1]**	**Mean difference**	**95% CI**	***p*[1]**
MVPA	min/week	52.5	11.0 to 94.0	**0.013**	67.7	36.4 to 99.0	**<0.001**	15.2	−12.0 to 42.4	0.274
MV10	min/week	29.8	−1.2 to 60.8	0.059	44.4	17.8 to 70.9	**0.001**	14.6	−1.5 to 30.7	0.075
Moderate PA	min/week	42.0	2.1 to 81.9	**0.039**	56.3	26.1 to 86.4	**<0.001**	14.2	−12.0 to 40.4	0.287
Light PA	min/week	−149.0	−342.9 to 44.9	0.132	41.9	−104.4 to 188.3	0.574	191.0	63.8 to 318.1	**0.003**
Sedentary time	hr/week	1.3	−0.9 to 6.3	0.469	−1.8	−4.5 to 0.9	0.201	−3.1	−5.5 to −0.7	**0.010**
Sedentary time (≥20-min bouts)	hr/week	1.2	−2.8 to 5.2	0.561	0.0	−3.0 to 3.0	0.991	−1.2	−3.8 to 1.5	0.383

Abbreviations: 95% CI, 95% confidence interval; MVPA, moderate-to-vigorous physical activity; MV10, minutes of moderate-to-vigorous physical activity completed in bouts of at least 10 min; PA, physical activity; T1, Baseline; T3, 24 weeks following baseline.

Note: Arm (Wearable vs. Control) by Time (T1, T2 vs. T3) interaction: MVPA $\chi^2(2)=8.9$, $p=0.012$; MV10 $\chi^2(2)=7.5$, $p=0.023$; Moderate PA $\chi^2(2)=8.1$, $p=0.017$; light PA $\chi^2(2)=4.0$, $p=0.136$; Sedentary time $\chi^2(2)=2.1$, $p=0.346$; Sedentary time (≥20-min bouts) $\chi^2(2)=1.1$, $p=0.565$. Mean differences are estimated from the mixed model; the estimation process may result in slight difference to that calculated from the observed means (Table 2). The bold simply shows that these are statitically significant at $p < 0.05$.

[1]*p*-value from the Wald χ^2 test that the difference equals 0.

TABLE 2 MVPA and secondary Actigraph activity outcome comparisons between T3 (24 weeks) and T2 (12-week end of intervention): Estimated between arm (Wearable change (T3–T2) – Control change (T3–T2)) and within arm (T3–T2) mean differences (95% CI).

		Between-arm comparison			Within-arm comparison			Within-arm comparison		
		Wearable change (T3–T2) – control change (T3–T2)			Wearable change (T3–T2)			Control change(T3–T2)		
Actigraph outcomes		**Nett mean difference**	**95% CI**	***p*[1]**	**Mean difference**	**95% CI**	***p*[1]**	**Mean difference**	**95% CI**	***p*[1]**
MVPA	min/week	−1.8	−43.7 to 40.0	0.932	−5.4	−37.1 to 26.3	0.738	−3.6	−30.9 to 23.7	0.797
MV10	min/week	−9.7	−34.1 to 4.7	0.436	−5.4	−25.3 to 14.5	0.595	4.3	−10.6 to 19.2	0.571
Moderate PA	min/week	−11.6	−51.9 to 28.6	0.571	−12.7	−43.2 to 17.8	0.414	−1.1	−27.4 to 25.2	0.936
Light PA	min/week	−190.8	−386.2 to 4.6	0.056	−127.3	−275.4 to 20.8	0.092	63.5	−64.0 to 191.0	0.329
Sedentary time	hr/week	2.7	−0.9 to 6.3	0.145	1.8	−1.0 to 4.5	0.210	−0.9	−3.3 to 1.4	0.437
Sedentary time (≥20-min bouts)	hr/week	2.2	−1.8 to 6.2	0.285	1.2	−1.9 to 4.2	0.447	−1.0	−3.6 to 1.6	0.450

Abbreviations: 95% CI, 95% confidence interval; MVPA, moderate-to-vigorous physical activity; MV10, minutes of moderate-to-vigorous physical activity completed in bouts of at least 10 min; PA, physical activity; T2, end of intervention (12 weeks after baseline); T3, 24 weeks following baseline.

Note: Arm (Wearable vs. Control) by Time (T1, T2 vs. T3) interaction: MVPA $\chi^2(2)=8.9$, $p=0.012$; MV10 $\chi^2(2)=7.5$, $p=0.023$; Moderate PA $\chi^2(2)=8.1$, $p=0.017$; light PA $\chi^2(2)=4.0$, $p=0.136$; Sedentary time $\chi^2(2)=2.1$, $p=0.346$; Sedentary time (≥20-min bouts) $\chi^2(2)=1.1$, $p=0.565$. Mean differences are estimated from the mixed model; the estimation process may result in slight difference to that calculated from the observed means (Table 2).

[1]p from the Wald χ^2 test that the mean difference equals.

in metropolitan cancer survivors. Contrary to our findings, Gell et al. (2020)[15] found that a Fitbit alone failed to avert a decline in MVPA following a supervised exercise program for cancer survivors. Singh et al. (2020)[16] found that provision of a Fitbit alongside a PA counseling (PAC) session was sufficient to support PA maintenance following a supervised exercise program, compared to a PAC alone.

In the present study, MVPA was maintained in the intervention group at follow-up. A Fitbit may be sufficient to prevent decline in PA if participants continue to self-monitor PA, review performance, and have developed key self-regulation skills, such as coping planning to avoid relapse. Indeed, BCTs associated with PA maintenance in cancer survivors including self-monitoring, goal setting, and feedback on performance[17] are incorporated into wearable technology and should theoretically continue to have an impact on behavior following intervention cessation, if participants continue to engage with the wearable. However, other BCTs associated with PA maintenance are not currently integrated into wearable technology which may explain why some studies have found that provision of a tracker alone is insufficient to foster maintenance. For example, action planning, coping planning, and the development of "if-then" plans to support habit formation have been hypothesized to be determinants of behavioral maintenance.[18] In the present study, the health coaching sessions included BCTs absent from the Fitbit including prompting action planning, problem solving, and coping planning. In this way, the combination of BCTs delivered through the health coaching, in conjunction with the Fitbit likely supported the preliminary PA maintenance observed.

5 | CONCLUSION

PPARCS is the first trial to demonstrate short-term maintenance of MVPA in nonmetropolitan cancer survivors following participation in a distance-based intervention using Fitbits and health coaching. Interventions that utilize smart wearables may be particularly helpful for increasing PA in geographically disadvantaged cancer survivors who may not have access to nearby programs or exercise facilities. Distance-based interventions using wearables and health coaching may support MVPA maintenance amongst breast and CRC cancer survivors.

AUTHOR CONTRIBUTIONS

SJH conceived the study, was the principal investigator, and took the lead role in producing the manuscript. CMS and MLR contributed to data collection. VC and TB contributed to study design and data curation. DH and MB contributed to data analysis and interpretation. CP, ML, CS, FS, SN, JM, CL, and PAC contributed to data collection. All authors contributed to manuscript writing. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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