Adults' Past-Day Recall of Sedentary Time: Reliability, Validity and Responsiveness

Clark BK[1], Winkler E[1], Healy GN[1,2], Gardiner PG[1,6], Dunstan DW[1,2,3,4,5], Owen N[1,2], Reeves MM[1]

[1]The University of Queensland, School of Population Health, Cancer Prevention Research Centre, Brisbane, Australia

[2]Baker IDI Heart and Diabetes Institute, Melbourne, Australia

[3]School of Exercise and Nutrition Sciences, Deakin University, Melbourne, Australia

[4]ECU Health and Wellness Institute, Edith Cowan University, Perth, Australia

[5]Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia

[6]Translating Research into Practice (TRIP) Centre, Mater Medical Research Institute, Brisbane, Australia

Corresponding Author

Bronwyn K Clark

Cancer Prevention Research Centre

School of Population Health

The University of Queensland

Herston Road, Herston, QLD 4006 Australia

E-mail: b.clark3@uq.edu.au

Phone: 61-7-3365-5528

Fax: 61-7-3365-5140

Running Title

Adults' Past-Day Recall of Sitting (PAST)

Competing Interests

The authors declare that they have no competing interests.

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Abstract

Purpose: Past-day recall, rather than recall of past week or typical behavior, may improve the validity of self-reported sedentary time measures. This study examined the test-retest reliability, criterion validity and responsiveness of the seven-item questionnaire, Past-day Adults' Sedentary Time (PAST).

Methods: Participants (n=90; breast cancer survivors; age 33-75 years; BMI 25-40kg/m^2) in a six-month randomised controlled trial of a lifestyle-based weight loss intervention completed the interviewer-administered PAST questionnaire about time spent sitting or lying on the previous day for: work, transport, television viewing, non-work computer use, reading, hobbies and other purposes (summed for total sedentary time). The instrument was administered at baseline, seven days later for test-retest reliability (n=86) and at follow-up. ActivPAL-assessed sit/lie time in bouts of ≥5mins during waking hours on the recall day was used as the validity criterion measure at both baseline (n=72) and follow-up (n=68). Analyses included Intraclass Correlation Coefficients (ICC), Pearson's correlations (r), Bland-Altman Plots and Responsiveness Index.

Results: The PAST had fair to good test-retest reliability (ICC: 0.50; 95%CI: 0.32, 0.64). At baseline, the correlation between PAST and activPAL sit/lie time was r=0.57 (95%CI: 0.39, 0.71). The mean difference between PAST at baseline and (a) retest was -25 minutes (i.e. 5.2%), 95%Limits of Agreement (LoA): -5.9, 5.0 hours; and, (b) activPAL sit/lie time was -9 minutes (i.e. 1.8%), 95%LoA: -4.9, 4.6 hours. The PAST showed small but significant responsiveness; responsiveness of activPAL sit/lie time was not significant.

Conclusion: The PAST questionnaire provided an easy-to-administer measure of sedentary time in this sample. Validity and reliability findings compare favourably with other sedentary time questionnaires. Past-day recall of sedentary time shows promise for use in future health-behavior, epidemiological and population-surveillance studies.

Key words: questionnaire, sedentary behavior, activPAL, surveillance

Introduction

Paragraph 1 In the USA and Australia, the adult population spends on average over 50% of waking hours sedentary [15, 22]. Time spent in sedentary behavior is detrimentally associated with risk biomarkers and health outcomes independent of meeting physical activity guidelines during leisure-time [25]. In order to advance the evidence to address this issue, the development of measures for use in epidemiological, health behavior and population-surveillance studies is essential. While there are now device-based measures (accelerometers, inclinometers) of sedentary time available to researchers, these devices are not able to identify time spent in specific sedentary behaviors or domains of behavior. Therefore, high quality self-report measures are necessary to complement the information from device-based measures or provide the best alternative when cost is an issue.

Paragraph 2 Sedentary behaviors are defined by both posture (sitting or reclining) and low energy expenditure (typically ≤1.5METS) [25, 36]. Time spent in sedentary behaviors has primarily been measured by questionnaires requiring recall of sitting time over the past week (or longer) or as typical behavior. Correlations (ρ) of these questionnaires with device-based criterion measures in 31 validity studies [14] usually have been only weak (15 studies, ρ <0.3) or moderate (10 studies, ρ 0.3 to <0.6), with the highest correlation being 0.61 (95% CI:0.42, 0.75).

Paragraph 3 Shorter-term recall, such as past-day, may improve the accuracy of self-reported sedentary time[23]. Dietary-assessment studies [5, 17] and physical activity studies with children [29, 34] have used past-day recall. For assessment of sitting behaviors, short-term recall has been used in the form of an activity log or a time-use diary demonstrating correlations (r>0.50) with device-based measures [12, 33], which are higher than most such correlations for sedentary behavior questionnaires [14]. However, logs or diaries can have

substantial participant burden and have thus not been widely used in sedentary behavior research. To date, there have been no questionnaires that have utilised short-term recall for capturing time spent in sedentary behaviors.

Paragraph 4 The modest relationships with criterion measures that have been reported for sedentary behavior questionnaires may be due to the particular criteria (accelerometer-derived sedentary time or a behavioral log) commonly employed in validity studies [14]. Issues associated with these criterion measures include inaccuracy in detecting true sitting time (waist-worn accelerometer [19] and error and bias associated with self-report (behavioral log; [3, 26]. The thigh-worn activPAL inclinometer device has been shown to be highly accurate at measuring sitting time (between 0.2 and 2.8% difference in detecting sitting compared to direct observation) [11, 19] and to be more sensitive to reductions in sitting time than the accelerometer [19]. The inclinometer device may therefore be a more appropriate criterion measure for validation of sedentary behavior questionnaires.

Paragraph 5 To assess the utility of questionnaires in intervention studies, determining the responsiveness of an instrument to detect change over time is necessary. Findings from the very few studies to assess the responsiveness of sedentary time questionnaires have shown mixed results. Responsiveness was shown to be similar to an accelerometer measure of sedentary time in one study (Actigraph, GT1M, <100cpm) [10], although questionnaires showed no correlation with change detected by the accelerometer (Actigraph, GT1M, <100cpm) [16] and were not able to detect change in the presence of significant change in sit/lie time on the activPAL [20] in other studies.

Paragraph 6 We examined the Past-day Adults' Sedentary Time (PAST) questionnaire, a seven-item instrument that uses past-day recall of sedentary time. The questionnaire was assessed in a study taking place in the Cancer Prevention Research Centre; a weight-loss trial

in breast cancer patients that included reducing sedentary time among the behavioral targets. Specifically, we examined: test-retest reliability of the PAST for a single day (weekday) administration, criterion validity of PAST total sedentary time as a single day (weekday) administration and a two-day (weekday and Sunday) administration; and, responsiveness to change. The activPAL inclinometer was used as the primary referent measure. The ActiGraph accelerometer was also used to allow comparison with previous validity studies.

Methods

Paragraph 7 Data for these analyses were derived from the *Living Well after Breast Cancer* feasibility trial, carried out between January 2011 and March 2012. This study was a randomised controlled trial evaluating a weight loss intervention delivered via the telephone, compared with a control group, on changes in weight, body composition, targeted behaviors (diet, physical activity and sedentary behavior) and patient reported outcomes (quality of life, fatigue, body image). Following baseline data collection, participants were randomised, using a computer-generated random number table by staff not involved with the study, to either the intervention (n=45) or control group (n=45). Follow-up data were collected after six-months. Ethical approval was obtained through The University of Queensland Behavioral and Social Sciences Ethical Review Committee and Queensland Health Research and Governance Unit; and participants provided written informed consent.

Paragraph 8 **Participants.** Women eligible for recruitment into the study were aged 18-75 years, had been diagnosed with breast cancer (Stage I-III) in the previous 9-15 months, and resided in an area within a 50km radius of Brisbane, Australia. Potential participants were required to have completed initial cancer treatment (surgery, radiation or chemotherapy),

speak sufficient English to undertake the assessments, and have a body mass index (BMI) of 25-40kg/m^2. They were excluded if they had distant metastases, had a previous diagnosis of invasive breast cancer, had been diagnosed with any other cancer in the past five years or had contraindications to participation in unsupervised exercise.

Paragraph 9 **Recruitment.** Participants were recruited through the Queensland Cancer Registry, which collects information on cancer incidence and mortality in Queensland, Australia. Potentially eligible participants were identified from the registry and a letter was sent to their treating doctor explaining the study and inquiring as to whether the patient was appropriate to participate. If deemed appropriate, the potential participants were sent a letter from their doctor seeking consent for them to be contacted about the study. Those consenting to contact then received a telephone call from study staff, who provided more information about the study and screened for eligibility. Those women who were eligible to participate and were interested in taking part signed and returned the consent to participate form. From 1077 patients identified in the Queensland Cancer Registry, 90 participants were included in the study. Reasons for exclusion were: doctor consent to contact not obtained (n=153), refusal (n=173), ineligible (n=139), no response or uncontactable (n=456), sample size reached before contact (n=58), did not attend baseline assessment (n=8).

Paragraph 10 **Intervention.** Participants allocated to the intervention group received a detailed workbook, self-monitoring diary, pedometer, calorie counter book and up to 16 calls over the six-month period from a lifestyle coach. Lifestyle coaches were dieticians with at least undergraduate bachelor degree in nutrition and dietetics who received study-specific training in exercise promotion. The intervention aimed to achieve 5-10% weight loss and targeted reducing dietary energy intake, increasing physical activity and reducing sedentary behavior using behavior change strategies. Participants were encouraged to reduce their

sedentary behavior by aiming to get up every 30 minutes and limiting screen time outside of work to no more than 2 hours per day. Participants were provided with feedback from their baseline assessment at the beginning of the intervention, including their self-reported sitting and lying time across behaviors from the PAST and total amount of sitting/lying time during waking hours from the activPAL for each monitored day.

Paragraph 11 Control participants received brief feedback following their baseline assessment, including the total amount of sitting/lying time during waking hours from the activPAL for each monitored day; they received no further contact between their baseline and six-month follow-up assessments.

Paragraph 12 **Data collection procedure.** Data were collected from all participants at baseline and at the six-month follow-up. At each assessment, participants attended the research center for measurement of height, body weight, body composition (bio-electrical impedance spectroscopy) and waist circumference by trained research staff members blinded to participants study group. At this visit they were provided with an activPAL (activPAL version 3, PAL Technologies, Glasgow, United Kingdom) device, an accelerometer (Actigraph GT3X+, Actigraph, Pensacola, Florida, USA) device and a log book to record monitor wear time and waking hours.

Paragraph 13 Participants were instructed to wear the activPAL inclinometer, attached with a hypoallergenic flexible adhesive dressing, continuously for the following seven days on the right, front mid-thigh. The device was waterproofed, thus removal was only to be undertaken for swimming in the sea (in case of loss) or for changing the adhesive dressing. For the same seven days, the GT3X+ accelerometer was to be worn during all waking hours on an elastic belt around the waist positioned on the right mid-axillary line. The GT3X+ accelerometer could be removed for sleep, swimming and bathing.

Paragraph 14 Participants also completed a telephone interview during the week that they were wearing the monitors. This telephone interview collected information on dietary intake (24-hour dietary recall), leisure-time physical activity (Active Australia Survey; [1]), and demographic and health-related information (education, marital status, occupation, work status, income level [optional] and details of breast cancer treatment). Participants completed the PAST questionnaire on four occasions during the study: at baseline during the standard telephone interview, recalling a weekday during device-wear (T1); at re-test seven days later, recalling the same weekday (T2); at follow-up, recalling a weekday during device-wear (T3); and, finally, at follow-up, recalling a Sunday (T4). The T4 administration recalled a Sunday for pragmatic reasons, to fit in with dietary recalls and the working hours of research staff. The T1 and T2 assessments were designed to establish criterion validity and test-retest reliability of a single (weekday) administration of the PAST, based on evidence that recall of weekday sitting is more reliable than weekend [21]. The T3 assessment enabled testing criterion validity after intervention, and coupled with the T4 assessment enabled validity to be examined for a two-day (weekday and Sunday, unweighted) administration. The T1 and T3 assessments were used in the analyses for responsiveness. The length of time taken to answer the PAST questionnaire was recorded for the T2 administration to provide information on usability in population surveys.

Measures

Paragraph 15 **PAST questionnaire**. The PAST questionnaire (see Supplemental Digital Content 1 Past-day Adults' Sedentary Time Questionnaire) asked about the time spent sitting or lying (while awake) on the previous day with questions about time spent sitting or lying while at work, travelling, watching television, using the computer (excluding work), reading

(excluding work), hobbies and any other purposes not reported in the previous items. Continuous time reported in the seven items was summed to provide a composite measure of overall sitting and lying time, termed sedentary time.

Paragraph 16 **activPAL device.** The activPAL continuously recorded posture (sitting/lying, standing or stepping). Time spent in a sitting or lying position recorded by the activPAL device during waking hours is referred to as sit/lie time. Using SAS 9.2, each activPAL bout of sit/lie time was compared with the overlapping log-reported sleeping and removal periods. When participants failed to indicate a sleep/wake time in the log, this was estimated from when movement or standing began/ceased according to the device. ActivPAL bouts that were predominantly (≥50%) sleep or removed were excluded as sleep or non-wear time. Comparison of a visual representation of the activPAL data was used to check for any very long uninterrupted movement that could reflect unreported removal and for consistency of the combined activPAL-log awake/worn time against the monitor.

Paragraph 17 For the daily data to be used, participants needed to have worn the activPAL for ≥10 hours and ≥80% of waking hours, or simply for ≥ 80% of waking hours if the participant reported being awake for <10 hours. Participants had to have worn the device for sufficient time on at least five days for data to be included in the analysis of weekly data. Sit/lie time (hours per day) during waking hours was recorded for both the day recalled in the PAST questionnaire, and also as average daily sit/lie time over all the days monitored. Participants are unlikely to recall and report very short bouts of sitting, and no respondent reported a sitting activity/domain of less than five minutes. Thus, sit/lie time that occurred in continuous bouts of five minutes or longer (sit/lie 5mins+) was examined as the main activPAL validity criterion measure in addition to all sitting/lying time (sit/lie total).

Paragraph 18 **Actigraph GT3X+ accelerometer device**. Actigraph GT3X+ accelerometer data were taken from the vertical axis only to provide comparison with previous validity studies [6, 10, 30]. Wear time was estimated using an automated algorithm with non-wear identified by bouts of ≥60mins of 0 counts per minute (cpm) with ≤2 interruptions of <50cpm (modification made to allow non-wear bouts to span midnight) [35]. For the daily data to be used, participants needed to have worn the accelerometer for close to the self-reported waking hours identified in the activity log (≤2hrs difference). For the included participants at baseline, mean accelerometer wear time was 14.8 hrs (SD: 1.1 hours) on the day of recall and 14.8 hours (SD: 0.9 hours) on average over the monitored days. Participants had to have worn the device for sufficient time on at least five days for data to be included in the analysis of weekly data. A minimum of five days of Actigraph accelerometer monitoring has been shown to be necessary to predict average time in sedentary behavior [13]. Sedentary time (<100 cpm, hours per day) was recorded for the day recalled in the PAST, and as an average of daily sedentary time over all the eligible monitored days.

Paragraph 19 **Statistical analyses.** Analyses were conducted in SPSS version 20.0 (IBM Corporation) with statistical significance set at $p<0.05$. Characteristics of the sample were described as % (n), median (25%, 75%) or mean (standard deviation, SD). Test-retest reliability of total sedentary time and each item from the PAST was examined using Intraclass Correlation Coefficients (ICCs) or Spearman's rank order correlations depending on the distribution of the data. The strength of correlation was interpreted as follows: ICC <0.4 poor repeatability, 0.4–0.75 fair to good repeatability, and > 0.75 excellent repeatability [27]. Test-retest was examined in the 86 women with re-test data on the relevant day, seven days after the T1 assessment. Women were excluded who did not answer the T2 questionnaire (n=2) or whose assessments were not seven days apart (n=2).

Paragraph 20 Pearson's correlations (r) were used to examine the correlation of a single (weekday) administration of PAST total sedentary time with activPAL sit/lie time (5+ mins and total time) on the day recalled and average activPAL sit/lie time over all monitored days, both before intervention (T1) and after intervention (T3). Analyses also included the correlation of a two-day (weekday and Sunday) administration of PAST total sedentary time (average of T3 and T4, unweighted) with average activPAL sit/lie time over monitored days at follow-up. The two day administration was not weighted for weekday and weekend and the findings are intended to be indicative of multiple administrations rather than a week of sitting. The 95% confidence intervals for the correlations were calculated using Fisher's transformation.

Paragraph 21 Comparisons were also made in terms of agreement between PAST total sedentary time test and retest (T1 and T2); and, PAST total sedentary time (T1) and activPAL sit/lie time (5+ mins and total time) on the day recalled and average activPAL sit/lie time over all monitored days. Agreement was examined using the method outlined by Bland and Altman [2]. Plots with mean difference and limits of agreement (±1.96 SD) are presented for test-retest reliability and comparison of PAST total sedentary time with the main criterion measure. Linear regression was used to check whether the mean difference and limits of agreement varied across average values of PAST sedentary time and activPAL sit/lie time [(total sedentary + acitvPAL sit/lie)/2] [4] after visual examination of the plots.

Paragraph 22 To provide a comparison with existing validity studies [8, 14], correlations of PAST total sedentary time (T1) were also made with GT3X+ accelerometer-derived sedentary time on the same day and as average over monitored days using data from the baseline assessment (n=59).

Paragraph 23 Criterion validity at baseline was examined in the 72 women with sufficient activPAL data available for the day of the T1 questionnaire and at follow-up in 64 women (intervention n=35, usual care n=29). Data loss at baseline and follow-up from the original 90 participants is shown in the participant flow chart (Supplemental Digital Content 2). A total of 57 participants provided complete data for the PAST and activPAL at both baseline and follow-up (intervention n=31, usual care n=26).

Paragraph 24 Responsiveness to change of PAST sedentary time and activPAL (5+ mins and total time) was evaluated using the responsiveness index and the difference in responsiveness between instruments was tested [32]. The responsiveness index, i.e., intervention group change divided by the comparison group standard deviation of change, and its 95% confidence interval (based on an assumed normal distribution) were calculated for the PAST and for each activPAL measure. The responsiveness of the PAST was compared with responsiveness of activPAL. For the responsiveness analysis, activPAL sit/lie time was standardised to 16 observed waking hours ([sit/lie time/observed hours] x 16) at both baseline and follow-up as observed waking hours differed significantly between baseline and follow-up. We adopted this approach as the least-complex practical solution eliminating the potential error that could have been associated with wear-time and sleep-time variations. Responsiveness was assessed and compared across instruments for the 57 participants who provided coinciding PAST and monitor data at both baseline and follow-up.

Results

Paragraph 25 Characteristics of the participants who undertook the baseline assessment (including the T1 PAST administration), provided sufficient activPAL data at the baseline

assessment and the follow-up assessment are presented in Table 1. The majority of participants were married or living together, had completed post high school education, and were working part-time or full-time. They were mid- to older-aged (range 33-75 years) and, as per the eligibility criteria, all were overweight or obese.

INSERT TABLE 1 ABOUT HERE

Paragraph 26 **Reported sitting times**. Median time taken to complete the questionnaire was 7 minutes (25^{th}, 75^{th} percentile: 6, 8 minutes). Table 2 shows the reported times for the total sedentary time and the individual items at the single (weekday) administrations at T1 and T2 of the PAST. Total sedentary time was normally distributed while the individual sedentary item times were not. Participants reported approximately eight hours a day on average in sedentary time on the day of recall at both T1 (mean: 8.20, SD: 2.81 hours) and T2 (mean: 7.78, SD: 2.77 hours). The highest median sedentary time reported for an individual item was for television viewing followed by transport. However, for those who worked on the day of recall (n=47), sitting for work represented the highest median sedentary time (median 4.5hrs, interquartile range: 2.5, 7.0hrs).

INSERT TABLE 2 ABOUT HERE

Paragraph 27 **Test-retest reliability.** The correlations between T1 and T2 administrations of the PAST questionnaire are shown in Table 2. Reliability for the composite measure of sedentary time was fair to good [27] (ICC=0.50; 95%CI: 0.32, 0.64). For the individual items, work sedentary time showed the highest test-retest correlation. However, when the data set was limited to those who had reported working on the recalled day (n=47, 55%) the correlation was lower but still statistically significant (ρ=0.37; 95%CI: 0.08, 0.60). The

questions asking about time spent sedentary for other purposes (such as eating and socialising) showed the lowest correlation between test and retest.

Paragraph 28 The Bland-Altman plot for total sedentary time from the T1 and T2 administrations of the questionnaire is shown in Figure 1. Here, a mean difference of -25 minutes (95% CI: =-61, 11 mins) was observed, which was not statistically significant (t-test, p=0.17) and only 5.2% of the average sedentary time of both measures indicating reasonable agreement at the group level. However, the 95% limits of agreement (LoA) were wide (-5.9, 5.0 hours) suggesting agreement is poor at the individual level.

INSERT FIGURE 1 ABOUT HERE

Paragraph 29 **Criterion Validity.** Table 3 shows the correlations with activPAL criterion measures of PAST total sedentary time as a single (weekday) administration at baseline (T1) and after intervention (T3); and as a two-day (weekday and Sunday) administration after intervention. A single (weekday) administration of PAST showed strong (i.e. ≥0.5) correlations at baseline with the main activPAL criterion measure (r=0.57) and with all sit/lie time (r=0.58) measured on the recall day; these correlations remained strong after intervention (both r=0.66). The 95% Confidence Intervals place the true correlations as likely to be at least moderate (i.e. ≥0.3 to <0.5) and possibly reaching the level desired for criterion validity (i.e. ≥0.7). Correlations with average activPAL sit/lie time were only moderate. While statistically significant, the 95% Confidence Intervals ruled out as unlikely a desirable level of criterion validity (i.e. ≥0.7), but did not rule out as unlikely that the true correlation may be weak (<0.3) or strong (≥0.5). By contrast, average sedentary time from the two (weekday and Sunday) PAST administrations showed strong correlation with average activPAL sit/lie time (r=0.54; 95%CI: 0.34, 0.69 for the main criterion measure and r=0.53;

95%CI: 0.32, 0.69 for all sit/lie time) with the 95% Confidence Intervals placing the correlation as at least moderate and potentially close to the desired level.

Paragraph 30 On the day of recall, the correlations with activPAL sit/lie time for those who reported working (n=36; r=0.64 95% CI: 0.40, 0.80) were higher than for those not working (n=36; r=0.40 95%CI: 0.08, 0.64). At follow-up, 54 participants recalled sitting on a Sunday and had device-measures for that day. Here, the correlation between the PAST and activPAL sit/lie time was r=0.57 (95%CI: 0.36, 0.73).

Paragraph 31 The correlations of PAST total sedentary time with accelerometer-derived sedentary time (mean sedentary time on day of recall: 8.9 SD: 1.4, on average over monitored days: 8.9 SD: 1.0) tended to be lower than those seen with activPAL. As had been the case with activPAL, correlations for the single (weekday) administration were higher for the day of recall (r=0.51; 95%CI: 0.29, 0.68) than for average sedentary time (r=0.45; 95%CI: 0.22, 0.63). Correlations between activPAL sit/lie time and accelerometer-derived sedentary time were r=0.53 (0.33, 0.69) for the day of recall and r=0.62 (0.44, 0.75) on average over the monitored days.

INSERT TABLE 3 ABOUT HERE

Paragraph 32 **Validity agreement**. The Bland-Altman plot for the agreement between total sedentary time (PAST) and the main criterion measure of activPAL sit/lie time on the recall day can be seen in Figure 2a. When sit/lie time was examined only in bouts of at least five minutes, the mean difference was small (-0.15 hours, 95% CI=-0.72, 0.42), not statistically significant (p=0.61) and represented a small proportion of the average time from both measures (1.8%). However, the limits of agreement were wide, indicating that for individuals, differences may possibly be incorrect by several hours (LoA: -4.90, 4.60hrs).

The PAST questionnaire produced estimates of sedentary time that were one hour less than activPAL total sit/lie time on the day of recall (mean difference (MD):-0.96hrs, 95% CI = -1.52, 0.39, p=0.001), which was 11.0% of the average of the PAST and activPAL total sit/lie time. As seen with the main criterion measure, the limits of agreement were wide (LoA: -5.67, 3.76hrs; plot not shown as similar to main criterion measure).

Paragraph 33 Linear regression analysis showed a significant positive association for the difference between the PAST and activPAL sit/lie time per monitored day over the week and the average of the two measures, but no association of variability with the average of the two measures. At lower levels of sedentary time, the PAST recorded less time than the activPAL recorded sit/lie time per monitored day and at higher levels of sedentary time the PAST recorded more time than the activPAL sit/lie time per monitored day. This was the case for the main criterion measure (MD: B=0.84, SE 0.15, p<0.001 LoA=MD ± 5.01hrs; Figure 2b) and for all sit/lie time (MD: B=0.85, SE 0.15, p<0.001 LoA=MD ± 4.97hrs). At the mean levels seen in this sample (average of the two measures= 8.1 hours/day for the main criterion measure and 8.5 hours total sit/lie time), these mean differences were -0.19hrs (95% CI: -0.45, 0.82) for the main criterion measure and -0.57hrs (95% CI: -1.12, 0.06) for total sit/lie time.

INSERT FIGURE 2 ABOUT HERE

Paragraph 34 **Responsiveness.** Changes over the intervention are shown in Table 4. Only PAST total sedentary time showed a significant difference in change within the intervention group (p=0.04), with the change being large according to the questionnaire (-77 mins) and negligible (<30 mins) according to the activPAL. No statistically significant changes in

PAST sedentary time or sit/lie time were observed in the control group on any measure, with the change reported being small according to the questionnaire (-32 mins) and negligible (<15 mins) according to the activPAL. The changes observed in the intervention group were exceeded by variation in change observed in the control group; hence the responsiveness index was consistently less than one. The responsiveness index was only significant for the PAST questionnaire (-0.44; 95% CI: -0.92, -0.04), however, the questionnaire was not shown to be more responsive than activPAL sit/lie time as the confidence intervals for the differences in responsiveness all included zero.

Paragraph 35 As with the validity findings, inter-instrument correlations in change scores were stronger for the recalled day than for average sit/lie time (Table 4). For both groups, change in PAST sedentary time had a strong correlation with change in activPAL sit/lie on the recalled day and a lower and non-significant correlation with average sit/lie time (Table 4).

INSERT TABLE 4 ABOUT HERE

Discussion

Paragraph 36 This study provides some of the first findings on the reliability, validity and responsiveness to change of a questionnaire measure of past-day recall of sedentary time in adults. A novel element of this study was the use of past-day recall, rather the past week or typical behavior, an approach that has been used with success in dietary and physical activity research [5, 17, 29] but has not yet been applied in the sedentary behavior field. The findings suggest that the PAST questionnaire, which has a short administration time (approximately 7

mins), provides fair to good test-retest reliability. The criterion validity showed a strong correlation with activPAL sit/lie time (r=0.57), which is high in terms of the correlations that have been generated from other questionnaires with device based criterion measures [14]. There was good agreement at the group level, with minimal mean differences that did not indicate a statistically significant bias at baseline, although agreement was poor at the individual level. The PAST questionnaire was responsive to change; however, as the behavioral changes were not verified by the objective monitoring, this may be attributable to biases in reporting.

Paragraph 37 A major strength of this study is the use of the activPAL device as a criterion measure for questionnaire measures of sedentary time since the activPAL has shown high agreement compared with direct observation [11], thus providing a good criterion for assessing both correlation and absolute agreement. Our findings compare favourably to a small study that used activPAL as criterion measure for the International Physical Activity Questionnaire (IPAQ) single item for sitting question (weekdays r=0.41, weekends r=0.55) and a composite measure of sitting time (weekdays r=0.30, weekends r=0.17) [20].

Paragraph 38 The inclusion of an accelerometer criterion measure permitted the comparison to previous studies reporting validity of sedentary behavior questionnaires. The correlation between PAST and accelerometer-derived sedentary time (r=0.51 for recalled day and r=0.45 for average monitored time over the week) was within the upper range of those reported for the IPAQ (ρ=0.07 to 0.61) [8], and other composite measures of sitting time (ρ=-0.01 to 0.54) [7, 14]. The validity findings for the PAST were similar to those of time-use diaries compared with accelerometer-derived sedentary time (non-occupational sedentary time, ρ=0.57-0.59) [33], which, while they provide more information on timing of behaviors, are more time consuming and have a higher participant burden than the PAST questionnaire. The

correlations between the PAST and accelerometer-derived sedentary time were lower than those observed for the activPAL sit/lie time on the day of recall. This suggests that previous studies that have used accelerometer-derived sedentary time as the criterion measure may not have correctly estimated validity correlations of those questionnaires. Future validity studies should attempt to employ the most accurate available measure of sedentary behavior as criterion measure.

Paragraph 39 Since sedentary behavior is likely to vary from day to day, it is acknowledged that it may be difficult to capture habitual sedentary behavior with a single past-day recall. Thus, as expected, the correlations of a single (weekday) recall of sedentary time with average sit/lie time were weaker than correlations with the recalled day. Nevertheless, the correlation of the single administration of the PAST with average accelerometer-derived sedentary time over the week (r=0.45) is comparable to those for existing sedentary behavior questionnaires that measure past week or typical behavior [14]. Two administrations (weekday and Sunday) of the PAST questionnaire were sufficient to show a stronger correlation (r=0.54) with average activPAL sit/lie time than the single administration (r=0.34). Further research should examine how many administrations of the PAST would provide a reliable habitual estimate (ICC >=0.8 or 0.9) and have good agreement with average monitored sit/lie time; and whether multiple administrations can successfully model usual behavior [24]. Examination of further measurement qualities, such as responsiveness and reliability, of multiple administrations of the PAST is also recommended.

Paragraph 40 Examining the agreement on test-retest and between a questionnaire and appropriate criterion measures is important to evaluate the questionnaire's utility as a surveillance tool. The difference in actual time recorded on repeat administrations of the PAST was small (twenty-five minutes) and not statistically significant. Therefore, in

surveillance studies where estimates of the actual time are required at a group level, this questionnaire may provide a reliable measure of sedentary time. The PAST questionnaire provided a close estimate of sedentary time compared with sit/lie time examined in bouts of at least five minutes (nine minutes less on average). However, it underestimated sedentary time relative to all sit/lie time by almost one hour, which is consistent with a previous study that used activPAL as criterion measure and showed mean differences of -41mins for IPAQ and +176mins for a composite measure of sitting time [20]. As the activPAL records sitting/lying continuously, it is likely that difficulty recalling all time in these postures, including very short bouts, leads to the large differences that are no longer present when examining sitting/lying that occurs in longer bouts (5 minutes or more, consistent with the shortest duration reported for any of the PAST sitting items). For all comparisons between the PAST and activPAL sit/lie time, the limits of agreement were wide, indicating that the measure may not accurately estimate an individual's sedentary time.

Paragraph 41 To examine longitudinal changes within individuals (for example in the context of an intervention trial), instruments must be sensitive, or responsive to change [31]. This study, one of the few studies to have examined the responsiveness to change of a sedentary time questionnaire, showed the PAST questionnaire to be responsive. The activPAL device has been shown to be highly accurate [11, 19] and to detect significant intervention changes [20]. The changes in activPAL sit/lie time between baseline and follow-up, although not significant, were negative on the day of recall but not on average over the monitored days, raising the possibility of reactivity. However, we would not expect reactivity to be a significant factor influencing our findings. The administration of the PAST interviews was through unscheduled calls to study participants, who did not know that they would be being asked to recall that sitting for that particular day at the time when they were telephoned. Given that no meaningful or significant change in activPAL-derived sit/lie time

were observed for either group, this suggests that the change detected by the PAST may be due to social-desirability bias or to participants' intention to change rather than representing a true change in sedentary time. The lack of activPAL changes and responsiveness in this study could also indicate that this intervention, in which weight loss was the main target and other diet and physical activity behaviors were included, simply did not affect sedentary behaviors. It is difficult to determine whether past-day recall provides better or worse responsiveness than other types of sedentary behavior questionnaires. A past-week recall questionnaire showed significant responsiveness to change, similar to the responsiveness of accelerometer-derived sedentary time [10]. However, questionnaires requiring recall of total sitting time on a typical day did not show responsiveness in interventions that resulted in change in accelerometer-derived sedentary time [16] and activPAL sit/lie time [20]. Likewise a questionnaire requiring recall of typical time spent sitting in domains did not show change in sitting despite change in sit/lie time being recorded by the activPAL [20]. Given that the reliability of the PAST was only fair, it is likely that a single administration of this measure may not be a good indicator for intervention studies of change in sedentary time.

Paragraph 42 One limitation of this study is the generalisability of the findings: participants were all overweight or obese women with a recent history of breast cancer. However, breast cancer survivors have been shown to be similar to the general female population in terms of BMI, fruit and vegetable intake, smoking status, alcohol intake and meeting physical activity guidelines [9]. Many test-retest reliability studies and validity studies are undertaken in non-generalizable samples [14]. Embedding such studies in this intervention trial has allowed examination of responsiveness and establishing of validity both pre and post intervention, which is important to identify the types of biases that can occur in interventions. An additional consideration is that the PAST questionnaire was interviewer-administered (by

telephone). It may have less reliability and validity in a self-completed format, which would be useful in large-scale mailed surveys.

Paragraph 43 In the current study, the criterion validity of the individual sedentary time items in the PAST questionnaire could not be examined as the device-based measures were not able to determine the context of behavior. Examination of the criterion validity of the particular items is necessary to determine which items may be more accurate and, therefore, appropriate for epidemiological and surveillance studies. Test-retest reliability was better for some sedentary time items in the PAST (work, transport, computer use) than others (sedentary time for other purposes). The validity of individual questionnaire items may also vary, as shown in studies that have used activity logs as criteria [21, 28]. Future studies should use device-based criterion measures that are able to determine context of behavior, such as the new SenseCam technology, which offers potential in identifying behaviors in context, such as travel behaviors [18].

Conclusions

Paragraph 44 The PAST questionnaire, which employs a single past-day recall method, shows promise for a number of applications in sedentary behavior research. It may provide accurate estimates of overall sedentary time in the context of population surveillance. The measure may also be useful in epidemiological studies, as correlations with criterion measures were in the upper range of those seen in previous validity studies on sedentary behavior questionnaires. However, the measure requires evaluation of reliability and validity in a more representative population sample, including men, and in self-completion format. Examination of the validity of the individual sedentary items and responsiveness to change in an intervention that specifically targets sedentary time should also be undertaken. Although

further development is required, the PAST questionnaire may be an easy-to-use self-report method for measuring sedentary time in population health research.

Competing Interests

The authors declare that they have no competing interests.

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The results of the present study do not constitute endorsement by ACSM.

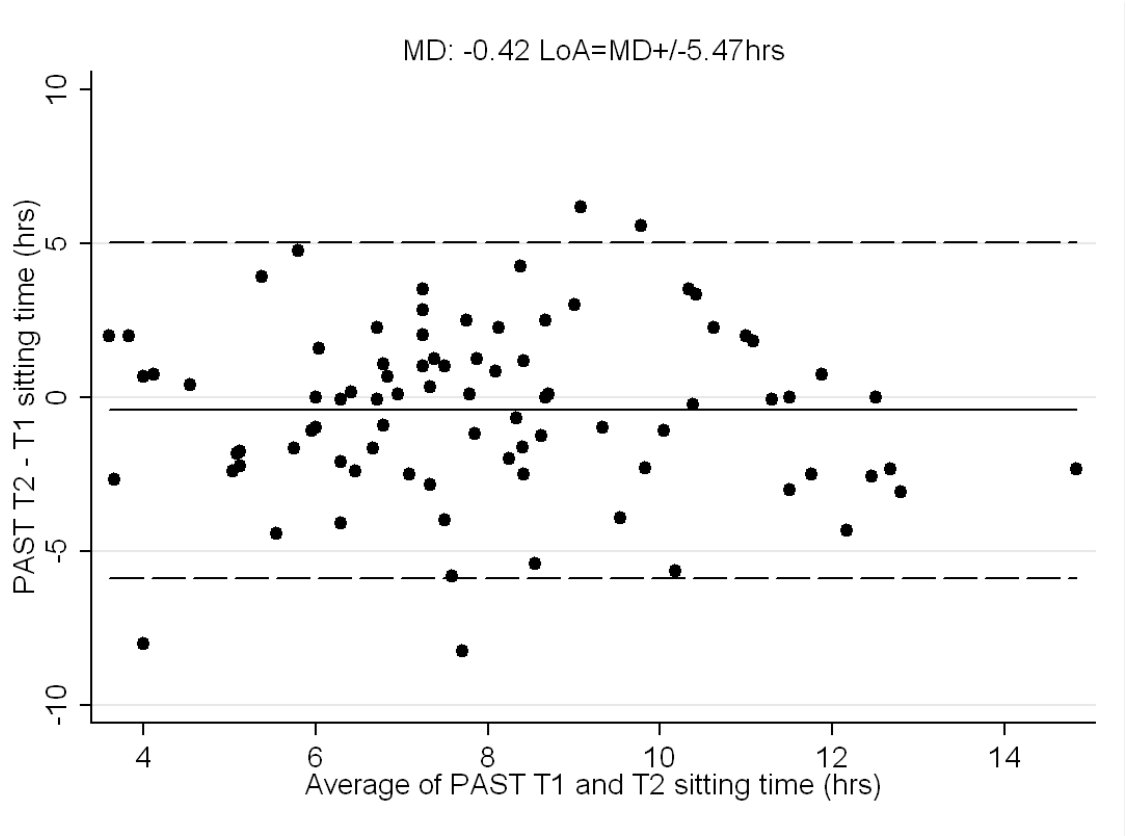


Figure 1: Bland-Altman Plot for Time 1 and 2 PAST sedentary time (n=86). The solid line represents the mean difference (MD, hours) between the two measures and the dashed lines are the 95% limits of agreement.

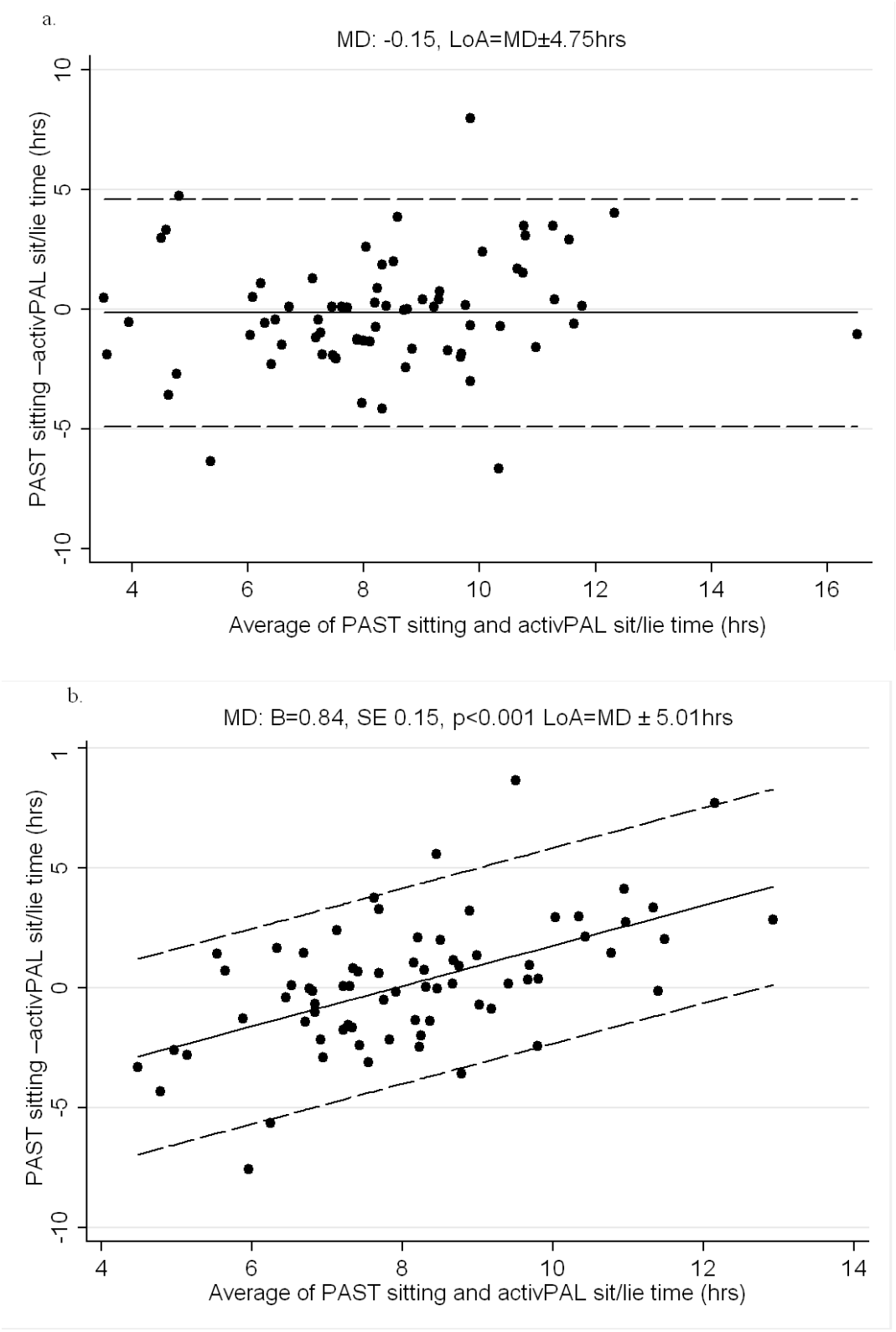


Figure 2: Bland-Altman Plot for PAST sedentary time and activPAL sit/lie time accumulated in bouts of at least five minutes (a) on recalled day and (b) over all monitored days at baseline

(n=72). The solid line represents the mean difference (MD, hours) between the two measures and the dashed lines are the 95% limits of agreement.

Supplemental Digital Content 1. txt

Supplemental Digital Content 2. txt

Table 1: Attributes of the study sample

	Baseline (n=90)	Validity Baseline (n=72)	Validity Follow-up (n=64)
Age (years), mean (SD)	56 (9)	56 (9)	56 (9)
BMI (kg/m^2), median (interquartile range)	29.7 (28.0, 34.0)	29.7 (28.0, 34.1)	29.4 (27.7, 33.3)
Education: Post high school education, n (%)	68 (76%)	54 (75%)	48 (75%)
Working, n (%)	62 (69%)	48 (67%)	44 (69%)
Married/living together, n (%)	69 (77%)	57 (79%)	52 (81%)
Meets physical activity guidelines, n (%)*	37 (44%)	31 (43%)	27 (42%)
Self-reported waking hours, day of recall (hrs), mean (SD)		15.4 (1.3)	15.3 (1.6)
Self-reported waking hours, average/monitored day (hrs), mean (SD)		15.2 (0.8)	15.4 (1.0)

*Data for meeting guidelines from GT3X+ accelerometer vertical axis ≥1952 counts per minute

Table 2: Time reported on the PAST questionnaire at T1 and T2; and one week test-retest reliability (n=86)

	T1 hrs/day	T2 hrs/day	Test retest correlation
Composite sedentary items	8.20 (2.81)	7.78 (2.77)	ICC=0.50 (0.32, 0.64)
Work	0.08 (0, 4.56)	0 (0, 4.31)	ρ=0.64 (0.49, 0.75)
Transport	1.00 (0.25, 1.49)	0.79 (0.31, 1.50)	ρ=0.44 (0.25, 0.60)
TV	2.00 (1.00, 3.00)	2.00 (1.00, 3.00)	ρ=0.38 (0.18, 0.55)
Computer	0.17 (0, 0.81)	0.17 (0, 1.00)	ρ=0.40 (0.21, 0.57)
Reading	0.25 (0, 0.50)	0 (0, 0.50)	ρ=0.37 (0.17, 0.54)
Hobbies	0 (0, 0)	0 (0, 0)	ρ=0.36 (0.16, 0.53)
Other sedentary	1.00 (0.50, 2.00)	1.00 (0.46, 2.00)	ρ=0.22 (0.01, 0.42)

Data for sedentary times are mean (SD) or median (25, 75%). ICC: Intraclass Correlation Coefficient, ρ: Spearman's correlation

Table 3: Correlations of the PAST questionnaire total sedentary time as a single (weekday) administration and a two-day (weekday and Sunday) administration with activPAL sit/lie time.

	activPAL sit/lie (hours/day)	Mean (SD) PAST (sedentary hours/day)		Pearson's correlation (95%CI)	
		Single (weekday)	Two-day	Single (weekday)	Two-day
Baseline (n=72)					
On day of recall					
5 mins+	8.4 (2.4)	8.2 (2.8)		0.57 (0.39, 0.71)	
total time	9.2 (2.4)			0.58 (0.40, 0.72)	
Average daily					
5 mins+	8.0 (1.5)			0.33 (0.10, 0.52)	
total time	8.8 (1.5)			0.34 (0.12, 0.43)	
Follow-up (n=64)					
On day of recall					
5 mins+	8.0 (2.3)	7.0 (2.7)		0.52 (0.32, 0.68)	
total time	8.8 (2.4)			0.52 (0.32, 0.68)	
Average daily					
5 mins+	8.2 (1.6)			0.34 (0.10, 0.54)	
total time	9.0 (1.1)			0.36 (0.11, 0.57)	
Follow-up (n=64)					
5 mins+	8.2 (1.6)		7.2 (2.1)		0.54 (0.34, 0.69)
total time	9.0 (1.1)				0.53 (0.32, 0.69)

5 mins+: sit/lie time accumulated in bouts of at least 5 mins

Table 4: Responsiveness to change in sedentary time (mins/day) of the PAST questionnaire and activPAL following the Living Well after Breast Cancer intervention

	Intervention (n=31)	Control (n=26)
Mean ± SD change from baseline		
PAST total sedentary (hours/day)	-77 ±209mins*	-32 ±174mins
activPAL sit/lie (hours / 16-hour day)		
recall day, 5+ minute bouts	-15 ±166mins	1 ±135mins
average, 5+ minute bouts	4 ±90mins	14 ±62mins
recall day, total time	-12 ±168mins	3 ±130mins
average, total time	8 ±87mins	14 ±63mins
Inter-instrument Pearson's correlations (change)		
recall day, 5+ minute bouts	0.71 (0.47, 0.85)†	0.24 (-0.17, 0.58)
average, 5+ minute bouts	0.25 (-0.12, 0.55)	-0.04 (-0.42, 0.35)
recall day, total time	0.71 (0.47, 0.85)†	0.24 (-0.17, 0.58)
average, total time	0.28 (-0.08, 0.58)	0.00 (-0.39, 0.39)
Responsiveness Index (95% CI)		
PAST	-0.44 (-0.92, -0.04)†	
activPAL sit/lie (hours / 16-hour day)		
recall day, 5+ minute bouts	-0.11 (-0.59, 0.37)	
average, 5+ minute bouts	0.06 (-0.50, 0.61)	
recall day, total time	-0.09 (-0.59, 0.41)	
average, total time	0.13 (-0.40, 0.67)	
Difference in responsiveness (95% CI) of PAST vs.…		
activPAL sit/lie (hours / 16-hour day)		
recall day, 5+ minute bouts	-0.34 (-0.71, 0.03)	
average, 5+ minute bouts	-0.52 (-1.14, 0.11)	
recall day, total time	-0.36 (-0.74, 0.01)	
average, total time	-0.59 (-1.20, 0.01)	

* t-test significant ($p<0.05$) difference between baseline and follow-up. †$p<0.05$

Supplemental Digital Content 1

Past-day Adults' Sedentary Time (PAST) Questionnaire

Section 2 Sedentary Time

Next I will ask you about particular activities you did yesterday while sitting down or lying down. Please note that this does not include sleeping, either in bed or if you fell asleep while doing another activity, for example watching television.

Interviewer: Record yesterday's date

Yesterday's date: _____

We are going to ask you about different times when you may be sitting or lying down: when working, travelling, watching TV, using the computer, and when doing other activities. For each of these, only count the time when this was your main activity. For example, if you watched TV and ate dinner at the same time, this might be TV or meal time, but not both. Your answers can be given in hours and minutes. Try to report only the time you spent sitting or lying down and not time you spent getting up for breaks (e.g. coffee, bathroom).

ST 1. The next question is about sitting for work. Did you work in a paid position yesterday?

	Yes
	No

Interviewer: if participant did not work yesterday, skip to ST 4. If they did work yesterday continue to ST 2.

Time spent for work

ST 2. How long **in total** did you spend at your workplace or working from home yesterday, including meal and snack breaks?

		hours			minutes

Sitting for work

ST 3. **How long** were you **sitting** at your workplace or working from home yesterday, including during meal and snack breaks?

		hours			minutes

Interviewer: if the respondent has difficulty, you can reassure them that their best estimate will be OK.

***Interviewer Check: the time for ST3 cannot be longer than ST2. If ST3 is exactly the same as ST2 (they say they sat for the whole time at work) prompt 'So, can I confirm that you sat for the whole time at work without getting up?'*

Sitting for Transport

ST 4. Thinking again of yesterday, please estimate the **total** time that you spent **sitting** to travel from one place to another. Please include sitting and waiting for transport. Do **not** include any time you were standing up while travelling or waiting.

		hours			minutes

Interviewer clarification: transport includes public and private, waiting for any type of transport and travel to all locations. This would not include time spent travelling as part of work which was reported in ST3 e.g. taxi driver

Television Viewing

ST 5. Please estimate the **total time** you spent sitting or lying down to watch TV or DVDs or play games on the TV, such as play station yesterday? This includes if you watch TV in bed.

Remember, your answer can be given in hours and/or minutes.

		hours			minutes

Computer, Internet, Electronic Games

ST 6. Please estimate the total time yesterday that you spent sitting or lying down and using the computer. For example, include time spent playing games, internet activities.

		hours			minutes

Interviewer: if the respondent reported working include the prompt 'Do not include time spent doing paid work on the computer as this should have been included in the previous question about sitting for work.'

Reading

ST 7. Please estimate the total time yesterday that you spent sitting or lying down while reading during your leisure time. Include reading in bed but do not include time spent reading for paid work.

		hours			minutes

Hobbies

ST 8. Please estimate the total time yesterday that you spent sitting or lying down for hobbies. For example, doing art, craft or cross words.

		hours			minutes

Sitting/lying for other purposes

ST 9. We are interested in any other sitting or lying down that you may have done that you have not already told us. For example this could include socializing with friends or family including time on the telephone; eating meals; or listening to music.

Again thinking of yesterday, please estimate the **total time** that you spent sitting or lying down **NOT** including time that you have told us about in the previous answers.

		hours			minutes

Interviewer: if the respondent has difficulty, you can reassure them that their best estimate will be OK.

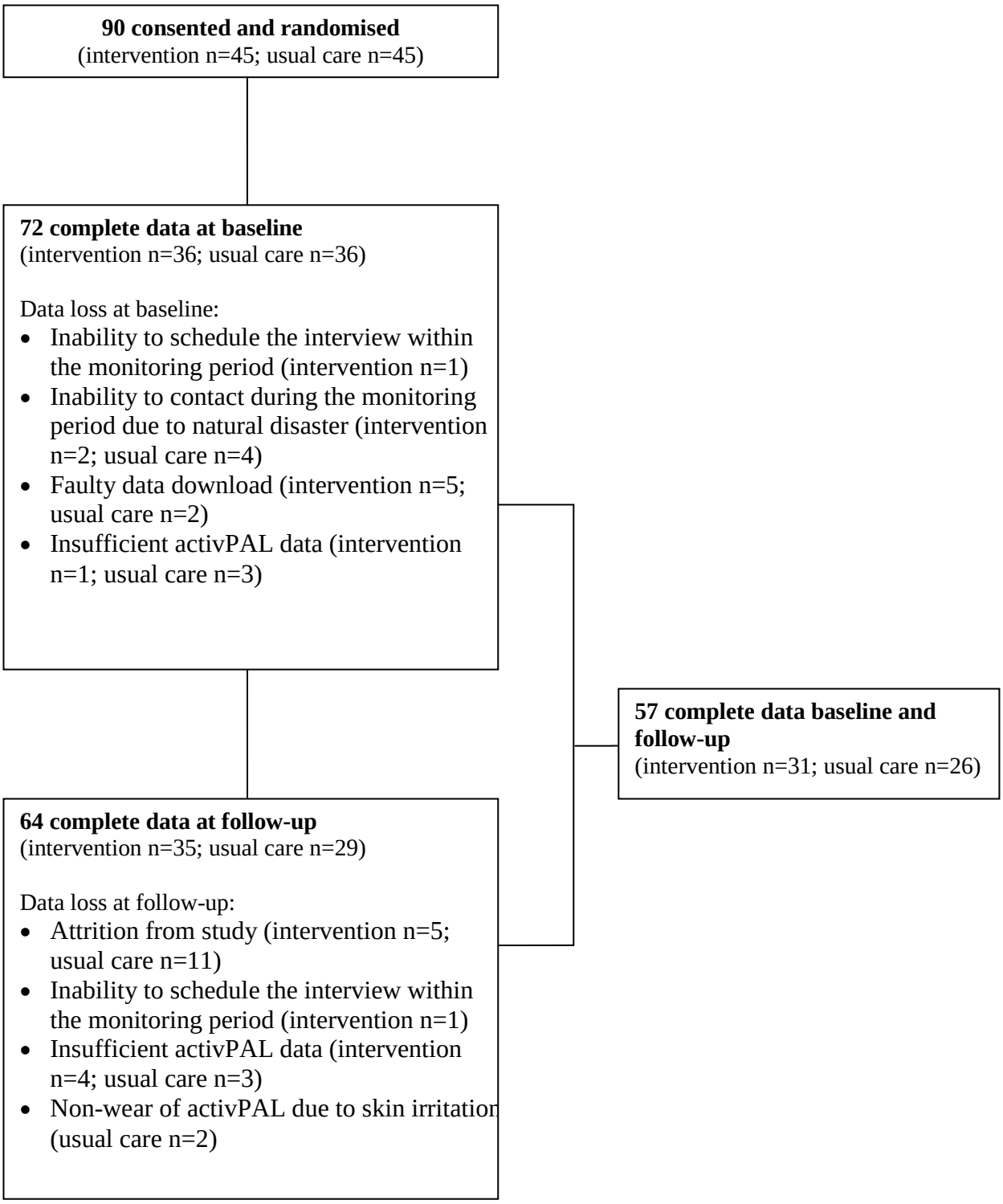
That's all the questions we have for you about the time you spent sitting or lying down yesterday. Thinking back on your answers, is there anything you would like to change?

Interviewer: This will give the participant an opportunity to confirm that they have given an accurate response to each question. Please change responses as required.

If the participant has reported sitting for over 16 hours in the day prompt them to consider their answers by saying 'I've got here that you spent ….. sitting yesterday. Are there any times where you might have over-estimated or doubled up on reporting sitting time?'

Supplemental Digital Content 2:

Participant flow chart for the PAST measurement study in the *Living Well after Breast Cancer* feasibility trial



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