Wireless physical activity monitor use among adults living with HIV in a community-based exercise intervention study: a quantitative, longitudinal, observational study

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ABSTRACT

Objectives Our aim was to examine wireless physical activity monitor (WPAM) use and its associations with contextual factors (age, highest education level, social support and mental health) among adults living with HIV engaged in a community-based exercise (CBE) intervention.

Design Quantitative, longitudinal, observational study.

Setting Toronto YMCA, Ontario, Canada.

Participants Eighty adults living with HIV who initiated the CBE intervention.

Intervention Participants received a WPAM to track physical activity during a 25-week CBE intervention involving thrice-weekly exercise, supervised weekly (phase 1) and a 32-week follow-up involving thrice-weekly exercise with no supervision (phase 2), completed in December 2018.

Outcome measures Uptake was measured as participants who consented to WPAM use at initiation of the intervention. Usage was defined as the proportion of days each participant had greater than 0 steps out of the total number of days in the study. We measured contextual factors using a baseline demographic questionnaire (age, highest education level), and median scores from the bimonthly administered Medical Outcomes Study-Social Support and Patient Health Questionnaire (mental health), where higher scores indicated greater social support and mental health concerns, respectively. We calculated Spearman correlations between WPAM usage and contextual factors.

Results Seventy-six of 80 participants (95%) consented to WPAM use. In phase 1, 66% of participants (n=76) and in phase 2, 61% of participants (n=64) used the WPAM at least 1 day. In phase 1, median WPAM usage was 50% (25th, 75th percentile: 0%, 87%; n=76) of days enrolled and in phase 2, 23% (0%, 76%; n=64) of days. Correlation coefficients with WPAM usage ranged from weak for age (ρ=0.26) and mental health scores (ρ=-0.25) to no correlation (highest education level, social support).

Conclusions Most adults living with HIV consented to WPAM use, however, usage declined over time from phase 1 to phase 2. Future implementation of WPAMs should consider factors to promote sustained usage by adults living with HIV.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The longitudinal study design enabled us to examine wireless physical activity monitor (WPAM) use among adults living with HIV over time engaged in a supervised community-based exercise intervention, followed by independent exercise.

⇒ Using objective measures of physical activity (WPAM) and self-reported (questionnaire) measures of physical activity enabled us to investigate associations of different measurement approaches of physical activity levels among adults living with HIV.

⇒ Findings in this study may inform WPAM users, clinicians and researchers on considerations for implementing WPAMs with adults living with HIV over time.

⇒ Limitations included variable and incomplete participant data across multiple data sources, such as WPAM synchronisation, self-reported step count and completion of weekly exercise questionnaires.

INTRODUCTION

As the life expectancy of people living with HIV increases, individuals may experience more physical, mental and social health-related challenges attributed to HIV, multimorbidity and ageing.1,2 These health-related challenges, known as disability, were described by adults living with HIV as episodic and multidimensional, including physical, cognitive, emotional and social health domains.3 Physical activity is an effective self-management strategy that can decrease risk of multimorbidity, and improve functional capacity, psychological well-being, and quality of life among adults living with HIV.4–6


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Despite these benefits, variability exists in physical activity levels among this population. This is consistent with the episodic nature of disability in the context of HIV and highlights the complexity of generalising overall physical activity levels across this population. Variability in physical activity levels among adults living with HIV may be due to barriers including HIV-associated stigma, stress, fatigue, low social support, and physical and mental health.7–10 Community-based exercise (CBE) programmes are one rehabilitation strategy to promote physical activity among adults living with HIV. CBE programmes are aimed to promote participation in regular exercise in the community to improve health outcomes—they consist of structured exercise supervised by an instructor for individuals with similar characteristics (eg, age and chronic conditions).11–13 Adults living with HIV who participated in a supervised 6-month CBE programme involving aerobic, strength, balance and flexibility training demonstrated improvements in cardiorespiratory fitness, strength and flexibility.14 However, adults living with HIV have a greater drop-out rate from physical activity interventions than other populations with chronic conditions.15 Due to barriers to exercise faced by adults living with HIV, technological devices could be incorporated into exercise interventions as an additional tool to measure and encourage consistent physical activity among this population.

Wireless physical activity monitors (WPAMs) are increasingly popular to promote and track physical activity.16–17 WPAMs including commercially available pedometers and accelerometers (eg, Fitbit, Garmin, Apple Watch) can objectively measure and encourage physical activity in general and chronic illness populations.16–18 WPAMs can track physical activity through measures of steps, distance, sedentary time and energy expenditure.20 Furthermore, WPAMs can facilitate self-monitoring and goal setting, which can motivate and reinforce positive behaviour change for physical activity participation.18–21 However, the use of WPAMs may be limited by factors such as technological design or inability to capture some features of physical activity (eg, type of exercise and perceived exertion).22

The utility of WPAMs depends on the extent of their uptake and usage over time. Research on long-term use of WPAMs suggested that usage among adults in the general population declined over time.23 Personal, psychosocial, environmental and technology-related factors have been shown to influence WPAM uptake and usage in older adults.24 Additionally, studies in the general population demonstrated that older age, and higher self-perceived health, education, and sense of community were positively correlated to adherence to WPAM use.25–26

WPAMs have been used to describe physical activity (eg, intensity, heart rate, energy expenditure, distance walked) and pedometers to measure steps taken and distance walked in adults living with HIV.9,10 However, less is known regarding the extent of WPAM use and their potential to promote physical activity in this population.10 Additionally, adults living with HIV have a higher prevalence of lower levels of education27 and social support,10 and higher risk of mental health conditions28 than the general population. Hence, the way in which these contextual factors may influence WPAM uptake and usage over time in adults living with HIV is unknown.

Our aim was to examine WPAM use among adults living with HIV engaged in a CBE intervention. Primary objectives were to (1) examine the extent of WPAM use among adults living with HIV engaged in a CBE study and to (2) examine the associations between WPAM usage and contextual factors including age, highest level of education, social support and mental health among adults living with HIV. Secondary objectives were to (3) describe physical activity levels as measured by a WPAM and a self-reported physical activity questionnaire and (4) explore the associations between self-reported (questionnaire) and objective measures (WPAM) of physical activity among adults living with HIV.

We hypothesised that older age, higher level of education, higher social support and better self-perceived mental health would each demonstrate a positive moderate association (0.4 ≤ ρ ≤ 0.59)29 with greater WPAM usage among adults living with HIV during a 25-week CBE intervention (objective 2). We hypothesised that self-reported physical activity would demonstrate a positive moderate association (0.4 ≤ ρ ≤ 0.59)29 with greater WPAM-measured median daily step count, among adults living with HIV engaged in a 25-week CBE intervention (objective 4).

**METHODS**

We conducted a quantitative, longitudinal, observational study using data from a CBE intervention study with adults living with HIV in Toronto, Canada. The CBE study included three phases: a 32-week baseline monitoring phase (phase 0), a 25-week CBE intervention (phase 1) and a 32-week follow-up monitoring period (phase 2).14,30 The time frame for the data collection of the CBE study occurred between August 2016 and December 2018. Details of the full mixed-methods CBE study protocol have been previously published.30 Primary outcomes of the CBE study including the impact of the CBE intervention on cardiorespiratory fitness, cardiovascular health, strength, flexibility and physical activity along with the qualitative inquiry of experiences of adults living with HIV and fitness coaches with the CBE intervention have been published.14,31,32

The focus of our study was on phases 1 and 2 of the larger CBE study (figure 1).

**Participants**

Participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included participants in the CBE study30 were recruited from the YMCA, community-based organisations and a specialty hospital. Participants included adults living with HIV (≥18 years) who considered themselves medically stable and safe to exercise on completion of the Physical Activity Readiness Questionnaire.33 This study included...
participants who enrolled in the CBE study and initiated phase 1. **Figure 1** outlines a timeline of the study components.

**Patient and public involvement**

We consulted with two participants living with HIV, after their involvement in the data collection stage of the CBE study, when developing the protocol for this substudy. These discussions helped shape our understanding of how participants interacted with the WPAM during the CBE study, informed our operationalisation of study variables on WPAM use and guided our investigation into contextual factors, which may impact WPAM use, in relation to the lived experiences of adults living with HIV.

**CBE intervention**

In phase 1 (25-week CBE intervention), participants were provided with a YMCA membership and expected to participate in 90min multimodal exercise sessions consisting of aerobic, strength, balance and flexibility thrice weekly, supervised weekly by a fitness instructor. In phase 2 (32-week follow-up monitoring), participants received an 8-month extension to their YMCA membership and encouraged to continue independent exercise thrice weekly. Further details on the intervention were published elsewhere.30 34

**WPAMs:** Participants were offered a Fitbit Zip at phase 1 initiation. The Fitbit Zip is a WPAM that objectively measures daily step count (number of steps/day), distance walked (km) and calories burned (calories),35 and a valid measure of step count in adults living with HIV.36 The Fitbit Zip has a battery capacity, which allows up to 6 months between charges, and is capable of storing up to 23 days of data.37 Participants who consented to WPAM use were asked to wear it on their waist all day, except when sleeping, showering, bathing and swimming. An online Fitbit account was created for each participant and instructions related to Fitbit setup, use and synchronisation were provided. Synchronisation required
connecting the Fitbit Zip to a computer or mobile device with an internet connection using Bluetooth and logging into a connected Fitbit account. Participants were encouraged to synchronise their WPAMs weekly to prevent data loss. Technical support was provided regarding synchronisation as needed. Fitbit Zips lost during the study were not replaced. At the end of the study, participants were able to keep their Fitbit Zip. Participants who possessed their own WPAM had the option to wear their own device. The type of WPAM used was recorded and daily data from Fitbit Zips and personal WPAMs were downloaded by the research team depending on availability to the online account.

Data sources and measurements
The primary data source for the study was the WPAM, used to measure daily step count. Participants were asked to synchronise their WPAM weekly. Participants were asked to complete an online weekly exercise questionnaire throughout both phases of the study, to capture the type of WPAM used, total weekly step count and total weekly distance walked (km). Additional data from self-reported questionnaires included demographic and HIV characteristics (administered at baseline), and the Medical Outcomes Study-Social Support Scale (MOS-SSS; social support), the eight-item Patient Health Questionnaire (PHQ-8; mental health), and the Rapid Assessment of Physical Activity aerobic component (RAPA-1; aerobic physical activity) (administered bimonthly) (figure 1).

Uptake and usage of WPAMs
WPAM uptake was defined as the number and proportion of participants (out of the total number of participants in the study) who consented to WPAM use and sharing of data at phase 1 initiation. WPAM usage was defined as the proportion of days each participant wore the WPAM and synchronised the device (days with ≥0 steps measured) out of the total number of days enrolled in the study during phase 1 (25 weeks), phase 2 (32 weeks) and both phases combined (57 weeks). Reasons related to WPAM non-usage were recorded by the research team during both phases to a spreadsheet.

Contextual factors and WPAM use
We examined associations between WPAM usage and age, highest level of education, social support and mental health during phase 1. We analysed the associations during phase 1 to maximise sample size. Participants’ age and highest level of education were reported in the baseline demographics questionnaire at CBE study initiation. Social support, defined as connectedness to one or multiple people who offer physical, emotional and relational support, was measured by participants’ median MOS-SSS scores (range 19–95), with higher scores indicating greater perceived social support. Mental health, defined as a person’s emotional, psychological and social well-being, was measured by participants’ median PHQ-8 scores (range 0–24), with higher scores indicating higher levels of mental distress. The MOS-SSS and the PHQ-8 have been previously used with adults living with HIV. The MOS-SSS and PHQ-8 were administered bimonthly during phase 1 (figure 1).

Physical activity
We measured aerobic physical activity objectively as participants’ median daily step count recorded by the WPAM (when >0 steps) in phase 1 and by self-report as participants’ median RAPA-1 score during phase 1. RAPA-1 scores range from 1 to 5, with higher scores indicating greater levels of activity. The RAPA-1 has demonstrated construct validity and responsiveness in adults living with HIV. In addition, participants reported the weekly step count (number of steps/week) and distance walked (km) recorded by their WPAM on the weekly online exercise questionnaire throughout phase 1.

Participant characteristics
We measured participant characteristics including age, gender, living situation, source of income and employment status using the baseline demographics questionnaire (phase 0 initiation). We measured the number of concurrent health conditions, general health status and exercise history from the demographic questionnaire completed at phase 1 initiation (figure 1).

Analysis
We calculated the median (25th, 75th percentile) for continuous variables (eg, age, number of concurrent health conditions), and frequencies and percentages for categorical variables (eg, gender, living situation, source of income, employment status, highest level of education, general health status, exercise history). We assessed the distribution of continuous and categorical study variables using the Shapiro-Wilk test, where α=0.05. For our correlation analyses, we interpreted correlation coefficients as very weak (ρ≤0.19), weak (0.2≤ρ≤0.59), moderate (0.4≤ρ≤0.59), strong (0.6≤ρ≤0.79) or very strong (ρ≥0.8) with significance of α=0.05.

WPAM uptake and usage
We calculated the number of participants who consented to WPAM use, out of the total number of participants enrolled in phase 1 (uptake). We calculated the number of days each participant wore the WPAM and synchronised their data out of the total number of days enrolled in the study, in phase 1, phase 2 and both phases combined (usage). Usage was expressed as the median (25th, 75th percentile) of days across all participants in the study. We also calculated the number of participants who had at least 1 day of WPAM use (defined as >0 steps) on a week-by-week basis throughout the study. We reported the primary reasons for no WPAM usage in each phase.

Associations between contextual factors and WPAM usage
We assessed the associations between WPAM usage during phase 1 and (A) age, (B) highest level of education, (C) median MOS-SSS score and (D) median PHQ-8 score for...
(1) all participants and then (2) for all participants with non-zero WPAM usage. We calculated Spearman coefficients (ρ) and 95% CIs for each of the four variables for non-normally distributed data.

**Physical activity**
We calculated the median daily step count, measured by the WPAM, for each participant in phase 1 and then calculated the median (25th, 75th percentile) of participants’ median daily step count in phase 1 for all participants with non-zero WPAM usage. To account for the potential influence of the WPAMs recording few steps that may reflect movement other than steps on days of low usage, we performed a sensitivity analysis to determine the median daily step count in phase 1 after removing days with greater than 0 but less than 100 steps. We calculated the median RAPA-1 score for each participant in phase 1 and then calculated the median (25th, 75th percentile) of participants’ median RAPA-1 scores for all participants who completed at least one RAPA-1 questionnaire during phase 1.

**Associations between objective and self-reported measures of physical activity**
We examined the association between each participant’s median daily step count, as measured by the WPAM, and median RAPA-1 scores in phase 1. We calculated Spearman coefficients (ρ) and 95% CIs for non-normally distributed data.

We accounted for missing data or participants who were lost to follow-up by performing calculations with all data that were available, resulting in a smaller sample size for some calculations, which were reported when applicable. We used Microsoft Excel and SPSS (Version 28.0.1.1 (14)) 43 to facilitate the statistical analysis.

**Sample size**
Eighty adults living with HIV initiated phase 1, of which 76 (95%) consented to WPAM use. Thus, our maximum sample size to assess the associations of WPAM usage with contextual factors was 76 participants. Using a significance of α=0.05 and β=0.1, our sample size allowed us to detect a moderate correlation of ρ=0.4 or greater.45

**RESULTS**
Eighty participants initiated phase 1, of which, 67 (84%) completed phase 1, and 52 (65%) completed phase 2 of the study.

**WPAM uptake**
Of the 80 participants who initiated phase 1, 76 (95%) consented to WPAM use to monitor their physical activity (uptake). Of the 76 participants who consented to WPAM use, 64 (84%) remained enrolled in the study at the end of phase 1, and 50 of the 64 participants (78%) who started phase 2, completed the study. Figure 2 describes the retention of participants, and WPAM usage and uptake during the study.

**Participant characteristics**
Of the 76 participants who consented to WPAM use at phase 1 initiation, the median age was 31 years (25th, 75th percentile: 44, 59). The majority of the participants identified as a man (89%), white (68%) and lived alone (63%). Twenty-seven (36%) of participants were employed, while 36 (48%) reported their primary source of income was from financial assistance programmes. The majority of participants (n=51; 53%) completed some form of post-secondary education or training. The median year of HIV diagnosis of the sample was 1999 (25th, 75th percentile: 1989, 2008). Sixty-two participants (82%) reported living with two or more concurrent health conditions in addition to HIV, of which joint pain (46%) was the most common, followed by mental health concerns (39%) and muscle pain (39%). Thirty-six (47%) participants reported exercising 3–5 days per week prior to initiating phase 1 of the CBE study. Participant characteristics for the 50 participants who had non-zero WPAM usage were similar to the characteristics of the entire sample described above (table 1).

**WPAM devices used**
Of the 76 participants who consented to WPAM use at phase 1 initiation, 36 (47%) provided a description of their WPAM device in at least 1-weekly exercise questionnaire. Twenty-five (69%) of the 36 participants reported using the Fitbit Zip exclusively during phase 1 and phase 2, while 6 (8%) participants reported using a combination of the Fitbit Zip and another WPAM (generic step counter, unspecified Fitbit device, wristband pedometer, Samsung Gear, iPhone, Fitbit Charge 2). Five (14%) of the 36 participants reported they used a personal WPAM during both phases, which included an Apple Watch (n=1), Fitbit Flex 2 (n=2), Fitbit Ionic (n=1) and an unspecified Fitbit device (n=1).

**WPAM usage**
Of the 76 participants who consented to WPAM use, 50 (66%) used their device at some point during phase 1. Of the 64 participants remaining in phase 2, 39 (61%) used their WPAM at some point during phase 2. Three participants who never used the WPAM in phase 1 began using it in phase 2. The median WPAM usage during phase 1 was 50% (25th, 75th percentile: 0%, 87%; n=76) of days out of the total number of days enrolled in phase 1, and 23% (0%, 76%; n=64) of days during phase 2 (figure 3). Median usage over the two phases combined was 31% (0%, 73%; n=76) of days out of the total number of days enrolled in phases 1 and 2. When the participants with no WPAM usage were removed from analysis, the proportion of WPAM usage was 79% (51%, 93%, n=50) during phase 1, 64% (31%, 87%, n=39) during phase 2 and 54% (23%, 84%, n=53) when both phases were combined together. Participants’ WPAM use declined over time (figure 4).
Reasons for WPAM non-usage
Twenty-six participants (34%) did not use the WPAM during phase 1, and 25 participants (39%) did not use the WPAM in phase 2. The most common reason reported for WPAM non-use in phase 1 was account or login issues (42%) and previous discontinuation of WPAM use during the intervention (36%) in phase 2 (figure 5).

Associations of contextual factors and WPAM usage
Among participants who consented to WPAM use, age demonstrated a weak positive correlation with WPAM usage ($\rho=0.26; p=0.02; 95\% \text{ CI}: 0.03 \text{ to } 0.46; n=76$). Self-reported mental health (median PHQ-8 scores) demonstrated a weak, negative correlation with WPAM usage ($\rho=-0.25; p=0.04; 95\% \text{ CI}: -0.47 \text{ to } -0.01$) meaning higher levels of mental health concerns were associated with less WPAM usage. WPAM usage was not associated with highest level of education ($\rho=0.06; p=0.63; 95\% \text{ CI}: -0.18 \text{ to } 0.29$) or social support (median MOS-SSS scores) ($\rho=-0.17; p=0.16; 95\% \text{ CI}: -0.40 \text{ to } 0.07$) (figure 6). When participants with no WPAM usage were removed from analysis, the results were similar (online supplemental file 1).

Physical activity
During phase 1, 50 of the 76 participants (65%) had greater than 0% WPAM usage, of which the median of participants’ median daily step count was 9540 steps (25th, 75th percentile: 6121, 10 990). When we removed days with greater than 0 and less than 100 steps recorded for each participant during phase 1 (130 days removed with greater than 0 and less than 100 steps from 31 out of 34 participants).

Figure 2 Participant flow chart. Flow chart of wireless physical activity monitor (WPAM) uptake (n=76), usage and retention of participants in phase 1 (intervention phase) and phase 2 (follow-up phase) of the community-based exercise (CBE) study.
<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Participants who consented to WPAM use at the start of the intervention (n=76)</th>
<th>Participants who used a WPAM during the intervention (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at study initiation (years)</td>
<td>Median (25th, 75th percentile)</td>
<td>Median (25th, 75th percentile)</td>
</tr>
<tr>
<td></td>
<td>51 (44, 59)</td>
<td>53 (45, 60)</td>
</tr>
<tr>
<td>Number of participants ≥50 years of age</td>
<td>44 (58)</td>
<td>32 (64)</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
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<tr>
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<td>6 (8)</td>
<td>5 (10)</td>
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<tr>
<td>Man</td>
<td>68 (89)</td>
<td>44 (88)</td>
</tr>
<tr>
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<td>2 (2)</td>
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<tr>
<td>Race and/or ethnicity</td>
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<td>34 (68)</td>
</tr>
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<td>Asian</td>
<td>14 (18)</td>
<td>8 (16)</td>
</tr>
<tr>
<td>Indigenous</td>
<td>3 (4)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Black or African</td>
<td>5 (7)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Hispanic</td>
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<td>3 (6)</td>
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<tr>
<td>Other (Arab, Jewish, Mediterranean, Indo-Caribbean)</td>
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<td>3 (6)</td>
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<tr>
<td>Living alone</td>
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<td>37 (74)</td>
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<tr>
<td>Primary source of income at study initiation</td>
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<tr>
<td>Employer</td>
<td>22 (29)</td>
<td>14 (28)</td>
</tr>
<tr>
<td>Pension</td>
<td>17 (23)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Financial Assistance (Ontario Disability Support Programme, Employment Insurance and Ontario Works)</td>
<td>36 (48)</td>
<td>26 (52)</td>
</tr>
<tr>
<td>Employment status at study initiation</td>
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<tr>
<td>Employed</td>
<td>27 (36)</td>
<td>16 (32)</td>
</tr>
<tr>
<td>Retired</td>
<td>7 (9)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Unemployed</td>
<td>42 (55)</td>
<td>29 (58)</td>
</tr>
<tr>
<td>Highest level of education completed at study initiation</td>
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<td></td>
</tr>
<tr>
<td>Less than high school diploma</td>
<td>9 (12)</td>
<td>6 (12)</td>
</tr>
<tr>
<td>Completed high school</td>
<td>2 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Some trade/technical training, college or university</td>
<td>14 (18)</td>
<td>12 (24)</td>
</tr>
<tr>
<td>Trade/technical training, college or university completed</td>
<td>35 (46)</td>
<td>20 (40)</td>
</tr>
<tr>
<td>Completed postgraduate degree</td>
<td>16 (21)</td>
<td>12 (24)</td>
</tr>
<tr>
<td>Self-reported general health status at CBE initiation</td>
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<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>4 (5)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Very good</td>
<td>23 (30)</td>
<td>18 (36)</td>
</tr>
<tr>
<td>Good</td>
<td>32 (42)</td>
<td>21 (42)</td>
</tr>
<tr>
<td>Fair</td>
<td>16 (21)</td>
<td>9 (18)</td>
</tr>
<tr>
<td>Poor</td>
<td>1 (1)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Smoking history at CBE initiation</td>
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<tr>
<td>Current smoker (in past 30 days)</td>
<td>12 (16)</td>
<td>7 (14)</td>
</tr>
<tr>
<td>Former smoker</td>
<td>34 (45)</td>
<td>24 (48)</td>
</tr>
<tr>
<td>Never smoked</td>
<td>27 (36)</td>
<td>17 (34)</td>
</tr>
<tr>
<td>Don’t know or prefer not to answer</td>
<td>3 (4)</td>
<td>2 (4)</td>
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<tr>
<td>Patient-reported outcome measures during CBE intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Outcome Survey-Social Support Scale (MOS-SSS) score (range 19–95) (n=69, 49)</td>
<td>58 (36, 76)</td>
<td>56 (29, 72)</td>
</tr>
<tr>
<td>Patient Health Questionnaire (PHQ-8) score (range 0–24) (n=69, 49)</td>
<td>6 (3, 10)</td>
<td>5 (2, 9)</td>
</tr>
</tbody>
</table>

Continued
of 50 participants who recorded non-zero usage), the median of the participants’ median daily step count was 9564 steps (25th, 75th percentile: 6314, 11 035) in phase 1 (online supplemental file 2). During phase 1, 69 participants completed at least one RAPA-1 questionnaire, of which the median of participants’ median RAPA-1 value was 5 (25th, 75th percentile: 4, 5) out of 5 indicating an ‘active’ physical activity status, exercising at moderate to vigorous intensity. Of the 76 participants consenting to WPAM use, 15 participants self-reported their weekly step count and 16 self-reported their weekly distance walked during phase 1 in a weekly exercise questionnaire. The median of participants’ median weekly step count was 57 729 steps (25th, 75th percentile: 1655, 70 684) and the median of participants’ median weekly distance walked was 39 km (25th, 75th percentile: 4, 49).

### Associations of self-report and objective measures of physical activity

Participants’ median daily step count and RAPA-1 scores were non-normally distributed. Hence, we calculated a Spearman correlation to assess the association between participants’ objective measure of physical activity (median daily step count as measured by the WPAM) with participants’ self-reported physical activity (median RAPA-1 scores). Forty-nine participants during phase 1 had step counts recorded by their WPAM and completed the RAPA-1 at least once. Median daily step count as measured by the WPAM was not associated with RAPA-1 scores ($\rho=0.14; p=0.33; n=49; 95\% CI: -0.15$ to $0.41$).

### DISCUSSION

Although WPAMs have been used in previous literature to quantify physical activity in adults living with HIV, to our knowledge, this is the first study to examine the extent of WPAM uptake and usage in this population. We found WPAM uptake was high where the majority of participants (95%, n=76) consented to WPAM use. This is consistent with a previous study by Hassani et al.\(^4\) that investigated consent to WPAM use for a 9-day period in older adults.\(^4\) Participants were provided with a WPAM as part of the intervention and researchers found the rate of consent was 92%. Participants were provided with a WPAM as part of the intervention and researchers found the rate of consent was 92%. As uptake in our study and the study by Hassani et al.\(^4\) was measured in the context of a research study where participants were provided with a WPAM, this may have facilitated participants’ willingness to use. Therefore, it is important to consider how to promote their use in a real-world setting. When different WPAMs were compared among older adults, aesthetics, price and comfort were factors that positively impacted the acceptability of devices.\(^4\) Due to HIV-related stigma that can be experienced with HIV disclosure, privacy concerns may

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### Table 1

<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Participants who consented to WPAM use at the start of the intervention (n=76)</th>
<th>Participants who used a WPAM during the intervention (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV characteristics</td>
<td>Median (25th, 75th percentile)</td>
<td>Median (25th, 75th percentile)</td>
</tr>
<tr>
<td>Median total # of concurrent health conditions in addition to HIV</td>
<td>5 (2.7)</td>
<td>4 (2.7)</td>
</tr>
<tr>
<td>Viral load undetectable (&lt;50 copies/mL) at CBE initiation (n=75, 49)</td>
<td>73 (97)</td>
<td>48 (98)</td>
</tr>
<tr>
<td>Receiving HIV care at CBE initiation</td>
<td>75 (99)</td>
<td>49 (98)</td>
</tr>
<tr>
<td>Most commonly self-reported concurrent health conditions at CBE initiation (&gt;30%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint pain (arthritis)</td>
<td>35 (46)</td>
<td>24 (48)</td>
</tr>
<tr>
<td>Mental health (eg, depression, anxiety)</td>
<td>30 (39)</td>
<td>20 (40)</td>
</tr>
<tr>
<td>Muscle pain</td>
<td>30 (39)</td>
<td>19 (38)</td>
</tr>
<tr>
<td>Bone and joint disorder</td>
<td>24 (32)</td>
<td>16 (32)</td>
</tr>
<tr>
<td>Living with ≥2 concurrent health conditions</td>
<td>62 (82)</td>
<td>42 (84)</td>
</tr>
<tr>
<td>Exercise characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days exercising per week at CBE Initiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 days</td>
<td>13 (17)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>1–2 days</td>
<td>18 (24)</td>
<td>11 (22)</td>
</tr>
<tr>
<td>3–5 days</td>
<td>36 (47)</td>
<td>26 (52)</td>
</tr>
<tr>
<td>6–7 days</td>
<td>9 (12)</td>
<td>8 (16)</td>
</tr>
<tr>
<td>Self-reported physical activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapid assessment of physical activity aerobic component score (RAPA-1) (range 1–5) (n=69, 49)</td>
<td>5 (4, 5)</td>
<td>5 (5, 5)</td>
</tr>
</tbody>
</table>

n=76 consented at start of intervention, and n=50 usage during the intervention for all characteristics, unless otherwise stated.
be a prevalent barrier to WPAM uptake among adults living with HIV as devices are often synced to a website or mobile app. In a survey that investigated the use of health apps and smart devices (including WPAMs) in adults living with HIV, only 22% of participants owned a smart device.48 The main concern surrounding the use of technology was privacy of personal information.48 Thus, further research on factors that facilitate or hinder WPAM uptake among adults living with HIV is necessary to understand how they can be encouraged among this population.

WPAM usage in this study was variable across the population despite high uptake (figure 3). Median usage decreased from 50% in phase 1 to 23% in phase 2. Our findings are consistent with Hermsen et al who found WPAM usage in the general population declined over a period of 320 days with approximately 50% of participants still using the WPAM after 6 months.23 Decline in usage over time may be attributed to decreased novelty of the WPAM, which was associated with a decrease in interest or competing life demands.48 External reminders and feedback related to goal setting via text messaging may be a strategy to combat the decline in usage as seen in a study that investigated the experiences of WPAM usage in older adults.21 Additionally, factors associated with long-term WPAM use beyond the novelty stage includes existing personal motivators (eg, goals to be physically active to improve health) and social support.49 Despite the potential novelty of WPAMs wearing off, a subset of our participants used the WPAM frequently throughout the study (figure 3C). This demonstrates that sustained WPAM use is possible in adults living with HIV. However, solely providing participants with WPAMs may not be sufficient to support sustained use and may be supplemented with additional strategies over time.

Although technical support was provided to participants in our study, the most prevalent reason for WPAM non-usage were account or login issues (figure 5). WPAM usage was likely underestimated in our study as participants may have used their WPAMs without synchronising it. These results highlight the potential difficulties around technology literacy and comfort in using mobile apps or computers to synchronise WPAMs, particularly in older adults.22 This may deter their use outside of a research context, as individuals may need to seek technical support from providers independently, or from community and social support networks.50 Thus, the availability of reliable technical support and device education may help to maintain sustained WPAM use among adults living with HIV.

Figure 3  Histograms of wireless physical activity monitor usage. Histograms of the proportion of days of wireless physical activity monitor (WPAM) usage out of the total number of days all participants (with or without WPAM usage) were enrolled during (A) phase 1 (intervention phase, n=76), (B) phase 2 (follow-up phase, n=64) and (C) phases 1 and 2 combined (n=76).
Our results found weak to no associations between WPAM usage and age, highest level of education, mental health and social support scores. While the coefficients for age and mental health were statistically significant, the CIs of the estimates approached zero, indicating a weak association. In the general population, older age, better self-perceived health and higher levels of education have been positively correlated with increased accelerometer use. In contrast, economically disadvantaged persons with lower physical and mental health and sense of community were correlated with less WPAM use. These studies, however, investigated the effects of these contextual factors in conjunction as a predictor of WPAM use, whereas our study investigated the factors independently. Experiences of adults living with HIV and the resulting disability are multidimensional including physical, social and emotional domains. Personal and environmental contextual factors such as social support, stigma and personal attributes (eg, age, comorbid illness), all interact to influence disability among this population. These intersections may influence one another to impact WPAM usage. Li et al suggested personal, psychosocial, environmental and technology-related factors collectively contributed to the long-term use of WPAMs in older adults. Intrinsic motivation was reported as the most prevalent factor for use, however, external support from friends and family and feedback on goals from the device also supported their usage. Thus, researchers and clinicians should consider the collective experiences of adults living with HIV, the various factors which may influence WPAM use, and how these factors may interact with each other when choosing and implementing WPAMs.

This study focused on a small subset of contextual factors, which may influence usage in adults living with HIV while other factors should also be considered. As mentioned, HIV-related stigma may influence participants’ usage of technology due to concerns of privacy, therefore, strategies to address these barriers may support usage. Also, adults living with HIV have previously described their experiences of disability as episodic, with unpredictable periods of illness and wellness. Investigations into WPAM usage corresponding to periods of episodic disability may speak to the usability of WPAM in adults living with HIV over sustained periods of time. Examining associations of WPAM usage with other HIV and health characteristics such as year of HIV diagnosis, number of concurrent health conditions, general health status and exercise history is an area of future inquiry.

**Self-reported and objective physical activity**

The median of the participants’ median daily step count was 9540 steps across the 25-week intervention. This level of physical activity was similarly reported by Cook et al where 60% of adults living with HIV performed

![Figure 4](http://bmjopen.bmj.com/)

**Figure 4** Weekly wireless physical activity monitor (WPAM) use. Number of participants who recorded at least 1 day of WPAM use (blue bar) during each week of the study. The height of the grey bar represents the total number of participants enrolled in the study each week.
greater than 10000 steps/day as measured by a WPAM.7
In a different study with older adults living with HIV, the
average daily step count was 3543 when not engaged in
an exercise intervention and increased by 43% during the
intervention.52 This demonstrates that step-based activities
can be an accessible mode of aerobic exercise for adults
living with HIV.7 53 The recommended daily step count for
older, chronically ill adults is approximately 7000–10 000
steps/day54 and a moderate pace is the minimum inten-
sity required to gain cardiovascular benefits.55 Although
the median step count of the participants in this study
was within the recommended range,54 the Fitbit Zip was
unable to capture the intensity of physical activity. Inten-
sity is important as the Canadian Physical Activity Guide-
lines recommends adults to engage in at least 150
min of moderate to vigorous aerobic physical activity per week.55
Quigley et al are currently investigating healthy lifestyle
living and goal management training among adults living
with HIV using a WPAM (Garmin VivoFit 4) to record
aerobic intensity to determine achievement of physical activity guidelines.96 Therefore, WPAMs that accurately
measure step count and aerobic intensity may help
researchers and clinicians in determining if adults living
with HIV are meeting physical activity guidelines.

When investigating a participant’s self-reported phys-
aical activity, the median of the participants’ median self-
reported RAPA-1 (aerobic) scores was 5, indicating that
participants commonly reported themselves as ‘active’,
exercising at moderate to vigorous intensity. However,
we found no correlation between the WPAM-measured
daily step count and the RAPA-1 scores. The absence of
a correlation may be attributed to a ceiling effect of the
RAPA-1 scores among the sample as they were engaged
in a structured exercise intervention. Nevertheless, self-
reported measures of physical activity can provide informa-
tion including perceived exertion, upper extremity
movement and swimming measures, which may not be
obtained by WPAMs.57 Validated self-reported measures
used in conjunction with WPAMs may provide supplemen-
tary qualitative information related to physical activity. A
combination of measures could equip researchers and
clinicians with a comprehensive toolset to aid physical
activity prescription, progression and monitoring among
adults living with HIV.

Limitations
Our study is not without limitations. Uptake was likely
overestimated as participants were provided a Fitbit

Figure 5 Reasons for non-usage of wireless physical activity monitors (WPAM). Reasons participants had no recorded WPAM usage during (A) the intervention phase (phase 1) (n=26) and (B) the follow-up phase (phase 2) (n=25) of the study. Fourteen participants included in A, were also included in B since these participants had no recorded WPAM usage during both phases. Definitions of Reasons: Account/login issues: Participant did not have any WPAM data downloaded by the research team due to difficulties with the login or account to synchronise the WPAM, including participants who did not have accounts created for the WPAM to synchronise. No downloaded data: Participant did not have any WPAM data downloaded by the research team due to unknown reasons. No steps recorded: Participant did not have any days where >0 steps were recorded by the WPAM (WPAM was not used/worn or the WPAM was not synchronised). Different device: Participant used a different WPAM other than the Fitbit Zip and data were synchronised to a personal account that the research team did not have access. Lost WPAM pre-intervention: Participant lost their WPAM prior to starting phase 1 (intervention) and it was not replaced. Lost WPAM during intervention: Participant lost their WPAM during phase 1 (intervention) and it was not replaced. Stopped using during intervention: Participant with a last day of >0 steps recorded by the WPAM in phase 1 (intervention) while they were enrolled in the study.
Zip as part of the intervention, which removed potential financial and personal barriers to uptake and use. Usage was likely underestimated due to reasons such as account or login issues (figure 5), which limited our ability to analyse WPAM use by participants who used the WPAM but were unable to synchronise their WPAM data. Furthermore, participants were engaged in a structured supervised exercise intervention during phase 1 of the study, which may have increased the likelihood of uptake and usage of WPAMs among participants in the study. This sample was predominantly white men, 50 years or older, living in Toronto, Canada. Therefore, the transferability of findings to the broader HIV population including women, adults living with HIV in rural or remote areas without Wi-Fi access, or those with financial constraints, is unknown. Furthermore, our fixed sample size of 76 limited our ability to detect correlations <0.4.45 While our analysis was descriptive and exploratory, results contribute to a broader understanding of WPAM use and may inform their implementation in research and clinical interventions. Another limitation was missing data across the data sources (self-report and WPAM) and across time points in the study. Strategies used to maximise available data included calculating median scores of the MOS-SSS, PHQ-8 and RAPA-1 questionnaires during phase 1, and including participants with any WPAM data available irrespective of the type of WPAM used. Furthermore, due to participants withdrawing from the study at different times, we were limited in our ability to analyse and report usage in relation to the number of days the WPAM was used in the study on an individual level. However, our definition of usage enabled the inclusion of participants that dropped out of the study before the end of phase 1 or phase 2, thus maximising our sample size for analysis. Finally, the WPAM used in this study, the Fitbit Zip, is clipped onto the hip and is not waterproof, limiting its ability to measure upper extremity activities as opposed to other WPAMs worn on the wrist.35 While the Fitbit Zip is no longer available for commercial purchase, the variable reasons for WPAM non-use discussed in our study are not exclusive to the Fitbit Zip, and may be used to inform strategies to promote sustained use of any commercially available WPAM.

Figure 6 Scatter plots of wireless physical activity monitor (WPAM) usage and contextual factor associations. Correlations between the proportion of days of WPAM usage out of the total number of days enrolled in phase 1 (intervention phase) of all participants (with and without WPAM usage) and (A) age (n=76), (B) highest level of education (n=76), (C) social support as assessed by the Medical Outcomes Survey-Social Support Scale (MOS-SSS) (n=69) and (D) mental health concerns as assessed by the eight-item Patient Health Questionnaire (PHQ-8) (n=69).
CONCLUSIONS
While the majority of adults living with HIV consented to WPAM use, WPAM usage was variable and declined over time. Furthermore, WPAM usage was not associated with age, highest level of education, mental health or social support and a self-reported measure of aerobic physical activity was not associated with WPAM-measured step count. Consequently, we recommend that future implementation of WPAMs in research or clinical settings should consider factors, which may promote sustained WPAM usage, including providing technical support and incorporating goal setting. While the contextual factors in our study did not appear to impact WPAM usage in isolation, future research should investigate how contextual factors may interact to affect WPAM usage. Finally, combining self-reported physical activity measures with WPAMs may provide a more complete understanding of physical activity among adults living with HIV.

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Contributors KKO’B and SCC were involved in the original CBE study team involved in the conceptualisation of the study design and data collection. KKO’B, SCC and MD provided guidance throughout all stages of the research including development of the research protocol, analysis, interpretation of results and manuscript development. MD provided assistance with the SPSS statistical analyses. KKO’B, SCC and MD supervised JRT, JC, Jusc, FH, HS and MS who developed the protocol, analysed the data, and drafted the manuscript in partial fulfillment of requirements for an MScPT degree at the University of Toronto. JRT, JC, Jusc, FH, HS and MS (MScPT students) developed skills in quantitative research methodology in course work on ethics, research strategies, literature review, study design, protocol development and learning to use SPSS statistical software. JRT and JC led the revisions and response to reviewers of the manuscript. All steps were closely reviewed and guided by advisors (KKO’B, SCC and MD). KKO’B is the senior responsible author and guarantor of the study. All authors read and approved the final manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, conduct, or reporting, or dissemination plans of this research. Refer to The Methods section for further details.

Patient consent for publication Consent obtained directly from patient(s)

Ethics approval This study was approved by the University of Toronto Health Sciences Research Ethics Board (Protocol #41886). Participants provided written informed consent to participate in the CBE study and were subsequently asked to provide written consent to WPAM use (see online supplemental file 3 for the study protocol and REB approval letter).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The data supporting the conclusions of this article are included within the article and its supplemental files. The data used and/or analysed during the current study are available from the corresponding author on reasonable request.

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