ARTICLE

SenseWearMini and Actigraph GT3X Accelerometer Classification of Observed Sedentary and Light-Intensity Physical Activities in a Laboratory Setting

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ABSTRACT

Purpose: To compare the ability of SenseWear Mini (SWm) and Actigraph GT3X (AG_3) accelerometers to differentiate between healthy adults' observed sedentary and light activities in a laboratory setting. ***Methods:*** The 22 participants (15 women, 7 men), ages 19 to 72 years, wore SWm and AG_3 monitors and performed five sedentary and four light activities for 5 minutes each while observed in a laboratory setting. Performance was examined through comparisons of accuracy, sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios. Correct identification of both types of activities was examined using area under the receiver operating characteristic curve (AUC). ***Results:*** Both monitors demonstrated excellent ability to identify sedentary activities (sensitivity > 0.89). The SWm monitor was better at identifying light activities (specificity 0.61–0.71) than the AG_3 monitor (specificity 0.27–0.47) and thus also showed a greater ability to correctly identify both sedentary and light activities (SWm AUC 0.84; AG_3 AUC 0.62–0.73). ***Conclusions:*** SWm may be a more suitable monitor for detecting time spent in sedentary and light-intensity activities. This finding has clinical and research relevance for evaluation of time spent in lower intensity physical activities by sedentary adults.

Key Words: accelerometer; physical activity; sedentary behaviour.

RÉSUMÉ

Objectif : Comparer la capacité des accéléromètres Sensewear Mini (SWm) et Actigraph GT3X (AG_3) de distinguer les activités sédentaires et d'intensité légère d'adultes en bonne santé observés en laboratoire. ***Méthodes :*** Les 22 participants (15 femmes), âgés de 19 à 72 ans, ont porté des moniteurs SWm et AG_3 et se sont livrés à cinq activités sédentaires et quatre activités d'intensité légère pendant cinq minutes dans chaque cas sous observation en laboratoire. On a analysé le rendement des appareils en comparant leur exactitude, sensibilité, spécificité et leurs valeurs prédictives positive et négative et ratios de probabilité positif et négatif. On a examiné la détermination correcte des deux types d'activités au moyen de la zone située sous les courbes des caractéristiques opérationnelles du récepteur (ZSC). ***Résultats :*** Les deux moniteurs ont démontré une excellente capacité de déterminer les activités sédentaires (sensibilité $> 0{,}89$). Le moniteur SWm était meilleur pour déterminer les activités d'intensité légère (spécificité variant de 0,61 à 0,71) que le moniteur AG_3 (spécificité variant de 0,27 à 0,47) et a donc montré une plus grande capacité de déterminer correctement les activités sédentaires et les activités d'intensité légère (ZSC: SWm $= 0{,}84$; AG_3: variant de 0,62 à 0,73). ***Conclusions :*** Le moniteur SWm peut convenir mieux pour détecter le temps consacré à des activités sédentaires et d'intensité légère. Cette constatation présente une pertinence clinique et de recherche pour l'évaluation du temps consacré aux activités physiques de plus faible intensité par des adultes sédentaires.

The World Health Organization[1] has identified physical inactivity as the fourth leading risk factor for global mortality, responsible for an estimated 3.2 million deaths per year. As a result, the message "exercise more," with the goal of meeting weekly physical activity guidelines for aerobic moderate to vigorous physical activity (MVPA), has been widely disseminated.[2,3] However, the equally important message "sit less" is not so well known, despite the emerging evidence of additional health benefits from a less sedentary lifestyle.[4–6]

Clinicians and researchers supporting sedentary adults to be less sedentary need measurement tools that can discriminate between sedentary and light-intensity physical activities.[7] An accelerometer is a tool that provides an

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objective measurement of a person's motion in space or a kinematic measure of physical activity, measuring energy expenditure and time spent in activities of different intensity. However, accelerometers were designed primarily to measure higher intensity activities.[8] Actigraph (AG) accelerometers (Actigraph LLC, Pensacola, FL) are those most frequently used in research, with the Actigraph GT3X (AG_3), the monitor used in this study, being a later triaxial model.[9] They are usually worn at the waist during waking hours and provide output that includes measures of number of steps (similar to pedometry) and number of activity counts (ACs) generated from the different motion axes of the accelerometer over a predefined measurement period (e.g., at 1-minute intervals).[10] Several validated data-reduction methods have been used to define AC cut-points associated with different intensities of activity and estimates of energy expenditure,[7,9–15] but the accuracy of these data-reduction methods for estimations of time spent in sedentary activities has often been questioned.[9,11–15]

SenseWear (SW) accelerometers (BodyMedia/JawBone, Inc., Pittsburgh, PA) are a newer design of multi-sensor monitors. SW monitors use proprietary pattern-recognition algorithms to integrate accelerometry measures with physiological sensors (heat flux, galvanic skin response, skin temperature, and near-body ambient temperature) and personal demographic data (age, sex, height, weight, and smoking status) to provide estimates of steps, energy expenditure (EE), and metabolic equivalent tasks (METs) per unit of time.[16] The SW Mini (SWm) is a triaxial model that can be worn 24 hours a day against the skin on the upper arm. SW monitors have been extensively evaluated for validity of measures of EE, with several recent studies using the SWm.[16–22] To our knowledge, only Reece and colleagues[19] specifically explored SWm measures of time spent in lower intensity activity; their study reported very high accuracy (89%) for SWm measures of time spent across a spectrum of sedentary, light, and moderate activities.

A few studies have compared SWm and AG_3 monitors' measures of EE.[23–30] In two recent and related studies, Calabro and colleagues[29] and Lee and colleagues[30] determined that SWm monitors provided more accurate measures of EE during light- to moderate-intensity activities in laboratory and free-living settings than the AG_3 and three other activity monitors. However, neither study specifically compared SWm and AG_3 monitors' measures of time spent in lower intensity activity. Two other studies compared measures of time spent in MVPA by older SW and AG monitor models and had inconsistent findings, with one study each showing both monitors to either underestimate[23] or overestimate[24] time spent in MVPA. To our knowledge, no previous study has specifically compared SWm and AG_3 monitors' measures of time spent in lower intensity activities.

The purpose of this study was to compare SWm and AG_3 measures of time spent in sedentary and light-intensity physical activities by healthy ambulatory adults in a laboratory setting. Our objectives were, first, to compare the ability of the SWm and the AG_3 to accurately identify and differentiate between observed sedentary activities and light-intensity activities in a laboratory setting and, second, to explore how categorization of sedentary and light activity differed between the two monitors.

METHODS

Our study was approved by the University of British Columbia Clinical Research Ethics Board. Volunteers were recruited from the Greater Vancouver Regional District metropolitan area and were eligible if they were at least 19 years old, lived independently in the community, and were able to walk without the use of a mobility aid. We excluded from the study those who could not provide written informed consent or who answered "yes" to any question on the Physical Activity Readiness Questionnaire.[31] With institutional permission, we distributed study recruitment fliers through direct posting, email notification, and website posting in selected health care and academic locations associated with the primary authors' affiliations. Interested volunteers contacted the study centre by phone and were screened for eligibility. Eligible participants provided informed consent before enrolment in the pilot study.

Participants attended a 2-hour evaluation session. Height (in cm) and weight (in kg) were measured using standard techniques. The SWm was placed on the skin over the triceps muscle, and the AG_3 was worn at the waist at the mid-axillary line, with both monitors placed on the dominant-arm side (Figure 1). The SWm was configured using handedness, smoking status, age, sex, height, and weight. The AG_3 was initialized to collect triaxial data, with the low-frequency filter turned off. Both monitors were synchronized to the second with Greenwich Mean Time and were set to collect data at 1-minute intervals.

Before testing, we demonstrated nine simulated lower intensity daily activities to the participants, who were then given the chance to ask questions and practice the activity. We selected these nine activities from among common activities listed in the *2011 Compendium of Physical Activities*[32] as sedentary (non-adjusted MET estimates $\leq$1.5) or light (non-adjusted MET estimates $>$1.5 and $<$3.0). The selected activities included three standing, three sitting, and three lying activities; one activity in each body posture involved moving the upper extremities, one involved moving the lower extremities, and one required no extremity motion (see Table 1). For two activities (walking on a treadmill and cycling on stationary bike), we asked participants to stay within a recommended range for speed (1.5–2 mph [2.4–3.2 km/h] and 30–50 rotations per minute, respectively). For one other activity (knee range of motion activity while lying down), we asked participants to use a pace similar to

Figure 1 The SenseWear Mini (SWm) accelerometer is worn on the skin over the triceps muscle on the upper arm, and the Actigraph GT3X (AG_3) is worn at the waist at the mid-axillary line.

how they would move their legs if they were walking slowly around a grocery store. For all other activities, we asked participants to perform the task at a pace that they considered similar to how they would typically perform that activity in their normal living environment. We did not ask participants to rate their perceived exertion during any activity.

Participants performed all nine activities in a random order for 5 continuous minutes each. The criterion measure used in this study was verification of the timing, type, and quality of activities performed through direct observation by a trained observer. The trained observer provided direct oral feedback if participants varied from the recommended performance parameters; if necessary, the task was stopped, instructions were repeated, and the participant was allowed to practice the activity again before repeating it. Lyden and colleagues[33] have shown direct observation of physical activity behaviours to be a valid criterion measure for estimating physical activity and sedentary behaviours.

We processed the raw SWm data using the SenseWear Professional software (version 7; BodyMedia/JawBone, Inc., Pittsburgh, PA) and the raw AG_3 data using the Actilife software (version 5; ActiGraph, LLC, Pensacola, FL) and then exported them to Microsoft Excel (version 14; Microsoft Corp., Redmond, WA) for coding and analysis. The SWm data were recoded into sedentary METs ($\leq$1.5) and non-sedentary METs ($>$1.5); the AG_3 ACs were recoded using three sedentary cut-point criteria: (1) single vertical axis (VA) $<$100 ACs per minute,[11,12] (2) VA $<$25 AC/minute,[15] and (3) triaxial vector magnitude (VM) $<$200 AC/minute.[15] We then extracted the recoded data from the middle 3 minutes of each 5-minute activity for further analysis to ensure that all included minutes had a full 60 seconds of the observed activity.

We compared sensitivity (i.e., correctly identified as a sedentary activity) and specificity (i.e., correctly identified as a light activity) and the proportion of sedentary or light minutes measured by each monitor and confirmed through observation as sedentary (e.g., positive predictive value [PPV]) or light (e.g. negative predictive value [NPV]) and also determined the positive likelihood ratio (LR+) and negative likelihood ratio (LR−), using Minitab statistical analysis software (version 16; Minitab Inc., State College, PA). We also gauged the relative ability of the SWm and AG_3 monitors to correctly classify both sedentary and light activities by examining the relationship between true positive (sensitivity) and true negative (1—specificity) rates, as evaluated via area under the receiver operating characteristic curve.[34] These analyses used IBM SPSS statistical analysis software (version 19; IBM Corp., Armonk, NY).

All our analyses were conducted using two definitions of *sedentary:* (1) a *sedentary activity,* defined as an activity estimated at 1.5 METs or less, performed in any posture (lying, sitting, or standing),[2] and (2) a *sedentary behaviour,* defined by the Sedentary Behavioural Research Network (SBRN) as an activity estimated at 1.5 METs or less, performed in either a sitting or a lying posture (i.e., excluding low-intensity standing activities).[35] These different definitions affected the categorization of two tasks: standing still texting and sitting on a swivel office chair doing active upper extremity computer workstation tasks (see Table 1).

Table 1 Nine Common Daily Activities Simulated in the Controlled Laboratory Setting

Motion condition	Standing	Sitting	Lying (supine)
Lower extremity motion	Treadmill, slow (2.4–3.2 km/h [1.5–2 mph]), self-paced walking, no incline (CPA: ~3.0 METs)*	Stationary bike, slow (30–50 rpm), self-paced cycling, no resistance (CPA: ~3.0 METs)*	Slow, self-paced, alternating knee range of motion over pillow (CPA: ~1.3 METs)†‡
Upper extremity motion	Washing, drying, and putting away dishes (CPA: ~2.5 METs)*	Swivel chair, repetitive, light effort, office workstation tasks (i.e., setting up a laptop, moving files and papers, and typing; CPA: ~1.6 METs)*‡	Reading magazines (CPA: ~1.3 METs)†‡
No lower or upper extremity motion	Standing still, text messaging on a handheld mobile device (CPA: ~1.3 METs)*†	Sitting still, comfortable chair, watching TV (CPA: ~1.3 METs)†‡	Lying still, relaxing, and listening to music (CPA: ~1.3 METs)†‡

Note: CPA[28] estimated METs value for daily activities similar to these simulated activities.
*Light-intensity activity (estimated 1.5 < METs < 3.0).[2]
†Sedentary activity (estimated ≤1.5 METs any posture).[2]
‡Sedentary behaviour (estimated ≤1.5 METs sitting of lying postures).[8]
mph = miles per hour; CPA = *2011 Compendium of Physical Activity;* METs = metabolic equivalent tasks; rpm = rotations per minute.

RESULTS

We recruited 22 community-dwelling adults (15 women, 7 men), aged 19 to 72 years (mean age 35.7 [SD 13.9] y), with a median BMI of 24.2 kg/m² (Q1 = 21.3, Q3 = 31.7). Of 594 minutes retained for analysis (3 min from each of nine simulated daily activities from 22 participants), 330 were from five sedentary activities and 264 were from four light activities. Table 2 shows the cross-tabulations for SWm and AG_3 measures of sedentary and light activities compared with the observed sedentary and light activity categorization, comparing the sedentary activity and sedentary behaviour definition conditions.

The SWm and AG_3 monitors both demonstrated excellent ability to correctly identify observed sedentary activities in the controlled laboratory setting, with sensitivity varying from 0.89 (SWm, sedentary behaviour) to 0.98 (SWm, sedentary activity) to 0.99 (AG_3, all three sedentary cut-point conditions). The SWm sedentary activity condition and all three AG_3 sedentary cut-point conditions rarely misidentified a light activity as sedentary (i.e., false negative); false negative rates varied from 4% for the SWm sedentary behaviour condition to less than 2% for the three AG_3 sedentary cut-point conditions. Thus, with the marginal exception of the SW sedentary behaviour condition (NPV 0.82; LR− 0.17), both monitors showed very high NPV, varying from 0.96 for the SW sedentary activity condition to 0.99 for all three AG_3 sedentary cut-point conditions, and a very low LR− (<0.04) for the SWm sedentary activity condition and for all three AG_3 sedentary cut-point conditions (see Table 3).

With respect to correctly identifying light activity minutes (i.e., specificity), the SWm sedentary activity condition (specificity 0.71) performed notably better than the SWm sedentary behaviour (0.61) and all three AG_3 sedentary cut-point conditions (varying from 0.47 [VM < 200] to 0.27 [VA < 100]). The SWm sedentary activity condition miscategorized a light activity as sedentary (i.e., false positive) 19% of the time, whereas the SWm sedentary behaviour and all three AG_3 sedentary cut-point

Table 2 Cross-Tabulations Comparing SWm and AG_3 Measures of Sedentary and Light Activities with Observed Light and Sedentary Activities in a Controlled Laboratory Setting

Accelerometer condition and measured activity	Observed activity		
	Sedentary	Light	Total
SWm (A)			
Sedentary	322	76	398
Light	8	188	196
Total	330	264	594
SWm (B)			
Sedentary	295	103	398
Light	35	161	196
Total	330	264	594
AG_3 VM < 200/min (A&B)			
Sedentary	327	141	468
Light	3	123	126
Total	330	264	594
AG_3 VA < 25/min (A&B)			
Sedentary	329	178	507
Light	1	86	87
Total	330	264	594
AG_3 VA < 100/min (A&B)			
Sedentary	329	192	521
Light	1	72	73
Total	330	264	594

Note: Actigraph results are the same for both sedentary-activity and sedentary-behaviour conditions as both activities were measured 100% of the time as sedentary in all three cut-point conditions. A:[2] ≤ 1.5 METs any posture[2] (e.g., standing texting = observed sedentary; active computer workstation activities = observed light). B:[8] ≤ 1.5 METs sitting or lying postures only[8] (e.g., standing texting = observed light; active computer workstation activities = observed sedentary).
SWm = SenseWear Mini; AG_3 = Actigraph GT3X; A = sedentary activity; B = sedentary behaviour; VM = vector magnitude; VA = vertical axis; METs = metabolic equivalent tasks.

Table 3 Summary of Results Examining the Comparative Ability of SWm and AG_3 Monitors to Differentiate between Observed Sedentary and Light Activities in a Laboratory Setting

	Mean (95% CI)				
Statistic	SWm (A)	SWm (B)	AG_3 VM < 200 (A&B)	AG_3 VA < 25 (A&B)	AG_3 VA < 100 (A&B)
Sensitivity (0–1)	0.98 (0.95, 0.99)	0.89 (0.86, 0.93)	0.99 (0.97, 0.99)	0.99 (0.98, 0.99)	0.99 (0.98, 0.99)
Specificity (0–1)	0.71 (0.65, 0.77)	0.61 (0.55, 0.67)	0.47 (0.40, 0.53)	0.33 (0.27, 0.40)	0.27 (0.22, 0.33)
PPV (0–1)	0.81 (0.77, 0.85)	0.74 (0.70, 0.78)	0.70 (0.65, 0.74)	0.65 (0.62. 0.69)	0.63 (0.59, 0.67)
NPV (0–1)	0.96 (0.92, 0.95)	0.82 (0.76, 0.87)	0.99 (0.93, 0.99)	0.99 (0.94, 0.99)	0.99 (0.93, 0.99)
LR+ (≥1)	3.40 (2.80, 4.10)	2.29 (1.96, 2.68)	1.86 (1.66, 2.08)	1.48 (1.36, 1.61)	1.37 (1.27, 1.48)
LR− (<1)	0.04 (0.02, 0.07)	0.17 (0.12, 0.24)	0.02 (0.01, 0.06)	0.01 (0.01, 0.07)	0.01 (0.01, 0.08)
ROC (AUC; 0.5–1)	0.84 (0.81, 0.88)	0.75 (0.71, 0.79)	0.73 (0.69, 0.77)	0.67 (0.62, 0.71)	0.64 (0.60. 0.68)

Note: A: ≤1.5 METs (any posture).2 B: ≤1.5 METs (lying or sitting postures only).8 A vs B definitions only affect standing texting and sitting computer workstation categorizations. Notably, all AG cut-points categorized both the standing texting and sitting computer workstation activities as sedentary 100% of the time, so the AG results were the same for both sedentary definition conditions.
SWm = SenseWear Mini; AG_3 = Actigraph GT3X; A = sedentary activity; B = sedentary behavior; VM = vector magnitude cut-point/minute; VA = vertical axis cut-point/minute; PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR− = negative likelihood ratio; ROC = receiver operating characteristics; AUC = area under the curve; METs = metabolic equivalent tasks.

conditions were more likely to make this error (false positive rates varying from 26% [SWm sedentary behaviour] to 37% [AG_3 VA < 100]). Thus, the SWm sedentary activity condition showed the best PPV (0.81) and LR+ (3.4); PPVs varied from 0.74 for the SW sedentary behaviour condition to 0.61 for the AG_3 VA < 100 condition, and LR+ varied from 2.29 for the SWm sedentary behaviour condition to 1.37 for the AG VA < 100 condition. The SWm was also better able than the AG_3 monitor to correctly identify both sedentary and light activities: AUC was 0.84 for the SWm sedentary activity condition and 0.75 for the SW sedentary behaviour condition, whereas AUC for the three AG_3 sedentary cut-point conditions varied from 0.74 (VM < 200) to 0.64 (VA < 100; see Table 3).

Both monitors, under all conditions, correctly identified all activities in lying position as sedentary. The two monitors also performed very similarly in terms of correctly identifying 97% or more of all minutes sitting still and more than 90% (SWm 91%; all AG_3 100%) of minutes standing still as sedentary, assuming that standing still is a sedentary activity on the basis of the sedentary activity definition.[2] Both monitors were also very likely to identify slow treadmill-walking activities as light, varying from more than 98% (SWm and AG_3 VA < 25 and VM < 200) to 89% (AG_3 VA < 100). The primary difference between the two monitors was that the SWm monitor was markedly more accurate in correctly identifying standing or sitting activities that involved upper extremity motion as light activity. SWm identified 97% of dishwashing minutes and 50% of computer workstation minutes as light activity, whereas the AG_3's best performance (VM < 200) identified 0% of dishwashing minutes and 35% of computer workstation minutes as light activity. Similarly, the SWm monitor identified 60% of minutes spent in slow pedalling with no resistance as a light activity, compared with an AG_3 accuracy that varied from 20% (VA < 25 and < 100) to 50% (VM < 200).

DISCUSSION

Our study extends the literature on the use of accelerometry for the objective measurement of time spent in lower intensity physical activities by examining the comparative ability of the SWm and AG_3 monitors to differentiate observed sedentary and light-intensity physical activity in a laboratory setting. We deliberately focused on measures of lower intensity activity because accuracy in differentiating time spent in sedentary and light physical activities is an important measurement characteristic to consider, especially in clinical and research situations focused on reducing time spent in sedentary lifestyle activities.

Our results show that, compared with the AG_3 monitor, the SWm monitor was much better able to distinguish between observed sedentary and light-intensity activities in the controlled laboratory setting. These differences are likely because the AG_3 monitor uses only triaxial accelerometry measures (i.e., measures of three-dimensional body motions in space) to define intensity of activity. Whereas the SWm monitor integrates triaxial accelerometry with additional physiological data (e.g., skin temperature and sweating with activity) and personal demographic data (e.g., age, sex, BMI), using proprietary algorithms, to define intensity of activity. Differences may also be related to where on the body the monitors were designed to be worn during activity (i.e., the SWm monitor is designed to be worn on the arm; the AG_3 monitor, at the waist). Positioning the SWm monitor on the arm provides a mechanical advantage in detecting upper extremity motions when the rest of the body is not moving in space. These technological advantages of SWm are an important consideration, given the SWm monitor's additional practical advantage in terms of providing a more comprehensive 24-hour picture of a person's sleep, wakeful physical activity patterns, and off-body times than the AG_3 monitor, which is intended to be worn only while a person is awake.[36]

We also found that the sedentary cut-points for the AG_3 monitor of VM < 200 AC/minute and single VA < 25 AC/minute better differentiated between sedentary and light activities than the more commonly used sedentary cut-point of single VA < 100 AC/minute.[11,12,15] This finding, which is consistent with those of Aguilar-Farías,[15] suggests that an AG_3 VM cut-point of less than 200 AC per minute may be a better sedentary cut-point when using a triaxial AG_3 monitor or, alternatively, using a VA cut-point of <25 AC/minute as a sedentary cut-point rather than the more commonly used VA < 100 AC/minute sedentary cut-point.

Our study also found that results vary depending on how *sedentary* is defined. The SBRN definition of sedentary behaviour[35] (i.e., wakeful sitting or lying activities of 1.5 METs or less) excludes any standing activity; in our study, by contrast, both SWm and AG_3 monitors identified standing still while texting as a sedentary activity, which may be more consistent with Bailey and Locke's[37] recent findings that "standing breaks" (breaks in sitting to stand still for 2 min) did not confer the same cardiometabolic benefits as light activity breaks (breaks consisting of 2 min of light-intensity walking). Bailey and Locke's findings suggest that standing still for short periods, similar to sitting still, could also be considered a sedentary behaviour.

That said, identifying standing still as either a sedentary or a light activity will not generally produce a marked over- or underestimation of time spent in sedentary activity, because most people do not typically spend prolonged periods standing still with minimal upper extremity motion during the day. However, some people may stand for longer periods, with minimal use of their arms, as part of their normal daily activities—for example, if they use a standing desk or perform other occupational activities that require prolonged periods of standing still. Therefore, it is important to consider exploring how these types of unique contextual standing-still activities might affect specific research or clinical use of these monitors.

More likely to make a marked difference in measures of time spent in sedentary or light activity for most people is the SWm's greater ability to identify sitting or non-ambulatory standing activities that involve upper extremity motion. As mentioned previously, better performance by the SWm monitor, compared with the AG_3 monitor, in identifying light activities that involve upper extremity motion is explained in part by the fact that the SWm monitor and its accompanying analysis software were designed for the monitor to be worn on the arm, whereas the AG_3 monitor is intended to be worn at the waist. As such, the SWm monitor will likely provide a more accurate identification of the time in a person's day when he or she is performing many common light-intensity standing or sitting activities of daily living involving the upper extremity—a large portion of the day that the AG monitor would, in contrast, potentially identify as sedentary time.

Our finding that the SWm monitor more accurately measures time spent in lower intensity activity is consistent with the findings of Calabró and colleagues (2014)[29] and Lee and colleagues,[30] who also found that the SWm was more accurate than the AG_3 for measuring EE from lower intensity activity. Together, these findings suggest that any direct comparison between time spent in, or EE from, lower intensity activities as captured by SWm and AG_3 monitors should be made with caution, because values for these metrics will differ markedly depending not only on the type of accelerometer used[7,38] but also on the definition of a sedentary activity[2,35] and the sedentary cut-point used with the AG_3 monitor.[11,15]

LIMITATIONS

Our study has several limitations. First, our sample was a small cohort of 22 ambulatory adult volunteers aged 19–72 years. Our findings therefore cannot be generalized to non-ambulatory adults, adults living with gait deficits, or adults who use a walking aid; generalization to adults living with chronic health conditions may also be limited because some systemic chronic health conditions may affect SWm physiological sensor data.[39] We did not screen specifically for chronic health conditions in any of our participants, so we are not able to comment on how living with chronic disease may or may not have affected the findings in this study.

Second, we simulated activities in a controlled laboratory setting, which may not replicate the movement pattern of similar activities as they would have been performed by participants in their own environment. Third, we did not select activities on the basis of an age- or body-mass-adjusted estimate of METs, which may have led to underestimation of EE for older participants and those with higher BMI.[40] This limitation is partially addressed by the SWm monitor, whose proprietary algorithms do adjust for age, sex, and BMI; this adjustment may help explain the better performance of the SWm monitor.

Fourth, we used direct observation as our criterion measure for defining each minute as a sedentary or light activity, rather than using indirect calorimetry for comparative measures of EE during the activity. Direct observation of a person's activity has been shown by Lyden and colleagues[33] to be a valid criterion measure for identifying different intensities of physical activity. Notably, the intent of our study was not to examine the monitors' measures of EE, which has been the primary focus of many other studies, but to examine their ability to detect differences in body motions occurring in different body postures associated with common light and sedentary activities. We consider this an important distinction because it is important to have measurement tools that are sensitive to changes in subtle body motion patterns associated with common sedentary and light activities.

Fifth, both monitors have technical limitations in terms of accurately detecting the number of steps at slower walking speeds.[41,42] The intent of this pilot study was not to explore the accuracy of the number of steps identified during slow walking. It is important to note, however, that this physical limitation of both monitors did not seem to affect either monitor's ability to correctly identify slow treadmill walking as a light activity, because both showed very high accuracy.

Finally, we did not examine the comparative accuracy of the SWm and AG_3 monitors using newly evolving AG_3 pattern-recognition algorithms for the AG_3 analyses,[43,44] the latest SW software (version 8),[38] or different positioning of the monitors on the body. Therefore, we do not know how these different approaches might have influenced either monitor's ability to differentiate between sedentary and light physical activities. On the basis of these limitations, further studies examining the comparative accuracy of the SWm and AG_3 monitors in differentiating time spent in sedentary and light physical activities are warranted.

CONCLUSIONS

We compared the ability of the SWm and AG_3 monitors to differentiate between sedentary and light activities performed by ambulatory adults in a controlled laboratory setting and found that the SWm was better able to distinguish observed sedentary and light activities. Our findings suggest that the SWm monitor may be more suitable for objective measurement of differences in time spent in sedentary and light-intensity activities. In addition, we found that using an AG_3 monitor VM sedentary cut-point of <200 AC/minute or a single VA sedentary cut-point of <25 AC/minute improved the AG_3 monitor's performance relative to the more commonly used single VA cut-point of <100 AC/minute. These findings are of particular clinical and research relevance for evaluation of physical activity participation in sedentary adults, with potential relevance as well in ambulatory adults living with chronic health conditions with limited ability to participate in higher intensity activities.

KEY MESSAGES

What is already known on this topic

Independent of the health benefits of meeting weekly moderate to vigorous physical activity guidelines, evidence is emerging of additional health benefits from also reducing time spent in sedentary activities. However, objective measurement of time spent in lower intensity activities presents a challenge for researchers and clinicians focusing on supporting people to be less sedentary throughout their day.

What this study adds

This study adds to the literature by demonstrating that the SenseWear Mini accelerometer was better able to differentiate between observed sedentary and light-intensity activities in a laboratory setting than the more commonly used Actigraph GT3X accelerometer. The Actigraph GT3X monitor performed better using a vector magnitude cut-point of less than 200 activity counts (ACs) per minute or the single vertical axis cut-point of less than 25 AC per minute for sedentary activity than with the more commonly used single vertical axis cut-point for sedentary activity of less than 100 AC per minute.

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