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Author post-print (accepted) deposited by Coventry University's Repository

Original citation & hyperlink:
Duncan, M, Rowlands, A, Lawson, C, Leddington Wright, S, Hill, M, Morris, M, Eyre, E & Tallis, J 2020, 'Using accelerometery to classify physical activity intensity in older adults: what is the optimal wear-site?', European Journal of Sport Science, vol. 20, no. 8, pp. 1131-1139. https://dx.doi.org/10.1080/17461391.2019.1694078

DOI 10.1080/17461391.2019.1694078
ISSN 1746-1391
ESSN 1536-7290

Publisher: Taylor and Francis

This is an Accepted Manuscript of an article published by Taylor & Francis in European Journal of Sport Science on 14/11/2019, available online: http://www.tandfonline.com/10.1080/17461391.2019.1694078

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Using accelerometery to classify physical activity intensity in older adults: what is the optimal wear-site?

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Abstract

This study aimed to determine the optimal accelerometer wear-site specific cut-points for discrimination of sedentary time, light physical activity and moderate-to-vigorous physical activity in older adults. Twenty-three adults (14 females) aged 55 to 77 years wore a GENEActiv accelerometer on their non-dominant wrist, dominant wrist, waist and dominant ankle whilst undertaking eight, five-minute bouts of activity: lay supine, seated reading, slow walking, medium walking, fast walking, folding laundry, sweeping and stationary cycling. VO_2 was assessed concurrently using indirect calorimetry. Receiver-operating-characteristic (ROC) analyses were used to derive wear-site specific cut-points for classifying intensity. Indirect calorimetry indicated that being lay supine and seated reading were classified as sedentary (<1.5 METs), laundry as light (1.51-2.99 METs) and sweeping, slow, medium and fast walking and cycling all classified as moderate intensity (>3 METs). Areas under ROC curves (AUC) indicated that classification of sedentary activity was good for the non-dominant wrist and excellent for all other wear sites. Classification of moderate-to-vigorous physical activity (MVPA) was excellent for the waist and ankle, good for the waist and poor for the dominant and non-dominant wrists. Overall, the ankle location performed better than other locations. Ankle-worn accelerometry appears to provide the most suitable wear-site to discriminate between sedentary time and MVPA in older adults.

Keywords: Indirect Calorimetry; Energy Expenditure; Sedentary Behaviour; Cut-Points; Accelerometer; Aging; Waist; Wrist; Ankle; GENEActiv

Introduction

Accelerometers are widely used as a measure of physical activity (PA) in public health research as they provide an objective assessment both PA and sedentary behaviour (SB) which is key in identifying relations between such behaviour and health outcomes as well as tracking the impact of health enhancing interventions (Lewis, Napolitano, Buman, Williams, & Nigg, 2017). In the context of an ageing society accelerometry is particularly appropriate to assess PA and SB in older adults as it requires no user input during monitoring resulting in greater wearer compliance in older adults, as compared to younger age groups (Doherty, et al., 2017). There is also evidence that recall of past behaviour declines with ageing (Barnett, van den Hoek, Barnett, & Cerin, 2016), which accelerometry overcomes (Guo, Key, & Reeves, 2019).

Despite the fact that accelerometry has only recently become common in assessing PA and SB in older adults (Mañas, del Pozo-Cruz, García-García, Guadalupe-Grau, & Ara, 2017, Oguma, et al., 2017), there are a dearth of studies that have calibrated accelerometer cutpoints with an older adult population. This has been a cited limitation of studies that have examined accelerometer derived PA and SB in older adults (Copeland and Esliger 2009) where the predominant approach has been to use cutpoints calibrated in younger adults (Falck, Davis, & Liu-Ambrose, 2016).

Calibrating accelerometer cut-points in older adults is important because the energy expenditure (EE) associated with a given metabolic equivalent (MET) is approximately 71% lower in older (60-90 years) compared to younger adults (Hall, Howe, Rana, Martin, & Morey, 2013). Thus, use of cut points developed on young adults with an older populations may lead to erroneous conclusions being drawn with a likely underestimation of time spent in MVPA being the outcome (Barnett et al. 2016).

An additional consideration with the use of accelerometry to assess PA and SB is the site of attachment. The hip has been the conventional attachment site for accelerometers because of its proximity to the centre of mass (Montoye, Mudd, Biswas, & Pfeiffer, 2018a, Troiano, McClain, Brychta, & Chen, 2014, Van Hees et al. 2011) but recent studies have suggested wrist-worn accelerometry may be a preferable attachment site because it can more accurately capture the arm motions of activities that are non-ambulatory in nature such as those used in tasks of daily living and household activities (Evenson, et al., 2015, Landry, Falck, Beets, & Liu-Ambrose, 2015). This may also be a disadvantage in that it will capture movements that are not associated with elevated EE. Wrist-worn assessment is also less likely to be influenced by atypical gait patterns more commonly observed in older adults (Ko, Jerome, Simonsick, Studenski, & Ferrucci, 2018). Indeed, a recent systematic review concluded that there is conjecture as to the optimal wear site for the measurement of PA, yet the veracity in literature for supporting wrist worn accelerometry over other placement locations in terms of accuracy of PA assessment remains unexplored (Clark, et al., 2018).

Of more recent research interest, ankle worn accelerometry has shown promise as a placement site to obtain valid estimates of PA (Crouter, Oody, & Bassett, 2018). There are however only a limited number of studies that have used ankle placement, and to date, no study has examined this issue in older adults. Previous work with young adults has reported that ankle worn accelerometery performs poorly compared to waist-worn accelerometry (De Vries, Engels, & Garre, 2011) whereas others have shown the use of the ankle location is similar or better than waist- or wrist-worn locations for estimating EE (Hibbing, LaMunion, Kaplan, & Crouter, 2017; Kim, Jung, Park, & Joo, 2014).

Given the paucity of studies calibrating accelerometers for use in older adults specifically, and that no study to date has examined the utility of ankle-based accelerometer estimates of SB and PA in older adults, the present study sought to:

- Calibrate wrist, hip and ankle worn accelerometry for the assessment of SB and PA at the wrist, hip and ankle placement sites using the GENEActiv accelerometer for the assessment of SB and PA in a sample of adults aged 55-80 years.
- Determine which wear site was optimal for the classification of SB and PA at the wrist, hip and ankle placement sites using the GENEActiv accelerometer in a sample of adults aged 55-80 years.

In addition, as there are only wrist based cut-points for the GENEActiv accelerometer calibrated for use with older adults, a secondary aim of the present work was to cross-validate published cut-points for the assessment of PA and SB at the wrist and hip placement sites in a sample of adults aged 55-80 years.

Methods

Participants

A sample of 23 healthy, Caucasian, adults (9 males, 14 females) aged between aged 55 and 77 years (63.2 ±6.5 years) took part in this study following institutional ethics approval and written informed consent. Mean ± SD of height, mass and body mass index (BMI), was 1.67 ± 0.9m, 73.8 ± 13.1 kg and 26.2 ± 4.04 kg/m^2 respectively. Participants were ‘apparently healthy’ and physically able to undertake exercise, as determined by pre-exercise health screen questionnaire. Participants were

independently able to walk on a treadmill and had no known medical, neuromuscular, cardiovascular or cognitive impairment prohibiting exercise in any way.

Procedures

All procedures were performed in accordance with the ethical standards of the institution's research committee and with the 1964 Helsinki declaration and its later amendments.

Participants wore a GENEActiv monitor (Activinsights Ltd, Cambridge, UK) on their non-dominant wrist, dominant wrist, dominant hip and dominant ankle, similar to other work (Duncan, et al., 2019). Monitors were worn through the testing period. The GENEActiv has been described in detail previously (Esliger, et al., 2011) and is one of the most widely used accelerometers for the assessment of PA and SB (See Clark, et al., 2018 for a review). Although other accelerometer brands are available the GENEActiv was chosen as it provides three-axis raw accelerometry that can be worn on multiple body locations, whereas other brands of accelerometer tend to require post processing software to analyse raw data and are less user friendly when locating on positions other than waist and wrist. The GENEActiv was set to record at 80Hz. Throughout the testing procedure VO_2 and VCO_2 were assessed using a MetaMax 3B (Cortex Biophysik GmbH, Leipzig, Germany) breath by breath gas analyser. The MetaMax was calibrated with gases of known concentration each day prior to commencing testing. All testing took place in the morning (9am-12pm). Prior to beginning the protocol, each participant was fully familiarised with the treadmill being used in the study (Woodway Inc, Wisconsin, USA).

After briefing and fitting with the monitors and gas analyser, each participant performed a series of activities reflective of different levels of PA. These were lying supine, seated reading, slow walking, medium walking, fast walking and were performed in order. Being lay supine was used to determine resting metabolic rate for subsequent determination of METs. Participants then performed bouts of folding laundry and sweeping the floor to represent household activity, and cycling at 50Watts (Monark Ergomedic 874e, Vannsbro, Sweden), similar to prior work (Montoye et al. 2018a). All activities were performed for 5 minutes with a 5-minute rest in between. Using previous protocols (Ryan and Gormley, 2013) as guidelines, walking speeds were set at 3kmph^{-1}(0.8 m/s), 4.5kmph^{-1}(1.25 m/s) and 5.5kmph^{-1} (1.52 m/s) to represent slow, medium pace walking and fast walking respectively. These speeds were taken from prior studies documenting treadmill walking speeds corresponding to slow, medium and brisk walking in older adults (Huijben et al. 2018; Parise et al. 2004).

Data processing

Upon completion of the protocol, each participant's accelerometer and calorimetry data was downloaded and stored on a computer. The first and last minute of each bout were discarded leaving a 3-minute period for analysis. This ensured that MET values for each bout were at the required intensity and is consistent with prior work (Ryan and Gormley 2013). Using the GENEActiv post processing software (Version 2.9), the raw 80Hz triaxial GENEActiv data were saved in raw format as binary files for subsequent signal processing. Signal processing of raw .bin files was completed using R-package GGIR version 1.5 (https://cran.r-project.org/web/packages/GGIR/) (van Hees, et al., 2013). Consistent with previous

research (Hildebrand, Van Hees, Hansen, Ekelund, 2014; Rowlands, Yates, Davies, Khunti, Edwardson, 2016), the Euclidean Norm Minus One (ENMO) (Van Hees, et al., 2013) was adopted to quantify the average magnitude of dynamic acceleration in milligravitational units (1 m*g* = 0.00981 m/s^{-2}), averaged over 1 second epochs. Participant-specific csv files with accelerometer output in 1-s epochs were generated to facilitate time-aligning the accelerometer data and the indirect calorimetry data to produce activity-specific outcomes.

The VO_2 values were then converted using measured METs and coded into one of four intensity categories (sedentary < 1.5 METs), light (1.5-2.99 METs), moderate (3-5.99 METs) and Vigorous (>6 METs). On inspection however, none of the activities undertaken by the participants resulted in MET values that were classified as vigorous in intensity. Data were subsequently recoded into three intensity categories reflecting sedentary, light and moderate to vigorous PA (MVPA).

Statistical Analysis

Pearson's product moment correlations were employed to examine criterion validity of the GENEActiv output at each wear location and METs. Receiver Operating Characteristic (ROC) curve analysis was undertaken to determine SB and MVPA cutpoints (Jago, Zakeri, Baranowski, & Watson, 2007). Area under the curve (AUC) was calculated as a measure of diagnostic accuracy for each analysis with AUC values of; ≥ 0.90 considered excellent, 0.80–0.89 good, 0.70–0.79 fair, and < 0.70 poor (Metz 1978). ROC curve analysis was conducted as described previously (Esliger et al., 2011) and cutpoints that maximised sensitivity (Se) and specificity (Sp) were derived (Perkins, and Schisterman 2006). Average acceleration values that fell between the

sedentary and MVPA cut-points were then classified as light PA, in line with prior work. Cut-points for light PA were classed as those higher than SB but lower than MPA but did not require AUC, Se or SP values to be determined as per other studies (Sanders, et al., 2018; Duncan, et al., 2019; Hildebrand, et al., 2014). These are subsequently labelled as not applicable (NA) in Table 1 and 2. ROC analysis was undertaken using the Statistical Package for Social Sciences (SPSS, version 25). Cutpoints reflected recommendations that the lower Se or Sp values should be ≥60% (Lugade, Fortune, Morrow, & Kaufman, 2014). This prioritization approach minimises the risk of individuals being misclassified in the target behaviour and is common in accelerometer calibration (Mackintosh, Fairclough, Stratton, & Ridgers, 2012) and fitness standards research (Welk, 2005).

In order to cross-validate the existing wrist based GENEActiv cut-points for the assessment of sedentary behaviour and moderate to vigorous physical activity the average acceleration values were also coded into sedentary, light, moderate and vigorous intensities using the previously validated cut-points by Sanders et al (2018), Hildebrand et al (2014; 2017) and Menai et al (2017). The average acceleration values for both the dominant and non-dominant wrists were coded into binary indicator variables (0 or 1) based on intensity (sedentary versus >sedentary, less than moderate versus moderate to vigorous, and vigorous versus <vigorous) in order for ROC analysis to be carried out as previously described (Esliger, et al., 2011). In this way we sought to compare how well the aforementioned cut points could classify intensity of the activities compared to the actual intensity determined by breath by breath indirect calorimetry and thus provide cross validation of their cut-points in an independent sample of adults, compared to the sample they were originally validated with.

Results

Results from indirect calorimetry are presented in Figure 1. Being lay supine and seated reading were classified as sedentary in nature (<1.5 METs), laundry was classified as light (1.51-2.99 METs) and slow, medium and fast walking and cycling were classified as moderate intensity (>3 METs). Mean values for sweeping indicated it was moderate intensity, however there was considerable variation in the individual energy costs for sweeping where energy costs for 11 participants were of light intensity but for the remaining 12 participants sweeping was moderate in nature.

Figure 1 here

Calibration of accelerometry for the assessment of SB and PA in a sample of adults aged 55-80 years.

Pearson's product moment correlations indicated significant weak-moderate relationships between METs and average acceleration at the non-dominant wrist (r = .188, P = .0001), dominant wrist (r = .174, P = .0001), waist (r = .599, P = .0001) and a moderate relationship at the ankle (r = .755, P = .0001). When analysis was rerun removing cycling-based activity the strength of the relationship between METs and GENEActiv counts at each location increased. Pearson's r values between METs and GENEActiv counts were r = .259 (P = .0001) for the non-dominant wrist, r = .270 (P =

.0001) for the dominant wrist, r = .771 (P = .0001) for the waist and r = .817 (P = .0001) for the ankle, demonstrating appropriate criterion validity.

ROC curve analysis for the GENEActiv monitors worn at the non-dominant wrist, dominant wrist, waist and dominant ankle were able to discriminate different intensities of activity. Sensitivity, specificity, AUC and resultant cut-points for each GENEA monitor are presented in Table 1. Discrimination of sedentary activity was good for the non-dominant wrist and excellent for dominant wrist, waist and ankle placement locations. Discrimination of MVPA behaviour was good for the waist, excellent for the ankle and poor for the dominant and non-dominant wrists. The ankle location performed better than other locations, with excellent discrimination for all intensities.

As the stable position of the wrist during cycling resulting in EE being misclassified when using wrist worn accelerometers, data were reanalysed with cycling activity removed from the analysis (See Table 2). This is similar to process used in recent work examining accelerometer performance in children (Duncan, et al., 2019). When this additional analysis was undertaken, discrimination of sedentary activity remained excellent for dominant wrist, waist and ankle and good for the non-dominant wrist. For MVPA activity, discrimination of activity was considered excellent for placement at the ankle, waist and the non-dominant wrist, and fair for placement on the dominant wrist.

Table 1 & 2 Here

Cross validation of previously validated wrist based cut-points

Table 3 shows the AUC, sensitivity and specificity for the Sanders et al (2018), Hildrebrand et al (2014; 2017) and Menai et al (2017) cut-points in correctly classifying activity intensity. ROC analysis indicated that all of the cut points were classed as 'fair' in distinguishing both sedentary behaviour and moderate to vigorous physical activity.

Table 3 Here

Discussion

The present study provides new data calibrating wrist, hip and ankle worn accelerometry using the GENEActiv accelerometer for the assessment of SB and MVPA in a sample of adults aged 55-80 years. This is the first study to evaluate the utility of the GENEActiv accelerometer across multiple wear locations in a sample of older adults, and as such presents an original contribution to the literature. The current study also presents independent cross-validation of the existing GENEActiv wrist-worn cut points for the assessment of SB and MVPA in a sample of adults aged 55-80 years.

The accelerometers at each wear location demonstrated acceptable criterion validity with METs, however the strength of association of Pearson's product moment correlation was lower when cycling activity was included in the protocol. This was particularly the case for accelerometers worn at the wrist and the waist. The inclusion of cycling with accelerometer calibration protocols has been a point of debate. Cycling

is health enhancing PA but results in minimal movement at the waist and wrist, compared to other more ambulatory activities and often results in misclassification of cycling activity by accelerometers worn at the wrist and waist (Welch et al. 2013). In the present study the strength of association between METs and accelerometer counts from the wrist and waist were weaker when cycling was included compared to when it was removed from the protocol. Irrespective of protocol, the strongest association and therefore best criterion validity, between accelerometer counts and METs was for the ankle wear location. Such a finding aligns with recent work which also highlighted the utility of ankle worn accelerometry for estimating PA in youth (Crouter, et al., 2018; Duncan, et al., 2019).

ROC curve analysis also supports the utility of ankle worn accelerometry given that the largest AUC values were found for MVPA assessment at this wear location. The results of the present study extend prior work in this area (e.g., Sanders et al. 2018; Menai et al. 2017; Hildebrand et al. 2014) that have used calibration activities involving predominantly ambulatory activity and examined wrist worn devices. These aforementioned studies provide distinct AUC data and subsequent cut-points for the waist and wrist. Adult movement patterns are omnidirectional and rarely comprise solely of walking/running type activity, therefore Bassett, Rowlands, & Trost, (2012) recommended that activities in calibration studies should be varied and not solely ambulatory. In the current study we included cycling, given its role as a lifelong health enhancing physical activity, and two activities of daily life (folding laundry and sweeping). It is important to note that there are differences across prior calibration studies in terms of activities involved, data collection and laboratory environment in which data took place. For example, Sanders et al. (2018) assessed 34 participants in 16 activities, each lasting three minutes in duration while Menai et al. (2017) used a

cut-off of 100mg in a sample of over 3000 adults in free living situations. There are pros and cons to different calibration approaches and, in such circumstances, we may assume there will be differences between data derived from the calibration sample and independent cross-validation. However, independent cross validation using comparable activities is needed to fully ascertain if calibration derived cut-points are transferable to other activities of the same intensities as derived in initial calibration.

The results of the current study are supportive of work conducted by Crouter et al (2018) suggesting ankle worn accelerometry has potential to measure PA accurately in youth. Other work using Actigraph accelerometers with adolescents (DeVries, Engels, & Garre, 2011) has suggested waist placement may be better than the ankle in predicting adult PA using artificial neural networks. Conversely, research using the Actical accelerometer (Heil, 2006) has reported no differences in EE estimation from devices worn at the wrist, ankle or waist. No study to date has examined the utility of GENEActiv accelerometers worn at the ankle to classify physical activities in older adults. It is therefore not possible for the present study to draw comparisons with prior work on this population. However, in the present study, ankle worn accelerometry offers a more accurate means to estimate PA whereas the waist location provides a marginally better site than the ankle and dominant wrist for the assessment of SB in older adults. The results presented here empirically confirm, for the first time in an older adult population, conclusions made by Clark et al. (2018) that there may not be a ‘one size fits all’ in terms of accelerometer location to characterise all types and intensity of SB and PA.

The data presented here are based on activities conducted in a laboratory setting and using standardised data collection and processing procedures. This is an important first step to calibrate the accelerometer against indirect calorimetry derived

EE. We are conscious of issues such as the Hawthorne effect, where participants may modify behaviour due to the knowledge they are being observed and, as such the next step for researchers is to cross-validate the cut-points derived in the present study in free living situations. Comparing accelerometer counts worn at all four locations against estimates of EE from direct observation or, if possible, expired gas, in more ecologically valid settings where different types of PA (e.g., leisure activity, household tasks) are typically performed would be a useful future research study. To that end, we also used the data from our sample to cross validate previously calibrated GENEActiv cut-points that have been used with older adults by Sanders et al (2018), Hildebrand et al (2014; 2018) and Menai et al (2017). These cut-points were however only calibrated for the wrist (Hildebrand, et al., 2014, 2018, Menai, et al., 2017) or wrist and hip (Sanders, et al., 2018) as no prior study has examined the utility of ankle worn GENEActiv accelerometers in older adults. The present study suggests that the aforementioned cut-points for both SB and MVPA classify these activities to a 'fair' standard when applied to our data. Of note the ENMO metric was employed in the present study. In the ENMO metric acceleration is averaged rather than summed. This makes the values independent of epoch length and the epoch length independent of sampling frequency, resulting in a metric which is easier to compare across studies (Hildebrand, et al., 2014). Using such approaches is a strength of the current paper and fits with recent advances in use of novel accelerometer analytics (e.g., Rowlands, et al., 2018; Fairclough, et al., 2019). Future work taking the same approach and integrating with other accelerometer metrics, such as intensity gradient (Fairclough, et al., 2019), and in free living situations would be welcome. Although the use of accelerometers to assess PA is becoming widespread, due to their ability in collecting objective measures of movement intensity and volume for relatively long periods of

time, they also fail to fully capture the context of PA and there remain challenges in the use of accelerometery to accurately assess some movements. The use of cycling in the present study is a good example whilst other sport and exercise movements may also be poorly classified using accelerometry only, depending on the location of accelerometer placement.

In the current study, participants were healthy adults aged 55-77 years of age and normal gait and no musculoskeletal impediments that impeded movement. The results presented here should be taken as indicative of this group. The laboratory protocol employed also comprised sedentary behaviour, ambulatory activity of different intensities, two activities of daily living and a bout of cycling. We used this protocol to represent activities that an older adult population might engage in. However, other laboratory based accelerometer calibration work (e.g., Montoye, Mudd, Biswas, & Pfeiffer, 2018b; Sanders, et al. 2018) has used a wider range of movement activities, albeit for a shorter period of time per activity, than is the case in the present study. It would therefore be useful for future work to cross validate the cut-points presented here for wrist, hip and ankle locations by using an protocol comprised of additional activities of daily living compared to those used in our initial calibration. Cross validating the current study with existing data sets that used a similar protocol but with another age group could also provide information regarding the transferability of recommended cut-points for PA intensity classification.

We are also conscious that although ankle worn accelerometry produced better classification of PA we did not examine any issues around compliance to ankle worn accelerometry wear protocols. Compliance to wear protocols in habitual physical activity studies are also important. Prior research (Tudor-Locke, et al., 2015) has suggested acceptable compliance rates using ankle worn accelerometry over 24

hours. To the authors' knowledge, no study to date has examined this issue using the GENEActiv accelerometer and in older adults. Such work would be useful in translating the results of the current study into wider use for multi day assessment of physical activity. The current study also used a standardised approach for accelerometer calibration where intensities for SB and moderate PA and above were defined and an assumption is made that activity counts falling between SB and Moderate PA are light in nature. This is consistent across prior studies (e.g., Sanders, et al., 2018; Duncan, et al., 2019), where light PA is not well investigated. Given the findings in the current study suggest that folding laundry, an important household task, is light intensity, it is important for future studies to examine the accuracy of estimations of light PA. Of note, the protocol employed in the present study did not result in participants undertaking EE of a vigorous intensity. Therefore, the cut-points established represent the threshold for MVPA only. While the MVPA threshold is essential for classifying whether individuals meet current physical activity guidelines, understanding differentiation of moderate and vigorous physical activity would be a useful next step.

This study enhances the literature in the area of physical activity assessment by quantifying EE in different tasks indicative of daily living and also calibrating the GENEActiv accelerometer during these physical activities when worn at different body locations. The results of the current study suggest that GENEActiv accelerometers demonstrated acceptable criterion validity to assess SB and MVPA. Ankle worn accelerometry appears to provide the most suitable wear location to quantify MVPA and waist worn accelerometry provides the most suitable wear location to quantify SB, in apparently healthy adults aged 55-77 years.

Funding: none

Conflicts of Interest: All authors declare they have no conflicts of interest

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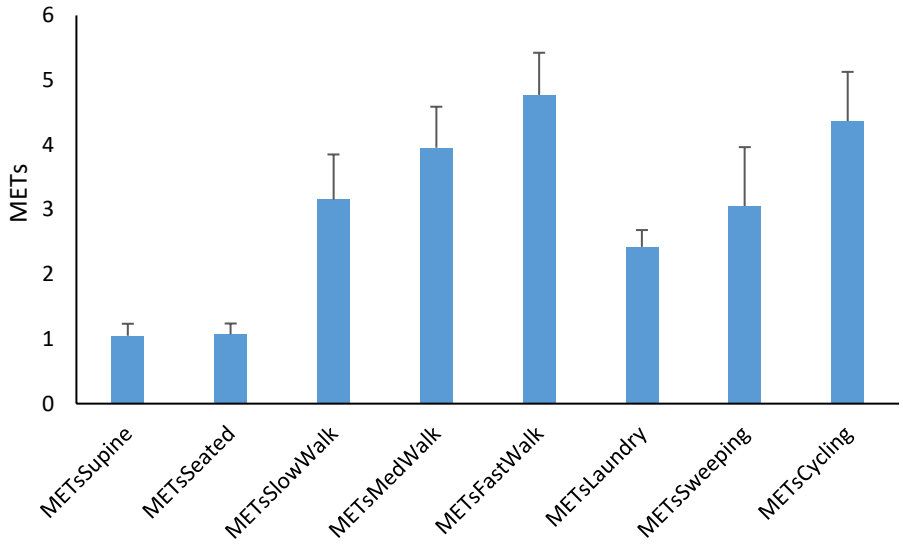

Figure 1. Mean ± SD of METs in activities undertaken reflective of different levels of PA

Table 1. Sensitivity, specificity and area under the curve and resultant cut-points for each GENEA monitor.

Intensity	Location	AUC	95% CI	Sensitivity	Specificity	Cutpoint (g)
Sedentary	Non-Dominant Wrist	.821	.808-.934	78.1	78.9	17.5
	Dominant Wrist	.910	.900-.920	88.2	83.8	10.1
	Waist	.915	.907-.923	85.9	84.1	11.7
	Ankle	.910	.901-.917	89.8	93.7	12.1
Light	Non-Dominant Wrist	NA	NA	NA	NA	17.6-121.8
	Dominant Wrist	NA	NA	NA	NA	10.1-18.1
	Waist	NA	NA	NA	NA	11.7-54.9
	Ankle	NA	NA	NA	NA	12.2-34.0
MVPA	Non-Dominant Wrist	.659	.643-674	86.6	64.6	121.9
	Dominant Wrist	.692	.677-.707	79.0	60.3	18.2
	Waist	.847	.836-.858	73.1	85.8	55.0
	Ankle	.936	.929-.942	73.3	86.4	34.1

Table 2. Sensitivity, specificity and area under the curve and resultant cut-points for each GENEA monitor with cycling removed from analysis.

Intensity	Location	AUC	95% CI	Sensitivity	Specificity	Cutpoint (g)
			Sedentary			
Sedentary	Non-Dominant Wrist	.814	.801-.827	73.8	80.7	19.2
	Dominant Wrist	.977	.973-.981	77.2	88.1	20.2
	Waist	.922	.914-.929	79.6	89.3	11.3
	Ankle	.974	.969-978	76.5	90.5	21.3
			Light			
Light	Non-Dominant Wrist	NA	NA	NA	NA	19.3-89.7
	Dominant Wrist	NA	NA	NA	NA	20.3-113.8
	Waist	NA	NA	NA	NA	11.4-55.8
	Ankle	NA	NA	NA	NA	21.4-114.9
			MVPA			
MVPA	Non-Dominant Wrist	.912	.902-922	67.4	80.6	89.8
	Dominant Wrist	.715	.700-.730	64.8	79.8	113.9
	Waist	.905	.896-.914	80.5	85.8	55.9
	Ankle	.904	.882-.909	89.0	86.1	115.0

Table 3. Area under the curve (AUC), sensitivity (%) and specificity (%) of the Sanders et al (2018), Hildebrand et al (2014; 2016) and Menai et al (2017) wrist worn cut-points for sedentary and moderate to vigorous physical activity from indirect calorimetry in a sample of British adults aged 55-77 years old

	Non-Dominant Wrist			Dominant Wrist		
Intensity	AUC	Sensitivity (%)	Specificity (%)	AUC	Sensitivity (%)	Specificity (%)
Sanders et al (2018)						
Sedentary	.669	71	80	.730	76	89
MVPA	.569	59	64	.656	62	59
Hildebrand et al (2014; 2016)						
Sedentary	.599	51	91	.620	51	93
MVPA	.623	79	59	.656	76	61
Menai et al (2017)						
MVPA	.626	81	61	.607	78	62