AGE-RELATED DIFFERENCES IN OBJECTIVELY MEASURING POPULATION-SPECIFIC PHYSICAL ACTIVITY INTENSITY AND SEDENTARY BEHAVIOUR

Declan Ryan[1], Jorgen Wullems[1], Georgina Stebbings[1] and Gladys Onambele-Pearson[1]
[1]Manchester Metropolitan University, Crewe, Cheshire, United Kingdom

Manchester Metropolitan University

Introduction

Objectively measuring **sedentary behaviour** (SB) **physical activity** (PA) levels through **accelerometry** utilises **regression equations** to determine the metabolic equivalent task (METs) for a given accelerometer output. These regression equations are developed through protocols that analyse accelerometer outputs and oxygen utilisation for a given PA.

To convert oxygen utilisation to METs, the '3.5 ml·kg·min^{-1} = 1 MET' equivalent is used. However, 1 MET should represent resting metabolic rate (RMR) [1].

RMR declines throughout the **ageing** process [2]. Therefore applying the '3.5 ml·kg·min^{-1} = 1 MET' equivalent could indicate that a given SB/PA is of the same intensity for young and elderly populations due to accelerometer outputs being similar when, in reality, the given physical activity is of a higher intensity for the elderly population [3].

Therefore, the aim of this study was to examine the **difference in SB/PA intensity classification** when applying 3.5 ml·kg·min^{-1}, and the mean observed RMR of elderly or young persons to the calculation of METs.

Methods

Three elderly (75 ± 13.1 yrs) and three young (24 ± 2.1 yrs) participants underwent an incremental **SB/PA protocol** that consisted of **nine stages** (see Figure 1.) in order to produce SB's and PA's that fell within the MET thresholds (SB < 1.5 METs, light intensity PA 1.5 – 2.99 METs, moderate intensity PA ≥ 3.0 METs, vigorous intensity PA ≥ 6.0 METs [4]).

Participants began with 20 minutes of rest in a quiet semi-darkened room. Each stage lasted three minutes with oxygen utilisation collected during the last minute of each stage using indirect calorimetry.

RMR was measured whilst the participant was performing a four minute seated stage. Two, one minute samples were collected in the final two minutes of the stage. Oxygen utilisation was converted to METs using the '3.5 ml·kg·min^{-1} = 1 MET' equivalent as well as the mean observed RMR = 1 MET for young and elderly persons. Participants also wore a triaxial accelerometer on each thigh, mounted anteriorly at 50% of femur length using adhesive patches.

The accelerometer output, Residual G, was calculated using the equation [5]:

$$=\sqrt{(x \text{ axis SD}^2 + y \text{ axis SD}^2 + z \text{ axis SD}^2)}$$

(standard deviations (SD) for 10 second epoch data)

Figure 1. MET threshold test. A Young participant performing the self selected walking speed stage. **B** Elderly participant performing the ambulation stage. The nine stages of the entire protocol included: supine, seated, standing, ambulation (30 cm steps side to side), self-selected walking speed, 3.2 km·h^{-1}, 1% incline treadmill walking, 1% incline self-selected treadmill walking speed, 1% incline self-selected walking speed with a weighted vest of 15% body weight, 1% incline self-selected quickest possible walking speed (no quicker than 6.5 km·h^{-1}).

Statistical Analysis

SPSS v21 was used to process all data. Following parametricity checks, an independent samples **Mann Whitney U** test was used to identify differences between the RMR of young and elderly persons. A similar analysis was run for the standard '3.5 ml·kg·min^{-1} = 1 MET' equivalent.

Mixed designed rANOVA's were used to ascertain any main effect of age (young vs elderly), SB/PA intensity (9 stages) , and any interaction between the two. This was carried out for the outcome measures of (i) Residual G, and (ii) METs. Data is presented Mean ± SD. Statistical significance was set at $p \le 0.05$.

Results

Table 1. Between age group difference in mean RMR.

Population	RMR (ml·kg·min^{-1})
Elderly	1.92 ± 0.119*§
Young	2.66 ± 0.345§

* RMR different between age groups ($p < 0.05$). § Measured RMR is lower than the standard '3.5 ml·kg·min^{-1} = 1 MET' equivalent normally used to calculate METs ($p < 0.05$). The RMR of both groups was lower than the standard 3.5 ml·kg·min-1 normally used to calculate METs while the RMR of elderly persons was lower than that of young persons ($p < 0.05$).

Table 2. Pearson correlations between accelerometer output and MET values.

Grouping	Explained Variance (r^2) (%)
Elderly RMR METs	81.0*
Young RMR METs	91.0*
Pooled RMR METs	63.0*
Elderly 3.5 METs	64.0*
Young 3.5 METs	91.0*
Pooled 3.5 METs	67.0*

* Significant correlation ($p < 0.05$). Residual G had strong correlations with RMR derived MET values for both groups ($p < 0.05$). However, a strong correlation was also found between Residual G and 3.5 ml·kg·min^{-1} derived MET.

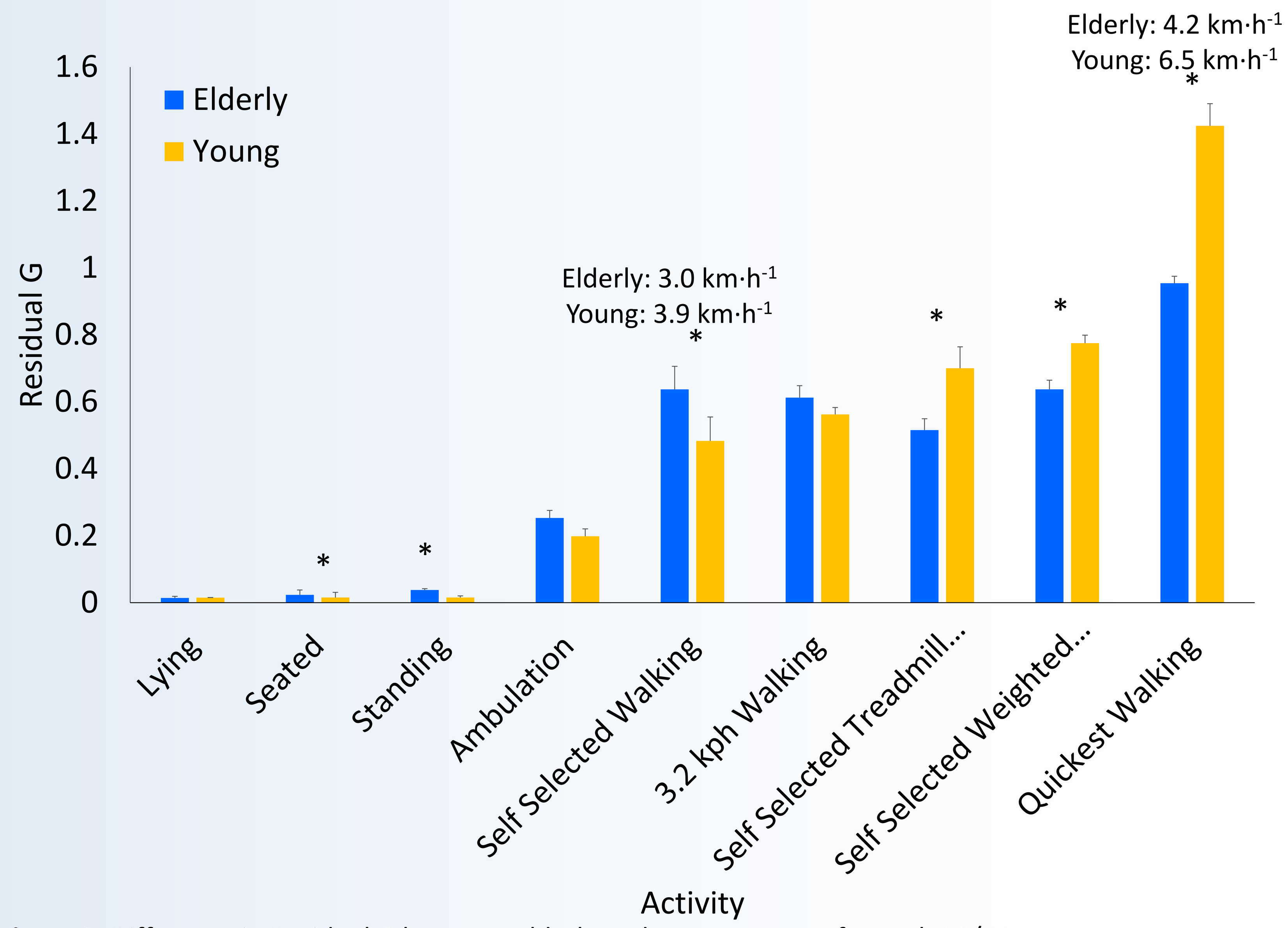

Figure 2. Difference in Residual G between elderly and young persons for each SB/PA stage.
* Difference between elderly and young person's Residual G for the given stage ($p < 0.05$). Speeds labelled on the graph indicate the mean speed chosen by each age group for self selected treadmill stages.

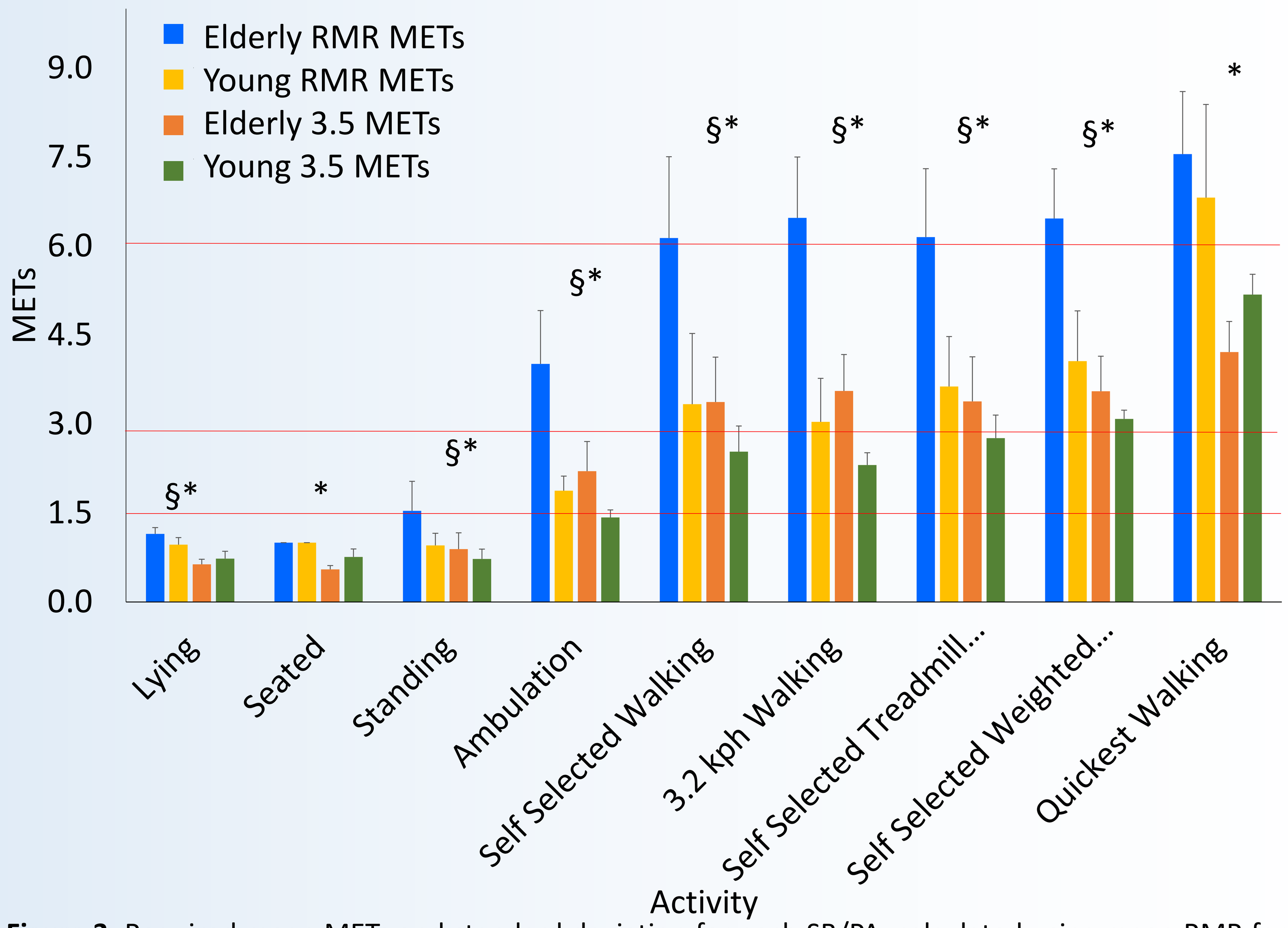

Figure 3. Required mean METs and standard deviation for each SB/PA, calculated using mean RMR for elderly and young persons and the standard '3.5 ml·kg·min^{-1} = 1 MET' equivalent. Red lines indicate MET threshold values for light, moderate, and vigorous intensity PA. § Difference between elderly and young person's METs ($p < 0.05$). * RMR derived METs different from 3.5 derived METs for both groups ($p < 0.05$).

The **Residual G** of the **young** group was different to that of the **elderly** group for **five out of the nine** stages ($p < 0.05$) (Figure 2.)

Calculating 1 MET **using 3.5 ml·kg·min^{-1}** instead of RMR **caused 77.7%** of the SB/PA to be **misclassified** under the wrong SB/PA intensity for the **elderly** group.

Calculating 1 MET **using 3.5 ml·kg·min^{-1}** instead of RMR **caused 44.4%** of the SB/PA to be **misclassified** under the wrong SB/PA intensity for the **young** group.

The **elderly** group found **66.6%** of the SB/PA to be of a **higher intensity** than the **young** group when MET values were calculated using **RMR**.

The **elderly** group found **44.4%** of the SB/PA to be of a **higher intensity** than the **young** group when MET values were calculated using standard **3.5 ml·kg·min^{-1}** (Figure 3.).

Discussion

Accurately assessing time spent performing different SB/PA intensities is essential to clarifying relationships between SB/PA and health status. As ageing occurs, **daily activities** can become more physically demanding [3], therefore accelerometer **cut-points** should be **population specific**. Indeed we show here that whilst accelerometer outputs for a given task may be similar between groups (Figure 2.), elderly populations may find the task to be more physically intense (Figure 3.). Additionally, using **RMR** derived METs **truly reflects** how intense a **SB/PA** is, since using the standard **'3.5 ml·kg·min^{-1} = 1 MET'** frequently **underestimates** the intensity of PA's for both **elderly** and **young** populations (Figure 3.).

Conclusion

SB/PA intensity accelerometer cut-points should be population specific and derived from RMR based MET values to **prevent misidentification** of time spent performing different **free-living** SB/PA intensities.

References

1 Jette, M., Sidney, K., & Blümchen, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clinical Cardiology 13.8: 555-565. **2** Krems, C., Lührmann, P.M., Straßburg, A., Hartmann, B., & Neuhäuser-Berthold, M. (2005). Lower resting metabolic rate in elderly may not be entirely due to changes in body composition. European Journal of Clinical Nutrition 59: 255-262. **3** Miller, N. E., Strath, S. J., Swartz, A. M., & Cashin, S. E. (2010). Estimating absolute and relative physical activity intensity across age via accelerometry in adults. Journal of Aging and Physical Activity, 18(2): 158-170. **4** American College of Sports Medicine. (2013). ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins. **[5]** Onambele, G. L., Narici, M. V., & Maganaris, C. N. (2006). Calf muscle-tendon properties and postural balance in old age. Journal of Applied Physiology, 100(6): 2048-2056.