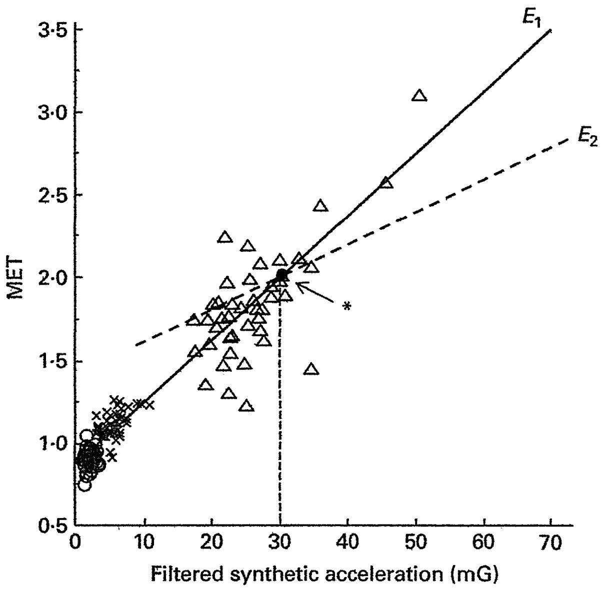

Fig. 5. Relationship between measured metabolic equivalents (MET) and filtered synthetic accelerations during sedentary activities in the validation group (n 44). E_1 (r 0·942, $P<0·001$, standard error of estimate 0·151 MET), regression line for sedentary activities; E_2, regression line for household activities. *Threshold point for the classification between sedentary and household activities (29·9 mG). Dishwashing was included in both E_1 and E_2. ○, Resting in the supine position; ×, personal computer work; △, dishwashing.

and developing equations. However, our accuracies for some activities, such as personal computer work, vacuuming and dishwashing, are slightly better than the results obtained by Crouter *et al.*(18–21,34), who used two equations with a classification algorithm based on the CV of the acceleration count. Moreover, our model possesses the following advantages over previous models: (1) our classification algorithm is accurate but simple, leading to immediate estimation of PA intensity following a long period of data collection; (2) our measuring device is secured to the waist by a clip only; (3) the Douglas bag method, not a portable analyser, was used as the reference method; (4) MET were calculated with measured RMR (not 3·5 ml/kg per min or 4·2 kJ/kg per h (1 kcal/kg per h)); (5) values from a triaxial accelerometer, not a uniaxial accelerometer, were used for developing equations.

Several algorithms have been developed for PA classification. These algorithms were constructed using the CV of the acceleration count based on the ActiGraph or Actical devices(18–21,34) or using the ratio of vertical acceleration counts to horizontal acceleration counts based on the ActivTracer device(22,25). In these studies, the percentage of correct classifications does not seem to be high, even for the subjects used in the classification development. Our algorithm may classify locomotive and household activities with higher accuracy. On the other hand, other reported classification algorithms(26,35,36) were developed to divide PA into further subtypes. These additional divisions require a large quantity of data, a complex calculation process or the placement of sensors over the whole body; it is difficult to maintain battery power over long periods, to check PA intensities in real time and to wear and remove the device easily. Our device is worn just on the waist, is held by a clip and PA intensities were displayed immediately. This unique device is useful for applied researchers or professional health advisers to investigate PA in the field, and general users can monitor their activity status by themselves, as the commercial product has an liquid crystal display that can indicate real-time MET values or step counts.

We employed the Douglas bag method as a reference for measuring EE, while previous studies used a portable metabolic system such as Aerosport TEEM 100 or COSMED K4b2. For these portable metabolic systems, validation of assessing EE during PA has been reported(37–40). A portable metabolic system also has the advantage of measuring various dynamic activities outdoors. However, portable metabolic systems slightly overestimate or underestimate O_2 uptake during exercise testing, compared with reference methods(40–43). Therefore, the Douglas bag method may be preferable to a portable metabolic system as a reference method for measuring EE during various types of PA.

Whether measured values or a constant value of 3·5 ml/kg should be used for the RMR value of 1 MET is debatable. Typical values for the normal-weight population were 3·5 ml/kg per min and 4·2 kJ/kg per h (1 kcal/kg per h). However, average measured RMR were much lower than 3·5 ml/kg per min or 4·2 kJ/kg per h (1 kcal/kg per h) in 671 subjects, although many were overweight or obese(44). In particular, body composition contributed to the variance in RMR. In the present study, the average RMR value was 4·1 kJ/kg per h (0·99 kcal/kg per h), but the standard deviation was relatively large (0·8 kJ/kg per h (0·19 kcal/kg per h)). To our knowledge, no description exists of whether the RMR value of 3·5 ml/kg per min was previously measured in a fasting state(45), although the present study and Byrne *et al.*(44) measured RMR in the fasting state. Therefore, the use of measured RMR as 1 MET could lead to increased accuracy of estimating the intensity of PA.

A triaxial accelerometer, capable of measuring both vertical and horizontal accelerations, is more informative than a uniaxial accelerometer, possibly permitting more accurate estimates of PA intensities. However, previous studies(16,25,46) have reported that the accuracy of estimating PA intensities did not differ between triaxial and uniaxial accelerometers if these values were estimated by a one-equation model. Although our classification algorithm can calculate the cut-off threshold even using a uniaxial accelerometer count, we confirmed that the classification developed with a synthetic accelerometer count is more accurate than that based only on a vertical (uniaxial) accelerometer count. Therefore, our estimation by triaxial accelerometer counts should lead to increased accuracy compared with a uniaxial accelerometer.

The present study had several limitations. We could not accurately estimate the intensity of ascending and descending stairs. Although previous studies(18–21,36) have estimated the intensities of these activities relatively well, validity was assessed by a condition combining ascension and descension of stairs, with only Yamazaki *et al.*(47) performing the individual assessments. Under daily living conditions, ascending and descending stairs are normally performed separately, and thus these activities should be assessed separately. In addition, we did not include stationary ergometer or cycling in the present study. Furthermore, the developed model tended to underestimate higher vigorous intensity activity. Therefore, future studies are needed using the doubly labelled water method or a metabolic chamber to investigate the validity of our model. In addition, studies are needed to compare our accelerometer with other types of accelerometers under free-living conditions. Furthermore, more investigation is needed to determine how well the model developed in the present study applies to other populations such as obese individuals or children.

We have recently reported a simple but accurate classification algorithm to differentiate between locomotive and household activities, with a cut-off determined by the $\text{ACC}_{\text{unfil}}$:$\text{ACC}_{\text{fil}}$ ratio(27). Additionally, sedentary activities could be discriminated from household and locomotive activities with accelerometer counts. With this classification algorithm, our new model exhibited improved accuracy in estimating the intensity of various PA, compared with non-classification models. Furthermore, this new model is capable of estimating PA intensity immediately. Therefore, the method is useful for field investigations by scientists as well as for self-monitoring of activity by the general public.

Acknowledgements

The present study was supported by the Health and Labor Sciences Research Grants for Comprehensive Research on Cardiovascular and Life-Style Related Diseases from the Japanese Ministry of Health, Labor and Welfare (principal investigator: S. T.). Heartfelt thanks are due to the subjects who participated in the present study. We wish to thank the members of the National Institute of Health and Nutrition and Omron Healthcare Company Limited, especially Hiroko Kogure, Emiko Taguri, Rieko Miyake, Ryosuke Doi and Kaori Kawaguchi for their help in data acquisition and analysis. K. O., S. T., Y. O., Y. H., K. I.-T. and I. T. designed the study; K. O., S. T., Y. O., Y. H. and K. I.-T. performed the experiments; K. O., S. T. and Y. O. analysed the data; K. O., S. T. and Y. O. wrote a draft of the manuscript; Y. H., K. I.-T. and I. T. reviewed and edited the manuscript. None of the authors had a conflict of interest.

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