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Validation of the Phillips et al GENEActiv accelerometer wrist cut-points in children aged 5-8 years old.

Abstract

This study examined the accuracy of the Phillips et al. GENEActiv accelerometer wrist worn cut-points in children aged 5-8. Fifteen children (6 girls, 9 boys) aged 5-8 years wore a GENEActiv monitor on their non-dominant wrist while undertaking 5 minute bouts of lying supine, playing Lego, walking at slow, medium and fast pace and running. Receiver Operating Curve (ROC) analysis was employed to establish how well the Phillips et al (2013) cut points classified intensity of the activities compared to the actual intensity determined by indirect calorimetry. Area Under the Curve (AUC) values were high for sedentary (.970), moderate (.815) and vigorous (.974) activity.

Conclusion: The Phillips et al (2013) cut-points for the GENEActiv accelerometer can be used in children aged 5-8 years old to distinguish sedentary behaviour, moderate and vigorous PA behaviour.

What is Known:

- Accelerometers are fast becoming the most widely used measure of physical activity in public health research.
- The GENEActive wrist worn accelerometer has been validated for use with children aged 8 years and older

What is New:

- The GENEActive wrist worn accelerometer can be used to assess physical activity in children aged 5-8 years old.

- Previously established cut-points for the GENEActiv accelerometer can be used in children aged 5-8 years old to distinguish sedentary behaviour, moderate and vigorous PA behaviour.

Keywords: Accelerometry; Physical Activity; Validation; Preschoolers

List of Abbreviations

AUC: Area Under the Curve

BMI: Body Mass Index

MET: Metabolic Equivalent

PA: Physical Activity

ROC: Receiver Operating Curve

Introduction

Accelerometers are becoming the most widely used measure of physical activity (PA) in public health research [1] and there are multiple accelerometry based devices now available that purport to assess PA and sedentary behaviour. Recently, the GENEActiv accelerometer has gained popularity with researchers as a means to assess PA, particularly because it is designed to be worn on the wrist, is waterproof has relatively long battery life, comparable to other monitors. The GENEActiv has been shown to be reliable and valid measure of PA in adults [2] and children [3].

Given PA recommendations for health emphasise accumulation of moderate to vigorous PA, [4] accelerometry based PA often use cut-points to determine the time spent in different intensities of PA [1]. Only one study has established wrist-mounted cut-points for British children and only for children aged 8 years or older [3]. To our knowledge no authors have examined the validity of these cut-points in children under the age of 8. This study examined how well the Phillips et al [3]. cut-points for sedentary, moderate and vigorous PA performed on an independent sample of British children aged 5-8 years old.

Method

Participants

An opportunistic sample of 15 healthy, Caucasian, children (6 girls, 9 boys) aged between 5 and 8 years of age (6.8 ±1.4 years) from central England took part in this study following institutional ethics approval, parental informed consent and child assent. Mean ± SD of height, mass and body mass index (BMI), was 1.3 ± 0.1m, 27.1 ± 7.1 kg and 16.5 ± 2.3 kg/m^2 respectively.

Procedures

Participants wore a GENEActiv monitor on their non-dominant wrist, similar to other work [5], throughout the testing period. The GENEActiv has been described in detail previously [2]. The GENEActiv was set to record at 80Hz and 1s epochs. 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. Participants wore

a junior face mask (Hans Rudolph) and 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 GENEActiv monitor and gas analyser, each participant performed a series of activities reflective of different levels of PA. These were lying supine, seated and playing with Lego, slow walking, medium walking, fast walking and a medium run. These were performed in order as per prior work [3]. All activities were performed for 5 minutes with a 5 minute rest in between. Using previous protocols [6,7] as guidelines, walking and running speeds were set at 3kmph^{-1}, 4.5kmph^{-1}, and 6kmph^{-1} to represent slow, medium and fast pace walking and 8kph^{-1} was used for running. 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. Using the GENEActiv post processing software, the raw 80Hz triaxial GENEActiv data were summed into a signal magnitude vector (gravity subtracted) expressed in 1s epochs, as is conventional [2, 3]. The VO_2 values were then converted into METs using age-specific values [8] 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).

The accelerometer counts were coded into sedentary, light, moderate and vigorous intensities using previously validated cut-points for the non-dominant hand [3]. The counts were then 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 a Receiver Operator Characteristic (ROC) curve analysis to be conducted as described previously [2]. In this way we sought to compare how well the Phillips et al [3]. cut points for children could classify intensity of the activities compared to the intensity determined by indirect calorimetry and thus provide cross validation of their cut-points. ROC analysis was undertaken using the Statistical Package for Social Sciences (SPSS, version 21).

Results

Table 1 shows the AUC, sensitivity and specificity for the Phillips et al [3]. cut-points in correctly distinguishing the breath by breath derived MET values, alongside mean ± SD of METs for each intensity activity. ROC analysis indicated that the Phillips et al [3]. cut-points were able to successfully discriminate between all intensity levels. Sedentary and vigorous activity were the easiest to classify showing the largest AUC with light activity being the most difficult to classify and indicating the Phillips et al [3]. cut-points for light activity were only able to correctly classify this intensity of activity 62% of the time.

Insert Table 1 Here

Discussion

This study sought to provide cross-validation of the Phillips et al [3]. cut-points for the wrist worn GENEActiv accelerometer in British children aged 5-8 years of age. No

117 study to date has examined GENEActiv determined cut-points for PA in British children
118 below the age of 8 years. The results of the present study support of the validity of the
119 Phillips et al [3]. cut-points in British children aged 5-8 years of age for sedentary,
120 moderate and vigorous PA. There was relatively poorer performance for light cut-
121 points. This may because there is greater 'noise' in light PA for younger children,
122 making it more difficult to distinguish from sedentary activity [1]. Given that children
123 spend a large proportion of time in light PA there is a need to better classify light PA
124 using the GENEActiv to avoid misreporting of PA. The data presented here, based on
125 laboratory based activities that were predominantly ambulatory in nature, suggest that
126 the Phillips et al [3]. cut-points can distinguish sedentary, moderate and vigorous PA
127 well. As locomotor activity is however the predominant activity in an individual's day
128 the validation of accelerometers during this activity is of primary importance [9]. The
129 protocol employed in the present study is comparable to those used previously to
130 validate accelerometers in pediatric populations [3, 7]. However, the study is limited
131 by the relatively small sample size. The time commitment needed by participants,
132 particularly given their age, limited our ability to recruit a larger sample. Post-hoc
133 power calculations indicate statistical power was 0.69, with an effect size of 0.25 and
134 P =0.05. We also used a fixed order of activities moving from sedentary to vigorous,
135 as per other work [3]. This might also be a limitation given the sporadic nature of
136 children's PA and the possibility of an order effect where fatigue from earlier activity
137 bouts may have influenced later activity bouts. METs were used as the criterion for the
138 cut-points, as per other studies [3]. However, using a percentage of METs at VO_2 max
139 as a criterion may be preferable in future work. Although we captured accelerometer
140 data across a range of PA intensities, including inactivity, future research would be

141 welcome examining the accuracy of the GENEActiv accelerometer during other free
142 living activities.

143

144 **Author Contribution:** MD and EE devised the Study. MD, SW, JT and EE collected
145 data and wrote the manuscript. MD performed statistical analysis.

146 **Compliance with Ethical Standards:** All procedures performed in studies involving
147 human participants were in accordance with the ethical standards of the institutional
148 and/or national research committee and with the 1964 Helsinki declaration and its later
149 amendments or comparable ethical standards

150 **Conflict of Interest:** None

151

152 **References**

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Table 1. Area under the curve (AUC), sensitivity (%) and specificity (%) of the Phillips et al. (2013) wrist worn cut-points in classifying physical activity intensity from indirect calorimetry in a sample of British children aged 5-8 years old (Data collected 2016).

Intensity	AUC	Sensitivity (%)	Specificity (%)	METS Mean (S.D.)
Sedentary	.970	92	90	1.31 (0.24)
Light	.621	81	56	2.29 (0.47)
Moderate	.815	97	83	4.11 (0.4)
Vigorous	.974	96	84	6.35 (0.5)