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Original research

Equating accelerometer estimates among youth: The Rosetta Stone 2

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ABSTRACT

Objectives: Different accelerometer cutpoints used by different researchers often yields vastly different estimates of moderate-to-vigorous intensity physical activity (MVPA). This is recognized as cutpoint non-equivalence (CNE), which reduces the ability to accurately compare youth MVPA across studies. The objective of this research is to develop a cutpoint conversion system that standardizes minutes of MVPA for six different sets of published cutpoints.
Design: Secondary data analysis.
Methods: Data from the International Children's Accelerometer Database (ICAD; Spring 2014) consisting of 43,112 Actigraph accelerometer data files from 21 worldwide studies (children 3–18 years, 61.5% female) were used to develop prediction equations for six sets of published cutpoints. Linear and non-linear modeling, using a leave one out cross-validation technique, was employed to develop equations to convert MVPA from one set of cutpoints into another. Bland Altman plots illustrate the agreement between actual MVPA and predicted MVPA values.
Results: Across the total sample, mean MVPA ranged from 29.7 MVPA min d^{-1} (Puyau) to 126.1 MVPA min d^{-1} (Freedson 3 METs). Across conversion equations, median absolute percent error was 12.6% (range: 1.3 to 30.1) and the proportion of variance explained ranged from 66.7% to 99.8%. Mean difference for the best performing prediction equation (VC from EV) was −0.110 min d^{-1} (limits of agreement (LOA), −2.623 to 2.402). The mean difference for the worst performing prediction equation (FR3 from PY) was 34.76 min d^{-1} (LOA, −60.392 to 129.910).
Conclusions: For six different sets of published cutpoints, the use of this equating system can assist individuals attempting to synthesize the growing body of literature on Actigraph, accelerometry-derived MVPA.

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1. Introduction

Accelerometers are widely used for assessing free living physical activity levels of children and adolescents.[1–3] The data typically derived from accelerometers, activity counts, are most commonly processed using a set of calibrated and cross-validated cutpoints.[1,4] The use of cutpoints allows for the data to be distilled into categories of intensity ranging from sedentary to vigorous intensity, with these commonly reported as minutes per day (min d^{-1}).[5] Over the past decade, different sets of cutpoints have been developed for use in studies investigating the activity levels of youth (<18 yrs).[6–8] Thus, even when raw accelerometer count data between or among studies are very similar, the application of different cutpoints for estimating minutes of moderate-to-vigorous physical activity (MVPA) to those raw data offer vastly different estimates of MVPA.[9] Unfortunately, even though studies report physical activity in minutes per day, direct comparison cannot be made across studies employing different sets of cutpoints.

Put simply, activity intensity estimates can differ greatly between studies investigating the same population solely because of the cutpoints chosen by the researchers.[10,11] Bornstein et al. defined this problem as 'cutpoint non-equivalence' (CNE).[12] The overarching limitation inherent in CNE is that direct comparisons across studies measuring physical activity via accelerometry cannot be made since the outcome metric (min d^{-1}) is not equivalent, even though expressed in the same units. Thus, attempts at synthesizing a body of literature, disregarding CNE, leads to distorted and biased conclusions (e.g., combining studies using overly conservative cutpoints with studies using overly generous cutpoints). An example of this issue can be found in the recent Institute of Medicine report "Early Childhood Obesity Prevention Policies" where physical activity recommendations were made for preschool-age children by evaluating studies that provide different estimates of physical activity based on different cutpoints.[13] This scenario substantially impacts the soundness of public health policies and initiatives.

A solution to CNE has been proposed by Bornstein et al. who employed secondary data to devise a conversion system to translate reported MVPA estimates from one set of cutpoints into another.[12] Within the findings, originally disparate estimates of MVPA were able to be compared by using a conversion equation. For instance, comparing three studies that used three different sets of cutpoints reporting 91.2 min d^{-1}, 55.2 min d^{-1}, and 20.8 min d^{-1} of MVPA was problematic. But after applying the conversion equations the estimates were similar, 59.2 min d^{-1}, 55.2 min d^{-1}, and 58.0 min d^{-1} of MVPA,[12] and, therefore, logical evaluations could be drawn on daily MVPA between the three studies. Converting activity estimates into the same set of cutpoints for evaluation purposes allows practitioners, policy-makers, and researchers to interpret the abundance of evidence on physical activity levels of populations from a common standpoint.

Currently, there are no universally accepted cutpoints, and with the different methodological approaches to calibration studies,[14,15] discrepancies in MVPA estimates between studies (i.e. CNE) will continue. Bornstein et al.[12] provided a solution to CNE for preschool aged children, therefore, the purpose of this study is to illustrate the use of a conversion system that will translate MVPA (min d^{-1}) produced by one set of cutpoints to an MVPA (min d^{-1}) estimate using a different set of cutpoints for children and adolescents.

2. Methods

This is a secondary data analysis using existing pooled data from the International Children's Accelerometer Database (ICAD, http://www.mrc-epid.cam.ac.uk/research/studies/icad/; Spring 2014). This database was constructed to gather data on objectively measured physical activity of youth from around the world.[16,17] All individual studies went through their own ethics committee approval. The aims, design, study selection, inclusion criteria, and methods of the ICAD project have been described in detail elsewhere.[17] In short, a PubMed search and personal contacts resulted in 24 studies worldwide being approached and invited to contribute data. Inclusion criteria consisted of studies that used a version of the Actigraph accelerometer (Actigraph LLC, Pensacola, FL) in children 3–18 years with a sample size greater than 400.[17] After identification, the principal investigator was contacted, and upon agreement, formal data-sharing arrangements were established. All partners (i.e. contributors of data) consulted with their respective research boards to obtain consent before contributing their data to the ICAD. In total, 21 studies conducted between 1998 and 2009 from 10 countries contributed data to the ICAD. The majority of the studies were located in Europe ($N = 14$), with the United States, Brazil, and Australia contributing 4 studies, 1 study, and 2 studies, respectively.[17] All individual data within the pooled data set were allocated a unique and non-identifiable participant ID to ensure anonymity of data.

For the present analysis, data from all 21 studies on children and adolescents aged between 3 and 18 years were used. These data are comprised of 44,454 viable baseline and repeated measures files from a total of 31,976 participants (female 62.4%). A comprehensive description of the assessment of physical activity is available elsewhere.[17] Across all studies, Actigraph accelerometers were waist-mounted,[17] and all children with a minimum of 1 day, with at least 500 min of measured accelerometer wear time were included. The ICAD database epochs varied from 5 s to 60 s, therefore reintegrated 60-s epochs formed the pooled ICAD database.[17] Although the reintegration procedure may slightly over or underestimate MVPA,[18] it is commonly accepted when handling different epoch lengths.[19,20]

In an effort to provide researchers with physical activity data derived from a range of Actigraph cutpoints, the ICAD distilled intensity categories (e.g. sedentary, light, moderate, vigorous) from six commonly used Actigraph cutpoints.[17,21] After receiving the ICAD dataset, a MVPA variable was created for each of the six cutpoints. A breakdown of these cutpoints, along with their corresponding MVPA counts-per-minute can be found in Table 1. The cutpoints used by ICAD, and for analysis in this study, were Pate et al. (PT),[7] Puyau et al. (PY),[8] Freedson equation et al., where the MVPA threshold can be either 3 METs (FR3) or 4 METs (FR4),[22–24] Van Cauwenberghe et al. (VC),[25] and Evenson et al. (EV).[26]

The development and validation of the prediction equations followed a similar procedure previously used by Bornstein et al.[12] Linear and non-linear regression models, accounting for valid days and repeated measures on a single participant (i.e. longitudinal data) were used to develop the conversion equations. Due to the nature of the dataset, access to raw accelerometer count data were not available. However, an additional analysis was run to explore if any fixed effects existed between studies that collected data using 60 s epochs ($n = 14$), and studies employing shorter epochs (e.g. 5–30 s epochs, $n = 7$). A 'leave one out' cross-validation procedure was employed to assess how well each equation performed.[27] In this procedure, each study assumed the role of the validation sample and the remaining 20 studies were used as the derivation sample. This procedure was repeated 21 times until each study had served as the validation sample.

The development of the prediction equations included linear and non-linear terms where appropriate. Furthermore, key covariates were incorporated into the equations where these added significantly to the model including: age (years); gender; and wear time (average wear time per day in minutes). Inclusion criteria for

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Table 1
Accelerometer cutpoints associated with moderate-to-vigorous physical activity (MVPA) in children and adolescents aged 3–18 years.

MVPA Cutpoint	Symbol	Age (yrs.)																Mean[a]	SD
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Pate et al.	PT	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	77.5	38.5
Puyau et al.	PY	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	3201	29.7	21.4
Freedson et al. (3 METS)	FR3	369	446	527	614	706	803	906	1017	1136	1263	1400	1547	1706	1880	2068	2274	126.1	75.8
Freedson et al. (4 METS)	FR4	1090	1187	1290	1400	1515	1638	1770	1910	2059	2220	2392	2580	2781	3000	3239	3499	64.9	47
Van Cauwenberghe et al.	VC	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	2340	47.8	28.5
Evenson et al.	EV	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	2296	49.4	29.2

Note: All cut-points are presented as counts per minute (CPM).

[a] MVPA minutes per day ($N = 43{,}112$).

these variables were contingent upon a significant increase in the proportion of variance explained (R^2), and a reduction in the average error and absolute percent error. Average error (a) and absolute percent error (b) were calculated using the following formulae:

$$\sqrt{\left[\sum\frac{(Y-Yprime)^2}{(N-1)}\right]} \qquad \text{(a)}$$

$$\left[\frac{(Y-Yprime)}{Y}\right]\times 100 \qquad \text{(b)}$$

Above, Y is the actual MVPA value and $Yprime$ is the predicted MVPA value from the generated equation.[12] All equations containing significant demographic variables (e.g. age, gender, wear time) were reported. Finally, Bland Altman plots[28] were used to illustrate the agreement between the actual MVPA value and the predicted MVPA values. Limits of agreement were calculated as $[\dot{m} \pm (2 \times \dot{s})]$ where $\dot{m}$ is the mean difference between the actual and predicted MVPA, and $\dot{s}$ is the mean standard deviation.[28] All statistical analyses were performed using Stata (v.12.1, College Station, TX).

3. Results

The final ICAD sample consisted of 43,112 files, representing 31,113 children (female 61.5%) between the ages of 3–18 years. Table 1 displays the average MVPA in minutes per day ($\text{min}\,\text{d}^{-1}$) for the six sets of cutpoints for the entire sample. Across the six cutpoints, MVPA estimates were from PY 29.65 $\text{min}\,\text{d}^{-1}$ (±21.38), VC 47.81 $\text{min}\,\text{d}^{-1}$ (±28.52), EV 49.38 $\text{min}\,\text{d}^{-1}$ (±29.17), FR4 64.87 $\text{min}\,\text{d}^{-1}$ (±47.02), PT 77.55 $\text{min}\,\text{d}^{-1}$ (±38.49), and FR3 126.12 $\text{min}\,\text{d}^{-1}$ (±75.82). Prediction models with the corresponding proportion of variance explained, average error, and absolute percent error are displayed in Table 2. In total, 61 prediction equations were generated. With the exception of two of these equations (VC from EV, and EV from VC), age contributed significantly to the models, while gender was included in three models (VC from FR3, EV from FR3, and PY from FR3). The third covariate under consideration, wear time, did not contribute significantly to any of the models. Additionally, there were no fixed effects between studies that originally used 60 s epochs, and those studies collecting data in shorter epochs, therefore, this was not considered further in any of the models. Using the best model from each possible conversion, the mean absolute percent error was 12.6%, with 1.3% and 30.1% representing the minimum (VC from EV) and maximum (PY from FR3) percent error, respectively. The proportion of variance explained ranged from 66.7% (FR3 from PY) to 99.8% (VC from EV). Fig. 1(a) and (b) illustrates the best (VC from EV) and the worst (FR3 from PY) prediction equations in the form of Bland Altman plots. The mean difference for VC from EV was −0.110 $\text{min}\,\text{d}^{-1}$, with −2.623 to 2.402 representing the lower and upper bounds of the limits of agreement (LOA), respectively. The mean difference for FR3 from PY was 34.76 $\text{min}\,\text{d}^{-1}$ (LOA −60.392 to 129.910).

4. Discussion

The use of accelerometers provides researchers with a practical, reliable, and valid tool to objectively measure physical activity levels of children and adolescents. Despite these benefits, the widespread use of accelerometers in the field of physical activity measurement has continued to be burdened by CNE.[4,11,29] The use of different cutpoints has resulted in contrasting estimates of physical activity for children and adolescents, thereby, significantly limiting comparisons of the estimates of physical activity intensity and the prevalence of meeting physical activity guidelines.[9,15,29]

This study has built on the concept of cutpoint conversion first demonstrated by Bornstein et al.[11,12] for preschool-aged

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Table 2

Prediction equations to transform estimates of moderate-to-vigorous physical activity (MVPA; min d^{-1}) from one set of cutpoints into MVPA (min d^{-1}) estimated from another set of cutpoints.

Accelerometer cutpoint MVPA min d^{-1}		Prediction equations[‡]				Demographics			Leave one out cross validation[*]	
Outcome variable[a]	Predictor variable	Intercept	MVPA (min d^{-1})	MVPA (min d^{-1}) Squared	MVPA (min d^{-1}) Square root	Age (years)	Gender[b]	Adjusted R^2	Average error[c] (min/day)	Absolute % Error[d]
Freedson (4 MET)	Van Cauwenberghe	−4.5855	1.7206	−0.0026				0.611	34.68	30.9
	Van Cauwenberghe	118.5514	1.0465	0.0004		−9.0859		0.931	15.18	13.0
	Evenson	−2.9598	1.4872	−0.0017				0.618	34.30	30.6
	Evenson	117.2174	1.0222	0.0004		−9.0203		0.933	14.97	12.8
	Pate	−15.8486	1.0409					0.726	29.15	25.5
	Pate	112.5384	1.0780	0.0003	−5.2759	−7.7031		0.945	13.43	12.3
	Freedson (3 MET)	−10.0605	0.4168	0.0002	1.4270			0.904	15.94	14.9
	Freedson (3 MET)	−57.4086	0.5821	0.0002	0.3919	3.3287		0.921	15.06	13.6
	Puyau	−6.5762	0.7572	−0.0009	9.8330			0.498	39.82	36.3
	Puyau	133.2262	1.3785	−0.0015	1.5535	−9.9722		0.894	18.81	16.3
Van Cauwenberghe	Freedson (4 MET)	−10.6973	0.0346	−0.0001	7.5217			0.640	20.88	24.7
	Freedson (4 MET)	−112.7420	0.6121	−0.0009	5.8395	7.1432		0.916	10.35	11.5
	Evenson	−0.4432	0.9772					0.998	1.28	1.3
	Pate	3.0936	0.8355	0.0001	−2.4403			0.937	8.07	11.1
	Pate	−11.4262	0.9492	−0.0002	−3.1015	1.1471		0.950	7.01	9.9
	Freedson (3 MET)	−17.4535	0.2050	−0.0005	4.7324			0.467	24.43	30.9
	Freedson (3 MET)	−148.3597	0.6616	−0.0007	1.8747	9.2024		0.778	15.73	20.3
	Freedson (3 MET)	−142.2791	0.5771	−0.0006	2.6592	8.9591	−5.2698	0.785	15.49	19.9
	Puyau	0.2787	1.1261	−0.0011	3.0543			0.946	7.31	10.0
	Puyau	11.4445	1.1768	−0.0011	2.3872	−0.7958		0.953	6.74	9.2
Evenson	Pate	−7.6013	0.7347					0.941	8.05	10.6
	Pate	−22.9695	0.7633			1.1398		0.953	6.87	9.4
	Freedson (3 MET)	−17.7246	0.2088	−0.0005	4.8722			0.475	24.86	30.3
	Freedson (3 MET)	−151.3777	0.6753	−0.0007	1.9502	9.3962		0.785	15.89	19.7
	Freedson (3 MET)	−145.2212	0.5898	−0.0006	2.7444	9.1499	−5.3351	0.792	15.64	19.2
	Van Cauwenberghe	0.5413	1.0215					0.998	1.31	1.3
	Freedson (4 MET)	−10.6026	0.0329	0.0000	7.7146			0.647	21.18	24.1
	Freedson (4 MET)	−114.2384	0.6204	−0.0009	5.9992	7.2554		0.919	10.39	11.2
	Puyau	−0.0162	1.0679	−0.0007	3.6674			0.942	7.77	10.4
	Puyau	12.2396	1.1234	−0.0008	2.9359	−0.8736		0.950	7.13	9.1
Pate	Freedson (3 MET)	−19.5240	0.2505	−0.0006	7.2571			0.616	28.65	21.2
	Freedson (3 MET)	−181.2504	0.8145	−0.0008	3.7267	11.3690		0.880	16.40	11.3
	Van Cauwenberghe	15.1517	1.3052					0.935	11.27	9.6
	Van Cauwenberghe	36.4870	1.2695			−1.7003		0.952	9.41	8.2
	Freedson (4 MET)	−5.3433	0.0244	0.0002	10.6224			0.754	23.44	17.4
	Freedson (4 MET)	−116.4227	0.6531	−0.0007	8.7913	7.7757		0.934	11.67	9.2
	Evenson	14.3381	1.2802					0.941	10.80	9.2
	Evenson	34.7490	1.2459			−1.6215		0.956	9.02	7.7
	Puyau		3.7073	0.8087	−0.0007					18.79
	Puyau		41.4428	0.9799	−0.0009		−2.6895			16.05

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Table 2 (*Continued*)

Accelerometer cutpoint MVPA min d^{-1}		Prediction equations[ǂ]				Demographics			Leave one out cross validation[*]	
Outcome variable[a]	Predictor variable	Intercept	MVPA (min d^{-1})	MVPA (min d^{-1}) Squared	MVPA (min d^{-1}) Square root	Age (years)	Gender[b]	Adjusted R^2	Average error[c] (min/day)	Absolute % Error[d]
Freedson (3 MET)	Van Cauwenberghe	−8.7703	1.0464	−0.0025	14.1213			0.430	68.67	33.3
	Van Cauwenberghe	247.3136	0.6734	0.0005	8.9683	−18.3805		0.908	27.39	13.7
	Freedson (4 MET)	12.5470	2.0066	−0.0022				0.910	26.89	13.0
	Freedson (4 MET)	120.4882	1.5802	−0.0017		−7.2474		0.950	19.98	9.9
	Evenson	22.1710	2.5511	−0.0065				0.436	68.31	33.1
	Evenson	266.2679	1.6217	−0.0021		−18.3044		0.910	27.26	13.5
	Pate	10.3366	1.5058					0.566	59.91	28.0
	Pate	233.2335	1.1204			−16.6202		0.940	22.86	10.3
	Puyau	1.1251	−0.5376	0.0011	27.3953			0.3234	74.95	37.2
	Puyau	273.8841	0.6415	−0.0001	11.7666	−19.4780		0.8735	31.42	16.3
Puyau	Pate	−8.8032	0.4958					0.799	10.66	23.2
	Pate	−27.3259	0.5302			1.3738		0.833	9.50	21.2
	Freedson (3 MET)	−2.0648	0.3641	−0.0007				0.343	19.80	41.5
	Freedson (3 MET)	−109.0616	0.5579	−0.0006		6.9629		0.659	14.00	30.7
	Freedson (3 MET)	−101.9867	0.5345	−0.0006		6.7734	−4.1982	0.667	13.85	30.1
	Van Cauwenberghe	−2.4459	0.6144	0.0009				0.943	5.61	11.8
	Van Cauwenberghe	−9.8824	0.6432	0.0007		0.5610		0.949	5.25	11.1
	Freedson (4 MET)	3.2866	0.5067	−0.0010				0.510	17.86	34.7
	Freedson (4 MET)	−82.9904	0.8491	−0.0014		5.7854		0.832	10.55	20.4
	Evenson	−2.5646	0.5941	0.0009				0.939	5.80	12.4
	Evenson	−10.5480	0.6249	0.0007		0.5994		0.946	5.40	11.7

ǂ Prediction equations developed using entire sample ($n = 43{,}112$).

[a] For example, predicting Freedson (4MET) MVPA min d^{-1} using Van Cauwenberghe cutpoints.

[b] 1 = males, 0 = females.

[c] Average error calculated using formula: $\sqrt{[\Sigma(Y - Y')^2/(N-1)]}$ where Y is the actual value and Y' is the predicted value.

[d] Absolute percent error calculated using formula: $[(Y - Y')/Y] \times 100$.

[*] One study used as validation, 20 studies as derivation. Repeated until each study served as validation.

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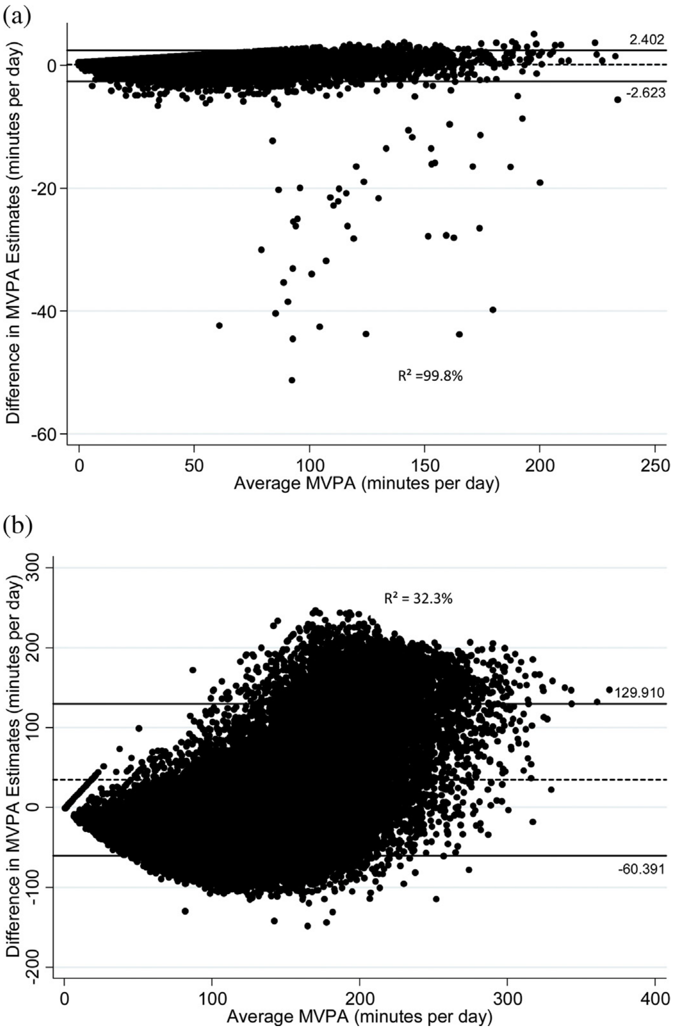

Fig. 1. Bland Altman plots of best (a) and worst (b) agreement between actual MVPA and predicted MVPA values. Van Cauwenberghe MVPA predicted from Evenson MVPA. Dashed line signifies mean difference (−0.110 min d^{-1}). Freedson (3MET) MVPA predicted from Puyau MVPA (Age not in model). Dashed line signifies mean difference (34.76 min d^{-1}).

children, and provides a solution to the problem of CNE for children and adolescents aged 3-to-18 years. Table 3 (supplementary table) demonstrates the utility and accuracy of this equating system by using previous research that has published MVPA estimates (min d^{-1}) on two or more cutpoints coinciding with the cutpoints used in this study.[10,25,29] Recognizing the problem of CNE, Guinhouya et al. examined MVPA of children aged 9 years using FR3 and PY cutpoints.[10] Of concern, was the difference in the estimate of MVPA between the two sets of cutpoints (113 MVPA min d^{-1}).[10] Using the specific conversion equation developed herein for these two cutpoints, the difference is reduced to 7 MVPA min d^{-1}. In comparison, converting FR3 MVPA in to PY MVPA has taken MVPA estimates from uninformative (141 MVPA min d^{-1} vs. 28 MVPA min d^{-1}),[10] to coherence (21 MVPA min d^{-1} vs. 28 MVPA min d^{-1}). It must be noted that a degree of heteroscedasticity can be observed in Fig. 1b, where the proportion of variance explained was low (>33%). Rosetta Stone users must interpret their MVPA predictions with caution when using some of the 'poorer performing' prediction equations (R^2 = <60%). Ultimately, these conversion equations present a practical solution to synthesizing the growing body of literature that reports estimates of youth MVPA using accelerometers to guide public health policy for children and adolescent physical activity recommendations.

A major strength of this study is the diversity and sample size of the data used to derive the conversion equations. The ICAD sample consisted of information on over 30,000 children and adolescents, from 10 different countries, representing 21 studies using waist-mounted Actigraph accelerometers.[17] Although the conversion equations are limited to the six cutpoints used for this study, the cutpoints employed herein are commonly used within the physical activity literature,[21] therefore providing widespread utility of the prediction equations for future research to evaluate their findings. Lastly, the equating system is relatively simple to use and requires commonly published and accessible information (e.g. MVPA min d^{-1}, age, gender).

On the other hand, there are limitations to this study that need to be considered. As mentioned previously, the original cutpoints provided by ICAD do not represent the entire range of cutpoints available for use in the field (e.g. Treuth[30], Mattocks[22]), however, future iterations of the Rosetta Stone should look to include new prediction equations developed on different cutpoints than those employed in this study. It must be noted that the cutpoints employed in this analysis were developed with some amount of error, and the prediction equations generated within this study bring an additional degree of error. However, while this error exists, one must consider what is worse—comparing estimates of MVPA that indicate a difference of over 100 min d^{-1} between cut points or 7 min d^{-1}? Also, the 21 studies forming the ICAD database reported epochs ranging from 5 s to 60 s. The ICAD database reintegrated seven of the 21 studies into 60 s epochs,[17] and research has shown how MVPA data collected in shorter epochs (e.g. 5 s) can result in higher estimates of MVPA compared to MVPA data collected in longer epochs.[18] Although an additional analysis confirmed no fixed effects existed between studies that collected data using 60 s epochs and studies employing shorter epochs, the impact the reintegration procedure may hold over conversion equations is still unknown. Further investigation is required into the degree of error surrounding the formation of prediction equations from different epoch lengths, and how that may compromise the generalizability of the conversions.

5. Conclusion

In summary, this study proposes a solution to CNE by illustrating the use of an equating system that demonstrates acceptable accuracy allowing for comparisons across six different sets of cutpoints used for measuring MVPA in children and adolescents. Until a universally accepted cutpoint can be agreed, researchers will continue to select different cutpoints, and disparities will continue among studies evaluating physical activity levels of similar populations. This considerably impedes efforts to synthesize the growing body of literature on children and adolescents physical activity behavior. Utilizing the equating system gives researchers, practitioners and policymakers the capacity to "paint a better picture" of physical activity levels through which relevant policies can be developed and evaluated.

6. Practical implications

- The prediction equations developed within this study allow practitioners to synthesize accelerometer-derived MVPA estimates of children and adolescents between the ages of 3 and 18 years across six commonly used Actigraph cutpoints.
- Converting accelerometer-derived MVPA estimates into the same set of cutpoints for evaluation purposes allows practitioners, policy-makers, and researchers to interpret the abundance of

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evidence on physical activity levels of populations (e.g. youth of different ages) from a common standpoint.

- With a coherent understanding of the population prevalence of physical activity, policy-makers can evaluate, and potentially reconsider, the realism of policies and standards pertaining to children and adolescents physical activity.

ICAD collaborators

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jsams.2015.02.006.

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