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Abstract

Background—The Compendium of Energy Expenditures for Youth assigns MET values to a wide range of activities. However, only 35% of activity MET values were derived from energy cost data measured in youth; the remaining activities were estimated from adult values.

Purpose—To determine the energy cost of common activities performed by children and adolescents and compare these data to similar activities reported in the compendium.

Methods—Thirty-two children (8–11 years old) and 28 adolescents (12–16 years) completed 4 locomotion activities on a treadmill (TRD) and 5 age-specific activities of daily living (ADL). Oxygen consumption was measured using a portable metabolic analyzer.

Results—In children, measured METs were significantly lower than compendium METs for 3 activities [basketball, bike riding, and Wii tennis (1.1–3.5 METs lower)]. In adolescents, measured METs were significantly lower than compendium METs for 4 ADLs [basketball, bike riding, board games, and Wii tennis (0.3–2.5 METs lower)] and 3 TRDs [2.24 $m{\cdot}s^{-1}$, 1.56 $m{\cdot}s^{-1}$, and 1.34 $m{\cdot}s^{-1}$ (0.4–0.8 METs lower)].

Conclusion—The Compendium of Energy Expenditures for Youth is an invaluable resource to applied researchers. Inclusion of empirically derived data would improve the validity of the Compendium of Energy Expenditures for Youth.

Keywords

physical activity measurement; Compendium of Energy Expenditures for Youth; energy expenditure

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There are a number of self-report and objective tools used to measure physical activity (PA), however PA assessment in children and adolescents remains particularly challenging. This is in part due to the inability of youth to accurately self-report their activity.[1] The immature cognitive skills of youth prevent accurate recall of activity, especially when asked to recall activities performed over multiple days.[1] Due to the inherent problems of self-reported PA in children and adolescents, researchers have suggested using objective means for quantifying PA such as heart rate monitoring, pedometers, and accelerometers. These techniques eliminate recall bias, but can be costly and burdensome in the pediatric population. Thus it is likely researchers, particularly for large-scale studies, will continue to use subjective self-reports to assess PA in youth.

The recent development of the Compendium of Energy Expenditure for Youth allows pediatric researchers to translate recall data into meaningful physical activity metrics [eg, MET-hrs·week^{-1}, time in moderate-to-vigorous PA (MVPA)].[2,3] The compendium is also used to support objective measures of PA. For example, when accelerometers are used to assess PA in youth, they are limited in that they cannot be worn during certain activities, including activities where they would be exposed to water (eg, swimming, bathing) and some organized sporting events (eg, soccer game) where such devices may be prohibited. In these instances, the compendium can be used to assign energy costs to activities performed when the accelerometer is not worn.

Researchers recognize the compendium for youth is a work in progress, as about 65% of the data are estimated from MET values reported in the adult compendium,[2,3] and the remaining values are based on empirical data from a very limited number of studies in small, homogeneous samples. To improve the Compendium of Energy Expenditures for Youth, the body of evidence of directly measuring energy expenditure (EE) in children and adolescents needs to be expanded. The primary aim of this paper is to provide directly measured oxygen cost values (expressed as METs) for several common activities performed by children and adolescents. We will also compare these empirically derived data to similar activities reported in the Compendium of Energy Expenditures for Youth. The secondary aim of this paper is to report the accelerometer output (counts per minute) for these activities, including the mean, range, and 95% confidence intervals of counts. The accelerometer data provide information about the amount of movement associated with a given activity and its measured energy cost.

Methods

Participants

Thirty-two children (17 males, 15 females), 8–11 years old, and 28 adolescents (13 males, 15 females), 12–16 years old, were recruited from Amherst, MA and the surrounding areas. Participants were free from any cardiovascular or metabolic disease and had no physical impairments that would interfere with participation in PA. A parent/guardian provided written informed consent and participants gave assent to participate in the study. The University of Massachusetts' institutional review board approved all study procedures and informed consent documents.

All testing procedures were performed during 1 visit to the Physical Activity and Health Laboratory. The visit lasted approximately 2–2.5 hours.

Anthropometric and Metabolic Measures

Participants reported to the Physical Activity and Health Laboratory following a 3-hour fast, having refrained from structured exercise, caffeine, and nicotine. Body weight was measured to the nearest 0.1 kg and height was measured to the nearest millimeter using a digital scale (Scaletronix 5602 Model scale; White Plains, NY) and stadiometer (Shorr Height Measuring Board; Olney, MD), respectively. Participants then rested supine for 10 minutes in a dimly lit and temperature-controlled room. Three-hour postprandial resting energy expenditure (REE) was measured using the MedGem metabolic analyzer (MicroLife, USA; Dunedin, FL), a portable indirect calorimeter that calculates oxygen consumption based on a modified Weir equation and a fixed respiratory exchange ratio of 0.85. Via a mouthpiece and a nose clip, the MedGem collects expired air for 10 minutes, or until a steady state is reached. The MedGem has been validated against several criterion methods, including the "gold standard" Douglas Bag method and is shown to be accurate and reliable in children and adolescents.[4,5] These procedures are consistent with recommendations for measurement of resting energy expenditure in youth.[6–8]

Protocol

Before starting the activity protocol participants were given a 150 kcal snack (eg, cereal bar and juice). The activity protocol consisted of 2 routines; treadmill activities (TRDs; Part A) and activities of daily living (ADLs; Part B). The order in which routines were performed was counterbalanced across subjects.

Part A: Treadmill Activities—Participants performed 4 treadmill activities for 7 minutes each (conditions: children—0.89 $m \cdot s^{-1}$ at 0% and 3% grade, 1.34 $m \cdot s^{-1}$ 0% grade and 1.56 $m \cdot s^{-1}$ 0% grade; adolescents—1.34 $m \cdot s^{-1}$ 0% grade, 1.56 $m \cdot s^{-1}$ at 0% and 3% grade and 2.24 $m \cdot s^{-1}$ 0% grade). The treadmill was calibrated with a tachometer before each testing session and if participants were novice treadmill users, they were provided with as much time as necessary to become familiar with treadmill locomotion. Participants rested for at least 5 minutes between each TRD activity and the order of treadmill conditions was counterbalanced across subjects.

Part B: ADLs—Participants performed 5 ADLs consisting of common leisure and sporting activities. ADLs were performed at a self-selected pace for 10 minutes each. Each participant was instructed to complete the activities "as they would in their own home" with no additional instruction to allow for individual variability in accomplishing each task. Children performed the following activities: walking with a 4.5 kg backpack, riding a bicycle over ground, playing basketball, arts and crafts, and Wii tennis. Adolescents performed the following activities: walking with a 6.8 kg backpack, riding a bicycle over ground, playing basketball, board games, and Wii tennis. Participants rested for at least 5 minutes between each ADL and the order of activities was counterbalanced across subjects. Table 1 provides a detailed description of each ADL performed.

Indirect Calorimetry

During each TRD and ADL, oxygen consumption was measured using a portable metabolic measurement system (Oxycon Mobile; Cardinal Health, Yorba Linda, CA). The Oxycon

Mobile is a portable respiratory gas exchange system that measures ventilation and expired concentrations of oxygen and carbon dioxide breath-by-breath and estimates EE using a modified Weir equation.[9] The Oxycon Mobile was calibrated immediately before both the TRD and ADL protocols. This metabolic measurement system is a valid device for measuring VO_2.10

ActiGraph Accelerometer

Participant wore the ActiGraph accelerometer (model GT1M; ActiGraph, LLC, Fort Walton Beach, FL) on a belt positioned on the anterior superior iliac crest of the nondominant hip. The ActiGraph is a uniaxial accelerometer that measures accelerations between 0.5–2.0 Gs in the vertical plane. The device was initialized to collect data in 1-second epochs and average counts·min^{-1} were determined for each activity. The ActiGraph has been validated to measure PA in children.[11–14]

Data Reduction and Statistical Evaluation

For each activity, the first 120 seconds were eliminated to ensure steady state had been reached and the last 10-seconds were eliminated to minimize errors in timing synchronization between the monitor and the metabolic measurements. From the Oxycon Mobile, participants' average VO_2 was determined and expressed as relative VO_2 in ml·kg^{-1}·min^{-1} and METs for each activity. Relative VO_2 was converted to METs by dividing by measured REE (ml·kg^{-1}·min^{-1}). This approach to calculating METs has been reviewed and supported in both the adult and pediatric literature.[3,15,16] Participants' ActiGraph counts were converted to average counts·min^{-1} for each activity over the same time period as the VO_2 data.

Two investigators familiar with the testing protocol searched the Compendium of Energy Expenditures for Youth and matched the 9 activities performed in this study to what was judged the most similar activity in the compendium. One-hundred percent of the time the 2 investigators matched the same activity from the compendium to the activities performed in this study. For walking and running activities the compendium provides prediction equations to estimate METs using speed and participant age. For these activities the appropriate speed and children's and adolescent's average age, respectively were inserted into the regression to determine compendium METs. If compendium METs were not between the lower and upper 95% confidence intervals (CI) of measured METs, the 2 measures were considered to be different.

Of the 9 activities completed by both children and adolescents, 5 were similar across groups (1.34 m·s^{-1} 0% grade and 1.56 m·s^{-1} 0% grade, riding a bicycle, playing basketball, and Wii tennis). We used a linear mixed model to test between group differences in average MET values and accelerometer counts for these activities.

Results

Sixty children (n = 32) and adolescents (n = 28) completed an average of 8.7 activities (range = 7–9). Participant characteristics are reported in Table 2. Seventeen activities were not performed for various reasons, including 1) inability to complete the task (eg, running at

2.24 m·s^{-1} was too intense, could not ride a bicycle), 2) scheduling conflicts (2 children did not complete the basketball activity), and 3) researcher error (in 2 instances the researcher provided the participant a backpack with incorrect weight). Metabolic data were not included for 8 activities (sample line occlusion), resulting in a total of 515 activities being used for data analysis. The number of observations for the individual activities is presented in Table 3. Compendium METs and measured METs (mean, SD, 95% CI) for each activity are also presented in Table 3 for children and adolescents. METs were similar between children and adolescents, except for basketball, where METs were significantly lower in children compared with adolescent (6.6 ± 1.3 METs vs. 7.6 ± 1.8 METs, respectively) and Wii tennis, where METs were significantly higher in children compared with adolescents (2.3 ± 0.6 METs vs. 1.9 ± 0.5 METs, respectively).

Measured METs were significantly lower than compendium METs 58.8% of the time (Table 3). In children, measured METs were lower than compendium METs for 3 ADLs [basketball, bicycling, and Wii tennis (1.1–3.5 METs lower)]. In adolescents, measured METs were lower than compendium METs for 4 ADLs [basketball, bicycling, board games, and Wii tennis (0.3–2.5 METs lower)] and 3 TRDs [2.24 m·s^{-1} 0% grade, 1.56 m·s^{-1} 0% grade, and 1.34 m·s^{-1} 0% grade (0.4–0.8 METs lower)].

ActiGraph data were not available for 2 activities, resulting in a total of 520 activities with valid accelerometer data. Average counts·min^{-1} for each activity are presented in Table 4 for children and adolescents. Counts·min^{-1} were significantly higher in children compared with adolescents for Wii Tennis (273 ± 315 counts·min^{-1} vs. 67 ± 99 counts·min^{-1}, respectively).

Discussion

The purpose of this paper was to present descriptive data on MET values and accelerometer output for common activities performed by children and adolescents. We also compared our measured MET values to MET values reported in the Compendium of Energy Expenditures for Youth (compendium METs).

Children (8–11 yrs) and adolescents (12–16 yrs) performed 4 treadmill activities and 5 ADLs. Activities were chosen based on their relevance to the respective age group. For example, children walked with a 4.5 kg backpack, while adolescents walked with a 6.8 kg backpack, as it is reasonable that adolescents will carry a backpack to school that contains heavier books than children. Five activities (1.34 m·s^{-1} 0% grade and 1.56 m·s^{-1} 0% grade, riding a bicycle, playing basketball, and Wii tennis) were similar between children and adolescents.

As reported earlier, the energy cost of activities were similar for children and adolescents, except for basketball, where measured METs were significantly lower in children compared with adolescents (6.6 ± 1.3 METs vs. 7.6 ± 1.8 METs, respectively) and Wii tennis, where measured METs were significantly higher in children compared with adolescents (2.3 ± 0.6 METs vs. 1.9 ± 0.5 METs, respectively). Accelerometer counts were also similar between groups except for Wii tennis, where counts were higher in children compared with adolescents (273 ± 315 counts·min^{-1} vs. 67 ± 99 counts·min^{-1}, respectively).

The different energy costs observed for basketball and Wii tennis could be caused by several factors. First, the 2 groups likely performed these activities differently. Basketball and Wii tennis are unconstrained activities, meaning participants self-selected the pace and movements employed to complete the task. For example, experienced Wii tennis players primarily use only quick movements of the wrist and very little lower-body movement, while inexperienced players intuitively think they must use their entire arm and body as is done in ‘real’ tennis. Children were not as familiar with Wii tennis as adolescents, and thus were not as economical in their choice of movement to complete the task. This is supported by the accelerometer data, where Wii tennis activity counts were significantly higher in children compared with adolescents (273 ± 315 counts·min^{-1} vs. 67 ± 99 counts·min^{-1}, respectively). Similarly, basketball accelerometer counts, although not statistically different, were considerably lower for children compared with adolescents (3650 ± 1068 counts·min^{-1} vs. 4245 ± 1495 counts·min^{-1}, respectively). A second factor that could contribute to differences in energy cost values between and within the 2 age groups is the interindividual variability in energy requirements for a given activity. It has been previously shown that there is interindividual variability in energy cost values among participants performing the same activity in a similar manner.[17] Little is known about what causes interindividual variability in relative energy cost data, but this may help explain the different energy cost values observed for ‘self-paced’ Wii tennis and basketball for children compared with adolescents and the variability in energy costs for a given activity within each group.

To aid in assigning the appropriate energy cost to self-reported activities that can be performed at various intensities (eg, Wii tennis), the authors of the Compendium of Energy Expenditures for Youth included light, moderate and hard MET values for select items.[2] For many activities however, little or no empirical data are available in children, leading researchers to assign MET values via a weighting system. For a given activity, if energy cost data were available for only 1 mean value, that value was ‘moderate’ and was multiplied by 0.75 and 1.25 to assign ‘light’ and ‘hard’ values, respectively. The authors of the compendium recognize the weighting system is ‘rather arbitrary’ but provide a brief rational for the calculation of MET values for each effort level. Along with knowledge of their own data, this information can be used by applied researchers to decide the most appropriate MET value to assign. This method allows some flexibility in determining energy costs for self-reported activities, but according to data from the current study, it may not produce accurate estimates.

Measured METs were different from compendium METs 58.8% of the time (10/17 activities; Table 3). These differences are likely the consequence of several factors. First, we may not have chosen the ‘correct’ (or most appropriate) item from the compendium to compare the activities performed from this study. We used the short descriptions provided and the cited literature from which the compendium value was derived to decide the most appropriate item for comparison. Two investigators directly involved with the data collection in this study independently searched the compendium and identified the same item for comparison 100% of the time. It is possible both individuals made the incorrect decision, but these decisions were unanimous given the provided information. Anecdotally, this information is interesting considering applied researchers would be required to go through a similar process when assigning MET values to self-reported activities. Second, even if we chose the *most appropriate* item from the compendium, it is possible that the protocol and the sample used to determine the compendium MET were different from what was used in the current study. For example, we chose to compare our basketball activity to 'basketball—hard effort' (code 342033) from the compendium. The compendium MET was derived from 1 child study[18] where participants (N = 19) were instructed to dribble through a marked track and shoot a basket at the end. Participants were instructed to score as many baskets as possible in 5-minutes. In our study, the basketball activity consisted of researchers randomly distributing markers in and around the 3-point line of a standard basketball court. Participants were instructed to score as many baskets as possible in 10-minutes. These 2 activities seem reasonably similar, but the energy costs reported in the current study were significantly lower for both children and adolescents than that reported in the compendium. This could be due to the differences in the samples (current study: 8- to 11-year-old children and 12- to 16-year-old adolescents vs. compendium: 11–13 year olds) or it could be due to differences in the protocol. There were no details reported about what constituted the 'marked track.' It is not known how long it was, if it was straight or did it require quick cutting movements as in basketball games, if it was a standard 10-foot basketball hoop or if it was adjusted to be more age appropriate. Answers to these questions may help explain differences between measured METs and compendium METs. Third, the compendium provides regression equations to estimate METs for walking and running activities when the speed and participant age is known. To determine the compendium MET for these activities we used the appropriate speed and the average age of the 2 groups. We may have seen a higher level of agreement using participants' individual age to determine a compendium MET for each participant.

And finally, we calculated METs using measured REE. This approach for calculating METs has been supported in both adult[15,16] and pediatric[3] literature. However, in the development of the Compendium, the Schofield equation was used to estimate METs.[3] This was done even when REE was measured for the purpose of reducing methodological variability across studies.[3] The Schofield equation estimates basal metabolic rate (BMR), while in this study resting energy expenditure was measured 3 hours postprandial. On average, our REE measurements were 116 and 75 kcals·day^{-1} (0.08 and 0.05 kcals·min^{-1}) higher for boys and girls, respectively, than if BMR was estimated using the Schofield equation. These differences may explain a portion of the difference in Compendium vs. measured MET values. However, we did not observe a consistent underestimation of measured MET values, indicating this reason alone cannot explain the observed differences between the Compendium and measured MET values.

None of the activities evaluated in this study were among the 65% of compendium activities derived from adult data. It is reasonable to assume that estimating youth specific METs from adult data will lead to error; however since all of the compendium items used for comparison were derived from youth specific data, this was not the cause of the MET differences observed in the current study.

The Compendium of Energy Expenditures in Youth is a valuable resource for researchers who are interested in characterizing physical activity and assigning energy costs to self-reported activities. However, using estimated mean values to assign energy costs to independent samples will always generate error. In addition to the interindividual variability of energy requirements, and the inevitable variability in how nonconstrained tasks are completed (eg, playing Wii tennis with wrist movement only vs. jumping, moving around and swinging your arm to complete the same task), there are several other person specific variables that will always make EE estimation on an individual level challenging. For example, many questionnaires ask individuals to self-report their effort to determine the appropriate intensity assignment for a given activity. However, it is possible that if 2 individuals are performing the same activity at the same EE, a more fit child may perceive the activity to be moderate effort, while the less fit child may perceive it to be vigorous.

Furthermore, the compendium expresses the energy cost of activities in METs. One MET represents the oxygen consumed (VO_2) at rest, and in adults, is often prescribed a standard value of 3.5 $ml \cdot kg \cdot min^{-1}$.[19–21] Physical activity and surveillance researchers express the energy costs of activities in multiples of REE (eg, a 3 MET activity requires 3 times the oxygen that is consumed at rest). Using this system, activities can be classified as light (< 3 METs), moderate (3–5.99 METs) or vigorous (≥ 6 METs) intensity, providing an easy to interpret and standard system for communicating energy cost data. However, since resting energy expenditure is influenced by several physical characteristics such as weight and maturation it can be highly variable in children and adolescents.[22,23] For example, in the current study, measured REE ranged from 3.0 $ml \cdot kg \cdot min^{-1}$ to 7.4 $ml \cdot kg \cdot min^{-1}$ (5.0 ± 1.1 [mean ± SD]). Because of the noted variability in REE, researchers recommend that MET costs in youth must be calculated using either, directly measured REE, or REE estimated from a regression equation based on gender and age.[22,24] By using person-specific REEs to determine METs, the work-rate of a given activity is standardized across populations. REE is variable in children and MET values are derived from multiples of REE. Thus, caution should be exercised when assigning METs to self-reported activities derived using a standard baseline REE.

This study has several strengths, including the large, diverse sample and the wide range of age-specific activities performed. Oxygen consumption was directly measured for more than 500 activities and resting energy expenditure was directly measured in each participant.[6,7] We also report the accelerometer output for these activities, thus providing information about the amount of movement employed to complete the task. By simultaneously presenting oxygen consumption values, accelerometer output and a detailed description of activities, these data can be easily compared across studies and are a valuable resource to the physical activity measurement community.

This study also has several limitations to note. We did not measure participants' body composition. Data indicate EE is more closely related to fat-free mass compared with total body mass. In addition, it has been reported that the relationship between EE and total body mass or fat free mass is not linear.[25] Allometric scaling to model the relationship between EE and body size has been advocated to address this issue. Although this may be an appropriate means to interpret EE data, we did not believe it was appropriate for the current study. The Compendium of Energy Expenditures for Youth does not express EE using allometric scaling and thus we decided the most appropriate way to report EE was per kilogram of body mass as is done in the compendium and is convention in the literature. An additional limitation is participants performed the entire protocol in a 2- to 2.5-hour testing session. Although we used multiple strategies (eg, provided sufficient rest between activities) to ensure fatigue did not influence the exercise responses, it is possible participants became fatigued during the protocol. If fatigue was noticeably affecting a participant, researchers terminated the test for the participant's safety.

In conclusion, there are several problems using estimated MET values to assign energy costs to independent samples, including individual variations in energy requirements, movement patterns and perceived level of effort. Despite these limitations, the Compendium of Energy Expenditures for Youth improves PA assessment by standardizing MET costs for 244 activities. To minimize error when assigning energy costs to self-reported activities it is important to continuously expand the compendium by acquiring empirical data in youth. It is also important to provide detailed descriptions on how these data are collected, including physical characteristics of the sample and comprehensive descriptions of the activities performed. This information will help in making appropriate decisions when assigning energy costs to a given population or activity.

This paper provides empirically derived METs for child and adolescent specific activities. We recommend the compendium values be adjusted according to the metabolic measurements obtained in this investigation. By incorporating more directly measured EE data, the compendium will be an improved resource for surveillance researchers interpreting self-reported activity behavior.

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Table 1

Activity Protocols

	Activities of Daily Living (ADL)
Backpack (4.5 kg)*	Participants walked back and forth a 36.6 meter hallway at a self-selected pace. The backpack contained books weighing 4.5 kg
Backpack (6.8 kg)**	Participants walked back and forth a 36.6 meter hallway at a self-selected pace. The backpack contained books weighing 6.8 kg
Basketball	Using a 28.5-inch basketball, participants shot baskets from markers randomly distributed in and around the 3-point line of a standard basketball court. If participants were not able to reach the hoop, the target was adjusted accordingly. After making a basket, participants picked up the marker and brought it to the center of the court. Participants were instructed to make as many baskets as possible in 10-minutes.
Bike	Participants were fitted to 1 of 2 bikes. The bike was chosen based on the participant's size. Participants biked at a self-selected pace over a gymnasium floor. The area was the size of 2 standard basket-ball courts and was completely flat.
Crafts*	Participants were free to do whatever they chose with a large bin of arts and crafts material (e.g. paper, glitter, glue, buttons, markers etc). Participants were seated at a large table for arts and crafts.
Board games**	Participants chose a game from a selection including several board, card, and puzzle games. If more than 1 participant was needed to play the chosen game, a researcher played against the participant. Participants were seated at a large table for board games.
Wii Tennis	Participants were given brief instructions on the rules of the game, but were not shown how to play the game (e.g. body movements required to complete the task). Participants used the standard, wireless hand-held Wii controller and were given approximately 10 × 30 feet of space to move around while playing the game.

Note. Each ADL was performed for 10-minutes.

*Performed only by children.

**Performed only by adolescents.

Table 2

Participant Characteristics (Mean ± SD)

		Age group		Gender	
	All subjects	8–11 y	12–16 y	Male	Female
N	60	32	28	30	30
Age (y)	11.5 ± 2.4	9.6 ± 1.1	13.6 ± 1.3	11.3 ± 2.3	11.7 ± 2.4
Height (cm)	151.5 ± 14.4	140.3 ± 8.5	164.3 ± 7.1	152.4 ± 14.7	150.5 ± 14.3
Weight (kg)	46.1 ± 14.1	36.6 ± 9.4	56.9 ± 10.2	48.7 ± 15.5	43.4 ± 12.3
BMI (kg/m^2)	19.7 ± 4.1	18.5 ± 4.3	21.1 ± 3.5	20.6 ± 5.0	18.7 ± 2.7
Waist circumference (cm)	70.3 ± 11.5	65.6 ± 11.0	75.8 ± 9.6	73.2 ± 13.5	67.2 ± 8.3
Tricep skinfold (mm)	16.6 ± 5.9	14.9 ± 5.8	18.6 ± 5.5	17.2 ± 7.0	16.1 ± 4.8
Resting metabolic rate (kcal/day)	1549 ± 363	1407 ± 263	1710 ± 398	1682 ± 395	1415 ± 276

Table 3

Energy Cost of Activities (METs)

		Children 8–11 yrs				Adolescents 12–16 yrs			
	Compendium code	Compendium MET	N	Mean ± SD	95% CI	Compendium MET	N	Mean ± SD	95% CI
Treadmill activities									
0.89 $m \cdot s^{-1}$ 0% gr	240051	2.6	31	2.8 ± 0.4	2.6–2.9	2.9	0	NA	NA
0.89 $m \cdot s^{-1}$ 3% gr	NA	NA	32	3.2 ± 0.4	3.0–3.3	NA	0	NA	NA
1.34 $m \cdot s^{-1}$ 0% gr	240052	3.7	31	3.7 ± 0.5	3.5–3.9	4.0*	28	3.6 ± 0.6	3.4–3.9
1.56 $m \cdot s^{-1}$ 0% gr	240053	4.5	27	4.4 ± 0.7	4.1–4.6	4.8*	28	4.3 ± 0.8	3.9–4.6
1.56 $m \cdot s^{-1}$ 3% gr	NA	NA	0	NA	NA	NA	28	5.2 ± 1.0	4.8–5.6
2.24 $m \cdot s^{-1}$ 0% gr	341481	7.3	0	NA	NA	8.4*	23	7.6 ± 0.2	7.1–8.1
Activities of daily living									
Backpack (4.5 kg)	240091	3.4	32	3.4 ± 0.5	3.3–3.6	3.4	0	NA	NA
Backpack (6.8 kg)	240091	3.4	0	NA	NA	3.4	25	3.5 ± 0.6	3.2–3.7
Basketball**	342033	10.1*	30	6.6 ± 1.3	6.1–7.1	10.1*	28	7.6 ± 1.8	6.9–8.3
Bike	341242	6.2*	27	4.2 ± 1.0	3.8–4.6	6.2*	26	4.0 ± 0.9	3.6–4.3
Crafts	420000	1.6	32	1.5 ± 0.2	1.4–1.6	1.6	0	NA	NA
Board games	721220	1.6	0	NA	NA	1.6*	28	1.3 ± 0.3	1.2–1.5
Wii Tennis**	732202	3.4*	31	2.3 ± 0.6	2.1–2.5	3.4*	28	1.9 ± 0.5	1.8–2.1

* Compendium MET different than Measured MET.

** Measured MET different between children and adolescents.

Abbreviations: gr, grade; Compendium code = code corresponding to activity selected from the Compendium for comparison.

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Table 4

Accelerometer Output (Counts·min^{-1})

	Children 8–11 yrs			Adolescents 12–16 yrs		
	N	**Mean ± SD**	**Range**	**N**	**Mean ± SD**	**Range**
Treadmill activities						
0.89 m·s^{-1} 0% grade	32	1023 ± 349	268–1708	0	NA	NA
0.89 m·s^{-1} 3% grade	32	1181 ± 399	459–1900	0	NA	NA
1.34 m·s^{-1} 0% grade	31	2481 ± 728	826–4758	28	2505 ± 681	1162–4097
1.56 m·s^{-1} 0% grade	27	3011 ± 966	1474–5957	28	3151 ± 863	1338–4676
1.56 m·s^{-1} 3% grade	0	NA	NA	28	3288 ± 834	1759–5009
2.24 m·s^{-1} 0% grade	0	NA	NA	24	6058 ± 1254	3429–8950
Activities of daily living						
Backpack (4.5 kg)	32	2220 ± 722	944–4665	0	NA	NA
Backpack (6.8 kg)	0	NA	NA	26	2579 ± 652	1260–3843
Basketball	30	3650 ± 1068	1625–6309	28	4245 ± 1495	2482–8739
Bike	28	341 ± 549	10–2384	26	130 ± 171	8–677
Crafts	32	24 ± 30	0–124	0	NA	NA
Board games	0	NA	NA	28	28 ± 44	0–160
Wii Tennis*	32	273 ± 315	1–1197	28	67 ± 99	0–380

*Counts different between children and adolescents.