

# Energy Expenditure and Intensity of Classroom Physical Activity in Elementary School Children

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**Background:** There is limited data regarding objectively measured energy cost and intensity of classroom instruction. Therefore, the purpose of current study was to objectively measure energy cost and subsequently calculate MET values using a portable indirect calorimeter (IC) for both normal classroom instruction (NCI) and active classroom instruction (ACI). **Methods:** We assessed energy expenditure (EE) and intensity levels (METs) in elementary school children (17 boys and 15 girls) using an IC (COSMED K4b2). Independent *t*-tests were used to evaluate potential sex and grade level differences for age, BMI,  $\text{VO}_2$ , EE, and METs. **Results:** The average EE for NCI and ACI were  $1.8 \pm 0.4$  and  $3.9 \pm 1.0$ , respectively. The average intensity level for NCI and ACI were  $1.9 \pm 0.4$  and  $4.2 \pm 0.9$  METs, respectively. **Conclusions:** PA delivered through ACI can elicit EE at a moderate intensity level. These results provide evidence for ACI as a convenient/feasible avenue for increasing PA in youth without decreasing instruction time.

**Keywords:** youth, measurement

Increasing opportunities for children to participate in physical activity (PA) is vital for addressing the high prevalence of youth inactivity in the US.<sup>1</sup> Currently, the 2008 PA Guidelines for Americans recommend that children participate in at least 60 minutes of moderate-to-vigorous intensity PA (MVPA) each day.<sup>2</sup> Since children spend approximately 14% of the year in the school environment,<sup>3</sup> schools offer an opportunity for increasing PA. Delivering academic lessons through PA is an innovative approach to increasing PA in children without decreasing academic instruction time in schools. To date, there is limited literature on objectively measured energy expenditure (EE) and intensity levels of classroom instruction.<sup>4</sup> Therefore, the primary aim of this study was to objectively measure EE and intensity levels of elementary school children during normal classroom instruction (NCI) and active classroom instruction (ACI) using a portable indirect calorimeter (IC). We hypothesize PA performed during ACI will reach a moderate intensity level of at least 3 metabolic equivalents (METs)<sup>5</sup> as well as EE and METs being significantly higher during ACI compared with NCI.

## Methods

### Participants

A convenience sample from schools involved in the Academic Achievement and Physical Activity Across the Curriculum (A+PAAC) intervention participated in this study. Details regarding

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the design and methods of the A+PAAC trial have been published.<sup>6</sup> Briefly, A+PAAC was a 3 year cluster-randomized trial designed to compare changes in academic achievement between elementary schools randomized to ACI (intervention,  $n = 9$  schools) or NCI (control,  $n = 8$  schools). The A+PAAC intervention was designed to provide 100 min/wk of moderate intensity PA (MPA) through academic lessons delivered by classroom teachers. Parents and students provided consent and assent before the initiation of A+PAAC. The investigation was approved by The University of Kansas Human Subjects Committee. These assessments were obtained in the spring of 2014.

### Procedures

As part of the ACI intervention, classroom teachers attended a 6-h training workshop that included strategies to deliver classroom lessons using MPA. For the current study, the EE and intensity (METs) of NCI and ACI were assessed in 32 children in 4 schools (16 different teachers). Examples of ACI included jumping to an "invisible" jump rope and performing calisthenics such as jumping-jacks or squats while reciting multiplication tables. Geography (eg, North, South, East, and West) was taught by having children marching to the appropriate designated area for each direction. Spelling was taught by having children perform standing lunges for each letter of the word while reciting the letter aloud.

### Assessments

#### Energy Expenditure.

EE was assessed during a regular school day, with the lesson time selected by the teacher, using a previously validated portable, open-circuit indirect calorimeter (Cosmed K4b2, Cosmed, Rome, Italy) that measures breath-by-breath ventilation, expired oxygen, and carbon dioxide.<sup>7</sup> After a minimum of a 30-min warm up, the calorimeter was calibrated with known gases. The flow turbine was

calibrated using a 3.00-L syringe. During the lesson, the participant breathed into a face mask that directed air into the unit housing the O<sub>2</sub> and CO<sub>2</sub> gas analyzers. The lightweight (~1.5 kg) portable system was attached by a harness around the waist and shoulders of the child before the assessment. The data were retrieved for analysis via serial port interface and software provided with the calorimeter. Calorimeter data were reduced to 20-second epochs, and the 1-minute average values are reported. MET levels were age corrected using the Schofield equation<sup>8</sup> as recommended by McMurray and colleagues.<sup>9</sup> All participants were assessed with the same calorimeter.

**Anthropometrics (Height/Weight).** Body weight was measured to the nearest 0.1 kg on a calibrated scale (Model #PS6600, Befour, Saukville, WI) with the child-wearing school clothes and without shoes. Standing height was measured with a portable stadiometer (Model #IP0955, Invicta Plastics Limited, Leicester, UK). BMI was later calculated as weight (kg)/height (m<sup>2</sup>). BMI percentile was calculated using the CDC growth charts.<sup>10</sup>

## Analysis

Descriptive statistics were calculated for participants' characteristics and physiologic responses for both NCI and ACI. The average VO<sub>2</sub> (L/min and kcal/kg/min), kilocalories (kcal/min), and age adjusted METs were examined. Independent *t*-tests were used to evaluate potential sex and grade level differences for age, BMI, VO<sub>2</sub>, EE, and METs. Dependent *t*-tests were used to evaluate differences between NCI and ACI for EE and METs. Statistical significance was determined at 0.05 alpha level, and all analyses were performed in SAS version 9.4 (SAS Institute Inc., Cary, NC).

## Results

### Participants

Data were obtained from 32 fourth and fifth grade children (17 boys, 15 girls; 28% minorities; 28% overweight/obese). Descriptive characteristics of the participants by sex and grade are presented in Table 1.

### Normal Classroom Instruction (NCI)

EE and MET levels of NCI are presented in Table 2. The average EE of NCI lessons was 1.8 ± 0.4 kcal/min (range = 1.2 to 3.4 kcal/min). The EE of NCI differed by grade and sex. Fifth grade children had significantly higher EE (2.0 ± 0.5 kcal/min) compared with those in

fourth grade (1.6 ± 0.3 kcal/min; *P* = .005). Energy expenditure of NCI was significantly higher in boys (1.9 ± 0.4 kcal/min) compared with girls (1.7 ± 0.4 kcal/min; *P* = .047). The average MET level of NCI was light intensity (Table 2) There were no significant differences in MET levels of NCI by grade or sex (all *P* > .05).

### Active Classroom Instruction (ACI)

EE of ACI are presented in Table 3. The average EE of ACI was 3.9 ± 1.0 kcal/min (range = 2.3 to 6.4 kcal/min) and was significantly higher compared with NCI (1.8 ± 0.4 kcal/min; *P* < .0001). The EE of ACI differed by sex with boys having significantly higher EE (4.2 ± 1.0 kcal/min) compared with girls (3.6 ± 1.0 kcal/min; *P* = .033). There were no significant differences in EE of ACI by grade (Fifth = 3.9 ± 1.1 kcal/min, Fourth = 3.9 ± 1.0 kcal/min; *P* = .851). The average MET level of ACI was 4.2 ± 0.9 (moderate intensity) and was significantly higher compared with NCI (1.9 ± 0.4; *P* < .0001). MET levels for fourth graders (4.5 ± 1.0) were significantly higher compared with fifth graders (3.8 ± 0.7; *P* = .039). There were no significant differences in MET levels between sexes.

## Discussion

The purpose of the current study was to examine the EE of elementary school children during NCI and ACI using a portable IC. Results indicated that the average EE during NCI was 1.8 ± 0.4 kcal/min and average EE during ACI was 3.9 ± 1.0 kcal/min. Thus, if a classroom completed the 100 min/wk of ACI, which was the goal of the A+PAAC intervention, an increase in EE of approximately 390 kcal/wk (range: 230 to 640 kcal/wk) would be achieved. In addition, average intensity was 1.9 ± 0.4 and 4.2 ± 0.9 METs in NCI and ACI respectively, which indicates ACI is delivered at a moderate intensity (moderate: 3 to 6 METs) according to the American College of Sports Medicine.<sup>5</sup>

Strengths of the current study include the sample represented a comparatively equal number of boys and girls and the use of a valid objective measure to assess EE. A potential limitation is the inability to differentiate between the EE costs of the individual activities used. Although many of the same activities were used during ACI (marching, jogging in place, jumping jacks, walking, jumping, and squatting), the type, order and combinations of activities used during the ACI were at the discretion of the teacher. In addition, these results should be interpreted with caution due to the small sample size and that the study was not specifically powered to detect between sex and grade differences.

**Table 1** Descriptive Characteristics of the Participants

		Age (yrs) <sup>d</sup>	Height (cm) <sup>c</sup>	Weight (kg) <sup>c</sup>	BMI (kg/m <sup>2</sup> ) <sup>b</sup>	BMI (Percentile)
Total	32	10.1 ± 0.8	144.5 ± 7.9	42.6 ± 12.3	20.2 ± 4.3	71.6 ± 21.3
Boys	17	10.2 ± 0.7	143.8 ± 6.7	42.2 ± 11.1	20.2 ± 4.1	75.0 ± 18.1
Girls	15	10.1 ± 0.8	145.4 ± 9.3	43.0 ± 13.9	20.1 ± 4.7	67.7 ± 24.5
Fourth grade	16 (8M, 8F)	9.6 ± 0.5	140.3 ± 6.3	36.8 ± 8.1	18.6 ± 3.2	64.9 ± 23.0
Fifth grade	16 (9M, 7F)	10.7 ± 0.5	148.7 ± 7.2	48.3 ± 13.3	21.7 ± 4.9	78.2 ± 17.7

Note. All value are reported Average ± Standard Deviation unless otherwise stated.

<sup>a</sup> Significant difference between sex (*α* < .05); <sup>b</sup> Significant difference between grade (*α* < .05); <sup>c</sup> Significant difference between grade (*α* < .01); <sup>d</sup> Significant difference between grade (*α* < .001).

Abbreviations: M, male; F, female; BMI, Body Mass Index.

**Table 2 Energy Expenditure of Normal Classroom Instruction**

	n	VO <sub>2</sub> (ml/kg/min)	Range	VO <sub>2</sub> (L/min) <sup>ab</sup>	Range	EE (kcal/min) <sup>ab</sup>	Range	METs	Range
Total	31	9.5 ± 2.5	5.0–14.5	0.4 ± 0.1	0.2–0.7	1.8 ± 0.4	1.2–3.4	1.9 ± 0.4	1.2–3.1
Boys	17	9.9 ± 2.8	5.0–14.5	0.4 ± 0.1	0.3–0.7	1.9 ± 0.4	1.6–3.4	2.0 ± 0.4	2.6–6.4
Girls	14	9.1 ± 2.1	5.3–12.4	0.3 ± 0.1	0.2–0.5	1.7 ± 0.4	1.2–2.4	1.8 ± 0.3	2.7–5.2
Fourth grade	16	9.6 ± 2.4	5.0–14.5	0.3 ± 0.04	0.2–0.4	1.6 ± 0.3	1.2–2.0	1.8 ± 0.3	1.3–2.6
Fifth grade	15	9.5 ± 2.7	5.0–13.7	0.4 ± 0.1	0.3–0.7	2.0 ± 0.5	1.6–3.4	2.0 ± 0.5	1.2–3.0

Note. All values are reported Average ± Standard Deviation unless otherwise stated.

<sup>a</sup> Significant difference between sex ( $\alpha < .05$ ); <sup>b</sup> Significant difference between grade ( $\alpha < .05$ ).

**Table 3 Energy Expenditure of Active Classroom Instruction**

	n	VO <sub>2</sub> (ml/kg/min) <sup>b</sup>	Range	VO <sub>2</sub> (L/min) <sup>a</sup>	Range	EE (kcal/min) <sup>a</sup>	Range	METs <sup>b</sup>	Range
Total	32	20.5 ± 5.6	11.3–31.9	0.8 ± 0.2	0.5–1.3	3.9 ± 1.0	2.3–6.4	4.2 ± 0.9	2.6–6.4
Boys	17	21.7 ± 6.8	12.4–31.9	0.9 ± 0.2	0.5–1.2	4.2 ± 1.0	2.3–5.9	4.4 ± 1.1	2.6–6.4
Girls	15	19.0 ± 3.4	11.3–25.7	0.7 ± 0.2	0.5–1.3	3.6 ± 1.0	2.5–6.4	3.9 ± 0.7	2.7–5.5
Fourth grade	16	22.7 ± 6.0	12.4–31.9	0.8 ± 0.2	0.5–1.2	3.9 ± 1.0	2.3–5.9	4.5 ± 1.0	2.6–6.4
Fifth grade	16	18.2 ± 4.2	11.3–27.2	0.8 ± 0.2	0.6–1.3	3.9 ± 1.1	2.7–6.4	3.8 ± 0.7	2.7–5.2

Note. All values are reported Average ± Standard Deviation unless otherwise stated.

<sup>a</sup> Significant difference between sex ( $\alpha < .05$ ); <sup>b</sup> Significant difference between grade ( $\alpha < .05$ ).

Overall, the current study contributes to the limited literature on EE of classroom activities. With increasing financial constraints on educational budgets, finding ways to increase PA without decreasing classroom instruction time is critical. The present research indicates that MPA can be performed by children during teacher delivered ACI and provides a convenient/feasible avenue for decreasing sedentary time in elementary schools and contributing toward meeting youth PA guidelines.

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