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Original article

Influence of personal and lesson factors on caloric expenditure in physical education

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Abstract

Background: Increasing caloric expenditure in physical education is considered an effective school-based approach to addressing the child obesity epidemic. This study was designed to determine synergistic influences of student characteristics and lesson factors on caloric expenditure in elementary and middle school physical education.
Methods: The study used a multi-level design. Level-1 factors included personal characteristics: age, gender, and body mass index. Level-2 factors included lesson length, content, and school level. Based on the Center for Disease Control and Prevention age−gender adjusted growth chart, students in 87 classes from 14 elementary and 15 middle schools were pre-screened into "Overweight", "Healthy weight", or "Thin" groups. One boy and one girl were randomly selected from each group in each class as data providers (264 elementary and 294 middle school students). Caloric expenditure was measured in 243 physical education lessons using accelerometers.
Results: Analysis of variance revealed and hierarchical linear modeling confirmed separate age by body mass index, age by gender, and content by lesson−length interaction effects, suggesting that the personal and lesson factors influenced caloric expenditure independently. Older male and heavier students burned more calories in all lessons. Students burned more calories in 45−60 min sport skill or fitness lessons than in shorter (30 min) or longer (75−90 min) game or multi-activity lessons.
Conclusions: The hypothesized cross-level interaction was not observed in the data. Caloric expenditure can be optimized in 45−60 min sport skill or fitness development lessons. It can be recommended that schools adopt 45−60 min lesson length and provide skill and fitness development tasks in physical education to maximize caloric expenditure.

Keywords: Caloric expenditure; Child obesity; Personal factors; Physical education

1. Introduction

An increasingly serious health challenge in U.S. schools is child obesity resulting from unhealthy eating and insufficient physical activity. Compared with their counterparts from 1976 to 1980, current American children and adolescents' overweight prevalence increased three folds, from 6.5% to 17.0% for the 6−11 year age group and from 5.0% to 17.6% for the 12−19 year age group.[1] It is a consensus that one cause of the child obesity epidemic is the caloric imbalanced living behavior, children simply taking in more calories than burning them out.[2−4]

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One way to increase children's caloric expenditure is to increase their physical activity during physical education. It is recommended that schools offer a weekly minimum of 150 min physical education and structure physical education lessons as such that children are physically active most of the time.[5,6] Therefore, empirical evidence is needed to help school administrators and physical/health educators to schedule and structure lessons to increase caloric expenditure in physical education.

Lesson factor variables such as content type and lesson length and personal factors such as body mass index (BMI), gender, and age can influence children physical activity participation and, consequently, their caloric expenditure.[7] For example studies on gender, a personal level variable, reported that boys tend to be more physically active than girls during school day[8] and in physical education.[9] For lesson factors, outdoor lessons seem to induce more physical activity than indoor lessons and children are likely to spend more calories in fitness and sport skill development lessons than in game or free play lessons.[10]

Conceptually, these factors can be viewed in a two-level structure: personal characteristics and lesson factors. In research, these factors usually are examined separately. A comprehensive review of research identified ethnicity, gender, age, physical characteristics, and personal fitness level as personal level determinants associated with physical activity behavior.[11] It has been argued, however, that these personal factors may have little intervention value because they are difficult to manipulate both in research and in life.[12] In physical education, teachers plan activities for children to participate collectively. Although the teacher should be encouraged to consider uniqueness of each child, it may not be realistic for a teacher to intervene with each child to increase physical activity and caloric expenditure.

In contrast, lesson factors may be manipulated to positively impact children physical activity. For example, an early review of research has established that the physical education curriculum has a significant impact on children's physical activity motivation and behavior.[13] Recently, the Center for Disease Control and Prevention (CDC) of the United States urged educators to strengthen physical education curricula, instruction, policy, and assessment to enhance physical activity opportunities for children.[14] It has become clear that synergetic studies are needed to examine simultaneously the joint influence from both personal and lesson factors to determine their respective function in helping children balance caloric intake and expenditure.

Thus, the purpose of this study was to determine the extent to which children caloric expenditure in physical education could be accounted for by personal and lesson factors synergistically and/or separately. The following specific questions guided this study: (a) to what extent could personal and lesson factors be considered as determinants for children in-class caloric expenditure? and (b) to what extent the lesson factors interacted with the personal factors to influence children in-class caloric expenditure?

Answers to these questions will have implications to school health/curricular policies that help address children's health. First, the answers can help us determine whether personal and lesson factors should be weighed equally in decision making about school-based child obesity intervention. Secondly, answers to the questions may provide useful research evidence for school administrators and physical educators to structure physical education content and lesson length to optimize caloric expenditure for children in physical education and promote caloric balanced living behavior in school.

2. Methods

A randomized two-level factorial design was used in this study. The dependent variable was students' in-class caloric expenditure in physical education. The Level-1 factors included student personal level variables: age, gender, and BMI. The Level-2 factors included lesson factors of lesson length, content type, and school level (elementary or middle). Instructional styles of physical education teachers were considered as possible confound and were controlled through randomization. The sampling plan, parent consent and student assent forms were approved by the university's Institutional Review Board (IRB) and the participating school district's research office for human subject protection purposes. Consent forms were received from parents and guardians of participating children.

2.1. Subjects

Subjects included 264 elementary school students (130 boys, 49.2%) and 294 middle school students (153 boys, 52.0%). They were from 14 elementary and 15 middle schools in a very large metropolitan school district in the eastern United States. Based on Heck and Thomas's recommendation[15] for multi-level design sampling, it was determined through a pre-sampling power analysis that 30 organization units (15 elementary and 15 middle schools) were needed to maintain adequate statistical power ($\geq$0.80 where $\alpha = 0.05$). A two-stage sampling was used. In the first stage, school sample was selected. There were 131 elementary and 38 middle schools in the school district. Free and Reduced Meal rate (FARMS %) quartiles were used to stratify the schools into four sampling brackets. Four elementary and four middle schools from each bracket then were randomly selected, except for one bracket from which three schools were selected (this bracket was randomly determined before sampling started). One elementary school was dropped during the study. The final random school sample included 14 elementary and 15 middle schools.

In the second stage, one class from each 3rd, 4th, and 5th grade from each elementary school and one class from each 6th, 7th, and 8th grade from each middle school were selected randomly as participating class. This procedure resulted in 87 intact classes. During a pre-screening, all students in these classes were measured in height and weight, and provided gender and age information. Based on the CDC age−gender adjusted growth chart,[16] they were classified into "Overweight", "Healthy weight", and "Thin" groups. One boy and

one girl were randomly selected from each group in each class as data providers. There were six data providers from each class. Additional students were selected as backup for data providing students. Each backup student shared identical height, weight, age, and gender attributes with the principal participant.

All students were required to take physical education in three of the four academic quarters each year. The minimum weekly allocated academic minutes for physical education were 30 min for elementary school and 150 min for middle school. However, most schools designated more time than the requirements. Lessons were either 30 min or 45−60 min long in the elementary schools and were either 30 min, 45−60 min, or 75−90 min long in the middle schools. Both elementary and middle schools were typically equipped for physical education. There was a gymnasium or a multi-purpose room in each elementary school. In each middle school, there was at least one large gymnasium and an outside field. Physical education was taught by certified physical education teachers in all schools.

2.2. Instruments

2.2.1. In-class caloric expenditure

In-class caloric expenditure in this study was defined as the total amount of caloric expenditure in physical education minus the resting (basal metabolic) caloric expenditure. Caloric expenditure in physical education was recorded using RT3 accelerometers (Stayhealthy.com™). RT3 accelerometers have been determined as a device that can generate valid and reliable caloric expenditure data in physical activity settings.[17] Each of the six students' caloric value recorded in a lesson was converted individually to metabolic equivalent (MET/min). One MET represents the average energy cost set at 3.5 mL/kg/min of oxygen, or 1 kcal/kg/h at seated, resting condition adjusted for age and gender.[18] Any additional caloric expenditure is considered due to physical activity the individual engages in such as those resulted from participating in physical education classes. The MET values were aggregated to represent the average caloric expenditure of the class and the aggregated MET were used also to signify the categorical physical activity levels (intensity) of a lesson: light (<3 METs), moderate (3−6 METs), or rigorous (>6 METs).[17]

2.2.2. Body mass index

Student BMI values were calculated using the formula, weight (kg)/height^2 (m). Students' height and weight were measured using standard equipment in inches and pounds which were converted into meters and kilograms. In addition to being used to calculate BMI, height and weight data were used to pre-program the accelerometers to collect accurate caloric expenditure data.

2.2.3. Gender, grade and age

Gender and grade information was identified by data collectors when the data collection began. The information was confirmed with the demographic information reported by the students and teachers in various occasions during the data collection period. Self-reported date of birth was used to determine age. The gender and age information was also used to pre-program the accelerometers.

2.2.4. Lesson length and content

The lesson lengths on schools' official schedules were recorded. Content categories included fitness development, sport skill development, game play, and multi-activities. The category for each lesson was determined by viewing teacher lesson plans' lesson-focus portion and on-site observation. For example, a lesson on lacrosse passing and receiving was determined as a sport skill lesson. A fitness lesson was one that provided physical activities to develop one or more specific fitness components; such as a lesson of jump-rope and aerobic relays for developing cardio-respiratory capacity. A lesson was determined as game when the lesson focus was on playing games that were not regulation sports such as scooter soccer. A multi-activity lesson focused on several activities that did not fall into the other three categories and did not have an activity theme. For example, playing kickball, playground activities, or field-day activities were typical multi-activity lessons. Lesson information was collected by data collectors using a standardized general-purpose systematic observation instrument.[19] Data collectors recorded lesson activities every 15 s on the instrument. A lesson focus was determined when one activity category exceeded 50% of lesson time.

2.3. Procedure

All data were collected by data collectors who were specifically trained for this study. Each data collector was assigned to two schools. A detailed data collection protocol for each variable was developed for the data collectors to follow during data collection. Students' height and weight data were collected first for calculating BMI and programming the accelerometers. Gender and age information was collected at the same time. In each data collection lesson, data collectors arrived at their assigned schools approximately 15 min before the bell. They calibrated equipment such as the stopwatch, weight and height scale, and laptop computer.

Caloric expenditure data were collected in three to four lessons from each of the 87 classes. Thus, the data represented a total of 270 lessons of various lengths and content. Before each lesson began, the data collector identified the data providing students and secured individually-programmed accelerometers on their waistband above the right knee. After the lesson, the data collector took down the accelerometer and uploaded the accelerometer data into a laptop computer. Two sets of accelerometers were available for collecting data from back-to-back lessons. Otherwise the data collector re-programmed accelerometers using a laptop computer between lessons. But data from 27 lessons were deemed unusable due to either equipment malfunctioning or incomplete data sets. The final lesson sample included 116 lessons from the elementary schools and 127 lessons from the middle schools.

2.4. Data analysis

Both total and activity calories were recorded on the accelerometers. Total calories were the sum of resting (basal metabolic) calorie expenditure and activity calories due to physical activity participation in class. Only activity calories were used in analyses to reflect lesson-induced caloric expenditure. In data reduction, caloric values were also converted to MET for each individual student. The conversion allowed meaningful interpretation of the caloric expenditure in relation to activity intensity. For example, a MET = 3.0 can be interpreted as the caloric expenditure resulted from moderate physical activity, indicating the individual is receiving health benefit.[20]

Preliminary statistical analysis included calculating descriptive statistics to determine data normality and variance homogeneity. Analysis of variance (ANOVA) on individual student means were used to determine the effects by the personal factors. ANOVA on class means were conducted to determine the effects by the lesson context factors. A hierarchical linear modeling (HLM) analysis was conducted to detect any impact from lesson length and content types on personal level caloric expenditure slope (rate of change) due to lesson factor variations. The HLM models were specified as follows:

Level-1 Model

$$Y = B0 + B1(\text{BMI}) + B2(\text{age}) + B3(\text{gender}) + R$$

Level-2 Model

$$B0 = G00 + G01(\text{schoollevel}) + G02(\text{lessonlength}) + G03(\text{content}) + U0$$

$$B1 = G10 + G11(\text{schoollevel}) + G12(\text{lessonlength}) + G13(\text{content}) + U1$$

$$B2 = G20 + G21(\text{schoollevel}) + G22(\text{lessonlength}) + G23(\text{content}) + U2$$

$$B3 = G30 + G31(\text{schoollevel}) + G32(\text{lessonlength}) + G33(\text{content}) + U3$$

where: Y = the caloric expenditure; $B0$ = Level-1 intercept, $B1$, 2, 3 = slopes of Level-1 (personal) factors; $G00$, $G10$, $G20$, $G30$ = intercepts of Level-2 models; $G01\ldots$, $G11\ldots$, $G21\ldots$, $G31\ldots$ $G33$ = slopes of Level-2 (lesson) factors. R = Level-1 random effect; U 0, 1, 2, 3 = Level-2 random effects. The function of the Level-2 model is to determine if the slope (effect on Y) of a particular Level-1 factor (i.e., BMI, age, and gender) was significantly influenced/moderated by any of the Level-2 factors (i.e., school level, lesson length, and content).

3. Results

Tables 1 and 2 report METs by personal and lesson factors, respectively. The ANOVA analysis revealed statistically significant age by gender (Type III $SS = 70.18$, $F_6 = 5.43$, $p = 0.001$, $\eta^2 = 0.06$, $R^2 = 0.28$) and age by BMI (Type III $SS = 76.12$, $F_{12} = 2.94$, $p = 0.001$, $\eta^2 = 0.07$, $R^2 = 0.34$) interaction effects. The ANOVA analysis on the lesson factor revealed lesson length by content (Type III $SS = 19.34$, $F_6 = 2.39$, $p = 0.02$, $\eta^2 = 0.06$) and school level by lesson length (Type III $SS = 9.15$, $F_2 = 3.40$, $p = 0.04$, $\eta^2 = 0.03$) interaction effects. These results indicate that students' caloric expenditure in physical education is likely to be influenced by, separately, personal or lesson factors. The visual indications can be seen in Figs. 1 and 2, respectively.

Table 3 reports individual students' average total activity calories (in kcal) expended in lessons with different length. Table 4 reports class-level average total activity calories (in kcal) accounted for by lesson length and content types. Results from univariate inferential statistical analysis, shown in Figs. 3 and 4, indicate a gender by grade interaction effect and a lesson length by content type interaction effect, respectively. The results suggest that the boys in middle school, after the 6th grade, expended more calories than the girls (Fig. 3). Students in 45−60 min and 75−90 min sport or fitness lessons expended similar amount of calories, which is higher than those expended in 30 min lessons (Fig. 4). These preliminary results warranted the use of HLM to further examine the impact from the personal and lesson factors on students' physical activity.

In the HLM analysis a visual inspection was conducted on the standard error terms from both ordinary and robust algorithms. The inspection showed that the standard errors from

Table 1
Student in-class calorie expenditure (METs) (mean ± SD) by age and gender ($n = 558$).

Age	Overweight ($n = 178$, 32%)		Healthy weight ($n = 307$, 55%)		Thin ($n = 73$, 13%)	
	Female ($n = 87$)	Male ($n = 91$)	Female ($n = 150$)	Male ($n = 157$)	Female ($n = 37$)	Male ($n = 36$)
8 ($n = 50$)	2.16 ± 0.49	3.00 ± 0.80	1.95 ± 1.37	1.94 ± 0.85	1.53 ± 0.70	1.28 ± 0.66
9 ($n = 100$)	2.56 ± 1.12	2.49 ± 0.88	1.99 ± 0.90	2.08 ± 1.01	1.80 ± 1.05	1.71 ± 1.07
10 ($n = 112$)	2.70 ± 1.03	3.29 ± 1.22	1.73 ± 0.79	1.99 ± 1.04	1.25 ± 0.51	1.37 ± 0.81
11 ($n = 95$)	3.49 ± 1.33	3.18 ± 1.04	2.53 ± 1.56	2.81 ± 1.13	1.26 ± 0.48	1.53 ± 0.85
12 ($n = 84$)	3.10 ± 1.58	3.43 ± 1.05	2.50 ± 1.57	2.69 ± 1.66	1.71 ± 1.13	2.41 ± 1.48
13 ($n = 84$)	3.30 ± 1.77	3.50 ± 1.41	2.22 ± 1.41	3.32 ± 1.94	2.11 ± 0.67	3.29 ± 1.32
14 ($n = 33$)	3.58 ± 1.61	3.82 ± 1.87	2.19 ± 1.61	3.90 ± 1.25	3.77 ± 1.11	3.26 ± 1.53

Abbreviation: MET = metabolic equivalent.

Table 2
In-class calorie expenditure (METs) (mean ± SD) by lesson length and content types (n = 243).

Content	Elementary School (n = 116)		Middle School (n = 127)		
	30 min (n = 69)	45−60 min (n = 47)	30 min (n = 60)	45−60 min (n = 32)	75−90 min (n = 35)
Sport (n = 106)	2.26 ± 0.71	2.35 ± 0.75	3.39 ± 1.47	3.98 ± 1.00	2.11 ± 0.86
Fitness (n = 37)	1.45 ± 0.49	2.24 ± 0.31	2.87 ± 1.43	4.41 ± 1.24	2.49 ± 0.95
Games (n = 62)	1.66 ± 0.67	1.79 ± 0.65	3.61 ± 1.21	2.72 ± 1.51	1.21 ± 0.54
Multi-activity (n = 38)	1.66 ± 0.62	2.65 ± 0.97	3.00 ± 0.59	3.85 ± 0.85	0.60 ± 0.21

Abbreviations: MET = metabolic equivalent; min = minute.

the two procedures were very similar (difference at two digits after the decimal), indicating that key assumptions for HLM statistics were not violated. Following the recommended guidelines,[21] the robust algorithms were chosen to minimize potential threats to data reliability.

As reported in Table 5, the HLM analysis generated a number of evidence that suggest no interaction cross Level-1 and -2 factors on caloric expenditure. For example, the reliability estimates for the random components of Level-1 factors were: BMI = 0.25, age = 0.03, and gender = 0.08. The small coefficients suggest that the cross-level impact from lesson (Level-2) factors would be minimal. Information reported in Table 5 indicates that influences from the lesson factors were rather independent and direct (G00, G01, G02, and G03) on the original intercept (grand mean of METs) rather than interactive or indirect through mediating the impact by personal factors (G10, G20, G30, G31, G32, and G33).

4. Discussion

Research findings on child obesity issues in the U.S. almost exclusively point to the need to increase children caloric expenditure through active participation in physical activity. Physical education is an ideal context that provides structured opportunities for all children to engage in physical activities to receive health benefits; one of which is burning calories. The goal of the study was to determine the impact of personal and lesson factors on children caloric expenditure in physical education classes. It was found that at the personal factor level, the data reflected caloric expenditures by students of both genders, with different BMI, and across an age span from 8 to 14. The data from this study support the notion that children across elementary and middle schools do have substantial opportunities to burn calories in a variety of physical education lessons. But the extent of caloric expenditure was uneven in terms of personal and lesson factors. The statistical analyses further indicate that both personal and lesson factors operated within their own parameters.

4.1. Separate impact of the factors

Three personal factors − age, gender and BMI, all identified in previous research to be influential on children's physical activity,[5,9] were identified as contributing factors to in-class caloric expenditure. The statistical analysis suggests, however, that their impacts are interactive rather than independent. Age seems to be a primary changing agent or determinant with sizable effect size on both age by gender (η^2 = 0.06) and age by BMI (η^2 = 0.07) interactions. Older and heavier children spent more calories than their younger and healthy weight or younger and thin counterparts; older male students spent more calories than younger female students (see Fig. 1 and Table 1 for broken-down statistics).

At the lesson factor level, the ANOVA results clearly show that lesson length and content interactively provided powerful influence on students' caloric expenditure (p = 0.02, η^2 = 0.06). Information in Figs. 2 and 4 as well as in Tables 2 and 4 suggests that modest lesson length (45−70 min) with a focus on sport skill and fitness development led to greater caloric expenditure than either shorter or longer lessons with a focus on game play or multi-activity.

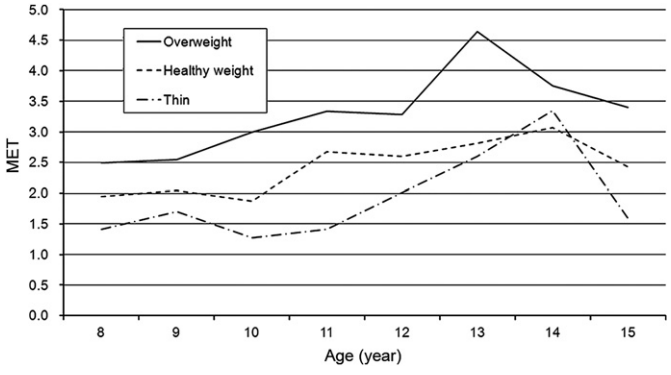

Fig. 1. Age by body weight interaction effect. MET means metabolic equivalent.

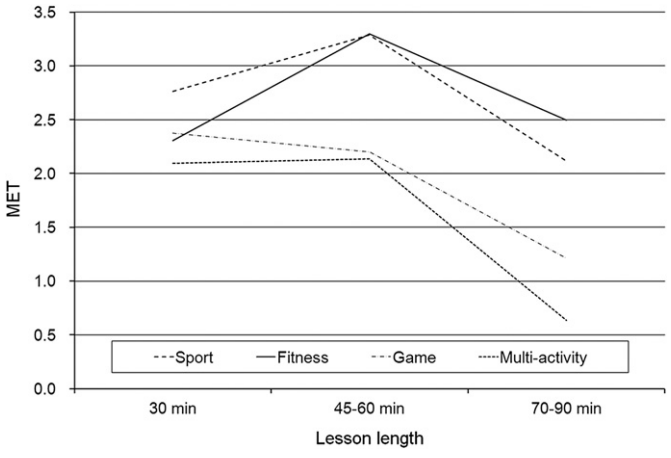

Fig. 2. Lesson length by content interaction effect. MET means metabolic equivalent; min means, minute.

Table 3
Individual average total calorie counts (kcal) (mean ± SD) by lesson length, gender, and grade ($n = 546$).

	30 min lesson		45–60 min lesson		75–90 min lesson	
	n	Total caloric counts	*n*	Total caloric counts	*n*	Total caloric counts
Female						
3rd Grade	18	76.26 ± 48.29	14	158.46 ± 203.29	n/a	n/a
4th Grade	14	62.25 ± 28.48	14	85.54 ± 51.42	n/a	n/a
5th Grade	18	73.24 ± 28.48	18	99.00 ± 103.07	n/a	n/a
6th Grade	18	149.55 ± 72.02	18	161.13 ± 78.15	22	278.16 ± 98.33
7th Grade	24	112.41 ± 57.13	24	169.52 ± 26.93	18	89.98 ± 52.04
8th Grade	24	130.23 ± 66.53	18	59.95 ± 20.08	12	183.87 ± 65.08
Subtotal	116	90.18 ± 55.56	106	119.64 ± 121.18	52	183.98 ± 97.37
Male						
3rd Grade	22	132.34 ± 165.88	22	132.34 ± 165.88	n/a	n/a
4th Grade	18	114.30 ± 42.99	18	114.30 ± 42.99	n/a	n/a
5th Grade	18	79.87 ± 48.76	18	79.87 ± 48.76	n/a	n/a
6th Grade	16	179.42 ± 83.82	16	179.42 ± 83.82	18	264.30 ± 44.92
7th Grade	18	206.21 ± 44.20	18	206.21 ± 44.20	18	110.01 ± 17.82
8th Grade	16	145.11 ± 95.71	16	145.11 ± 95.71	20	209.50 ± 67.28
Subtotal	108	130.56 ± 95.39	108	130.56 ± 95.39	56	192.33 ± 75.99

Abbreviation: min = minute.

Table 4
Class average total caloric count (kcal) (mean ± SD) by lesson length and content types ($n = 243$).

Content	Elementary school ($n = 116$)		Middle school ($n = 127$)		
	30 min ($n = 69$)	45–60 min ($n = 47$)	30 min ($n = 60$)	45–60 min ($n = 32$)	75–90 min ($n = 35$)
Sport ($n = 106$)	75.68 ± 24.84	120.42 ± 39.59	108.94 ± 52.48	177.20 ± 65.46	171.71 ± 65.46
Fitness ($n = 37$)	62.28 ± 27.38	107.89 ± 19.41	96.93 ± 51.19	241.52 ± 85.39	184.76 ± 55.32
Games ($n = 62$)	65.51 ± 27.38	82.01 ± 34.90	116.85 ± 56.18	86.83 ± 25.73	91.62 ± 20.19
Multi-activity ($n = 38$)	59.50 ± 25.66	117.27 ± 141.34	150.18 ± 39.33	155.62 ± 60.63	48.33 ± 28.58

Abbreviation: min = minute.

A significant finding of the study is that the personal and lesson factors functioned independently. The HLM analysis revealed that the lesson factors would not change the impact from the personal factors in both elementary and middle school physical education. Based on the variance explained by the personal factors ($R^2 = 0.28$) and the lesson factors ($R^2 = 0.34$), the HLM model indicates that both sets of factors deserve further research attention to effectively clarify the extent to which different factors contribute to physical activity.[22] Taken together, the findings support the notion that while reducing calorie intake to balance caloric intake and expenditure is necessary,[4,23] promoting caloric expenditure in

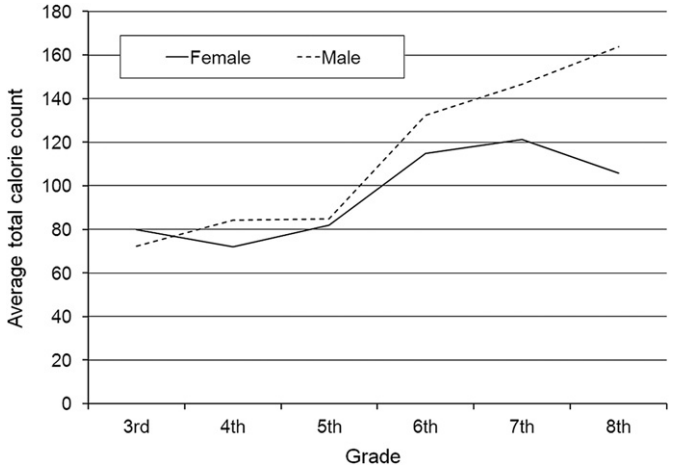

Fig. 3. Grade by gender interaction effect ($f = 4.81$, $p < 0.001$, effect size $\eta^2 = 0.18$).

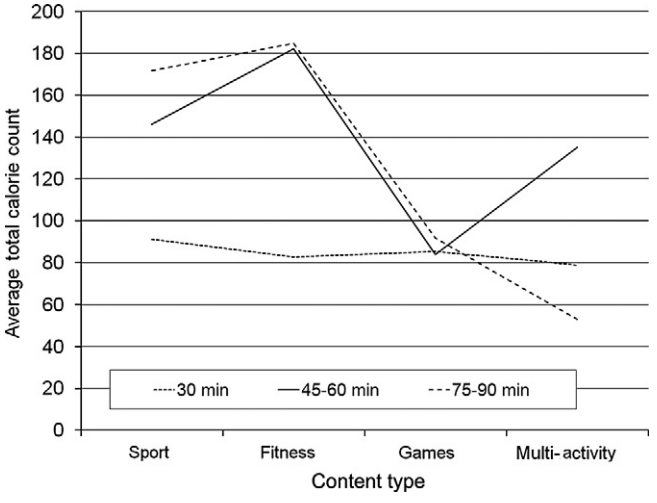

Fig. 4. Content type and lesson length interaction effect ($f = 4.97$, $p < 0.001$, effect size $- \eta^2 = 0.11$).

Table 5
Hierarchical linear modeling analysis results on cross-level interaction effect.

Fixed effect	Symbol	Coefficient	SE	Tao	*df*	*p*	CI-95%
For intercept 1	*B*0						
Intercept 2	*G*00	1.93	0.26	7.34	237	0.00	1.43−2.43
School level	*G*01	0.93	0.16	5.68	237	0.00	0.62−1.24
Lesson length	*G*02	−0.01	0.00	−3.24	237	0.00	0.015−0.017
Content	*G*03	−0.08	0.06	−1.29	237	0.19	−0.21−0.05
For BMI slope	*B*1						
Intercept 2	*G*10	−0.01	0.01	9.20	240	0.00	0.08−0.12
For age slope	*B*2						
Intercept 2	*G*20	−0.02	0.05	−0.42	240	0.67	−0.03−0.01
For gender slope	*B*3						
Intercept 2	*G*30	−0.01	0.23	−0.07	237	0.94	−0.49−0.45
School level	*G*31	0.05	0.13	3.94	237	0.00	0.27−0.77
Lesson length	*G*32	0.00	0.00	−1.20	237	0.23	−0.01−0.003
Content	*G*33	−0.06	0.05	−1.22	237	0.22	−0.16−0.04

Abbreviations: SE = standard error; df = degree of freedom; $p = p$ value; CI = confidence interval.

physical education can be effective to increase caloric expenditure, especially for overweight children,[24,25] to help them further balance energy intake and expenditure.

Intuitively, interventions can only be effective if they target factors that will make a difference on outcome variables. In addition, the targeted factors must be receptive to the intervention. In other words, they should be those factors that researchers or practitioners are able to manipulate to maximize its impact. It is clear that the personal factors examined in this study and others such as ethnicity and personal fitness levels are difficult to manipulate in an intervention. In contrast, lesson factors can be manipulated by school administrators and teachers. Content and lesson length examined in this study are such factors whose joint effect accounted for a significant amount of variance (34%) in the children's in-class caloric expenditure. In addition, the results clearly indicate that a "less-is-more" approach to coupling content with lesson length can be effective. The 45−60 min long lesson focusing on sport skill development (e.g., lacrosse skill development) or fitness development (e.g., animal movement circuit training for upper body strength) can help students burn more calories than game or multi-activity lessons with shorter or longer durations. The evidence suggests a need for future intervention in physical education to use sport skill and/or fitness development tasks as primary intervention content and the 45−60 min lesson length as the intervention delivery and dosage structure.

The data, however, also demonstrate a need to increase overall physical intensity in all physical education lessons. The physical activity levels of these lessons were rarely higher than moderate level (MET: 3.0−4.0). Most lessons were below the 3.0 MET threshold. To help students receive health benefits through burning more calories, the lessons should be structured to provide more opportunities for them to engage in activities at an intensity level that requires spending more calories. To accomplish this goal, research studies are needed to focus on other influential personal and lesson factors that can be manipulated by teachers such as student motivation, teacher planning, and equal opportunity and access to equipment and meaningful content.

5. Conclusion

The study revealed that children's caloric expenditure in physical education could be accounted for by personal and lesson factors separately. The hypothesized synergistic, cross-level interactive influence was not observed in the data. Based on the findings, it can be concluded that children in-class physical activity is determined by separate sets of personal and lesson factors. Each set functions independently in influencing children in-class caloric expenditure directly. But the level of caloric expenditure can be optimized in 45−60 min long lessons that offer sport skill development or fitness development opportunities. It can be recommended that future intervention studies focus on manipulating these lesson factors for maximizing caloric expenditure in physical education.

On a broader scope, physical education has comprehensive, multiple, and diverse goals for children to accomplish. All these goals are for helping children develop life-long physically active lifestyle to enjoy their productive and healthy lives. Caloric expenditure that this study focused on is but one small aspect of the comprehensive educational experience in physical education. The findings shall not be understood as fulfilling all other important goals of physical education.

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