Is in-class physical activity at risk in constructivist physical education?

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Abstract:

Constructivist physical education emphasizes cognitive engagement. This study examined the impact of a constructivist curriculum on in-class physical activity. Caloric expenditure in metabolic equivalents (MET) and vector magnitude count (VM) data from a random sample of 41 constructivist lessons were compared with those from a random sample of 35 nonconstructivist lessons. Statistical analyses revealed that students in both curriculum conditions were active at a similarly low-moderate level (MET = 2.6 for experimental, 2.5 for comparison, $p = .30$). Differences ($p < .05$) were found between the three units within the constructivist curriculum. The findings suggest that the constructivist approach may facilitate knowledge learning with little risk of reducing in-class physical activity.

Keywords: Caloric expenditure | Elementary school education | Health benefits

Article:

Constructivism has been gradually accepted as a viable theory that explains the process of learning and learning behavior change. Based on extensive research in cognitive processes, constructivism takes a position that learning and learning behavior change are a holistic process in which the learner is actively constructing knowledge and behavior within the cognitive, physical, and social constraints of the environment (Mclnerney, 2005). From this perspective, knowledge and skill are not acquired through a one-way, teacher-to-learner transmission; rather they are acquired through the learner's active construction of meanings relevant to his or her life (Hung, Tan, & Koh, 2006). In physical education, similarly, it is believed that motor skills and physically active behavior are acquired through the same construction process (e.g., Allison & Barrett, 2000; Rovegno & Bandhauer, 1997).

Because learning is to construct meaning, the teacher should help the learner understand the relationship between the content/task and the goal to be achieved and why the content/task is meaningful and desirable in real life, rather than understanding the trudi for "truth's sake" (von Glasersfeld, 1995). The learner should be motivated intrinsically or internally through understanding the attractiveness of the task, usefulness of the task, and relevance of the task for life (Alexander, 2006). In a constructivist curricular environment, learners are provided with opportunities to actively use language, in oral and written forms, along with physical movement to help master new knowledge, skills, and behaviors (Hung et al., 2006; von Glasersfeld, 1995). The most important factor in the constructivist approach is for the teacher to provide a learning environment where the learner follows an active learning cycle from active perceiving, conceptualizing, filtering, memorizing, inferring, reflecting, interacting, and structuring of knowledge, skills, and learning behaviors (von Glasersfeld, 1995). During this process, the knowledge, skills, and behaviors that the teacher intends for the learner to construct are actively processed in the learner's mind though active action at the level of social interaction with the content, the teacher, and peers, and of self-regulated cognitive information processing (Hung et al., 2006; von Glasersfeld, 1995).

It is apparent that the constructivist approach demands a high level of cognitive engagement (Alexander, 2006; von Glasersfeld, 1995). While the strong cognitive demand is a natural ingredient in classroom-based learning, it poses a potential challenge to physical education where the physical dimension has been (or at least is perceived to be) the core in the content. Although the recent curriculum reform movement has begun to call on physical educators to incorporate into the curriculum more cognitive content (Griffin & Placek, 2001), especially those focused on health-related knowledge (Cone, 2004; Corbin, 2002), we have little empirical evidence available to assess the impact of increased cognitive emphasis on learner in-class physical activity. The current study was designed to examine the extent to which a constructivist physical education curriculum would affect learner in-class physical activity.

A Constructivist Physical Education Curriculum

The Be Active Kids! (BAR) curriculum used in the study was designed by following the principles of constructivism (Ennis & Lindsay, in press). The central goal of the curriculum is to help elementary school learners construct health-related knowledge and skills through actively participating in relevant physical activities. The curriculum consists of three units: cardiorespiratory health, muscular health, and flexibility health and physical activity principles. Each unit includes 10 lessons each for the third, fourth, and fifth grades. The 90-lesson curriculum was written by a team of university researchers and elementary school expert teachers in physical education and science education. With a spiral sequencing structure (Gagné, Briggs, & Wager, 1992), scientific concepts, principles, and related physical activities are sequenced within and across grades. The curriculum document includes (a) an instructional manual, (b) a student Science Journal in three grade-specific versions, (c) Family Science Activity Night resource materials, (d) a short video featuring exercise scientists and their work as related to physical activity, and (e) a music CD (Ennis & Lindsay, in press).

The content delivery system is based on a learner-centered 5-E scientific inquiry mechanism: engagement, exploration, explanation, elaboration, and evaluation. A sentence-by-sentence lesson script was developed for each lesson. Teachers can choose to teach a scripted lesson so as to follow the 5-E delivery system as closely as possible. During engagement, students enter the physical education class and assume the role of a "Junior Scientist" (often an exercise physiologist). The teacher then involves the students in an instant activity that includes both science knowledge and a physical activity component. In exploration, students predict, observe, and collect data to document how their body responds to physical activity. They record and document the data in their Science Journal in learning centers while continuing to move throughout the physical education space. During the explanation, the teacher leads small or large group discussions using constructivist strategies, such as "Think, Pair, Share," for students to examine their data and compare it to criteria and norms presented on science reference sections in their Science Journal. During elaboration the students consider the life implications of their findings outside of class and school. During this time they have the opportunity to discuss their findings with others in this science community and situate the science principles and concepts within a meaningful life context.

Throughout a lesson, students continuously use the Science Journal to document and process their responses to physical activity, discuss the meaning of their observations, and come up with conclusions. The curriculum constantly requires students to connect cognitive knowledge about physical activity to the physical activities they are currently engaged in. During learning, students often move, stop, think, discuss, record, calculate, conclude, then move again. Apparently, the heavy emphasis on cognition during the learning process might cost precious physical activity time, which might lead to a reduction of the benefit that students ought to receive from physical education lessons. To address this concern, the curriculum-writing team used strategies to shorten the time needed for journaling, such as carefully structuring journal entries; manipulating page arrangements (the left pages present science vocabulary, principles, and concepts, while the right pages present structured working spaces for students to answer questions, complete data observation tables, graph findings, and write science notes); recommending class-organization techniques for effective management of journaling; and incorporating small group discussion with simultaneous low-intensity physical activities.

Despite the strategies, we did not know whether the curriculum put physical activity at risk in the lessons. Thus, this study was designed to gather empirical evidence to examine whether there was such a risk in the constructivist curriculum. In this study, we operationally defined students' in-class physical activity as caloric expenditure in metabolic equivalents (MET) and three-dimensional physical movement counts in vector magnitude (VM) rather than total physical activity time of the lessons. It was hypothesized that the constructivist curriculum might reduce the in class physical activity but not to the extent that would constitute a significant reduction of the benefit that students should be receiving from a physical education lesson.

Method

Research Design

The study was part of a large-scale curriculum intervention research study that was designed to develop, field-test, and evaluate a health-science-based physical education curriculum. The research involved 6,700 third-, fourth-, and fifth-grade students from 1,043 classes in 30 elementary schools. The schools were randomly selected from a very large metropolitan area in the United States and stratified on school socioeconomic status and standardized science test scores. The 30 schools were highly representative of the school districts in the largest metropolitan areas in the United States (National Center for Education Statistics, 2003).

Experimental Conditions. The schools were randomly assigned to either an experimental (n = 15) or a control (n = 15) curriculum condition. In the experimental condition, the constructivist curriculum was delivered using the 5-E system (engage, explore, explain, elaborate, and evaluate) to help children construct knowledge of physical activity principles and benefits. As we described earlier, cognitive tasks were central in all lessons. Children used their science journals to record their experiments and measurements associated with physical activity and to write their conclusions (for details see Ennis & Lindsay, in press).

For comparison purposes, the schools in the control condition followed a curriculum that the school board approved for elementary school physical education. The curriculum is based on the current national and state learning standards. The curriculum goal is to expose students to many physical activities and movements with various sports and games as part of their socialcultural experiences. The curriculum is often taught with direct teaching style. Some teachers, however, use guided inquiry or problem-solving approaches. Student assessment is based on a variety of indicators, including daily participation, skill tests, and written tests.

Teacher Intervention. To maintain the highest data quality for external validity, we followed the randomization and control principles recommended by the U.S. Department of Education (2003) for school-based clinical research for generating high impact and meaningful findings. After their schools were randomly assigned to either the experimental or control curriculum condition, the teachers participated in separate training workshops during the research to enhance effectiveness in teaching their respective curriculum. The teachers received three days of instructional inservice training during the summer and two half-day inservice workshops during the semester. Those in the experimental condition received training specific to teaching the constructivist curriculum, including its unique 5-E instructional approach. Teachers in the comparison condition were trained in the same format and time allotment. But the content of their training focused on the effectiveness of teaching the comparison curriculum, including class management, many activities that children would like, principles of skill development, the tactical games approach, and skill and fitness assessments. The training of the comparison group is considered null/placebo treatment. Coupled with the random assignment to the experimental or comparison conditions, the placebo training helped maintain the integrity of the research design. It did this by controlling for uncurricular impact, such as years of teaching experiences and differences in teaching styles, on students' responses and by preventing the Hawthorne effect, in which positive responses from the experimental group are due to special attention received rather than the impact of the experimental curriculum. Throughout the study, teachers from both curriculum conditions received similar amounts of visitation (about 20 lessons during the semester) from the researchers. Their questions and concerns were addressed in a swift and effective manner.

Variables and Measures. The variable for this study is students' in-class physical activity levels in their respective curriculum conditions. In-class physical activity was measured on activity caloric expenditure (in MET and VM counts). The measurements were taken using RT-3 accelerometers (Stayhealthy, Inc., Monrovia, CA), which have been deemed one of the most reliable devices to record physical activity in field settings and convert it into caloric consumption data (Freedson, Melanson, & Safrit, 1998; Hendelman, Miller, Baggett, Debold, & Freedson, 2000; Johansson, Rossander-Hulthen, Slinde, & Ekblom, 2006; Welk, 2002). The accelerometers were calibrated in our laboratory with undergraduate students and in the field with elementary school students.

Data Sources. A total of 27 intact classes were randomly selected from the experimental condition (n = 14) and comparison condition (n = 13) to provide data. By consulting with the teachers about student attendance records, the researchers identified for each class a pool of students who were rarely absent and selected from the pool 3 male and 3 female students with various height, weight, and body size measurements to represent their class. A total of 162 students represented a total of 27 classes and provided data. The data were collected from 41 lessons from the 14 classes in the experimental condition and 35 lessons from the 13 classes in the comparison condition. The 41 lessons from the experimental condition included 14 from the cardiorespiratory health unit, 14 from the muscular health unit, and 13 from the flexibility health and physical activity principles unit. Each accelerometer was designated to a particular student and his or her height, weight, gender, and age information programmed before each data collection lesson. Caloric expenditure and VM counts were measured by minute. All data-providing students had their parents' permission to participate in the study.

Data Collection, Reduction, and Analysis. The data from both conditions were collected on alternating days of the week throughout the semester. The alternating data collection schedule, by and large, helped control for contextual influences that were uncontrollable through research design, such as weather. Before data collection, the students were taught to ignore the accelerometers and not to play, tap, or take them off during the lesson. All data were collected by the researchers, who always arrived at the school at least 15 min before the first lesson began with the accelerometers preprogrammed for all data-providing students on that day. Students' demographic information (e.g., height and weight) was measured before each experimental curriculum unit began.

Total and activity caloric expenditures and VM counts were collected and downloaded to the computer on site. The total and activity caloric expenditures were measured in age-adjusted MET units. One MET represents the average energy cost at 3.5 $mL/kg^{-1}/min$ of oxygen, or 1 $kcal/ kg^{-1}/hr^{-1}$ at seated, resting condition adjusted for age and gender (Plowman & Smith, 1997). VM counts were based on physical activity in three-dimensions recorded simultaneously on separate X, Y, and Z axes, but were then combined into the amount of total physical activity (Welk, 2002). In other words, VM represents the activity amount aggregated from all three dimensions. The accelerometer is about the size of a small pager. Each must be programmed for the specific user from whom the data are recorded. Demographic information used for programming the device includes gender, age, height, and weight. The information must be entered into the device during the programming before data collection to allow the device to adjust the recordings based on the demographic information of the user.

Each student's data were averaged by total minutes of each lesson. The six students' data from a lesson were aggregated and averaged to represent their class's total in-class physical activity level. Given the purpose of the study, we used multivariate analysis of variance (MANOVA) as the primary data analysis method to examine the differences of the class means between the two curriculum conditions. Naturally, we expected there would be differences among the means from different units and between the experimental units' means and that of the comparison condition. We examined tins difference using an ANOVA to keep our primary analysis focused, yet to gather evidence to guard against naive or spurious conclusions that the three different units in the experimental curriculum would provide equal opportunities for in-class physical activity.

Results

Preliminary data analysis included those on student demographics and descriptives on the dependent measures by groups. The information is reported in Table 1 and Table 2, respectively. The ANOVA analysis on the means in Table 2 revealed statistical significance among the group means on caloric expenditure, $F(3, 72) = 6.83$, $p < .001$ (Levene statistic = 8.84, $p < .001$), and VM counts, $F(3, 72) = 3.17$, $p = .03$ (Levene statistic = 2.51, $p = .07$). We chose to use the Bonferroni post hoc test for its sensitivity to small sample size. The results reported in Table 3 indicate an array of statistically significant differences among the units and between the experimental curriculum units and the control curriculum.

Table 1. Participating student demographics

	All participants (%) (*n* = 162)	**Experimental group (%) (*n* = 84)**	**Comparison group (%) (*n* = 78)**
Gender			
Girls	81/50	42/50	39/50
Boys	81/50	42/50	39/50
Grade			
Third	54/33.3	30/35.7	24/30.8
Fourth	54/33.3	24/28.6	30/38.5
Fifth	54/33.3	30/35.7	24/30.8
Age (years)			
8	44/27.2	24/28.6	20/25.6
9	59/36.4	28/33.3	31/39.7
10	44/27.2	26/31.0	18/23.1
11	15/9.3	6/7.1	9/11.5
Ethnicity			
Asian	4/2.5	3/3.6	1/1.3
Black	87/53.7	40/47.6	47/60.3
Latino	22/13.6	10/11.9	12/15.4
White	11/6.8	7/8.3	4/5.1
Other	13/8.0	9/10.7	4/5.1
Missing	25/15.4	15/17.9	10/12.8
Height (inches & cm)			
M/SD	55.4/3.9 (140.7/9.9)	55.8/3.7 (141.7/9.4)	55.1/4.1 (139.9/10.4)
Min/max	41.0/66.0 (104.1/167.7)	49.0/66.0 (124.5/167.7)	41.0/65.0 (104.1/165.1)
Weight (pounds & kg)			
M/SD	88.7/27.8 (39.9/12.5)	91.1/29.1 (40.9/13.1)	86.2/26.3 (38.8/11.8)
Min/Max	44.0/195.0 (19.8/87.7)	49.0/171.0 (22.1/76.9)	44.0/195.0 (19.8/87.7)

Note. M = mean; *SD* = standard deviation; Min = minimum; max = maximum.

Table 2. Metabolic equivalents and vector magnitude count by units and control (lesson means)

	N	*M*	*SD*	Min	Max
METs					
Cardio	14	2.92	.46	2.07	3.93
Flexibility	14	2.51	.13	2.28	2.70
Muscle	13	2.32	.20	1.95	2.76
Control	35	2.46	.44	1.74	3.43
VM counts					
Cardio	14	1254.42	249.91	808.76	1905.19
Flexibility	14	1105.81	191.90	773.82	1428.89
Muscle	13	891.27	210.50	582.30	1262.53
Control	35	1145.29	338.11	542.53	2144.33

Note. M = mean; *SD* = standard deviation; Min = minimum; Max = maximum; MET = metabolic equivalents; VM = vector magnitude.

Table 3. Bonferroni post hoc analysis on means by curricular units

	Unit	*M* diff.	*SE*	Sig.
METs				
Cardio	Flexibility	.41*	.14	.030
	Muscle	.59*	.14	.001
	Control	.45*	.12	.002
Flexibility	Muscle	.18	.14	1.000
	Control	.04	.12	1.000
Muscle	Control	-.14	.12	1.000
VM counts				
Cardio	Flexibility	148.61	106.43	1.000
	Muscle	363.16*	108.46	.008
	Control	109.13	89.05	1.000
Flexibility	Muscle	214.54	108.46	.310
	Control	-39.49	89.05	1.000
Muscle	Control	-254.03*	91.46	.042

Note. M = mean; *SE* = standard error; Sig. = significance; MET = metabolic equivalents; VM = vector magnitude.
*The mean difference is significant at the .05 level.

The MANOVA analysis was conducted to examine the extent to which students in the two curriculum conditions differed on caloric expenditure and VM count. Because the data came from classes of third, fourth, and fifth grade, we included Grade as well as Curriculum Condition as independent variables to examine possible Grade x Curriculum interaction effects. Table 4 reports the means and standard deviations broken down by the independent variables. As can be seen in Table 5, the MANOVA multivariate procedure revealed no statistically significant Curriculum x Grade interaction, but statistically significant main effects by curriculum and grade. The results indicated that the students in the experimental curriculum were more active than those in the comparison curriculum (see Table 4).

But, it is likely that the MANOVA procedure was overly empowered due to relatively small multivariate error generated by pulling together errors of the two dependent variables (MET and VM) that were highly correlated within each curriculum condition (experimental group: r = .74, comparison group: r = .83). Therefore, a univariate follow-up analysis was deemed necessary to verify the results. We expected that the analysis would further reveal which variable, caloric expenditure and/or VM counts, differed and which factors, curriculum condition and/or grade, contributed to the difference. As reported in Table 6, this conservative analytical procedure revealed no statistically significant differences between the curriculum conditions and among the grades, suggesting that the students in me two curriculum conditions and different grades were similarly active in their respective physical education lessons.

Table 4. Metabolic equivalents and vector magnitude count descriptives by curricula and grade

	Grade	*N*	*M*	*SD*
METs				
Experimental	Third	13	2.43	.22
	Fourth	15	2.67	.50
	Fifth	13	2.66	.33
	Total	41	2.59	.38
Comparison	Third	12	2.43	.52
	Fourth	14	2.38	.27
	Fifth	9	2.62	.56
	Total	35	2.46	.44
VM counts				
Experimental	Third	13	1169.91	181.26
	Fourth	15	1097.85	314.29
	Fifth	13	996.39	248.78
	Total	41	1088.53	260.66
Comparison	Third	12	1260.58	450.43
	Fourth	14	1000.33	179.70
	Fifth	9	1217.07	303.16
	Total	35	1145.29	338.11

Note. M = mean; *SD* = standard deviation; MET = metabolic equivalents; VM = vector magnitude.

Table 5. Multivariate analysis of variance results

Effect	Pillai's trace	*F*	Hypo *df*	Error *df*	*p*	Partial η^2	Observed power
Intercept	.98	1687.51	2.00	69.00	.000	.98	1.000
Curriculum	.20	8.42	2.00	69.00	.001	.20	.958
Grade	.39	8.46	4.00	140.00	.000	.20	.999
Curriculum grade	.09	1.62	4.00	140.00	.173	.04	.488

Note. Box M = 33.87, $p = .008$.

Discussion

The purpose of the study was to compare a constructivist physical education curriculum with a traditional one on student in-class physical activity levels, one of the important learning outcomes in physical education. Based on a randomized, controlled, experimental research design, the study yielded important findings suggesting (a) that students are likely to be physically active in both curriculum conditions and (b) that there is a possibility that the level of physical activity is content specific. We think that these findings help clarify the role of the curriculum in relation to in-class physical activity and contribute to a deeper understanding of the constructivist approach to physical education. In the following, we will attempt to explore the meaning of in-class physical activity as related to cognitive learning of knowledge and elaborate on the variation of physical activity level as related to content specificity.

Table 6. Univariate follow-up of analysis results

Source and variable	Type III SS	*df*	M^2	*F*	*p*	Partial η^2	Observed power
Intercept							
METs	474.28	1	474.28	2,804.74	.00	.98	1.00
VM counts	93,457,374.30	1	93,457,374.30	1,107.55	.00	.94	1.00
Curriculum							
METs	.20	1	.20	1.2	.02	.02	.19
VM counts	94,005.71	1	94,005.71	1.11	.30	.02	.18
Grade							
METs	.48	2	.24	1.43	.25	.04	.30
VM counts	375,798.93	2	187,899.47	2.23	.12	.06	.44
Group curriculum							
METs	.33	2	.17	.97	.38	.03	.21
VM counts	322.382.54	2	161,191.27	1.91	.16	.05	.38
Error							
METs	11.84	70	.17				
VM counts	5,906,755.48	70	84,382.22				

Note. M^2 = mean square; MET = metabolic equivalents; VM = vector magnitude; Leven's test: experimental: $F = 3.58$, $p = .006$; comparison: $F = 1.81$, $p = .12$.

In-Class Physical Activity and the Curriculum

The in-class physical activity in both curriculum conditions seems to fall into a low-moderate intensity level. The MET level suggests that students were active at the level of walking at a speed of 2.0 to 2.5 miles per hour (American College of Sports Medicine, 2005). Although this level is below the typical moderate level (MET = > 3.0, Freedson, Pober, & Janz, 2005, or MET = > 4, Nichols, Morgan, Sarkin, Sallis, & Calfas, 1999), it should not be considered unreasonable given the 30-minute lesson length in these schools.

Physical education should offer many opportunities to help students become knowledgeable about the benefits of physically active living and to learn knowledge and skills for motivated, regular participation in physical activity (National Association of Sport and Physical Education [NASPE], 2004). The physical education curriculum, in many forms, has often incorporated the development of knowledge as one of the most important goals. A challenge to accomplishing the goal in many cases is whether we are able to effectively teach relevant knowledge that will help students, especially young learners, change their misconceptions about many aspects of physical activity, including principles of exercise, tactics of physical games, and benefits and function of regular participation (Corbin, 2002; Griffin & Placek, 2001). Providing opportunities for students to cognitively engage in learning physical activities is necessary.

In the experimental curriculum, learning health-related scientific knowledge about physical activity is the primary goal and the core content. It is reported that this goal has been successfully accomplished at least in the cardiorespiratory health unit (Chen, Ennis, Martin, & Sun, 2006). Learners in the experimental curriculum gained significantly more knowledge than those in the comparison curriculum condition. The current analysis on physical activity levels from a representative group of lessons further demonstrates that the knowledge gain was obtained through adequate involvement in physical activity, rather than at the expense of it. Together with the findings in Chen et al. (2006), the findings from this analysis show that a constructivist physical education curriculum can effectively help students learn necessary knowledge important to their health as well as keep them physically active in order to receive benefits from an adequate amount of physical activity.

The findings also help advance our understanding of the role of the cognitive and physical components in physical education. While the belief that the two components are necessary in a physical education curriculum has been acknowledged since the inception of physical education as a school-based discipline (Arnold, 1979), the emphasis on teaching the cognitive component has been overridden by a historically strong focus on the physical, with exceptions of movement education curricula (e.g., Logsdon et al., 1984) and skill development curricula based on motor learning theories (Gallahue & Cleland, 2003).

In a curriculum intended to change the physical activity behavior of children and adolescents, two different approaches are commonly employed. With a behaviorist approach, the curriculum focuses on providing children with an immediate health benefit. For example, a running-for-health program, "Roadrunner," as reported in a series of studies by Xiang and her colleagues (e.g., Xiang, Chen, & Bruene, 2005; Xiang, McBride, & Bruene, 2006), can be implemented. This approach is equivalent to what von Glasersfeld (1995) has criticized as "truth for truth's sake" education (p. 177) with little contextualized meaningfulness to the learner. As reported by Xiang et al. (2005, 2006), this approach may have a negative impact on children's motivation for participating in future running activities due to physical discomfort, boredom, and/or purposelessness. Its effectiveness relies on students' recognition of the usefulness and interesting qualities of the activity of running. In other words, for those students who understand the importance of running for health (a cognitive component), running becomes an endurable and tolerable activity, although they might still dislike it.

Another approach is a cognition-based approach, where concepts and knowledge about physical activities and health are taught. Sample curricula include Fitness for Life by Corbin and Lindsay (2002) or Foundations of Personal Fitness (Rainey & Murray, 2005). Each involves large amounts of cognitive information about physical activity and behavioral change. Although limited, research studies have shown that Fitness for Life may have a positive impact on high school students' learning of knowledge and skills for regular physical activity (Dale, Corbin, & Cuddihy, 1998). However, the separate classroom lecture and lab-activity format makes these curricula potentially difficult to implement in programs for younger children.

We believe that our data provide limited but significant evidence suggesting the possibility of using a constructivist curriculum approach to strike a balance between the cognitive and physical demands in physical education. With cognitive learning tasks embedded in the physically active, 5-E, experiential-learning processes, elementary school children are likely to learn important cognitive knowledge about health-related physical activity (Chen et al., 2006) along with carefully choreographed moderate physical activities that provide them with health benefits.

Content Specificity Issue With Physical Activity

It is apparent that the overall physical activity level from both curriculum conditions is at the low end of recommended moderate levels (Freedson et al., 2005; Nichols et al., 1999). We believe that this is due to the short lesson duration (30 min) scheduled by the schools for physical education. Given the content in both conditions to be learned in this short period, knowledge in the experimental curriculum and skills in the comparison, it may be difficult for teachers to monitor and maintain high levels of physiological intensity throughout a lesson and across various units and activities.

The data raise the issue of content specificity for curriculum designers. The levels of MET and VM varied between different units in the experimental condition with statistical significance (see Tables 2 and 3). It appears that physical activity level is lowest in the unit of muscular capacity, while it rose to the highest in the cardiorespiratory health unit. Although it is quite possible that the accelerometry technology might be less sensitive to stationary upper-body movements in comparison with whole-body locomotor movements (Hendelman et al., 2000; Johansson et al., 2006), we should not overlook the possibility that a unit devoting the majority of content to muscular capacity has inherent characteristics that prohibit a high level of whole-body physical activity and caloric expenditure.

This piece of evidence suggests that we should have reasonable, content-specific expectation for students' in-class physical activity levels and expect varied in-class physical activity levels in different units. Extended from this school of thought, we challenge physical educators and researchers to consider the question: do we need to specify a universal standard for in-class physical activity, if the goal of the curriculum is to help students develop a physically active lifestyle? Constructivist curricular theories are based on an assumption that behavior and behavioral change are rooted in and derived from an individual's cognition. As an individualized process, the expected behavior change is nurtured, reasoned upon, inferred from and applied to experiences, further reflected upon, and socially tested in one's immediate physical and social environment; eventually the behavior is fostered, developed, and sustained (von Glasersfeld, 1995). Accordingly, it stands to reason that although a student might be less active in learning knowledge and exercise principles in the muscular capacity unit, it should not follow that they have learned less about the importance of developing muscular capacity through relevant exercises and physical activities.

The evidence challenges the idea that we need a universal standard for physical activity to evaluate physical education lessons. Obviously, some content will demand more physical activity than others. While being cognizant about the importance of providing a health benefit through in-class physical activity, physical educators may also need to be concerned with broader goals that help students become physically educated (NASPE, 2004) through providing behavior-shaping knowledge (Evans, Rich, & Davies, 2004).

Being physically active is but one outcome we expect from physical education lessons. This goal seems to rely on situational factors, especially situational interest defined as the appealing characteristics of a task or activity (Mitchell, 1993). Shen and Chen (2006) reported that in-class physical activity levels may not necessarily lead to acquisition of knowledge and skills that are commonly acknowledged to be necessities for prolonged physically active living. Thus, pursuing in-class physical activity at the expense of learning cognitive knowledge and physical skills may not be consistent with the ultimate goals of physical education. For example, in-class physical activity induced by seductive details (situational factors that generate "fun" experiences but are unrelated to learning) may not be contributing to the learning outcome that we value for our students (Shen, McCaughtry, Martin, & Dillon, 2006). When we strive to create physically active lessons for K-12 students, we need to be concerned with the approach we use to generate high-level physical activity relevant for learning knowledge and skills and for shaping their physically active behavior. Because our data are among the very first in physical education research related to the issue of content specificity, we believe follow-up replication studies are needed to further clarify the issue. Readers should take precautions when interpreting this finding.

Summary

This randomized, controlled experimental study clearly demonstrates that a constructivist physical education curriculum focusing on cognitive knowledge acquisition can generate adequate amounts of in-class physical activity for students. Constructivist psychologists (e.g., Lave & Wenger, 1991; Vygotsky, 1978) have long suggested that students learn more deeply and remember the content materials longer when they engage in tasks requiring both cognitive (thinking) and physical (hands-on) involvement. The experimental curriculum used in this study was developed within this framework of constructivism. Cognitively, the learner is expected in every lesson to use high-level cognition skills such as predicting, hypothesizing, calculating and reasoning, and evaluating. Physically, moving in the gymnasium is no longer for moving's sake or "fun" only. Through physical movement, students experiment with various physical activity patterns, generate data (e.g., heart rate, breathing frequency, number of games played), and verify and evaluate their own predictions. In this curriculum, both cognitive and physical tasks are intertwined closely to help students effectively construct scientific knowledge about physical activity and its health benefits to their body.

Physical education is facing many challenges in the current educational environment (Tappe & Burgeson, 2004) and is considered in "high need" but in "low demand" (Ennis, 2001). O'Sullivan (2004) argued that as physical education in the educational enterprise has become an issue of public health policy, the current emphasis on fitness development, in-class physical activity, and health without long-term and broad educational goals may lead to an ambiguous definition of goals. As O'Sullivan pointed out, the issue can be reduced, after all, to the question of balancing ends and means among health benefits, educational values, and enjoyment in physical activity. We believe that the data reported here suggest the possibility of a balanced physical education curriculum that provides elementary school learners with in-depth knowledge about physical activity benefits and principles and with opportunities to be physically active in physical education classes.

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