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Physically Active Academic Lessons in Elementary Children

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Abstract

Background—Although schools are an ideal location to conduct interventions that target children, the emphasis on standardized testing makes it difficult to implement interventions that do not directly support academic instruction. In response, physically active academic lessons have been developed as a strategy to increase physical activity while also addressing core educational goals. Texas I-CAN! is one incarnation of this approach.

Methods—We will review on-going research on the impact of these active lessons on: teacher implementation, child step count, child attention control, and academic performance.

Results—The collected studies support the impact of physically active academic lessons on each area of interest.

Conclusions—If these data can be replicated, it suggests that teachers might find these lessons of benefit to their primary role as educators, which should ease dissemination of these and other physically active lessons in elementary schools.

Introduction

The articles in this issue provide compelling evidence that physical activity is associated with both cognitive function and academic performance in children. However, the amount of physical activity declines across childhood (Kim et al., 2000), with the greatest declines occurring during elementary school (Trost, et al., 2002). This trend is particularly apparent in low SES, ethnic minorities who are both disproportionately inactive by the age of 11 years (Broderson et al, 2005; Broderson et al., 2007; Hoelscher et al., 2004) and perform poorly in school (Heard et al., 2007). One would expect that these data would compel school districts to increase the time spent in physical education. Unfortunately, the current economic conditions and the use of high stakes standardized testing to evaluate schools and teachers has placed enormous pressure on districts to maximize instructional time at the expense of physical education and recess (Center for Education Policy, 2007; Trost & van Der Mars, 2010). In fact, only 3.8% of elementary students receive daily physical education in the U.S. (Lee, Burgeson, Fulton, & Spain, 2007).

School-based physical activity interventions may need to target the regular education classroom. Working within the academic classroom introduces a complication where teachers must choose between time spent on academics and on health interventions. Thus, while teachers are generally supportive of physical activity interventions, they question their

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ability to find sufficient time to sustain the implementation of any health-related, non-academic intervention (Ward et al. 2006). In response, a number of research groups are working to combine physical activity interventions with academic content (Donnelly et al., 2009; Mahar et al., 2006; Stewart et al., 2004). These are generally teacher-implemented academic lessons that utilize moderate-vigorous student movement in the review or teaching of core academic content. Teachers and children have been uniformly positive in their ratings of this approach (Gibson, et al., 2008) and students have consistently shown increases in physical activity (Gibson, et al., 2008; Stewart, et al., 2004). Likewise, the consistent use of these active academic lessons over two years has led to lower BMI scores across elementary children (Donnelly et al., 2009).

Texas I-CAN! Active, Academic Lessons

Texas I-CAN! (Initiatives for Children's Activity and Nutrition) is one example of this approach. Our original efforts were developed in three elementary schools with students who were disproportionately minority and of low socioeconomic status. Our approach was to train teachers to modify their lesson plans to incorporate physical activity during academic time. We provided teachers with sample lessons, e.g. graphing distance run or time on a jump rope. Teachers were then trained to use this strategy to develop similar lessons across their core curriculum (math, language arts, science). The training was highly regarded by teachers, receiving an average rating of 4.7 on a 5-point Likert-type scale. In addition, pedometer counts with 4th and 5th grade children indicated that children within 2 of the 3 intervention schools executed significantly more steps than these same children did on control days, (Cohen's d=.40, p< .05). Unfortunately, few teachers (< 25%) implemented lessons on a daily basis as was intended. The process evaluation indicated that while teachers strongly supported the concept, lack of planning time and available resources (model lesson plans/equipment) was a significant barrier to implementation. In response, we sought to minimize the barriers to implementation through a pilot test of Take 10 (International Life Sciences Institute, 2010). Take 10 provides a series of 10-minute active lessons, using repetitive activity to reinforce existing knowledge. These have been successfully utilized to increase physical activity in elementary school children (Stewart et al., 2004). However, our focus groups revealed that teachers considered the lessons as lacking integration within their curriculum and with activity merely "tacked on" to an overly basic lesson. In response, we decided to develop a set of active lessons.

We formed a committee of teachers from bi-lingual schools to develop a novel set of active lessons across Kinder-5th grades as well as across subjects. The Texas I-CAN! Committee included teachers from each of the elementary school grades, including teachers with specific specializations in English as a second language, physical education, and special education. Lesson development included creating two types of lessons. The first set of the lessons incorporated the teaching of new information through physically active games. One example is called, *Cardiac Relay.* In this lesson, children are divided into relay teams. The first child is handed a blue-colored rubber disk. This represents an unoxygenated red blood cell. The child begins in the "muscle," then runs through the "heart" to the "lungs." There, they "pick-up oxygen" by exchanging the blue disk for a red disk. They then return through the "heart" to the "muscle" where the next child begins. Children learn the basic structure of the circulatory system through the actions involved within the game. The second set of lessons emphasized drill and practice of factual information. One example is called, *Spelling Freeze Tag.* Children are released to run within an outdoor area marked off by cones. When tagged, they "freeze" in place with their hands raised. Another student with a list of spelling words quizzes the "frozen" student. If correct, the student is released to continue running and try to avoid being tagged. If not, a second word is presented. Thus, this lesson is used to review factual information. This basic structure can be applied to any fact-based knowledge

set (e.g. state capitals, vocabulary words, math facts, etc.) and requires little effort from the teacher to adapt. Although each lesson was specifically tied to the Texas Essential Knowledge and Skills (TEKS, Texas Education Agency, 2010), the state-mandated curriculum for each grade, they are easily modified for use in other state curriculums that differ more in the order of presentation than in content. Finally, an independent pair of teachers, a PE specialist and an independent elementary teacher with certifications in regular and special education, evaluated the lessons, providing feedback during their development.

Impact on Physical Activity

As an initial evaluation, the newly developed Texas I-CAN! active academic lessons were implemented by 22 teachers, who were drawn from Kinder – 5th grades within a predominantly low socioeconomic school with a disproportionate number of Hispanic children. These teachers were provided a single day of training. The training exposed teachers to the lessons, materials and supplies. In addition, teachers worked in groups to find lessons that would match their upcoming curricular goals and participated in sample lessons. Finally, we worked in small groups to consider and problem-solve potential barriers to implementation as the teachers utilized the lessons for 4 weeks. The impact of lessons on physical activity was evaluated through one week of pedometer counts comparing two days with- and two days without lessons following the 4-week run-in. The order of these days was randomly assigned within each classroom across Kinder through 5th grade. The intervention resulted in a significant increase of approximately 1,000 steps for all grades, with no difference in the magnitude of the increase between Hispanics and Caucasians. This increase in steps is more than triple the increase shown in the initial pilot. Additionally, 1,000 steps correspond to approximately 10 minutes of MVPA and 7–8% of the total number of steps recommended for children of this age (Tudor-Locke, & Bassett, 2004). Thus, the use of the Texas I-CAN! active academic lessons successfully increased children's activity in line with public health recommendations and the goals of the project. In addition, teachers were asked to rate the lessons through a series of single-item indicators scored on 5-point, Likert-type scales. The 22 teachers uniformly found the directions to be easy to understand (M = 4.64, SD = .60) and implement (M = 4.55, SD = .58). The content was rated as providing a strong fit with the state-mandated curriculum (M = 4.59, SD = .66) and their own lessons (M = 4.56, SD = .69). Thus, the lessons appear to provide a strong fit to each grade's curriculum and, despite minimal training, teachers were able to implement the lessons and produce significant increase in physical activity.

These data were limited by the use of a single school. In response, we recently completed was a NIDDK-funded project (1R21DK071975) to test the use of the Texas I-CAN! active, academic lessons across eight schools, using 3rd grade children as the target population. Third grade was selected, as this is a high stakes testing grade in Texas, where passing scores on the standardized math and language arts exams are required for promotion into 4th grade. As such, 3rd grade provides the strongest barriers to teacher implementation. We recruited 8 schools, with 4 serving as intervention and 4 serving as no intervention controls. Forty-seven teachers (25 I-CAN! intervention, 22 control) participated in the study. Teachers were asked to implement Texas I-CAN! lessons on a minimum of 4 of 5 school days per week (one lesson per day on average). Physical activity was assessed through pedometer counts, with results analyzed via a 3-level (students, teachers, and condition) hierarchical model. Results are presented in figure 1, and indicated a significant difference between conditions, with intervention students increasing activity by more than 300 steps, while control students reduced their steps by nearly the same degree. In addition, a sub-sample of 200 students wore the Actigraph GT1X accelerometers to collect the intensity of physical activity. These data indicated that approximately 20% of the lessons was spent in moderate-vigorous physical activity (MVPA). This finding coincides with observational

data that we collected through a modification of the SOPLAY (McKenzie, et al., 2000) method for random moment sampling. In addition, this change was consistent across levels of BMI and ethnic categories (Bartholomew, et al., 2009). The Texas I-CAN! lessons resulted in a significant increase in activity that was consistent across demographic and BMI categories.

Teacher Implementation Rates

One of the benefits of targeting the academic day is that it makes use of children's non-discretionary time. That is, the elementary school is a narrow environment in which children do not possess behavioral control, i.e. teachers determine when students may leave their desks. While this is problematic when it precludes children from active choice, it may be beneficial if this non-discretionary time is used to compel activity. Such an effect is dependent upon strong teacher implementation rates. For example, Donnelly and colleagues (2009) found that 9 of 14 interventions schools achieved more than 75 minutes of exposure to active, academic lessons and that the change in BMI was only significant for these schools. As a result, it is important to consider factors that are associated with teacher implementation of these lessons. One of the strengths of our most recent evaluation is that it has sufficient teachers (n=25) to provide this type of assessment. Implementation rates were collected over six months of intervention. First, teachers provided self-report of the lesson implemented, the lesson intensity, duration and the lesson quality. In addition, teachers were spot-checked by research staff twice/month. To predict implementation rates, teachers completed measures of: (a) lesson quality, e.g. relationship to required curricular content; (b) self-efficacy to implement the lessons, e.g. confidence in the ability to maintain behavior control over the class; (c) perceived barriers to implementation, e.g. lack of time; (d) years of experience; (e) 7-day physical activity recall; and (f) height and weight to determine teacher BMI. Bivariate correlations indicated that the percent of lessons completed were associated with teacher ratings of lesson quality ($r = 0.52$), self-efficacy ($r = 0.47$), and perceived barriers ($r = -0.58$). Lesson quality was associated with years teaching ($r = 0.45$), and perceived barriers ($r = 0.42$). Self-efficacy to implement lessons was associated with perceived barriers ($r = -0.84$). Neither teacher physical activity nor their BMI were associated with lesson implementation. These data emphasize the importance of teacher attitudes and perceived behavioral control. As a result, teacher-training programs might best be centered on the Theory of Planned Behavior (TPB, Ajzen, 1985), which emphasizes these factors. TPB also emphasizes perceived social pressure. Although this was not addressed in our work, this could be leveraged in future studies by examining the role of principal support for the use of active academic lessons. The TPB would be interpreted to emphasize this type of social pressure as a means to establish a social norm for lesson use.

Time on Task

Although primarily designed to impact physical activity, a secondary aim of our project was to determine the impact of the Texas I-CAN! lessons on academic-related outcomes, with a particularly interest in engagement with academic material. Academic engagement refers to the ability to pay attention in class and to make an effort to learn (Johnson et al., 2001). This has been shown to be a key predictor of academic success (Greenwood et al., 2002). Engagement was assessed through observations of time spent focused on academic tasks, or Time on Task (TOT; Grieco et al., 2009). Mahar and collegues (2006) have shown that participation in these types of lessons results in a significant increase in TOT for subsequent, sedentary lessons. That is, there appears to be a lagged effect of physical activity. Physical activity is accrued during one of the active academic lessons, with improved behavior control occurring following the intervention and during the subsequent academic period taught in a traditional, sedentary style. If replicated, this would provide an additional benefit

to these lessons. Not only would the lessons be used to teach and review academic material, they would also benefit learning during the lessons that follow.

To collect TOT in conjunction with the Texas I-CAN! lessons, two trained staff were provided seating charts for participating students. Each child was observed prior to and following either an active or a control lesson. In each case, children were observed for a series of 5-second intervals. The observer would note if the behavior was on-task or off-task and then move to the next child when prompted through an auditory MP3 file. Off-task behaviors included gazing off, placing her head on the desk, reading inappropriate material, talking to or looking at other students, etc. Inter-rater reliability was over .90 at both baseline and a mid-study follow-up. Results indicated a significant reduction in TOT for inactive, control days. Specifically, TOT dropped from approximately 83% at pre-sedentary lessons to an average of approximately 72% post the sedentary lessons. In contrast, TOT was approximately 86% prior to the active, academic lessons, and increased to 89% post the active lessons. Interestingly, this effect was linearly associated with BMI category. These data are presented in figure 1 and show that heavier children were less able to maintain TOT than on-weight children following a traditional, sedentary lesson, with only 58% of their time focused on the assigned academic material. In contrast, these same children were able to maintain a focus for 93% of the time on the assigned material following the active lesson (Grieco et al, 2009). This increase in TOT has clear implications for classroom behavior and provides strong potential to enhance teacher motivation to implement this type of active, academic lessons.

Academic Performance

Given the effect on TOT, one would expect these lessons to provide a clear academic benefit. To this end, Donnelly and colleagues (2009) assessed performance on standardized testing. They found positive results, with a three-year exposure to active academic intervention resulting in significantly higher scores on a composite of reading, math and spelling tests (Donnelly, et al., 2009). However, teachers are likely to be more sensitive to academic outcomes that follow a standard elementary schedule of one week of instruction followed by testing. In response, we recently completed a pilot study of the Texas I-CAN! lessons on proximal spelling scores. A sample of 6, 4^{th} grade classes (independent from the TOT study) was selected to participate. Teachers were randomly assigned to complete either a week of normal spelling instruction or to use the I-CAN! active lessons. For example, during an I-CAN! lesson the children would be asked to compete in relay teams in which each team member would race - in turn - to the board to write the one letter of a word. The next child adds to the word or corrects an earlier error by a teammate. The first team to correctly spell the word wins that relay. For a sedentary lesson the children might create a spelling diamond. In this case the child would write the full word, and then move down a line and write all but the last letter. Then, they would move down a line and write all but the last two letters and so on until there was one letter and the process was reversed. The process in both the active and sedentary lessons would be continued for all words on that weeks spelling list. To assess spelling, a pre-test was provided on Monday. Intervention or control lessons would occur on Tuesday, Wednesday and Thursday, with a posttest on Friday. In addition, a retention test was taken two weeks post. Results are presented in Table 2 and were mixed. For the initial posttest, the traditional lesson provided a small, but non-significant benefit relative to intervention (Cohen's d = −.22; p = .11). For the follow-up retention test, the Texas I-CAN! lessons provided a moderate, significant benefit (Cohen's d = .63, $p<.05$). Given the small sample and mixed results, these data need to be replicated, but they are intriguing.

Although physical activity has been suggested to be particularly beneficial for children who are kinesthetic learners – that is, children who tend to prefer tactile rather than auditory or oral information gathering and or being physically involved in learning (Zapalsky & Dabb, 2002), these lessons are not an adequate test of kinesthetic learning. Rather than providing true tactile stimulation, e.g. writing in sand, or an activity that is instrumental to learning, the physical activity in these spelling lessons is merely overlaid on the spelling content. As a result, it is more likely that the observed benefit is due to physical activity alone rather than individual differences in learning styles. This may be due to the effects of physical activity on either increased time on task, as discussed above, or enhanced cognitive functioning as discussed elsewhere in this issue. Regardless, if replicated, these data can be combined with the TOT data to provide a strong argument for implementation in the elementary classroom. In this way, we can achieve our public health goals for physical activity along with teachers' goals for academic performance.

Conclusion

Texas I-CAN! has progressed through a comprehensive examination of the effect of physically active academic lessons on: 1) children's in-school step count, 2) student time on task, 3) academic outcomes, and 4) teacher implementation and willingness to include activity within academic content lessons. The evidence from studies examining the Texas I-CAN! intervention may be summarized as follows: 1) teacher implementation rates are enhanced following training based around the Theory of Planned Behavior (Ajzen, 1985) and through the provision of active lessons and needed equipment for the classroom, 2) teacher personal physical activity levels and BMI scores do not significantly affect implementation rates, 3) the lessons result in significant increase in children's step counts that are in-line with public health goals, 4) children's TOT is increased following active lessons when compared to TOT following traditional sedentary lessons, and 5) children's 2-week retention of spelling appears to be enhanced following the use of active rather than sedentary lessons. Taken together, these data provide strong support for the inclusion of physically active lessons throughout each school day in the elementary classroom. As such, these data can be used to enhance the dissemination of this Texas I-CAN! and similar, active, academic lessons as an approach to school-based promotion of physical activity.

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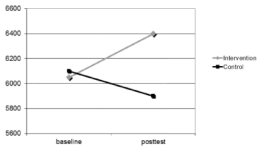

Figure 1.
Change in average steps/day from baseline to posttest between the Texas I-CAN! intervention schools with active, academic lessons (n=4) and control schools with traditional, sedentary lessons (n=4).

Table 1

Means and standard deviations for percentage of TOT of 4th grade students. TOT was collected through direct observation prior to and following both active, and sedentary lessons.

	Pre-lesson	Post lesson
	Sedentary Control Lesson	
On-weight	81.8 (± 16.2)	74.4 (± 22.1)
At Risk	85.8 (± 17.9)	72.2 (± 22.1)
Overweight	84.4 (± 16.2)	57.9 (± 25.3)
	Texas I-CAN! Physically Active Lesson	
On-weight	85.5 (± 19.4)	87.8 (± 16.2)*
At Risk	86.1 (± 14.5)	89.6 (± 12.2)*
Overweight	90.8 (± 10.6)	93.3 (± 8.7)* †

* Indicates a significant pre-, post-difference, $P < .05$.

† Indicates significant difference from on-weight group, $P < .05$

Table 2

Spelling scores (percentage correct) by condition and adjusted for pre-test scores.

	Inactive/control	Physically active lessons
Pre-test	67.41 (± 31.54)	57.51 (± 23.47)
Posttest	89.45 (± 17.30) *	80.69 (± 22.87) *
-adjusted mean	85.65	82.93
Retention	85.95 (± 18.60) *	89.64 (± 19.71) *
-adjusted mean	82.93	91.35 †

† Indicates a difference between groups, controlling for pre-test scores, $P < .05$.

* Indicates a significant difference from the pre-test, $P < .05$.