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A Quantitative Review of Physical Activity, Health, and Learning Outcomes Associated With Classroom-Based Physical Activity Interventions

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Research suggests that physical activity may foster improved academic performance, yet schools are receiving more pressure to achieve high academic standards. It is important for classroom teachers, administrators and school psychologists to understand the benefits of incorporating physical activity into the school day. This article serves as a quantitative review of classroom physical activity interventions in terms of their physical activity, health and learning outcomes for students, with implications of findings discussed for school personnel.

KEYWORDS academic achievement, exercise, children

It is well documented that obesity rates of U.S. children and adolescents have dramatically increased over the past three decades (Hedley et al., 2004; Ogden, Carroll, & Flegal, 2008). Along with a myriad of other factors, physical inactivity contributes to childhood overweight and obesity (National Center for Health Statistics, 2009). Health professionals recommend that youth accumulate 60 min or more of moderate to vigorous physical activity on a daily basis (Strong et al., 2005).

Despite these suggested amounts of physical activity, many American youth are not meeting the recommendations (Centers for Disease Control

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and Prevention, 2008). Because most U.S. youth attend school (Snyder, Dillow, & Hoffman, 2009) and most of their moderate to vigorous physical activity opportunities are offered during school (Guinhouya, Lemdani, Vilhelm, & Hubert, 2009), school-based interventions have been advocated as ideal locations for promoting physical activity (Pate et al., 2006) with physical educators leading the charge (Castelli & Beighle, 2007).

Furthermore, the Child Nutrition and WIC Reauthorization Act of 2004 (Public Law 108-265, 2004) mandates that schools with a federally funded school meals program implement a wellness policy that addresses physical activity and nutrition. To this end, the National Association for Sport and Physical Education (2008) released a position statement on Comprehensive School Physical Activity Programs, indicating that quality physical education and a number of school-based physical activity opportunities are imperative for youth. Included within the school-based physical activity opportunities are physical activity breaks, recess, before- and after-school programs, intramurals, interscholastic sports, and active transport to and from school. For appropriate implementation and sustainability of school-based physical activity, it is important that classroom teachers and other necessary school personnel, such as school psychologists and administrators, promote school physical activity as well (Beets et al., 2008; Han & Weiss, 2005). This article focuses specifically on physical activity breaks that take place in the classroom setting.

Physical Activity and Academic Performance

The wellness policy mandate and the Comprehensive School Physical Activity Programs position statement (National Association for Sport and Physical Education, 2008; Public Law 108-265, 2004) are opportune and may slow the trend of fewer physical activity opportunities in schools because of legislative pressures of achieving high academic standards (House of Representatives 1804, 1994). Research suggesting that physical activity may foster improved academic performance (i.e., higher standardized test scores, enhanced facilitators of learning such as concentration or attentiveness) challenges the notion that increasing academic time and reducing physical activity time is the most effective method for improving learning outcomes.

For instance, a multitude of studies have supported the positive relation between physical activity and academic performance (Bluechardt, Wiener, & Shephard, 1995; Budde, Voelcker-Rehage, Pietrassyk-Kendziorra, Ribeiro, & Tidow, 2008; T. Dwyer, Blizzard, & Dean, 1996; Ericsson, 2008; McNaughten & Gabbard, 1993; Reynolds & Nicolson, 2007; Sallis et al., 1999); however, other studies have shown little or no relation (Daley & Ryan, 2000; Fisher, Juszczak, & Friedman, 1996). For example, Budde et al. (2008) found that providing bilateral coordinative exercises was more effective than teaching a normal sport lesson in physical education for student completion of coordination and attention tasks. Ericsson (2008) found that an intervention group receiving physical activity and motor training for one lesson per day had improved scores on mathematics and Swedish tests as compared with a control group receiving physical education two times per week. Sallis and colleagues (1999) found that by using a physical education curriculum designed to maximize physical activity, reading standardized test scores were higher for students in the physical education specialist group, and reading, language, and the basic battery standardized test scores were higher for students in the trained teacher group, as compared with those in the control group (not receiving the chosen curriculum or training). Using a questionnaire with adolescents, Fisher et al. (1996), however, found no association between students' sports involvement and academic performance as measured by grades. Despite the number of studies documenting the relation between physical activity and children's learning outcomes, there has yet to be a consensus on whether physical activity truly exerts a significant effect on children's cognitions (Bailey, 2006; Sibley & Etnier, 2003), particularly with respect to classroom-based physical activities (Ahamed et al., 2007).

School Personnel Perspectives on Incorporating Classroom-Based Physical Activity

From a physical education and public health perspective, it is important for classroom teachers, administrators, and school psychologists to understand the benefits of incorporating physical activity into the school day, as the value of the intervention is only as successful as its implementation. Research has reported various findings with respect to teachers' perceptions of implementing physical activity in the school day. Although some teachers hold very positive attitudes regarding physical activity and its reported effects on students' learning and behavior (Morgan & Hansen, 2008), other studies have found that teachers lack the confidence, time, interest, or skill in implementing physical activity interventions throughout the school day (Faucette & Patterson, 1989; Morgan, 2008). Moreover, some teachers hold negative perceptions of physical activity and its value in replacing instructional time, even when they are not leading the physical activity (i.e., recess, physical education; Faucette & Hillidge, 1989; Morgan, 2008). Yet, studies examining the effects of recess breaks show that short instructional periods followed by brief physical activity breaks lead to students who demonstrate higher attention levels and willingness to work on cognitive tasks (Pellegrini & Bohn, 2005).

In addition to teachers having an understanding of the importance of physical activity breaks in the classroom, administrators and school psychologists are also key players in this movement. There is evidence that school administrators view recess as expendable (Simon & Childers, 2006) and thus have a significant influence on how much time is allotted to recess breaks. As professionals who specialize in optimizing learning for all students and because of their notable presence in schools, it is important for school psychologists to advocate for the continued need for recess and physical activity breaks in the classroom to support the healthy physical and social development of schoolchildren. While creating an academic intervention for a student struggling with reading or consulting with a teacher to create an effective behavioral intervention for a student with attention difficulties is a weekly occurrence for many school psychologists, many may be unaware of the significant benefit in advocating for more physical activity in school. Yet, consulting with teachers and administrators on interventions that will benefit all children's learning and physical well-being can be one of the most effective means in creating change on a systemswide level (Ysseldyke et al., 2006). To this end, it is important to condense the research in this area as a way of gaining a comprehensive picture of the effects of classroom-based physical activity interventions.

To date, no studies have been published summarizing classroom-based physical activity interventions and their outcomes relevant to physical activity, health, and learning occurring in this particular setting. Further, little research has examined the implications for school personnel when incorporating physical activity interventions in the classroom. Therefore, the purpose of this article was twofold. First, this article serves as a quantitative review of physical activity, health, and learning outcomes from previously published studies of physical activity interventions that take place in the classroom. Thus, we investigated whether physical activity interventions conducted in a classroom setting resulted in an increase in physical activity levels, as well as better health and learning outcomes for students. Specifically, implications of these findings are discussed for school personnel.

METHOD

Identification of Studies

We conducted a systematic review of the literature to identify studies focused on classroom-based physical activity interventions (provided by classroom teachers in the classroom setting). Because of the classroom emphasis of the review, the search focused on three key elements: setting (classroom-based), behavior (physical activity), and student outcomes (accumulation of physical activity, facilitators of learning). The following databases were consulted: Ovid MEDLINE, PsycINFO, PubMed, and SPORTDiscus. In addition, we searched articles cited in included article and published reviews on school-based physical activity. All selected articles were published between

January 1990 and February of 2010. The key terms for searches consisted of *classroom*, *physical activity*, and *school*.

Criteria for Inclusion/Exclusion

Articles were included in the review if they met the following criteria: (a) study participants were school-aged youth (5–18 years), (b) reported findings were derived from physical activity conducted specifically in the classroom setting, (c) reported outcome measures consisted of physical activity and/or facilitators of learning (e.g., behavior, concentration), (d) articles were published between 1990 and 2010, and (e) studies provided statistical data that allowed for the calculation of an effect size. Studies were excluded in the following instances: (a) study described implementation and/or design only, (b) publication was not in English, and (c) study included classroom-based component as one of several arms of an intervention and results were not reported specific to classroom-based physical activity effects.

The process of identifying the included studies initially included 379 potential articles. Upon review of the titles and abstracts, we considered and examined 55 full-text articles. After examination of all full-text articles, we determined that six studies (i.e., Fredericks, Kokot, & Krog, 2006; Honas, Washburn, Smith, Greene, & Donnelly, 2008; Liu et al., 2007; Lowden, Powney, Davison, & James, 2001; Maeda & Randall, 2003; Stewart, Dennison, Kohl, & Doyle, 2004) did not provide sufficient information for computing an effect size. Twenty studies did not involve an intervention specific to the classroom context and were removed from analysis. Four studies involved classroom interventions that were combined with a physical education, recess, and/or after-school intervention. A remaining 16 articles were excluded for reasons such as they provided descriptive data only (e.g., no intervention), were review articles, were not full-text articles (e.g., abstracts or unpublished papers), or were intended to validate a measure as opposed to report on the outcome of an intervention. Thus, nine studies were included in the final meta-analysis.

Coding

On the basis of systematic reviews of nine included studies, the following variables for the meta-analysis were identified and independently coded by two authors (AF, SA). This study focused on the three types of outcomes related to the classroom-based physical activity as an intervention. First, intervention outcomes were coded as (1) physical activity outcome (e.g., average step counts per minute), (2) health outcome (e.g., the frequency of neck pain per week), and (3) learning outcome (e.g., reading scores).

Second, total length of physical activity intervention in days was collected. Third, grade level of participants was coded into three categories (i.e., Kindergarten to Grade 3, Grades 4–6, and wide range). Last, study location (i.e., United States, Canada, Europe, New Zealand) was also coded. The percentage of agreement between two coders was 100%.

Table 1 summarizes the classroom physical activity interventions that specifically reported physical activity outcomes as a result of the intervention. Examples of such interventions included Take10! and Energizer interventions wherein teachers use pre-made activity cards and worksheets that integrate learning objectives with physical activity. For example, teachers involved in a Take10! or Energizer intervention during a math lesson might ask the students to jog in place at their desks, then do 50 jumping jacks when asked to multiply 10 and 5. Table 2 provides information on the classroom physical activity interventions that measured learning outcomes associated with the intervention. Such measures included the Gates-MacGinitie Reading Test and standardized measures of on-task behavior and concentration. Table 3 provides details of studies reporting health outcomes associated with classroom physical activity interventions and included measures such as the Physical Activity Questionnaire for Children and bone-mass indices.

Effect Sizes

Effect sizes were computed as the difference between treatment and control group means in a pooled standard deviation unit (d). When pretest and posttest means and standard deviations were presented, effect sizes for pretests were subtracted from effect sizes for posttests so that group differences in pretests were adjusted. From the studies that did not provide descriptive statistics but F or t statistics were reported, effect sizes were computed using the formula presented in Lipsey and Wilson (2001).

In addition, if the study (i.e., Cardon, De Clercq, De Bourdeaudhuij, & Breithecker, 2004) provided the frequencies of correct answers for both treatment and control group, the logarithm of odds ratio representing treatment and control group difference was first computed. Then, the logarithm of odds ratio was converted to the d metric using the formula developed by Cox (Sanchez-Meca, Marin-Martinez, & Chacon-Moscoso, 2003).

These computed effect sizes were broken down into three measures of classroom-based physical activity intervention outcomes: (a) physical activity outcomes, (b) health outcomes, and (c) learning outcomes. Effect sizes were analyzed separately for each intervention outcome.

Analysis

Statistical analyses were based on the methods proposed by Hedges and Olkin (1985) and also described in Cooper, Hedges, and Valentine (2009).

TABLE 1 Summary of Interventions Examining Physical Activity Outcomes Associated With Classroom-Based Physical Activity ($N = 5$)

Study/location	Participants	Intervention	Measures	Physical activity results
Cardon et al. (2004)/Germany, Belgium	47 participants (2nd graders); I: $n = 22$, C: $n = 25$	I: “Moving school” to increase seating quality of students (e.g., stand at desks, reclining surfaces, floor space) C: traditional classroom seating (e.g., seated desks)	Accelerometry (one 30-min language or math lesson); portable ergonomic observation method to measure duration and frequency of different postures in classroom; back and neck pain questionnaire	Intervention participants accrued significantly more counts/min than control participants ($538_{intervention}$ vs. $134_{control}$). A significantly larger amount of time was spent on dynamic sitting, standing, walking around and being active in intervention group.
Erwin et al. (2009)/United States	75 participants (4th–5th graders); I without C	I: Teachers delivered 5–10-min math lessons integrating physical activity with math content; 3 weeks	Pedometry (17 days) during integrated math lesson and during school day	Participants accumulated significantly more steps/min during physical activity integration than during baseline ($8.27_{intervention}$ vs. $3.61_{baseline}$).
Gibson et al. (2008)/United States	4905 participants (2nd–5th graders); I: 2505, C: 2400	I: 90 min of moderate intensity physical activity delivered as part of academic instruction (Take 10!) C: regular academic instruction	System for Observing Fitness Instruction Time conducted weekly during Year 1; overall student enjoyment level rated by research assistants	Intervention participants engaged in significantly greater levels of physical activity than control participants ($3.40_{interventionSOFIT}$ vs. $2.17_{controlSOFIT}$).

Mahar et al. (2006)/United States	243 participants (K–4th graders); I: $n = 135$, C: $n = 108$	I: Energizers implemented daily, 10 min each C: no Energizers	Pedometry (5 days) during school day during and energizers; observations of behavior during 30 min before and 30 min after energizers	Intervention participants averaged significantly more daily in school steps (782) than control participants. Energizer steps ranged from 160 to 1,223.
Oliver et al. (2006)/New Zealand	78 participants (5th–6th graders); I without C	I: "virtual" walk incorporating English, social studies, mathematics, statistics and physical education, 4 weeks	Pedometry (16 weekdays and 3 weekends) during school and outside of school	No significant differences were found between baseline and intervention weekday physical activity. Participants were significantly more active on weekdays than weekends during the intervention. When analyzed by physical activity stratifications, significant increases in physical activity were found for boys and girls who accumulated less than 15,000 steps per day and for girls in the lowest three quartiles of physical activity.

TABLE 2 Summary of Interventions Examining Learning Outcomes Associated With Classroom-Based Physical Activity ($N = 4$)

Study/location	Participants	Intervention	Measures	Learning results
Lowden et al. (2001)/Scotland, Wales	192 student participants (years P–7), 6 detailed study schools (3 Scottish, 3 Welsh); 24 teacher participants; I without C	I: Teachers delivered 10–15-min physical activity sessions; 3 months	Class observations during intervention, semi-structured interviews with head teachers and teachers at each school, semi-structured group interviews with students from each class, teacher-completed diaries/logs, telephone interviews with parents, feedback sessions with teachers, questionnaires about The Class Moves! intervention	Teachers reported a positive impact on students' concentration and attention as a result of the intervention. They also noted that it helped calm a class, as well as improve student balance and movement. Students noted that it positively impacted their concentration.
Mahar et al. (2006)/United States	243 participants (K-4th graders); I: $n = 135$, C: $n = 108$	I: Energizers implemented daily, 10 min each C: no energizers	Pedometry (5 days) during school day during and energizers; observations of behavior during 30 min before and 30 min after energizers	Intervention participants significantly improved on-task behavior from pre- to postenergizer implementation ($70.9\%_{pre}$ vs. $79.2\%_{post}$). The mean percentage of on-task behavior increased by 20% postenergizer in the least on-task students.

Norlander et al. (2005)/Sweden	88 participants (primary and secondary school); I: 5 classes, C: 1 class	I: 5–10-min relaxation program 2 times per day, 4 weeks C: no relaxation program	Noise monitor measuring noise levels in classroom before and after intervention; questionnaires on noise and stress levels in classroom before and after intervention	Noise levels in 5 classes were significantly reduced after intervention (63.24 $db_{baseline}$ vs. 50.50 $db_{intervention}$). Control group experienced significantly higher levels of noise both before and after treatment as compared to the intervention group.
Uhrich & Swalm (2007)/United States	41 participants (5th graders); I: $n = 20$, C: $n = 21$	I: bimanual activity (sport stacking) during snack time, 18 20-min sessions, 6 weeks C: no activity during snack time	Reading achievement test pre- and postintervention	Intervention participants scored significantly higher on reading comprehension scores postintervention than control participants. There were no significant differences on reading decoding scores between groups.

TABLE 3 Summary of Interventions Examining Health Outcomes Associated With Classroom-Based Physical Activity ($N = 4$)

Study/location	Participants	Intervention	Measures	Other health outcomes
Cardon et al. (2004)/Germany, Belgium	47 participants (2nd graders); I: $n = 22$, C: $n = 25$	I: "Moving school" to increase seating quality of students (e.g., stand at desks, reclining surfaces, floor space) C: traditional classroom seating (e.g., seated desks)	Accelerometry (one 30-min language or math lesson); portable ergonomic observation method to measure duration and frequency of different postures in classroom; back and neck pain questionnaire	15 participants reported back or neck pain in the past week (I: $n = 9$; C: $n = 6$) and 11 reported visiting a doctor for back or neck pain (I: $n = 5$; C: $n = 6$).
Macdonald et al. (2007)/Canada	410 participants (4th–5th graders), 10 schools, I: 7 schools, $n = 281$ (145 boys, 136 girls), C: 3 schools, $n = 129$ (64 boys, 65 girls)	I: Action Schools! British Columbia Bounce at the Bell. Students performed various jumps 3 times per day; 1.25 school years C: normal PE	Self-Report Physical Activity Questionnaire for Children, bone strength index taken at distal tibia and tibial midshaft	Intervention was effective in distal tibia bone strength in prepubertal boys.
Macdonald et al. (2008)/Canada	310 participants (4th–5th graders), 10 schools, I: 7 schools, $n = 193$ (151 boys, 142 girls), C: 3 schools, $n = 117$ (62 boys, 55 girls)	I: Action Schools! British Columbia Bounce at the Bell. Students performed various jumps 3 times per day, 4 times per week; 1.25 school years C: normal PE	Self-Report Physical Activity Questionnaire for Children, bone mineral content measured at proximal femur, lumbar spine, and total body	Intervention boys experienced greater gains in bone mineral content at the lumbar spine and in total body than control boys.
Norlander et al. (2005)/Sweden	88 participants (primary and secondary school); I: 5 classes, C: 1 class	I: 5–10-min relaxation program 2 times per day, 4 weeks C: no relaxation program	Noise monitor measuring noise levels in classroom before and after intervention; questionnaires on noise and stress levels in classroom before and after intervention	No significant differences existed for stress between control and intervention.

Under the fixed-effects model, the computed effect sizes were weighted by the inverse of its weighted variances (Cooper et al., 2009; Lipsey & Wilson, 2001), and the overall homogeneity test of effect sizes was first performed. When the overall homogeneity did not hold (i.e., Q_{total} was not significant under the chi-square distribution the significance level of .05), then the overall effect sizes were computed under the random-effects model (Hedges & Vevea, 1998), which incorporated additional uncertainty to the effect sizes that were estimated using the method-of-moment estimation (Raudenbush, 2009). Otherwise, the overall effect-size was computed under the fixed-effects model (Konstantopoulos & Hedges, 2009).

Further, the series of moderator analyses with categorical variables (e.g., gender, grade level) or continuous variables (e.g., total length of physical activity in days) were applied to explain variations in effect sizes (Hedges, 1994). When there were unexplained within-variances (i.e., Q_{within} was significant), a mixed-effects model with moderator variables was performed by incorporating additional uncertainty within each level of the moderator, which was estimated using the method-of-moment estimation (Raudenbush, 2009).

Dependency

Studies often provide multiple effect sizes from various measures of variables, which, in turn, violate the assumption of independence (Gleser & Olkin, 2009). For instance, Cardon et al. (2004) provided several measures of physical activity outcomes (e.g., frequency and duration of static sitting, the frequency and duration of standing, and frequency of neck pain). Of several ways to handle the issue of dependency (Becker, 2000), we chose an effect size that was based on the most frequently used outcome measure. Thus, the effect size based on the frequency of being active was used from Cardon et al. (2004). Then, effect sizes were grouped into subcategories of intervention outcomes, and thus they were no longer dependent within each subcategory for the computation of the overall effect sizes.

RESULTS

Description of Studies

Nine studies provided a total of 16 effect sizes representing the effect of classroom-based physical activity intervention on three outcomes (e.g., physical activity, health, learning). The included nine studies were published in the past 5 years, with an exception of one study published in 2004. These studies were conducted in various countries (4 in the United States, 1 in Germany, 1 in Sweden, 2 in Canada, and 1 in New Zealand).

TABLE 4 Counts of Effect Sizes (*k*), by Study Features

Study features	*k*
Outcomes	
Physical activity	6
Frequency of total activity	2
Average counts of step per day	4
Health	6
Learning	4
Grade level	
K–3	3
4–6	8
Wide range	4
Gender	
Girl	2
Boy	2
Girls and boys	12
Total length of intervention in days	
13	1
20	4
30	1
60	2
200	1
250	4
300	3
Study location	
United States	5
Canada	4
New Zealand	2
Europe	5

Sample sizes varied from 21 to 4,549 (M = 894.13, SD = 1,681.12) and participants were in K–6, resulting in a total of 8,947 to 9,751 subjects from nine studies. All the studies were based on boys and girls in their study, whereas one study provided study findings separately by gender. Table 4 shows the counts of effect sizes (k = number of effect sizes extracted) organized by characteristics of the study.

Publication Bias

Publication bias often occurs when publication status depends on the statistical significance of study findings. Publication bias can be assessed by examining a plot of effect sizes against study size (N) or using Egger's regression test of asymmetry for effect sizes (Sutton, 2009).

As shown in Figure 1, a scatterplot of effect sizes against study size appears to be somewhat asymmetric. Since only published studies were included, an asymmetric shape of a funnel plot is highly probable. Thus, the shape of a funnel plot was statistically tested using the method developed

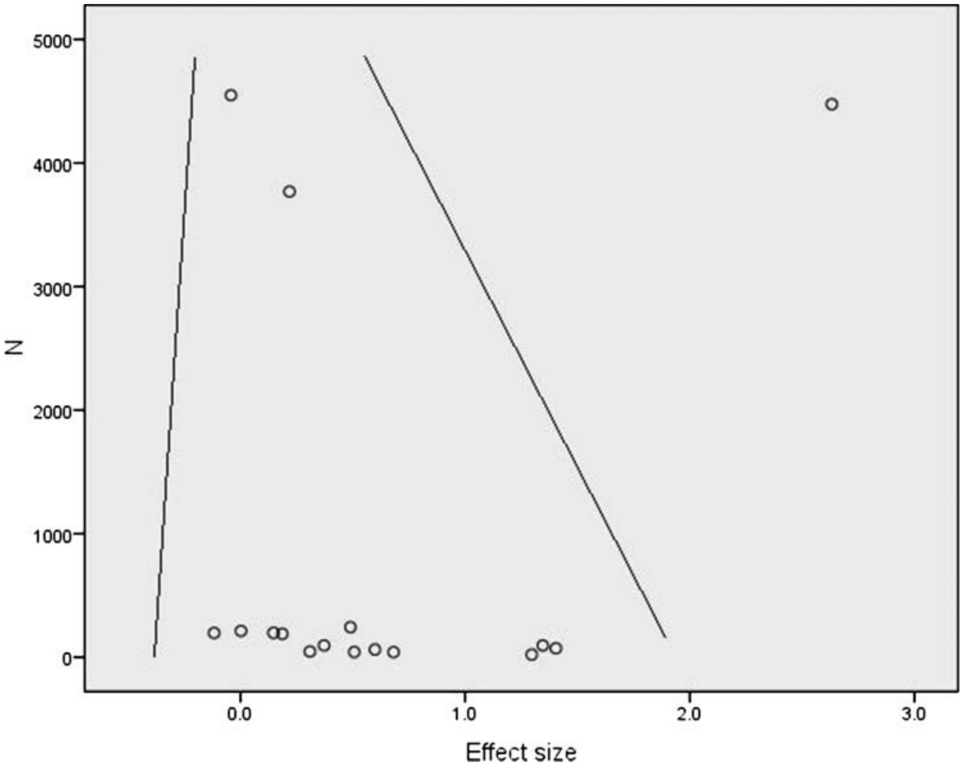

FIGURE 1 A funnel plot of effect sizes.

by Egger and his colleagues (Sutton, 2009). Egger's regression test indicated that the shape of effect sizes is statistically symmetric ($t = 1.44$, $p = .17$), indicating that publication bias was not problematic.

Overall Intervention Effect

Under the random-effects model, the estimated overall effect size was .22 with a standard error of .06 ($z = 3.67$, $p < .01$), suggesting a significant intervention effect on the outcome as a whole. However, the overall homogeneity test of 15 effect sizes showed there was a considerably large variation, $Q_{total}(15) = 3{,}279.32$, $p < .01$; suggesting further analyses to examine the sources of variation. Therefore, we performed a series of moderator analyses to explain differences across the 15 effect sizes using study features such as type of outcomes, grade level, and study location.

Intervention Effect on Physical Activity Outcomes

The overall homogeneity test of seven effect sizes was statistically significant, Q_{total} (6) $= 3251.61$, $p < .01$; indicating that these effect sizes were from different populations. The estimated effect size under the random-effects model was .99 with a standard error of .40 (95% CI [0.20, 1.77]). Such a statistically significant mean difference ($z = 2.46$, $p = .007$) suggests that physical activity outcome scores for the treatment group were statistically different from those of the control group. The magnitude of intervention effect on physical activity outcomes was large, implying 46% nonoverlap between the two groups.

We performed a series of moderator analyses using several moderators (i.e., grade level, total length of physical activity in days, study location, and outcome measure) that showed variations across effect sizes. Of them, three moderators (i.e., grade level, outcome measure, and study location) explained a significant amount of between effect size variations. However, total length of physical activity in days was not a statistically significant predictor in explaining variations of outcome effect sizes, Q_{model} (1) = 2.62, $p = .11$.

First, mean effect sizes differed by grade level (i.e., K–3, Grades 4–6, and wide grade range), $Q_{between}$ (2) = 2811.94, $p < .01$. As a result of the remaining within-group variations, Q_{within} (2) = 440.69, $p < .01$; a mixed-effect model using grade level as a predictor was applied to compute the mean effect size for each category. The weighted mean effect sizes were 1.29 ($SE = 0.17$, $k = 1$), 0.51 ($SE = 0.44$, $k = 2$), and 1.56 ($SE = 1.07$, $k = 2$) for K–3, Grades 4–6, and wide grade range, respectively.

Second, effect sizes varied depending on the measure of physical activity outcomes (i.e., overall activity level vs. average step counts per day). A significant between-group Q statistics of 3,034 with 1 degree of freedom shows that treatment effects significantly differed by the measure of physical activity. Because of the remaining within-group variations, Q_{within} (4) = 216.69, $p < .01$, a mixed-effects model was also applied to estimate the mean effect size for each category. The weighted effect size was statistically significant when total activity was used as the outcome measure ($M = 2.08$, $SE = 0.66$, $k = 2$), whereas intervention effect was not significant when average step counts per day was used ($M = 0.50$, $SE = 0.31$, $k = 4$).

Third, the estimated effect sizes were 1.51 ($SE = 0.62$, $k = 3$) for the United States, 1.29 ($SE = 0.17$, $k = 1$) for Europe, and 0.09 ($SE = 0.13$, $k = 2$) for New Zealand. These means were statistically different, $Q_{between}$ (2) = 2,840.28, $p < .01$, but there were still unexplained within-group differences left, Q_{within} (3) = 411.33, $p < .01$.

Intervention Effect on Health Outcomes

A homogeneity test of seven effect sizes examining the intervention effect on health outcomes was not statistically significant, Q_{total} (5) = 5.91, $p = .32$. Thus, the overall mean effect size was computed under the fixed-effects model. The estimated weighted standardized mean difference was 0.16 with a standard error of 0.06 (95% CI [0.04, 0.28]), which was statistically significant ($z = 2.54$, $p = .006$). Such a significant result indicates that classroom-based physical intervention was effective in yielding higher mean scores on health outcomes (versus controls). However, the magnitude of intervention effects on health outcomes was small, indicating approximately 87% of shared distribution between treatment and control groups.

Intervention Effect on Learning Outcomes

A significant total Q statistic of 8.22 ($df = 3$) indicates that four effect sizes which examined the intervention effects on learning outcomes varied and thus should be computed under the random-effects model. The weighted mean difference under the random-effects model was statistically significant ($M = 0.67$, $SE = 0.21$, $z = 3.17$, $p < .001$). The 95% CI of the overall mean ranged from 0.26 to 1.09.

To examine differences between effect sizes, three moderators (i.e., study location, the length of physical activity, and grade level) that varied across effect sizes were examined in a series of mixed-effects models. Of three moderators, only study location significantly predicted variations in effect sizes, $Q_{between}$ (1) = 4.32, $p = .04$. The estimated effect sizes were 0.47 ($SE = 0.10$, $z = 4.57$, 95% CI [0.27, 0.67]) and 1.00 ($SE = 0.23$, $z = 4.30$, 95% CI [0.55, 1.46]) for the United States and Europe, respectively.

Other moderators, grade level and total length of physical activity (in days), were not statistically significant: $Q_{between}$ (2) = 3.97, $p = .14$ for grade level; Q_{model} (1) = 1.57, $p = .21$ for total length of physical activity. These insignificant results suggest that intervention effects did not differ by grade level or the length of physical activity. Thus, no further analyses were conducted (i.e., separate means were not computed for these moderators).

DISCUSSION

There are multiple health benefits as a result of physical activity, including improved cardiovascular endurance, blood pressure and a decreased future risk of depression and heart attack (U.S. Department of Health and Human Service, 2008). School is a primary location for reaching the majority of American children and providing physical activity opportunities for them. On the basis of the present findings, the benefits of physical activity during the school day include increased frequency of total physical activity for students and positive learning outcomes—outcomes that are critical in optimizing youth's health and academic achievement.

Our review shows that classroom-based physical activity interventions may be infrequent, are often presented and analyzed simultaneously with other physical activity interventions (e.g., recess, after school), or are seldom published in peer-reviewed journals. More important, few articles were found that provided details on the effect of these interventions on children's learning and/or other health outcomes. More research on the effect of classroom-based physical activity interventions on physical activity, learning, and health outcomes is warranted.

On the basis of the results of the present meta-analysis, it is likely that physical activity interventions can be incorporated into a child's school day to enhance learning outcomes. They have been shown to increase the amount of physical activity children accrue each day. Students in elementary school were affected more significantly by these interventions; perhaps teachers from these grade levels were more aware of the need for physical activity breaks for the students, or children at this age are more perceptive of the movement opportunities provided. Research has found that young children acquire particular cognitive skill sets through play and movement (Leppo, Davis, & Crim, 2000; Pica, 1997). Thus, perhaps physical activity interventions are inherently more developmentally accessible for younger children than for older youth, which replicates findings from prior studies (see Sibley & Etnier, 2003).

It appears that interventions offered in the United States were more effective than those from other countries. Possible explanations may include the following: (a) American students are less active during the school day overall, so these short physical activity breaks made more of an effect for this population (Beets, Bornstein, Beighle, Cardinal, & Morgan, 2010); (b) classroom teachers in the studies conducted in the United States may have been provided more training so they were more confident in their abilities to present movement for students and/or had more positive attitudes toward classroom physical activity; and (c) the context of American schools was more conducive for physical activity to occur in the classroom setting. Cross-cultural studies investigating this finding are warranted, as these are merely hypotheses because no research to date has explored this question.

The fact that length of the physical activity intervention did not significantly influence the effect of the intervention can be viewed positively. The interventions reviewed in this article ranged from 13 to 300 days; therefore, implementing physical activity for as few as 13 days may exude a positive effect on children's physical activity levels. More classroom-based physical activity research is necessary in order to provide convincing evidence of the explicit outcomes of such practice; however, trends suggest physical activity offered in the classroom during the school day may help students reach recommended levels of physical activity and positively influence facilitators of learning, such as behavior and comprehension (Erwin, Abel, Beighle, &

Beets, 2009; Erwin, Beighle, Morgan, & Noland, 2011; Mahar et al., 2006; Ulrich & Swalm, 2007).

There are two methodological limitations that bear mention before generalizing the findings from the present study. Even though Egger's regression test of asymmetry indicates that publication bias does not seem to be problematic, the study findings were based on effect sizes extracted from only published studies. Because there were only few published studies since 1990, the overall means were computed on the basis of a small number of effect sizes, which might lower the overall statistical power. Given the dearth of well-designed studies examining classroom-based physical activity interventions, it is clear more research is needed in this area to explore the relation between these interventions and children's health, physical activity and learning outcomes. As a result of a lack of variation in study designs (i.e., sampling, assignment, or whether matching was used), we were unable to examine whether effect sizes differ by study designs. In addition, caution should be exercised in interpreting the findings as sample biases, data retrieval, data quality, and the small number of studies may limit generalizability.

Classroom-based physical activity opportunities are just one part of a comprehensive approach to school-based physical activity for youth. Because of the current emphasis on standardized testing (House of Representatives 1804, 1994) and the difficulty of allocating school time for physical activity (J. J. M. Dwyer et al., 2003; Faucette & Patterson, 1989; House of Representatives 1804, 1994; Morgan, 2008), it is important that classroom-based physical activity interventions have positive health and/or learning outcomes. The present findings suggest a limited number of studies have examined the effect of classroom-based physical activity on youth physical activity and learning. However, the studies that have been conducted have been positive and show a significant and moderate effect on children's physical activity and learning outcomes. Given the limited amount of time and resources these interventions take to implement and their beneficial influences on physical activity, health and learning outcomes for students, it is suggested that school psychologists and administrators promote and support teacher-led classroom physical activity.

A number of interventions have been developed to promote the integration of physical activity into the school day (Salmon, Booth, Phongsavan, Murphy, & Timpiero, 2007; Ward, Saunders, & Pate, 2007). In a review of school-based interventions designed to increase students' physical activity levels, Salmon and colleagues (2007) identified a number of effective interventions for school-age youth. These interventions need not be extensive or use a lot of resources to be effective. Integrating physical activity into teachers' preexisting lesson plans can be both simple and cost-effective (Erwin et al., 2011). A variety of resources for integrating physical activity into the classrooms can be found through the Promoting Physical Activity and

Health in the Classroom physical activity cards (Pangrazi, Beighle, & Pangrazi, 2009), Energizers, Take10!, and Brain Breaks[1]. The first two resources listed (Promoting Physical Activity and Health in the Classroom physical activity cards and Energizers) were used in two of the studies included in the meta-analysis for this article (Erwin et al., 2011; Mahar et al., 2006). Take10! has also been evaluated with regard to intensity level of physical activity accrued during sessions (Stewart et al., 2004). School psychologists may take advantage of and use these resources to encourage and assist teachers in implementing physical activity breaks for their students without missing academic instructional time. That is, many of these activities are built into curricular concepts, such that students are learning while they are moving. In an age where stakes are high and accountability for academic standards is ubiquitous, it seems that school psychologists may emphasize the benefits of incorporating physical activity into the classroom for all students.

Physical education and time spent in recess has diminished significantly in schools. While schools have received federal pressures to increase test scores and overall academic proficiency levels, federal mandates have simultaneously charged schools with enhancing the physical health of children. As demonstrated in this meta-analysis, physical activity may be one such means of fulfilling these responsibilities. Schools serve as a barrier and a catalyst for enhancing the physical activity of children. Thus, it is argued that school psychologists, teachers, and other school stakeholders should serve as promoters of school-based physical activity. For school psychologists and teachers, it is necessary to act as change agents and advocates for our students. Given school budget constraints, limited resources, and pervasive stress among teachers and administrators, incorporating physical activity into the school day is an inexpensive and effective intervention for improving outcomes for all students. Whether at a classroom, school, or district level, there is little question that psychologists, teachers, physical education teachers, and other key players in the schools can play an active role in supporting the need for school-based physical activity.

NOTE

1. For more information on these resources, please see the manufacturers' websites: Energizers (http://www.ecu.edu/cs-hhp/exss/apl.cfm); Take10! (http://www.take10.net); and Brain Breaks (http://www.emc.cmich.edu/BrainBreaks).

REFERENCES

Ahamed, Y., Macdonald, H., Reed, K., Naylor, P. J., Liu-Ambrose, T., & McKay, H. (2007). School-based physical activity does not compromise children's academic performance. *Medicine and Science in Sports and Exercise*, *39*, 371–376.

Bailey, R. (2006). Physical education and sport in schools: A review of benefits and outcomes. *Journal of School Health*, *76*, 397–401.

Becker, B. J. (2000). Multivariate meta-analysis. In H. E. A. Tinsley & S. Brown (Eds.), *Handbook of applied and multivariate statistics and mathematical modeling* (pp. 499–525). San Diego, CA: Academic Press.

Beets, M., Bornstein, D., Beighle, A., Cardinal, B. J., & Morgan, C. F. (2010). Pedometer-measured physical activity patterns of youth: a 13-country review. *American Journal of Preventive Medicine*, *38*, 208–216.

Beets, M., Flay, B., Vuchinich, S., Acock, A., Li, K. K., & Allred, C. (2008). School climate and teachers' beliefs and attitudes associated with implementation of the Positive Action Program: A diffusion of innovations model. *Prevention Science*, *9*, 264–275.

Bluechardt, M. H., Wiener, J., & Shephard, R. J. (1995). Exercise programs in the treatment of children with learning-disabilities. *Sports Medicine*, *19*(1), 55–72.

Budde, H., Voelcker-Rehage, C., Pietrassyk-Kendziorra, S., Ribeiro, P., & Tidow, G. (2008). Acute coordinative exercise improves attentional performance in adolescents. *Neuroscience Letters*, *441*, 219–223.

*Cardon, G., De Clercq, D., De Bourdeaudhuij, I., & Breithecker, D. (2004). Sitting habits in elementary schoolchildren: A traditional versus a "moving school." *Patient Education and Counseling*, *54*, 133–142.

Castelli, D., & Beighle, A. (2007). Physical education teacher as the school activity director. *Journal of Physical Education Recreation and Dance*, *78*(5), 25–29.

Centers for Disease Control and Prevention. (2008). *Youth risk behavior surveillance—United States, 2007*. Atlanta, GA: Author.

Child Nutrition and WIC Reauthorization Act of 2004. Pub. L. No. 108-265, 118 Stat. 731.

Cooper, H. M., Hedges, L. V., & Valentine, J. C. (2009). *The handbook of research synthesis and meta-analysis* (2nd ed.). New York, NY: Russell Sage Foundation.

Daley, A. J., & Ryan, J. (2000). Academic performance and participation in physical activity by secondary school adolescents. *Perceptual and Motor Skills*, *91*, 531–534.

Dwyer, J. J. M., Allison, K. R., Barrera, M., Hansen, B., Goldenberg, E., & Boutilier, M. A. (2003). Teachers' perspective on barriers to implementing physical activity curriculum guidelines for school children in Toronto. *Canadian Journal of Public Health*, *94*, 448–452.

Dwyer, T., Blizzard, L., & Dean, K. (1996). Physical activity and performance in children. *Nutrition Reviews*, *54*, S27–S31.

Ericsson, I. (2008). Motor skills, attention and academic achievements. An intervention study in school years 1–3. *British Educational Research Journal*, *34*, 301–313.

*Erwin, H. E., Abel, M. G., Beighle, A., & Beets, M. W. (2011). Promoting children's health through physically active math classes: A pilot study. *Health Promotion Practice*, *12*, 244–251.

*References included in meta-analysis.

Erwin, H. E., Beighle, A., Morgan, C. F., & Noland, M. P. (2011). Effect of a low-cost, teacher-directed classroom intervention on elementary students' physical activity. *Journal of School Health*, *81*, 455–461.

Faucette, N., & Hillidge, S. B. (1989). Research findings—Physical education specialists and classroom teachers. *Journal of Physical Education Recreation and Dance*, *60*(7), 51–54.

Faucette, N., & Patterson, P. (1989). Classroom teachers and physical education: What they are doing and how they feel about it. *Education*, *110*(1), 108–114.

Fisher, M., Juszczak, L., & Friedman, S. B. (1996). Sports participation in an urban high school: Academic and psychologic correlates. *Journal of Adolescent Health*, *18*, 329–334.

Fredericks, C. R., Kokot, S. K., & Krog, S. (2006). Using a developmental movement programme to enhance academic skills in grade 1 learners. *South African Journal for Research in Sport, Physical Education, and Recreation*, *28*(1), 29–42.

*Gibson, C. A., Smith, B. K., Dubose, K. D., Greene, J. L., Bailey, B. W., Williams, S. L., ... Donnelly, J. E. (2008). Physical activity across the curriculum: Year one process evaluation results. *International Journal of Behavioral Nutrition and Physical Activity*, *5*, 36.

Gleser, L. J., & Olkin, I. (2009). Stochastically dependent effect sizes. In H. M. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 339–356). New York, NY: Russell Sage Foundation.

Goals 2000: Educate America Act, Pub. L. No. 103-277, 20 U.S.C. $5801(1994).

Guinhouya, B. C., Lemdani, M., Vilhelm, C., & Hubert, H. (2009). How school time physical activity is the "big one" for daily activity among schoolchildren: A semi-experimental approach. *Journal of Physical Activity & Health*, *6*, 510–519.

Han, S. S., & Weiss, B. (2005). Sustainability of teacher implementation of school-based mental health programs. *Journal of Abnormal Child Psychology*, *33*, 665–679.

Hedges, L. V. (1994). Fixed effects model. In H. M. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 285–299). New York, NY: Russell Sage Foundation.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. Orlando, FL: Academic Press.

Hedges, L. V., & Vevea, J. L. (1998). Fixed- and random-effects models in meta-analysis. *Psychological Methods*, *3*, 486–504.

Hedley, A. A., Ogden, C. L., Johnson, C. L., Carroll, M. D., Curtin, L. R., & Flegal, K. M. (2004). Prevalance of overweight and obesity among US children, adolescents, adn adults, 1999–2002. *JAMA*, *291*, 2847–2850.

Honas, J. J., Washburn, R. A., Smith, B. K., Greene, J. L., & Donnelly, J. E. (2008). Energy expenditure of the physical activity across the curriculum intervention. *Medicine and Science in Sports and Exercise*, *40*, 1501–1505.

Konstantopoulos, S., & Hedges, L. V. (2009). Analyzing effect sizes: Fixed-effects model. In H. M. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 279–294). New York, NY: Russell Sage Foundation.

Leppo, M. L., Davis, D., & Crim, B. (2000). The basics of exercising the mind and body. *Childhood Education*, *76*, 142–147.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage.

Liu, A. L., Hu, X. Q., Ma, G. S., Cui, Z. H., Pan, Y. P., Chang, S. Y., . . . Chen, C. M. (2007). Report on childhood obesity in China (6) evaluation of a classroom-based physical activity promotion program. *Biomedical Environmental Science*, *20*(1), 19–23.

Lowden, K., Powney, J., Davidson, J., & James, C. (2001). *The Class Moves! pilot in Scotland and Wales*. Glasgow, Scotland: University of Glasgow, Scottish Council for Research in Education.

*Macdonald, H. M., Kontulainen, S. A., Khan, K. M., & McKay, H. A. (2007). Is a school-based physical activity intervention effective for increasing tibial bone strength in boys and girls? *Journal of Bone Mineral Research*, *22*, 434–446.

*Macdonald, H. M., Kontulainen, S. A., Petit, M. A., Beck, T. J., Khan, K. M., & McKay, H. A. (2008). Does a novel school-based physical activity model benefit femoral neck bone strength in pre- and early pubertal children? *Osteoporos International*, *19*, 1445–1456.

Maeda, J. K., & Randall, L. M. (2003). Can academic success come from five minutes of physical activity? *Brock Education Journal*, *13*(1), 14–22.

*Mahar, M. T., Murphy, S. K., Rowe, D. A., Golden, J., Shields, A. T., & Raedeke, T. D. (2006). Effects of a classroom-based program on physical activity and on-task behavior. *Medicine and Science in Sports and Exercise*, *38*, 2086–2094.

McNaughten, D., & Gabbard, C. (1993). Physical exertion and immediate mental performance of 6th-grade children. *Perceptual and Motor Skills*, *77*, 1155–1159.

Morgan, P. J. (2008). Teacher perceptions of physical edudation in the primary school: Attitudes, values and curriculum preferences. *Physical Educator*, *65*(1), 46–56.

Morgan, P. J., & Hansen, V. (2008). Physical education in primary schools: Classroom teachers' benefits and outcomes. *Health Education Journal*, *67*, 196–207.

National Association for Sport and Physical Education. (2008). *Comprehensive school physical activity programs*. Reston, VA: Author.

National Center for Health Statistics. (2009). *Health, United States, 2008*. Hyattsville, MD: U.S. Department of Health and Human Services.

*Norlander, T., Moas, L., & Archer, T. (2005). Noise and stress in primary and secondary school children: Noise reduction and increased concentration ability through a short but regular exercise and relaxation program. *School Effectiveness and School Improvement*, *16*(1), 91–99.

Ogden, C. L., Carroll, M. D., & Flegal, K. M. (2008). High body mass index for age among U.S. children and adolescents, 2003-2006. *JAMA*, *299*, 2401–2405.

*Oliver, M., Schofield, G., & McEvoy, E. (2006). An integrated curriculum approach to increasing habitual physical activity in children: A feasibility study. *Journal of School Health*, *76*, 74–79.

Pangrazi, R. P., Beighle, A., & Pangrazi, D. (2009). *Promoting physical activity and health in the classroom*. San Francisco, CA: Pearson Benjamin Cummings.

Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L., & Young, J. C. (2006). Promoting physical activity in children and youth: a leadership role for schools: A scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation*, *114*, 1214–1224.

Pellegrini, A. D., & Bohn, C. M. (2005). The role of recess in children's cognitive performance and school adjustment. *Educational Researcher*, *34*(1), 13–19.

Pica, R. (1997). Beyond physical movement: Why young children need to move. *Children*, *52*(6), 4–11.

Raudenbush, S. W. (2009). Analyzing effect sizes: Random-effects models. In H. M. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 295–316). New York, NY: Russell Sage Foundation.

Reynolds, D., & Nicolson, R. I. (2007). Follow-up of an exercise-based treatment for children with reading difficulties. *Dyslexia*, *13*(2), 78–96.

Sallis, J. F., McKenzie, T. L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of health-related physical education on academic achievement: project SPARK. *Research Quarterly for Exercise and Sport*, *70*, 127–134.

Salmon, J., Booth, M. L., Phongsavan, P., Murphy, N., & Timperio, A. (2007). Promoting physical activity participation among children and adolescents. *Epidemiologic Reviews*, *29*, 144–159.

Sanchez-Meca, J., Marin-Martinez, F., & Chacon-Moscoso, S. (2003). Effect-size indices for dichotomized outcomes in meta-analysis. *Psychological Methods*, *8*, 448–467.

Sibley, B. A., & Etnier, J. L. (2003). The relationship between physical activity and cognition in children. *Pediatric Exercise Science*, *15*, 243–256.

Simon, J. B., & Childers, H. (2006). Principals perceptions of school recess: Sources of information, beliefs, and drawbacks. *Research in Schools*, *13*, 37–46.

Snyder, T. D., Dillow, S. A., & Hoffman, C. M. (2009). *Digest of Education Statistics 2008*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Stewart, J. A., Dennison, D. A., Kohl, H. W., & Doyle, J. A. (2004). Exercise level and energy expenditure in the TAKE 10! in-class physical activity program. *Journal of School Health*, *74*, 397–400.

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., . . . Trudeau, F. (2005). Evidence based physical activity for school-age youth. *Journal of Pediatrics*, *146*, 732–737.

Sutton, A. J. (2009). Publication bias. In B. S. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 435–452). New York, NY: Russell Sage Foundation.

*Uhrich, T. A., & Swalm, R. L. (2007). A pilot study of a possible effect from a motor task on reading performance. *Perceptual and Motor Skills*, *104*, 1035–1041.

U.S. Department of Health and Human Services. (2008). *2008 Physical activity guidelines for Americans*. Washington DC: Office of Disease Prevention and Health Promotion.

Ward, D. S., Saunders, R. P., & Pate, R. R. (2007). *Physical activity interventions in children and youth*. Champaign, IL: Human Kinetics.

Ysseldyke, J., Burns, M., Dawson, P., Kelley, B., Morrison, D., Ortiz, S., . . . Telzrow, C. (2006). *School psychology: A blueprint for training and practice III*. Washington, DC: National Association of School Psychologists.