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Energy expenditure estimates during school physical education: Potential vs. reality?

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ABSTRACT

Schools are salient locations for addressing the high prevalence of overweight and obesity. Most US states require some physical education (PE) and the energy expended during PE has potential to positively affect energy balance. We previously used 2012 data to examine state policies for PE to calculate estimated student energy expenditure (EEE) under potential (i.e., recommendations followed) and existing conditions. Since then, data have been updated on both state policies and the conduct of PE. Based on updated data, we used PE frequency, duration, and intensity, student mass, and class size to calculate EEE for the delivery of PE under (a) national professional recommendations, (b) 2016 state policies, and (c) school-reported conditions. Although increased from four years ago, only 22 states currently have policies mandating specific PE minutes. EEE over 10 years shows the enormous impact PE could have on energy balance. For the average recommended-size PE class, resultant annual EEE based on professional recommendations for min/week far exceeded those based on average state ($n = 22$) policy for min/week by 44.5% for elementary, 62.7% for middle, and 59.5% for high schools. Since 2012 more states adopted policies for PE minutes than dropped them, however, EEE over 10 years showed a net loss of 1200 kcal/student. With no overall recent improvements in state PE policy and professional recommendations currently not being met, PE remains an underutilized public health resource for EEE. Strong policies, coupled with enhanced accountability of PE teachers and administrators, are needed to ensure PE exists in schools.

1. Introduction

Despite intervention efforts, the prevalence rates of overweight and obesity among US children remain high (Ogden et al., 2016; Skinner et al., 2016). Based on 2013–2014 National Health and Nutrition Examination Survey (NHANES) data, Skinner et al. (2016) reported 33.4% of 2–17 year olds to be overweight and 17.4% to be obese. A premise underlying overweight and obesity is that energy intake exceeds energy expenditure over a prolonged period (Hall et al., 2012; IOM, 2012). Relative to energy expenditure, objective measures have indicated US children accumulate only about 71% (42.7 min) of the recommended 60 min/day of moderate-to-vigorous physical activity (MVPA) (Evenson et al., 2016). Among children aged 6 to 17 years, daily MVPA of 60 min promotes a healthy body weight and body composition (U.S. Department of Health and Human Services [USDHHS], 2008), suggesting that intervention efforts should include increasing physical activity. Examining policy and practices relative to overweight and obesity is important (Farley and van Wye, 2012) but where and when to target interventions is subject to debate.

Schools have long been recognized as a venue for providing children with much of their recommended daily MVPA (Sallis et al., 2012), and a systematic review of school interventions recommended using a multicomponent approach (e.g., changes in educational, curricular, and environmental elements) to increase the physical activity of children attending them (Kriemler et al., 2011). In general, school-based physical activity interventions have been reported to be cost effective (median of $0.42/MET-hour/day/person) and able to generate about 16% of children's recommended daily physical activity (Wu et al., 2011).

Physical education (PE) is the foundation of the Center for Disease Control and Prevention's [CDC] *Comprehensive School Physical Activity Plan* [CSPAP], which also includes physical activity before and after school, physical activity during school, staff involvement, and family and community engagement components (CDC, 2013). CSPAP recommends the provision of at least 150 min/week and 225 min/week in elementary and secondary schools, respectively (CDC, 2013). Evidence from 97 schools in the UK suggests that PE delivered in a 150 min/week dosage in elementary schools (i.e., meets professional recommendations) resulted in a 1.56 unit decrease in BMI percentile among first grade boys (Fernandes and Sturm, 2011). Thus, PE has the potential to influence energy balance that in turn may lower BMI. Nonetheless a review of 14 CSPAP interventions revealed that none of the studies incorporated all 5 program components and that the interventions that

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included PE were not much more effective (i.e., effect size = 0.10–0.16) at increasing physical activity than those that did not (Russ et al., 2015). The authors also emphasized that none of the interventions delivering PE did so at the recommended dosage.

Inadequate PE time allocations are endemic (Sallis et al., 2012), and they run counter to PE being long cast as having an important role in public health (Sallis and McKenzie, 1991). The dosages of PE (i.e., 150 min/wk. in elementary schools and 225 min/wk. in middle and high schools) advocated by SHAPE America (2015) and CSPAP are also those recommended in the 2016 *National Physical Activity Plan* (http://www.physicalactivityplan.org/); this, however, does not mean they are followed (National Physical Activity Plan Alliance, 2014; SHAPE America, 2016). Researchers have been encouraged to evaluate PE policy to ensure that children have daily, high-quality PE (Sallis et al., 2012), with PE quality operationally defined as providing the recommended minutes and students being engaged in MVPA during at least 50% of lesson time (CDC, 2010). We previously used 2012 data from the *Shape of the Nation* [SON] *Report* (National Association for Sport and Physical Education [NASPE] and American Heart Association [AHA], 2012) to examine time-specific policies on the provision of PE in US states to estimate student energy expenditure under potential (i.e., PE recommendations followed) and current (i.e., reality) conditions (Kahan and McKenzie, 2015). Since that time, data on state policies for PE (i.e., SON 2016; SHAPE America et al., 2016) and for how it is conducted in schools (i.e., *School Health Policy and Practices Study* 2014;USDHHS/CDC, 2015) have been updated. Thus, the purpose of the current study was to update and compare energy expenditure estimates for PE delivered under three conditions: (a) national professional recommendations for PE [aka, SHAPE America], (b) 2016 US state policies for PE [aka, state policy], and (c) school-reported practices for PE frequency and duration [aka, practice-based]. Specifically, we focused on answering three main questions: (a) What qualitative and quantitative changes – if any – occurred in PE time requirements between previous and new data sources?, (b) What quantitative changes – if any – occurred in potential energy expenditures based on previous and new data sources?, and (c) What are the energy expenditure estimates for PE based on current data?

2. Methods

2.1. Data sources

To derive national level estimates of the energy expended during PE at professionally recommended levels we used *The Essential Components of Physical Education* guidance document (SHAPE America, 2015); it recommends that elementary and secondary school students receive 150 min and 225 min of PE per week, respectively, with 50% of lesson time spent in MVPA. To determine state level estimates, we used the 2012 and 2016 iterations of the *Shape of the Nation* [*SON*] *Report* (NASPE and AHA, 2012; SHAPE America et al., 2016) that summarized questionnaires completed by state PE coordinators and included the amount of PE required by states and the District of Columbia (DC). For our estimates, we retained only states ($n = 22$) that indicated having a numerical time allocation policy for PE (i.e., required minutes or hours of PE during a certain time period). We then averaged across the 22 states to obtain a single state-level estimate, and for all potential energy expenditure calculations we assumed PE was provided daily for 36 weeks annually. We also compared the verbiage in the 2012 and 2016 *SON* iterations to determine changes in state policy over time.

To compute estimated energy expenditure (EEE) we used findings from the most recent meta-analytic reviews of the percentage of PE time spent in MVPA—45% for elementary schools (Hollis et al., 2016) and 50% for middle and 37% for high schools (Hollis et al., 2016, under review). In our original paper, we used published estimates that are now at least 10 years old and assumed PE was provided daily for 36 weeks. For the updated estimates we used data from the latest *School Health and Policy Practices* [SHPPS] study (USDHHS/CDC, 2015), and were able to calculate EEE using more precise grade level averages for PE lesson length, lessons per week, and weeks per year.

2.2. Overall EEE calculations

The overall methods were described in detail previously (Kahan and McKenzie, 2015). Briefly, we based EEE calculations for elementary, middle, and high schools on data comprising grades 1–6, 7–8, and 9–10, respectively, and performed calculations for hypothetical boys and girls between ages 6 and 15. We excluded kindergarten because few states had a PE duration policy, and we excluded grades 11 and 12 as only two states had high school graduation requirements beyond 2.0 PE units (NASPE/AHA, 2012) and less than 9% of schools require PE in those grades (USDHHS/CDC, 2015).

The general approach we took to calculate yearly EEE for an individual student included data for lesson length (min/PE lesson/day), lesson frequency/week, school weeks/year, weighted physical activity intensity (calculated using proportions of a PE lesson spent in MVPA at 4.5 METS and non-MVPA at 1.8 METS), and national data for student body mass at the 50th percentile for age and gender (Fryar et al., 2012).

We used a mean MET value of 3.15 for calculations using 50.0% of lesson time in MVPA. For calculations of practice-based EEE we used lesson MVPA% based on recent meta-analyses (Hollis et al., 2016, under review) to calculate a weighted MVPA% for a lesson (i.e., %MVPA × 4.5 METS + %non-MVPA × 1.8 METS). We used the 2014 SHPPS grade-level reports for mean number of weeks of PE/year, days of PE/week (USDHHS/CDC, 2015), and adjusted mean lesson length which accounted for time lost changing clothes before and after class (USDHHS/CDC, 2015).

To reduce confusion from the diverse ways state policies reported PE frequency and duration, we calculated a common metric: minutes per day. Additionally, to determine overall EEE in PE for an entire class, we used the mean of the 50th percentile mass values for males and females and multiplied by NASPE (2006) recommended class size maximums for elementary (25), middle (30), and high (35) schools.

Fig. 1 displays the resulting formula we used in calculations along with data sources. A sample calculation follows based on a 7th-grade female student under practice-based conditions:

EEE (kcal/yr) = [[(49.3 min/lesson − 8.9 min/lesson lost) ÷ 60 min/h)] × [(3.8 days PE/week ×30.1 weeks/school year)] × [(50.3% MVPA × 4.5 METS) + (49.7% non-MVPA × 1.8 METS)] × 52.3 kg] = 12.721 kcal/year.

To compute cumulative EEE over a 10-year period we summed the yearly totals from 1st through 10th grades. We also calculated school-level EEE separately for elementary (grades 1–6), middle (grades 7–8), and high (grades 9–10) school configurations.

3. Results

3.1. Overview

Table 1 displays key verbatim language from the 2016 *SON Report* (SHAPE America et al., 2016) for the 22 states and DC that had a specific time requirement for PE or identified having one in the 2012 *SON Report* (NASPE/AHA, 2012). Nineteen of the 22 states and DC had specific PE minutes for elementary schools (mean = 20.7 ± 1.8 min/day), 15 for middle schools (mean = 27.7 ± 3.2 min/day), and 7 for high schools (mean = 28.8 ± 4.1 min/day) (see Tables 1 and 2).

Grade-level, school-level, and total 10-year potential (based on professional guidelines and state policy averages) and practice-based (aka, actual) EEE for individual boys and girls at the 50th percentile body mass are presented in Table 3. Grade-level, school-level, and total EEE were highest for both boys and girls when computed using the professional guidelines, and practice-based EEE was about 6.8% higher than state policy estimates. Over 10 years of schooling, the average student