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Research Articles

*Effects of States' Laws on Youth Physical Activity Participation and Obesity Prevalence**

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ABSTRACT

The alarming prevalence of obesity and lack of physical activity among adolescents led to immediate policy action to address these concerns. Accordingly, many states introduced and enacted their own legislation to encourage physical activity in schools. Few studies have explored the effectiveness of the new legislation, however, especially at the state level. To answer the fundamental question of whether policy is effective and to describe the varying effects of state obesity policies, this study analyzed the Youth Risk Behavior Surveillance System from 2007 to 2017. Using the difference-in-differences method, this study found that legislative efforts to encourage physical activity had a significant and substantial effect on enhancing physical-activity participation and reducing adolescent obesity; however, subgroup analyses revealed that the effect was concentrated on female and white adolescents only. Additionally, the subsequent sensitivity analysis revealed that since 2015, when national attention started to divert to new health concerns (opioid abuse, for example), physical activity levels pulled back to 2009 levels. Rates of obesity and overweight have been on a sharp rise again since 2015. Lawmakers should reconsider changes in the law merging physical environments with digital environments, particularly for members of Generation Alpha, who will have ever more enticements for screen time.

KEY WORDS Adolescent Obesity; Adolescent Overweight; Physical Activity; State Law

The prevalence of obesity among adolescents has risen tremendously over the past four decades, a phenomenon commonly referred to as the obesity epidemic. According to Hales

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and colleagues (2017), for 2015–2016, 20.6 percent of adolescents aged 12–19 years were obese, defined as having a body mass index (BMI) greather than or equal to the 95th percentile for their age. The potential adverse effects of obesity on obese adolescents—such as increased morbidity and mortality (Daniels 2006)—and concurrent rising health-care expenditures (Trasande and Chatterjee 2009) as well as indirect social costs—such as increased school absenteeism and poor academic performance (Datar, Sturm, and Magnabosco 2004; Story, Kaphingst, and French 2006)—make it incumbent upon health professionals, policymakers, and researchers to come up with a comprehensive plan to reduce and reverse adolescents' excess-weight problem.

Weight gain is usually explained as an outcome of a sedentary lifestyle and physical inactivity, though the exact causal mechanisms behind physical inactivity are unclear. In fact, numerous reports present that many young adults do not engage in recommended levels of physical activity (Eaton et al. 2010; Gordon-Larsen et al. 2000; Lowry et al. 2005). As a result, the provision of more opportunities to engage in physical activity at schools as a policy instrument has received a tremendous amount of national attention, media coverage, and parental support (Story et al. 2006). Legislative efforts are no exception. Congress enacted the Child Nutrition and WIC Reauthorization Act of 2004, which encourages state and local authorities to promote physical activities and requires schools participating in the National School Lunch Program and School Breakfast Program to design and implement local wellness policies. This law change at the federal level also coincided with a plethora of state legislation aimed at increasing physical activity in schools.

A fundamental but unanswered question is whether legislative action, especially at the state level, achieves its goal in tackling the obesity epidemic. Specifically, does the enactment of state law induce more physical activity and eventually contribute to reducing obesity among adolescents? Although a few studies have analyzed the effect of state physical education (PE) requirements on physical activity among adolescents (Cawley, Meyerhoefer, and Newhouse 2007; Kim 2012), little empirical research has been done to investigate whether the enactment of new state laws increases adolescents' participation in physical activity and, consequently, contributes to reducing the prevalence of adolescent obesity.

This study, using the Youth Risk Behavior Surveillance System (YRBSS), finds that legislative efforts on encouraging physical activity have had a significant and substantial impact on enhancing physical-activity participation and reducing adolescent obesity. Despite such efforts, however, overall physical-activity participation has decreased and the rates of obesity and overweight began to increase again in 2015, when national attention diverted to the opioid epidemic. Urgent alerts should be recalled to reduce youths' excessive-weight problems.

LITERATURE REVIEW AND RESEARCH QUESTION

The importance of physical activity in preventing obesity has been widely acknowledged in the literature. According to Goran, Reynolds, and Lindquist (1999), physical activity can restrain the development of obesity through several potential channels: (1) physical activity

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results in increased energy expenditure, ultimately restoring energy balance; (2) physical activity develops substrate metabolism, conducive to utilizing fat relative to carbohydrates, ultimately reducing body fat; and (3) physical activity may also have other positive spillover effects on food-intake regulation.

Though the causal mechanisms through which physical activity reduces and/or prevents obesity are less clear, recent research findings provide evidence indicating the positive impact of physical activity in reducing obesity-related measures (Lowry et al. 2005; Shaya et al. 2008; Story et al. 2006). Numerous studies have shown the positive impact of comprehensive school-based intervention on physical activity. For instance, analyzing the Planet Health program, Gortmaker and colleagues (1999) found that unbalanced nutrition, physical activity, and sedentary behavior (e.g., TV watching) are associated with the reduction of obesity prevention, especially among female middle school students. Nader and colleagues (1999) reported that children exposed to the Coordinated Approach to Child Health program exhibited more healthy behaviors, such as lower intake of fat and more physical activity, compared to their counterparts. Berkey and colleagues (2003), using the longitudinal Growing Up Today Study, found that physical activity over one year was associated with a relative decrease in BMI for girls and overweight boys. A recent study also confirmed the findings of the earlier studies. Schaefer and colleagues (2015), analyzing a community-based intervention program called Niños Sanos, Familia Sana (Healthy Children, Healthy Family), found that daily moderate to vigorous physical activity was associated with having a healthy BMI, particularly among girls.

A number of researchers have examined the effectiveness of specific interventions designed to increase physical activity within randomized experimental settings. For example, in a randomized experiment, Carrel and colleagues (2005) demonstrated that obese middle school children who participated in a school-based fitness program showed greater improvement in fitness, fatness, and insulin sensitivity compared to their counterparts who were enrolled in a standard gym class. Similarly, Jamner and colleagues (2004) reported significant improvement in cardiovascular fitness, lifestyle activity, and physical activity of female high school students who took special PE classes, although BMI, BMI percentiles, and psychosocial variables (e.g., self-efficacy, enjoyment, family support) did not change. In their meta-analysis of 52 studies published between 2000 and 2011, Vasques and colleagues (2014) found that intervention programs had a positive effect in enhancing physical activity and reducing obesity, particularly when combined with nutrition education in the school setting, when parents controled leisure-time practice and food choice, and when the programs lasted for more than one year.

Reports have offered evidence that, despite the benefits of physical activity, many young adults do not engage in recommended levels of physical activity (at least 60 minutes of moderate to vigorous physical activity per day, according to the 2008 physical activity guidelines from the U.S. Department of Health and Human Services (USHHS)) and that participation in physical activities has decreased significantly over the past few decades. Gordon-Larsen, McMurry, and Popkin (2000), using data from the National Longitudinal Study of Adolescent Health, reported that only 21.3 percent of adolescents engaged in a weekly PE class. Lowry et al. (2005) reported that the percentage of high school students

attending PE class daily decreased significantly, from 41.6 percent in 1991 to 28.4 percent in 2003, and that only around 40 percent of high school students enrolled in PE class were actually engaged in moderate or vigorous physical activity on at least 3 days per week. Likewise, Li, Treuth, and Wang (2010) reported that only 34.7 percent of youth (25.6 percent of female adolescents) engaged in the recommended level of physical activity and only 30.3 percent of adolescents attended PE class daily in 2007. Turner and colleagues (2015) reported that 48 percent of high school girls did not participate in the five most common female high school sports and 29 percent of high school boys did not participate in the five most common male high school sports. Strikingly, one out of four high school students did not participate in at least 60 minutes of any kind of physical activity per week (Eaton et al. 2010; Li et al. 2010).

The reasons for lower physical activity levels among adolescents are not clear. Indeed, the factors contributing to low levels of physical activity are diverse. Marshall and colleagues (2004) suggested that sedentary behaviors, including screen time (particularly video games), crowd out physical activity time, though by a small amount. Robinson and colleagues (2017) suggested that digital media exposure not only displaces physical activity but also influences children's eating preferences and habits through advertisement, increases eating while viewing, and reduces sleep duration, which together result in obesity. Besides individual choice, environmental barriers may also be critical factors contributing to the decline in physical activity. For instance, Li et al. (2010) suggested that having fewer material resources and human resources, as well as less program support, may hamper adolescents' activity levels, especially within poor school districts. Story et al. (2006) brought up another important environmental barrier from the era of academic accountability, arguing that the No Child Left Behind Act of 2001, underscoring students' academic achievement as measured by standardized test scores in core subjects, was a major hurdle for the provision of PE in schools because PE was rendered of lower priority than students' academic performance.

The prevalence of obesity—and weight problems generally—and low levels of physical activity among adolescents calls for immediate policy action to address these concerns, especially in schools. Although students may frequently engage in after-school activities, schools are critical settings for policy intervention because school curricula have the potential to influence habitual physical activity and schools may also provide diverse tools to encourage physically active lifestyles, such as walking to school (Li et al. 2010; Lowry et al. 2005; Story et al. 2006; Taber, Chriqui, and Chaloupka 2012).

Legislative efforts are no exception. The Child Nutrition and WIC Reauthorization Act of 2004 encourages state and local authorities to promote physical activity and requires schools participating in the National School Lunch Program and School Breakfast Program to design and implement local wellness policies, including policies to improve levels of physical activity in schools.

States—which hold much of the authority over public health through legislative and regulatory power—also introduced and enacted their own legislation with regard to increasing physical activity in schools. It is, however, not surprising that the adoption and content of laws vary across states, considering that the enactment of a bill is significantly affected by the bill's specific characteristics as well as by a given state's contextual

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influences (Boehmer et al. 2009). For instance, bills mandating physical education and physical activity are less likely to be enacted than are bills with optional physical activity (Boehmer et al. 2009). Furthermore, a variety of policy endogeneity (e.g., public concern about the obesity rate) may influence the adoption of new interventionist policies (Cawley et al. 2007).

States' policy intervention through legislation raises a fundamental question about policy effectiveness and avenues for further improvements in policy through rigorous ex-post evaluation. Numerous previous evaluations have investigated the impact of school-based policy interventions within experimental settings. Though findings are heterogeneous, one general finding is that youth exposed to comprehensive intervention over a longer period show less frequent incidence and remission of overweight compared to their counterparts experiencing little or no intervention (Brown and Summerbell 2009; Cook-Cottone, Casey, and Feeley 2009; Khambalia et al. 2012). A well-designed experiment will be a useful tool for exploring the effectiveness of policy intervention, as such an experiment can manipulate and track the dose of intervention. To evaluate statewide policy interventions to reverse the obesity problem, however, one needs to investigate whether the policy tools bring about the policy's desired outcome. In other words, it is necessary to examine whether state legislation has induced a substantial increase in the level of physical activity to tackle the obesity problem among adolescents.

A handful of empirical studies examine the effect of state policy intervention on physical activity, albeit with inconsistent findings. Using national YRBSS data for 1999–2003 and PE credit requirements for 2001, Cawley et al. (2007) found that cross-state variation in PE credit requirements resulted in different amounts of time spent in physical activity among girls,, although Kim (2012) observed that PE requirements stipulated by state law were not associated with either an increase in vigorous physical activity time among high school students or a decrease in weight outcome. In the same study, however, Kim (2012) found that PE requirements in schools were significantly correlated with physical activity time—though not BMI—among girls. This discrepancy in findings between the two studies may be due to the fact that each study adopted cross-sectional analyses investigating the impact of PE requirements pertaining to different time periods. Furthermore, both focused on the cross-sectional between-state variation, not reflecting longitudinal within-state variation.

To address the fundamental issue of policy effectiveness and to describe the varying effects of state obesity policies, this study, adopting difference-in-differences (DID) methods, examines whether the enactment of new state laws increases physical activity and decreases the risk of obesity or weight problems among adolescents.

DATA

This study uses data pooled from two sources: (1) state YRBSS for 2007–2017, containing information about high school adolescents' heights, weights, and other attitudinal-behavioral variables indicating levels of physical activity, and (2) the Centers for Disease Control and Prevention (CDC) Chronic Disease State Policy Tracking System.

The state YRBSS is a biennial school-based survey conducted by a state's health or education department. The questions are similar to those of the national YRBSS survey, except for minor modifications or omissions in the number of questions across states and years. The survey monitors the prevalence of risky youth behaviors, including those relating to obesity and physical activity. Several critical questions related to adolescents' physical activity ask about the number of days that adolescents are physically active (at least 60 minutes per day), the number of days they have PE classes, and the number of sports teams on which they played, for example. This study uses the number of days on which adolescents were physically active for at least 60 minutes per day, which meets the USHHS (2008) guidelines. (All data are available at https://www.cdc.gov/healthyyouth/data/yrbs/data.htm.)

Data about the introduction of new state laws were pooled from the CDC's Chronic Disease State Policy Tracking System. This study collected all state bills about physical activity that were enacted (excluding those dead or only introduced) between the years 2001 and 2017 and eliminated duplicate bills. During this period, a total of 1,890 laws about physical activity in the school setting were introduced; 729 were enacted (38.6 percent). Policy topics in each enacted law were diverse and included access to recreational opportunities, appropriations, built environment, bicycling, walking, safe route to school, school siting, physical education/activity requirements, public safety, initiatives and programs, parks and trails, and more.

Next, this study looked closely at the clauses of each law and selected 347 laws enacted for (1) specific physical education or physical activity requirements, including length or duration, and (2) subsequent appropriations. For instance, these laws stipulated provisions to

1. establish a task force or advisory committee to examine barriers facing schools in providing physical activity and make recommendations for overcoming those obstacles (IL SJR80);
2. regulate mandated physical education for graduation and retract PE exemptions (FL S610, ME H983, NM R5102, etc.);
3. provide students with healthy-weight pilot programs (GA H229, RI R3669) or substitutes such as interscholastic sports, JROTC, marching bands, and the like (MS R12463);
4. provide resources for physical activity instruction and assessment for health and PE teachers (CA S1016, PA H101, TX S226, etc.);
5. encourage school districts to share school facilities with local communities (NY S587); and
6. encourage stakeholders to create a strategic plan aimed at achieving and maintaining a healthy weight in children for their future (GA H229).

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This study then carefully identified states that had enacted laws regarding both physical activity requirements and appropriations in 2011. For example, in 2009, the state of Indiana enacted a law (R9382) requiring PE for students to receive diplomas but did not pass any appropriation laws implementing PE requirements. The state of Indiana therefore did not meet the selection criteria. Table 1 presents a brief summary of the enactment of state laws requiring physical activity and the appropriation of funds for physical activity. As can be seen in the table, 25 states met the selection criteria, and the majority of state legislation enacted was concentrated around the year 2011, which allows this study to utilize a DID method, or controlled before-and-after study.

Table 1. Summary of State Laws Regarding Physical Activity

State	Law Citation	Effective Year	Title
Alabama	H123	2011	Public Education and State Appropriation
Arkansas	S581	2011	Appropriation to the Department of Human Services
	H1743	2011	Health and Safety of Students in Public School
Arizona	SB1186	2011	Children's Physical Activity Grant (Appropriations and Physical Activity Requirement)
California	S70	2011	Education Finance: Budget Act of 2011
	S1016	2011	Education Finance
Delaware	S310	2010	State Appropriations
	R2740	2011	Junior High and Middle School Interscholastic Athletics
Florida	H7207	2011	Growth Management (Appropriations)
	S610	2008	Physical Education
Georgia	H229	2009	Student Health and Physical Education Act
	H77	2011	Supplemental Appropriations
Illinois	H684	2010	School Code (Appropriation)
	SJR80	2010	Daily Recess in Schools (Physical Activity Requirement)

Continued next page

Table 1. Summary of State Laws Regarding Physical Activity, cont.

State	Law Citation	Effective Year	Title
Maine	H983	2009	Physical Education in Schools (Appropriations and Physical Education Requirement)
Missouri	H4	2009	Education Reform
	H2004	2010	Department of Revenue Appropriation
Mississippi	R12463	2010	Physical Education and Comprehensive Health Education
	H1078	2010	Healthier School Initiative
North Carolina	H2437	2007	Appropriation Act
	H901	2010	Health and Physical Education Classes
Nebraska	R1685	2009	Bonds (Appropriation)
	R1610	2009	School Accreditation
New Mexico	R5102	2009	Curriculum and Standards
	R5499	2010	Application/Grant Assistance Procedures
Nevada	SCR12	2009	Physical Fitness
	S92	2011	Redevelopment Agencies (Appropriations)
New York	R21731	2010	Qualified School Construction Bonds
	S587	2010	Chancellor of City School District (Physical Activity Requirement)
Ohio	H119	2007	Appropriations for Operation of State Programs
	S210	2010	School Nutrition and Health
Oklahoma	S1169	2010	Schools (Appropriations)
	S1876	2010	Schools Physical Education

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Table 1. Summary of State Laws Regarding Physical Activity, concl.

State	Law Citation	Effective Year	Title
Pennsylvania	H101	2010	Value Added Assessments and Dropout Prevention
	H1485	2011	Payment of Bills from the General Fund (Appropriations)
Rhode Island	R3669	2009	School Health Programs
	H5960	2011	Exeter and West Greenwich Regional School District (Appropriations)
South Carolina	SJR228	2005	Physical Education and Nutritional Standards
Texas	S226	2011	Student Physical Fitness Performance Reporting
	HR2723	2011	Conference Committee Jurisdiction (Appropriations)
Vermont	R1224	2009	Special Education Rules
	H446	2011	Capital Construction Appropriations
Washington	S5551	2009	School
	HB1115	2015	An act relating to the capital budget (Appropriations)
West Virginia	H2816	2005	Healthy Lifestyles

Source: CDC Chronic Disease State Policy Tracking System.

After compiling the data, this study identified 552,267 samples collected from 2007 to 2017 for 38 states as analytical samples. Not all states collected YRBSS data, and not all variables are available for every year. Table 2 indicates which states had YBRSS data available and which did not; Table 3 displays the description of the analytical samples; and Figure 1 illustrates the trend of physical activity, obesity rate, and overweight rates for adolescents.

Table 2. Treatment States vs. Comparison States

	Treatment-Group States (n = 15)	Comparison-Group States (n = 20)	Excluded States[a] (n = 3)
YRBSS data available (n = 38)	AL, AR, AZ, CA, DE, FL, IL, ME, MO, MS, NC, NY, NV, OK, RI	AK, CO, HI, IA, ID, KS, KY, LA, MI, MT, ND, NH, NJ, PA, SD, TN, UT, VA, WI, WY	NE, SC, WV
YRBSS data unavailable (n = 12)	CT, GA, IN, MD, MA, MN, NM, OH, OR, TX, VT, WA		

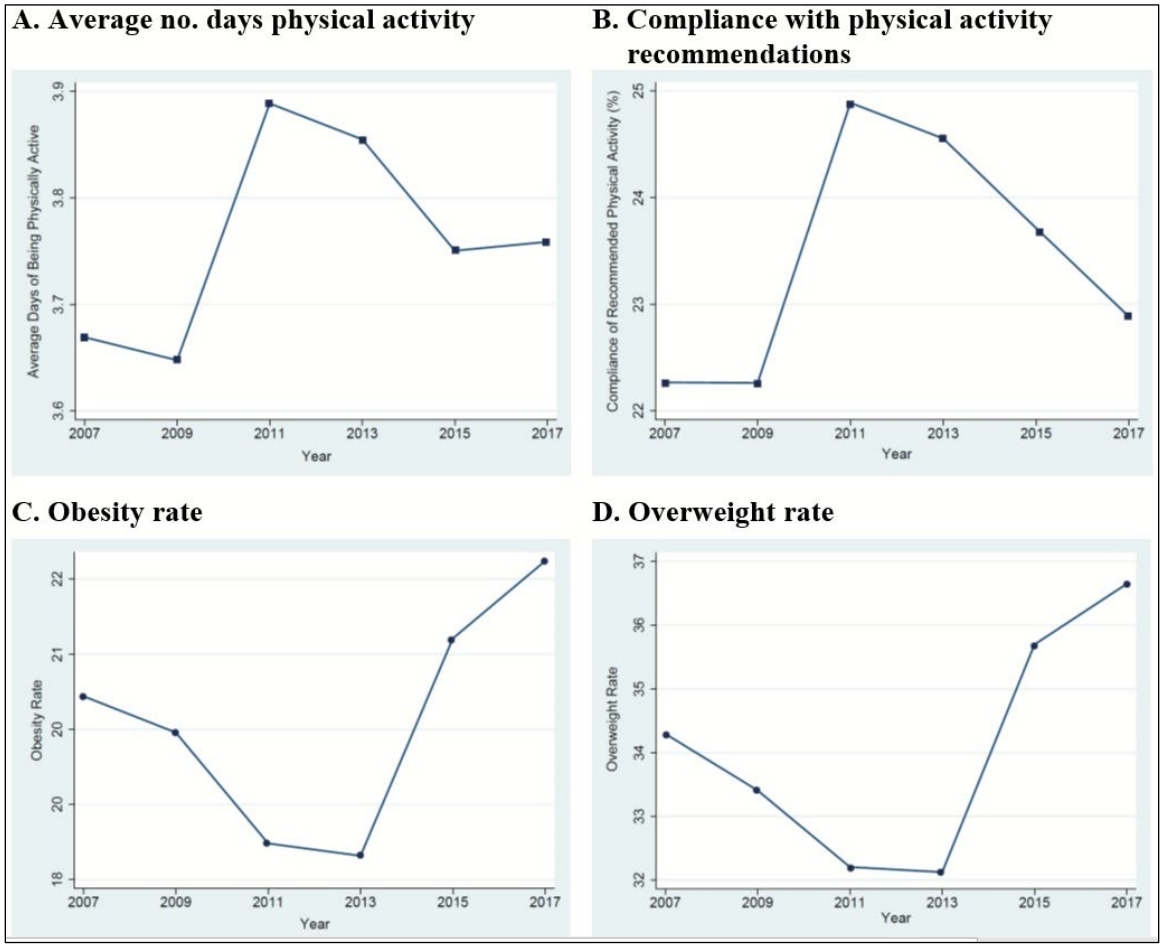
[a] Excluded from empirical analysis because of ineligibility.

Table 3. Sample Description

	Treatment Group	Comparison Group
Average Physical Activity (No. of days physically active per week)	3.64	3.89
Required Physical Activity Compliance (≥1 hour of daily physical activity)	22.55%	24.21%
Obese (BMI ≥95th percentile)	22.50%	17.60%
Overweight (BMI ≥85th percentile)	36.43%	31.49%
Gender		
Male	48.72%	49.29%
Female	51.28%	50.71%
Grade		
9	28.04%	28.26%
10	27.26%	26.73%
11	24.58%	24.18%
12	20.12%	20.29%
Race		
White	46.63%	64.57%
Black	18.10%	7.70%
Hispanic	23.55%	11.34%
Other	11.73%	16.39%
Number of Observations	291,370	260,897

Source: Youth Risk Behavior Surveillance System (2007–2017).

Figure 1. Overall Adolescent Physical Activity, Obesity, and Overweight Rates, 2007–2017



METHODOLOGY

To examine the impact of states' enactment of laws regarding physical activity and funding on the physical-activity participation and obesity/overweight rates of adolescents, this study employs DID methods, which are useful for analyzing the effects of policies in nonexperimental settings (Wooldridge 2015). The basic idea of the DID method is to examine the effect of an exogenous shock by comparing a treatment group with a comparison (control) group both before and after treatment, under the assumption that the difference between the treatment and control groups would remain the same over time in the absence of the treatment.

This study treats the enactment of state laws as an exogenous shock. For example, the state of Illinois enacted new state laws (SJR80 and H684) in 2010 that mandated physical education, created a Recess in Schools Task Force to examine barriers facing schools in providing daily recess and to design programs providing the opportunity for

youths to get physical exercise during the school day, and appropriated funds to support the programs. Naively, the effect of the new law on adolescents' physical activity can be examined by comparing the average number of days that the adolescents were physically active before and after the enactment of the new law, but environmental changes other than the law change may also affect adolescents' physical activity over that time. By using the comparison group, the DID method removes the effect of other environmental changes, assuming that such changes affect physical activity identically in both the treatment and comparison groups.

To address the research questions, the following DID regression model was constructed.

$$y_{it} = \beta_0 + \delta_1 D_i + \delta_2 T_t + \delta_3 D_i T_t + \mathbf{X\beta} + u_{it}$$

In the equation, for adolescent *i* at year *t*, y_{it} is the outcome variable of interest, such as number of days of physical activity per week, compliance with USHHS recommendations, probability of being obese, and probability of being overweight, respectively. D_i is the dummy variable indicating states with new laws (1) or without new laws (0), and T_t is the dummy variable indicating the year (1 = 2011 or later, after enactment of new laws; 0 = 2009 or earlier, before enactment of new laws). Thus, δ_1 captures the baseline year difference between states with new laws and states without, and δ_2 captures the difference for before and after the laws' enactment. The key variable of interest is $D_i T_t$, an interaction term between the state dummy and the year dummy. The DID estimator, δ_3, indicates the average treatment effect driven by the enactment of physical-activity laws:

$$\delta_3 = \left(\bar{y}_{trt,2011} - \bar{y}_{trt,2009}\right) - \left(\bar{y}_{cp,2011} - \bar{y}_{cp,2009}\right)$$

X is a vector of control variables that include gender, grade, race, and state of residence.

For the analysis, this study recoded states with the enactment of new state laws as a treatment dummy (1) and the year 2011, when the majority of new laws were enacted, as a time dummy (1). As seen in Table 2, of 38 states for which YBRSS data were available, 15 states were assigned to the treatment group and 20 states to the comparison group. The treatment-group states had enacted laws in 2011, whereas the comparison-group states had no enacted laws. Nebraska (NE), South Carolina (SC), and West Virginia (WV) were excluded because new laws in these states were enacted in or before 2009.

EMPIRICAL RESULTS

This section presents the longitudinal trend of physical activity, obesity, and overweight rates of adolescents visually. Figure 1A shows that the average number of days that adolescents were physically active rose from 3.65 in 2009 to 3.90 in 2011 but decreased thereafter. The percentage of youth reporting at least 60 minutes of vigorous or moderate

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physical activity daily also increased, from 22.2 percent in 2009 to 24.9 percent in 2011, and then decreased thereafter, as shown in Figure 1B. The results shown in Figure 1 also suggest that adolescents' physical activity levels and rates of obesity and overweight are negatively associated with each other. As physical activity levels increased, obesity and overweight rates decreased, and vice versa.

Figure 2 demonstrates the trends of physical activity and obesity and overweight rates for the treatment and comparison groups. Overall, the comparison group had higher physical activity and lower obesity and overweight rates, whereas the treatment group had lower physical activity and higher obesity and overweight rates. In treatment states, average number of days of physical activity was highest in 2011, as was the percentage of adolescents having at least 60 minutes of daily physical activity. The obesity and overweight rates for the treatment states were lowest in 2011, the year when new laws regarding physical activity requirements and subsequent fund allocation were enacted and went into effect. Interestingly, after 2011, physical activity decreased and obesity and overweight rates rebounded in these states. In the comparison states, average number of days of physical activity and compliance with daily physical activity recommendations was also highest in 2011, while obesity and overweight rates were still on the rise. These charts suggest that states with higher youth obesity and overweight rates passed new laws requiring physical activity and allocating funds for encouraging physical activity and that, consequently, youth physical activity levels in those states increased while obesity and overweight rates decreased. To verify this speculation, this study conducted statistical analyses using the model specified in the previous section.

Tables 4–7 present the estimated impact of states' enactment of new laws encouraging physical activity on the average number of days of physical activity, compliance with recommended physical activity, obesity rate, and overweight rate, respectively, after controlling for adolescents' gender, grade, race, and state of residency. The estimated coefficient of the treatment-state dummy captures the baseline-year (2009) difference between the treatment and comparison states. The estimated coefficient of the treatment-year dummy captures the year trend of physical activity. The estimated coefficient of the interaction term (State*Year) indicates the impact of states' enactment of physical-activity requirements and appropriations on the various dependent variables, assuming that the baseline difference between the treatment and comparison states would be the same if there had been no law change. The estimated coefficient of the interaction term is of interest in this study.

As shown in Table 4, states' enactment of these laws had a positive effect on adolescents' physical activity. In 2009, youth in the treatment states had 0.233 fewer days of physical activity than did youth in the comparison states. With other conditions remaining the same, youth in 2011 had 0.165 more days of physical activity compared to youth in 2009. Youth in the treatment states in 2011, however, had 0.079 more days of physical activity than youth in the comparison states in the same year; 0.079 ($p < .001$) more days can be interpreted as the effect of the new state law. The subsequent subgroup analysis, however, identifies that the effect was concentrated only on female and white adolescents. Female adolescents in the treatment states in 2011 had 0.129 ($p < .001$) more days of physical activity compared to their female counterparts in the comparison states.

White adolescents in the treatment states had 0.135 ($p < .001$) more days of physical activity in 2011 than did white adolescents in the comparison states. The effect of state laws on the average amount of physical activity per week was not statistically significant among male adolescents or among other racial groups.

Figure 2. Adolescent Physical Activity, Obesity, and Overweight Rates for Treatment vs. Comparison States, 2007–2017

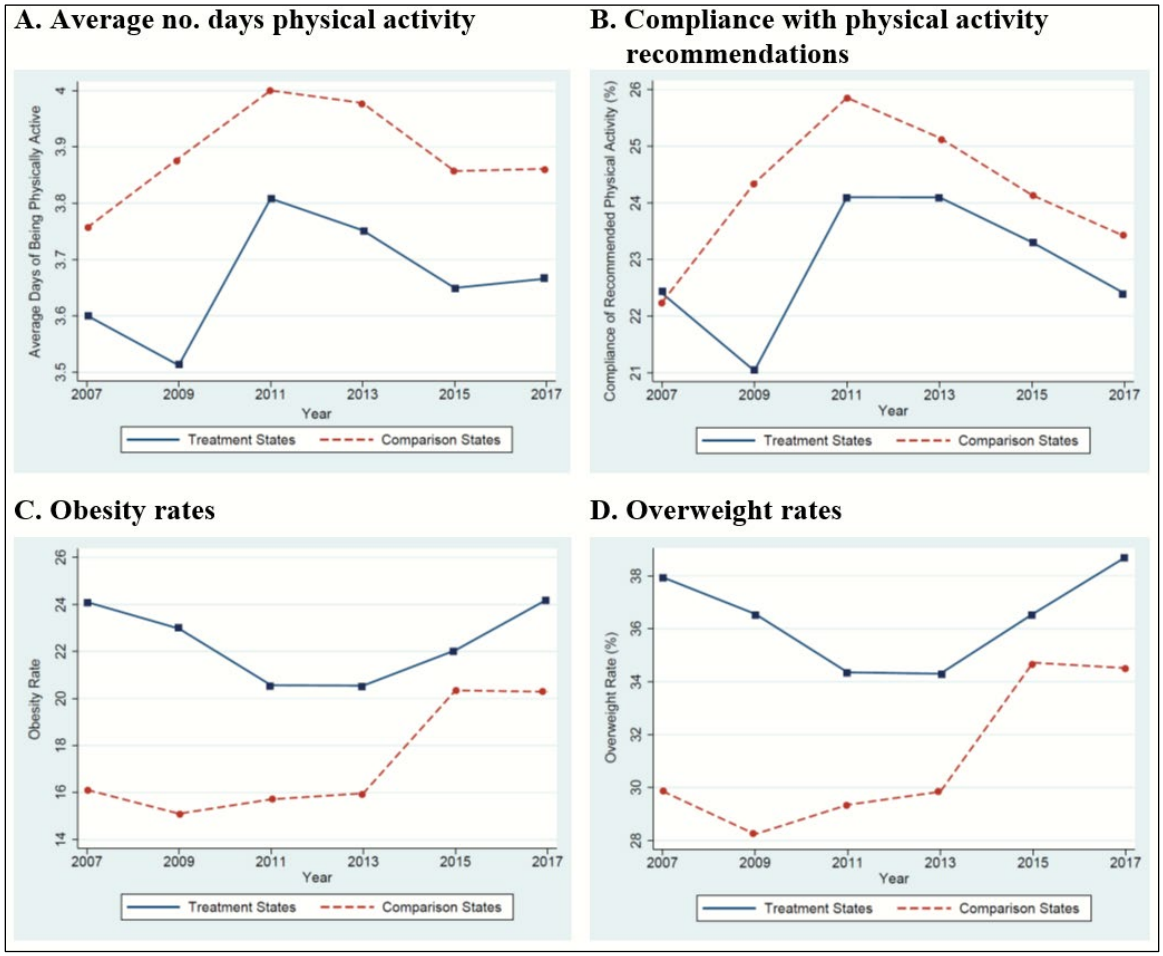

Table 5 displays the effect of the laws on adolescents having at least 60 minutes of daily physical activity. Because the dependent variable was a binary indicator of whether adolescents had a recommended level of physical activity, logistic regression controlling for gender, grade, race, and state of residence was employed. Youth in the treatment states in 2011 were 5.3 percent ($p < .05$) more likely to have at least 60 minutes of physical activity every day than were youth in the comparison states. The effect was concentrated only on female and white adolescents, however. Female adolescents in the treatment states in 2011 were 7.7 percent ($p < .05$) more likely to have at least 60 minutes of physical

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activity daily than were female adolescents in the comparison states. White adolescents in the treatment states were 14.8 percent ($p < .001$) more likely to engage in at least 60 minutes of physical activity daily than were their white counterparts in the comparison states. State laws had no statistically significant effect in enhancing physical activity to the recommended level among male adolescents or among other racial groups.

Table 4. DID Model Estimates for Average Number of Days of Physical Activity

	All	Gender		Race			
		Male	Female	White	Black	Hispanic	Other
Treatment-state dummy	–0.233***	–0.262***	–0.204***	–0.271***	–0.059	–0.326***	–0.097
	(0.019)	(0.028)	(0.026)	(0.024)	(0.065)	(0.055)	(0.055)
Treatment-year dummy	0.165***	0.191***	0.143***	0.148***	0.256***	0.200**	0.185***
	(0.020)	(0.028)	(0.027)	(0.023)	(0.077)	(0.061)	(0.051)
State*Year interaction	0.079**	0.019	0.129***	0.135***	–0.057	0.013	0.006
	(0.026)	(0.039)	(0.036)	(0.034)	(0.089)	(0.073)	(0.075)
Male	0.910***			0.874***	1.071***	0.862***	0.977***
	(0.013)			(0.017)	(0.039)	(0.033)	(0.036)
10th grade	–0.206***	–0.156***	–0.252***	–0.275***	–0.159**	–0.076	–0.136**
	(0.018)	(0.026)	(0.024)	(0.023)	(0.053)	(0.044)	(0.049)
11th grade	–0.371***	–0.246***	–0.485***	–0.484***	–0.200***	–0.141**	–0.343***
	(0.018)	(0.027)	(0.025)	(0.023)	(0.052)	(0.046)	(0.050)
12th grade	–0.485***	–0.343***	–0.616***	–0.594***	–0.310***	–0.205***	–0.525***
	(0.019)	(0.028)	(0.026)	(0.025)	(0.056)	(0.048)	(0.052)
White	0.585***	0.572***	0.598***				
	(0.019)	(0.028)	(0.025)				
Black	–0.069**	0.038	–0.159***				
	(0.025)	(0.038)	(0.034)				
Other race	0.110***	0.151***	0.072*				
	(0.025)	(0.037)	(0.034)				
Constant	3.269***	4.111***	3.328***	3.957***	2.905***	3.217***	3.271***
	(0.025)	(0.036)	(0.033)	(0.023)	(0.068)	(0.055)	(0.052)
Number of observations	138,377	66,286	72,091	79,898	17,809	22,222	18,448
Adjusted R^2	0.056	0.018	0.030	0.044	0.046	0.036	0.045

Notes: Robust standard error in parentheses. Residency state is also controlled.

* $p < .05$ ** $p < .01$ *** $p < .001$

To answer the question of whether state laws achieved their intended goal of reducing rates of obesity and overweight among adolescents, the same model was run with dummy variables indicating being obese and being overweight as dependent variables. Table 6 presents the effect of the laws on obesity. In 2009, before the laws had been introduced, adolescents in the treatment states were 54.5 percent more likely to be obese than were adolescents in the comparison states; the obesity rate in the treatment states was 23.12 percent, compared to 15.10 percent in the comparison states. In both groups, adolescents in 2011 were 3.7 percent more likely to be obese than were adolescents in 2009; however, the coefficient of the interaction term indicates that in 2011, adolescents in treatment states were 19.4 percent ($p < .001$) less likely to be obese than were their counterparts in comparison states. Subgroup analyses reveal that both

male and female groups enjoyed the effect of the reduction in obesity rates. Additionally, all racial groups except "other races" in the treatment states benefited when compared to their counterparts in comparison states. For example, in 2011, white adolescents in the treatment states were 20.3 percent ($p < .001$) less likely to be obese than were white adolescents in the comparison states. Black adolescents in the treatment states were 25.1 percent ($p < .001$) less likely to obese than were black adolescents in the comparison states.

Table 5. DID Model Estimates for Compliance with Recommended Physical Activity (Logistic Regression)

	All		Gender			
			Male		Female	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	–0.141*** (0.019)	0.869	–0.147*** (0.024)	0.863	–0.132*** (0.030)	0.877
Treatment-year dummy	0.107*** (0.019)	1.113	0.114*** (0.025)	1.121	0.098*** (0.030)	1.104
State*Year interaction	0.052* (0.026)	1.053	0.036 (0.034)	1.036	0.074* (0.037)	1.077
Constant	–1.652*** (0.025)		–0.828*** (0.031)		–1.576*** (0.037)	
Wald χ^2	5335.50		535.16***		468.68***	
Pseudo R^2	0.037		0.007		0.008	

	Race							
	White		Black		Hispanic		Other Race	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	–0.177*** (0.024)	0.838	–0.093 (0.062)	0.911	–0.173** (0.055)	0.841	–0.001 (0.056)	1.001
Treatment-year dummy	0.085*** (0.023)	1.088	0.127* (0.072)	1.136	0.168** (0.060)	1.182	0.170*** (0.052)	1.185
State*Year interaction	0.138*** (0.033)	1.148	–0.060 (0.084)	0.941	–0.074 (0.073)	0.928	–0.065 (0.075)	0.936
Constant	–1.341*** (0.023)		–1.583*** (0.065)		–1.637*** (0.057)		–1.683*** (0.054)	
Wald χ^2	3336.54***		528.11***		626.14***		628.58***	
Pseudo R^2	0.038		0.030		0.029		0.033	

Note: Control variables include gender (male), grade, race, and state of residence.

*$p < .05$ **$p < .01$ ***$p < .001$

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Table 6. DID Model Estimates for Obesity (Logistic Regression)

	All		Gender			
			Male		Female	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	0.289*** (0.015)	1.336	0.286*** (0.022)	1.331	0.292*** (0.022)	1.339
Treatment-year dummy	0.048** (0.016)	1.049	0.052* (0.023)	1.053	0.042* (0.024)	1.043
State*Year interaction	–0.158*** (0.021)	0.854	–0.179*** (0.030)	0.836	–0.134*** (0.031)	0.875
Constant	–0.727*** (0.020)		–0.471*** (0.027)		–0.718*** (0.027)	
Wald χ^2	3293.94		795.40***		2200.82***	
Pseudo R^2	0.015		0.007		0.021	

	Race							
	White		Black		Hispanic		Other Race	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	0.363*** (0.020)	1.437	0.200*** (0.044)	1.222	0.249*** (0.041)	1.283	0.127** (0.044)	1.135
Treatment-year dummy	0.004 (0.021)	1.004	0.174** (0.047)	1.190	0.113* (0.047)	1.119	0.067 (0.042)	1.069
State*Year interaction	–0.137*** (0.029)	0.871	–0.290*** (0.055)	0.749	–0.178** (0.055)	0.837	–0.139* (0.060)	0.871
Constant	–1.219*** (0.021)		–0.706*** (0.042)		–1.637*** (0.057)		–0.911*** (0.042)	
Wald χ^2	1215.78***		76.47***		148.01***		132.90***	
Pseudo R^2	0.011		0.002		0.004		0.005	

Note: Control variables include gender (male), grade, race, and state of residence.

*$p < .05$ **$p < .01$ ***$p < .001$

Table 7 displays the effect of the state laws on rates of overweight. The result is similar to the rates of obesity. In 2009, youth in the treatment states were 33.6 percent ($p < .001$) more likely to be overweight than were youth in the comparison states. In 2011, youth were 4.9 percent ($p < .01$) more likely to be overweight than were all youth in 2009 overall, but youth in the treatment states were 14.6 percent ($p < .001$) less likely to be overweight than were youth in the comparison states. All subgroups in the treatment states saw reduction in excessive weight-gain problems because of the laws requiring physical activity.

Table 7. DID Model Estimates for Overweight (Logistic Regression)

	All		Gender			
			Male		Female	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	0.289*** (0.015)	1.336	0.286*** (0.022)	1.331	0.292*** (0.022)	1.339
Treatment-year dummy	0.048** (0.016)	1.049	0.052* (0.023)	1.053	0.042* (0.024)	1.043
State*Year interaction	–0.158*** (0.021)	0.854	–0.179*** (0.030)	0.836	–0.134*** (0.031)	0.875
Constant	–0.727*** (0.020)		–0.471*** (0.027)		–0.718*** (0.027)	
Wald χ^2	3293.94		795.40***		2200.82***	
Pseudo R^2	0.015		0.007		0.021	

	Race							
	White		Black		Hispanic		Other Race	
	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR	β (SE β)	OR
Treatment-state dummy	0.363*** (0.020)	1.437	0.200*** (0.044)	1.222	0.249*** (0.041)	1.283	0.127** (0.044)	1.135
Treatment-year dummy	0.004 (0.021)	1.004	0.174** (0.047)	1.190	0.113* (0.047)	1.119	0.067 (0.042)	1.069
State*Year interaction	–0.137*** (0.029)	0.871	–0.290*** (0.055)	0.749	–0.178** (0.055)	0.837	–0.139* (0.060)	0.871
Constant	–1.219*** (0.021)		–0.706*** (0.042)		–1.637*** (0.057)		–0.911*** (0.042)	
Wald χ^2	1215.78***		76.47***		148.01***		132.90***	
Pseudo R^2	0.011		0.002		0.004		0.005	

Note: Control variables include gender (male), grade, race, and state of residence.

*$p < .05$ **$p < .01$ ***$p < .001$

This study also investigated whether the state laws had continuously enhanced physical activity levels and reduced obesity and overweight rates among adolescents even after 2011. To answer this question, additional analyses were run using data from 2013, 2015, and 2017. Results are presented in Tables 8 and 9. Note that the coefficients of the treatment-state dummy should be the same because they indicate the difference between the treatment and comparison states in the base year, 2009. As seen in Table 8, the average number of days of physical activity among adolescents in the comparison states increased by 0.165 ($p < .001$) in 2011 and by 0.098 ($p < .001$) in 2013, then dropped back to the level of 2009. Youth in the treatment states were increasingly more engaged in physical activity than were youth in the comparison states, however, with 0.102 ($p < .001$) more days of physical activity in 2013, 0.139 ($p < .001$) more in 2015, and 0.156 ($p < .001$) more in 2017.

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Table 8. DID Model Estimates for Average Days of Physical Activity over Time

	Year			
	2011	2013	2015	2017
Treatment-state dummy	–0.233***	–0.233***	–0.233***	–0.233***
	(0.019)	(0.019)	(0.019)	(0.019)
Treatment-year dummy	0.165***	0.098***	–0.023	–0.019
	(0.020)	(0.019)	(0.018)	(0.018)
State*Year interaction	0.079**	0.102***	0.139***	0.156***
	(0.026)	(0.026)	(0.025)	(0.025)
Constant	3.269***	3.473***	3.496***	3.410***
	(0.025)	(0.065)	(0.065)	(0.068)
Number of observations	138,377	151,209	168,883	160,334
Adjusted R^2	0.056	0.059	0.056	0.056

Notes: Base year: 2009. Control variables include gender (male), grade, race, and state of residence.

*$p < .05$ **$p < .01$ ***$p < .001$

Youth in the treatment states were also 10.4 percent ($p < .001$), 14.3 percent ($p < .001$), and 12.2 percent ($p < .001$) more likely in 2013, 2015, and 2017, respectively, to have 60 minutes of daily physical activity than were youth in the comparison states, as seen in Table 9. Table 9 also shows that state laws encouraging physical activity contributed to restrain the resurging rate of obesity in adolescents. Surprisingly, the obesity rate among youth in the comparison states rose continuously. For example, youth in the comparison states were 44.0 percent ($p < .001$) and 37.2 percent ($p < .001$) more likely in 2015 and 2017, respectively, to be obese than were youth in the same states in 2009. Without the new laws, youth in the treatment states would have experienced more excessive weight-gain problems, but the laws significantly and substantially reduced the obesity rate for these youth. Youth in the treatment states were 19.4 percent ($p < .001$), 34.6 percent ($p < .001$), and 24.5 percent ($p < .001$) less likely in 2013, 2015, and 2017, respectively, to be obese than were their counterparts in the comparison states.

Table 9. DID Model Estimates for Compliance with Recommended Physical Activity and Obesity Rates over Time

	Compliance with Physical-Activity Recommendations				Obesity Rates			
	2011	2013	2015	2017	2011	2013	2015	2017
Treatment-state dummy	–0.141*** (0.019) OR: 0.869	–0.141*** (0.019) OR: 0.869	–0.141*** (0.019) OR: 0.869	–0.141*** (0.019) OR: 0.869	0.435*** (0.019) OR: 1.545	0.435*** (0.019) OR: 1.545	0.435*** (0.019) OR: 1.545	0.435*** (0.019) OR: 1.545
Treatment-year dummy	0.107*** (0.019) OR: 1.113	0.056** (0.018) OR: 1.058	–0.005 (0.018) OR: 0.996	–0.032 (0.018) OR: 0.969	0.037* (0.021) OR: 1.037	0.046* (0.020) OR: 1.047	0.336*** (0.019) OR: 1.440	0.317*** (0.193) OR: 1.372
State*Year interaction	0.052* (0.026) OR: 1.053	0.098*** (0.025) OR: 1.104	0.133*** (0.024) OR: 1.143	0.116*** (0.016) OR: 1.122	–0.204*** (0.026) OR: 0.816	–0.215*** (0.261) OR: 0.806	–0.425*** (0.024) OR: 0.654	–0.281*** (0.025) OR: 0.755
Constant	–1.652*** (0.025)	–1.666*** (0.025)	–1.624*** (0.024)	–1.604** (0.024)	–1.639*** (0.024)	–1.654*** (0.024)	–1.624*** (0.021)	–1.584*** (0.023)
Wald χ^2	5335.50	5493.32	5823.16	5441.99	3260.23	3258.62	3110.24	3279.56
Pseudo R^2	0.037	0.035	0.033	0.033	0.019	0.019	0.016	0.018

Notes: Base year: 2009. Control variables include gender (male), grade, race, and state of residence.

*$p < .05$ **$p < .01$ ***$p < .001$

DISCUSSION

The prevalence of obesity among adolescents has increased dramatically over the past four decades. Well-known adverse effects of obesity on physiological and psychological health, health-care expenditures, and indirect social costs such as school absenteeism and poor academic performance have motivated health professionals, policymakers, and researchers to come up with more-comprehensive action plans to halt or reverse the obesity epidemic. Considering that not many adolescents meet a recommended level of daily physical activity, attention focused on the provision of more opportunities for adolescents to engage in physical activity and to avoid sedentary behaviors at schools as a policy instrument (Story et al. 2006). Legislatures responded by enacting laws. Both federal laws, such as the Child Nutrition and WIC Reauthorization Act of 2004, and newly enacted state laws mandate that schools provide students with more physical exercise and health information.

This study investigated 347 enacted state laws pertaining to physical activity, especially physical-activity requirements in schools and the allocation of funds. Although the language in each state law was different, these laws were intended to provide resources and incentives for physical activity and to deter unhealthy and sedentary behaviors. Those provisions, in general, include establishment of advisory committees regulating physical activity, mandatory PE, and/or voluntary physical-activity programs, provision of resources for the programs, and strategic planning, among others.

As Sallis and Glanz (2009) suggested, constructing a physical-activity environment stimulates physical activity and consequently contributes to reducing obesity. Few studies have explored the effectiveness of the new legislation, however, especially at the state level. Using the DID method and analyzing YBRSS data from 2007 to 2017, this study

found that state laws induced adolescents to participate in more physical activity and consequently contributed to significantly reducing the prevalence of obesity. It is reassuring that state laws had some, albeit limited, effect in reducing obesity rates.

The results require legislatures to consider changes to these laws in order to address what they have previously overlooked, however. First, subgroup analyses revealed that the effect was concentrated on female and white adolescents, although all groups benefited from the laws in reducing obesity and weight problems. This finding is compatible with the findings of Gordon-Larsen and colleagues (2006), who explain that inequitably distributed physical-activity resources limit minorities' access to the facilities. Similarly, Zhu and Lee (2008) found that unsafe neighborhoods and poor street conditions limit the engagement of minority students in physical activities. It is unclear why the effect was concentrated in female adolescents. Considering that male adolescents already participated more in vigorous sports activities than did female adolescents, there may be a possibility that a sharp increase in physical activity was observed only among female adolescents in treatment states. Further investigation is recommended.

Second, it is worth noting that the average number of days of physical activity and the percentage of adolescents participating in the recommended level of physical activity increased even in the comparison states in 2011. This was the effect not of state laws but of adolescents' voluntary choices to be physically active, considering that numerous media and government reports started to warn of the risks and adverse effects of obesity, sedentary lifestyles, and unhealthy eating. Surprisingly, the subsequent sensitivity analysis revealed that since 2015, when national attention started to shift to new health concerns (opioid abuse, for example), physical-activity levels in comparison states fell back to 2009 levels. Rates of obesity and overweight have also been on a sharp rise since 2015; nevertheless, adolescents in the treatment states have continued to be more engaged in physical activity and have been less likely to be obese than have their counterparts in the comparison states. With that in mind, lawmakers should pay more attention to the recent sharp increase in obesity and should consider changing the laws with the aim to induce behavioral changes.

Third, few new state laws encouraging physical activity have been enacted since 2015. As mentioned earlier, previous studies warned that adolescents' physical activity levels have significantly declined due in part to changes in media time (Gordon-Larsen et al. 2000; Li et al. 2010; Lowry et al. 2005; Turner et al. 2015). It is expected that members of Generation Alpha will have ever more enticements for screen time and should be expected to continue with sedentary behaviors. Accordingly, lawmakers should invest resources in developing ways to merge old-fashioned physical environments with new digital environments. Interestingly, a new line of study provides evidence that social media reinforces physical activity (Shimoga, Erlyana, and Rebello 2019). Lawmakers should provide support for the creation of programs that lead adolescents to engage in physical activity more interactively, more responsively, and with more fun. At the same time, lawmakers should also invest in building infrastructure to overcome the digital divide and to enhance technological literacy.

Although this study contributes to the existing literature by using nationally represented cross-sectional data from the YBRSS, it is not free from limitations. First, like other survey methods, self-reported responses and inaccurate memory may hurt the internal

validity. Additionally, this study was able to use data from only 38 states. If a significant difference exists between the analytical samples and the missing data, the results could be biased. Second, this study could not control for individual dietary habits, which is one side of the energy-balance equation, in explaining obesity. This was partly because of survey questions being inconsistent over time and partly because of the mediating effect of dietary habits on the relationship between physical activity and obesity. Third, compared to randomized experimental studies, the DID method relies on the less strict assumption that unobserved differences between treatment and control groups are the same over time. If this assumption were not met, the estimated effect would be biased. A panel study that would cancel out individual unobservable heterogeneity should be developed for future study. Finally, because this study focused only on between-group comparison (i.e., treatment states vs. comparison states) over the years, this study could not account for within-group variation; thus, this study could not answer whether one law or provision was more effective than others. Further studies are needed to investigate the most effective way to enhance adolescents' physical activity.

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