Original Article
EPIDEMIOLOGY/GENETICS

Obesity

Deconstructing Race and Gender Differences in Adolescent Obesity: Oaxaca-Blinder Decomposition

Daniel R. Taber[1], Whitney R. Robinson[2], Sara N. Bleich[3], and Y. Claire Wang[4]

Objective: To analyze sources of racial and gender disparities in adolescent obesity prevalence in the United States using Oaxaca–Blinder decomposition.

Methods: Data were obtained from the National Youth Physical Activity and Nutrition Study, a 2010 nationally representative study of 9th-12th grade students. Obesity status was determined from objective height and weight data; weight-related behaviors and school, home, and environmental data were collected via questionnaire. Oaxaca–Blinder decomposition was used to independently analyze racial and gender obesity prevalence differences (PD), i.e., comparing Black girls to White girls, and Black girls to Black boys.

Results: Overall, measured characteristics accounted for 46.8% of the racial PD but only 11.9% of the gender PD. Racial PD was associated with Black girls having less fruit/vegetable access at home, obtaining lunch at school more often, and playing fewer sports than White girls. Gender PD was associated with differential associations between physical activity (PA) measures—including total activities in the past year and days of moderate to vigorous physical activity (MVPA) in the past week—and obesity.

Conclusions: School lunch and home food environmental variables accounted for racial disparities, but not gender disparities, in obesity prevalence. Gender differences in mechanisms between PA and obesity should be explored further.

Obesity (2016) **24**, 719–726. doi:10.1002/oby.21369

Introduction

Racial disparities in childhood obesity have been a persistent public health problem in the United States (U.S.) for decades (1). The prevalence of childhood obesity increased among all race–ethnic groups from 1980 to 2000; since then, it has been steady overall (2) but consistently higher among non-Hispanic Blacks than non-Hispanic Whites (3). Particularly among girls, racial disparities in adolescent obesity (age 12-19) have grown over time (4). By 2009-2010, adolescent obesity prevalence was nearly 10 percentage points higher among non-Hispanic Black girls (24.8%) than non-Hispanic White girls (14.7%) (5).

Studies have drawn different conclusions about the root causes of racial disparities in obesity. Measures of socioeconomic status (SES), for example, are often found to account for racial health disparities (6,7), yet some studies suggest that socioeconomic disparities in childhood obesity shrank over time while racial disparities persisted (8), and that effects of SES on obesity vary by race and gender (4,8). Various studies reported disparities in determinants of obesity in different contexts—schools (9), homes (10), and neighborhoods (11)—but studies rarely examine all contexts.

Understanding the determinants across contexts is crucial as policymakers implement initiatives to reduce obesity. Schools have been the primary target of policy changes, but state and federal initiatives (e.g., *Let's Move!*) have also targeted menu labels (12), food deserts (13), sweetened beverage taxes (14), and other environmental determinants of obesity outside of the school (15). Few studies have analyzed how these environmental changes affect disparities in obesity (16) even though a prominent goal of *Healthy People 2020* was to

[1] Department of Health Promotion and Behavioral Sciences, School of Public Health, University of Texas Health Science Center at Houston—Austin Regional Campus, Austin, Texas, USA. Correspondence: Daniel R. Taber (daniel.taber@uth.tmc.edu) [2] Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA [3] Department of Health Policy & Management, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, Maryland, USA [4] Department of Health Policy & Management, Mailman School of Public Health, Columbia University, New York City, New York, USA.

Funding agencies: Support for this research was provided by grant number 4R00HD073271-02 from the National Institute of Child Health and Human Development (PI: Daniel Taber). The views expressed herein are solely those of the authors and do not reflect the official views or positions of the National Institute of Child Health and Human Development or the National Institutes of Health.

Disclosure: The authors declare no conflict of interest.

Additional Supporting Information may be found in the online version of this article.

Received: 8 June 2015; **Accepted:** 21 September 2015; **Published online 3 February 2016. doi:10.1002/oby.21369**

eliminate health disparities (17). This research gap is troubling because improving overall population health can come at the expense of greater disparities (18). Closing disparities in obesity prevalence will likely require targeted efforts focused on social and environmental determinants of obesity that disproportionately affect disadvantaged populations (18).

Disentangling these determinants is further complicated because different predictors may contribute to disparities through different mechanisms. Commonly used epidemiological methods are not designed to account for differential associations. Many epidemiology studies are based on a counterfactual framework that focuses on differences in population averages (e.g., mean household income), implying that if Blacks and Whites had the same characteristics (e.g., equal income), then disparities would be reduced. Even in this counterfactual scenario, however, disparities may persist if the effects of income vary by race. Even if Blacks and Whites had equal income, disparities may persist if income influences obesity differently in White vs. Black communities due to unmeasured contextual factors.

The Oaxaca–Blinder decomposition method is a more nuanced econometric technique for studying sources of disparities. It distinguishes disparities attributable to population characteristics from disparities attributable to the association between population characteristics and the outcome of interest. It was applied to study gender wage discrimination in the 1970s (19,20), and has since been applied to study disparities in smoking (21), HIV/AIDS (22), and undernutrition (23). Few studies have applied Oaxaca–Blinder decomposition to study racial disparities in weight status. Sen applied it to study racial disparities in adult body mass index (BMI) in Mississippi and Alabama, and found that behavioral and socioeconomic factors accounted for only a small proportion of disparities (24). Powell et al., in contrast, found that adolescent, parental, and economic contextual measures accounted for the majority of racial/ethnic disparities in adolescent BMI (25). Neither study examined gender disparities by racial group.

The objective of this study was to apply Oaxaca–Blinder decomposition to explore both racial and gender disparities in obesity in a nationally representative sample of 9th-12th grade students. Oaxaca–Blinder decomposition is informative to policymakers because it quantifies the degree to which disparities could theoretically be reduced if group differences in determinants of obesity were eliminated. We analyzed sources of disparities from a wide range of student behaviors and environmental measures in different contexts, including contexts that were unexplored in previous Oaxaca–Blinder analyses (e.g., schools).

Methods

Data

Data in this study were drawn from the National Youth Physical Activity and Nutrition Study (NYPANS), conducted by the Centers for Disease Control and Prevention (CDC) in 2010 (26). NYPANS measured a wide range of diet, physical activity (PA), and sedentary behaviors; environmental determinants of these behaviors; and objectively-measured weight status in a nationally representative sample of 9th-12th grade students. The design of NYPANS is modeled after the national Youth Risk Behavior Surveillance System (YRBSS), which has been conducted by the CDC in odd-numbered years since 1991. Students were sampled using a three-stage cluster sample design; school and student participation was voluntary, and local permission procedures were followed. In NYPANS, the school response rate was 82%, the student response rate was 88%, and the overall response rate was 73%. Overall, 11,458 students participated in NYPANS, but our study focused only on non-Hispanic White and non-Hispanic Black students (hereafter referred to as "White" and "Black," respectively). We chose to expand the analysis of Blacks by analyzing both racial and gender differences, rather than expand the study to other racial/ethnic groups (e.g., Hispanics).

Variables

The dependent variable of interest was obesity status, determined from objective height and weight data measured by CDC staff. Students were categorized as having obesity if their BMI was greater than or equal to the age- and sex-specific 95th percentiles of the 2000 CDC growth charts (27). Independent variables included 23 measures of individual behaviors and students' school, home, and neighborhood environments. Variables were selected for analysis if racial/ethnic disparities in the variables have been reported elsewhere (9-11), or if they are frequently targeted by policy initiatives (e.g., school vending machines) (9). The independent variables were collected via written questionnaire completed by students in class.

Dietary behaviors included consumption of fruits, vegetables, fast food, soda, diet soda, other sugar-sweetened beverages (e.g., sports drinks), and water. With the exception of fruits and vegetables, each dietary behavior was measured in servings per day within the past 7 days. Fruits and vegetables were measured in cups per day and, for this analysis, summed to create one measure of total cups per day. PA and sedentary behaviors included days of moderate to vigorous physical activity (MVPA, defined as "physical activity that increased your heart rate and made you breathe hard some of the time") within the past 7 days; days of physical education (PE) class in an average week; number of sports teams on which they played in the past year; number of total activities, from a list of 34, in which they participated within the past year; number of days walking to or from school in an average week; and hours per day of watching television (TV), using a computer, and watching DVD or videos in the past 7 days. We summed TV, computer, and DVD use to create a single measure of "screen time."

Measures of the school environment included: 1) access to vending machines that sold sweetened beverages, 2) access to vending machines that sold snacks, 3) access to vending machines that sold fruits/vegetables, and 4) the source of lunch on a school day. For each vending machine question, students had the option of reporting "yes," "no," or "I don't know"; students who reported "I don't know" were treated as a separate category. For school lunch source, student responses were "home," "complete school lunch," "other source at school," or "away from school."

Measures of the home/neighborhood environment included: 1) Frequency of access to fruits/vegetables at home; 2) frequency of access to chips, cookies, or cakes, which we refer to as "unhealthy snacks," at home; 3) whether students had a TV in their bedroom; 3) perceived safety of their neighborhood for PA; 4) perceived quality of local PA facilities; 5) perceived access to PA equipment. Aside from TV access, which was dichotomous, each of these

TABLE 1 Unadjusted measures of weight status, weight-related behaviors, and the school, home, and neighborhood environment, overall and by race/gender[a]

	Overall	Black girls	Black boys	White girls	White boys
N	5153	866	799	1712	1776
Weight status					
Overweight (%)	17.2	16.8	19.5	16.7	17.4
Obesity (%)	18.5	29.2	18.7	18.1	16.7
Dietary consumption (mean)					
Fruits/vegetables—cups/day	2.2	1.8	2.0	2.4	2.2
Fast food—days/week	1.9	2.4	2.5	1.6	1.8
Regular soda—servings/week	5.3	7.5	6.8	3.9	5.9
Diet soda—servings/week	1.5	1.4	1.6	1.6	1.4
Other SSBs—servings/week	11.4	13.0	17.0	9.5	11.8
100% fruit juice—servings/week	5.7	7.4	8.5	4.8	5.8
Water—servings/week	15.6	13.9	15.9	15.7	15.9
PA/sedentary behaviors (mean)					
MVPA—days/week	4.3	3.5	4.5	3.9	4.9
Team sports in the past year	1.2	0.8	1.4	1.1	1.3
Activities in the past year	10.0	6.7	7.9	10.5	10.7
PE classes—days/week	2.3	2.1	2.5	2.0	2.5
Active school transportation—days/week	3.2	3.8	3.9	2.9	3.2
Screen time—hours/day	4.6	7.3	6.2	3.9	4.5
School food environment					
Access to vending machines—SSBs (%)	82.1	77.6	79.9	83.9	81.9
Access to vending machines—snacks (%)	68.1	60.3	67.6	68.0	70.0
Access to vending machines—fruits/vegetables (%)	9.2	7.4	9.5	6.6	12.3
Source of lunch on school day (%)					
Brought from home	23.3	11.8	10.6	30.7	21.1
Complete school lunch	46.3	48.7	55.2	38.4	51.7
Other source at school	16.8	22.3	19.6	17.8	14.0
None/elsewhere	13.6	17.2	14.6	13.1	13.2
Home/neighborhood environment					
Fruit/vegetable access (mean, range 1-5)	4.0	3.5	3.5	4.1	4.0
Unhealthy snack access (mean, range 1-5)	3.6	3.6	3.5	3.6	3.5
TV in bedroom (%)	69.1	7.1	7.3	24.5	30.2
Access to PA facilities (mean, range 1-5)	2.3	2.3	2.2	2.3	2.2
Quality of PA equipment (mean, range 1-5)	2.0	2.7	2.2	2.1	1.8
Perceived safety for PA (mean, range 1-5)	1.9	2.4	2.1	2.0	1.6

[a]Non-Hispanic only.
SSB = sugar-sweetened beverage; MVPA = moderate to vigorous physical activity; PE = physical education; PA = physical activity.

variables was measured on a 5-point scale, with higher scores indicating a greater degree of access, safety, or quality.

Statistical analysis

All analyses were weighted to account for the complex sample design in NYPANS. In preliminary analyses, we found that obesity prevalence in the total NYPANS sample was approximately equal in Black boys (17.4%), White boys (15.9%), and White girls (18.4%), but higher in Black girls (29.2%, $P < 0.001$). Therefore, we studied both racial differences in obesity among girls (i.e., Black girls versus White girls) and gender differences in obesity among Blacks (i.e., Black girls versus Black boys).

A brief description of Oaxaca–Blinder decomposition is presented here; for a more thorough description, we recommend papers by Sen (24) and Powell et al. (25). The basic concept of Oaxaca–Blinder decomposition is to divide between-group differences in the dependent variable into two components: 1) differences associated with population characteristics (e.g., mean soda consumption), commonly referred to as the “explained” or “endowment” portion, and 2) disparities associated with differential response to characteristics, commonly referred to as the “unexplained” or “coefficient” portion. The latter essentially represents the magnitude of disparities that would theoretically remain if the two groups had identical means of variables included in the model.

TABLE 2 Proportion of racial and gender differences in adolescent obesity prevalence attributable to weight-related behaviors, school environmental measures, and home/neighborhood environmental measures

	Black girls vs. White girls				Black girls vs. Black boys			
	Difference	Model 1	Model 2	Model 3	Difference	Model 1	Model 2	Model 3
Difference in obesity prevalence	11.2				10.5			
Proportion "explained"[a]								
Weight-related behaviors		39.1%	23.5%	21.4%		32.4%	30.1%	25.6%
School environment		–	16.5%	15.3%		–	−4.1%	−3.6%
Home/neighborhood environment		–	–	10.6%		–	–	−10.1%
Total		39.1%	40.0%	46.8%		32.4%	26.0%	11.9%

[a]Proportion associated with group differences in mean levels of weight-related behaviors, school environmental measures, and home/neighborhood environmental measures.

This method is commonly used to analyze differences in continuous dependent variables, but it can be applied to analyze absolute differences in a binary variable such as obesity status (28). We did this using the "oaxaca" command and "logit" option in Stata, Version 13. The "pooled" option was used to estimate coefficients for the explained portion of the model, using a pooled regression model; this accounts for the "index number problem" in which results from the Oaxaca–Blinder model can depend on which group is the referent group. We explored using an alternative method developed by Powers et al. (29) to overcome the "indicator variable problem," in which results for independent variables depend on the referent group, but found that results were substantively similar.

Our modeling strategies were adapted from Powell et al., who modeled three categories of variables—individual/household characteristics, parental SES, and economic contextual factors—sequentially (25). Similarly, we sequentially modeled three categories of independent variables from NYPANS—student behaviors, school environment, and home/neighborhood environment. In our study, students who were missing data for any independent variable were excluded from all models to ensure that each model represented the same sample. The final sample for the Oaxaca–Blinder analysis included 866 Black girls, 799 Black boys, and 1712 White girls. Overall, 14.8% of participants were excluded due to missing data. Obesity prevalence was approximately equal in our study sample, compared to the full NYPANS sample, in every race/gender group, but Blacks were more likely to be missing data for most measures ($P < 0.05$) except PA/sedentary behaviors.

We subsequently estimated associations between independent variables and obesity status in each race/gender subgroup, using a logistic regression model and "margin" command to estimate the average difference in obesity prevalence associated with each variable.

Results

Table 1 presents unadjusted descriptive statistics for obesity status and each measure in the analysis, overall, and by race and gender. Overweight prevalence was approximately equal across all four race/gender groups, and as discussed earlier, obesity prevalence was higher only among Black girls. Regardless of gender, Blacks tended to report higher dietary consumption than Whites for every measure except fruits/vegetables, diet soda, and water. Boys tended to report more days of MVPA, sports, and days of PE, regardless of race, but Black boys also reported more screen time. In the school food environment, vending machine access was generally equal, but White girls were more likely to bring lunch from home and less likely to obtain a complete school lunch. In the home/neighborhood environment, Blacks reported less fruit/vegetable access but equal unhealthy snack access at home. They also reported higher quality of PA facilities, higher perceived safety for PA, and were more likely to report having a TV in their bedroom.

The "explained" portions of the Oaxaca–Blinder models are presented in Table 2. Percentages represent the proportion of obesity prevalence differences that are associated with group characteristics,

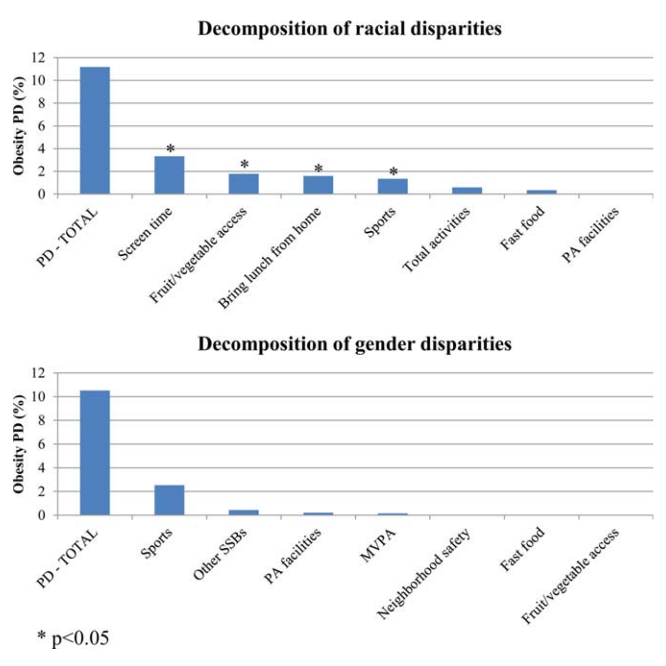

Figure 1 Oaxaca-Blinder decomposition of racial and gender prevalence differences (PD) in adolescent obesity. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

TABLE 3 Adjusted associations between behavioral/environmental measures and the probability of having obesity, by race/ethnicity and gender

	Black girls		Black boys		White girls	
	AME[b]	95% CI	AME[b]	95% CI	AME[b]	95% CI
Dietary consumption						
Fruits/vegetables—cups/day	2.5	−0.4, 5.4	1.0	−0.8, 2.8	2.2[c]	0.8, 3.5
Fast food—days/week	−1.4	−4.0, 1.1	−0.7	−2.7, 1.3	0.7	−0.9, 2.3
Regular soda—servings/week	−0.2	−0.6, 0.3	0.4	−0.1, 0.8	−0.3	−0.8, 0.1
Diet soda—servings/week	1.2[c]	0.6, 1.7	0.1	−0.6, 0.7	0.3	−0.2, 0.8
Other SSBs—servings/week	0.1	−0.2, 0.4	−0.3	−0.5, 0.0	−0.1	−0.3, 0.1
100% fruit juice—servings/week	−0.1	−0.6, 0.3	−0.2	−0.7, 0.3	0.0	−0.3, 0.4
Water—servings/week	0.2	−0.2, 0.6	0.0	−0.2, 0.2	0.2	−0.6, 0.5
PA/sedentary behaviors						
MVPA—days/week	1.8	−0.3, 3.8	−1.9[c]	−3.9, 0.0	−0.4	−2.0, 1.2
Sports in the past year	−9.3[c]	−13.2, −5.4	−1.9	−4.5, 0.7	−2.4	−5.3, 0.4
Activities in the past year	0.7	−0.1, 1.5	−0.8[c]	−1.5, −0.1	−0.2	−0.9, 0.4
PE classes—days/week	−2.1[c]	−4.2, −0.1	−0.9	−2.6, 0.7	−0.9	−1.8, 0.1
Active transportation—days/week	1.0	−0.2, 2.2	0.7	−0.3, 1.7	−0.3	−1.5, 0.9
Screen time—hours/day	−0.6	−1.6, 0.3	−0.7	−1.7, 0.3	1.4[c]	0.8, 2.0
School food environment						
Vending machines—SSBs (%)	2.0	−8.6, 12.6	5.1	−2.4, 12.6	4.2	−5.4, 13.8
Vending machines—snacks (%)	1.1	−6.8, 8.9	−6.1	−14.6, 2.4	−0.5	−6.0, 5.1
Vending machines—fruits/vegetables	0.0	−11.1, 11.1	6.2	−4.2, 16.5	−2.6	−10.7, 5.6
Source of lunch on school day						
Home	-	-	-	-	-	-
Complete school lunch	8.3	−6.4, 23.1	0.6	−12.3, 13.5	13.1[c]	7.3, 18.9
Other source at school	0.0	−17.0, 16.9	−3.1	−18.3, 12.2	2.4	−6.0, 10.8
None/elsewhere	−7.2	−25.4, 11.0	3.4	−9.9, 16.7	4.7	−2.8, 12.1
Home/neighborhood environment						
Access to fruits/vegetables (range: 1-5)	−1.1	−4.3, 2.1	1.9	−0.4, 4.3	−3.0[c]	−5.2, −0.6
Access to unhealthy snacks (range: 1-5)	−1.4	−5.8, 3.1	−2.4	−5.0, 0.3	−1.5[c]	−2.9, −0.1
TV in bedroom (yes/no)	7.4	−3.2, 18.0	8.9	−1.3, 19.1	−2.8	−8.7, 3.1
Quality of PA equipment (range: 1-5)	−0.5	−3.5, 2.6	−2.6[c]	−4.8, −0.3	−0.5	−2.6, 1.6
Access to PA facilities (range: 1-5)	1.0	−1.5, 3.6	3.6[c]	1.3, 5.9	1.3	−0.3, 2.8
Perceived safety for PA (range: 1-5)	−1.5	−4.0, 0.9	0.5	−2.1, 3.2	1.5	−0.4, 3.5

[a]AME=average marginal effect—i.e., average difference in the prevalence of obesity associated with the behavioral/environmental variable.
[b]$P < 0.05$.
SSB = sugar-sweetened beverage; MVPA = moderate to vigorous physical activity; PE = physical education; PA = physical activity.

i.e., the amount that would be eliminated if associations were causal and the comparison groups had the same mean. Behaviors, school environments, and home/neighborhood environments collectively accounted for 46.8% of racial differences among girls (Model 3) but only 11.9% of gender differences in obesity prevalence among Blacks. Neither school nor home/neighborhood environment, in particular, accounted for gender differences among Blacks.

Though the proportions in Table 2 were relatively large for racial disparities, Figure 1 illustrates how these results were driven by a small number of measures. Figure 1 displays the prevalence differences associated with specific behavioral and environmental characteristics. (The figure includes selected variables and is designed primarily for illustrative purposes; results for all variables can be found in the Supporting Information Table S1.) Racial differences were associated primarily with Black girls reporting more screen time (30.1% of prevalence difference); less fruit/vegetable access at home (16.2%); greater probability of obtaining a complete school lunch, relative to lunch from home (14.5%); and less sports participation (12.3%). Sports participation accounted for virtually all of the explained portions of gender differences, though it was only statistically significant in Models 1 and 2. No environmental variable was associated with gender differences in obesity prevalence among Blacks.

MVPA and total activities were statistically significant in the unexplained portion of the gender differences model ($P < 0.05$). This suggests that gender differences were partially attributable to the fact that MVPA and total activities had differential associations

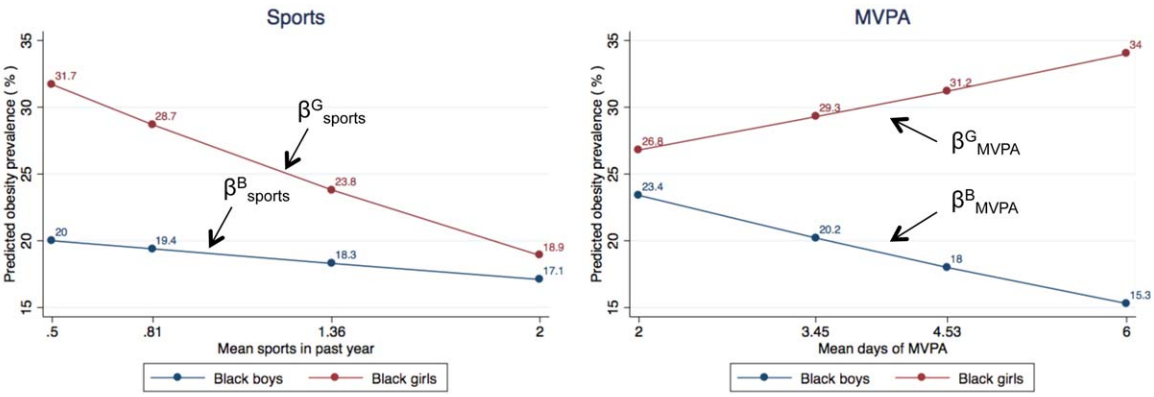

Figure 2 Predicted prevalence of obesity among Blacks by gender, sports participation, and MVPA. β^{G}_{sports} and β^{G}_{MVPA} = Difference in obesity prevalence associated with sports participation and MVPA among Black girls, adjusted for other weight-related behaviors and school, home, and neighborhood environmental measures. β^{B}_{sports} and β^{B}_{MVPA} = Difference in obesity prevalence associated with sports participation among Black boys, adjusted for other weight-related behaviors and school, home, and neighborhood environmental measures. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

with obesity in Black boys versus Black girls. This is reflected in Table 3, as MVPA was inversely associated with obesity prevalence in Black boys (average marginal effect (AME) = −1.9, 95% CI: −3.9, 0.0) but not Black girls (AME = 1.8, 95% CI: −0.3, 3.8). The same was true for total activities (boys: AME = −0.8, 95% CI: −1.5, −0.1; girls: AME = 0.7, 95% CI: −0.1, 1.5). The unexplained portion of gender differences was also associated with "other" sugar-sweetened beverages (e.g., fruit punches), but the effect size was considerably smaller.

The implications of the coefficient effect of MVPA are illustrated in Figure 2, which presents the adjusted prevalence of obesity by levels of sports and MVPA. Lines represent the associations between sports/MVPA and obesity for Black boys and girls (e.g., β^{G}_{sports}), based on stratified models. Each line is marked at the mean levels of the independent variable for boys and girls. The left half suggests that if Black girls participated in as many sports as Black boys (mean = 1.4 versus 0.8), then gender disparities in obesity would be reduced, whereas the right half suggests that if Black girls averaged as much MVPA as boys (mean = 4.5 versus 3.5), then gender disparities would grow.

Screen time had a negative, statistically significant coefficient effect in the decomposition of racial differences among girls. This implies that disparities would be greater if screen time had the same association with obesity in Black girls and White girls. This is reflected by screen time having a positive association with obesity prevalence among White girls (AME = 1.4, 95% CI: 0.8, 2.0) but an inverse, non-significant association with obesity prevalence among Black girls (AME = −0.6, 95% CI: −1.6, 0.3).

Sensitivity analyses were conducted to explore whether sports, MVPA, and total activities should be modeled separately due to their relatively high correlation (r = 0.25-0.40) and the possibility that MVPA mediates the effect of sports or activities. We modeled one variable at a time and found results were not substantively different than modeling all three variables together (results are not presented but available upon request). The sensitivity models tended to produce larger parameter estimates, and thus we conservatively chose to include all three measures in our final results.

Discussion

Obesity prevalence is at an alarmingly high level in the general U.S. adolescent population, but particularly among Black girls. This study provides new insight into sources of obesity disparities by utilizing an econometric technique that has been applied to study disparities in other social and economic issues. This study was unique in using both White girls and Black boys as references. Some experts have argued that White and Black populations are incomparable due to structural confounding (30), underscoring the value of using Black boys as an additional reference. Though this study was cross-sectional, precluding any conclusions about causality, the contrast in results for racial and gender analyses raises questions about how causes and mechanisms of racial and gender disparities differ.

Racial differences were associated with group characteristics in select behavioral and environmental variables, but the same variables generally did not account for gender differences. Sports participation was the only measure that "explained" a large proportion of both racial and gender differences, though sports participation was only statistically significant in Models 1 and 2 of the gender decomposition. Environmental measures that were associated with racial differences in obesity prevalence (e.g., school lunch source, home fruit/vegetable access) were not associated with gender differences. The fact that environmental differences did not account for gender disparities is not a surprise given that, on average, Black boys and girls were exposed to the same environments. Yet it raises the question of why any effect of environmental measures on racial disparities, if causal, did not apply to the difference between Black boys and girls?

Gender disparities among Blacks were more attributable to differential associations between activity-related measures and obesity, as opposed to activity levels alone. Figure 2 suggested that gender disparities in obesity among Blacks would not be reduced even if Black girls were as active as Black boys. This distinction illustrates the value of using Oaxaca–Blinder decomposition as a complement to other statistical techniques. These differential associations could be explained by a variety of factors. Duration or intensity of activity among girls may not be as high compared to boys, even when girls report being physically active. Alternatively, the physiological effect of PA on weight status could differ by gender. Sports had a strong, inverse association with obesity among Black girls, but we found that controlling for MVPA did not reduce this association (results not shown), suggesting that any beneficial effect of team sports may come from factors other than activity (e.g., social support). We can only speculate about the mechanisms, but this finding underscores the need to study both how to increase activity-related behaviors among girls and explore the causal mechanisms between MVPA and obesity. Prior research calls for developing and refining culturally and contextually relevant approaches to effectively reduce obesity among Black Americans (31). Our findings suggest it will also be important to examine alternative gender approaches among Black youth.

The analysis of racial disparities illustrates the need for comprehensive public health initiatives that target different sectors, ideally in concert. Policies to improve school lunch standards are one example, as racial disparities in obesity among girls were associated with Black girls obtaining school lunches more than White girls. It is important to point out that NYPANS was conducted in 2010, shortly before federal nutrition standards for the National School Lunch Program (NSLP) were updated. Prior to updates, studies reported that students who obtained more lunches at school tended to gain more weight over time (32), particularly among girls (33). The association between obtaining a school lunch and obesity is not necessarily causal (34,35), as the NSLP is inherently designed to benefit students from lower-income households. Nonetheless, there is no evidence that past NSLP nutrition standards were successful in reducing disparities, whereas one study suggested that improved school meal nutrition standards may reduce socioeconomic disparities in obesity (36). Early evidence also suggested that updated NSLP standards improved students' diet (37,38), and therefore if our study were repeated today, school meals may no longer account for disparities. Additional research is needed to explore this issue further.

Racial disparities were also associated with Black girls having less access to fruits/vegetables at home, which underscores the need to address economic, environmental, or other barriers to healthy food access. Initiatives to eliminate food deserts have been promoted to reduce disparities (13), but studies have found little evidence that new supermarkets changed residents' diet (35,39). This lack of effect may be due to the higher cost of fruits and vegetables, i.e., purchasing behavior may be a function of price more than proximity (40). Furthermore, fruit/vegetable access could be a proxy for socioeconomic factors such as household income that may account for disparities through additional mechanisms. Further research is needed to understand why fruit/vegetable access accounted for a relatively large proportion of racial disparities in obesity among girls.

The inability to ascribe causality to fruit/vegetable access or any independent variable is an important limitation to highlight. Although Oaxaca–Blinder decomposition explores potential mechanisms in more detail than a conventional cross-sectional analysis (e.g., ordinary least squares), the study design remained cross-sectional. An additional limitation is the reliance on self-reported data that are vulnerable to self-report bias. Furthermore, the survey went into exceptional detail about different behaviors but did not include socioeconomic and contextual variables that may contribute to disparities in obesity (e.g., household income.) Finally, the proportion of missing data varied by race for most measures in our analyses. The degree of missing data varied by race for dietary behaviors, in particular, which may have biased analyses of dietary behaviors.

Conclusion

Racial disparities in adolescent obesity continue to persist in the U.S. as obesity remains particularly high among Black girls. The results of this Oaxaca–Blinder study suggest that school lunches and healthy food access at home may be effective policy targets for the purpose of reducing racial disparities in obesity among girls; additional intervention research is needed to confirm this. Future studies should also aim to understand why changing other population characteristics, such as PA, may not be as effective as hoped. O

References

1. Wang Y, Beydoun MA. The obesity epidemic in the United States—gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiol Rev* 2007;29:6-28.
2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. *JAMA* 2014;311:806-814.
3. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA* 2002;288:1728-1732.
4. Wang Y. Disparities in pediatric obesity in the United States. *Adv Nutr* 2011;2:23-31.
5. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *JAMA* 2012;307: 483-490.
6. Zilanawala A, Davis-Kean P, Nazroo J, Sacker A, Simonton S, Kelly Y. Race/ethnic disparities in early childhood BMI, obesity and overweight in the United Kingdom and United States. *Int J Obes (Lond)* 2015;39:520-529.
7. Rossen LM, Talih M. Social determinants of disparities in weight among US children and adolescents. *Ann Epidemiol* 2014;24:705-713 e702.
8. Wang Y, Zhang Q. Are American children and adolescents of low socioeconomic status at increased risk of obesity? Changes in the association between overweight and family income between 1971 and 2002. *Am J Clin Nutr* 2006;84:707-716.
9. Johnston LD, O'Malley PM, Terry-McElrath YM, Colabianchi N. School Policies and Practices to Improve Health and Prevent Obesity: National Secondary School Survey Results: School Years 2006-07 through 2011-12. Ann Arbor, MI: Bridging the Gap Program, Survey Research Center, Institute for Social Research; 2014.
10. Ranjit N, Evans AE, Springer AE, Hoelscher DM, Kelder SH. Racial and ethnic differences in the home food environment explain disparities in dietary practices of middle school children in Texas. *J Nutr Educ Behav* 2015;47:53-60.
11. Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. *Epidemiol Rev* 2009;31:7-20.
12. Swartz JJ, Braxton D, Viera AJ. Calorie menu labeling on quick-service restaurant menus: an updated systematic review of the literature. *Int J Behav Nutr Phys Act* 2011;8:135.
13. Holzman DC. White House proposes healthy food financing initiative. *Environ Health Perspect* 2010;118:A156.
14. Powell LM, Chriqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes. *Obes Rev* 2013; 14:110-128.
15. Brennan LK, Brownson RC, Orleans CT. Childhood obesity policy research and practice: evidence for policy and environmental strategies. *Am J Prev Med* 2014;46: e1-e16.
16. Kumanyika SK, Swank M, Stachecki J, Whitt-Glover MC, Brennan LK. Examining the evidence for policy and environmental strategies to prevent childhood obesity in

black communities: new directions and next steps. *Obes Rev* 2014;15 (Suppl 4): 177-203.

17. U.S. Department of Health and Human Services. *Healthy People 2020*. Washington D.C.: US Government Printing Office; 2010.
18. Rosas LG, Stafford RS. Practical research strategies for reducing social and racial/ethnic disparities in obesity. *Int J Obes (Lond)* 2012;2012:s16-s22.
19. Blinder AS. Wage discrimination: reduced form and structural estimates. *J Hum Resour* 1973;8:436-455.
20. Oaxaca R. Male–female wage differentials in urban labor markets. *Int Econ Rev* 1973;14:693-709.
21. Chung W, Lim S, Lee S. Factors influencing gender differences in smoking and their separate contributions: evidence from South Korea. *Soc Sci Med* 2010;70: 1966-1973.
22. Sia D, Onadja Y, Nandi A, Foro A, Brewer T. What lies behind gender inequalities in HIV/AIDS in sub-Saharan African countries: evidence from Kenya, Lesotho and Tanzania. *Health Policy Plan* 2014;29:938-949.
23. Kumar A, Singh A. Decomposing the gap in childhood undernutrition between poor and non-poor in urban India, 2005-06. *PLoS One* 2013;8:e64972.
24. Sen B. Using the Oaxaca-Blinder decomposition as an empirical tool to analyze racial disparities in obesity. *Obesity (Silver Spring)* 2014;22:1750-1755.
25. Powell LM, Wada R, Krauss RC, Wang Y. Ethnic disparities in adolescent body mass index in the United States: the role of parental socioeconomic status and economic contextual factors. *Soc Sci Med* 2012;75:469-476.
26. Centers for Disease Control and Prevention. National Youth Physical Activity and Nutrition Study. Available at: http://www.cdc.gov/healthyyouth/yrbs/nypans.htm, accessed on December 16, 2015.
27. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. *Adv Data* 2000;314:1-27.
28. Fortin N, Lemieux T, Firpo S. Decomposition methods in economics. In: Ashenfelter O, Card D, eds. Handbook of Labor Economics, Vol.4. Amsterdam: Elsevier, B.V.; 2011; pp 1-102.
29. Powers DA, Yoshioka H, Yun M-S. mvdcmp: Multivariate decomposition for nonlinear response models. *Stata J* 2011;11:556-576.
30. Messer LC, Oakes JM, Mason S. Effects of socioeconomic and racial residential segregation on preterm birth: a cautionary tale of structural confounding. *Am J Epidemiol* 2010;171:664-673.
31. Kumanyika SK, Whitt-Glover MC, Haire-Joshu D. What works for obesity prevention and treatment in black Americans? Research directions. *Obes Rev* 2014; 15:204-212.
32. Miller DP. Associations between the home and school environments and child body mass index. *Soc Sci Med* 2011;72:677-684.
33. Hernandez DC, Francis LA, Doyle EA. National School Lunch Program participation and sex differences in body mass index trajectories of children from low-income families. *Arch Pediatr Adolesc Med* 2011;165:346-353.
34. Hofferth SL, Curtin S. Poverty, food programs, and childhood obesity. *J Policy Anal Manage* 2005;24:703-726.
35. Mirtcheva DM, Powell LM. National school lunch program participation and child body weight. *East Econ J* 2013;39:328-345.
36. Taber DR, Chriqui JF, Powell L, Chaloupka FJ. Association between state laws governing school meal nutrition content and student weight status: implications for new USDA school meal standards. *JAMA Pediatr* 2013;167:513-519.
37. Cohen JF, Richardson S, Parker E, Catalano PJ, Rimm EB. Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *Am J Prev Med* 2014;46:388-394.
38. Schwartz MB, Henderson KE, Read M, Danna N, Ickovics JR. New school meal regulations increase fruit consumption and do not increase total plate waste. *Child Obes* 2015;11:242-247.
39. Gundersen C, Kreider B, Pepper J. The impact of the National School Lunch Program on child health: a nonparametric bounds analysis. *J Econometrics* 2012;26: 79-91.
40. Drewnowski A, Aggarwal A, Hurvitz PM, Monsivais P, Moudon AV. Obesity and supermarket access: proximity or price? *Am J Public Health* 2012;102:e74-e80.