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ORIGINAL ARTICLE

Reduced Physical Activity Levels Associated with Obesity in Rural Hispanic Adolescent Females

Ruben Rodriguez,[1] Simón E. Weffer, PhD, MA, BA,[2] Jessica Romo BA, BS,[1]
April Aleman, RN, CSN, MS,[3,4] and Rudy M. Ortiz, PhD, MS, BA[1]

Abstract

Background: The associations among physical activity (PA), screen behaviors (SB), and body mass in Hispanic adolescents in rural communities are not well defined.

Methods: Surveys were used to collect self-reported data on time spent in PA and SB along with direct measurements of BMI and waist circumference from non-Hispanic white (312 males, 301 females) and Hispanic (671 males, 610 females) adolescents (13–17 years old).

Results: Regardless of ethnicity, females participated in less PA (in [PA_i] or outside [PA_o] of school) than males. Obese Hispanic males and females participated 20% and 31%, respectively, less in PA in school than their obese non-Hispanic white counterparts, and 17% and 37%, respectively, less in PA outside of school. Furthermore, obese Hispanic females participated 28% less in PA outside of school than normal-weight Hispanic females, suggesting that reduced PA levels, especially outside of school, may contribute to the development of obesity in this group. Males and females were over two-fold more likely to be obese when they participated in PA_o for <1 hr/day, which further suggests the importance of PA_o for the odds of developing obesity, and supports the national PA guidelines for this age group.

Conclusions: The prevalence of overweight and obesity in Hispanics, especially females, is closely associated with reduced PA in and outside of school. The time spent on SB had no significant impact on the prevalence of overweight or obesity in non-Hispanics whites and Hispanics, suggesting that PA levels in this population may have a greater impact on body mass than SB; however, the causal relationships in this population warrant further investigation.

Introduction

The prevalence of overweight and obesity among US adolescents has been increasing for the past two decades,[1,2] and our recent data indicate that this prevalence is greater in rural populations.[3] Rural populations may be at an increased risk for overweight and obesity as a result of a clustering of risk factors that occur more frequently in rural than urban populations, such as lower socioeconomic status, poor dietary habits, and limited recreational facilities and opportunity for physical activity (PA).[4] For these reasons, the increase in the prevalence of overweight and obesity in rural communities could be partly explained by decreased levels of PA and increased levels of sedentary behaviors.[5–7] Moreover, patterns of activity and inactivity can differ by ethnicity, with minority groups engaging in less PA and more inactivity than their non-Hispanic white counterparts,[5,8,9] suggesting that inactivity is an important and modifiable determinant of overweight and obesity status. Inactivity, in particular TV viewing, has been associated with obesity in children, adolescents, and adults.[5,6,10–13] Although variations in activity levels can be partially attributed to complex interactions among socioeconomic, environmental, and cultural factors,[6] the contribution of activity levels (either active or passive) to body mass in Hispanic adolescents in a rural community has not been examined.

Although Hispanics generally engage in less PA,[5] data associating activity level with body mass in rural Hispanics adolescents are lacking. Therefore, the purpose of this study was to describe the differences in activity and inactivity levels between non-Hispanic white and Hispanic adolescents in a predominately minority populated, rural area. A secondary aim of this study was to describe gender differences in these respects between non-His-

[1]School of Natural Sciences, and [2]School of Social Sciences, University of California, Merced, CA.
[3]Health Services, Merced Union High School District, CA.
[4]Present address: Department of Nursing, California State University, Stanislaus, Turlock, CA.

panic white and Hispanic adolescents. We addressed the hypothesis that the prevalence of overweight and obesity in Hispanic adolescents in a rural population is associated with reduced levels of PA as opposed to increased levels of screen behaviors (SB).

Methods

This study protocol was reviewed and approved by the University of California, Merced's Institutional Review Board (IRB #UCM-183). Details of the study subjects and protocols have been published elsewhere,[3] but are included here briefly for completeness.

Subjects

The study population consisted of 613 non-Hispanic white (312 males, 301 females) and 1281 Hispanic (671 males, 610 females) adolescents (13–17 years). Merced Union High School District (MUHSD) is comprised of five high schools with a total enrollment of approximately 10,000 students. Students in Merced Union High School District are predominately Hispanic/Latino (54%), followed by non-Hispanic white (24%), Asian/Hmong (15%), African American (5%), and other (2%). This study population is representative of Merced County, which has a population of predominately Hispanic/Latino residents (53%), followed by non-Hispanic white (35%), Asian/Hmong (7%), African American (4%), and other (1%). The Hispanic population is predominately Mexican American (94%). Analyses focused only on comparisons between non-Hispanic whites and Hispanics because of the lack of sufficient recruitment and enrollment of adolescents from other groups, which prohibited our ability to make any meaningful comparisons. Merced County is characterized by: (1) An unemployment rate of 22%, (2) 17% of families and 22% of the population below the poverty line, (3) 20% of the population working in agriculture, (4) only 12.5% having a bachelor's degree or higher, (5) 32% of the population being under the age of 18, and (6) a median income for the county of $44,338.[14] Because of the lack of data on obesity prevalence and PA levels in rural Hispanics (predominately Mexican American), the present study provided an ideal, opportunistic sampling to better ascertain the impact of PA levels and screen time behaviors on obesity prevalence in this particular population.

The data were collected during the MUHSD annual health assessments and sport physicals. Prior to enrollment in the study, students were read the assent form in the presence of their parents, allowed to read it for themselves, asked if they understood the procedures, and asked to sign the form if they agreed to participate. Parents were then asked to sign their parental consent form.

Measurements

Self-reported age, gender, and ethnicity of participants were attained from the annual health assessment and sports physicals. Trained technicians and nurses measured each participant's height, weight, and waist circumference (WC) by using standardized protocols. WC was measured to the nearest 0.1 cm using a measuring tape in a horizontal plane at the level of the high point of the iliac crest as previously detailed, with the subject standing at minimal respiration.[15] BMI was calculated using the standard metric formula (kg/m^2).

Anthropometric Definitions

Overweight and obesity were defined according to BMI index cutoff points for age and gender published by the CDC.[16] Participants were classified as follows: BMI <5th percentile = "underweight," BMI ≥5th percentile and <85th percentile = "normal weight," BMI ≥85th and ≤94.9th percentile = "overweight," and BMI ≥95th percentile = "obese."[17] Only 53 (33 males; 20 females; 2.8%) of the 1894 adolescents were determined to be underweight and were removed from the analyses. Because there is no agreed upon definition of excess adiposity in children and adolescents based on WC, we used the 90th percentile values of WC for gender and age generated in Third National Health and Nutrition Examination Survey (NHANES III) as cutoff values to identify abdominal obesity.[15] These definitions were the same as those used previously.[3]

Behavioral Measures

As part of the self-report survey, participants were asked about a wide range of PA and SB. The survey was developed using the NHANES 2001–2002 survey as a template and modified for our purposes to facilitate time constraints because the survey was administered during the MUHSD physicals and annual health assessments. The survey had to be completed by each student within 20 min to accommodate the physical and health assessments; therefore, we used an abbreviated survey that focused on PA and SB times. Modifications included confining the time frame of the participation to a typical week as opposed to the last 30 days and limited the answers to number of hours per week. The survey differentiated between time spent in PA in (PA_i) and out (PA_o) of school. Total physical activity (PA_t) was calculated as the sum of PA_i and PA_o. Participants were able to indicate a range of hours per day and per week that they engaged in physical activity. Frequency distributions identified that a natural break point occurred at more or less than 1 hr of PA per day, both in and out of school. SB were used as a surrogate measure of inactivity and divided into two categories: Interactive SB (SB_a) and passive SB (SB_p). For the purposes of this paper, SB_a are defined as SB that require some responses to information on the screen of a television, computer, or some other electronic device and are associated with some PA, regardless of how minimal. Nonetheless, we did not equate SB_a with PA for these analyses. Passive SB are those that are sedentary in nature and not associated with any physical or active interaction. The surveys were constructed to easily delineate between the two types of SB without explicitly defining on the survey. These definitions and examples were determined *a priori*. Again, frequency distributions revealed a break at more or less than 1 hr per day for both interactive and passive SB.

Statistical Analysis

Means were compared by analysis of variance (ANOVA) for ethnic groups, gender, and group × gender differences. Prevalence rates according to gender and ethnicity were compared using chi-squared distribution statistics as previously described.[3,18] Prevalence values are presented as percentage with lower and upper 95% confidence intervals (CIs). Age had no significant effect on any of the variables in the analyses, so data for each age were combined. Means and regressions were considered significant at $p < 0.05$. Statistical analyses were performed using Statview software (SAS, Cary, NC).

Categorical definitions of BMI and WC were also used in our analyses because they offered an alternative approach to interpreting the data. In this study, we were primarily interested in the differences across discrete categories (*i.e.*, "normal weight" vs. "overweight" vs. "obese"). Because of our use of categorical variables, logistic regression was used to calculate adjusted odds ratios (OR). When analyzing abdominal obesity using WC, a WC less than or equal to the 90th percentile was used as the baseline, or control outcome. Non-Hispanic white was the comparison group for analyses using ethnicity. OR (95% CIs) and predicted probabilities were estimated using multinomial, logistic regression using Stata© (Stata, College Station, TX).

After running a pooled logistic regression model of both male and female respondents, both gender and ethnicity effects were apparent. Models were then estimated using gender and ethnicity interaction terms. Gender was the most important characteristic in the multivariate models, therefore a strategy of running separate logistic regression with only males and only females was employed. Our logistic models used both BMI and WC as dependent variables, gender, ethnicity, PA (both in and out of school), and SB_a and SB_p as independent variables.

Results

Prevalence Data and Population Means

Prevalence data of body weight category by BMI and WC as well as on participation in PA_i, PA_o, SB_a and SB_p are provided in Table 1.

Body Mass

As expected, an effect of BMI category ($p < 0.0001$) on mean body mass was apparent within gender for both ethnicities, but no effect of ethnicity was observed within either gender for any of the BMI categories (Table 2). An effect of gender ($p < 0.01$) within both ethnicities was apparent, such that body mass of normal-weight non-Hispanic white males was greater than normal-weight non-Hispanic white females. This was the case for normal-weight and overweight categories only (Table 2). These data are provided to confirm that the changes in

Table 1. Prevalence of BMI and Waist Circumference (WC) Categories, Physical Activity (PA) Levels, and Screen Behaviors (SB) by Ethnicity and Gender

	White, Non-Hispanics		Hispanics	
	Male (312)	Female (301)	Male (671)	Female (610)
BMI categories*				
Normal Weight	57%	66%	52%	65%
Overweight	17%	19%	18%	21%
Obese	26%	15%	30%	14%
WC categories**				
Normal weight	84%	85%	78%	83%
Obese	16%	15%	22%	17%
Physical Activity				
PA in school <1 hr/day	47%	58%	62%	79%
PA in school ≥1 hr/day	53%	42%	38%	21%
PA outside school <1 hr/day	58%	73%	67%	86%
PA outside school ≥1 hr/day	42%	27%	33%	14%
Screen behaviors				
Interactive SB ≤2 hr/day	74%	77%	81%	82%
Interactive SB >2 hr/day	26%	23%	19%	18%
Passive SB ≤2 hr/day	61%	61%	50%	47%
Passive SB >2 hr/day	39%	39%	50%	53%

*Normal weight, BMI <85th percentile; overweight, 85th <BMI <95th percentile; obese, BMI ≥95th percentile.

**Normal weight, WC <90th percentile; obese, WC ≥90th percentile.

Table 2. Mean (± SD) Body Mass (kg) for White, Non-Hispanic and Hispanic Males and Females for Each BMI Category (see Methods for Definitions)

	Normal Weight (Sample size)	Overweight (Sample size)	Obese (Sample size)
Male			
White non-Hispanic	60.6 ± 9.3 (178)	77.3 ± 8.0 (53)	95.5 ± 17.1 (81)
Hispanic	59.2 ± 7.5 (349)	73.2 ± 6.6 (121)	94.9 ± 15.6 (201)
Female*			
White non-Hispanic	54.7 ± 7.1 (199)	68.2 ± 7.5 (57)	93.5 ± 20.8 (45)
Hispanic	53.5 ± 6.0 (397)	67.5 ± 6.8 (128)	89.7 ± 17.5 (85)

Within each gender, no ethnicity effects were observed for any of the BMI categories.

Normal weight, BMI <85th percentile; overweight:, 85th <BMI <95th percentile; obese, BMI ≥95th percentile.

*Females were significantly ($p < 0.01$) lower than their male cohorts for each BMI category with the exception of Obese ($p > 0.10$).

BMI are associated with changes in body mass and not necessarily changes in height.

PA Levels In School (PA_i)

When weight categories were defined by BMI, mean PA_i levels were consistently lower ($p < 0.05$) in Hispanic females (30%, 30%, and 33%, respectively, among the three weight categories) compared to Hispanic males (Figure 1A,B). Among non-Hispanic whites, a gender effect was only detected in the obese category, with mean PA_i 37% lower in females (Figure 1A,B). Normal-weight and obese Hispanic males had mean PA_i levels that were 15% ($p < 0.01$) and 20% ($p < 0.05$), respectively, lower than non-Hispanic white counterparts (Figure 1A). An effect of ethnicity on mean PA_i was not detected for overweight males (Figure 1A). Among females, normal-weight and overweight Hispanics had mean PA_i levels that were 37% ($p < 0.0001$) and 31% lower ($p < 0.01$), respectively, than non-Hispanic whites (Figure 1B). Among non-Hispanic whites, mean PA_i levels were 35% lower ($p < 0.05$) in obese females compared to normal-weight females (Figure 1B).

When weight categories were defined by WC, gender effects on mean PA_i levels were not detected for any weight category or ethnicity (Figure 1C,D). Mean PA_i levels were 18% ($p < 0.01$) and 34% lower ($p < 0.0001$) in normal-weight Hispanic males and females, respectively, compared to their non-Hispanic white counterparts (Figure 1C,D). Although an effect of ethnicity on mean PA_i was not detected in obese males, activity levels were 29% lower ($p < 0.05$) in obese Hispanic females compared to their non-Hispanic white counterparts (Figure 1D).

PA Levels Outside of School (PA_o)

When weight categories were defined by BMI, a gender effect on mean PA_o levels was detected with females consistently participating less (34 ± 5%; ± standard error of the mean [SEM]) ($p < 0.05$) than males, regardless of weight category or ethnicity (Figure 2A,B). Similar to the trend observed for PA_i of males, participation of normal-weight and obese Hispanic males in PA_o levels was 11% and 17% lower ($p < 0.0001$), respectively, than non-Hispanic white counterparts (Figure 2A). The 13% lower level ($p < 0.10$) of PA_o in overweight Hispanics was

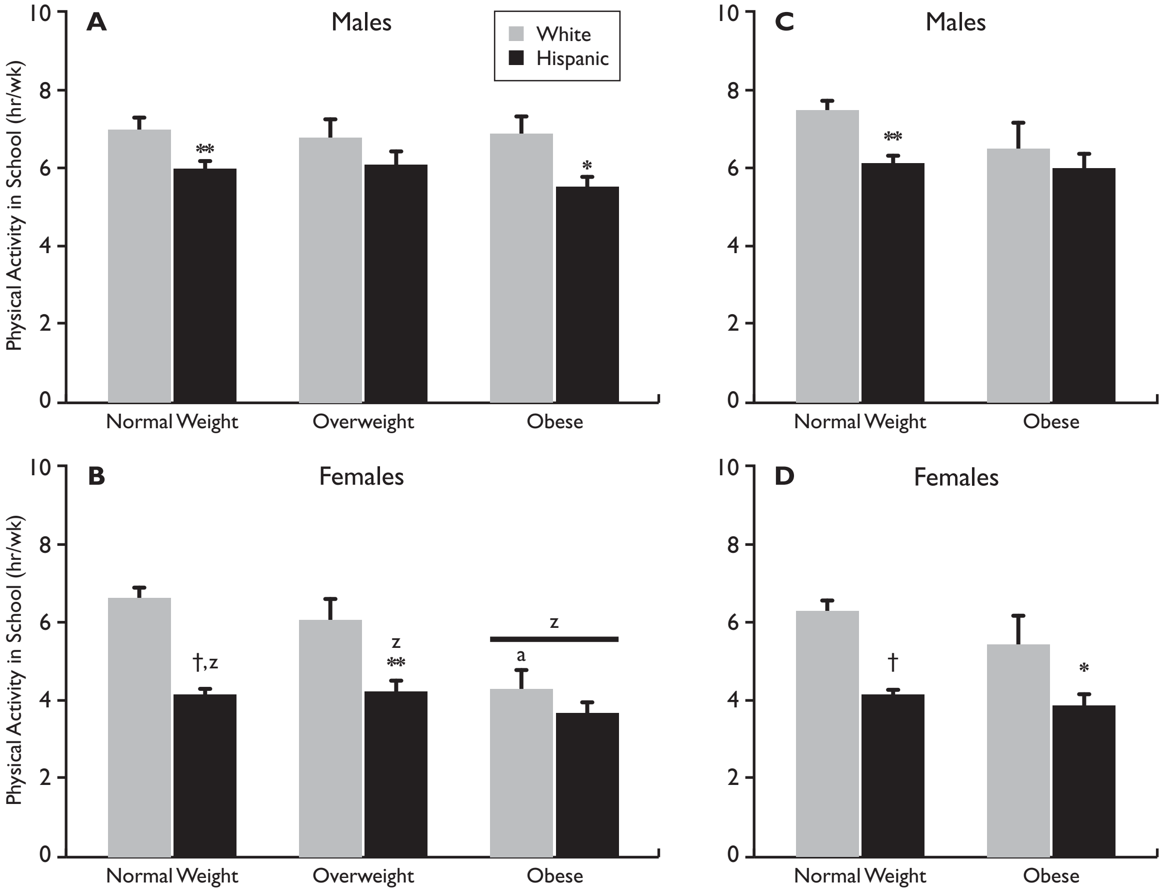

Figure 1. Mean (± standard error of the mean [SEM]) physical activity spent (hr/week) in school as a function of the BMI categories (normal weight, <85th percentile; overweight, ≥85th percentile and <95th percentile; obese, ≥95th percentile) for male (A) and female (B) adolescents of either non-Hispanic white or Hispanic descent, and as a function of waist circumference (WC) categories (normal weight, <90th percentile; obese, ≥90th percentile) for male (C) and female (D) adolescents of either non-Hispanic white or Hispanic descent. (*) Different from non-Hispanic whites at $p < 0.05$; (**) different from non-Hispanic whites at $p < 0.01$; (†) different from non-Hispanic whites at $p < 0.0001$. a = Different from normal weight at $p < 0.05$, z = different from male cohorts at $p < 0.05$.

not different at $p < 0.05$ (Figure 2A). An effect of weight category was not observed for either group in males (Figure 2A). Mean PA_o in normal-weight, overweight, and obese Hispanic females was 27%, 35%, and 37% lower, respectively, compared to non-Hispanic white females (Figure 2B). Furthermore, mean PA_o levels in obese Hispanic females was 28% lower ($p < 0.05$) compared to normal-weight Hispanic females (Figure 2B). No effect of weight category on mean PA_o levels was observed in non-Hispanic white females (Figure 2B).

When weight categories were defined by WC, a gender effect on mean PA_o levels was detected in the normal-weight group, with non-Hispanic white females participating 32% ($p < 0.01$) and Hispanic females participating 41% less ($p < 0.001$) than their male cohorts (Figure 2C,D). Although a gender effect was not detected between obese non-Hispanic white males and females, mean PA_o levels were 49% lower ($p < 0.05$) in obese Hispanic females compared to their male cohorts (Figure 2C,D). Among normal-weight males, mean PA_o levels were 12% lower ($p < 0.05$) in Hispanics than in non-Hispanic whites (Figure 2C). The effect of ethnicity on mean PA_o levels in obese males was not detected, but both groups exhibited an effect of weight category with levels 37% lower ($p < 0.05$) in obese non-Hispanic whites and 21% lower ($p < 0.05$) in obese Hispanics compared to their normal-weight cohorts (Figure 2C). Among females, mean PA_o levels were 24% ($p < 0.01$) and 48% ($p < 0.0001$) lower in normal-weight and obese Hispanic females, respectively, compared to non-Hispanic white females (Figure 2D). Although there was no difference in mean PA_o between normal-weight and obese non-Hispanic white females, levels were 31% lower ($p < 0.05$) in obese Hispanics compared to normal-weight Hispanics (Figure 2D).

Total PA Levels (PA_t)

When weight categories were defined by BMI, a gender effect on mean PA_t levels was detected, with females consistently participating less (32 ± 10%) ($p < 0.0001$) than males, regardless of weight category (with the exception of overweight non-Hispanic white females) or ethnicity (Figure 3A,B). Regardless of gender or weight category, Hispanics reported participating in less PA_t (22 ± 9%) ($p < 0.0001$) than their non-Hispanic white counterparts (Figure 3A,B). Comparing normal-weight to obese Hispanics,

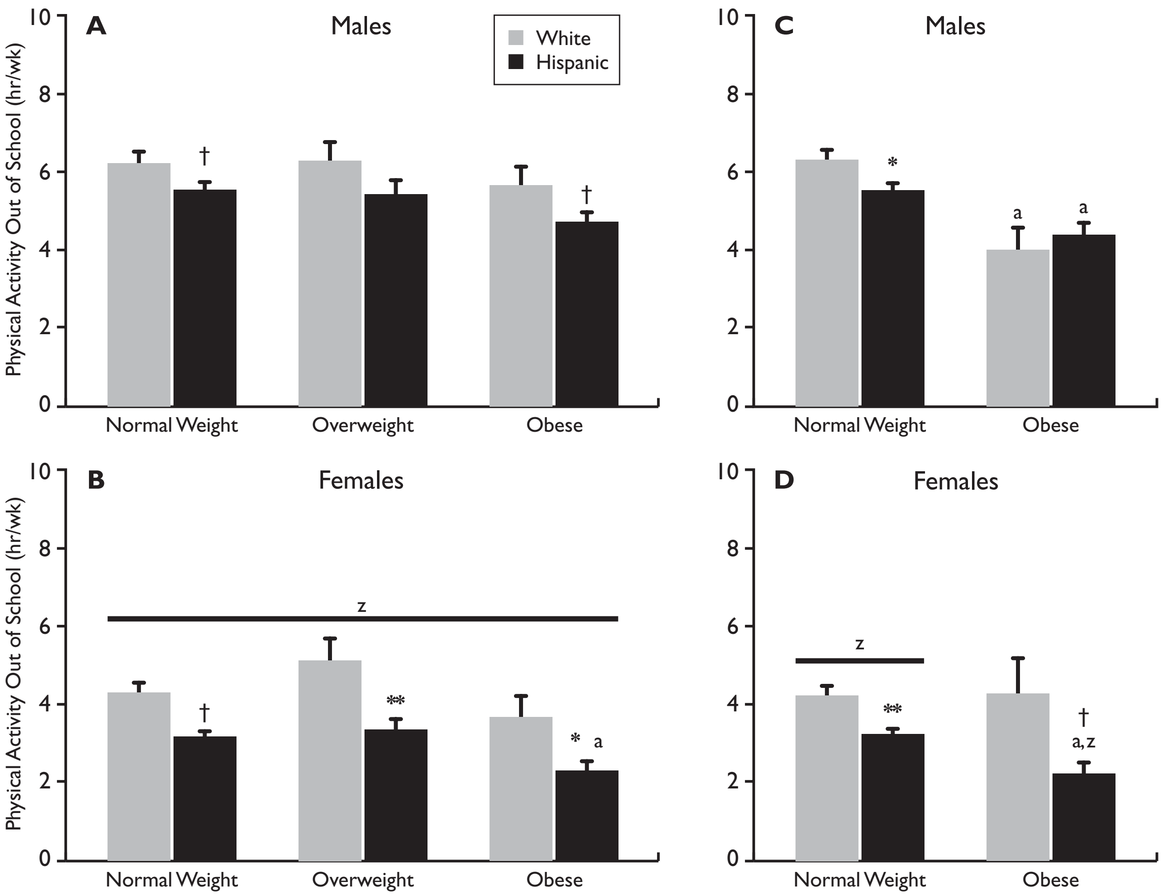

Figure 2. Mean (± standard error of the mean [SEM]) physical activity spent (hr/week) out of school as a function of the BMI categories (normal weight, <85th percentile; overweight, ≥85th percentile and <95th percentile; obese, ≥95th percentile) for male (A) and female (B) adolescents of either non-Hispanic white or Hispanic descent, and as a function of waist circumference (WC) categories (normal weight, <90th percentile; obese, ≥90th percentile) for male (C) and female (D) adolescents of either non-Hispanic white or Hispanic descent. (*) Different from non-Hispanic whites at *p* < 0.05; (**) different from non-Hispanic whites at *p* < 0.01; (†) different from non-Hispanic whites at *p* < 0.0001, a = Different from normal weight at *p* < 0.05,; z = different from male cohorts at *p* < 0.05.

mean PA_t levels were 11% ($p < 0.05$) and 19% ($p < 0.05$) lower in obese males and females, respectively (Figure 3A,B). While no effect of weight category on mean PA_t was observed in non-Hispanic white males (Figure 3A), obese non-Hispanic white females reported 29% less PA_t than their normal-weight counterparts (Figure 3B).

When weight categories were defined by WC, a gender effect on mean PA_t levels was detected, with females participating less (32 ± 9%) than their male cohorts (Figure 3C,D). With the exception of obese males, strong ethnicity effects were detected, with Hispanics participating less (27 ± 11%) ($p < 0.01$) than their non-Hispanic white counterparts (Figure 3C,D). Among normal-weight males, mean PA_t levels were 15% lower ($p < 0.0001$) in Hispanics than in non-Hispanic whites (Figure 3C). Although the effect of ethnicity on mean PA_t in obese males was not detected, both groups exhibited an effect of weight category with levels 24% lower ($p < 0.05$) in obese non-Hispanic whites and 11% lower ($p < 0.05$) in obese Hispanics compared to their normal-weight cohorts (Figure 3C). Among females, mean PA_t levels were 30% ($p < 0.0001$) and 37% ($p < 0.0001$) lower in normal-weight and obese Hispanic females, respectively, compared to non-Hispanic white females (Figure 3D). There was no difference in PA_t between normal-weight and obese non-Hispanic white females; however, levels were 17% lower ($p < 0.05$) in obese Hispanics females compared to their normal-weight cohort (Figure 3D).

Interactive SB (SB_a)

Regardless of how weight categories were defined (BMI or WC), the effect of gender on SB_a was not detected for either ethnicity, with the exception of overweight Hispanics, in which screen time was 36% lower in females (Figure 4A,B). Among males, SB_a time was 12% and 18% lower ($p < 0.05$) in normal-weight and overweight Hispanics, respectively, compared to their non-Hispanic white counterparts (Figure 4A). An ethnicity effect on SB_a in obese males was not detected (Figure 4A). Whereas an ethnicity effect on SB_a in normal-weight females was not detected, screen time was 47% ($p < 0.01$) and 42% lower ($p < 0.05$) in overweight and obese Hispanic females, respectively, compared to their non-Hispanic white counterparts (Figure 4B). An

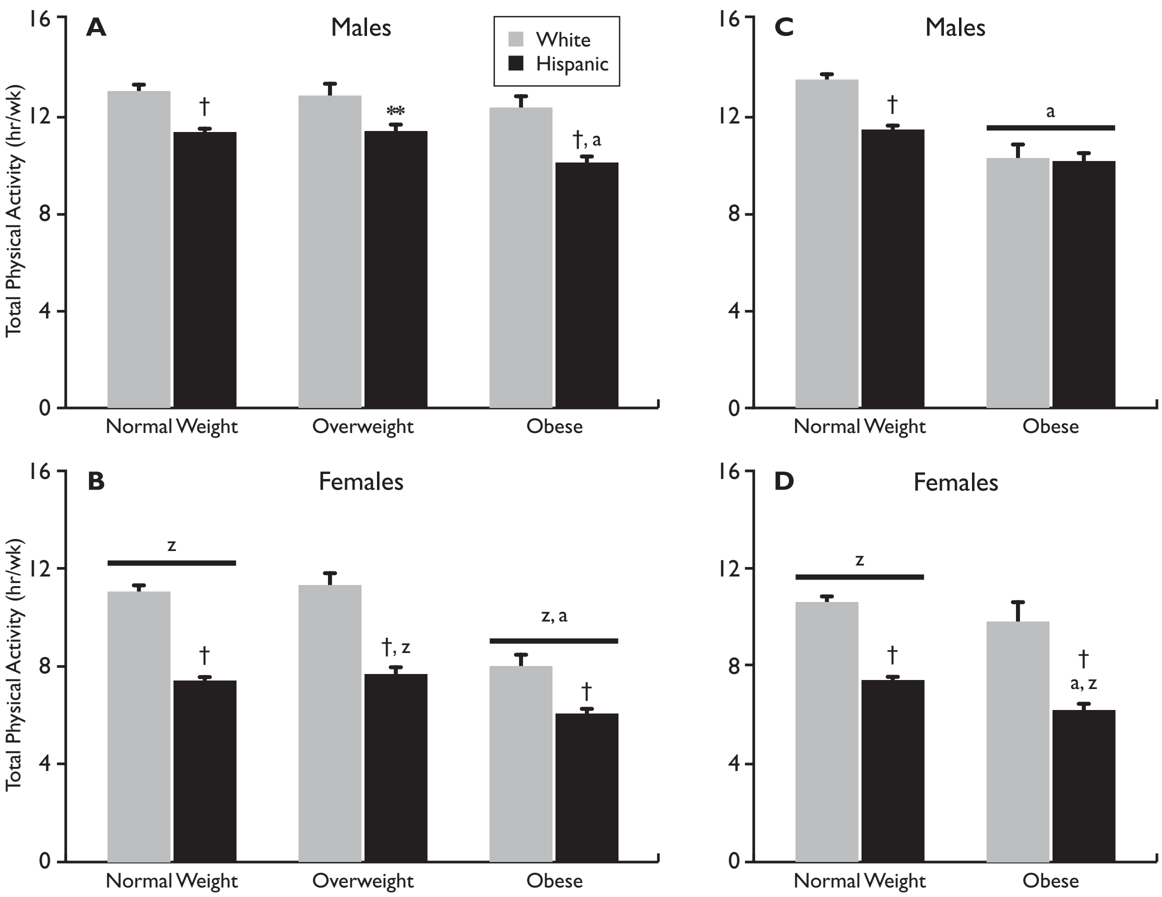

Figure 3. Mean (± standard error of the mean [SEM]) total (combined physical activity [PA] in and outside of school) PA (hr/week) as a function of the BMI categories (normal weight, <85th percentile; overweight, ≥85th percentile and <95th percentile; obese, ≥95th percentile) for male (A) and female (B) adolescents of either non-Hispanic white or Hispanic descent, and as a function of waist circumference (WC) categories (normal weight, <90th percentile; obese, ≥90th percentile) for male (C) and female (D) adolescents of either non-Hispanic white or Hispanic descent. (*) Different from non-Hispanic whites at *p* < 0.05; (**) different from non-Hispanic whites at *p* < 0.01; (†) different from non-Hispanic whites at *p* < 0.0001. a = Different from normal weight at *p* < 0.05, z = different from male cohorts at *p* < 0.05.

effect of weight category on SB_a was not detected in non-Hispanic white females; however, screen time was 35% and 28% lower ($p < 0.05$) in overweight and obese Hispanic females, respectively, compared to normal-weight cohorts (Figure 4B).

When weight categories were defined by WC, SB_a time was 13% ($p < 0.01$) and 22% lower ($p < 0.05$) in normal-weight and obese Hispanic males, respectively, when compared to their non-Hispanic white counterparts (Figure 4C). The same trend was detected for females with screen times 11% and 24% lower ($p < 0.05$) in normal-weight and obese Hispanics, respectively (Figure 4D). An effect of weight category on SB_a was not detected for either gender or ethnicity in this overweight group.

Passive Screen Time Behaviors (SB_p)

Regardless of how the weight categories were defined (BMI or WC), gender effects on SB_p were not detected within each ethnic group for any of the weight categories (non-Hispanic white males, 3.0 ± 0.1; Hispanic males, 3.1 ± 0.1; non-Hispanic white females, 3.0 ± 0.1; and Hispanic females, 3.3 ± 0.1 hr/day) (Figure 5). When weight categories were defined by BMI, an effect of ethnicity on SB_p was only observed between normal-weight males (2.9 ± 0.1 vs. 3.2 ± 0.1 hr/day) (Figure 5A) and females (2.8 ± 0.1 vs. 3.2 ± 0.1 hr/day) (Figure 5B) with Hispanics 8% and 14% greater ($p < 0.05$), respectively. When weight categories were defined by WC (Figure 5C,D), the only detectable difference was between normal-weight females with Hispanics (3.2 ± 0.1 hr/day) 14% greater ($p < 0.05$) than non-Hispanic whites (2.8 ± 0.1 hr/day) (Figure 5D). Effects of weight category by gender on SB_p were not detected within an ethnic group.

Multinomial, Logistic Regression Models

Using BMI as the dependent variable, adolescent females are over 2.25 times ($p < 0.01$) more likely to be obese compared to their normal-weight counterparts when they participate in <1 hr/day PA_i (Table 3). The odds of being obese increased by 10% ($p < 0.05$) in males and by 72% ($p < 0.05$) in females (by 22% combined; $p < 0.05$) when they participate in <1 hr/day PA_i compared to overweight adolescents (Table 3). Using WC as the dependent variable, there is over a two-fold ($p < 0.001$ in males; $p < 0.05$ in females) increase in the odds of being obese for both males and females if they participate in < 1 hr/day PA_o (Table 3). Using BMI as

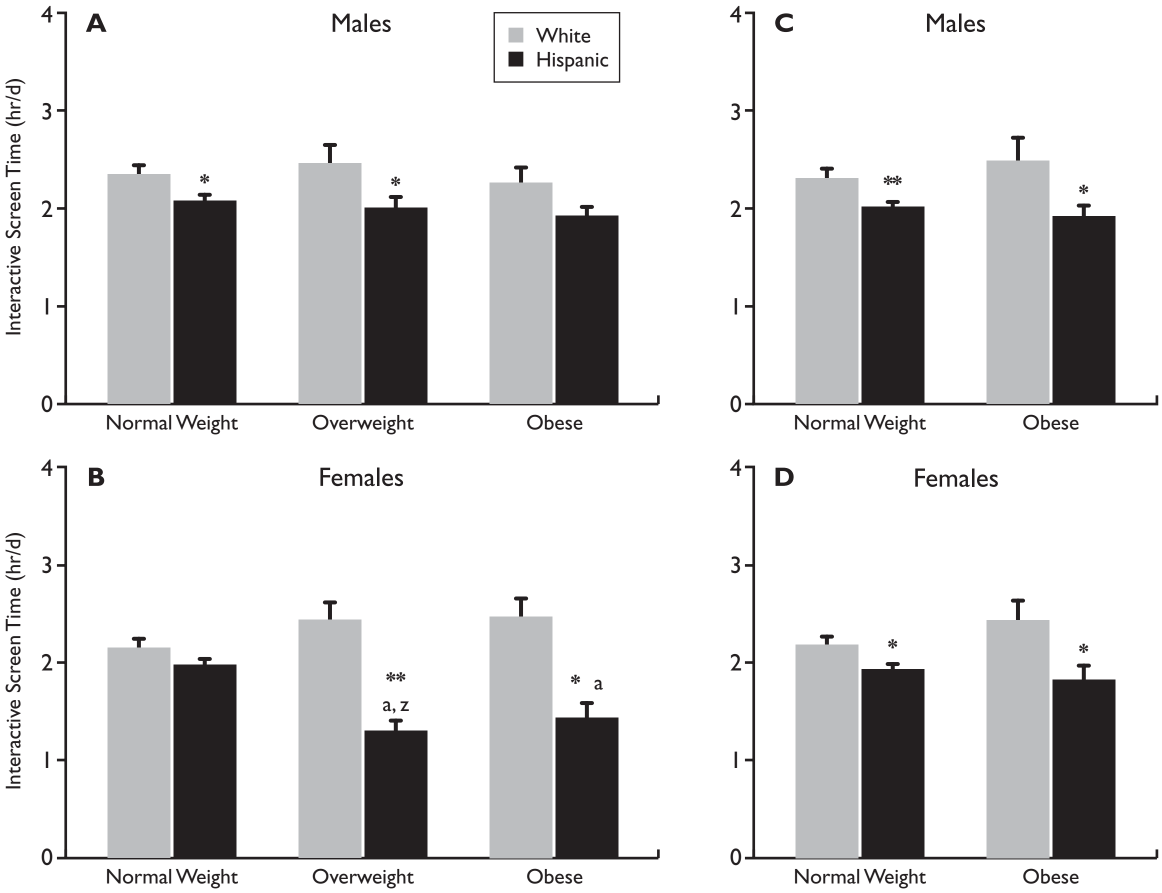

Figure 4. Mean (± standard error of the mean [SEM]) interactive screen time spent (hr/day) on computer or similar electronics as a function of the BMI categories (normal weight, <85th percentile; overweight, ≥85th percentile and <95th percentile; obese, ≥95th percentile) for male (A) and female (B) adolescents of either non-Hispanic white or Hispanic descent, and as a function of waist circumference (WC) categories (normal weight, <90th percentile; obese, ≥90th percentile) for male (C) and female (D) adolescents of either non-Hispanic white or Hispanic descent. (*) Different from non-Hispanic whites at $p < 0.05$; (**) different from non-Hispanic whites at $p < 0.01$. a = different from normal weight at $p < 0.05$, z = different from male cohorts at $p < 0.05$.

the dependent variable, the level of PA_o did not significantly change the odds of being overweight compared to normal-weight cohorts (Table 3). However, males were 60% ($p < 0.01$) and females were 90% ($p < 0.05$) more likely to be obese than their normal-weight cohorts when they participate in <1 hr/day PA_o (Table 3). In females, the odds of being obese increased to over three-fold greater ($p < 0.01$) compared to their overweight cohorts, whereas the odds were only 16% ($p < 0.05$) greater in males (although the odds for both genders combined was 42% greater) (Table 3).

Regardless of whether body mass was assessed by WC or BMI, SB_a >2 hr/day or <2 hr/day there was no impact on increasing the odds of being overweight or obese (Table 3). Similar to that observed with SB_a, passive SB_p >2 hr/day or <2 hr/day had no impact on increasing the odds of being overweight or obese (Table 3).

Discussion

As childhood and adolescent obesity continue to be a serious public health concern,[19] efforts to assess direct and indirect causes are increasingly more critical for developing strategies for remediation. While decreased PA and increased sedentary behaviors (*i.e.*, viewing television or surfing the web) have been implicated in some populations,[5,6,8,9,12,20–30] the associations between these factors and body mass have not been examined in Hispanic adolescents from a rural population. The present study demonstrates that, in this specific population, the lack of PA had a bigger impact on females than males and, moreover, on Hispanic females than on Hispanic males. There was no apparent association between participation time in SBs and BMI in this population of adolescents. However, reduced participation in PA in and especially out of school had a highly significant impact on increasing the odds of being obese in females moreso than males. Furthermore, the present study categorized BMI data for each group and constructed analyses with the PA and SB outcomes as a function of the discrete BMI or WC categories to better ascertain the impacts of the outcome variables on BMI and WC. Analyses in this regard are a unique quality of this study and its data presentation.

Similar to other studies,[5,9,31] the present study demonstrates that Hispanic adolescents participate in PA to a lesser extent than their non-Hispanic white counterparts.

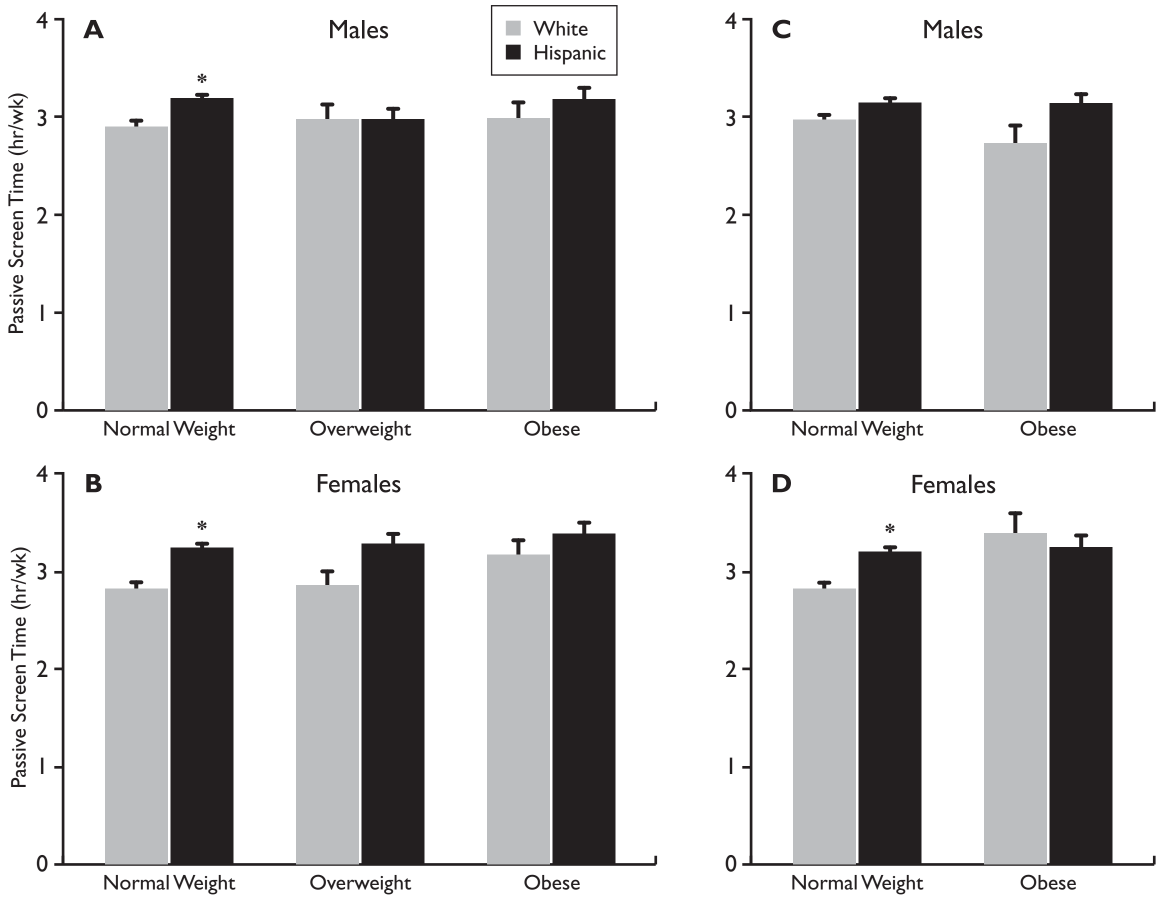

Figure 5. Mean (± standard error of the mean [SEM]) passive screen time spent (hr/day) on computer or similar electronics as a function of the BMI categories (normal weight, <85th percentile; overweight, ≥85th percentile and <95th percentile; obese, ≥95th percentile) for male (A) and female (B) adolescents of either non-Hispanic white or Hispanic descent, and as a function of waist circumference (WC) categories (normal weight, <90th percentile; obese, ≥90th percentile) for male (C) and female (D) adolescents of either non-Hispanic white or Hispanic descent. (*) Different from non-Hispanic whites at $p < 0.05$.

More importantly, however (and unlike other studies), the present study clearly demonstrates how the reduction in PA (whether in or outside of school) in Hispanic adolescents is distributed among the three BMI weight categories for both males and females. The fact that Hispanics participate in PA to a much lesser extent than their non-Hispanic white counterparts, regardless of BMI category, suggests that there exists strong cultural and/or socioeconomic (*i.e.*, available resources or facilities) components that impede Hispanics from participating in PA in rural, underserved communities. Additionally, females, independent of ethnicity, participate in PA to a lesser extent than males, but the effect is more pronounced among Hispanics. This suggests that the gender roles in Hispanics may be an important contributor to discourage PA in females. Therefore, extramural and scholastic programs in these communities that focus on encouraging participation of females would be well served.

With the exception of non-Hispanic white males, all other groups of obese adolescents reported lower total

Table 3. Odds Ratio from Multinomial, Logistic Regression of Waist Circumference (WC) and BMI by Gender (95% Confidence Interval)

	Male	Female	Total Population
BMI: Normal weight vs. overweight			
White	1	1	1
Male	—	1	1.22 (0.93–1.58)
Hispanic	1.13 (0.76–1.68)	1.20 (0.80–1.82)	1.16 (0.87–1.55)
PA in school <1 hr/day	0.88 (0.60–1.31)	1.39 (0.89–2.18)	1.08 (0.81–1.45)
PA outside school <1 hr/day	1.40 (0.94–2.08)	0.72 (0.45–1.16)	1.10 (0.79–1.46)
Active SB >2 hr/day	1.03 (0.65–1.63)	0.86 (0.53–1.39)	0.95 (0.73–1.24)
Passive SB >2 hr/day	0.91 (0.62–1.32)	0.98 (0.67–1.42)	0.95 (0.68–1.32)
BMI: Normal weight vs. obese			
White	1	1	1
Male	—	1	3.05*** (2.31–4.00)
Hispanic	1.43* (1.00–2.05)	0.80 (0.50–1.28)	1.19* (0.90–1.58)
PA in school <1 hr/day	0.99 (0.69–1.37)	2.27** (1.23–4.17)	1.22 (0.91–1.62)
PA outside school <1 hr/day	1.61** (1.13–2.29)	1.90* (0.90–4.00)	1.62** (1.19–2.22)
Active SB >2 hr/day	1.05 (0.71–1.55)	0.95 (0.55–1.64)	0.99 (0.72–1.36)
Passive SB >2 hr/day	1.08 (0.78–1.48)	1.43 (0.92–2.23)	1.21 (0.93–1.57)
BMI: Overweight vs. obese			
White	1	1	1
Male	—	1	2.53*** (1.80–3.54)
Hispanic	1.30* (0.83–2.04)	0.59 (0.32–1.08)	1.10* (0.71–1.46)
PA in school <1 hr/day	1.10* (0.71–1.69)	1.72* (0.85–3.47)	1.22* (0.85–1.76)
PA outside school <1 hr/day	1.16* (0.73–1.83)	3.23** (1.38–7.49)	1.42* (0.96–2.09)
Active SB >2 hr/day	1.02 (0.62–1.68)	1.07 (0.54–2.13)	1.02 (0.68–1.53)
Passive SB >2 hr/day	1.20 (0.80–1.80)	1.61 (0.95–2.74)	1.32 (0.96–1.82)
WC: Normal weight vs. obese			
White	1	1	1
Male	—	1	1.89*** (1.39–2.56)
Hispanic	1.86*** (1.20–2.89)	1.44 (0.83–2.49)	1.70** (1.21–2.39)
PA in school <1 hr/day	0.98 (0.59–1.31)	1.63 (0.88–3.02)	1.07 (0.77–1.49)
PA outside school <1 hr/day	2.14*** (1.38–3.31)	2.01* (0.88–4.62)	2.06*** (1.41–3.02)
Active SB >2 hr/day	0.91 (0.56–1.46)	0.70 (0.37–1.33)	0.82 (0.56–1.21)
Passive SB >2 hr/d	0.91 (0.62–1.31)	1.38 (0.87–2.21)	1.10 (0.80–1.44)

WC ≤90th percentile is the baseline outcome. Normal weight, BMI <85th percentile; overweight, 85th <BMI <95th percentile; obese, BMI ≥95th percentile. Normal weight, WC <90th percentile; obese, WC ≥90th percentile.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

PA, Physical activity; SB, screen behaviors.

PA levels compared to their normal-weight cohorts, suggesting that reduced participation in PA in and/or outside of school is contributing to their obesity. Alternatively, this relationship between obesity prevalence and PA levels may not be causal. It was recently shown in young English children (7–10 years of age) that the relationship between fatness and PA was dominated by the impact of fatness on activity and not at all by activity on fatness suggesting that physical inactivity was the result of increased percent body fat rather than the cause.[32] The implications here are that increased weight gain may be caused by excessive positive caloric intake, resulting in social, psychological (low self-esteem, depression, etc.), and/or physical factors that impede participation in PA. If so, then the design of intervention programs would need to incorporate some social or psychological components in addition to nutritional and physical participation components.

Although the change in mean total PA between normal-weight and obese cohorts for Hispanic males and females was only 1.3 (11%) and 1.4 (19%) hr/week, respectively, some calculations of caloric expenditure and input can put the magnitude of this seemingly small difference into perspective (the magnitude of the difference in non-Hispanic white females was much greater 3.0 (28%) hr/week). Data for obese Hispanic females are used for this example. If a conservative estimate of their energy expenditure based on their mean body mass of 90 kg (198 lb; Table 1) is used, assuming that their PA is moderate (0.035 kcal/lb per min),[33] then their weekly active energy expenditure (AEE) is approximately 2500 kcal/wk (357 kcal/day). To have obtained their body weight status (obese), these adolescents had to have had a positive energetic balance for some time prior to our measurements, but with no further information on their caloric budgets, we will assume they have reached a neutral energetic status (input = output). Thus, any potential loss that could be attributed to this AEE would have to be offset by a reciprocal decrease in caloric intake of a similar magnitude (*i.e*., decrease caloric intake by 360 kcal/day). A decrease in caloric intake of 360 kcal/day results in 131,400 kcal/year, and can be accomplished by eliminating what amounts to a bag of commercial potato/corn chips and half to a whole candy bar (depending on brand and size) a day. When the respiratory quotient (RQ) is 0.84, which is a conservative estimate for obese adolescents,[34] fat and carbohydrate metabolism contribute 52.8% and 47.2%, respectively (protein is negligible and not considered here), to caloric output[20]; thus, 69,379 kcal cand 62,021 kcal are attributed to the fat and carbohydrate metabolism, respectively. Given that the energetic densities of body fat and carbohydrate are 7.7 kcal/g of fat (which accounts for some adipose water) and 4.0 kcal/g of carbohydrate,[20] respectively, these caloric losses equate to 9 kg of body fat and 15.5 kg of glycogen stores. The loss of 24.5 kg would result in a 27% decrease in BMI (34.0 to 24.7) and recategorization from "obese" to "normal weight." The body mass loss would undoubtedly be associated with some water loss so the estimate is conservative, but the 27% decrease in body mass translates to 0.47 kg/week, which is a safe and realistic goal for a weight reduction program. If obese, Hispanic females would increase their total PA levels to match that of their normal-weight cohorts (Δ = 1.4 hr/week = 84 min/week), they would only benefit from the additional loss of 2.1 kg of body fat and 3.6 kg of glycogen afforded by the increase in PA.

Recognizing the simplicity of these calculations, they at least provide a realistic estimate of the impact a slight modification in caloric input can have on alleviating obesity in adolescents. But we emphasize that an 18% decrease in caloric input alone will not be sufficient to achieve the degree of body mass reduction calculated here; maintenance of their current AEE is still required. These calculations provide some perspective into the significance of the relatively low PA levels, but also a reasonable and realistic option for reconciling the predicament. These calculations are based on reasonable assumptions that cannot account for other biotic or abiotic factors that may compromise an adolescent's ability or capacity to participate in PA. Nonetheless, programs aimed at promoting and encouraging increased participation in PA in and/or outside of school would only improve the described situation.

Another important contribution of the present study is the differentiation of the PA in school versus that outside of school to the development of obesity. To the best of our knowledge, no large-scale study has differentiated PA in this manner, although studies have examined PA levels by grade[24] or by PA level (*i.e*., moderate vs. vigorous).[9,24] Although there is no doubt that categorizing and comparing grade or activity level is informative, our current approach focusing on activity context is interesting and informative. Because the national guideline for PA in adolescents of the age surveyed here is 1 hr/day, presenting OR data with a cutoff of greater than or less than 1 hr/day is of particular interest and highly relevant.

Using WC to categorize normal weight and obese, the adjusted ORs indicate that males and females are approximately two-fold more likely to be obese if their PA levels outside of school are <1 hr/day. The BMI data are equally indicative, with females 90% and males 60% more likely of being obese if their PA levels outside of school are <1 hr/day. The likelihood of overweight males becoming obese increases 16% if they participate in PA outside of school for <1 hr/day; overweight females are over three-fold more likely of being obese if they do not participate in PA for more than 1 hr/day outside of school, which is truly alarming. This OR data clearly emphasizes the need for adolescents, especially overweight females, to participate in PA outside of school for at least 1 hr/day to avert the increased probability of being obese.

With respect to PA in school, the only striking outcome is that normal-weight (by BMI) females are over 2.25-fold more likely to become obese if their PA levels are <1 hr/day in school. Collectively, these data suggest that participation in PA outside of school is extremely important to minimizing the likelihood of being obese in adolescents, especially females. Careful examination of the PA_i–PA_o relationship reveals that all Hispanic females and obese non-Hispanic white females constitute the lower end of the range, suggesting that these groups are not active in or outside of school. Efforts to target enhanced participation of these groups either in or outside of school may be reciprocated and result in increased PA regardless of locale.

Limitations

The novelty of the current data lies in the unique population among others, but we recognize the limitations of the study design and results. Ideally, PA levels would be estimated by employing accelerometers over a finite time frame in addition to self-reported data[26,35]; however, a number of larger-scale studies have relied solely on self-reported PA levels,[5,6,9,36] producing robust data with which our data are consistent. This consistency in data amongst the studies using self-reported PA levels provides some degree of reliability and validity in the current data. In addition, our survey did not include questions that could capture the intensity (moderate vs. vigorous) of the PA level; however, it provides novel and unique data on PA levels between in-school and out-of-school settings, which may be more relevant since other studies have already examined issues of intensity.[6] The survey also did not account for socioeconomic status (SES) effects, which are established effectors of BMI in adolescents.[37] However, questions to capture SES effects would ideally be addressed by parents/guardians of the participants, and given the setting for this survey, it was not realistic to ask such questions. Because of these limitations, the data need to be interpreted with some degree of caution; however, the consistency of the findings with that of previous studies provides evidence of their reliability and validity.

Summary

In summary, these data demonstrate a strong association between reduced total PA and obesity in Hispanic adolescents. Whereas PA levels in females in general are lower than their male cohorts, the reduced participation in PA outside of school in Hispanic females was stark compared to non-Hispanic white females. Moreover, the probability of becoming obese in females increases two- to three-fold if they participate in PA and outside of school for <1 hr/day, or less than the national guideline for PA in adolescents. The lack of associations between any screen time behaviors and body mass category suggests that this is not a significant contributing factor to the obesity prevalence in this population and that other abiotic factors such as social, economic, and cultural barriers to PA should be further assessed. Nonetheless, reduced PA appears to drive the disparity in obesity, especially in Hispanic females, in this rural, primarily Hispanic population. Therefore, programs that encourage and promote PA in and outside of school should be initiated in these communities to help abate the prevalence of obesity in adolescents.

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Address correspondence to:
Rudy M. Ortiz, PhD, MS, BA
Associate Professor of Physiology & Nutrition
University of California
5200 N. Lake Road
Merced, CA 95343

E-mail: rortiz@ucmerced.edu