Objective: To examine whether and to what extent the relationship between television viewing and children's weight status differs according to parental weight status.

Design: Population-level survey including in-home and telephone interview components.

Setting: United States.

Participants: Representative sample of children aged 6 to 19 years in 2002 (n=1483).

Main Exposure: Hours of television viewing.

Main Outcome Measures: Child weight status (normal weight, at risk for overweight, overweight) as defined by current Centers for Disease Control and Prevention standards.

Results: Parental obesity increased the risk of child overweight for all of the children except boys aged 6 to 9 years. There were significant interactions between television viewing hours and parental obesity among boys aged 14 to 19 years and girls aged 10 to 13 years. For these 2 groups, the odds of overweight status increased with viewing hours for children with at least 1 obese parent but not at all for children of normal-weight parents.

Conclusions: Results indicate that when parental obesity is taken into account, television viewing hours do not significantly relate to increased odds of childhood overweight, and parental body mass index may serve to moderate the relationship between television viewing and child weight status among adolescents (but not among younger children). Further examination of the moderating effect of parental body mass index on the relationship between television viewing and child weight status is warranted.

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THE PREVALENCE OF OBESITY in American youth has reached alarming levels. The proportion of overweight children and adolescents, defined as a body mass index (BMI) exceeding the 95th percentile for age- and sex-based norms, has tripled in the past 3 decades. Current estimates indicate that among children aged 6 through 19 years, approximately 31% are at risk for overweight and 16% are overweight. Many believe that time spent watching television is at least partly to blame for obesity in the nation’s youth. Children spend 3 to 5 hours per day watching television, more than in any other single free-time activity except sleep. Perhaps because of this, the notion that television use must somehow be responsible for the increased prevalence of obesity in American children and adolescents in recent years is dearly held by the lay public and scholars alike. In their seminal study, Dietz and Gortmaker found that the prevalence of obesity in a large epidemiologic sample of adolescents aged 12 to 17 years increased 2% for each additional hour of television watched. It is this study that is widely cited as evidence that television causes obesity in children and adolescents. However, this finding has been surprisingly difficult to replicate. Robinson and Killen found that television viewing was only weakly associated with BMI among white boys in a large sample (n=1912) of ninth-graders. Robinson et al found that baseline hours of television viewing were not associated with either baseline or longitudinal changes in BMI in a large sample (n=971) of sixth- and seventh-grade girls. McMurray et al found no relationship between television or video game use and BMI in a sample of 2389 adolescents aged 10 to 17 years once the influence of socioeconomic status and ethnicity were controlled. Finally, DuRant
et al also found no relationship between BMI and television watching in a longitudinal sample of young children (aged 3-4 years).

However, it is worth noting that interventions with random controlled trial designs have found a causal relationship between reduction of television viewing and reduction of children's BMI. Gortmaker et al designed a school-based intervention to reduce obesity in middle school youth (grades 6-8) by altering key physical activity and dietary risk factors, including reductions in television viewing. They found reductions in the prevalence of obesity related to reduced television viewing for girls (although not for boys). Robinson found that elementary school children (third- and fourth-graders) who received classroom curriculum designed to reduce television use over 1 school year showed significant decreases in BMI.

The general discrepancy between findings from epidemiologic and intervention studies (although they are somewhat more limited in number) is puzzling. We believe that the answer may lie in the influence of moderating variables. That is, the generally weak relationship found between children's television use and their weight status in epidemiologic samples may be owing to the fact that the strength of this relationship differs for different groups of children, thus diluting the linear relationships in heterogeneous samples. Identification of moderating influences would be an important step for both epidemiologic researchers as well as those interested in designing targeted interventions. However, examination of moderators of the relationship between television viewing and child weight status is surprisingly lacking.

In this article, we focus on 1 possible moderator of the relationship between children's television viewing and their weight status—parental weight status. Parental (especially maternal) BMI has been found to explain as much as 70% of the variance in children's BMI. Thus, parental weight status represents both environmental and genetic risk factors that may importantly moderate the relationship between media use and obesity. Two mechanisms for this moderating effect seem readily apparent. First, the inactivity accompanying television viewing may be more consequential for the weight status of children at familial risk of overweight than for those without such risk. Second, children with familial risk of obesity may be more susceptible to televised food advertising—the vast majority of which is for nutrient-poor, high-fat foods. This may be either because their parents themselves are more likely to buy and consume such foods or because of evidence indicating that overweight children eat more in response to food advertising than normal-weight children. Although we cannot discern the various mechanisms with these data, both scenarios suggest that television viewing might be related to increased risk of overweight or obesity more so among children at familial risk of overweight than among those without such risk.

However, to the extent that parental weight status has been included in studies at all (and often it is not), it has been treated as a covariate. Although this approach has its utility, controlling for its effects obviates the researcher’s ability to assess how relationships among variables of interest might differ at different levels of the covariate (ie, moderator effects). If the relationship between television viewing and child weight status operates differently for children with different levels of familial risk for overweight, then this might at least partly explain some of the lack of findings in studies using heterogeneous samples of children that fail to take parental BMI into account. This study examines the question of whether the relationship between television use and weight status differs for children at different levels of familial risk for obesity as indicated by parental weight status.

**METHODS**

**SAMPLE**

The sample was drawn from cross-sectional data collected as a part of the Child Development Supplement (CDS) to the Panel Study of Income Dynamics in 2002 to 2003. Since 1968, the Panel Study of Income Dynamics has been an ongoing, nationally representative panel study focusing primarily on the transfer of social and economic capital within families. As its name implies, the CDS to the Panel Study of Income Dynamics focuses on children and provides additional information about parents' and children's education, health, cognitive and behavioral development, and time use. In 2002 to 2003, the CDS contacted families who remained active in the Panel Study of Income Dynamics as of 2001. The CDS successfully reinterviewed 2017 families (91%) who provided data on 2908 children and adolescents aged 6 to 19 years. For a complete description of sampling and data collection procedures, see the CDS user guide.

The sample used for the present study comprised 1483 children aged 6 to 19 years (736 boys and 747 girls) for whom complete data on all of the variables of interest were available. The median income of the families was $53,375, with 16.1% of the families falling below poverty level. Twenty percent of the parents had not graduated high school, 31% had a high school diploma, 23% had some college, and 26% had attained a bachelor degree or higher. Fifty-six percent were European American and 44% were African American. The study was approved by the institutional review boards of the University of Michigan, Ann Arbor, where the data were collected, and the University of Texas, Austin, where analyses for this study were conducted.

**MEASURES**

**Child BMI**

Weight and height information was collected via strain-gauge lithium bath scales and measurement tape, respectively, during the home interview. Children were measured in stocking feet and, in the case of weight, in light clothing with pockets emptied. Body mass index was calculated from height and weight by using the formula from the National Center for Chronic Disease Prevention and Health Promotion (weight in kilograms divided by the height in meters squared). Because BMI varies by age and sex, BMI was converted to a BMI z-score using the Centers for Disease Control and Prevention's BMI growth reference to determine an age- and sex-specific BMI z score for subjects aged 2 to 20 years.

The definition of overweight among children is a statistical definition based on the 2000 Centers for Disease Control and Prevention growth reference for the United States. Overweight is defined as being at or above the 95th percentile of BMI for age. Being at risk for overweight is defined as being at or above the 85th percentile but less than the 95th percentile of BMI for age. (Descriptive statistics for this and all of the other measures are presented in Table 1.)
Biological Parent BMI

Parents’ weight and height information was collected via self-report in 1999 and 2001. Data collected in 2001 were used to calculate parental BMI. However, in a small number of cases where 2001 data were unavailable, 1999 data were used (for father’s weight status, n=36; for mother’s weight status, n=42). Parental BMI was used to categorize the weight status of parents using the Centers for Disease Control and Prevention recommended cutoff points for overweight (BMI >25) and obesity (BMI >30).29 Parental obesity was considered present when 1 or both parents had a BMI greater than 30. Parental overweight was considered present when 1 or both parents had a BMI greater than 25 but no more than 30.

Amount of Children’s Television Viewing

Information on children’s television viewing was assessed via two 24-hour time-use diaries providing detailed accounts of type, number, duration, and location of activities that children engaged in during each 24-hour period.3,30,31 On 1 randomly chosen weekday and 1 randomly chosen weekend day, all of the activities that the child engaged in were reported. Children aged 10 years and older were encouraged to complete their own time-use diaries; younger children were aided by primary caregivers. A primary activity and its duration were recorded to account for every minute of the two 24-hour diaries, and, if appropriate, a secondary activity was also noted. The measure was created by summing the minutes children spent watching television as a primary or secondary activity across both days. This sum was then divided by 60 to express television viewing in hours.

Validity of Time-Use Diaries

A fairly extensive body of research has demonstrated the validity and reliability of time-use diaries as representations of the ways both children and adults spend their time.12-15 When direct observation techniques are compared with time-use diaries, the mean values for time allocated to different activities are very close and the correlations are quite high, on the order of 0.70 to 0.80.30,35 Of particular relevance to this study, Anderson et al35 specifically examined the accuracy of parent report of young (aged 5 years on average) children’s media use. Using video cameras, they recorded all of the children’s viewing in approximately 100 families for a 10-day period while the children’s parents also completed a viewing diary. The correlation between the 2 methods was quite high (0.84), indicating that time-use diaries filled out by parents provided fairly accurate representations of children’s weekly viewing. Thus, time-use diaries have been shown to be a highly reliable and valid method of recording the way individuals spend their time in large-scale survey samples, such as that used here, where observing individuals over 24-hour periods is neither logistically nor financially feasible.

**COVARIATES**

**Sociodemographic Characteristics**

Based on demonstrated relationships with television viewing, weight status, or both, a number of sociodemographic characteristics were treated as covariates in the analyses. These included the following: (1) family income-to-needs ratio, which was a proportion of the family’s income by the poverty threshold for that family, with higher income-to-needs ratios reflecting more disposable income in a family; (2) education of the household head, denoting the number of years of education completed by the household head; and (3) child race.

**Child Maturational Status**

Because maturation-related misclassification may result in overestimations of overweight prevalence rates among early-maturing adolescents and underestimations among later-maturing adolescents,37,38 we controlled for child maturational status. This was assessed using the Khamis-Roche method for predicting the percentage of adult stature.39 The method is applicable to children aged 4 to 17 years and thus was not applied to children in the sample who were aged 18 or 19 years. Percentage of adult stature has been shown to be significantly correlated with maturational status (range, r=0.50-0.70) and thus a good proxy for maturational status when other, more invasive measures are not available.40-42 It is calculated using current stature (meters), current weight (kilograms), and mid-

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Aged 6-9 y (n = 135)</th>
<th>Aged 10-13 y (n = 281)</th>
<th>Aged 14-19 y (n = 320)</th>
<th>Aged 6-9 y (n = 134)</th>
<th>Aged 10-13 y (n = 249)</th>
<th>Aged 14-19 y (n = 365)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictors</strong></td>
<td></td>
<td></td>
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<tr>
<td>Parental weight status, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Both parents of normal weight</td>
<td>16 (12.1)</td>
<td>20 (7.1)</td>
<td>21 (6.6)</td>
<td>23 (17.4)</td>
<td>18 (7.2)</td>
<td>20 (5.5)</td>
</tr>
<tr>
<td>≥1 Parent overweight</td>
<td>52 (39.0)</td>
<td>43 (15.3)</td>
<td>42 (13.1)</td>
<td>35 (26.2)</td>
<td>46 (18.4)</td>
<td>39 (10.7)</td>
</tr>
<tr>
<td>≥1 Parent obese</td>
<td>32 (23.8)</td>
<td>37 (13.2)</td>
<td>37 (11.6)</td>
<td>42 (31.3)</td>
<td>36 (14.4)</td>
<td>41 (11.3)</td>
</tr>
<tr>
<td><strong>Television viewing, mean (SD), h</strong></td>
<td>5.55 (2.07)</td>
<td>5.61 (2.68)</td>
<td>5.64 (3.83)</td>
<td>4.25 (2.77)</td>
<td>5.36 (3.36)</td>
<td>5.26 (3.70)</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
<td></td>
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<td>Family income-needs ratio, mean (SD)</td>
<td>3.38 (2.26)</td>
<td>4.46 (4.67)</td>
<td>4.65 (5.15)</td>
<td>3.62 (2.20)</td>
<td>4.73 (6.68)</td>
<td>5.32 (7.73)</td>
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<tr>
<td>Household head education, mean (SD), y</td>
<td>13.16 (2.24)</td>
<td>13.74 (2.20)</td>
<td>13.63 (2.25)</td>
<td>13.65 (1.99)</td>
<td>13.75 (2.12)</td>
<td>13.70 (2.48)</td>
</tr>
<tr>
<td>Child race, %</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>White</td>
<td>56 (42.1)</td>
<td>55 (19.6)</td>
<td>51 (16.0)</td>
<td>57 (42.5)</td>
<td>61 (24.2)</td>
<td>59 (16.2)</td>
</tr>
<tr>
<td>African American</td>
<td>44 (32.7)</td>
<td>45 (16.0)</td>
<td>49 (15.9)</td>
<td>43 (32.2)</td>
<td>39 (15.7)</td>
<td>41 (11.3)</td>
</tr>
<tr>
<td>Child maturational status, mean (SD)</td>
<td>70.93 (2.30)</td>
<td>80.47 (5.40)</td>
<td>96.46 (3.75)</td>
<td>71.82 (2.49)</td>
<td>84.10 (5.37)</td>
<td>97.29 (2.42)</td>
</tr>
</tbody>
</table>
parent stature (meters), where mid–parent stature represents the average height of both parents. The regression equation for predicting adult stature takes the following form: predicted adult stature = β3 + β4(stature) + β5(weight) + β6(mid–parent stature), where β3, β4, and β5 are the coefficients by which stature, weight, and mid–parent stature, respectively, should be multiplied. Percentage of adult stature at a given age is then predicted by dividing adult stature by current stature. The β weights used in the equation differ for boys and girls at individual ages, respectively, and are specified by Khamis and Roche.39

### STATISTICAL ANALYSIS

Multinomial logistic regressions predicting child weight status were used to examine the possibility that the relationship between television use and weight status differs for children at different levels of familial risk for obesity. The odds of a child being at risk for overweight (BMI, 85th-94th percentile) and of being overweight (BMI, ≥95th percentile) were each compared with the odds of a child being of normal weight based on television viewing (in hours), parental weight status, and the interaction of television viewing and parental weight status. Ellipses indicate nonsignificant interaction terms, with only main effects reported. If interaction terms were not statistically significant at $P<.05$, the model without interaction terms was presented in this article. Otherwise, the model with interaction terms was interpreted.

Stata version 8.0 (StataCorp, College Station, Tex) was used for all of the analyses. Because of the existence of sibling pairs in the data, standard errors were corrected for nonindependence. Stata version 8.0 provides options for correcting possible deflation of standard errors due to nonindependence in the data (such as when siblings each provide data) by means of using a robust estimator of variance that does not assume independence of observations.

### RESULTS

Table 1 displays descriptive statistics for the variables of interest. Results of multinomial logistic regression models for each sex and age group are presented in Table 2. The odds ratios shown in Table 2 represent the odds of a child being either at risk for overweight (compared with children of normal weight) or overweight (compared with children of normal weight). Odds ratios of 1.0 represent exactly even odds. Odds ratios above 1.0 indicate increased odds, and odds ratios below 1.0 indicate decreased odds. Interactions between television viewing hours and parental weight status, which significantly predicted child weight status at $P<.05$, are plotted in Figure 1 and Figure 2.

### DESCRIPTIVE STATISTICS

Of the children included in this study, more than one third either were at risk of overweight or were overweight. Many
children had parents who were overweight or obese. About four fifths of all of the children had at least 1 overweight or obese parent. Only one fifth of the children had both parents of normal weight. Children in this sample watched an average of 4 to 6 hours of television across 2 days (1 randomly selected weekday and 1 randomly selected weekend day).

**PARENTAL WEIGHT STATUS**

Having at least 1 obese parent presented an increased risk of child overweight for most of the age × sex groups. The 1 exception to these findings was among boys aged 6 to 9 years for whom parental weight status was unrelated to child weight status. Having at least 1 overweight parent was generally unrelated to risk of being at risk for overweight or being overweight. The 1 exception to this finding was among girls aged 14 to 19 years for whom at least 1 overweight parent as well as at least 1 obese parent dramatically increased the odds of being either at risk for overweight or overweight compared with being of normal weight (Table 2).

**TELEVISION VIEWING HOURS**

Hours of television viewing were related to increased odds of child overweight relative to normal weight among 3 groups: boys aged 6 to 9 years, boys aged 10 to 13 years, and girls aged 14 to 19 years. Television viewing hours were generally unrelated to odds of being at risk for overweight compared with normal weight.

**INTERACTION OF PARENTAL WEIGHT STATUS AND TELEVISION VIEWING**

There were significant interactions between parental weight status and television viewing for 2 of the 6 age and sex groups: older adolescent boys (aged 14-19 years) and younger adolescent girls (aged 10-13 years) (Table 2). These interactions are plotted in Figure 1 and Figure 2, respectively. As shown in Figure 1, the risk of overweight increased with television viewing hours for boys with at least 1 overweight parent but not for boys with normal-weight parents. For boys with normal-weight parents, by contrast, television viewing hours and risk of overweight were unrelated. This same pattern is evident, but much more so, among girls aged 10 to 13 years. Among girls aged 10 to 13 years with at least 1 obese parent, the probability of overweight status dramatically increased as television viewing increased. For younger adolescent girls with normal-weight parents, increases in television viewing were unrelated to increased risk of overweight.

**COMMENT**

We began this study with the premise that the relationship between television viewing hours and child weight status would be moderated by parental weight status. Specifically, we speculated that for children who were at risk of familial obesity, the relationship between television viewing and a status of child at risk for overweight or overweight would be strongly positive. Though reasonable, this hypothesis received only moderate support. Results indicated that this was the case for 2 of the 6 sex × age groups that we examined—girls aged 10 to 13 years and boys aged 14 to 19 years.

For these 2 groups, the probability of elevated weight status increased with television viewing only among children whose parents were obese. This was particularly true for younger adolescent girls (aged 10-13 years), but it was also evident among older adolescent boys (aged 14-19 years). Among these sex and age groups, children with normal-weight parents could seemingly watch television with impunity—at least with regard to risk of elevated weight status.

These findings may be owing to developmental changes with respect to the relationship between parental weight status and child weight status or between television viewing and weight status. Whatever the case, they certainly have implications for intervention designs. It seems that among younger children (particularly those with normal-weight parents), decreasing television viewing may be an important component of prevention of a status of childhood at risk for overweight or overweight. For older children, however, decreasing television viewing as either an over-
weight prevention or an intervention strategy seems most likely to have an impact on children with obese or overweight parents. These findings highlight the importance of attending to familial characteristics (in this case, parental weight status) when attempting to assess the relationship between television viewing and child weight status.

PARENTAL WEIGHT STATUS AND CHILD WEIGHT STATUS

We believe that these findings point to the crucial importance of including parental weight status in research examining factors related to child weight status. Parental weight status was consistently and strongly related to child weight status. This was particularly true if at least 1 parent was obese.

TELEVISION VIEWING AND CHILD WEIGHT STATUS

Overall, television viewing seemed to be more implicated in increased odds of a child being overweight than a child being at risk for overweight. Looking across the age and sex groups, television viewing hours were significantly related to an increased risk of overweight compared with normal weight for boys aged 6 to 9 and 10 to 13 years and for girls aged 14 to 19 years. Despite the general conviction that television viewing is strongly and consistently related to childhood obesity, this pattern of results is, in fact, much like those from previous epidemiologic research in this area—equivocal and not particularly strong. The relationships are there for some children but not others, or they are even reversed (with more television viewing related to decreased risk of elevated weight). Moreover, the magnitude of the effects were not particularly large—the highest positive odds ratio was 1.42 (the lowest 1.24).

LIMITATIONS AND FUTURE DIRECTIONS

In these analyses, we examined age and sex groups, controlling for ethnicity. It is quite possible (and indeed probable) that the relationship between television viewing and child weight status varies importantly by ethnicity as well as age and sex. Unfortunately, the sample size limited our ability to examine associations among different age and sex groups also defined by ethnicity. Examining the extent to which ethnicity plays a role in the relationships among parental weight status, television viewing, and child weight status will be an important area for further research.

Although a number of studies indicate that self-reported height and weight are highly correlated with observed measures (on the order of $r = 0.90$), there is also evidence that a systematic bias exists such that adults tend to overestimate their height and underestimate their weight. Thus, to the extent that parents in this study underestimated their BMI, the findings would be biased toward the null hypothesis.

Another important limitation is the lack of information regarding parents' viewing habits. That is, it seems likely that parental media use itself would be a strong moderator of the relationship between childhood media use and BMI. Our ability to examine this possibility in these data was hampered by the fact that information regarding parents' own viewing habits was not collected. The connection between parents' and children's viewing habits and the intersection of these viewing habits with both parental and child obesity is a crucial area of further investigation.

Parental weight status represents both genetic and environmental influences on children's weight status. Although we cannot separate these influences in these data, doing so is an important component to furthering the understanding of the nature of familial influences on childhood obesity. Similarly, although we had theoretical reasons for focusing on parental weight status, other familial factors (such as parents' own activity levels, media use, family eating habits) clearly merit further investigation.

CONCLUSIONS

We believe that the varied nature of these results highlights the notion that the relationship between television viewing and child weight status is neither simple nor the same across children of differing sexes and ages. These findings may help to explain the generally weak association between television viewing and child weight status often found in existing research based on heterogeneous populations. These findings may also have important implications for prevention and intervention designs. Our findings suggest that reductions in BMI with concomitant reductions in television viewing will be evident in some groups of children but not others. Specifically, television viewing hours alone seemed importantly related to risk of overweight among younger groups of boys (between the ages of 6 and 13 years) but not for other groups of children. However, for other children, especially adolescent boys and girls, the relationship between television viewing and overweight was only evident among children at familial risk of obesity (those with at least 1 obese parent). Thus, these findings suggest that researchers interested in designing childhood weight status interventions should certainly consider parental obesity in their project designs.

We understand that this message is somewhat at odds with both popular and scholarly convictions that television viewing—alone—is largely to blame for the current epidemic of being at risk for overweight and being overweight among American children. Although it is not an unreasonable hypothesis, empirical evidence for it is, to date, surprisingly equivocal. The findings of this study suggest that parental weight status is an important moderator of the relationship between television viewing and child weight status and that researchers interested in understanding and intervening in childhood obesity would do well to collect information from parents as well as children. As noted, in this study, we focused exclusively on parental weight status as a moderator of the relationship between television viewing and child weight status. It seems reasonable to assume that there may be other important familial moderators (or mediators) as well. To date, however, surprisingly few studies, either epidemiologic or experimental in nature, include parental or familial contextual information in their data collection schemes. Thus, we know little about the
contextual factors affecting relationships between television viewing and childhood overweight.19,30 Our view is that it behooves us to understand the true nature of the role that media use plays in the development of obesity. To do this, we would argue that research agendas must move beyond a focus on single linkages between television viewing and childhood overweight so that we may arrive at a more nuanced and complex understanding of the ways in which (and for whom) they are related and unrelated. As a very real threat to public health, it is crucial to identify central contributing factors to the development of obesity so that we may appropriately target prevention and intervention efforts. It seems safe to say that technology is here to stay, and it is virtually guaranteed to play an ever-increasing role in our daily lives. Thus, a thorough understanding of the nature of its impact on health and well-being is a vital component of the public health agenda in the United States.

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