Objective: To determine if limited ability to delay gratification (ATDG) at age 4 years is independently associated with an increased risk of being overweight at age 11 years and to assess confounding or moderation by child body mass index z score at 4 years, self-reported maternal expectation of child ATDG for food, and maternal weight status.

Design: Longitudinal prospective study.

Setting: Ten US sites.

Participants: Participants in the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development.

Main Exposure: Ability to delay gratification at 4 years, measured as pass or fail on a validated task.

Outcome Measures: Overweight at 11 years, defined as a body mass index greater than or equal to the 85th percentile based on measured weight and height.

Results: Of 805 children, 47% failed the ATDG task. Using multiple logistic regression, children who failed the ATDG task were more likely to be overweight at 11 years (relative risk, 1.29; 95% confidence interval, 1.06-1.58), independent of income to needs ratio. Body mass index z score at 4 years and maternal expectation of child ATDG for food did not alter the association, but maternal weight status reduced the association significantly.

Conclusions: Children with limited ATDG at age 4 years were more likely to be overweight at age 11 years, but the association was at least partially explained by maternal weight status. Further understanding of the association between the child's ATDG and maternal and child weight status may lead to more effective obesity intervention and prevention programs.

the last 20 years, the research in self-regulation has shifted from ATDG specifically to impulsivity as a more general construct,17,18 of which ATDG is just 1 component.19 That shift likely connects to the broader belief that overeating reflects problems with several control/ inhibitory and excitatory mechanisms that may reorganize themselves throughout one’s life.

To our knowledge, no study has evaluated the potential role of ME-ATDG in altering the association between ATDG and overweight status in children. If we consider limited ATDG to be an early-appearing or innate characteristic, mothers who expect their children to have ATDG for food may reduce the effect of this characteristic on obesity risk through parenting. An alternative hypothesis is that a child’s ATDG is not innate, but rather entirely the result of parenting, in which case maternal expectations of the child and the child’s actual observed ATDG would each predict the child’s weight status in the same way.

To our knowledge, no study has evaluated the potential role of maternal weight status in altering the association between children’s ATDG and risk of overweight. Maternal obesity strongly predicts child obesity,20 and 1 study found that obese women have limited ATDG.21 If the link between a child’s ATDG and obesity is reduced or eliminated by maternal weight status, this suggests that a child’s ATDG is either a learned behavior from a mother who herself has limited ATDG or possibly a genetically mediated phenotype associated with an increased risk of overweight.

If there is an association between ATDG and overweight risk, this could provide a specific point of intervention. The first aim of this study was to test the hypothesis that children with limited ATDG at 4 years will have a higher risk of being overweight at 11 years, independent of potential confounders. The second aim was to determine if this association is confounded or moderated by the child’s body mass index (BMI) z score at 4 years, ME-ATDG, and maternal weight status.

Although the task has always used food as the experimental stimulus, it has been conceptualized as a general, and not food-specific, measure of ATDG. During a videotaped laboratory session, children first chose candy, animal crackers, or pretzels as their preferred food. They were shown a large and a small quantity of their chosen food, and it was confirmed that children identified the larger quantity as preferable. The waiting game was then explained to the child: the examiner would leave the room and 2 plates would be left with the child, one with a large quantity of the chosen food and the other with a small quantity. The child was told that he would be allowed to eat the large quantity of the chosen food if he waited until the examiner returned. If he could not wait until the examiner returned, he could ring a bell to summon the examiner back into the room, at which time he could eat the small quantity. Children’s understanding of the instructions was confirmed. Of the 1038 children who participated, 72 were excluded because they did not understand the task, resulting in a final sample of 966.

The examiner then left the room and observed the child through a 2-way mirror. If the child waited the prescribed 7 minutes until the examiner returned, he or she was given a passing score and was given the large quantity of the chosen food (n=514). If the child rang the bell to summon the examiner back into the room before 7 minutes had passed, he or she was scored as failing and received the small quantity of the chosen food (n=334). The child was also scored as failing if, before the 7 minutes had passed, he ate the food without summoning the examiner, became distressed, went to the door, or called for his parent or the examiner (n=118). These final 2 categories were combined such that 452 children were considered to have failed.

**MAIN OUTCOME MEASURE**

At ages 4 and 11 years, heights and weights were measured by standardized protocol.22 Body mass index was calculated (weight in kilograms divided by height in meters squared) and children with a BMI greater than or equal to the 85th percentile for age and sex23 at age 11 years were categorized as overweight.24 Body mass index z score was calculated at age 4 years and used to control for baseline weight status.

**COVARIATES**

**Demographics**

Demographic covariates included sex, race, and income to needs (TEN) ratio. These covariates were considered because of their association with overweight and ATDG. Specifically, a more limited ATDG has been reported among males,29 lower-income groups,30 and children with absent fathers31; and overweight in children has a higher reported prevalence among black and Hispanic populations,28 lower-income groups,32 and children of single mothers.33

**Maternal Expectation of Child ATDG for Food**

Maternal expectation of child ATDG at 4 years was assessed with a question in the Home Observation for Measurement of the Environment Inventory,34 a standardized instrument using combined observation and semi-structured interviewing designed to assess the quality and quantity of support and stimulation provided to the child in a home environment. A research assistant trained to reliability in interview technique asked each mother whether or not she allowed her child to eat whenever the child expressed interest in eating or if she im-

**METHODS**

**SAMPLE**

The National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD-SECCYD) is a longitudinal study of the child care environment and its association with child health, behavior, and development. Details of study eligibility, recruitment, and characteristics of the original cohort have been described elsewhere.21 The study was approved by the institutional review boards of all relevant institutions.

We used data collected at ages 4 and 11 years. The ATDG task in the NICHD-SECCYD was performed at age 4 years, an age during which self-regulatory competence is developing.1,22 We focused on age 11 years as the time to examine outcome, because between ages 5 and 11, the incidence of childhood overweight increases significantly24,25 and children develop more independence in eating such that limited ATDG may begin to go unchecked by parental supervision.

**MAIN EXPOSURE**

Ability to delay gratification at age 4 years was assessed using Mischel and Ebbesen’s20 validated, self-imposed waiting task.
posed some restrictions on him or her regarding eating. The mother was encouraged to tell in her own words what she did and how she expected her child to show ATDG. If there was a lack of clarity, the interviewer then followed a protocol to probe further to determine precisely what restrictions were placed on eating until the interviewer had established whether the standards stipulated in the question item were met. “Some delay of food gratification is expected” was scored as yes vs no based on the mother’s responses. A score of yes was given if (1) rules were established and enforced regarding eating between meals and (2) routines were established for snacking between meals. To get credit for the item, the child was not allowed to snack whenever he or she chose, was not permitted a snack within 30 minutes of a meal, and was not permitted to “nibble” all day, with logical and reasonable exceptions. A score of no was given if the mother reported that a child could obtain snack items on his or her own or with the aid of a sibling, was typically given snacks upon request, or if the child was allowed to eat within 30 minutes of a planned meal. If the parent’s initial response to the interviewer’s question about rules and routines pertaining to snacking was unclear, the interviewer probed more to determine whether the criteria for obtaining a yes response were satisfied.

Maternal Weight Status

The NICHD-SECCYD data set does not include measured maternal weight or height. Figure ratings based on pictorial scales correlate with actual measured weight status, with $r=0.87$ using the 9-point Stunkard Figure Rating Scale with videotaped images and BMI. Videotaped images of the mother during standardized study tasks when the child was aged 15 (n=1114), 24 (n=1161), and 36 (n=1175) months were coded for maternal weight status using the Stunkard Figure Rating Scale, in which higher scores represent a higher BMI. All tapes were double-coded by independent raters blind to study hypotheses and subject characteristics not observable in the videotapes (intraclass correlation coefficient, 0.80-0.90). Data points at which the mother was pregnant were excluded (n=48 at 15 months, n=69 at 24 months, and n=358 at 36 months) and the remaining values were averaged to obtain the maternal weight status variable used in this analysis. This coded maternal weight status variable (n=1233) was correlated with maternal BMI based on self-reported weight and height when the child was aged 15 years (n=912), with $r=0.74$.

**STATISTICAL ANALYSIS**

Univariate and bivariate statistics, including $x^2$ and t-tests, were used to describe the sample by ATDG at age 4 years. We tested the unadjusted association of each demographic covariate (sex, race, ITN ratio, and maternal marital status) with the outcome, overweight status at age 11 years. Multiple logistic regression was used to evaluate the association between failing the ATDG task at age 4 years and being overweight at age 11 years, controlling for the demographic covariates that were significantly associated with the outcome in unadjusted analyses. Covariates that were no longer significantly associated with the outcome in this multivariate model were removed to generate the base model. Interaction terms for ATDG with each covariate in the base model were tested.

In the base model, we then individually tested child BMI $z$ score at 4 years, ME-ATDG, and maternal weight status. Each covariate was assessed for its main effect on child overweight, its role as a potential mediator via its effect on the main effect of ATDG on overweight, and its role as a potential moderator via testing the interaction of each of these covariates with ATDG.

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**RESULTS**

Almost half (47%) of the children failed the ATDG task at age 4 years. Characteristics of the sample by ATDG are provided in Table 1.

Results of the multiple logistic regression analyses are presented in Table 2. One third (33%) of the children were overweight at age 11 years. In unadjusted bivariate analyses, overweight was associated with both race (20.2% of overweight children were not white vs 14.2% of nonoverweight children, $P=.03$) and ITN ratio (3.0 [standard deviation (SD), 2.4] among overweight children vs 3.9 [SD, 3.5] among nonoverweight children, $P<.001$). When both race and ITN ratio were included in the model with ATDG, race was no longer significant and therefore excluded from the final base model. Children who failed the ATDG task had 1.3 times the risk of being overweight at age 11 years independent of ITN ratio. The interaction of ATDG and ITN ratio was not significant ($P=.45$).

The main effect of ATDG was not altered when the child’s BMI $z$ score at 4 years was included in the model (relative risk, 1.30; 95% confidence interval, 1.08-1.57, 0.80).
for the main effect of ATDG). The main effect of ATDG was also not altered when ME-ATDG was included in the model (relative risk, 1.28; 95% confidence interval, 1.04-1.56, for the main effect of ATDG). The main effect of ATDG was, however, significantly reduced when maternal weight status was included in the model (relative risk, 1.16; 95% confidence interval, 0.95-1.42, for the main effect of ATDG). There was no significant interaction between ATDG and BMI z score at 4 years ($P = .63$), ME-ATDG ($P = .61$), or maternal weight status ($P = .51$).

We considered that the association between failing the ATDG task and risk of overweight may have differed based on the manner in which the child failed the ATDG task. We found that there was no difference in the risk of overweight based on whether the failure was due to the child failing by ringing the bell vs spontaneously eating the food or becoming distressed ($P = .29$).

### Table 2. Overweight at Age 11 Years in Relation to ATDG at Age 4 Years in Unadjusted and Adjusted Analyses

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unadjusted (n=818)</th>
<th>Base Model Adjusted for Child's BMI z Score at 4 Years (n=797)</th>
<th>Base Model Adjusted for ME-ATDG (n=792)</th>
<th>Base Model Adjusted for Maternal Weight (n=801)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inability to delay gratification$^a$</td>
<td>1.44 (1.18-1.75)</td>
<td>1.30 (1.08-1.57)</td>
<td>1.28 (1.04-1.56)</td>
<td>1.16 (0.95-1.42)</td>
</tr>
<tr>
<td>Income to needs ratio$^b$</td>
<td>0.92 (0.88-0.97)</td>
<td>0.95 (0.91-0.99)</td>
<td>0.92 (0.87-0.96)</td>
<td>0.96 (0.92-1.01)</td>
</tr>
<tr>
<td>BMI z score at 4 y</td>
<td>1.90 (1.73-2.10)</td>
<td>1.21 (0.99-1.47)</td>
<td>1.32 (1.24-1.40)</td>
<td></td>
</tr>
<tr>
<td>No ME-ATDG for food</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean maternal weight status at 15, 24, and 36 mo$^c$</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ATDG, ability to delay gratification; BMI, body mass index; ME-ATDG, maternal expectation of child ATDG.

$^a$Failed ATDG task.

$^b$Reflects ratio of family income to poverty line; family living at poverty line has an income to needs ratio of 1.0, evaluated continuously with each 1-unit increase reflecting increase in income relative to the poverty line.

$^c$Range 1 to 9, with obesity (BMI [calculated as weight in kilograms divided by height in meters squared] $\geq 30$) at about 6; each 1-unit increase reflects increasing BMI.

To our knowledge, this is the first study to find that children with limited ATDG are more likely to be overweight several years later independent of ITN ratio. Although our study cannot prove causality, results support prior studies that suggest that ATDG is a potential factor in overweight risk among children. Controlling for BMI z score at 4 years did not change the association between failing the ATDG task and overweight risk, indicating that the effect of limited ATDG on overweight risk operated at least in part after age 4 years.

Children with limited ATDG may be particularly at risk in today’s environment of ubiquitous food availability when parents provide limited guidance. Indeed, children with insecure attachment have less ATDG, and insensitive or neglectful parenting increases overweight risk. To our surprise, our hypothesis that parenting (in the form of ME-ATDG) would moderate or eliminate the association between the child’s observed ATDG and overweight risk was not supported. Results suggest that parenting in the form of ME-ATDG is not wholly responsible for the child's actual ATDG, and that the mother's self-reported expectations surrounding the child’s ATDG seem to do little to mute the risk conferred by limited ATDG.

Our hypothesis that maternal weight status would attenuate the association between limited ATDG and increased risk of overweight was supported. The influence of maternal weight status on child weight reflects genetic as well as environmental factors, such as feeding patterns and availability of food. Although children’s limited ATDG for food may reflect behavior learned from an overweight mother, there is evidence that eating behaviors are inherited as well as learned. Children with this eating style have higher BMIs. We postulate that children with a heritable disinhibition, or propensity to eat in the absence of hunger, may have limited ATDG for food, increased consumption, and therefore may be more likely to be overweight.

Preschoolers’ ATDG has been shown to develop with age and can be modified. Children have better ATDG when they believe there are consequences to others rather than themselves; they are provided distractions, and the desired reward is out of sight. Three- and 4-year-old children demonstrated an improved ATDG when they were taught the difference in immediate vs long-term rewards between 2 choices. Hence, focusing on improving children’s ATDG for food during the preschool years when self-regulatory competence is developing presents itself as 1 potentially interesting area for future intervention research.

Our study has limitations. This is an observational study and not a randomized controlled trial, thus the ability to infer causation is limited. It remains possible that the observed association is due to other unmeasured construct underlying both limited ATDG and childhood overweight. There was also some loss to follow-up with missing data, which may affect our results. This sample, though more diverse than previous cohorts, primarily earn middle to upper incomes, are white, and may not be generalizable to low-income or African American or Hispanic populations, which have higher preva-
lences of both overweight and limited ATDG. Finally, though maternal weight status was based on observational data with high interrater reliability, measured weight status would clearly be optimal.

Our ATDG measure used food as a stimulus and we are therefore unable to answer with this study whether the association between limited ATDG and increased overweight risk is reflective of only limited food-related ATDG or limited general ATDG. Some studies have shown that the association between limited ATDG and increased overweight risk is moderated by stimulus type, such that the association is present only for food-related ATDG and not non–food-related ATDG. Other studies have provided no evidence for stimulus type (food vs nonfood) as a moderator of the association. Future research could test effect modification by stimulus type in large samples.

Another limitation of the study is that we did not measure parental attempts to control food/caloric intake beyond ME-ATDG. It may well be that other aspects of parental control over their children’s food intake (eg, limiting what is served, limiting children’s discretion pertaining to food intake during meals, eliminating or strongly limiting snacks) are more critical than expectations regarding delay of gratification; or, it may be that it is the combination of various control techniques that is critical. Maternal expectation of child ATDG may be part of that package, but its effects may only be discernible if a broader array of parental control strategies is examined holistically, of which some strategies deal with food intake and some with child self-regulation more broadly.

A better understanding of how parenting styles can help children develop ATDG may guide the development of more effective prevention and treatment programs for overweight children. Pediatric health care providers may help in several ways. First, they could educate families about the concept of ATDG and interview parents to determine if the child seems to have limited ATDG. When a child is described as having limited ATDG, the pediatric health care provider could introduce parents to parenting strategies that would accomplish 1 of 2 goals. First, the parents may try to enhance the child’s ATDG. Some strategies that have been described in prior studies have been keeping the desired item (in this case, food) out of sight (and therefore out of mind) or distracting the child’s attention from the food to another engaging activity. Another possibility is simply providing a logical structure to snacks and meals and that the child learns that food is not to be eaten the moment it is desired, but to wait until the next snack or meal time. A second parenting strategy to address a child’s limited ATDG might be to simply manage the environment so that the child’s limited ATDG does not result in overconsumption. Specifically, for some children, parents may simply need to limit access to unhealthy, calorically dense foods. Doing so will decrease temptation and likely decrease frustration for both child and parent.

In summary, parents may be advised that limited ATDG for food at age 4 years may be associated with an increased risk of overweight at age 11 years. With the introduction of parents to effective strategies to help the child delay gratification for food, it may be possible to reduce the risk of children becoming overweight in the future.

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Correspondence: Julie C. Lumeng, MD, Center for Human Growth and Development, 300 N Ingalls Bldg, 10th Floor, University of Michigan, Ann Arbor, MI 48109-5406 (jlmeng@umich.edu).

Author Contributions: Ms Seeyave had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Seeyave, Bradley, and Lumeng. Acquisition of data: Corwyn, Bradley, Davidson, and Lumeng. Analysis and interpretation of data: Coleman, Appugliese, Corwyn, Kaciroti, and Lumeng. Drafting of the manuscript: Seeyave, Davidson, and Lumeng. Critical revision of the manuscript for important intellectual content: Coleman, Appugliese, Corwyn, Bradley, Kaciroti, and Lumeng. Statistical analysis: Coleman, Appugliese, Corwyn, Kaciroti, and Lumeng. Obtained funding: Bradley and Lumeng. Administrative, technical, and material support: Seeyave, Davidson, and Lumeng. Study supervision: Lumeng.

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REFERENCES


Correction

Change in Dosage. In the Advice for Patients page in the February issue of Archives (2009;163:192), it was recommended that “all infants, including those who are exclusively breastfed, have a minimum intake of 200 IU of vitamin D per day beginning in the first 2 months of life.” In November 2008, the American Academy of Pediatrics changed this recommendation to 400 IU of vitamin D per day “beginning in the first few days of life.”