



# Blunted cortisol response to stress is associated with higher body mass index in low-income preschool-aged children



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## KEYWORDS

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**Summary** No known studies have tested the hypothesis that a blunted pattern of cortisol reactivity to stress, which is often found following exposure to chronic life stressors, is associated with a higher body mass index (BMI) in very young children. Low-income children ( $n = 218$ , mean age 56.6 (range: 38.1–78.5; SD 7.0) months, 49.1% male, 56.4% white, 16.1% black, 11.5% Hispanic/Latino) participated in a series of behavioral tasks designed to elicit stress. Cortisol was sampled in saliva 5 times during the protocol, and area under the curve (AUC), representing total cortisol output during stress elicitation, was calculated. Children were weighed and height measured and body mass index (BMI) z-score was calculated. Linear regression was used to evaluate the association between cortisol AUC and BMI z-score, controlling for child age, sex, and race/ethnicity (non-Hispanic white vs. not); primary caregiver weight status (overweight, defined as BMI  $\geq 25$  vs. not); and family income-to-needs ratio. Mean child BMI z-score was 0.88 (SD = 1.03). Mean cortisol AUC was 6.11  $\mu\text{g}/\text{dL}/\text{min}$  (SD = 10.44). In the fully adjusted model, for each 1-standard deviation unit decrease in cortisol AUC, the child's BMI z-score increased by 0.17 (SE 0.07) standard deviation units ( $p < 0.02$ ). A blunted cortisol response to stress, as is often seen following chronic stress exposure, is associated with increased BMI z-score in very young children. Further work is needed to understand how associations between stress, cortisol, and elevated body mass index may develop very early in the lifespan.

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## 1. Introduction

More than one third of low-income United States preschool-aged children are overweight (Kimbro et al., 2007). Living in poverty can expose children to significant life stressors (Evans and English, 2002), which can be biologically manifested through changes in the hypothalamic–pituitary–adrenal (HPA) axis leading to altered patterns of cortisol secretion (Zalewski et al., 2012). Chronically stressed children and adults have also been shown to display atypical HPA-axis responses to an acute stressor. Typically, stress signals originating in the brain result in the activation of the adrenal glands to secrete cortisol, which rises to a peak in blood or saliva in 20–40 min after a stressor, followed by a decline to baseline 40–60 min post-stressor (Dickerson and Kemeny, 2004). Chronically stressed individuals instead can show either a blunted cortisol reactivity response to a stressor, or prolonged elevation with little to no recovery to baseline (Van Ryzin et al., 2009). Such changes in stress response have been proposed as a pathway through which poverty can “get under the skin” and lead to health problems, specifically obesity (Gundersen et al., 2011). Cortisol increases appetite and shifts food preferences to so-called “comfort foods” (foods high in fat and added sugars) (Pasquali et al., 2010) that may reduce feelings of stress via dampening of HPA axis activity (Dallman et al., 2003). Repeated stressors and associated cortisol release may lead to excessive consumption of foods high in sugar and fat, and ultimately excessive weight gain. Therefore, following exposure to repeated stressors, both a blunted cortisol reactivity response to a stressor and elevated body mass index (BMI) may be observed. In the current study, we examined cortisol responses to an acute stressor in relation to BMI in a sample of low-income preschool-age children.

Six prior studies in adults have examined associations between cortisol reactivity to a stressor and adiposity, with conflicting results. These studies found no association of cortisol reactivity with BMI (Brydon, 2011; Epel et al., 2000; Therrien et al., 2010); high cortisol reactivity (peak response) associated with greater central adiposity (Epel et al., 2000) and BMI (Benson et al., 2009); and less (blunted) cortisol reactivity associated with higher BMI (Jones et al., 2012; Phillips et al., 2012) and greater central adiposity (Jones et al., 2012). Only two studies have evaluated the association of cortisol reactivity with adiposity in children, finding that high cortisol reactivity was associated with a higher BMI in children ages 8–13 years (Dockray et al., 2009) or 8–9 years (Francis et al., 2013), but not in children ages 5–7 years (Francis et al., 2013).

Young, preschool-age children are in a unique developmental period both for the establishment of effective responses for coping with stress (Cole, 1986; Cole et al., 2009), as well as childhood obesity, which, once established during the early childhood years, tends to persist into adulthood (Freedman et al., 2001). Documenting the nature of cortisol reactivity–obesity associations at younger ages is important in order to understand the development of such associations over time. In addition, understanding these associations among low-income children is particularly important, since children growing up in poverty are at risk for both self-regulation challenges (Evans and English, 2002) and obesity (Shrewsbury and Wardle, 2008).

Thus, in the context of these conflicting findings and the lack of data in young children, we sought to test the hypothesis that blunted patterns of cortisol reactivity to an immediate stress are associated with a higher BMI z-score (BMI<sub>z</sub>) among low-income preschool-aged children.

## 2. Methods

### 2.1. Study design and participants

Participants were children who had attended Head Start, a free, federally funded preschool program for low-income children, who were participating in a longitudinal study of child eating behavior. Families were invited to participate in the current study, which was described as a study of whether children with different levels of stress hormone eat differently. Exclusion criteria were: parent with  $\geq 4$  year college degree; parent or child not English-speaking; child in foster care, with food allergies, significant medical problems or perinatal complications, or children who were  $< 35$  weeks gestation at birth. The sample described in this report includes participants with complete data for the predictor, outcome, and all covariates in this analysis ( $n = 218$ ). Children were 56.6 months old on average (range: 38.1–78.5;  $SD = 7.0$ ). The sample was 49.1% male. Most children (56.4%) were white, 16.1% were black, and 15.1% were biracial; 11.5% were of Hispanic/Latino ethnicity. Family income-to-needs ratio was below 1.0 ( $M = 0.93$ ,  $SD = 0.88$ ), confirming that this was a very low-income sample. The majority of children's mothers were overweight (78.9%). The study was approved by the University of Michigan Institutional Review Board.

### 2.2. Procedure and measures

Children and their primary caregivers attended a study visit at 1:00 pm on one afternoon during which children participated in a stress-elicitation challenge protocol and were weighed and measured. The primary caregiver reported child race/ethnicity, family income and number of family members; and for the child on the day of the protocol, any medication use, illness, unusually good or bad events, exact time of morning awakening and if it was the usual time, and the last time the child ate.

### 2.3. Stress-elicitation challenge protocol

The child was brought to a room separate from the parent and was first engaged in calming free play with the examiner for 20 min. The child then participated in four challenge tasks. Each task was designed to elicit a mild to moderate level of stress, with tasks including a negative social evaluation component, which is a particularly robust elicitor of cortisol reactivity (Dickerson and Kemeny, 2004; Gunnar et al., 2009).

The child first rated six prizes from most preferred (e.g., toy car or doll) to least preferred (e.g., broken comb or deflated ball) and was told he or she could have the most preferred prize as a gift later. The examiner then removed the prize from the room.

During the first challenge task, *Perfect Circles* (Goldsmith and Rothbart, 1996), the examiner instructed the child to

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