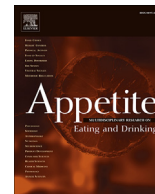




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Executive functioning in a racially diverse sample of children who are overweight and at risk for eating disorders

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ABSTRACT

Difficulties with executive functioning may underlie both overweight and loss of control (LOC) eating behavior across the age spectrum, but there is a relative paucity of research in children with both conditions. This study aimed to characterize general executive functioning among children with overweight and LOC eating as compared to their overweight and normal-weight peers. Participants were 75 racially diverse children (58.7% female; 81.3% African-American), aged 9–12y (M age = 10.5 ± 1.1), of whom 26 were overweight/obese and endorsed LOC eating (OW-LOC), 34 were overweight controls (OW-CON), and 15 were normal-weight controls (NW-CON). All children completed interview-based measures of eating pathology, and behavioral measures of executive functioning. Parents reported on behavioral facets of children's executive functioning. Groups were compared across parent-report measures and behavioral tasks using analyses of covariance (ANCOVAs) and multivariate analyses of covariance (MANCOVAs) which adjusted for general intellectual functioning. Significant group differences were revealed on a behavioral measure of planning, the Tower of London task [$F(5,65) = 3.52$; $p = 0.007$], and a behavioral measure of working memory, the List Sorting task [$F(2,71) = 6.45$; $p = 0.003$]. Post-hoc tests revealed that OW-LOC and OW-CON performed worse than NW-CON on the Tower of London, with relative decrements in accuracy rather than performance time. Further, OW-LOC performed worse than both OW-CON and NW-CON on the List Sorting task. Overweight with or without concomitant LOC eating in children may characterize a unique pattern of executive dysfunction. Interventions for eating- and weight-related problems in youth should address underlying deficits in planning and working memory.

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Abbreviations: OW-LOC, overweight with loss of control; OW-CON, overweight control; NW-CON, normal-weight control; ANOVA, analysis of covariance; MANCOVA, multivariate analysis of covariance; LOC, loss of control; BMI, body mass index; CDC, Centers for Disease Control and Prevention; BED, binge eating disorder; ADHD, attention deficit hyperactivity disorder; EDE, Eating Disorders Examination; CRS, Conners Rating Scale; BRIEF, Behavior Rating Inventory of Executive Function; DCCS, Dimensional Change Card Sort; IGT, Iowa Gambling Task; TOL, Tower of London; WASI, Wechsler Abbreviated Scale of Intelligence.

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1. Introduction

Pediatric obesity is a major public health concern that is linked to the development of cardiovascular risk factors in childhood (Reilly et al., 2003) and a wide range of health concerns in adulthood (Al Mamun, Cramb, O'Callaghan, Williams, & Najman, 2009; Baker, Olsen, & Sorensen, 2007; Field, Cook, & Gillman, 2005). Loss of control (LOC) eating, characterized by a sense that one cannot control what or how much one is eating, is an obesity-related phenotype that presents in up to 20% of non-treatment seeking youth with overweight or obesity (He, Cai, & Fan, 2016) and is associated with the development of eating disorders and other serious health impairments (Goldschmidt, Loth, et al., 2015;

Goossens, Braet, & Decaluwe, 2007; Schluter, Schmidt, Kittel, Tetzlaff, & Hilbert, 2016). Preliminary research suggests that difficulties with executive functioning may underlie both obesity (Fitzpatrick, Gilbert, & Serpell, 2013; Liang, Matheson, Kaye, & Boutelle, 2014) and LOC eating behavior (Van den Eynde et al., 2011) across the age spectrum, with LOC eating in adults characterized by difficulties with problem-solving, decision-making, and inhibition, above and beyond the effects of obesity (Manasse et al., 2015, 2016, 2014). However, there is a relative paucity of research in children. Characterizing executive functioning in children with comorbid overweight and LOC eating could have important implications for prevention and treatment development, including helping to identify youth who may be at risk for excess weight gain and eating disorders (Tanofsky-Kraff et al., 2006, 2011, 2009), and highlighting relevant early intervention targets.

Executive functioning refers to cognitive activities directed towards achievement of a desired goal and involves a range of processes such as decision-making, planning, attention, problem-solving, inhibition, and cognitive flexibility, among others (Anderson, 2008; Chan, Shum, Touloupoulou, & Chen, 2008). Healthy regulation of eating behavior and body weight involves several aspects of executive functioning (e.g., generating a meal plan, inhibiting goal-incompatible responses to food cues). Poorer performance on behavioral measures of executive functioning has been related to obesity in both children (Liang et al., 2014; Verbeke, Braet, Claus, Nederkoorn, & Oosterlaan, 2009) and adults (Fitzpatrick et al., 2013). While few prospective studies have investigated the relation between obesity onset and executive functioning (Graziano, Calkins, & Keane, 2010), performance on respondent-based and behavioral measures of goal-oriented behavior appears to predict overweight status (Guxens et al., 2009) and weight change (Bub, Robinson, & Curtis, 2016; Duckworth, Tsukayama, & Geier, 2010; Francis & Susman, 2009; Goldschmidt, Hipwell, Stepp, McTigue, & Keenan, 2015; Groppe & Elsner, 2015; Koike, Hardy, & Richards, 2016) in children and adolescents.

In addition to its associations with body weight and weight gain, poor executive control appears to be predictive of increased food intake in adults (Guerrieri et al., 2007; Houben, 2011), suggesting that one possible pathway to obesity may involve disinhibited eating (i.e., eating in response to stimuli other than physiological hunger) as a result of poorer executive functioning. Indeed, adults with overweight/obesity and LOC eating show poorer performance on executive functioning tasks relative to controls with overweight/obesity only (Duchesne et al., 2010; Manasse et al., 2015, 2016, 2014; Mobbs, Iglesias, Golay, & Van der Linden, 2011). Similarly, recent data on children and adolescents also suggest that LOC eating is both concurrently related to diminished performance on measures of inattention/impulsivity (Hartmann, Czaja, Rief, & Hilbert, 2010; Reinblatt, Leoutsakos, et al., 2015; Reinblatt, Mahone, et al., 2015), and may mediate the prospective association between impulsivity and weight gain (Goldschmidt, Hipwell, et al., 2015). However, research in children has typically been constrained by self-report data or by the use of a limited number of domain-specific measures of executive functioning. Therefore, it is largely unknown how children with overweight and LOC eating perform across the spectrum of executive functioning constructs, which could inform screening and suggest relevant targets for early intervention programs.

Given that executive functioning deficits appear to be related to both obesity and eating disorders, there is a need to better characterize executive functioning in the subset of youth with comorbid obesity and LOC eating. Therefore, the aim of the current study was to assess performance on a range of executive functioning measures among children with obesity and LOC eating as compared to

overweight and normal-weight controls without LOC eating. Because no other studies, to our knowledge, have investigated executive functioning in children with both overweight and LOC eating, we focused on non-food-specific executive functions as a first step in this line of research to establish whether more general executive functioning deficits characterize this subset of youth with overweight. Furthermore, previous data in adults suggest that some executive dysfunctions associated with LOC eating are not food specific (Manasse et al., 2016). We hypothesized that children with overweight, regardless of LOC eating status, would show poorer performance across executive functioning assessments as compared to healthy controls, and that those with comorbid obesity and LOC eating would show the poorest performance.

2. Material and methods

2.1. Participants

Participants were 75 children (58.7% female; $n = 44$), aged 9–12y (M age = 10.5 ± 1.1), who self-identified as African-American (81.3%; $n = 61$), non-Hispanic Caucasian (12.0%; $n = 9$), non-Caucasian Hispanic (5.3%; $n = 4$), or Asian (1.3%; $n = 1$), which reflects the demographics of the study site. The sample was comprised of 26 youth with overweight/obesity (body mass index [BMI; kg/m^2] \geq 85th percentile for age and sex according to Centers for Disease Control and Prevention (CDC) normative data; Kuczmarski et al., 2000) who reported recent LOC eating (i.e., ≥ 1 episode of LOC eating in the 3 months prior to assessment; OW-LOC), 34 controls with overweight who reported no history of LOC eating (OW-CON); and 15 (BMI < 85th percentile for age and sex) controls who were normal-weight and denied any history of LOC eating (NW-CON). Within the OW-LOC sample, 5 participants (19.2%) reported objectively large LOC episodes only, 17 (65.4%) reported subjectively large LOC episodes only, and 4 (15.4%) reported both objectively and subjectively large LOC episodes. The sample size was selected to provide 80% power to detect a moderate effect (Cohen's $d = 0.69$), based on effect sizes reported in a previous study of neurocognitive functioning among youth with disordered eating (Allen et al., 2013). Because the primary comparisons of interest concerned OW-LOC and OW-CON, effect sizes and power calculations were based on these two groups.

Participants were recruited from the community via flyers distributed throughout The University of Chicago Medicine and surrounding areas, and from direct pediatrician referrals. Participants were excluded if they had medical conditions or were taking medications known to influence weight or appetite; met criteria for an eating disorder other than binge eating disorder (BED); or had a diagnosis of attention deficit-hyperactivity disorder (ADHD). Interested individuals completed a phone screen to assess basic study entry criteria, and eligible participants were invited to attend a study visit, along with a parent or guardian, in the Department of Psychiatry and Behavioral Neuroscience at The University of Chicago Medicine. Each participant and his/her caregiver provided written informed assent/consent, respectively. Study procedures were approved by The University of Chicago Institutional Review Board.

2.2. Measures

2.2.1. Anthropometric and sociodemographic variables

Height and weight were measured in light indoor clothing by a trained research assistant via stadiometer and calibrated digital scale, respectively. Child **z-BMI** was calculated using CDC growth charts and accompanying procedures (Kuczmarski et al., 2000). **Demographic data** were reported by children and parents, and

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