Structural equation modeling of the associations between the home environment and obesity-related cardiovascular fitness and insulin resistance among Hispanic children

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ABSTRACT

Hispanic children are disproportionally affected by obesity-related risk of metabolic disease. We used the structural equation modeling to examine the associations between specific diet and physical activity (PA) behaviors at home and Hispanic children's metabolic health. A total of 187 Hispanic children and their parents from an urban community in Wisconsin participated in the study. Exposure variables included, children's daily intake of sugar-sweetened beverages (SSB) and PA; home availability of SSB and PA areas/equipment; and parents' intake of SSB and PA, assessed through self-administered questionnaires. Outcome variables for children's metabolic health included, measured anthropometrics; cardiovascular fitness assessed using the Progressive Aerobic Cardiovascular Endurance Run (PACER); and insulin resistance determined with the homeostasis model assessment of insulin resistance ($HOMA_{IR}$). We found that children's daily intake of SSB was positively associated with BMI z-score, which in turn, was positively associated with $HOMA_{IR}$ ($P < 0.05$). Specific diet behaviors at home associated with children's intake of SSB, included home availability of SSB, which mediated the association between parents' and children's intake of SSB ($P < 0.05$). Children's PA was positively associated with PACER z-score, which in turn, was inversely associated with $HOMA_{IR}$ ($P < 0.05$). Specific PA behaviors at home associated with children's PA, included home availability of PA areas/equipment, which mediated the association between parents' and children's PA ($P < 0.05$). The structural equation model indices suggested a satisfactory model fit (Chi-square, $X^2 = 53.1$, comparative fix index $= 0.92$, root-mean-squared error associated $= 0.04$). The findings confirm the need for interventions at the family level that promotes healthier home environments by targeting poor diet and low levels of PA in all family members.

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1. Introduction

Childhood obesity in the United States (U.S.) has increased dramatically in the past three decades, with 30% of U.S. children and adolescents being overweight or obese, while that of Hispanic children is even higher at 40% (Ogden, Carroll, Kit, & Flegal, 2012). Obesity greatly increases the risk for developing type 2 diabetes (T2D), cardiovascular disease, sleep apnea, and asthma (Park, Falconer, Viner, & Kinra, 2012). Further, obese children manifest lower cardiovascular fitness (CVF) than their normal weight counterparts, further increasing the risk for T2D given that poor CVF is associated with insulin resistance (IR) (Pate, Wang, Dowda, Farrell, & O'Neill, 2006; Sinha et al., 2002).

Childhood obesity is likely attributed to both genetic and

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lifestyle factors, such as diet and physical activity (PA) (Wells & Siervo, 2011), since genetic susceptibility alone cannot fully explain the rapid increase in obesity rates in the past three decades. The interaction between genetic susceptibility and environments that promote diets high in energy-dense, nutrient poor foods and beverages with sedentary behaviors can explain, in part, a positive imbalance and excess weight gain (Johnson, Mander, Jones, Emmett, & Jebb, 2008; Sirard, Laska, Patnode, Farbakhsh, & Lytle, 2010). The social-ecological model emphasizes that childhood obesity (Davison & Birch, 2001) may be affected by multiple levels of influence, including biologic, demographic, psychological, social, and environmental, factors (Booth et al., 2001; Bronfenbrenner, 1986). Based on the social-ecological model, the neighborhood community has an impact on the school and home environments, including but not limited to the availability of foods and PA areas/ equipment, as well as parents' diet and PA, all of which have an influence on children's diet and PA (Booth et al., 2001; Elder et al., 2007). Parents not only create food and PA environments at home, but they also serve as role models influencing children's diet and PA behaviors (Bauer, Nelson, Boutelle, & Neumark-Sztainer, 2008; Johannsen, Johannsen, & Specker, 2006).

There has been an increasing interest in investigating associations between the availability of specific foods and PA areas/ equipment at home, and parents' diet and PA in relation to children's diet and PA. However, most studies have focused on one of these factors, limiting the understanding of how all of these factors mediate an individual's behavior within a particular environment. Existing analyses have focused on either the association between the home environment (HE) and children's diet and PA or the association between parental modeling of diet and PA with children's diet and PA alone (Campbell, Crawford, & Ball, 2006; G. Hendrie, Sohonpal, Lange, & Golley, 2013; Patnode et al., 2010; van der Horst et al., 2007). Whereas, only few have investigated the clustering of diet and PA behaviors at home in relation to children's lifestyle behaviors or risk of obesity (Crawford et al., 2010; Rodenburg, Oenema, Kremers, & van de Mheen, 2013). However, to the best of our knowledge, none of these studies have extended these associations to the risk of metabolic disease. Generally, these studies only provide partial evidence that a healthy HE and parental modeling of healthy diet and PA behaviors influence children's diet and PA and therefore their risk of metabolic disease. Taken together, these studies point out the need to simultaneously evaluate how all of these modifiable behaviors influence children's metabolic disease, including risk of obesity, poor CVF and IR.

The Structural Equation Modeling (SEM) is a powerful statistical tool that fits the social-ecological models for multivariate analysis. In social-ecological models, behavior is viewed as being affected by, and affecting multiple levels of influence. The SEM incorporates simultaneous structural equations where variables may influence one-another reciprocally, either directly or indirectly through other variables as mediators (Kline, 2010). Using the SEM approach, the present study is able to provide deeper insights into the directional associations between an array of individual, parental and familial correlates and children's risk of metabolic disease, as well as to explore any significant indirect associations. There are very few studies that have utilized the SEM approach and simultaneously evaluated the HE in relation to children's diet or PA and consequent risk of metabolic disease. Most importantly, most of these studies were primarily conducted among non-Hispanic white children, which limit the generalizability of the results (Heitzler et al., 2010; G. A. Hendrie, Coveney, & Cox, 2012).

To date, no such trans-disciplinary study approaches have been applied to the problem of childhood obesity, poor fitness, and risk of T2D, let alone applied to a Hispanic community. In this study, we developed a series of SEMs to examine the associations between the specific diet and PA behaviors at home, including home availability of SSB and PA areas/equipment, parents' intake of SSB and PA, and children's intake of SSB and PA in relation to risk of metabolic disease as assessed by obesity, CVF and IR measures. We previously showed that SSB consumption was associated with Hispanic children's BMI z-score, while the availability of SSB at home mediated the association between parents' and children's intake of SSBs (Santiago-Torres et al., 2016). In the present study, we use the SEM to extend this finding by incorporating the interactions with PA specific behaviors at home to evaluate their associations with children's obesity-related CVF and IR. We hypothesized that a home environment that promotes high intakes of nutrient-poor beverages and sedentary behaviors will be associated with children's diet and PA, which in turn, contributes to potential risk of metabolic disease.

2. Methods

2.1. Study population

A total of 187 Hispanic children (aged 10–14 years, 47% male) and 173 of their parents (75% mothers) participated in the cross-sectional study. More details on recruitment and study protocols are presented elsewhere (Santiago-Torres, Adams, Carrel, LaRowe, & Schoeller, 2014; Santiago-Torres et al., 2016). Briefly, the present study was part of a multidisciplinary community-based participatory research between the University of Wisconsin-Madison and the United Community Center—Bruce Guadalupe Charter School (BGCS). As part of this research initiative, enrollment was open to all children with academic attendance at BGCS in fifth to eight grades ($n = 300$). Inclusion criteria also included Hispanic ethnicity. The University of Wisconsin-Madison Institutional Review Board approved the study and all participants provided consent.

2.2. Familial demographics and the home environment assessments

Parents who participated in the study provided data on familial demographics and the HE through self-administered questionnaires that were designed for this study and have been described in more details (Santiago-Torres et al., 2014; Santiago-Torres et al., 2016). Briefly, the familial demographics form queried parents' age, ethnicity and family income. The HE was assessed using a one-time home environment survey that queried parents on the home food availability, PA areas and equipment availability at home, and parents own diet and PA behaviors. Single measures of the HE, parents' diet and PA behaviors were taken from the most widely used and validated HE surveys (Gattshall, Shoup, Marshall, Crane, & Estabrooks, 2008; Hanson, Neumark-Sztainer, Eisenberg, Story, & Wall, 2005). In other words, we combined these constructs as previously tested and validated in separate surveys (e.g., home food environment or parental diet alone) into one document to minimize participants' burden rather than providing participants with four different surveys. In details, parents were asked: 'During the past week, did you have the following food items available at your home (e.g., SSB, sugars-sweetened beverages; soda and fruit drinks)'; 'Does your child have any of the following areas and/or equipment available at home' with response options, yes or no. As for parents own diet and PA behaviors, parents were asked: 'Thinking about last week, how often did you consume the following foods/beverages (e.g., SSB)?'; and 'How often did you participate in any of the following PA-related activities' with response options: never, once per week, 2–4 times per week, 5–6 times per week, once per day or 2 or more per day. Parents (both mothers and fathers) also self-reported on their height and weight,