RELATIONS BETWEEN CHILD OBESITY AND EXECUTIVE FUNCTION AMONG LOW-INCOME LATINX FAMILIES PARTICIPATING IN AN OBESITY INTERVENTION: A SECONDARY ANALYSIS

by

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A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Psychology

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Date: July 29, 2020

Summer Semester 2020
George Mason University
Fairfax, VA

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Summer Semester 2020
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ABSTRACT

RELATIONS BETWEEN CHILD OBESITY AND EXECUTIVE FUNCTION AMONG LOW-INCOME LATINX FAMILIES PARTICIPATING IN AN OBESITY INTERVENTION: A SECONDARY ANALYSIS

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Rates of obesity have tripled worldwide since 1975 (World Health Organization, WHO, 2017), with the epidemic affecting both pediatric and adult populations. Given the increasingly widespread prevalence of childhood obesity, research has focused on how childhood obesity affects long-term physical and mental health outcomes, such as executive functioning. Research supports a bidirectional relationship between childhood obesity and executive functioning. Executive functioning (EF) describes the cognitive capabilities necessary for an individual to engage in goal-directed behavior (Miyake & Friedman, 2012). It includes constructs such as cognitive flexibility, working memory, and inhibition (Miyake & Friedman, 2012). Executive functions affect obesity through influencing the individual's ability to initiate healthy activities and to inhibit consumption of unhealthy food (Gettens & Gorin, 2017). This pattern of behaviors (i.e., failure to initiate healthy activities and overconsumption of unhealthy foods) results in weight gain

over time. Conversely, obesity changes the physical structure of the brain through decreased blood flow to the pre-frontal cortex in adolescents and adults (Fitzpatrick, Gilbert, & Serpell, 2013), which could result in the development of EF deficits over time. Although there is research examining links between EF and obesity, few studies have examined if such links are found in Latinx communities and in young children.

This dissertation explored relationships between childhood obesity, EF, and English language proficiency in a sample *(n=44)* of low-income, Latinx, immigrant, elementary school students. Childhood obesity was assessed through Body Mass Index (*z*BMI), waist circumference (cm), and blood sample measures. EF skills were assessed through the parent-report Spanish version of the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2015), the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001), and a computerized go-no-go task (Fillmore, Rush, & Hays, 2006). English language proficiency of children was assessed via the English version of the Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997) and parental reports of the child's language competence. By design, all children were classified as obese at baseline, but none of the children met criteria for clinically significant deficits on the BRIEF, and only three of the children met criteria for clinically significant deficits on the CBCL.

This study was a secondary analysis of data collected from the VALÉ program, which was a pediatric obesity intervention conducted in Prince William County. Although the original study included three cohorts, the current study only used the two cohorts (fall 2017 and spring 2018) who participated in additional EF and language assessment. Participants were recruited through referrals from school and community programs (Gallo et al., 2019). The participants were assessed twice - the first time at baseline (before the intervention began; *n= 44*) and the second time directly after the intervention was completed (10-12 weeks after baseline; *n= 25*). Following baseline testing, parents and children participated in a ten-week multi-modal family obesity intervention designed to improve weight maintenance for children who were experiencing pediatric obesity (Gallo et al., 2019).

Concurrent correlational analyses at baseline indicated that child obesity (as measured by *z*BMI, weight circumference and blood markers) was generally not associated with the EF measures. Although small correlations (i.e., .11 to .30) were generally in the hypothesized direction, they were typically not significant given the small sample sizes, except for triglyceride counts (r= .27 to .38) which were positively related to parent-reported child EF and behavior problems. Sedentary activity scores (r = .29 to .69) were positively related to parent-reported child EF and behavior problems. Parental report of child English proficiency was negatively correlated with EF problems (r = -.28 to -.35). Although child obesity measures were unrelated to the English vocabulary assessment, they were positively associated with parent report of child English proficiency.

Overall, there was a pattern of non-significant positive correlations between baseline EF scores and obesity change scores - children with higher baseline EF problems made slightly poorer progress following the intervention. The overall relationships between baseline EF and dietary change scores were not significant. Finally, relationships between baseline EF and change in child physical fitness markers were also not significant, but the trend was children with greater EF problems at baseline showed somewhat more reductions in sedentary activity and increases in physical activity overtime. Changes in EF over time were not related to changes in obesity, food intake, and physical activity. In conclusion, this study, although limited by attrition and small sample sizes, contributes to the literature by establishing preliminary estimates of how executive functioning abilities may be involved in weight loss behaviors in a minority population.

INTRODUCTION

Obesity is the presence of excessive or abnormal amounts of fat accumulation that results in health impairment (WHO, 1999; WHO, 2020). According to the *z*BMI scales adjusted for age and sex, children (ages 2-18) are *overweight* if they have a *z*BMI greater than the 85th percentile but less than the 95th percentile, and *obese* if they have a *z*BMI greater than the 95th percentile (Barlow & Expert Committee, 2007; CDC, 2002). The increasing rates of obesity are especially alarming, because research shows that prolonged exposure to excess body weight (i.e., obesity beginning in childhood) is linked to more severe health outcomes in adulthood. According to the World Health Organization (WHO, 2017), rates of obesity have tripled worldwide since 1975, and obesity has become the second leading preventable cause of death (Wang & Lobstein, 2006). This epidemic impacts both pediatric and adult populations, with one in five children meeting the criteria for obesity in the United States (Pearce, Leonhardt, & Vaidya, 2018; Sibler et al., 2020), and 17% of children ages 2-19 experiencing obesity (Ogden et al., 2016). These findings are especially significant due to the relatively young age of the obese pediatric population; and data indicates that over the past 30 years the childhood obesity rate has doubled for children ages 2 to 5, and tripled for children ages 6 to 19 (Sibler et al., 2000). However, obesity rates vary somewhat by culture/ethnicity, which leads to some cultures having higher risk factors for obesity than others.

Culture and Obesity

When evaluating the impact of culture on obesity, it is important to note that Latinx cultures are heterogeneous and may differ based on their country of origin, preferred language, and length of time in the United States (Lindberg, Stevens, & Halperin, 2013). However, in America, many Latinx sub-cultures carry several risk factors for obesity. For example, in Latinx cultures, heavier body weight is often viewed as a sign of good health (Alexander, Grant, Pedrino, & Lyons, 2014; Falbe et al., 2015; Garcia, Gatdula, Bonilla, Frank, Bird, et al., 2019; Karp et al., 2014). This means that Latinx families are less likely than White families to agree with a medical professional that their child needs to lose weight; they are less likely to change their lifestyles to aid their child's weight loss; and they are less likely to be concerned about their child's weight (Garcia, et al., 2019; Karp et al., 2014). Additionally, some research indicates that Latinx parents are less likely to believe that there are genetic contributions to obesity, and that a lack of physical activity can contribute to obesity (Knerr, Ceballos, Chan, Beresford, & Bowen, 2020). Furthermore, Latinx parents may have more trouble accessing foods from their native diet, and may be forced to replace those native foods with high caloric items (Garcia, et al., 2019; Mussad, Paige, Teran-Garcia, Donovan, Fiese & The Strong Kids Research Team, 2013). Since parental obesity increases the likelihood for childhood obesity, the high prevalence rates of adult obesity in Latinx populations may also lead to increased childhood obesity (Alexander et al., 2014; Garcia, et al., 2019). Finally, several studies have found that Latinx parents engage in more indulgent feeding styles than other minority groups (Barlow & Expert Committee, 2007;

Olvera & Power, 2009). Indulgent feeding style is associated with a high consumption of sugar, low consumption of whole grains, and a low consumption of vegetables; which can lead to weight gain over time.

Additionally, as Latinx immigrants spend more time in the United States, they face a greater likelihood of becoming obese (Creighton, Goldman, Pebley, & Chung, 2012). This finding supports that acculturation may be a risk factor for obesity in Latinx families. Acculturation is defined as the process by which immigrants achieve assimilation into their new society (Lara, Gamboa, Kahramanian, Morales, & Bautista, 2005). While many positive outcomes may occur as a result of this assimilation, there are also some negative outcomes as the protective factors of the native culture are lost (Creighton et al., 2012; Kaplan, Huguet, Newsom, & McFarland, 2004). In the case of Latinx Americans, these protective factors often include a healthy native diet, a physically active lifestyle, and a strong social network (Creighton et al., 2012; Garcia, et al., 2019; Kaplan et al., 2004; Villegas, Coba-Rodriguez, & Wiley, 2018).

An immigration paradox, where the first generation does better than their U.S. counterparts, but the succeeding generations do worse is evident for obesity among Latinx immigrants to the United States (Gordon-Larsen, Harris, Ward, & Popkin, 2003). According to a national survey conducted on over 20,000 adolescents, first-generation Latinx immigrants tend to have healthier diets and lower rates of obesity than their U.S. counterparts; however, second-generation Latinx immigrants and the successive generations have unhealthier diets and higher rates of obesity than their U.S. counterparts (Gordon-Larsen et al., 2003). The mechanism behind this paradox may be that when

Latinx immigrants come to the United States they gain access to unhealthy foods that they could not previously afford, and that makes unhealthy foods more desirable than healthy foods (Lindberg et al., 2013). Additionally, in the United States, fast food is also cheaper and more convenient (Garcia, et al., 2019). Finally, in addition to the cultural risk factors, a significant amount of Latinx Americans also live in poverty, which carries multiple risk factors for the likelihood that a child becomes obese.

Poverty and Obesity

Socioeconomic status is a significant risk factor for the development of obesity in America (Hemmingsson, 2018). Although obesity rates have risen across all populations, they are higher and have increased disproportionally more for minority and low-income populations (Anderson & Butcher, 2006; Barlow & Expert Committee, 2007; Drewnowski & Specter, 2004; Ebbeling et al., 2002; Hannon et al., 2005; Sen et al., 2020; Wang & Lobstein, 2006; World Health Organization [WHO], 1999). Studies have found that low-income environments promote obesity due to limited access to healthy and low caloric food; lack of nutritional education; lack of access to supermarkets; high density pockets of fast food restaurants and convenience stores; expensive costs of fruits and vegetables; limited time and financial resources; and limited access to recreational activities (Barlow & Expert Committee, 2007; Ebbeling et al., 2002). Furthermore, neighborhood quality, as defined by the types of food stores and restaurants in that neighborhood, is predictive of obesity (Nobari, Wang, Chapparro, Crespi, Koleilat, & Whaley, 2013). In particular, families are more likely to be obese if they are living in environments that lack stores that sell fresh produce and that have an abundance of fast food restaurants (Nobari et al., 2013). These types of neighborhoods provide cheap high caloric foods and a shortage of affordable nutrient-dense foods (Nobari et al., 2013). Finally, low-income neighborhoods tend to have a high crime rate and a shortage of safe play areas (Alexander et al., 2014; Andersen et al., 1998). This makes children in these neighborhoods less likely to engage in physical activity than their more affluent peers (Alexander et al., 2014; Andersen et al., 1998).

Measurement of Obesity

The most common measure of obesity is the Body Mass Index (BMI; Cole, Bellizzi, Flegal, & Dietz, 2000; Deane & Thomson, 2006; WHO, 1999). However, BMI may not be an accurate measure of obesity for children (especially before the age of five), because their height varies dramatically across childhood and adolescence (Roberts & Dallal, 2001). Additional problems include arbitrary norms and cutoff points which fail to address culture and gender differences (Anderson & Butcher, 2006; Cole et al., 2000; WHO, 1999); the lack of compensation for the child's developing body (Anderson & Butcher, 2006); the lack of specificity in differentiating between fat and muscle (WHO, 1999); and the lack of compensation for variable onset of puberty (WHO, 1999). These problems may result in both the classification of healthy weight children as overweight and the classification of overweight children as being a healthy weight. In order to compensate for these weaknesses, it is necessary for BMI charts to be age referenced and relative to the population in which the child exists, making the BMI adjusted for age and sex the gold standard for obesity research (Barlow & Expert Committee, 2007; Epstein, Paluch, Roemmich, & Beecher, 2007; WHO, 1999; WHO, 2017).

In the United States, there are two separate BMI growth charts. One is published by the CDC and is designed to be a reference chart, the other is published by the WHO and is designed to be a standards chart (CDC, 2010). A reference chart describes the growth of a child within a specific time and place, while a standards chart describes the growth of a child within optimal conditions (CDC, 2010). The current CDC charts are normed on children who grew up between 1963-1994 (CDC, 2010). A major difference between the two charts is that the WHO used a sample where 100% of children were breastfed, while the CDC used a sample where only 50% of children were breastfed (CDC, 2010). This has resulted in some controversy as to whether or not breastfeeding is an acceptable standard to measure infants and toddlers against, and it is important to note that breastfeed infants do have a different growth pattern than infants who are formula fed (CDC, 2010). Additionally, the WHO charts end at 59 months (CDC, 2010). Currently, the recommendation is to use the WHO charts until the age of 24 months, and then switch to the CDC charts following the child's second birthday (CDC, 2010). As our sample is over the age of 24 months, we followed CDC guidelines/charts.

Although BMI is the acceptable standard for the categorization of obesity, alternative methods exist which address some of the abovementioned problems. Alternative measures of obesity include abdominal fat thickness, waist circumference, waist circumference to height ratio, waist circumference to hip ratio, skinfold thickness, adnominal fat measures from Computed Tomography (CT)/Magnetic Resonance Imaging (MRI) scans, bioelectrical impedance, dual energy x ray absorptiometry (DEXA), underwater weighing, magnetic resonance imaging, energy expenditure and intake measurements and direct measures of fat through blood work (Deane & Thomson, 2006; Moffat, 2010; Moleres, Martinez, & Marti, 2013; Wilczynski et al., 2018; WHO, 1999). The main strength of these measures is that they provide an objective measure of obesity that better correlates with risk for disease. However, many of these measures lack standardization of methodology and data, are resource intensive to implement, are invasive, and have large measurement errors (Moffat, 2010; WHO, 1999). Additionally, all of the aforementioned techniques (with the exception of DEXA), including BMI, are unable to measure body composition directly, and are only predictions of body composition (Wells & Fewtrell, 2006). Therefore, due to the risk for error, researchers currently believe that it is best to use multiple techniques for measuring obesity and look for convergence (Wells & Fewtrell, 2006).

Outcomes of Childhood Obesity

Childhood obesity is correlated with many negative physical health consequences, including asthma, sleep apnea, type-2 diabetes, difficulty with movement, difficulty breathing, increased risk of fractures, hypertension, hepatic steatosis, abnormal glucose metabolism, dyslipidemia, orthopedic complications, structural abnormalities in the prefrontal cortex and insulin resistance (Chrysaidou et al., 2020; Deane & Thomson, 2006; Hannon, Rao & Arslanian, 2005; WHO, 1999, 2017). It is important to note that some of these health risks are present for individuals with only minor amounts of excess body fat, and that the health risks significantly increase as the amount of excess body fat increases (WHO, 2017). Research shows that children who struggle with obesity during childhood are also at risk for adulthood obesity, cardiovascular diseases, diabetes, hypertension, musculoskeletal disorders, hyperlipidemia, hyperinsulinaemia, atherosclerosis, and cancer (Anderson & Butcher, 2006; Barness, Opitz, & Gilbert-Barness, 2007; Cole et al., 2000; WHO, 2017).

In addition to the plethora of poor physical health outcomes, children who are classified as obese during childhood are at risk for mental health challenges including childhood stigmatization by adults and peers, impaired academic success, and poor social functioning in school (WHO, 1999, 2017). They also face an increased risk for poor mental health outcomes during adulthood. These include a higher likelihood of being in poverty, lower rates of marriage, and an increased risk for mental health disorders such as anxiety and depression (WHO, 1999, 2017).

Causes of Obesity

The development of childhood obesity is very complex, with only about 19% of cases being attributable to a single cause (Kleinendorst et al., 2020). According to the World Health Organization (WHO), obesity is caused by an interplay of biological, environmental, and cultural factors (Anderson, et al., 2003; Ebbeling, et al., 2002; Nestle & Jacobson, 2000; WHO, 1999; Young & Nestle, 2002). From a biological perspective, genetics play a large role in the development of obesity, accounting for 25%-40% of the variance in BMI (WHO, 1999). It is a common notion among experts that genes predispose a child to the development of obesity, and an obesogenic environment supports and maintains weight gain (Jansen, Houben, & Roefs, 2015). Therefore, it is important to examine the intersection between genetic vulnerability and environmental factors.

Environmental factors can be examined through a micro lens in terms of the family unit, and a macro lens in terms of the greater cultural environment. For example, parental obesity is the most predictive factor of childhood obesity, followed by meal frequency and child inactivity (Brogan et al., 2012; Krahnstoever Davison & Birch, 2002; Martin, 2008). This relationship occurs for three reasons. First, parental obesity signifies that there may be a genetic vulnerability to obesity. Second, parental obesity increases the likelihood that the parents will engage in poor modeling of eating and physical activity habits. Finally, obese parents are more likely than non-obese parents to have poor nutritional knowledge and create an “obesogenic” home environment that makes calorically dense foods easily accessible, normalizes large portion sizes, and limits opportunities for physical activity (Krahnstoever Davison, Francis, & Birch, 2005). Parental obesity may also increase the likelihood of childhood obesity during pre-natal development, as high maternal weight or maternal under-nutrition during pregnancy leads to the over\under transmission of nutrients across the placenta which changes the child’s appetite and metabolism following birth (Ebbeling et al., 2002).

The child’s community environment is also important to the development of obesity. Research shows that childhood obesity is correlated with increases in the availability of and consumption of fast food in the neighborhood; food eaten outside of the home; snacks; and sweetened beverages (Anderson & Butcher, 2006; Anderson, Butcher & Levine, 2003; Drewnowski & Specter, 2004; Ebbeling et al., 2002; Epstein et al., 2007; French et al., 2001; Nestle & Jacobson, 2000; Young & Nestle, 2002). All of these things are widely available in modern American society. There has also been a cultural shift toward the normalization of larger portion sizes (Epstein et al., 2007; Young & Nestle, 2002). These environmental changes may be especially salient to a pediatric population, because food companies that sell high caloric foods invest a great deal of money and commercial airtime marketing to children; and children are especially vulnerable to advertising (Borzekowski & Robinson, 2001; Nestle & Jacobson, 2000). Studies have found that even brief exposure to food related commercials (less than 30 seconds) influence the food that children choose to consume (Borzekowski & Robinson, 2001).

Finally, it is important to examine the role of physical activity in the development of childhood obesity. Recently there has been a cultural shift toward decreased pediatric engagement in physical activity and increased engagement in sedentary activities such as watching television and playing video games (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Anderson & Butcher, 2006; Ebbeling et al., 2002; Epstein et al., 2007; Hannon et al., 2005; Lewis & Hill, 1997; Taras & Gage, 1995; WHO, 1999). A study done by Ebbeling et al. (2002) found that children in the United States spend approximately 12 minutes a day being vigorously active, and over 75% of their waking hours engaged in sedentary activities. Increased sedentary activity has had been shown in more recent studies as well (Biddle, Pearson, Ross, & Braithwaite, 2010; Leandro, Viana da Silva da Fonseca, Rolim de Lim, Tchamo, & Ferreira-e Silva, 2019).

Sedentary activities (i.e., watching television and playing video games) affect children's weight through multiple mechanisms. First, children typically have lower metabolic rates when engaging in sedentary activity. Second, television consumption offers a competing pathway to physical activity, which makes it less likely that the children will choose to engage in physical activity. Third, children typically eat more while watching television and the foods they eat at that time are less likely to contain fresh produce. Finally, as discussed above, television advertisements for high caloric foods have immediate impact on the child's short-term food preferences (Andersen et al., 1998; Anderson, et al., 2003; Borzekowski & Robinson, 2001; Ebbeling et al., 2002; Epstein et al., 2007; Hannon et al., 2005; Lewis & Hill, 1997; Nestle & Jacobson, 2000; Taras & Gage, 1995). This relationship may be bidirectional, with children who are obese enjoying physical activity less due to their weight, and the lack of physical activity causing a caloric surplus that predisposes a child to become overweight. Research supports that although television is strongly correlated with childhood obesity, it is difficult to isolate the directionality of the trend (Anderson et al., 2003). Finally, there are some cognitive factors that might predispose the individual to develop obesity.

Relation Between Childhood Obesity and Executive Function

As the rate of childhood obesity increases, there has been increased interest in studying how obesity affects the child's development across the lifespan, especially the child's cognitive functioning. One of the most widely studied domains of cognitive functioning is executive functions (EF). Research indicates that there are multiple relationships between childhood obesity and EF. The term executive functions describes the cognitive capabilities necessary for an individual to engage in goal-directed behavior. Although researchers debate how to best categorize the cognitive skills comprising EF, the three main components are cognitive flexibility, working memory, and inhibition

(Groppe & Elsner, 2014; McAuley & White, 2012; Miyake & Friedman, 2012; Morra, Panesi, Traverso, & Usai, 2017; Muller, Kerns, & Konkin, 2012; Pearce, Leonhardt, & Vaidya, 2018). The body of research concerning the relationship between obesity and EFs is very robust and encompasses both childhood and adulthood. For the purposes of this paper, only the relationship between childhood obesity and childhood EFs will be discussed. The research concerning this relationship in adults will be omitted unless it is discussing both children and adult populations, or is otherwise noted.

There is a substantial body of literature that suggests multiple relationships between childhood obesity and executive functions. The following executive functions are negatively correlated with Body Mass Index (BMI) in children ages 2-25: inhibition and initiation (Xu, Zhang-Yan, Huang, Zhang, & Huangn, 2017), behavior regulation (Chrysaidou et al., 2020), and working memory (Alarcon, Ray, & Nagel, 2016; Reinert et al., 2013). Negative correlations indicate that as the individual's levels of executive function increases, the individual's body mass index decreases. The inverse is true as well, that as the individual's levels of executive functions decreases his or her body mass index increases. Additionally, scores of overall executive functioning are negatively associated with the following in children ages 2-21: an individual's risk for being classified as overweight and obese, the frequency that the individual engages in caloric snack consumption, and the frequency that the individual engages in sedentary behavior (Liang, Matheson, Kaye, & Boutelle, 2014; Pearce et al., 2018). Conversely, high levels of executive function are correlated with increased engagement in healthy eating behaviors and physical activity for children ages 2-21 (Liang et al., 2014). Researchers using latent growth curve modeling have also found that behavioral self-regulation (ages 3-4) during early childhood can predict placement in a severe obesity trajectory at age 15 (Francis, Rollins, Bryce, & Granger, 2020). The directionality of the relationship between obesity and EF is not clear. Some studies support that executive function deficits can lead to the development of obesity and others report that obesity can lead to the development of executive function deficits. Currently, the majority of researchers believe that there is a bidirectional relationship, with each of the constructs influencing the development and maintenance of the other construct (Gettens & Gorin, 2017).

For example, obesity influences executive functions by changing the physical structure of the brain and decreasing blood flow to the pre-frontal cortex as measured in populations of adolescents and adults (Fitzpatrick et al., 2013). Researchers have found that even a 1.0 unit increase in BMI can lead to some brain atrophy in children ages 2-18 (Reinert et al., 2013). Other studies have linked obesity to low-grade inflammation in the brain for children and adolescents (Yang, Shields, Guo, & Liu, 2018). Finally, the brains of obese adolescents also have gray matter reduction, less release of brain-derived neurotropic factor (BDNF), and reduced brain volume (Alarcon et al., 2016).

These changes in the brain seem to be reversible. Smith et al. (2010) examined the neurocognitive profiles of 124 overweight adults before and after participation in a weight loss intervention. They found that individuals who lost weight during the intervention, consumed a healthy diet, and engaged in aerobic exercise showed improvements in executive functioning, memory, learning and processing speed at the end of the intervention. There are also several studies which show that an individual's executive functions improve following bariatric surgery during adulthood. Longitudinal studies done by Alosco et al. (2014a, 2014b) examined the executive function scores of 50 bariatric patients for up to three years following bariatric surgery. Both studies found significant improvements in executive function skills following surgery. Unfortunately, there are few similar studies done in a pediatric population.

Conversely, executive function capabilities play a role in the development and maintenance of obesity, by changing the likelihood that an individual will engage in or avoid obesity-related behaviors (Fitzpatrick et al., 2013). Gettens and Gorin (2017) proposed two mechanisms in which executive functioning deficits may cause obesity in adults. The first is that deficits in initiation prevent the individual from engaging in healthy activities. An example of this is that individuals who have low levels of initiation are less likely to initiate engagement in fruit and vegetable consumption and physical activity. Over time, the decrease in the consumption of healthy food and the decreased engagement in physical activity can lead to the development of obesity. The second mechanism is that deficits in flexibility and inhibitory control increase the likelihood that the individual will overindulge in unhealthy activities. An example of this is that individuals with low levels of cognitive flexibility and inhibition are more likely to engage in the overconsumption of food or to overindulge in sedentary activities. Over time, the overconsumption of food and the overindulgence in sedentary activities lead to an increase likelihood of obesity development. The authors propose that inhibition, working memory, and cognitive flexibility drive different maintenance behaviors (i.e., exercise, dietary restraint, impulse control, etc.) that in turn lead to either initial or sustained weight loss, at least for adults (Gettens & Gorin, 2017). Conversely, similar engagement in unhealthy behaviors driven by EF deficits could lead to weight gain. Hayes, Eichen, Barch, and Wifley (2018) conducted a literature review for children younger than 19 years of age, where they proposed two more ways that EF deficits drive the development of obesity. First, deficits in working memory and cognitive flexibility prevent the individual from using behavioral strategies to create behavior change in his or her physical activity and diet. An example of this would be that individuals with working memory and cognitive flexibility deficits struggle to adequately develop and maintain an exercise plan for a sustained period. Second, deficits in cognitive flexibility prevented the individual from engaging in coping mechanisms when faced with the temptation to engage in unhealthy behaviors. An example of this would be that individuals with cognitive flexibility deficits struggle to make a new healthy snack choice when they are bored.

Based on the above literature, it is reasonable to conclude that there is a negative correlation between overall executive functioning and BMI. It is important to note that most of these studies were done using a pediatric population, unless otherwise note. However, the research discussing the relationship between specific executive functions (i.e., working memory, inhibition, initiation, cognitive flexibility, etc.) and BMI is less consistent. The most robust and widely studied finding is the negative correlation between the child's BMI and the child's ability to inhibit his or her responses to stimuli for children 2-18 years old (Groppe & Elsner, 2014; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen 2006; Reinert et al., 2013).

The Relationship Between Obesity and Inhibition

Evidence supports that inhibition skills decrease as a person's BMI increases in children (Graziano, Calkins, & Keane, 2010; Nederkoorn, et al., 2012). Researchers believe that the mechanism driving this correlation is that inhibition deficits may predispose the child to consume more unhealthy food items, overeat in response to negative emotional states, and binge eat (Groppe & Elsner, 2014; Liang et al., 2014; Nederkoorn et al., 2012). These inhibition deficits lead to an increase in caloric consumption, which ultimately results in weight gain for children ages 7-9 (Nederkoorn et al., 2012). Additionally, high levels of inhibition may help the child to maintain a healthy weight due to associations between high levels of inhibitory control and an increased likelihood of engaging in physical activity and consuming healthy foods (Pearce et al., 2018). Conversely, poor inhibitory control in children is associated with decreased intake of healthy foods, over eating in response to negative emotional states, over response to external food cues, binge eating, overeating high caloric foods, the over consumption of alcohol, and engaging in substance abuse (Groppe & Elsner, 2014; Liang et al., 2014; Nederkoorn et al., 2012). All of these negative health behaviors may also result in increased caloric consumption and an increase in BMI.

The relationship between EF skills and obesity is very important to understand, as it can be used to predict the individual's success in a weight loss intervention. Although the research concerning the directionality of this relationship is inconclusive, there is evidence that the relationship is influenced by several environmental factors such as increased cognitive demand, cognitive fatigue, obesogenic environments, food industry advertising, and culture (Appelhans, French, Patgoto, & Sherwood, 2016; Hayes et al., 2018; Heatherton & Wagner, 2011; Weiss et al., 2015). While the impact of these factors and their relationship with obesity has already been discussed, it is important to also think about how these factors interact with executive functioning.

The Impact of Acculturation and Culture on Executive Functions

The relationship between executive functioning and culture is an understudied topic, especially as it pertains to Latinx Americans. However, there is convincing, albeit limited evidence, that culture plays a role in the development of EF capabilities. For example, children in Eastern countries have relatively high levels of EF when compared to their Western peers (Sabbagh, Fen, Carlson, Moses, & Lee, 2006). Researchers believe that the Eastern school system and Eastern parenting styles promote stronger executive function development by focusing on self-control (Sabbagh et al., 2006).

Acculturation refers to the individual's assimilation into a dominant culture following immigration. No literature was found concerning the topic of Latinx acculturation and executive functions. On one hand, bilingualism may promote the development of superior executive functions (Bialystok, 2010). Additionally, some elements of the heritage culture may also promote the development of superior executive functions. This could be the case if Latinx parents follow a different cultural model that focuses on raising children with a strong sense of self-control. However, Latinx families are more likely that others to be living in poverty, and poverty is detrimental to the child's executive functions (Evans & Fuller-Rowell, 2013). Based on the research, it is unclear if abovementioned strengths are strong enough to protect children against the impact of poverty. Therefore, it is difficult to estimate what the impact of acculturation is on executive functions.

The Impact of Poverty on Executive Functions

However, there is a robust body of literature linking poverty to executive functions. Studies have consistently found strong positive correlations between socioeconomic status and executive functions in children as young as 2-years-old (Hackman, Gallop, Evans, & Farah, 2015). Furthermore, children from low socioeconomic backgrounds consistently perform worse on tasks of overall executive functioning, inhibition tasks, working memory tasks, flexibility tasks, attention tasks, and planning tasks (Escobar et al., 2018; Evans & Fuller-Rowell, 2013; Hackman et al., 2015; Tomlinson et al., 2020). Several experimental studies illustrate this particularly well. Escobar et al. (2018) conducted a study that examined 286 elementary-aged children in Chile. They compared the executive functioning performance of children of low socio-economic backgrounds to the executive functioning performance of children with significantly higher socio-economic backgrounds. They found that children from high socio-economic classes performed better on tests of flexibility (F (1, 285) = 28.13, p = .00), behavioral inhibition (F (1, 285) = 4.04, p = .45), and cognitive inhibition (F (1, 285) = 56.02, p = .00). Another study by Mezzacappa (2004) examined the attending ability of a low-income population of 249 6-year-old children. The researcher used a computerized version of the Attention Network Test (ANT) that measured alerting, orienting, and executive attention. They found that socioeconomic status at birth was predictive of scores on the test (F (1, 239) = 12.40, p = .0005), with more disadvantaged children performing poorer than their more advantaged peers.

There are two proposed mechanisms for the relationship between executive functions and socioeconomic status. The first mechanism is that parents of low socioeconomic backgrounds do not have the resources to respond to the child's material, educational, interpersonal and cognitive stimulation needs (Blair & Raver, 2016; Escobar et al., 2018; Hackman et al., 2015; Mezzacappa, 2004; Vernon-Feagans, Garrett-Peters, Willoughby, The Family Life Project Key Investigators, 2016). The second mechanism is that parents of low socioeconomic backgrounds are often less able to engage in high quality and sensitive parenting due to the stress placed upon them by their environment (Hackman et al., 2015). Although there are equally strong theoretical rationales for both explanations, the second mechanism receives more empirical support (Blair & Raver, 2016; Hackman et al., 2015). Additionally the impact of stress on executive functions, might be especially salient for a predominantly immigrant population; because the families may experience more stress as they struggle to adapt to a new environment with a different culture and language.

The Impact of Language and Bilingualism on Executive Functions and Obesity

Language is essential to the development of executive functions (van der Niet, Hartman, Moolenaar, Smith, & Visscher, 2015). Inner or private speech (i.e., talking to oneself) is a crucial part of making decisions, evaluating decisions, using working memory and self-regulating (van der Niet et al., 2015). Additionally, children with language delays often experience corresponding delays in executive functioning (van der

Niet et al., 2015). The impact of language on shaping the development of executive functions is most clearly illustrated in individuals who are fluent in more than one language (i.e., multilingual or bilingual).

Children who are multilingual or bilingual have to simultaneously converse in one language while inhibiting the other language(s) (Hervais-Adelman, Egorova, & Golestani, 2018). This could give them extra practice in utilizing executive function skills such as inhibition. Theoretically, this additional practice could allow bilingual children to develop superior executive function skills over their monolingual peers (Baumgart, & Billick, 2018; Hervais-Adelman et al., 2018). Bialystok (2010) conducted several studies which showed that multilingual children demonstrate superior performance to monolingual children on measures of flexibility inhibition, and attention; and completed the tasks more efficiently (Trails A, $t(40) = 2.7$, $p < .01$); Trails B, $t(49) = 2.8$, $p < .008$). Additionally, in a review of the current literature, Baumgart and Billick (2018) found that individuals who are fluent in both sign language and a verbal language (which can be performed simultaneously and therefore do not require inhibition) perform the same as monolinguals on executive function tasks. However, it is also plausible that superior pre-existing executive functioning skills make it possible for children to learn more than one language (Baumgart, & Billick, 2018).

The literature concerning the impact of language on the obesity-executive functioning relationship is incomplete. This is especially important to a Latinx American population, as the majority of the children are fluent or have been exposed to both English and Spanish. Although the research shows that greater proficiency in multiple languages is correlated with the development of superior EF, it is not clear based on the research if language offers protection from obesity.

Based on the above literature review, this study examines the relationships between obesity, executive functioning, acculturation, culture, socioeconomic status, and language in the context of a pediatric obesity intervention for Latinx children.

Obesity Intervention Designs

Due to the high prevalence of childhood obesity and the associated health risks, it is imperative that obesity interventions are created to address this epidemic. Many studies have shown that a family and community approach to obesity interventions is the most effective. Unfortunately, these types of interventions are resource intensive, and have very small long-term success rates. This makes obesity difficult to overcome, and the prevention of the development of childhood obesity crucial (Epstein, Voloski, Wing, & McCurley, 1994; Gilman, et al., 2001; von Kries, et al., 1999; Wang & Lobstein, 2006). Therefore, top priorities in obesity intervention design are developing ways to increase response rates, prevent the development of obesity, and to increase weight maintenance following the intervention (Appelhans et al., 2016). The most successful pediatric obesity interventions target children who are at risk for obesity (but have not met the full BMI criteria), provide parent training, incorporate behaviorism principles, have dedicated intervention staff, and are lengthy in duration (Sadeghi, 2016).

There is very limited research on obesity interventions with minority populations (Bender & Clark, 2011; Branner, Koyama, & Jensen, 2012; Brown, 2007; Wilson, 2009). However, research does show that weight loss interventions are often less effective for

Latinx children due to a lack of cultural competency on behalf of the interventionist (Lindberg, 2013). These deficits can include inaccurately modifying the intervention language and not giving enough weight to the importance of family during the intervention (Lindberg, 2013). Additionally, many systematic barriers exist for Latinx families including cost, time, and transportation (Gallo et al., 2019) and lack of access to employer-provided health insurance (Falbe et al., 2015), which can lead to high attrition and non-completion rates. Research concerning other types of interventions robustly supports that it is important to take into account cultural values, beliefs, and the socioeconomic status of the families when designing high- quality interventions for ethnic minorities (Bender & Clark, 2011). Examples of cultural modifications include ensuring that the culturally modified measures are equivalent to the original instrument; that the measures are reliable and valid with their target population; and that the measures and intervention protocol are culturally, conceptually and contextually relevant (Bender & Clark, 2011). It may also be helpful to work with community organizations to increase cultural competency; and to perform interventions in a group setting to emphasize the development of a social support network and to increase cost effectiveness (Gallo et al., 2019).

Obesity Interventions in Minority Populations

Some studies have been done examining obesity in minority populations. Johnston, Tyler, McFarlin, Poston, Haddock, Reeves, and Foreyt (2007) provided a weight loss intervention to Mexican-American adolescents (ages 10-14) in Houston, TX. The participants received either 12-weeks of parent guided classes (through a manual) or

12 weeks of daily nutritional classes followed by 12 weeks of bi-weekly classes at their school. The school-based group had significantly greater decreases in their *z*BMI (F = 11.72, $p < .001$), lower cholesterol (F = 5.27, p = .027), and LDL (F = 7.43, $p < .01$), when compared to the home-based control group. These changes were maintained for up to six months post intervention. This intervention prioritized individual feedback and daily monitoring. Although this study was effective, it was also resource intensive.

Sadeghi et al. (2016) provided a three-year intervention (Ninos Sanos, Familia Sana) to Mexican-American children, ages 3 to 8, in California that was designed to slow BMI increases over time. The intervention included both community-based and school-based teaching sessions about nutrition and physical education. Parents were also provided with nutrition education, and vouchers to buy healthy food in the community. A focus of this study was the community-based research, which depended heavily on the community for feedback, program design, and recruitment. The intervention found that BMI increase was slowed within one year of the intervention for obese males but not for females (*B*-coefficient = -1.94, p = .05). The authors explained the gender differences by discussing that Mexican American boys may be more likely to consume more energy from fat, and to spend more time engaged in sedentary activities than girls. Additionally, the authors felt that boys are more likely to have parents who engage in permissive parenting than girls; which allows the boys to spend more time outside, and to have more opportunities for outdoor physical activity. Finally, Mexican- American males face higher rates and severity of obesity than females, so it is possible that they are better primed for early response to intervention.

Falbe, Cadiz, Tantoco, Thompson, and Madsen (2015) conducted another intervention, *Familias Activas y Saludables,* for low-income children (ages 5-12) of Mexican American immigrants. They provided ten weeks of family and group counseling pertaining to parental education on nutrition, food preparation, cultural perception of food-related behaviors, stimulus control, limit setting, goal setting, self-monitoring, and physical activity. Both families and children participated together, and children participated in physical activity while the adult members discussed adult sensitive topics. The intervention was conducted by physicians, dieticians, and promotoras (Latinx community health providers with a basic health education, but not a professional healthcare worker). The staff all spoke basic Spanish, and several members of the staff spoke fluent Spanish. To increase cultural competency, there was an increased emphasis on the role of the family in the intervention, and the program focused on foods commonly consumed by the target population. Furthermore, there was a focus on addressing some of the unhealthy cultural misconceptions about weight maintenance practices, and a session concerning immigration problems. It was implemented through appointments at Federally Qualified Health Centers (FQHC), which allowed it to be carried out without the use of grants (Falbe et al., 2015)**.** This intervention resulted in improvements to the child's *z*BMI, weight, and triglycerides.

Project Valé

The current intervention, Project Valé, was established through a grant from the Potomac Health Foundation to serve low-income children of Latinx immigrants. Participants were referred to the study through community contacts in local clinics and schools, a method of community-based recruitment that is considered the most effective and efficient recruitment model for reaching minority populations (Yancey, Ortega, & Kumanyika, 2006). Its efficacy is a result of allowing community-based personnel to act as a bridge between the participant and the research staff rather than placing the responsibility for enrollment on the participant (Yancey, Ortega, & Kumanyika, 2006). Furthermore, community involvement may act as a support system for addressing some of the barriers to participation for minority populations, and increase retention in interventions (Gallo et al., 2019; Yancey et al., 2006).

Families were chosen to participate in this program if the child's BMI was above the 85th percentile for age and sex; if the family resided in Prince William County, Virginia; and if the family identified as Latinx. Only two mothers and one father in the sample identified as being born in the United States. The rest of the parents identified their country of birth as being El Salvador, Guatemala, Honduras, and Mexico. This study including immigrant families fills a gap in the literature in that immigrants are an under-studied group. Ash, Agaronov, Young, Aftosmes-Tobio, and Davison (2017) found that in articles published between 2008-2015, only 28% involved immigrants as their target population. A similar review by Gicevic et al. (2016) of articles published between 2009-2015 found that only 7% of articles involved immigrant populations. All of the children in the study were elementary school aged, which is the most popular age at which to implement this type of intervention (Ash et al., 2017; Gicevic et al., 2016).

Participants were divided into fall and spring cohorts, based on the time at which they enrolled in the study. Unfortunately, a control group could not be utilized due to low enrollment. Participants received the intervention as a family, and they were given the opportunity to have as many family members attend as possible. Research robustly shows that family-based interventions have superior results when compared to individual interventions for children who struggle with obesity (Arauz Boudreau, Kurowski, Gonzalez, Diamond & Oreskovic, 2013; Epstein et al., 2007; Hayes, Altman, Coppock, Wilfley, & Goldschmidt, 2015; Sung-Chan, Sung, Zhao, & Brownson, 2013). Additionally, the focus on the family as an agent of change complements the strong familial values in the Latinx culture.

Following baseline testing, families participated in ten weeks of 75-90 minute nutrition and psychoeducation classes from a pre-established manual (Gallo et al., 2019). Ten weeks is considered to be within a standard time for obesity interventions, as the majority of interventions last between four and 12 weeks (Vine, Hargreaves, Briefel, & Orfield, 2013). Additionally, research shows that when compared to outcomes-based interventions (i.e., interventions with a pre-determined set of outcomes but no protocol manual), obesity interventions with pre-established protocols are more likely to cover the majority of obesity management behavioral domains and to utilize theory during instruction (Ash et al., 2017). The treatment protocol was based on cognitive behavioral principles (i.e., problem solving, emotional distress tolerance, stimulus control, and the use of an operant conditioning based behavioral modification system) and Epstein's Traffic Light Diet (Gallo et al., 2019). During the fall, the nutrition classes were provided in Spanish. The psychoeducation classes were first provided in English, and then immediately translated into Spanish by an undergraduate research assistant. During the spring, both the nutritional classes and the psychoeducation classes were provided in English first, and then translated into Spanish by an undergraduate research assistant.

Children and adults were taught separately, with adults receiving verbal instruction and children receiving physical fitness lessons. The majority of instruction was provided to the parents, as they are the primary agents of behavioral and dietary changes for children (Ash et al., 2017; Gicevic et al., 2016; Sung-Chan et al., 2013). Lack of childhood agency in obesity management is largely due to the child's limited ability to provide his or her own food, and to fully control his or her own leisure activities. Research demonstrates interventions that combine nutritional education for the parents with a physical activity component for the children have a greater efficacy than interventions that only focus on parental instruction (Jelalian & Saelens, 1999).

Families also participated in community outings to the grocery store, family-style dinners with traditional food, a group soccer game, and other activities designed to emphasize the importance of family and Latinx culture. These activities potentially allowed for an increase in the relevancy of the intervention to the participant's lives (Yancey et al., 2006). This intervention focused on three out of the four behavioral domains (diet, physical exercise, media use, and sleep) that are commonly targeted in pediatric obesity interventions (Ash et al., 2017; Gallo et al., 2019; Gicevic et al., 2016; Vine et al., 2013). Interventions that address multiple behavioral domains are more efficacious than interventions that focus on only one domain (Jelalian & Saelens, 1999). Although sleep was not targeted in this intervention, pilot testing was conducted to add it to future iterations.

In order to decrease barriers to participation for low-income and minority populations, classes were held at night so that parents could attend them after work, and childcare was provided (Arauz Boudreau et al., 2013; Gallo et al., 2019; Yancey et al., 2006). Additionally, the families were invited to join social media groups; staff turnover was kept low; and the families were encouraged to talk to and share information with each other in order to increase social connectedness within the intervention, increase engagement within the community, and improve retention (Yancey et al., 2006). Finally, regular telephone follow-ups were scheduled following the termination of the intervention in order to increase the likelihood that the families would return for follow-up testing (Yancey et al., 2006).

After the conclusion of the intervention, families participated in a 3-month, 6-month, and 9-month follow-up assessment. The inclusion of follow-up measures is essential in order to track relapse and continued weight loss\weight maintenance (Sung-Chan et al., 2013). Unfortunately, attrition was high for this sample. Although the majority of families completed the intervention program, only 65% of participants (*n*=13) from the fall 2017 cohort, and 50% of participants (*n*=12) from spring 2018 cohort returned for follow-up testing. This could be improved for future projects by having follow-up testing on the last day of the intervention rather than asking the families to return for follow-up testing.

Goals of Current Study

Based on the above literature, it is clear that children growing up in Latinx immigrant families are exposed to a wide variety of factors, which might increase their risk of developing childhood obesity. These factors include limited nutritional education, a greater likelihood of living in low SES environments, difficulty obtaining resources to engage in physical activity, difficulty obtaining healthy and nutritious food, and a greater likelihood of parental obesity. Furthermore, it is well established in the literature that executive function skills may influence the likelihood of a child developing obesity. It is also well established that executive functioning skills are influenced by many of the same factors that influence childhood obesity (i.e., SES, access to resources, and cultural variables). This study examines the intersection of environmental factors, executive function deficits, language skills, and pediatric obesity; with the hope that with a better understanding of what factors influence a child's successful weight loss we can better allocate limited public health resources. Additionally, this study fills a gap in the literature, because there is little research concerning the impact of language skills on childhood obesity, especially among Latinx children. While cognitive functioning and executive functioning have been examined, the child's language competence has not. Given the robust relationship between language competence and executive functions competence; as well as the relationship between obesity and executive function deficits, it can be expected that there is a relationship between language competence and childhood obesity as well.

The current study is a secondary analysis of obesity intervention data (Gallo et al., 2019), with the addition of new baseline data on language skills and EF, and new post-intervention data on EF skills that have not been previously examined in the original intervention study (Gallo et al., 2019). This study seeks to answer the following research questions:

1. How are the baseline executive functions of the child related to baseline levels of child obesity, English language proficiency, and baseline biological markers of obesity (i.e., total cholesterol, total glucose, total triglycerides and HOMA-IR levels)? Additionally, how is the child's baseline English language proficiency related to baseline levels of obesity, baseline biological markers of obesity, and baseline executive functions?

    I hypothesize that children with higher baseline executive functions will have lower baseline measures of obesity, higher baseline levels of English language proficiency and lower levels of biological markers of obesity. I further hypothesize that children with higher English language proficiency will have higher EF, lower baseline measures of obesity and lower baseline levels of biological markers of obesity.

2. Is the child's response to the intervention (as measured by changes in eating habits, changes in physical fitness levels, changes in engagement in physical activity, and changes in childhood BMI) related to the child's baseline scores on measures of executive functions and English language proficiency?

    I hypothesize that children with higher levels of baseline executive functions will have a greater response to the intervention. I further hypothesize that children with higher levels of English language proficiency will have a greater response to the intervention.

3. Do changes in the child's executive function skills following the intervention correlate with changes in the child's BMI, changes in child eating habits, and changes in child engagement in physical activity?

    Due to the relatively small period of time between testing points (10 weeks), I do not expect the children to have any significant changes to executive function points due to development alone. Therefore, I hypothesize that any significant changes to executive functioning will be due to an outside factor, such as a weight loss. Although the design of this study does not allow for a causal inference, I hypothesize that children with larger gains in executive function skills following the intervention will have correlations with a decrease in BMI, and a decrease in obesity-related behaviors (i.e., increase in physical activity and decrease in unhealthy food consumption).

METHOD

Participants

Participants in this study were participants in an intervention, Project Valé. The original study used three cohorts of children (spring 2017, fall 2017, spring 2018). However, this study analyzes a subset of the data (two cohorts; fall 2017, spring 2018), which equaled 44 children and their families. Family income ranged from $15,000 per year to $100,000 per year. The average income was approximately $32,000 per year and the median income was $22,000 per year. There were 29 males and 15 females in the study. The children ranged in age from 5-years old to 10-years old, with the average age being approximately 7.5-years old (*SD* = 1.47). Forty-two of the participating parents were born in a country other than the United States (i.e., El Salvador, Guatemala, Honduras, and Mexico).

Thirty-seven of the 44 children were born in the United States, and spoke predominantly English. English proficiency was determined through caregiver report, and scores on the PPVT-III. The average standard score on the PPVT-III at baseline was an 82.64 with a range of 40-117. The parents reported that their children were approximately equal in their proficiency in speaking Spanish (mean was 2.55 on a 5-point scale) and English (mean was 2.07 on a 5-point scale). This scale is discussed in greater detail in the measures section and the results are reported in greater detail in Table 3. All of the households reported that Spanish was used in the home, and 25 households (39.7%) reported that English was spoken in the home. The majority of families reported that their children used approximately the same amount of Spanish and English when talking to the other adults in the home; and that adults in the home used predominantly Spanish when talking to the children. Due to the high level of child English proficiency, the child's portion of the intervention was delivered in English only. The demographic variables are discussed further on Table 1, Table 2, and Table 3.

In order to participate in the study, the child's weight had to be above the 85th percentile according to the BMI percentile scores for age and sex. The average BMI percentile score at baseline was greater than or equal to the 98th percentile. A trained healthcare professional determined the obesity classification of the children during baseline testing. Only participants who met or exceeded the pre-established BMI cut off scores were included in the study. Children and their families were measured at baseline *(n=44),* and immediately following the conclusion of the ten week intervention *(n=28).*

This sample is a subset of the full data set from the Project Valé study (Gallo et al., 2019). The original study used three time points (spring 2017, fall 2017 and spring 2018). The current study only uses data from fall 2017 and spring 2018. Additionally, the original study had four testing time points (baseline, T1, T2, T3). This study only uses the data from baseline and the first follow-up testing point (T1).

Procedures

Potential participants were screened through phone calls before the baseline testing, and participants who met screening criteria were asked to come to a baseline testing session. The children were asked to fast before attending. During the baseline testing session, the child's BMI was measured, and those who met criteria continued with the assessment battery, which is discussed in greater detail in the measures section of this paper. Examiners also measured the child's waist circumference (cm), and took a blood sample (cholesterol, glucose and triglyceride levels). Additionally, the caregivers filled out a demographic survey, Early Years Physical Activity Questionnaire (EYPAQ), Child Behavior Checklist (CBCL), Food Frequency Questionnaire (FFQ), and Behavior Rating Inventory of Executive Functioning Skills-2 (BRIEF-2). While the parents were filling out the assessments, the children completed physical fitness assessments, a Go/No-Go computerized assessment and the Peabody Picture Vocabulary Test-III, English (PPVT-III). With the exception of one family, all caregivers received the assessments in Spanish. All of the children received their assessments in English.

As discussed above, the eligible families then participated in a ten-week intervention. Following the intervention, the participants were asked to return for a follow-up testing session. During this time, the child's BMI and waist circumference (cm) was measured for a second time. Additionally, the child's blood was drawn; the families filled out a second EYPAQ, FFQ, and BRIEF-2; and the children were re-administered the physical fitness assessments. The PPVT-III was not re-administered at follow-up. Some children received an administration of the Go/No-Go task during follow-up testing; however, not enough children received this to make analysis of this variable meaningful. Due to high attrition, only the time 2 follow-up (directly after the conclusion of the intervention) was analyzed.

Measures

The data for this study were collected from participants in Project Valé, a nutrition and psychological based intervention for Latinx children identified as having childhood obesity. The intervention used family-based nutrition psychoeducational classes loosely based on Epstein's Traffic Light Diet to modify the nutrition, physical activity, and eating practices of the participants (Gallo et al., 2019). The goal of the original study was to measure the efficacy of the intervention in terms of child improvement on various obesity measures. The current dissertation looks at the relationship between childhood obesity measurements, language, and childhood EF. Additionally, this study looks at the relationships between changes in childhood EF and Response To Intervention (RTI); as well as the relationships between baseline EF and language measurements and RTI. The following section is an explanation of the variables used in this study. These variables are also summarized in Table 4.

Demographic Questionnaire

Demographic questions were completed by parents. They included: the total number of people living in the household; the number of adults living in the household; the number of children living in the household; the marital status of the parents; self-reported parental weight; self-reported parental height; parental perception of the child's weight, the child's health, and the child's risk of disease; maternal and paternal age; maternal and paternal education; maternal and paternal country of origin; maternal and paternal employment; maternal and paternal length of time in the United States; the participating child's country of birth; parental perception of their own health, weight and risk of disease; parental confidence in their ability to help their child to make healthy food and activity choices; indicators of food insecurity; child IEP classification; and family income. The collection of these variables is an important component of elucidating the differences in our sample instead of treating the sample as a homogenous ethnic group (Yancey et al., 2006).

Obesity Measures

As discussed in previous sections, there are many weaknesses to using only the BMI as an indicator of obesity status. Therefore, the best practice for determining childhood obesity classification is to use multiple measures and look for convergence. Baseline and follow-up measurements of obesity classification included anthropometrics (*z*BMI and waist circumference in cm), and blood biochemistry (total cholesterol, total glucose, total triglycerides and HOMA-IR levels).

zBMI & Waist Circumference. This study used the child's *z*BMI and waist circumference (cm) as variables that indicated improvements in obesity. Trained healthcare professionals measured both variables during baseline and follow-up testing. Based on recommendations from the CDC, we used CDC norms for BMI since the children were over the age of two years old. For waist circumference, higher numbers indicate that the child had a larger waist circumference. For *z*BMI scores, bigger numbers mean that the children had higher BMIs. Due to the exclusion criteria, we did have a limited range of *z*BMI scores (range: .80-3.45). When conceptualizing BMI improvements in children, it is typical to report outcomes in terms of the mean change in BMI *z* scores (*z*BMI; Hayes et al., 2015), because there is a considerable variation in what is considered to be a healthy BMI across the course of the child's physical development due to rapid growth in height. For children, a *z*BMI score change of .25 points correlates with significant health-related changes; and, therefore, can be considered to have practical significance for an intervention study (Hayes et al., 2015). It is also important to note that just maintaining BMI can be important for children as their BMI may naturally decrease as they grow older and their height increases.

Blood Biochemistry. A venous blood sample of the children was taken by a registered nurse after a fasting period. It was analyzed using point-of-care testing, and samples were centrifuged at 2,500 rpm for 15 minutes. Following centrifuge, the serum was stored at -80 C to allow for analysis of insulin levels (Gallo et al., 2019). This project uses the following labs: total cholesterol, total glucose, total triglycerides and HOMA-IR levels.

For cholesterol, glucose and triglycerides, larger numbers means that the child's labs had higher concentrations of the substance in the blood, which is not ideal. HOMA-IR is a measure of an individual's insulin resistance, and can indicate that an individual may be pre-diabetic. Larger numbers for HOMA-IR are also indicators of poor health. The range for these variables was also relatively limited: cholesterol (range: 100-206), glucose (range: 80-101), triglycerides (range: 45-175), HOMA-IR (range: .68-143.1).

Physical Activity Measures

Physical Activity. The Early Years Physical Activity Questionnaire (EYPAQ) is a questionnaire that measures moderate-vigorous physical activity (MVPA), and sedentary time (ST). It was designed for young children (under five years old). To complete the questionnaire, caregivers are given a list of different activities (i.e., playing actively in the house, watching TV, playing a non-active computer game, etc.), and are asked to report the frequency and duration of the child's engagement in those activities within a typical week in the previous month. The assessment has fair reliability for MVPA and moderate reliability for ST. When assessed against a measure of accelerometry, the assessment had good validity for the measurement of MVPA and poor validity for the measurement of ST (Bingham et al., 2016). For this measure, higher numbers indicate that the child engaged in more MVPA and ST. More MVPA would be considered healthier, and more ST would be considered to be unhealthier.

Direct Physical Fitness Measures. Physical fitness refers to the individual's ability to perform tasks without pain or excessive energy expenditure (O'Malley et al., 2017). Typically, it is measured through the examination of the individual's cardiorespiratory fitness, muscle function, agility, balance, and flexibility (O'Malley et al., 2017). When assessing physical fitness levels in children, it is important to account for reduced endurance (relative to adults); as well as their decreased ability and motivation to follow instructions (Fjortoft, Pedersen, Signundsson, & Vereijken, 2011). Additionally, it is important to take into account that physical fitness is comprised of many different sub-components, and to clarify the weight of the individual sub-components to the child's overall physical fitness score (Fjortoft et al., 2011). Based on a study done by Fjortoft et al. (2011), the following physical activity measures have been found to have high convergent validity with assessments of physical fitness from a child's physical education teacher: a standing broad jump, a seated medicine ball throw, and a shuttle run. In this study, child physical fitness levels were measured through a battery of physical fitness testing which included a vertical jump test, a seated medicine ball throw, and a modified shuttle run.

A vertical jump test is a measure of lower body strength and power. During the assessment, the children jumped as high as they could (taking off from two feet) using a jump mat which measured the child's jump height using his or her flight time. The height of the jump was measured in inches (Castetbon & Andreyeva, 2012; Merrigan, Gallo, Fields, Mehlenbeck, & Jones, 2020). The test was repeated three times during the baseline testing, and three times during the follow-up testing. The scores were averaged together, and the average from the baseline and follow-up testing were used in the analysis, with larger values indicating stronger health. A study done by Ramíerz-Vélez et al. (2015) found that this test has high reliability in Latinx youth.

Participants also completed a seated medicine ball throw using a 2kg ball. During the test, the children sat against a wall and threw the medicine ball as hard as they could in a straight line in a "basketball pass" motion. The distance that the child threw the ball was measured by a tape measure, and recorded in centimeters (Korsten-Reck et al., 2006; Merrigan et al., 2020). The test was repeated six times during the baseline testing, and six times during the follow-up testing. The scores were averaged together, and the average from the baseline and follow-up testing were used in the analysis, with larger values indicating stronger health. The seated medicine ball throw has been shown to have high test-retest reliability (ICC = 0.88 across two days), and to have known-difference and correlational validity with height, weight, and age (Davis, Kang, Boswell, DuBose, Altmann, & Binkley, 2008).

The 40-m shuttle run test is one of the most popular tests for measuring the cardiovascular endurance of children and adolescents. During the test, the participants run in a straight line and pace themselves according to audio measures given by a recording. The test is terminated when the participant can no longer keep up with the pace set by the audio recording for two or more consecutive occasions (Ruiz et al., 2006; Merrigan et al., 2020). The test was run three times during baseline testing, and three more times during follow-up testing. The results of the test were recorded to the nearest second, and are presented as an average number of minutes that the child was able to run during the three trials, with larger values indicating better health. This test has a high reliability with VO_{2max}, and a high test-retest reliability ($r = 0.98$; Bianco et al, 2015). Another study done by Ramíerz-Vélez et al. (2015) found that this test has high reliability in Latinx youth.

Nutrition Measures

Food Frequency Questionnaire (FFQ). Child changes in eating habits were measured through an assessment of food consumed in the past week (Food Frequency Questionnaire, FFQ). For this study, the Spanish version of the Block Kids Food Screener (BKFS; Hunsberger, O'Malley, Block, & Norris, 2015) was used. The FFQ provides an estimate of the frequency in which food was consumed; as well as an estimate of the total amount of micronutrients and macronutrients consumed by the individual. This assessment was administered through a questionnaire at baseline line and follow-up testing. We analyzed the data collected for the total added sugar and total saturated fat values from the BKFS data. The BKFS has high validity with other FFQs (0.48-0.88) and high correlations with 24-hour recalls (Hunsberger, O'Malley, Block, & Norris, 2015). For this assessment, higher numbers indicate that the child consumed more grams of saturated fat and sugar.

Psychological Measures

Child Behavior Checklist (CBCL). The parental report on the Spanish Version of the Child Behavior Checklist (CBCL), a childhood psychopathology screener was used to screen for the psychological health of the child (Achenbach & Rescorla, 2001). Multiple studies have found that the English version of the CBCL has high internal consistency values, high content validity, and high test-retest reliability. A study done by Lacalle, Ezpeleta, and Domenech (2012) also found that the Spanish version of the CBCL had good to moderate internal consistency. Furthermore, they found high correlations in diagnostic conclusions when comparing the CBCL results to results from the Diagnostic Interview for Children and Adolescents (DICA-IV) for all diagnosis except for social phobia. For this assessment, higher numbers indicate that the child has more deficits in that domain. It is important to note that the CBCL is not a direct assessment of executive functions. However, the attention subscale captures the child's ability to attend to stimuli (inattention), demonstrate behavioral regulation (hyperactivity), and inhibit impulses (impulsivity; Achenbach & Rescorla, 2001). Therefore, this scale does provide some insight to the child's behavior and overall EF. Additionally, the externalizing subscale on the CBCL has been found to overlap with the BRIEF BRI subscale, also indicating that it can provide some insight into the child's EF (Familiar et al., 2015). In this study, both of the CBCL scales were significantly correlated with all of the BRIEF subscales (r = .50-.69, $p < .01$).

The vast majority of the children scored within the normative range on the CBCL assessment. The CBCL attention scale had a range of 27 and a mean of 54.56. The externalizing scale had a range of 50 and a mean of 54.56. Scores on the CBCL are not typically considered for clinical interpretation if they are below 60.

Executive Function Measures

Behavior Rating Inventory of Executive Function Skills-2, Spanish Version (BRIEF-2). The BRIEF is one of the most widely utilized executive function measures due to it's capacity to measure the levels of EF deficits relative to the child's stage of development (Anderson, Anderson, Northam, Jacobs & Mikiewicz, 2002; Ezpeleta, Granero, Penelo, de la Osa, & Domenech, 2015; Gioia et al., 2000; Roth, Erdodi, McCulloch, & Isquith, 2015). It is a Likert scale questionnaire, designed to measure the behavioral aspects of executive functioning deficits in individuals' ages 2-90 (Anderson et al., 2002; Ezpeleta et al., 2015; Fernandez, Gonzalez-Pienda, & Perez, 2014; Gioia et al., 2000). For this study, we used the Spanish edition of the BRIEF-2 (school aged version, parental report). High scores on the BRIEF correlate with clinical deficits of specific executive function(s) (Fernandez et al., 2014). The BRIEF consists of three composite scales: Behavior Regulation Index (BRI), Emotional Regulation Index (ERI), and the Cognitive Regulation Index (CRI), which then combine to form one composite score, the Global Executive Composite (GEC; Ezpeleta et al., 2015; Gioia et al., 2000;

Roth et al., 2015). This project analyzes each of the three sub-scales and the composite score.

The BRIEF was normed on a population that was representative of multiple cultures and socioeconomic statuses. The norming population included 1,419 parent forms and 720 teacher forms (Gioia et al., 2000; Usher, Leon, Standord, Holmbeck, & Bryant, 2016). The majority of the sample was taken from private and public schools in the state of Maryland (Gioia et.al., 2000). None of the participants had a history of psychiatric medication or special educations status (Gioia et.al., 2000). Parent forms have a test-retest reliability of .76 to .85 and an internal consistency of .80 to .98 (Gioia et.al., 2000).

Although the BRIEF is widely utilized in English-speaking countries (Roth et al., 2015), its international use has been somewhat limited (Fernandez et.al., 2014). Fernandez et al. (2014) tested the validity of the Spanish BRIEF using a clinical sample of 125 child and adolescent participants. In their study, the Spanish BRIEF had good internal reliability and convergent validity with the Evaluation del Deficit de Atencion con Hiperactividad (EDAH). McCoy, Raver, Lowenstein, and Tirado-Strayer (2011) conducted a study using 215 Head Start students from an urban area. These students were either African American or Latinx with a median annual household income of $22, 096. Their study showed that the BRIEF was able to assess behavioral regulation similarly across race, poverty risk status, and gender. The BRIEF normative data itself also indicates that parent educational level, socioeconomic status and ethnic background do not impact test scores (Gioia et.al., 2000). For this assessment, higher numbers indicate that the child has more deficits. The vast majority of the children scored within the normative range on the BRIEF. At baseline, the BRIEF variables had a range between 30-34. The BRIEF composite score (GEC) had a mean of 50.59. Children with scores above a 60 would be considered for clinical interpretation.

Go/No-Go Task. Inhibitory control was also measured using a computerized Go/No-Go task from the online software provider Inquisit (Filmore et al., 2006). The task consisted of one of two rectangles being presented on a white 13" computer screen. The children were verbally instructed to press the space key when the rectangle was green and to refrain from pressing it when the rectangle was blue. The children were asked to repeat back the instructions to the examiner, and given three practice trials to ensure that they understood the directions. There were 250 total trials, with the go stimulus being presented 125 times and the no-go stimulus also being presented 125 times. The rectangles were presented at 500ms intervals, and the task itself took approximately 15 minutes to complete. Correct rates of responding to the go stimulus and error rates of responding to the no-go stimulus were used for analysis. This task has been used in several studies and has been shown to have high convergent validity with the diagnosis of Attention Deficit Hyperactivity Disorder, which is characterized by low inhibitory control (Roberts, Milich & Fillmore, 2016). For this assessment, higher numbers in the correct category indicate that the child has less EF deficits, and higher numbers in the errors category indicate that the child has more EF deficits.

Language Measures

Peabody Picture Vocabulary Task- III (PPVT-III). Child English proficiency was measured through the PPVT-III, which is one of the most frequently used measures of receptive vocabulary (Olabarrieta-Landa et al., 2017; Pae, Greenberg, & Morris, 2012; Simos, Sideridis, Protopapas, & Mouzaki, 2011). The main benefit of the test is that it does not require any verbal output on behalf of the examinee, as the test consists of pointing at one of four images that best corresponds to an auditory stimulus given by an examiner (Olabarrieta-Landa et al., 2017; Pae et al., 2012; Simos et al., 2011). The English version of the test was normed on a United States population that included Asian, African American, Native American, and Latinx participants. During the creation of the third edition of the test, a concentrated effort was made to decrease gender, race, and religious bias (Olabarrieta-Landa et al., 2017; Pae et al., 2012). We only administered the English version of the test, and did not administer a Spanish version of the test. For this assessment, higher numbers indicate that the child has better receptive English vocabulary skills.

The relevant variables from each of these measures is summarized in Table 4.

Change Score Calculations

Change score calculations for all the variables were completed by subtracting the value at T1 (baseline) from the value at T2 (follow-up; T2-T1). For variables where high numbers indicated more deficits or poorer health, then higher change scores indicate that the participant got worse in that domain following the intervention. For variables where lower numbers indicated more deficits or poorer health, then higher change scores indicate that the individual was better in that domain following the intervention. The interpretation of these change scores is summarized in Table 4.

Operational Definition of Behavioral Variables

For this project, the operational definition of the variables is as follows. Response to intervention was measured through change in child *z*BMI (direct measure), change in biological obesity markers (direct measure), change in child physical fitness levels (direct measure), change in the child's engagement in sedentary activity (indirect measure), and change in the child's engagement in physical activity (indirect measure). Executive function competence was measured through a behavioral inhibition task (Go-No-Go, direct measure) and child scores on a parent version of the BRIEF (indirect measure). Receptive childhood language was measured through scores on the PPVT (direct measure) and parental report on a Likert Scale measure (indirect measure).

This study uses the principles of operant conditioning to create behavioral change that is manifested in the response to intervention variables. More specifically, parents were taught how to use non-edible positive reinforcement and behavior charts in order to increase the likelihood that their children would engage in healthy eating and physical activity behaviors. The frequency of engagement in healthy eating behaviors was measured through change scores in nutritional intake on a Food Frequency Questionnaire (FFQ, indirect measure). The frequency of engagement in physical activity was measured through change scores on a childhood physical activity questionnaires (indirect measures), and improvements in child physical fitness levels (direct measures). The hypothesis of this study was that the cognitive functioning and language abilities of the participants served as motivating operations for the link between the environmental triggers (antecedents) and the behavioral response of engagement in unhealthy or healthy behaviors.

STATISTICAL ANALYSIS

During the original design of the study, the plan was to analyze the first research question about relationships between baseline variables using correlations. The second two questions about the relationships between baseline variables and the child's Response to Intervention (RTI), and the relationships between EF change scores and the child's RTI were to be analyzed using multivariate regressions. However, the attrition at the second time point was high (*n's* = 19-25), and resulted in too small a sample size for multivariate regressions. Therefore, the choice was made to analyze all the questions using correlational analysis. Although we cannot make causal inferences from these data, it does shed some light on the relationships between the measured constructs. Additionally, it provides a good foundation for further research to build upon.

Finally, there were some significant differences between the group that had T2 data points and the group that did not. Children were less likely to have T2 data if they had a lower baseline waist circumference; greater deficits on the baseline BRIEF BRI and ERI subscales; had more children living in the household at baseline; were female; had higher scores on the shuttle run at baseline; and had lower scores on the seated medicine ball throw at baseline.

RESULTS

Preliminary Analyses

This sample was comprised of Latinx children of immigrants. There were 29 males and 15 females in the sample (Table 1), and the average age of the sample was 7.57 years old (*SD* = 1.5; Table 3). While the children did speak English as measured by receptive vocabulary scores on the PPVT-III (*M* = 82.64, *SD* = 18.1), the majority of parents did not report to using English in the home (as measured by self-reported Likert scales; Table 3). At baseline, all of the children had *z*BMI scores within the range to be considered obese. The average *z*BMI score at baseline was 2.18.

Overall the intervention was successful. Response to Intervention (RTI) analysis was completed using two methods. First, by running repeated-measures, paired-sample T tests from pre to post on all obesity/health indicators. Second, by using the Wilcoxon signed-rank nonparametric tests since the samples at T1 and T2 were dependent. The same results were found in both tests, with the exception of child waist circumference, which was only marginally significant using the Wilcoxon signed rank test. Overall, the intervention was successful according to five of the 13 metrics/variables. Table 8 contains the means for T1, T2, and the change scores for all of the outcome variables. Children had a significant loss in *z*BMI scores between time point 1 (2.18 +/- .39) and time point 2 (2.09 +/- .39). This was a statistically significant decrease of .09 (95% CI, -

.15 to -.04), $t(27) = -3.55$, $p < .05$. Children also had a significant loss in waist circumference (cm) between time point 1 (80.18 +/- .39) and time point 2 (78.94 +/- 9.55). This was a statistically significant decrease of 1.23 cm (95% CI, -2.44 to -.03), $t(26) = -2.10$, $p < .05$. The children also had a significant gain in their vertical jump score from time point 1 (9.20 +/- 1.70) and time point 2 (9.79 +/- 1.98) with an average improvement of .59 (95% CI, .14 to 1.05), $t(27) = 2.67$, $p < .05$; and marginally decreased the amount of sugar consumed from time point 1 (8.06 tsp. +/- 7.62) to time point 2 (5.38 tsp. +\- 4.50) by an average of 2.68 tsp (95% CI, -5.46 to .11), $t(20) = -2.00$, $p < .05$. There were no significant effects of the intervention on the other variables, and the children did get slightly worse on one measure. The children had an increase in Glucose levels from T1 (91.33 +/- 5.05) to T2 (94.19 +\- 5.36) with an average increase of 2.85 (95% CI, .52 to 5.19), $t(26) = 2.51$, $p <.05$.

These results were similar to the results of the original study with three cohorts. The original study found significant decreases in child BMI, child *z*BMI, child waist circumference, and child % body fat (Gallo et al., 2019). However, the original study did not find significant differences in the biochemistry markers following the interventions (Gallo et al., 2019). The differences in the results of the RTI scores for the studies is most likely explained by the fact that this study only uses the subset of the participants from the original sample who had EF and child language data.

Question 1

The first research question examined the relationships between baseline child EF, obesity, and language measures, and was analyzed using concurrent correlational analysis. All of the measured variables are summarized in Table 4.

Language and EF. Overall, correlations between child baseline language scores and child baseline EF scores were largely non-significant (Table 5). However there were significant negative relationships between parental report of child English proficiency and EF problems on the GEC *($r = -.28$, $p < .10$)*, BRI *($r = -.35$, $p < .05$)*, and the ERI *($r = -.30$, $p < .10$)*. This means that better parent-perceived child English language proficiency was associated with fewer EF problems (stronger EF). Parental report of child Spanish proficiency did not show the same pattern, with either none or slightly positive relations with EF problems (non-significant, $r = .04$ to .21). The amount of English the child and adults used in the home was generally unrelated ($r = .00$ to .26) to child executive function. The direct measure of English proficiency, the PPVT-III, also showed nonsignificant negative correlations with EF problems ($r = -.02$ to -.25).

EF and Obesity. Baseline executive function scores and baseline measures of child obesity were generally not significantly related to one another, however they were in the hypothesized direction ($r = .03$-.23) (Table 6). There were significant positive relationships between triglyceride levels and the GEC *($r = .34$, $p < .05$)*, BRI *($r = .38$, $p < .05$)*, ERI *($r = .32$, $p < .05$)*, CRI *($r = .30$, $p < .10$)*, CBCL attention score *($r = .27$, $p < .10$)* and CBCL externalizing score *($r = 34$, $p < .05$)*. This means that those with higher triglyceride levels showed more problems with EF. Additionally, there were significant positive relationships between engagement in sedentary activity and deficits on all of the EF measures ($r = .29$ to $.69$). Finally, the amount of sugar consumed was significantly related to the GEC ($r = .33, p < .10$), BRI ($r = .37, p < .05$), ERI ($r = .38, p < .05$), and the CBCL Externalizing ($r = .33, p < .10$); and the amount of saturated fats consumed was significantly related to the GEC ($r = .32, p < .10$) and CRI ($r = .29, p < .10$).

Language and Obesity. Finally, baseline language scores and baseline measures of child obesity were also generally not significantly related to one another (Table 7). However, caregiver report of child English proficiency was significantly positively correlated with child *z*BMI ($r = .31, p < .05$) and child waist circumference ($r = .33, p < .05$) at baseline. This means that children whose parents reported that the child had stronger English skills also tended to be heavier or more obese. There was an additional positive correlation with child English use in home and the child's *z*BMI ($r = .27, p < .10$), and adult English use in the home and child *z*BMI ($r = .30, p < .10$). Relatedly, parent report of child Spanish proficiency was marginally negatively correlated with child baseline *z*BMI ($r = -.28, p < .10$). Importantly, the direct PPVT measure of English proficiency was generally unrelated to child obesity markers at baseline.

Question 2

The second research question looks at the relationships between the child's response to the intervention, and both the child's baseline EF and English proficiency, and was also analyzed using correlations. Again, all of the measured variables are summarized in Table 4. It is important to remember that the attrition was extremely high for the second time point, which means that the *n* for all of these correlations was low (*n's* = 19-25).

The relationships between the baseline EF scores and the child obesity change scores were not generally significant (Table 9). There were significant positive relationships between the child's change in cholesterol and their baseline scores on the CBCL attention ($r = .42, p < .05$) and externalizing ($r = .42$ $p < .05$) scales. This indicates that those with more initial behavior and attention problems showed greater increases over time in their cholesterol. Interestingly, there was a significant negative relationship between the child's scores on the CBCL externalizing scale and the child's change in waist circumference over time ($r = -.39, p < .05$) meaning that children with worse initial externalizing problems made more positive reductions in waist circumference by the end of the intervention. A similar pattern was found for HOMA-IR change scores ($r = -.41, p < .10$) and CBCL scores following the intervention.

The overall relationships between baseline EF deficits and dietary change scores were not significant (Table 10). Note that the Ns are very small for these correlations (*n* = 11-21) making the interpretation suspect; however, there were no major outliers affecting the correlation patterns.

Finally, the overall relationships between baseline EF scores and change in child physical fitness markers were also not significant (Table 11). Counterintuitively, children with more EF problems at baseline (GEC) tended to show stronger increases in physical activity over time ($r = .46, p < .05$). This was supported by the significant positive correlations between changes in the child's engagement in physical activity and the baseline ERI ($r = .47, p < .05$), CRI ($r = .46, p < .05$) and the baseline CBCL externalizing score ($r = .46, p < .05$); as well as positive improvements to the child's shuttle run score and the CBCL externalizing score ($r = .41, p < .05$). Furthermore, the number of incorrect responses on the Go-No-Go assessment was related to positive improvements in the child's vertical jump score ($r = .59, p < .05$).

Question 3

The final research question looked at the relationship between the child's change in EF over time and the child's response to the intervention (changes in child eating habits, changes in child's physical activity, and changes in the child's *z*BMI). As discussed for question 2, the *n* for this sample was very small due to attrition. This question was also answered using correlational analysis. The variables for this question are also summarized in Table 4.

Overall, changes in executive functions were not significantly related to changes in obesity scores (Table 12). However, in the case of the triglyceride levels and the ERI subscale, there was a significant negative correlation ($r = -.50, p < .05$). Table 12 also shows similar correlations with food intake variables. Changes in executive functions were significantly related to changes in saturated fat intake ($r = .52$ - $.62$) and sugar added intake ($r = .60$-$.70$). These were positive correlations, which means that the children who got worse in terms of EF over time according to parent report were also the children who showed unhealthy/larger *increases* over time in saturated fats and sugar consumption. Finally, the extent to which change in EF was correlated with change in markers of child physical fitness scores is shown in Table 13. These correlations were again nonsignificant generally due to small sample sizes. However, there were significant relationships between vertical jump skills and EF in the opposite direction than expected – those who got worse in terms of BRI ($r = .49$, $p < .10$), CRI ($r = .54$, $p < .05$), and GEC ($r = .48$, $p < .10$) over time showed better gains in vertical jump skills over time. A similar pattern happen with the shuttle run scores, children who got worse in terms of ERI ($r = .49$, $p < .10$) and CRI ($r = .49$, $p < .10$) over time showed better gains in scores over time.

DISCUSSION

There is a well-established bidirectional relationship between obesity and executive functions (Gettens & Gorin, 2017; Limbers & Young, 2015; Wyckoff et al., 2017; Xu et al., 2017). Studies have shown that adults increase their executive functioning abilities after losing weight through surgery (Alosco et al., 2014a, 2014b); and that both children and adults with better executive functioning abilities are able to lose weight faster and maintain weight loss longer (Gettens & Gorin, 2017). However, research does not clearly demonstrate the impact of culture and language on executive functioning and obesity, and prior research is silent on whether executive functioning is a meaningful correlate of obesity intervention in young Latinx children.

This study examined the impact of an obesity intervention for a minority population that is not often included in research studies. It looked specifically at particular cognitive and cultural factors that might provide protection from or vulnerability to childhood obesity. Additionally, it provides insight into which types of children (in terms of EF skills) may be more likely to change their diet or exercise habits following an obesity intervention.

Baseline Correlations. The study found that the child's executive functioning problems were significantly positively related to the child's triglyceride levels, sedentary activity engagement, sugar consumption and saturated fat consumption at baseline. This means that the children with greater EF problems tended to score worse on these measures. This pattern followed the results of previous studies (Gettens & Gorin, 2017; Limbers & Young, 2015; Wyckoff et al., 2017; Xu et al., 2017), and the relationships were in the expected directions. Of note, triglyceride levels at baseline were significantly related to most of the executive function measures at baseline. Triglyceride levels frequently fluctuate throughout the day, and are extremely sensitive to changes in physical activity and diet. In fact, triglyceride levels are so sensitive that they are typically measured after a fast so that the person's diet does not interfere with the study. Higher triglyceride levels are also inconsistently associated with lower engagement in physical activity as triglycerides are broken down after the body utilizes its store of energy from simple carbohydrates. Therefore, our finding may be partially explained by our findings that the children in our study with higher deficits on the BRIEF and CBCL attention scales were more likely to have diets with higher sugar and engage in more sedentary activity at baseline. This follows previous research that indicates children with higher EF deficits are more likely to over consume foods which are high in sugar and engage in more sedentary activities (Liang, Matheson, Kaye, & Boutelle, 2014; Pearce et al., 2018). Since triglyceride levels are particularly sensitive to diet and exercise, it is possible that the correlation between EF was stronger for triglycerides than it was for the other metabolic indicators that are not as sensitive to diet and exercise.

Additionally, some of the variables that measured the child's English language proficiency (parental report of child English proficiency, the child's English language use in the home, and the adult's English language use in the home) were significantly positively correlated with the child's *z*BMI at baseline. This means that children who were more obese were perceived as having stronger English skills by their parent. Parental report of the child's English proficiency was also positively related to the child's waist circumference. Interestingly, the standardized PPVT English assessment was not significantly related to the obesity measures, but was significantly related to parental report of English proficiency. This result was surprising, as we had originally predicted that the additional EF gains conferred by bilinguism would be protective for the child's weight and obesity status. Perhaps, parental perception of child English competence was more a measure for how well the family assimilated into American culture. This is in line with how the parental perception of child English competence was measured (parental rating on a Likert scale), which would have been heavily influenced by the parent's ability to understand and speak English. As discussed in the previous section, assimilation carries multiple risk factors for obesity as children adopt American diets and lose access to protective factors from their native cultures (Garcia, et al., 2019; Gordon-Larsen et al., 2003; Lindberg et al., 2013). Since parental report of child English skills and parent report of child Spanish skills were not associated with each other, it may be that children whose parents report that they have good English skills are not truly bilingual. Therefore, we may see two different mechanisms at work here where child English proficiency is a marker of assimilation, and child Spanish proficiency is tied with extra barriers for the parents to gain access to a healthy diet.

Previous research has not examined the impact that parent English proficiency has on child obesity, except when it is used as a proxy for acculturation. This area needs further research with additional standardized measures of parent English competence. However, it does speak to the need to ensure that interventions are modified to the preferred language for the caregiver in order to help overcome any risk factors conferred by a lack of parental English proficiency.

Response to Intervention. Overall, the participants in the intervention made positive changes according to some obesity indicators. However, since there was no control group it is not possible for us to determine if the intervention was the cause of these changes. The participants made significant decreases in their *z*BMI, waist circumference, and sugar added into their diets. Additionally, they made significant increases in their vertical jump scores. The amount of sugar added into the diet was especially significant, because a focus of the intervention was to reduce the amount of sugary beverages (i.e., juice and soda) consumed.

Several indicators (HOMA-IR, cholesterol, and triglycerides) did not show significant change at the follow-up testing. It is possible that due to the short time between baseline and follow-up testing (3-4 months), the children did not have time to make lasting changes in their levels. Additionally, on average, the children increased their glucose (blood sugar) and HOMA-IR (non-significant) levels from baseline testing to follow-up testing. The increase in glucose levels was statistically significant. However, there is some evidence to indicate that fasting glucose levels may not be related to BMI and waist circumference (Ludvigsson et al., 2007).

EF and Intervention Change Scores. Overall, patterns in change scores as they related to baseline EF were non-significant; however there were significant positive relationships between: CBCL scores and cholesterol. This means that children with poorer EF skills at baseline were less likely to make positive changes to their cholesterol levels at follow-up. However, when looking at the change scores, a surprising pattern emerged that children who had higher executive functioning problems were also the children who increased their engagement in physical activity following the intervention, made improvements in some of their physical fitness measures, were more likely to lose cm from their waist circumference, and were more likely to lower their HOMA-IR change score. This was surprising, as previous research has indicated that people with EF deficits tend to have difficulty initiating exercise (Gettens & Gorin, 2017). However, it is possible that children do not always conceptualize exercise as work, and may consider it to be leisure or play activity. Additionally, the families of children with executive function deficits may have begun to use physical activity as a coping mechanism for managing the child's behavior during the intervention. It is important to note that none of the children had clinically significant EF problems on any measure, so this pattern may change for children with significant functional impairment.

Finally, children with positive changes in EF scores at follow-up were more likely to make positive changes to their diet and some obesity measures. Since the period between test administrations was so short (10-12 weeks), we would not expect a change in EF skills due to normal development. Therefore, changes in EF might be caused by an outside environmental factor, such as the child's weight loss. This lends support to the idea that there is a possibility of a bidirectional relationship between EF and obesity; and that interventions specifically targeting EF could be added to weight loss programs, as a potential tool for increasing the efficacy of the physical activity and nutrition portions of the intervention. In support of the abovementioned findings, children who got worse on EF measures also made more gains in shuttle run scores and vertical jump scores. This may indicate that exercise is a helpful coping mechanism and leisure activity for young children with EF deficits.

Implications. The baseline correlations in this study show that there are some relationships between language skills and obesity; as well as EF and obesity. The language relationships were not clear or consistent, and further study is needed with standardized measures of parental English proficiency. However, the existence of significant relationships between some language measures (parent report of child English proficiency, child and adult English use in the home) and the child's *z*BMI at baseline speaks to the need for the design and implementation of culturally sensitive weight loss interventions for minority populations. Additionally, it draws attention to the community-based resource deficits that could make it difficult for Spanish-speaking families to implement weight loss interventions in the US. Furthermore, it provides support that culturally sensitive interventions should focus on mitigating the possible harmful impacts of acculturation on the child's weight. This could include attaching additional value to traditional diets, and helping families to locate food sources within their neighborhoods. It may also be helpful for the interventionists to devalue American dietary habits and food sources, as immigrants may have some overvaluation of these unhealthy American habits (Lindberg, Stevens, & Halperin, 2013). Finally, the relationships observed here between EF and obesity indicate that it would be helpful to consider EF deficits of the child in the planning stages of the intervention. Since children with larger triglyceride levels, more sedentary activity engagement, more sugar consumption and more saturated fat consumption were more likely to have larger EF deficits (which make it harder for them to implement dietary\exercise change), future projects may focus on adding EF supports for such children so that they can take advantage of the nutrition and physical activity components of the intervention.

Subsequent interventions could also focus on the possibility that executive function deficits may provide some protective factors for childhood obesity. This is especially true if families are able to use physical activity as a potential means for coping with the challenges of raising children who are struggling to regulate their behavior and hyperactivity. This would be most effective if exercise is viewed as a "fun" activity, and the child enjoys the exercising process. Finally, it may be helpful to conceptualize cognitive functioning as a type of motivating operation when considering the link between antecedents and engagement in healthy\unhealthy behaviors. This study indicates that for some children, cognitive predispositions may make it more difficult for them to engage in healthy behaviors and inhibit unhealthy behavioral responses to environmental antecedents. Therefore, it may be helpful for children to engage in behavioral interventions directed toward improving EF deficits. Some examples of effective interventions may include computerized training of EF skills, attention training, and episodic, future thinking interventions (Hayes et al., 2018).

Limitations. Although the study is greatly limited by the small sample size, it contributes a valuable perspective to the intervention literature about ways to adapt interventions to achieve maximum effectiveness and cultural competency. Future work could improve upon this study by decreasing the attrition at follow-up. One possible way to do this is to make the T2 follow-up appointment a part of the final intervention class. Additionally, it may be helpful to add a standardized assessment of the child's Spanish language skills to gain a true understanding of the child's bilingualism, as well as utilize standardized measures of English fluency from parents.

Furthermore, some of the variables used in the study had a relatively small range. For example, none of the children on the BRIEF scored within the clinical range of EF deficits, and only a small number scored within the clinical range on the CBCL. At baseline, the BRIEF variables had a range between 30-34. At follow-up testing, the BRIEF variables had a similar but lower range between 15-21. The CBCL variables also had a similar pattern, with the attention score having a range of 27 and the externalizing score having a range of 50. Since the children did not score within the clinical range for any of the executive function measures, this study is limited in its ability to generalize to a clinical population. Additionally, both the CBCL and the BRIEF are designed to identify a clinical population, it therefore it is possible that there was not enough sensitivity in the measures to adequately differentiate between the EF skills within typically developing children. Another consideration is that ten weeks may not have been enough time to allow the BRIEF to account for subtle changes in executive function abilities. Future studies should use a more sensitive measure, or leave more time between test points. Another example is that the *z*BMI of the children had a strong floor because only children above the 85^{th} percentile at baseline were allowed to participate in the study. The limited variance within these variables may be responsible for some of the non-significant findings within our study, and they limit the generalizability of the results. Finally, the acculturation measure was weak (only one question about language) and it would be beneficial to add additional questions for future surveys.

In conclusion, this study looked at the relationships between Latinx children's executive functions, language, and obesity indicators. The study found that executive functioning and language were both loosely related to improvement in childhood obesity indicators. It provides an important foundation for future work looking at how to predict success in a weight loss intervention.

APPENDIX

Table 1. Child demographic statistics for categorical variables.

Child Demographic Variables	***n***	**%**
Gender		
Male	29	65.9%
Female	15	34.1%
Child Individualized Education Plan Status		
No	35	79.5%
Yes	6	14.6%
Missing	3	6.8%
Child Country of Birth		
El Salvador	5	11.4%
Honduras	1	2.3%
Mexico	1	2.3%
United States	36	81.2%
Missing	1	2.3%
Child Born in the US		
Yes	36	81.8%
No	7	15.9%
Missing	1	2.3%

Table 2. Parent demographic statistics for categorical variables.

Parental Demographic Variables	***n***	**%**
Marital Status		
Single Parent	11	25%
Dual Parent	22	50%
Missing	11	25%
Maternal BMI Category		
Non-Obese (BMI = < 25)	4	9%
Overweight (BMI = 25- <30)	10	22.7%
Obese (BMI = >30)	16	36.4%
Missing	14	31.8%
Paternal BMI Category		
Non-Obese (BMI = < 25)	0	0.0%
Overweight (BMI = 25- <30)	3	6.8%
Obese (BMI = >30)	10	22.7%
Missing	31	70.5%
Maternal Country of Birth		
El Salvador	27	61.4%
Guatemala	1	2.3%
Honduras	4	9.1%
Mexico	7	15.9%
United States	2	4.5%
Missing	3	6.8%
Paternal Country of Birth		
El Salvador	16	36.4%
Guatemala	1	2.3%
Honduras	2	4.5%
Mexico	7	15.9%
United States	1	2.3%
Missing	17	38.6%
Maternal Education Level (n=38)		
Elementary School	5	11.4%
High School	22	50.0%
Vocational\Apprenticeship	4	9.1%
College	5	11.4%
University	2	4.5%
Missing	6	13.6%

Paternal Education Level (n=23)		
Elementary School	9	20.5%
High School	9	20.5%
Vocational\Apprenticeship	2	4.5%
College	1	2.3%
University	2	4.5%
Missing	21	47.7%
Maternal Employment		
Yes	20	45.5%
No	23	52.3%
Missing	1	2.3%
Paternal Employment		
Yes	25	56.8%
No	2	4.5%
Missing	17	38.6%

Table 3. Demographic statistics for continuous variables.

Variables	**Mean**	**(SD)**	***n***	**% Missing**	**Range**
PPVT Standard Score	82.64	(18.1)	42	7.9%	40-117
Parent Report Child English Prof.	3.93	(1.0)	42	7.9%	1-5
Parent Report Child Spanish Prof.	3.45	(1.3)	42	7.9%	1-5
Adult English Use in Home	2.37	(0.8)	43	8.5%	1-4
Child English Use in Home	1.85	(1.1)	42	10.6%	1-5
People in the House	5.49	(2.1)	43	6.3%	3-10
Adults in the House	2.88	(1.5)	43	6.3%	1-7
Children in the House	2.67	(1.3)	43	6.3%	1-6
Maternal Age	36.50	(6.4)	42	6.3%	20-51
Paternal Age	39.28	(8.5)	29	28.6%	23-62
Maternal Education (Years)	7.35	(4.1)	34	20.6%	1-13
Paternal Education (Years)	7.16	(3.9)	19	44.4%	2-16
Maternal Years in the US	13.68	(6.5)	40	20.6%	1-30
Paternal Years in the US	18.56	(7.6)	27	38.1%	5-35
Income	31,90K	(23,84K)	34	27.7%	$15-$100K
Child Age	7.57	(1.5)	44	6.4%	5-10
CBCL Externalizing	50.12	11.65	38	9.5%	33-83
CBCL Attention	54.56	7.21	38	9.5%	50-77
BRIEF GEC	50.59	9.39	38	9.5%	36-70

Table 4. Variable table.

Variables	Higher Numbers	Lower Numbers	Time Points Administered	*n*
Language Variables				
Parental Report of Child English Proficiency	More English Proficiency	Less English Proficiency	Baseline only	42
Parental Report of Child Spanish Proficiency	More Spanish Proficiency	Less Spanish Proficiency	Baseline only	42
Child English Use in Home When Speaking to Adults	More English	More Spanish	Baseline only	42
Adult English Use in Home When Speaking to Children	More English	More Spanish	Baseline only	43
Executive Function Variables				
BRIEF, Global Executive Composite (GEC)	More problems	Better EF	Baseline and Follow-Up	41
BRIEF, Behavior Regulation Index (BRI)	More problems	Better EF	Baseline and Follow-Up	42
BRIEF, Emotional Regulation Index (ERI)	More problems	Better EF	Baseline and Follow-Up	41
BRIEF, Cognitive Regulation Index (CRI)	More problems	Better EF	Baseline and Follow-Up	41
Go\No Go Correct	Better EF	Poorer EF	Baseline and Follow-Up	20
Go\No Go Error	More problems	Better EF	Baseline and Follow-Up	20
CBCL Attention Scale	More problems	Fewer Problems	Baseline and Follow-Up	41
CBCL Externalizing Scale	More problems	Fewer Problems	Baseline and Follow-Up	41

Obesity Markers				
Body Mass Index (BMI)	Higher BMI	Lower BMI	Baseline and Follow-Up	44
Waist Circumference	Larger waist circumference	Smaller waist circumference	Baseline and Follow-Up	42
HOMA-IR	More insulin resistance	Less insulin resistance	Baseline and Follow-Up	40
Cholesterol	Higher Cholesterol	Lower Cholesterol	Baseline and Follow-Up	43
Glucose	Higher Glucose	Lower Glucose	Baseline and Follow-Up	43
Triglycerides	Higher Triglycerides	Lower Triglycerides	Baseline and Follow-Up	43
Dietary Change Variables				
Saturated Fat	Worse diet	Better diet	Baseline and Follow-Up	39
Sugar Added	Worse diet	Better diet	Baseline and Follow-Up	38
Physical Activity				
Sedentary Activity	More sedentary	Less sedentary	Baseline and Follow-Up	39
Physical Activity	More physical activity	Less physical activity	Baseline and Follow-Up	38
Vertical Jump	Higher jump	Lower jump	Baseline and Follow-Up	44
Shuttle Run	Slower/Worse	Faster/Better	Baseline and Follow-Up	44
Medicine Ball	Further throw	Shorter throw	Baseline and Follow-Up	44

Table 5. Correlations between language and executive functions.

	Childhood Baseline EF Variables							
Childhood Baseline Language	**GEC**	**BRI**	**ERI**	**CRI**	**GNGC**	**GNGE**	**CBCLA**	**CBCLExt**
Parent Report Child English Prof.	-.28+ *(n=39)*	-.35* *(n=40)*	-.30+ *(n=39)*	-.24 *(n=39)*	.23 *(n=19)*	-.26 *(n=19)*	-.15 *(n=39)*	-.20 *(n=39)*
Parent Report Child Spanish Prof.	.09 *(n=40)*	.04 *(n=41)*	.15 *(n=40)*	.11 *(n=40)*	-.25 *(n=20)*	.21 *(n=20)*	.14 *(n=40)*	.19 *(n=40)*
Child English Use in Home	.01 *(n=39)*	-.00 *(n=40)*	-.01 *(n=39)*	-.06 *(n=39)*	.19 *(n=20)*	-.24 *(n=20)*	-.06 *(n=39)*	-.01 *(n=39)*
Adult English Use in Home	-.17 *(n=40)*	-.10 *(n=41)*	-.17 *(n=40)*	-.21 *(n=40)*	.26 *(n=20)*	-.24 *(n=20)*	-.06 *(n=40)*	-.01 *(n=40)*
English Proficiency (PPVT-III)	-.11 *(n=40)*	-.15 *(n=41)*	-.18 *(n=40)*	-.10 *(n=40)*	.22 *(n=20)*	-.22 *(n=20)*	.02 *(n=39)*	-.25 *(n=39)*

* $p < .05$
+$p < .10$

Table 6. Correlations between baseline weight and EFs.

	Childhood Baseline Obesity Variables									
Childhood Baseline EF Variables	**Child *z*BMI**	**Child Waist Circum., cm**	**HOMA**	**TC mg/dL**	**GLC mg/dL**	**TG mg/dL**	**SF (g)**	**Sugar Added (g)**	**Sedentary Activity**	**Physical Activity**
BRIEF GEC	.14 *(n=25)*	.01 *(n=39)*	.04 *(n=37)*	.24 *(n=40)*	-.02 *(n=40)*	.34* *(n=40)*	.32$^+$ *(n=36)*	.33$^+$ *(n=35)*	.44* *(n=36)*	-.12 *(n=35)*
BRIEF BRI	.23 *(n=42)*	-.07 *(n=40)*	.10 *(n=38)*	.26 *(n=41)*	.13 *(n=41)*	.38* *(n=41)*	.27 *(n=37)*	.37* *(n=36)*	.34* *(n=37)*	-.13 *(n=36)*
BRIEF ERI	.16 *(n=41)*	.09 *(n=39)*	.16 *(n=37)*	.17 *(n=40)*	.07 *(n=40)*	.32* *(n=40)*	.23 *(n=36)*	.38* *(n=35)*	.40* *(n=36)*	-.12 *(n=35)*
BRIEF CRI	.03 *(n=41)*	.02 *(n=39)*	-.02 *(n=37)*	.23 *(n=40)*	-.13 *(n=40)*	.30$^+$ *(n=40)*	.29$^+$ *(n=36)*	.19 *(n=35)*	.42* *(n=36)*	.23 *(n=35)*
Go-No-Go Correct	-.07 *(n=20)*	.30 *(n=20)*	.09 *(n=18)*	-.21 *(n=20)*	-.03 *(n=20)*	-.15 *(n=20)*	-.25 *(n=19)*	-.15 *(n=19)*	-.68* *(n=17)*	-.49* *(n=17)*
Go-No-Go Errors	.10 *(n=20)*	-.29 *(n=20)*	-.09 *(n=18)*	.24 *(n=20)*	.05 *(n=20)*	.17 *(n=20)*	.23 *(n=19)*	.13 *(n=19)*	.69* *(n=17)*	.40 *(n=17)*
CBCL Attention	.09 *(n=41)*	.15 *(n=40)*	.18 *(n=38)*	.24 *(n=41)*	.08 *(n=41)*	.27$^+$ *(n=41)*	.32 *(n=36)*	.29 *(n=36)*	.36* *(n=37)*	.10 *(n=36)*
CBCL Externalizing	.03 *(n=41)*	.20 *(n=40)*	.26 *(n=38)*	.14 *(n=41)*	.04 *(n=41)*	.34* *(n=41)*	.26 *(n=36)*	.33$^+$ *(n=36)*	.29$^+$ *(n=37)*	-.02 *(n=36)*

* $p < .05$, +p < .10

GEC: Global Executive Composite. BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index; TC: Total Cholesterol, GLC: Glucose, TG: Triglycerides, SF: Saturated Fats

Table 7. Correlations between baseline weight and baseline language.

	Childhood Baseline Obesity Variables					
Childhood Baseline Language	**Baseline Childhood *z*BMI**	**Baseline Childhood Waist Circumference, cm**	**Baseline HOMA**	**Baseline Cholesterol mg/dL**	**Baseline Glucose mg/dL**	**Baseline Triglycerides**
Parent Report Child English Prof.	.31* *(n=42)*	.33* *(n=40)*	.06 *(n=38)*	.18 *(n=41)*	.03 *(n=41)*	-.10 *(n=41)*
Parent Report Child Spanish Prof.	-.28+ *(n=42)*	-.20 *(n=40)*	.00 *(n=39)*	.08 *(n=41)*	-.01 *(n=41)*	-02 *(n=41)*
Child English Use in Home	.27+ *(n=42)*	.06 *(n=40)*	-.22 *(n=38)*	.23 *(n=41)*	.19 *(n=41)*	-.14 *(n=41)*
Adult English Use in Home	.30+ *(n=43)*	.08 *(n=41)*	-.23 *(n=39)*	.28+ *(n=42)*	.13 *(n=42)*	-.05 *(n=42)*
English Proficiency (PPVT-III)	.04 *(n=42)*	.16 *(n=40)*	.02 *(n=38)*	.09 *(n=41)*	.14 *(n=41)*	-.15 *(n=41)*

* $p < .05$
+p < .10

Table 8. Overall Intervention Response

Obesity Variables.	Change Score Mean	T1 Mean	T2 Mean
*z*BMI	-0.09* *(n=28)*	2.18 *(n=28)*	2.09 *(n=28)*
Waist Circumference	-1.23* *(n=27)*	80.18 *(n=27)*	78.94 *(n=27)*
HOMA-IR	5.36 *(n=21)*	27.90 *(n=21)*	33.27 *(n=21)*
Cholesterol	-2.19 *(n=27)*	151.00 *(n=27)*	148.81 *(n=27)*
Glucose	2.85* *(n=27)*	91.33 *(n=27)*	94.19 *(n=27)*
Triglycerides	-1.19 *(n=27)*	86.74 *(n=27)*	85.56 *(n=27)*
Saturated Fat	-2.55 *(n=23)*	15.30 *(n=23)*	12.76 *(n=23)*
Sugar Added	-2.68^{+} *(n=21)*	8.06 *(n=21)*	5.38 *(n=21)*
Sedentary Activity	-14.06 *(n=22)*	123.11 *(n=22)*	109.05 *(n=22)*

Physical Activity	-4.38 *(n=22)*	49.48 *(n=22)*	45.10 *(n=22)*
Vertical Jump	.59* *(n=28)*	9.20 *(n=28)*	9.79 *(n=28)*
Shuttle Run	-.30 *(n=28)*	14.76 *(n=28)*	14.46 *(n=28)*
Seated Medicine Ball Throw	1.79 *(n=28)*	78.43 *(n=28)*	80.22 *(n=28)*

Table 9. Correlations between change scores in weight and baseline scores in EF.

	Childhood Weight Change Scores					
Childhood EF Baseline Scores	**BMI Change Score**	**Waist Circumference Change Score, cm**	**HOMA Change Score**	**Cholesterol Change Score, mg/dL**	**Glucose Change Score, mg/dL**	**Triglycerides Change Score**
BRIEF GEC	.11 *(n=25)*	.04 *(n=24)*	.05 *(n=18)*	.05 *(n=24)*	.11 *(n=24)*	-.01 *(n=24)*
BRIEF BRI	.19 *(n=26)*	.01 *(n=25)*	-.13 *(n=19)*	.19 *(n=25)*	-.19 *(n=25)*	.18 *(n=25)*
BRIEF ERI	.17 *(n=25)*	-.08 *(n=24)*	.17 *(n=18)*	.27 *(n=24)*	.02 *(n=24)*	.28 *(n=24)*
BRIEF CRI	.08 *(n=25)*	.13 *(n=24)*	.04 *(n=18)*	-.00 *(n=24)*	.16 *(n=24)*	-.12 *(n=24)*
CBCL Attention	.09 *(n=26)*	-.21 *(n=26)*	-.21 *(n=19)*	.42* *(n=25)*	-.00 *(n=25)*	.24 *(n=25)*
CBCL Externalizing	.13 *(n=26)*	-.39* *(n=26)*	-.41+ *(n=19)*	.42* *(n=25)*	.03 *(n=25)*	.09 *(n=25)*
Go-No-Go Correct	.65* *(n=13)*	.30 *(n=13)*	.07 *(n=9)*	.15 *(n=13)*	.03 *(n=13)*	.10 *(n=13)*
Go-No-Go Incorrect	-.65* *(n=13)*	-.30 *(n=13)*	-.07 *(n=9)*	-.15 *(n=13)*	-.03 *(n=13)*	-.10 *(n=13)*

* $p < .05$, +p < .10

GEC: Global Executive Composite, BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index

Table 10. Correlations between change scores in diet and baseline scores in EF.

	Change Scores in Diet	
Childhood Executive Function Baseline Scores	**Change Scores in Grams of Saturated Fat**	**Change Scores in Grams of Sugar Added**
BRIEF GEC	-.35 *(n=20)*	-.35 *(n=18)*
BRIEF BRI	-.33 *(n=21)*	-.36 *(n=19)*
BRIEF ERI	-.28 *(n=20)*	-.39 *(n=18)*
BRIEF CRI	-.32 *(n=20)*	-.24 *(n=18)*
CBCL Attention	-.27 *(n=21)*	-.36 *(n=20)*
CBCL Externalizing	-.25 *(n=21)*	-.27 *(n=20)*
Go-No-Go Correct	.37 *(n=12)*	.51 *(n=11)*
Go-No-Go Incorrect	-.37 *(n=12)*	-.51 *(n=11)*

* $p < .05$, +p < .10

GEC: Global Executive Composite, BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index

Table 11. Correlations between change scores in physical activity and baseline scores in EF.

	Change Scores in Physical Activity				
Childhood Executive Function Baseline Scores	**Sedentary Activity**	**Physical Activity**	**Vertical Jump**	**Shuttle Run**	**Medicine Ball Throw**
BRIEF GEC	-.27 *(n=19)*	.46* *(n=19)*	-.22 *(n=25)*	-.01 *(n=24)*	.06 *(n=25)*
BRIEF BRI	-.09 *(n=20)*	.40 *(n=20)*	-.23 *(n=26)*	-.01 *(n=25)*	.01 *(n=26)*
BRIEF ERI	-.20 *(n=19)*	.47* *(n=19)*	-.25 *(n=25)*	-.09 *(n=24)*	.03 *(n=25)*
BRIEF CRI	-.29 *(n=19)*	.46* *(n=19)*	-.14 *(n=25)*	.03 *(n=24)*	.11 *(n=25)*
CBCL Attention	-.08 *(n=21)*	.31 *(n=21)*	-.28 *(n=26)*	.11 *(n=25)*	.13 *(n=26)*
CBCL Externalizing	.16 *(n=21)*	.46* *(n=21)*	-.09 *(n=26)*	.41* *(n=25)*	.07 *(n=26)*
Go-No-Go Correct	.02 *(n=9)*	.35 *(n=10)*	-.59* *(n=13)*	.05 *(n=13)*	.07 *(n=13)*
Go-No-Go Incorrect	-.02 *(n=9)*	-.35 *(n=10)*	.59* *(n=13)*	-.05 *(n=13)*	-.07 *(n=13)*

* $p < .05$, +$p < .10$ GEC: Global Executive Composite, BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index

Table 12. Correlations between change scores in weight and change scores in EF.

Childhood EF Change Scores	**Childhood Weight Change Scores** **BMI Change Score**	**Waist Circumference Change Score, cm**	**HOMA Change Score**	**Cholesterol Change Score, mg/dL**	**Glucose Change Score, mg/dL**	**Triglycerides Change Score**	**Change Scores in Grams of Saturated Fat**	**Change Scores in Grams of Sugar Added**
BRIEF GEC	-.29 *(n=16)*	-.20 *(n=15)*	-.44 *(n=14)*	.01 *(n=16)*	.02 *(n=16)*	-.26 *(n=16)*	.62* *(n=13)*	.70* *(n=11)*
BRIEF BRI	-.29 *(n=16)*	-.19 *(n=15)*	-.40 *(n=14)*	.23 *(n=16)*	.13 *(n=16)*	-.04 *(n=16)*	.55+ *(n=13)*	.61* *(n=11)*
BRIEF ERI	-.31 *(n=17)*	-.25 *(n=16)*	-.44 *(n=14)*	-.14 *(n=17)*	-.02 *(n=17)*	-.50* *(n=17)*	.57* *(n=14)*	.66* *(n=12)*
BRIEF CRI	-.26 *(n=16)*	-.20 *(n=15)*	-.47 *(n=14)*	-.04 *(n=16)*	.03 *(n=16)*	-.21 *(n=16)*	.52+ *(n=13)*	.60+ *(n=13)*

* p < .05, +p < .10
GEC: Global Executive Composite, BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index

Table 13. Correlations between change scores in physical fitness measures and change scores in EF.

	Change Scores in Physical Fitness Measures				
Childhood EF Change Scores	**Sedentary Activity**	**Physical Activity**	**Vertical Jump**	**Shuttle Run**	**Medicine Ball Throw**
BRIEF GEC	.31 *(n=13)*	-.37 *(n=12)*	.48+ *(n=16)*	.44 *(n=15)*	.06 *(n=16)*
BRIEF BRI	.15 *(n=13)*	-.34 *(n=12)*	.49+ *(n=16)*	.21 *(n=15)*	.02 *(n=16)*
BRIEF ERI	.43 *(n=14)*	-.26 *(n=13)*	.29 *(n=17)*	.49+ *(n=16)*	.28 *(n=17)*
BRIEF CRI	.32 *(n=13)*	-.41 *(n=12)*	.54* *(n=16)*	.49+ *(n=15)*	-.13 *(n=16)*

* $p < .05$, +$p < .10$
GEC: Global Executive Composite, BRI: Behavioral Regulation Index, ERI: Emotional Regulation Index, CRI: Cognitive Regulation Index

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