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Utilizing a Board Game to Measure Family/Parenting Factors and Childhood Obesity Risk

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Abstract

Objective: To describe a direct observational approach (i.e., interactive family board game) for measuring family functioning and parenting behaviors of relevance to child weight and weight-related behaviors and to examine family functioning and parenting factors from multiple family dyads (e.g., siblings, parent-child) and their associations with child weight and weight-related behaviors.

Design: Cross-sectional, mixed-methods study.

Setting: Two home visits were conducted with families ten days apart, with an seven-day observational period in between home visits.

Participants: Children (n=150) ages 5-7 years and their families from one of six racial/ethnic or immigrant/refugee groups, including: African American, Hispanic, Hmong, Native American, Somali, or White participated in the *Family Matters* study between 2014-2016.

Main Outcome Measure: Child weight status and weight-related behaviors (i.e., diet quality, physical activity).

Analysis: Adjusted logistic and linear regression models with robust standard errors were used in analysis.

Results: Higher family functioning scores across the majority of family dyads were significantly associated with lower child weight status. In addition, some family functioning scores were associated with child diet and physical activity, but not consistently. Parenting behavior scores were inconsistently associated with child weight and weight-related outcomes.

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Conflict of interest: Authors have no conflicts of interest to report.

Conclusions and Implications: Results suggest that the interactive family board game task is a direct observational approach that researchers can use with family members to measure family functioning and parenting behaviors related to childhood obesity. Future interventions may want to consider including multiple family members in both measurement and intervention development to target childhood obesity.

Keywords

Childhood Obesity Disparities; Direct Observation; Video-Recorded Interactive Family Task; Mixed-methods; Minority; Low-income

INTRODUCTION

The high prevalence of childhood obesity among school-aged children remains an important public health problem and disparities across race/ethnicity and income status continue to be evident.^{1–7} At the same time, numerous studies have shown that home environment factors such as negative family functioning (e.g., conflict, hostility, lack of communication), unhealthy parenting practices (e.g., controlling feeding practices such as restricting certain foods), and parenting style (e.g., authoritarian style such as being strict/rigid with low warmth) are associated with increased risk for childhood obesity.^{8–19} However, there has been low to moderate success with intervening on these home environment factors to reverse childhood obesity.^{20–22} One potential limitation with prior research is measurement. Many prior studies have used survey-based measurements and non-observational approaches to assess familial factors related to childhood obesity, which are often prone to social desirability issues and assessing behaviors as if they are static or unchanging.^{23,24} Direct observational approaches allow for capturing behavior(s) as they unfold in the real world, potentially leading to increased specificity, and valid and reliable measures of behaviors.^{15,25–28}

Although direct observational approaches to data collection are common in the fields of child development, psychology, and family science, these methods are just beginning to be used in the public health field in relation to childhood obesity.^{15,25,29} One direct observational approach is video-recording behaviors during a specific task assigned by a researcher. The direct observational task often includes the entire family (or multiple family members) engaging in a structured task and is conducted in the home. The family is directed to engage in a specific task such as planning a family vacation/trip or solving a challenging dilemma or issue (e.g., game, puzzle, a common problem the family disagrees about). These direct observational tasks allow for families to engage in both prosocial behaviors and conflictual behaviors that require problem solving, conflict resolution, and communication skills.^{15,25} Additionally, parenting style, family functioning, interpersonal interactions, and relationship quality can be assessed. Furthermore, these tasks allow for observing dyadic- (i.e., parent-child, sibling, couple) and family-level behaviors in real-time in order to identify interpersonal patterns (e.g., parenting style, parenting practices). Direct observational approaches in the family science, psychology, and child development fields have shown these measures to be reliable, valid, and the gold-standard for collecting parenting and family-level behaviors.^{15,25–28}

In addition, measuring multiple family members or dyads (e.g., parent-child, parent-sibling, siblings) when assessing family functioning and parenting behaviors is important in order to identify which family factors are related to child weight status and weight-related behaviors. Prior studies have shown that parents engage in different types of parenting behaviors (e.g., feeding practices, weight conversations, modeling)^{30–33} with their school-aged children. For example, two prior studies showed that parents used different feeding practices (e.g., restriction, pressure to eat) between siblings^{30,34} and other studies have shown that siblings have more similar eating behaviors and dietary intake compared to parents and children.^{32,35}

Given the high prevalence of childhood obesity and the disparities by race/ethnicity and socioeconomic status, it is important to identify ways to improve the measurement of parent and child behaviors with regard to weight and weight-related behaviors.^{1–7} The improved accuracy of measures will likely allow for identifying modifiable factors in the home environment to target in reducing childhood obesity. In addition, it is important to use these improved measures to examine associations between familial factors and childhood obesity risk across multiple dyads in the family and within diverse populations. Thus, the main aims of the current study include: (1) describe a direct observational method for measuring dyadic- and family-level behaviors of relevance to childhood obesity; and (2) examine associations between family functioning and parenting behaviors and child weight status and weight-related behaviors (e.g., diet quality, physical activity) among multiple family dyads (e.g., parent-child, sibling, and family-level) from racially/ethnically diverse populations. We hypothesize that higher family functioning and positive parenting behaviors will be associated with lower weight status, higher diet quality, and more physical activity in school-aged children.

Conceptual Framework

Family Systems Theory (FST)^{36,37} is the conceptual framework guiding the current study design, hypotheses, and analysis. FST recognizes multiple levels of influence on a child's weight status and weight-related behaviors, with the family environment being the most proximal level of influence. According to FST, dyadic- and family-level factors such as, parenting behaviors and family functioning are seen as reciprocal, in that each family member's behavior (e.g., parent hostility, parent modeling healthy eating and physical activity) influences and shapes the other family member's behavior (e.g., child hostility, child healthy eating and physical activity) iteratively. These parent, sibling, and familial reciprocal interactions ultimately influence child eating behaviors, physical activity patterns, and weight status.

METHODS

Data for the current study are from *Family Matters*,²³ a 5-year incremental (Phase I = 2014-2016.; Phase II = 2017-2019), mixed-methods (e.g., video-recorded tasks, ecological momentary assessment—EMA, interviews, surveys) longitudinal study designed to identify novel risk and protective factors for childhood obesity in the home environments of racially/ethnically diverse and primarily low-income children. Phase I included an in-depth, mixed-methods, cross-sectional examination of the family home environment of diverse families

(n=150). Phase II is a longitudinal epidemiological cohort study with diverse families (n=1200). In-depth details regarding both Phases of the *Family Matters* study have been published elsewhere.²³

Data utilized in the current analyses are cross-sectional and from Phase I of the *Family Matters* study. In Phase I, a mixed-methods analysis of the home environments of children ages 5-7 years old from six racial/ethnic groups including, African American, American Indian, Hispanic/Latino, Hmong, Somali, and White (n=25 from each racial/ethnic group) was conducted to identify individual, dyadic, and familial risk and protective factors for childhood obesity. Two home visits ten days apart (see Figure 1), conducted by two trained research staff matching the cultural background of the participant, occurred in families' homes for data collection. Families could choose the language in which they preferred the home visit to be carried out in (e.g., English, Spanish, Hmong, Somali). The University of Minnesota's Institutional Review Board Human Subjects Committee approved all protocols used in both phases of the *Family Matters* study. All family members were consented/assented to the study during the first home visit.

Recruitment and Eligibility Criteria

Eligible children ages 5-7 (n=150) and their families were recruited from the Minneapolis/St. Paul, MN area via a letter sent to them by their family physician. School-aged children ages 5-7 years were chosen for recruitment in this study given the adiposity rebound that occurs at this age.^{38,39} A priori power calculations, based on Phase I main study hypotheses examining familial factors associated with child overweight/obesity, diet quality, physical activity, were used to determine the sample size of n=150. Children were eligible to participate in the study if they were between the ages of 5-7 years old, had a sibling between the ages of 2-12 years old living in the same home, lived with their parent/primary guardian more than 50% of the time, shared at least one meal/day with the parent/primary guardian, and were from one of six racial/ethnic or immigrant/refugee categories (African American, American Indian, Hispanic/Latino, Hmong, Somali, and White). If there was more than one eligible sibling, the closest aged sibling to the child enrolled in the study was chosen. Given numerous prior studies showing racially/ethnically diverse populations are at highest risk for childhood obesity,¹⁻⁷ the sample was intentionally stratified by race/ethnicity, immigrant/refugee, and weight status (overweight/obese=BMI ≥85%ile; non-overweight=BMI <85%ile) of the child to identify potential weight- and/or race/ethnic-specific home environment factors related to obesity risk. Sample demographics are presented in Table 1.

Video-recorded interactive family board game.—The interactive family board game task, referred to as the *Family Matters Game* (see Figure 2) to participants, was developed for the current study, based on best practice in direct observational research in the field of family science (see Supplemental Material for full description of *Family Matters Game* and rules).^{26,28} Families engaged in this task on the first home visit, before any other data was collected (besides weight to confirm eligibility) to decrease potential influences on family members' behaviors during the game. Families were told that anyone they considered "family" and that lived in the home could participate in the *Family Matters Game*. The game

had instructions that families read detailing the rules, objectives of the game, and frequently asked questions related to the game. Allowing the family to play the board game on their own was intentional to ensure that they engaged in problem solving processes themselves rather than interacting with, or relying on, the research team member. In addition, families playing on their own minimized feelings of being watched/observed or judged to reduce the potential for social desirability bias. Video-recording took place while families participated in the *Family Matters Game*. A video camera was set up in the family's home by one of the research team members. Once the recording started, the research team member left the room and engaged in other study tasks (e.g., conducting the home food inventory, confirming form completion) until the game was over. Families typically took between 20 to 50 minutes to complete the entire *Family Matters Game*.

Exposure variables.—The *Iowa Family Interaction Rating Scales (IFIRS)* were used to measure familial interpersonal interactions by coding these behaviors during the video-recorded interactive family game. The IFIRS is an existing quantitative behavioral coding system used in direct observational research.^{15,25,40} This global/macrolevel observational coding system was designed to measure behavioral and emotional interpersonal interactions across multiple family dyads (e.g., primary caregiver-child; primary caregiver-sibling; siblings) and at a family level.⁴⁰ *IFIRS* scales have been tested with racial/ethnic minorities and have shown high validity ($r=.77-.86$).⁴⁰

Coding of the video-recorded family interactive task.—Four research team members, who were blinded to the study hypotheses, were extensively trained on the IFIRS⁴¹ (Table 2) coding system. Three of the coders spoke one of the three languages of the study participants (i.e., Hmong, Somali, Spanish) and the fourth coder spoke English. Fidelity to measures and inter-rater reliability was assessed for all training components. Practice video-recordings in the English language were used until coders reached 95% reliability with a gold standard and then 95% inter-rater reliability among coders. Coding was checked at a ratio of 1:5 to ensure fidelity to protocols.

All IFIRS family and parenting variables coded are listed in Table 2. IFIRS variables that represented positive family functioning (n=3 items) included: warmth/support, communication, and relationship quality. IFIRS variables that represented negative family functioning (n=3 items) included: hostility, dominance/control, and lecture/moralize. Parenting-specific variables that represented positive parenting (n = 6 items) included: positive reinforcement, consistent discipline, sensitive/child centered, stimulates cognitive development, parental influence/limit setting, and inductive reasoning. Negative parenting (n = 4 items) variables included: inconsistent discipline, intrusive, indulgent/permissive, and neglecting/distancing.

For the family-level measures, bi-directional coding was completed for up to six dyads present during the *Family Mailers Game* (i.e., primary caregiver-child; primary caregiver-sibling; secondary caregiver-child; secondary caregiver-sibling; sibling-sibling; primary caregiver-secondary caregiver) and for the overall family group. For the parenting measures, two dyads were coded including parent-child and parent-sibling. Consistent with the IFIRS

coding protocol, the interactive family game video-recordings were watched and coded separately for each dyad.

There were four specific components of the *Family Mailers Game* that were coded. First, each of the three “interactive tasks” were coded separately on the six family functioning variables and ten parenting variables across all family dyads. Second, an “overall score” was coded that took into consideration dyadic behavior during the entire video-recording from beginning to end, including all three interactive tasks, for all six family functioning variables and all ten parenting variables, and across all family dyads. IFIRS scales for analysis were dichotomized at the median value due to observing low variation between families and because the loss of statistical precision when dichotomizing is minimized when there is low variance.⁴² Participant scores equal to the median value were assigned to the reference group for comparison. IFIRS dyadic measurements were available for N=149 families (1 family had missing data). Cronbach’s alpha for the IFIRS scores across all three interactive family tasks had high internal consistency ($\alpha = 0.80$ to 0.97), and the overall score did not differ substantively from the mean of the three interactive family tasks scores for each IFIRS scale. For several IFIRS scales (e.g., hostility, lecture/moralize), minimal population variation in the constructs was observed. Table 3 presents cell counts in the reference and contrast for all dichotomous predictors as well as the interquartile range (IQR) surrounding the median to assist with interpretation. Dichotomous measures were employed as an alternative to a continuous measure to minimize extrapolating outside of the observed data range.

Outcome variables.—To assess *child weight status* anthropometric measurements were completed following standardized procedures.⁴³ Height was assessed to the nearest 0.1 cm using a stadiometer (Seca, Hamburg, Germany) and weight to the nearest 0.1 kg using a calibrated scale (Seca, Hamburg, Germany). To ensure inter-rater reliability, both measures were taken twice, and agreement of less than 1 cm for height and 0.5 kg for weight was required. Child heights and weights were converted to child body mass index (BMI) percentile, based on Centers for Disease Control (CDC) criteria.⁴⁴ Child obesity was defined as 95th BMI percentile or greater, and child overweight was defined as 85th percentile or greater.

Child overall diet duality was assessed with three 24-hour dietary recalls using Nutrition Data System for Research (NDS-R; Minneapolis, MN) software version 2012.⁴⁵ The NDSR system aggregates foods into food subgroups (e.g., Citrus Juice, Dark-green Vegetables). Recalls were conducted by trained staff on two weekdays and one weekend day.^{46,47} The first and third recalls were conducted during home visits; the second was a telephone recall in between visits. Recalls for 5-7 years old were conducted with the child’s parent/guardian with the child’s assistance. All target children completed three dietary recall interviews; 100% of recalls were reviewed for accuracy and completeness by registered dietitians.

Healthy Eating Index (HEI-2010 Score.): The HEI is broken into 12 components: 9 that assess adequacy of diet and 3 that assess components to be consumed in moderation. Using data from the child’s 24-hour dietary recalls, a total HEI score was calculated. The maximum HEI score possible is 100, with a larger number indicating a healthier diet. Detailed descriptions of calculating HEI-2010 scores are available online.^{20,33}

Physical and Sedentary Activity.: Child physical activity was measured by accelerometer to capture participant frequency and intensity of motion.⁴⁸ Children and the primary parent were instructed to wear the device on their wrist for at least 4 days for 8 hours each day, including at least one weekend day. Sedentary, light, moderate, and vigorous physical activity classification were performed in ActiGraph software using metabolic equivalent threshold cutpoints established via best practice recommendations for children ages 5-7 years⁴⁹ old, corresponding to average daily time spent in each activity category.

Covariates.—Children's and parents' race/ethnicity and age were assessed by self-report. *Race ethnicity* was assessed with the item, "Do you think of yourself as 1) white, 2) black or African-American, 3) Hispanic or Latino, 4) Asian-American, 5) Hawaiian or Pacific Islander, or 6) American Indian or Native American?," and respondents were asked to check all that apply. Participants who checked two race options were included in the "mixed/other" category. Parent and child *age* was calculated using self-reported birth date and survey completion date. Family *income* category was evaluated with the item, "What is your yearly total household income? (i.e., income from all family members whose job helps support the family). This included wages, cash assistance, Social Security, child support, etc). Child *temperament* was constructed as a dichotomous variable corresponding to difficult and easy temperament from items drawn from the Child Behavior Questionnaire (CBQ) for each construct of the full scale.⁵⁰

Statistical Analysis

Descriptive analyses were performed to describe the sample and evaluate modeling assumptions. Internal consistency and agreement across the IFIRS scores was evaluated with Cronbach's alpha.⁵¹ Validity testing was not conducted because prior studies have shown that direct observational tasks result in valid and reliable measures of behavior.^{26–28}

Adjusted logistic and linear regression models with robust standard errors were used to examine if dyadic interactions across all family members (i.e., family functioning behaviors) were associated with child overweight status, diet quality (HEI-2010), physical activity, and sedentary behavior. Similarly adjusted logistic and linear regression models with robust standard errors were used to examine if specific parent-child and parent-sibling interactions (i.e., parenting behaviors) were associated with child overweight status, child diet quality (HEI-2010), physical activity, and sedentary behavior. Huber-White sandwich estimator of robust standard errors account for the potential misspecification of the variance family. Marginal probability differences and 95% confidence intervals were calculated for logit variance family regressions to characterize associations on an absolute scale (as opposed to a multiplicative scale; e.g., odds ratios). All models are adjusted for parent and child sex, age, and weight status, child race and temperament, and family atmosphere and household income. Analyses for the secondary caregiver dyads were excluded because of small numbers. An example interpretation of results is included in each table to assist in the interpretation of study findings. All analyses were performed in Stata 15. SE (College Station, TX).

RESULTS

Associations Between Family Functioning and Child Weight Status, Diet Quality, and Physical Activity

Findings related to family functioning are discussed below according to the six family dyads that were coded in the video-recorded family interactive board game task (i.e., primary caregiver-child; primary caregiver-sibling; child-primary caregiver; sibling-primary caregiver; child-sibling; and sibling-child). For each of the three dependent variables, the full models explained between 0.39 and 0.55 of the amount of variance (R^2). The strongest contributors to the amount of variance explained were race and household income.

Weight status.—There was a significant positive association found between engaging in dominant/controlling behaviors and the probability of the child being overweight/obese ($p < 0.05$) for all six family dyads. In addition, there was a significant negative association between engaging in warmth/supporting behaviors and positive communication skills and the probability of the child being nonoverweight ($p < 0.05$) for four of the family dyads. There were no significant associations found between other family functioning behaviors including hostility, lecture/moralize, or relationship quality and child weight status for any of the six family dyads.

Diet quality.—There was a significant negative association found between engaging in lecturing and moralizing behaviors and lower diet quality ($p < 0.05$) for the child across three of the six dyads. There were no significant associations found between other family functioning behaviors including hostility, dominance control, warmth/support, communication, or relationship quality and child diet quality for any of the family dyads.

Physical activity.—There was a significant positive association found between engaging in warmth/supportive behaviors and the child engaging in more hours of moderate to vigorous physical activity (MVPA) ($p < 0.05$) for three of the six dyads. In addition, for primary caregiver-child and primary caregiver-sibling dyads there was a significant association between relationship quality and the child engaging in more hours of MVPA. In sibling dyads (i.e., child-sibling; sibling-child) there was a significant negative association between hostility, dominance/control, and lecture/moralize and the child engaging in fewer hours of MVPA ($p < 0.05$). There were no significant associations found between other family functioning behaviors including warmth/support or communication and child physical activity for any of the six family dyads.

Associations Between Parenting Behaviors and Child Weight Status, Diet Quality, and Physical Activity

Findings related to parenting behaviors are discussed below according to the two parent-child dyads (i.e., primary caregiver-child; primary caregiver-sibling) that were coded in the video-recorded family interactive board game task.

Positive parenting behaviors (i.e., positive reinforcement, consistent discipline, sensitive/child centered, stimulates cognitive development, parental influence/limit setting, and

inductive reasoning) were associated with lower risk of child overweight/obesity for some parenting behaviors, but not all of the parenting behaviors (see Table 4). For example, parental influence was associated with higher risk of child overweight/obese status ($p < 0.05$) and providing an environment that stimulates cognitive development was associated with decreased probability of child overweight/obese status ($p < 0.05$). In addition, negative parenting behaviors (i.e., inconsistent discipline, intrusive, indulgent/permissive, and neglecting/distancing) were associated with increased risk of the child being overweight/obese. There were no significant associations found between parenting behaviors and child diet quality or physical activity.

DISCUSSION

The current study presented a description of the *Family Matters Game*, a direct observational method for measuring family functioning and parenting behaviors via a video-recorded interactive task (i.e., board game) and examined associations between family functioning and parenting behaviors and child weight status, diet quality, and physical activity. Given prior research showing that direct observational approaches are highly valid, reliable, and superior to static measures (e.g., self-report) at capturing dyadic behaviors,^{26,28} this interactive board game task provides another option for childhood obesity researchers to utilize in measuring and examining factors in the home environment and their associations with child weight status and weight-related behaviors.

Results of the current study both support and extend prior research on family functioning^{13,15,22} and parenting behaviors^{15,22} in relation to child weight status, diet quality, and physical activity. For example, current study findings showed significant associations between multiple family dyads' interpersonal behaviors and lower child weight status, better diet quality, and more hours of physical activity. Prior studies have also shown that lower family functioning was associated with higher risk of child overweight, unhealthy weight control behaviors, less healthy diet quality, and fewer hours of physical activity.^{11,13,22,30} In addition, previous studies found that parenting style (i.e., authoritative)^{11,12,14} and parenting practices⁵² such as feeding practices (i.e., non-controlling) and modeling healthy eating patterns and physical activity⁵³ were associated with healthy child weight status, better diet quality, and more hours of physical activity^{22,52}.

Findings from the current study also extend prior research by showing that *multiple family member's* interpersonal behaviors were associated with child weight status and weight-related behaviors. One prior study showed that sibling dietary and physical activity patterns were more similar than parent-child dietary and physical activity patterns.³⁵ The current study found that interpersonal behaviors across different family dyads (i.e., primary caregiver-child; primary caregiver-sibling; siblings) all had a significant association with the child's weight status and weight-related behaviors (depending on the outcome).

Results of the current study should be considered in light of certain limitations. For example, while there were several statistically significant results in the current study, the IQR for some variables was narrow and may reduce the confidence of the relationship between the variables and child outcomes for the sample. In addition, overall, the sample size for this

cross-sectional, secondary analysis was small and may be underpowered to detect small standardized effect sizes (i.e. <0.6) in outcome measures. Furthermore, this study intentionally oversampled under-represented subpopulations given prior research indicating that racially/ethnically diverse groups are at highest risk for obesity¹⁻⁷ and because of the paucity of existing research with these diverse communities. Thus, study findings may not be generalization to a larger population (e.g. U.S. population). Another limitation of the study is the use of a cross-sectional study design, which does not allow for temporal associations between variables to be established. Additionally, due to the low number of secondary caregivers, analyses were only examined for primary caregivers, children, and a sibling.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Findings from the current study inform implications for future research and interventions. Future research should consider employing direct observational methods to improve the measurement of family and parenting factors in childhood obesity research. Such research would improve the self-report nature of surveys that the majority of childhood obesity researchers utilize and would allow for capturing multiple family dyad's interpersonal behaviors, as well as parenting behaviors in the moment, when behaviors occur in the real world. If more studies used this approach it may be possible to compare outcomes across studies and/or develop standardized measures. It may also be important for future intervention researchers to consider utilizing family-level interventions to target family functioning to thereby reduce child unhealthy weight status and weight-related behaviors. Many prior interventions have been designed to be "family-based," however this can mean anything from sending a newsletter to parents with suggestions for healthy parenting to conducting home visits with parents. Few studies use a true family-based approach, including multiple family members such as parents and siblings when intervening in weight-related behaviors. By intervening on interpersonal behaviors (e.g., family functioning, parenting behaviors) of multiple family members, a more effective and sustainable change may occur.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:
In-home visiting protocol for Phase I of the Family Matters Study

Figure 2:
Family Matters Interactive Task Board Game

Table 1.

Family Matters Study Phase I Demographic Characteristics (N=150)

	Primary Caregiver (n=150)	Study Child (n=150)
Participant Characteristics		
	N (%)	N (%)
Female	137 (91%)	71 (47%)
Age in years (sd)	34.5 (7.1)	6.4 (0.8)
Adult BMI (BMI %ile child)	30.9 (7.2)	75.9 (23.1)
<i>Weight Status</i>		
Nonoverweight	35 (23%)	77 (51%)
Overweight/Obese	115 (77%)	73 (49%)
<i>Race/Ethnicity</i>		
American Indian or Alaskan Native	21 (14%)	25 (17%)
Asian	25 (17%)	25 (17%)
Black or African American	22 (15%)	25 (17%)
White	27 (18%)	25 (17%)
Somali	25 (17%)	25 (17%)
Hispanic	23 (15%)	25 (17%)
Mixed/Other	7 (5%)	--
Household Characteristics		
<i>Household Structure</i>		
One Parent (no other adults)	37 (25%)	
One Parent (w/other adults)	18 (12%)	
Two Parents (no other adults)	78 (52%)	
Two Parents (w/other adults)	17 (11%)	
<i>Primary Caregiver Marital Status</i>		
Married	78 (51%)	
Committed dating relationship or engaged	31 (21%)	
Casually dating	2 (1%)	
Separated or Divorced	6 (4%)	
Widowed	1 (1%)	
Single/never married	31 (21%)	
Missing	1 (1%)	
<i>Educational Attainment</i>		
Middle school or junior high	15 (10%)	
Some high school	17 (11%)	
High school or GED	60 (40%)	
Vocational, technical, trade certificate program, or associate degree	28 (18%)	

	Primary Caregiver (n=150)	Study Child (n=150)
College degree (e.g., bachelor, masters, or doctorate)	25 (16%)	
Other	4 (3%)	
Missing	1 (1%)	
<i>Primary Caregiver Work Status</i>		
Working full-time	63 (42%)	
Working part-time	32 (21%)	
Stay at home caregiver	25 (17%)	
Currently unemployed, seeking work	18 (12%)	
Not working for pay (unable to work, retired, student, etc)	11 (7%)	
Not Applicable	1 (1%)	
<i>Household Income</i>		
Less than \$20,000	50 (33%)	
\$20,000 - \$34,999	55 (37%)	
\$35,000 - \$49,999	16 (11%)	
\$50,000 - \$74,999	12 (8%)	
\$75,000 - \$99,999	7 (5%)	
\$100,000 or more	9 (6%)	
Missing	1 (1%)	
<i>Household Income Source (all that apply)</i>		
Wages from self	85 (57%)	
Wages from other guardian	34 (23%)	
Another family member	14 (10%)	
Unemployment compensation	4 (3%)	
Worker's compensation	0 (0%)	
Social Security	11 (7%)	
Public assistance (e.g., MFIP)	34 (23%)	
Alimony/Child support	17 (11%)	
Other sources	21 (14%)	

Note: Percentages may not sum to exactly 100% due to rounding

Table 2: Iowa Family Interaction Rating Scales (IFRIS)⁴¹ Used for Coding the Video-recorded Family Interactive Task

Variable Name	Definition	Example of Low Score = 1-4	Example of High Score = 6-9
Family Functioning Scales			
Hostility	Degree of hostile, angry, critical, disapproving and/or rejecting behavior toward another	Mild criticism, occasional abrupt remark, a scowl or frown, a cynical smile or tease	High degree of shouting, angry tones of voice, heavy use of sarcasm, frequent criticism or mocking
Dominance/Control	Degree of dominating, influencing, controlling other people or the situation	None to minimal attempts to dominate or control the behaviors or opinions of others in the interaction	Fairly often or frequently attempts to dominate or control individual and/or group interactions or opinions.
Lecture/Moralize	Degree of lecturing, preaching, intrusive, pushy, and/or moralizing behavior towards another	Brief, infrequent, and low intensity lectures	Extended and unrelenting lectures that inhibit two-way communication
Warmth/Support	Degree of expressing liking, appreciation, praise, care, concern or support for another	None to minimal examples of warmth or support are observed during the meal	Offers a high degree of encouragement and praise, high degree of affectionate touching, warm smile, and/or positive comment
Communication	Extent of neutral or positive expression of needs and wants, rules and regulations, as well as clearly expresses information and ideas that may be useful to another	Communication skills are almost entirely absent; rarely or never uses reasoning, explanations, and clarification to make himself/herself understood	Frequently uses appropriate reasoning, explanations, and clarifications to make him/herself understood
Relationship Quality	Quality of the relationship between two people engaging in the task	Characterized as unhappy, conflicted, brittle or uninvolved.	Open, satisfying, pleasing, communicative, and/or warm. Family members appear to enjoy each other's company
Parenting Behaviors			
Sensitive/Child Centered	The extent to which the parent's interactions toward the child display awareness of the child's needs, moods, interests, and capabilities	The parent rarely or never displays sensitivity to the child's needs and capabilities	The parent often or frequently is sensitive and responsive to the child's needs and cues, and shows a good mix of support and fostering independence
Stimulates Cognitive Development	The degree to which the parent fosters the child's cognitive development by taking advantage of task activities and engaging in a variety of explicit interactions to facilitate the child's development, achievement, and learning	The parent's overt attempts to purposefully engage in development-fostering experiences with the child are nonexistent or limited (e.g., labeling, providing information)	The parent often or frequently sets up situations for learning, and expands on concepts and vocabulary to create a higher learning opportunity
Inductive Reasoning	The extent to which a parent tries to guide the behavior of a child through an exchange of information with their child that encourages the child to think through the consequences of the	The parent never or rarely uses induction with their child to control the child's behavior	The parent often or frequently uses induction to influence or control the child's behavior
Positive Reinforcement	The extent to which a parent's response to a child includes the use of praise, approval, rewards, special privileges, or smiles	Parental responses are never affirming or positively reinforcing	Responses to child behavior are frequently affirming and positive
Consistent Discipline	The consistency and persistence with which the parent sets limits and rules for a child's behavior and disciplines the child when	The parent never or rarely is consistent with maintaining and adhering to rules and standards of conduct set for the child	The parent often or frequently consistent in maintaining and adhering to rules and standards of conduct for the child

Variable Name	Definition	Example of Low Score = 1-4	Example of High Score = 6-9
	the child violates the rules or standards of conduct		
Parental Influence/Limit Setting	Parent's attempts to socialize the child	Parent rarely attempts to regulate, control or influence the child's behavior	Parent consistently attempts to control and regulate the child's behavior, frequently setting standards or provides expectations for age-appropriate behaviors
Intrusiveness/Control	Assesses intrusive and over controlling behaviors that are parent-centered rather than child-centered	Few to no instances in which the parent is over controlling and unnecessarily imposes their own agenda on the child	Parent controls the interaction, allowing the child little self-direction in activities, may forcefully and physically control the child
Inconsistent Discipline	Parental inconsistency in following through on expected consequences; failure to maintain and adhere to rules/standards set for child behavior	Parent is consistent or if a parent has no rules, or if there is no evidence of disciplinary behavior	Frequently inconsistent in maintaining and adhering to rules and standards of conduct
Indulgent/Permissive	The degree to which a parent gives the child an inappropriate degree of freedom to regulate or control his/her own behavior	Rare demonstrations of indulgent behaviors	Fails to make attempts to control the child's behavior and/or almost never provides regulations or sets standards for the child to follow
Neglecting/Distancing	The degree with which a parent is uncaring, apathetic, uninvolved, ignoring, aloof, unresponsive, self-focused, and/or adult focused	None to minimal distancing or lack of involvement with the child	Parent frequently displays ignoring, uninvolved, unresponsiveness, or uncaring behavior towards the child

Table 3:

Child Weight Status, Healthy Eating Index (HEI)^{20,33} and Moderate to Vigorous Physical Activity (MVPA) associations with Dichotomized Iowa Family Interaction Rating Scales (IFIRS)⁴¹ * by Family Dyads: Primary Caregiver to Child, Primary Caregiver to Sibling, Child to Sibling, Child to Primary Caregiver, Sibling to Child and Sibling to Primary Caregiver. **

IFIRS Scale	N		Median	N > Median	Median(IQR)	Weight Status (Obese/Overweight)			HEI			MVPA		
						Prob. Diff	95% CI	P value	Mean Difference	95% CI	P value	Mean Difference	95% CI	P value
Primary Caregiver to Study Child														
Hostility	122			27	1 (1, 1)	-0.06	(-0.27, 0.15)	0.566	-0.99	(-5.09, 3.11)	0.636	-3.67	(-13.29, 5.95)	0.455
Dominance/Control	77			72	5 (3, 7)	0.24	(0.05, 0.43)	0.012	-1.98	(-5.56, 1.60)	0.278	0.20	(-6.15, 6.54)	0.951
Lecture/Moralize	116			33	1 (1, 1)	0.14	(-0.06, 0.33)	0.175	1.73	(-2.17, 5.62)	0.386	-1.30	(-10.87, 8.27)	0.789
Warmth/Support	83			66	6 (5, 7)	0.04	(-0.14, 0.22)	0.649	-1.7	(-6.13, 2.74)	0.454	11.87	(4.99, 18.75)	0.001
Communication	131			18	7 (5, 7)	0.08	(-0.29, 0.12)	0.425	-2.69	(-7.34, 1.96)	0.258	1.53	(-7.9, 10.96)	0.751
Relationship Quality	111			38	7 (6, 8)	0.02	(-0.19, 0.14)	0.792	-2.59	(-6.73, 1.55)	0.220	9.20	(1.73, 16.67)	0.016
Primary Caregiver to Sibling														
Hostility	123			26	1 (1, 1)	-0.13	(-0.29, 0.02)	0.092	-2.76	(-6.98, 1.47)	0.201	-2.33	(-10.31, 5.64)	0.566
Dominance/Control	77			72	5 (3, 7)	0.24	(0.05, 0.43)	0.012	-1.98	(-5.56, 1.60)	0.278	0.20	(-6.15, 6.54)	0.951
Lecture/Moralize	118			31	1 (1, 1)	0.06	(-0.16, 0.28)	0.591	0.28	(-3.45, 4.01)	0.885	1.48	(-6.48, 9.43)	0.716
Warmth/Support	83			66	6 (5, 7)	0.02	(-0.16, 0.21)	0.822	-1.95	(-6.22, 2.31)	0.369	11.85	(5.06, 18.65)	0.001
Communication	130			19	7 (5, 7)	0.08	(-0.29, 0.12)	0.425	-1.78	(-6.44, 2.88)	0.454	1.26	(-7.71, 10.24)	0.783
Relationship Quality	110			39	7 (6, 8)	0.02	(-0.19, 0.14)	0.793	-1.95	(-6.05, 2.14)	0.349	8.59	(1.39, 15.79)	0.019
Study Child to Sibling														
Hostility	129			20	1 (1, 1)	0.07	(-0.25, 0.38)	0.686	0.53	(-4.2, 5.25)	0.827	-12.16	(-21.93, -2.39)	0.015
Dominance/Control	75			74	3 (1, 5)	0.37	(0.24, 0.50)	0.000	2.62	(-0.81, 6.05)	0.134	-6.40	(-12.23, -0.56)	0.032
Lecture/Moralize	137			12	1 (1, 1)	-0.03	(-0.31, 0.25)	0.841	-7.91	(-14.32, -1.50)	0.016	-14.52	(-27.48, -1.56)	0.028
Warmth/Support	89			60	5 (4, 6)	-0.27	(-0.42, -0.12)	0.001	-1.20	(-4.93, 2.52)	0.526	3.80	(-2.46, 10.05)	0.235
Communication	87			62	5 (5, 6)	-0.28	(-0.44, -0.12)	0.001	-0.92	(-4.64, 2.80)	0.628	2.92	(-3.75, 9.58)	0.391
Relationship Quality	91			58	6 (5, 7)	-0.30	(-0.45, -0.16)	0.000	-2.75	(-6.1, 0.61)	0.108	3.55	(-2.96, 10.05)	0.285
Study Child to Primary Caregiver														
Hostility	128			21	1 (1, 1)	0.12	(-0.17, 0.42)	0.413	3.36	(-1.41, 8.13)	0.168	-10.16	(-19.33, -0.99)	0.030
Dominance/Control	106			43	4 (1, 5)	0.33	(0.18, 0.47)	0.000	1.99	(-1.12, 5.11)	0.210	-4.33	(-10.02, 1.37)	0.136
Lecture/Moralize	139			10	1 (1, 1)	0.00	(-0.39, 0.39)	0.999	-8.39	(-15.12, -1.65)	0.015	-8.18	(-21.65, 5.3)	0.234
Warmth/Support	92			57	5 (4, 6)	-0.26	(-0.41, -0.12)	0.000	-1.63	(-5.32, 2.06)	0.386	3.30	(-3.19, 9.78)	0.319
Communication	86			63	5 (5, 6)	-0.23	(-0.4, -0.07)	0.006	-2.16	(-5.94, 1.62)	0.262	4.90	(-1.82, 11.61)	0.153
Sibling to Study Child														

IFIRS Scale	N	Median	N > Median	Median(IQR)	Weight Status (Obese/Overweight)			HEI			MVPA		
					Prob. Diff	95% CI	P value	Mean Difference	95% CI	P value	Mean Difference	95% CI	P value
Hostility	127		22	1 (1, 1)	0.08	(-0.19, 0.36)	0.564	-0.81	(-4.97, 3.35)	0.704	3.20	(-6.27, 12.66)	0.508
Dominance/Control	90		59	3 (1, 5)	0.21	(0.06, 0.36)	0.006	-0.37	(-3.88, 3.14)	0.837	-2.94	(-9.19, 3.32)	0.357
Lecture/Moralize	139		10	1 (1, 1)	-0.29	(-0.41, -0.17)	0.000	-9.48	(-15.46, -3.49)	0.002	1.79	(-11.95, 15.52)	0.799
Warmth/Support	105		44	5 (4, 6)	-0.42	(-0.53, -0.3)	0.000	-1.11	(-4.86, 2.64)	0.562	1.66	(-4.64, 7.97)	0.605
Communication	91		58	5 (5, 6)	-0.41	(-0.53, -0.28)	0.000	-0.54	(-3.86, 2.77)	0.748	3.18	(-3.11, 9.47)	0.322

Sibling to Primary Caregiver													
Hostility	129		20	1 (1, 1)	0.10	(-0.16, 0.36)	0.439	-0.81	(-5.25, 3.62)	0.718	0.35	(-9.65, 10.35)	0.945
Dominance/Control	90		59	3 (1, 5)	0.19	(0.04, 0.34)	0.014	-1.18	(-4.67, 2.3)	0.506	-1.67	(-8.04, 4.7)	0.607
Lecture/Moralize	136		13	1 (1, 1)	-0.14	(-0.33, 0.05)	0.150	-4.53	(-10.57, 1.5)	0.141	-0.43	(-11.24, 10.37)	0.937
Warmth/Support	103		46	5 (4, 6)	-0.38	(-0.52, -0.24)	0.000	-1.24	(-5.01, 2.54)	0.521	2.35	(-3.97, 8.67)	0.467
Communication	91		58	5 (5, 6)	-0.38	(-0.51, -0.25)	0.000	-1.26	(-4.54, 2.01)	0.450	3.16	(-3.12, 9.44)	0.324

* IFIRS Scales are all dichotomized at the median to protect against influential points of skewed distributions. There is one score per dyad for Relationship Quality because it was coded bi-directionally.

** Marginal probability differences and 95% confidence intervals were calculated with binomial variance family (binary outcome) and Gaussian family (continuous outcomes) with Huber-White sandwich estimator of robust standard errors account for the potential misspecification of the variance family. All models are adjusted for study child race/ethnicity, age and sex; primary parent weight status, age and sex; family income and family atmosphere. Bold indicates that effects are significant at P < 0.05. IFIRS scales and covariate measures were available for 149 families.

Table 3 Interpretation example: Families above the median of 5 on the measure of warmth and support (N=60) with communications from the study child to the sibling have a −0.27 lower probability of an obese/overweight study child (p=0.001) compared to families who scored below the median measure for warmth and support (N=89).

Study Child Weight Status, Healthy Eating Index (HEI)^{20,33} and Moderate to Vigorous Physical Activity (MVPA) associations with Dichotomized Iowa Family Interaction Rating Scales (IFIRS)⁴¹ Parenting Scale^{*} by Primary Caregiver to Child^{***}

Table 4:

IFIRS Scale	N >= Median	N < Median	Median (IQR)	Obese/Overweight			HEI			MVPA		
				Contrast	95% CI	P value	Contrast	95% CI	P value	Contrast	95% CI	P value
Primary Caregiver to Child												
Child Centered	97	52	6 (5, 7)	0.08	(−0.08, 0.24)	0.317	−0.75	(−4.96, 3.46)	0.728	2.43	(−4.35, 9.20)	0.483
Stimulates Cog. Development	78	71	3 (2, 4)	−0.27	(−0.44, −0.10)	0.002	1.88	(−1.57, 5.33)	0.286	1.43	(−4.46, 7.32)	0.634
Promotes Inductive Reasoning	92	27	3 (2, 5)	−0.16	(−0.35, 0.02)	0.084	0.97	(−3.57, 5.51)	0.675	−0.84	(−7.96, 6.27)	0.816
Positive Reinforcement	92	57	4 (3, 5)	−0.13	(−0.32, 0.05)	0.159	0.76	(−3.18, 4.70)	0.705	2.36	(−4.19, 8.90)	0.480
Consistent Discipline	26	123	9 (9, 9)	0.08	(−0.12, 0.28)	0.412	−1.84	(−6.28, 2.61)	0.418	0.67	(−10.95, 12.28)	0.911
Parental Influence	96	53	4 (3, 5)	0.23	(0.08, 0.38)	0.003	−1.43	(−4.76, 1.90)	0.401	−3.02	(−9.11, 3.07)	0.331
Intrusive	129	20	1 (1, 1)	−0.05	(−0.34, 0.24)	0.729	−3.46	(−9.25, 2.33)	0.241	−4.69	(−17.07, 7.7)	0.458
Inconsistent Discipline	125	24	1 (1, 1)	−0.07	(−0.29, 0.15)	0.553	2.73	(−1.67, 7.13)	0.224	0.09	(−13.64, 13.81)	0.990
Indulgent/Permissive	121	8	1 (1, 1)	0.06	(−0.16, 0.28)	0.603	−0.21	(−4.57, 4.15)	0.925	1.14	(−7.64, 9.93)	0.798
Neglecting/Distancing	137	12	1 (1, 1)	Not Estimable			−3.25	(−9.95, 3.46)	0.342	3.17	(−16.35, 22.68)	0.751

^{*} IFIRS Parenting Scales are all dichotomized at the median to protect against influential points of skewed distributions.

^{***} Marginal probability differences and 95% confidence intervals were calculated with binomial variance family (binary outcome) and Gaussian family (continuous outcomes) with Huber-White sandwich estimator of robust standard errors account for the potential misspecification of the variance family. All models are adjusted for study child race/ethnicity, age and sex; primary parent weight status, age and sex; family income and family atmosphere. Bold indicates that effects are significant at P < 0.05. IFIRS scales and covariate measures were available for 149 families.

Table 4 Interpretation example: Families above the median of 3 on the measure of stimulates cognitive development (N=71) with communications from the primary caregiver to the study child have a −0.27 lower probability of an obese/overweight study child (p=0.002) compared to families who scored below the median measure for stimulates cognitive development (N=78).