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Evaluation of Dyadic Changes of Parent-Child Weight Loss Patterns During a Family-Based Behavioral Treatment for Obesity

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Abstract

Background: Family Based Treatment (FBT) for children with overweight and obesity is a package that includes nutrition and physical activity education, as well as parenting and behavior therapy skills. To date, the majority of research suggests that one of the best predictors of child weight loss, is parent weight loss. However, the bidirectional processes facilitating parent-child weight loss are not well understood.

Objective: To evaluate the strength and direction of parent-child weight-change patterns during a 6-month intervention with FBT for childhood obesity.

Methods: Parent-child weight change dynamics were evaluated using a bivariate multilevel approach.

Results: Significant positive weight reductions throughout treatment were observed among both parents and children (p's<0.01 for both parent and child). In the model adjusting for the conditional influence of attendance over time, parents' initial weight loss was associated with subsequent weight loss by their child (B=0.102, p<0.05; d=0.352) across the first 10 sessions. Child's weight loss also was associated with subsequent weight loss by their parent (B=0.105, p<0.01; d=0.412) across the first 10 sessions. A small and negative effects of parents' weight loss on children and children's weight loss on parents from sessions 10–20 may have been reflective of slowed rates of weight loss as treatment progressed.

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Conclusions: Together these data suggest parent-child dyads mutually influence weight loss in FBT. Future studies should leverage how to make best clinical use of these dynamic effects in the context of family based interventions.

Keywords

family-based interventions; obesity treatment; statistics; weight change; weight loss

Introduction:

Family-based behavioral treatment (FBT) programs are considered the most efficacious interventions for the treatment of children with overweight or obesity (OW/OB)(1, 2, 3, 4). These programs are typically 6 months in length and are delivered to both the parent and child. FBT includes nutrition and physical activity education, as well as parenting skills and behavior therapy techniques focused on behavior change (e.g., reinforcement, self-monitoring, modeling, stimulus control, etc.). Together, this program is designed to increase the likelihood of children adopting behaviors that facilitate healthier weight management. As part of the program, eating and physical activity recommendations are prescribed to both the parent and child, with the expectation that parents will also improve their eating, increase their physical activity, and lose weight (1, 5).

Previous literature suggests that successful weight loss among parents is highly correlated with weight loss in children(6, 7, 8). Studies using FBT for children with obesity have found that change in parent body mass index (BMI) was an important predictor of changes in child BMI among either parents with obesity or with mixed BMI status (9, 10, 11, 12). Furthermore, parent-only treatments (PBT) have been shown to be noninferior to FBT on child weight loss, highlighting the critical role that parents play in assisting their child in losing weight.(10) Since weight loss is a shared condition within the dyad, considering both the parent and child in the analysis of their relationships is necessary.This information can contribute to improved treatments, especially in pediatric interventions involving parents as the agents of change. (11, 12)

While the concept of weight loss process in the context of FBT has been described as bidirectional between parent and child, (13, 14, 15) there is little empirical information regarding the mutual influence or strength of the dyadic weight outcomes (e.g., whether a parent's weight loss affects the child's subsequent weight loss or a child's weight loss affects the parent's subsequent weight loss). Disentangling the dynamic weight loss processes of both parents and children during weight loss treatment may contribute to our understanding of the dyadic influences on weight changes, and could lead to targeted treatments. Clinical trials of FBT with repeated anthropometric measurements provide an opportunity to investigate this dynamic interactions of weight loss processes within each parent-child dyad.(16, 17) However, the choice of research design and analysis significantly limit the validity of the evidence for bidirectionality. For instance, a strong analytic approach, such as structural equation modeling (SEM), to evaluate bidirectionality would require a sample size of greater than 250 participants (18). Intensive early phase clinical studies typically do not afford large samples to explore complex longitudinal relationships.

Advanced analytic methodologies utilizing multilevel modeling are flexible with a smaller sample size and can be extended to dyads in order to obtain estimates of the relative strength of parent-child influences in temporal sequence. Multilevel models facilitate estimation of bidirectional effects of weight changes on each member using prior weight status changes to assess the subsequent weight status changes of their dyad-partner.(18, 19) Furthermore, inverse probability weighting (IPW) can be especially useful in providing estimates of marginal effects in the context of a clinical trials where potential influences of both attrition and weight loss can be conditioned to better understand dyadic influences on weight loss when participants do not fully complete treatment assessments.(20, 21) Using this methodology, potentially confounding factors are adjusted when estimating the true dyadic effects provided all potential confounders are identified. In sum, the present study evaluated the strength and direction of parent-child weight-loss patterns during 6-months of behavioral treatment for childhood obesity.

Methods:

Subjects and study design:

We conducted a 6 month randomized 2-arm non-inferiority weight-loss trial among 150 children with overweight or obesity and their parent. Details with respect to study design, flow, and primary outcomes have been reported elsewhere.(9, 10) Briefly, parent-child dyads were randomly assigned to FBT or PBT stratified by the child's sex. Both treatment arms received 20 one-hour group sessions of behavior modification strategies, with the only difference being the child's participation. On average, participants attended 13.4 out of 20 treatments sessions. Children were included in the trial if they were 8–12 years of age with a BMI% between the 85^{th} and 99.9^{th} percentiles, had a parent in the household with a BMI≥25 kg/m^2 who could read English at a minimum of a 5^{th} grade level, and the dyad agreed to participate in the study on the designated evenings. Those with major psychiatric disorders, physical limitations, or food restrictions that would interfere with the intervention were excluded. The institutional review boards of University of California, San Diego approved the study. Written consent and assent were obtained from the parents and children, respectively.

Measurements:

In the FBT condition, parent and child anthropometrics were collected at each of the 20 treatment sessions. In the PBT condition, parent anthropometrics were collected at each of the treatment sessions and parents reported their child's anthropometrics for all sessions except for sessions 10 and 20, where child anthropometrics were collected in the lab. BMI (kg/m^2) was calculated from recorded or reported height and weight. In order to estimate the change at the dyadic level using the same unit, we used BMI for children and adjusted for child age and sex. Mean BMI z-score was included for description of the sample only. Planned covariates included treatment groups and time, in addition to the following from baseline: parent age, parent sex, child age, child sex, treatment arms, and treatment timepoints.

Statistical analyses:

All analyses were based on a linear mixed effects model implemented in R software (version 3.5).(22) Of the parent/child dyads enrolled (n=150), data from 83% (n=125) and 83% (n=124) were available at sessions 10 and at the post-treatment assessment in the initial trial, respectively. Of note, this analyses only used treatment weights measured during treatment visits, where 78% of the data came from session weights. Missing data were handled through multilevel multiple imputations with 100 iterations and results were aggregated.(23) The imputation model consisted of outcome variables at all 20 timepoints and planned covariates. Stabilized inverse probability weights were estimated using the 'ipw' package in R.(24) To evaluate dyadic processes, we conducted two planned analyses. The first analysis incorporated Bauer's parallel approach to modify the model by first extending a single outcome variable to capture the parent-child dyadic changes and allowing multiple sources of random effects and correlated errors.(25) We then modified repeated data by brining down the assessment of the weight variable from time T to the row of the data containing measurement at $T+1$. These time-lagged variables were created separately and dummy variables were used to invoke parameter estimation for each lagged time point. In order to estimate the direction and strength of influence of within- and between-individual weight, we created piecewise constants over 2 equal interval phases when children's anthropometrics were collected in the lab (baseline to session-10; sessions 11–20). A linear change was assumed within each phase. The second was the marginal approach, as an extension of the first analysis, adjusting for the influences of time-varying confounder effects measured from attendance to the treatment sessions using inverse probability weighting (IPW). To facilitate with interpretations, we included cumulative effect sizes (Cohen's d). All models included covariates from child and parent age and sex.

Results:

Since the PBT arm was noninferior to the FBT arm in the primary publication (10), data from both arms were aggregated for this analysis. Table 1 presents the sample characteristics of the parents and children. Of the parent-child dyads enrolled, about two-thirds of children were female (66.70%), all with overweight or obesity (mean child BMI (sd): 26.3 (3.6); mean child BMI z-score(sd): 2.0 (0.3)). With regard to parents, 87.3% of participating parents were women with mean BMI (sd) of 32.1 (6.3). Across the two arms we observed child BMI changes of 0.977 kg/m^2 from baseline to session-10, and 1.191 kg/m^2 from baseline to session-20. Parent anthropometrics followed a similar pattern, as we observed adult BMI changes of 1.104 kg/m^2 from baseline to session-10, and 1.475 kg/m^2 from baseline to session-20. Average attendance (sd) was 7.69 (2.56) between baseline and session-10, and 5.71 (3.54) between sessions 10–20.

In the first model treating child and parent BMI as the dyadic outcomes, there were significant positive within-individual associations (i.e., within-child and within-parent) throughout the entire treatment (see Table 2), such that BMI of the prior session significantly predicted subsequent BMI for the same individual. The within-individual effect was stronger during the first 10 sessions for child (B=0.107, p<0.01; d= 0.559) and parent (B=0.126, p<0.01; d=0.498) compared to the second half of the treatment (B=0.032, p<0.01; d= 0.168

for child and B=0.035, $p<0.01$; d= 0.138 for parent). The lagged effect between parent and child BMI varied across the two equal intervals of treatment (baseline to session-10; sessions 11–20). Parent weight prospectively and positively predicted child weight during the first 10 sessions (B=0.028, $p<0.01$; d=0.108), while after the 10th session the effect was small and negative (B=−0.007, p=0.02; cumulative d= −0.028). The lagged effect from child-to-parent BMI was also positive and statistically significant during the first 10 sessions (B=0.029, $p<0.01$; d=0.154), but the effect was again small and negative after the 10th session (B=−0.004, p=0.02; d=−0.021).

In the second model adjusting for the conditional influence of attendance over time, there were significant positive within-individual associations (i.e., within-child and within-parent) throughout the entire treatment (see Table 3), such that BMI of the prior session significantly predicted subsequent BMI for the same individual. The within-individual effect was stronger during the first 10 sessions for child (B=0.153, $p<0.01$; d=0.597) and parent (B=0.323, $p<0.01$; d=1.113) compared to the second half of the treatment (B=0.007, $p>0.05$; d=0.026 for child and B= −0.013, $p<0.01$; d=−0.045 for parent). The lagged effect between parent and child BMI varied across the two equal intervals of treatment (baseline to session-10; sessions 11–20). Parent weight prospectively and positively predicted child weight during the first 10 sessions (B=0.102, p=0.02; 0.352), while after the 10th session the effect was small and negative (B=−0.029, $p<0.01$; d=−0.099). The lagged effect from child-to-parent BMI was also positive and statistically significant during the first 10 sessions (B=0.105, $p<0.01$; d=0.412), but the effect was again small and negative after the 10th session (B=−0.023, $p<0.01$; d=−0.092). Consistent with the previous finding from the main paper,(10) no significant differences were noted in weight loss pattern by treatment arms.

Discussion

This study evaluated the dyadic interactions of both within- and between-individual relationships of parent-child weight loss patterns. Consistent with previous literature, changes in parent BMI were an important predictor of child weight loss.(26) To our knowledge, this is the first empirical evidence regarding the dynamic interaction of weight loss in parent-child dyads, such that weight-loss occurs both in parallel between parent and child and a change in one member of the dyad induces change in the another early in treatment (during first 10 sessions). The negative parallel and lagged effect between parent and child after the 10th session was small and may be the result of slowed weight loss for both parent and child after the first half of the treatment. As weight loss stabilizes after the treatment midpoint, this may serve as a strategic timepoint in which to address and adjust intervention strategies to better optimize weight-loss.

One of the possible reasons that parent weight loss directly influences child weight loss for the first 10 sessions, but not for the second 10 sessions, may be due to the rate of weight loss during treatment. Studies suggest that weight loss is greatest during the initial weeks of treatment in youth (27, 28) and adults.(29) It is possible that the influences of the dyadic relationship are stronger during the initial phases of behavior change, and as weight and behavior change stabilizes, the dyadic relationship becomes less important.

It is also possible that the number of sessions attended could influence the impact of the dyadic relationship. In this study, the average number of sessions attended during the first 10 treatment sessions was 7.7, whereas the second 10 sessions attended was 5.7. Number of visits attended has been linked to weight loss in children (1) and adults (30). In the current study, we included evaluations of dyadic weight loss conditioning for the potential confounding factors due to the number of attendance to treatment sessions. (Table 3) Notably, after adjusting for the influence of time-varying confounder effects measured from attendance, the effect sizes for the first 10 and second 10 treatment sessions stabilized. These finding highlight the cumulative attendance effects between parent and child weight loss during the first 10 sessions and suggests that this effect may be a stronger indicator for treatment success compared to the second 10 sessions.

Finally, it is also possible that the psychoeducation and skills learned in the first 10 sessions are sufficient for weight loss, and the information and skills in the second half of treatment are not as effective in impacting weight loss. FBT includes psychoeducation on nutrition and physical activity education, as well as numerous parenting skills and behavior skills, such as stimulus control, self-monitoring, planning ahead, goal-setting, reinforcement and modeling. It is possible that families learn these skills sufficiently in the first 10 sessions, and the second 10 sessions are less important. Future studies could explore dismantling FBT treatment and provide a greater understanding of program components necessary to produce weight loss.

This study has several strengths, including its use of advanced empirical approaches that have not been approached from previous studies investigating dyadic outcomes. Given its relatively straightforward interpretation, the bivariate multilevel approach and time-varying inverse probability weighting could be a powerful modeling tool in exploring the parent-child dynamic in relatively small samples often seen in clinical treatment studies of weight-loss. Future studies with larger sample sizes (greater than 250) could evaluate the dyadic changes using structural equation modeling.(16, 18, 31)

However, the present study is not without limitations. As the data were drawn from a treatment-seeking sample, generalizability to community samples of parent-child dyads with overweight or obesity should be made with caution. Moreover, across analyses, we have assumed weight change from baseline to mid-treatment and mid- to post-treatment to be linear. A more comprehensive modeling approach accounting for time-specific slopes and change points of heterogenous weight loss pattern is warranted. Despite these limitations, this study supports the body of literature that weight loss in parent-child dyads is influenced by both their own weight changes and the dyad member's weight changes, particularly throughout the first half of treatment. The dynamic and bidirectional processes of parent-child weight loss over time weakens over the second half of treatment, which can inform treatment efficacy.

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Table 1.

Baseline sample characteristics

Characteristics	Mean (SD)
Child BMI	26.44 (3.67)
Child BMI z-scores	2.01 (0.33)
Adult BMI	31.93 (6.34)
Child age	10.41 (1.27)
Adult age	42.89 (6.50)
Parent ethnicity	
Hispanic	47 (31.3%)
Non-Hispanic	103 (68.6%)
Attendance	14.43 (4.90)

Values are n (%) for categorical variables and mean (SD) for continuous variables;

Abbreviation: BMI= body mass index; MVPA= moderate to vigorous physical activity

Table 2.

Time-lagged relations on body mass index

	Value[a]	SE	P value	d[b]
Within-individual lagged relationships				
Child – (sessions 0~10; phase 1)	0.107	0.005	<0.01	0.559
Child – (sessions 11~20; phase 2)	0.032	0.001	<0.01	0.168
Parent – (phase 1)	0.126	0.005	<0.01	0.493
Parent – (phase 2)	0.035	0.001	<0.01	0.138
Between-dyad lagged relationships				
Child->parent (phase 1)	0.029	0.005	<0.01	0.153
Child->parent (phase 2)	−0.004	0.001	0.012	−0.021
Parent->child (phase 1)	0.028	0.005	<0.01	0.108
Parent->child (phase 2)	−0.007	0.001	<0.01	−0.028

[a]Adjusted parameters from bivariate mixed-effects regression models reflecting differences between phases. Linearity is assumed within each phase. All models include following planned covariates: child age, child sex, adult age, adult sex, treatment arms, and treatment sessions.

[b.]Cumulative effect size by phases.

Table 3.

Time-lagged relations on body mass index adjusting for the conditional influence of attendance

	Value[c]	SE	P value	d[d]
Within-individual lagged relationships				
Child – (sessions 0~10; phase 1)	0.153	0.023	<0.01	0.597
Child – (sessions 11~20; phase 2)	0.006	0.003	0.061	0.026
Parent – (phase 1)	0.323	0.005	<0.01	1.113
Parent – (phase 2)	−0.013	0.001	<0.01	−0.045
Between-dyad lagged relationships				
Child->parent (phase 1)	0.105	0.020	<0.01	0.412
Child->parent (phase 2)	−0.023	0.002	<0.01	−0.092
Parent->child (phase 1)	0.102	0.042	0.015	0.352
Parent->child (phase 2)	−0.029	0.006	<0.01	−0.099

[c] Adjusted parameters from bivariate mixed-effects regression models reflecting differences between phases. Linearity is assumed within each phase. All models include following planned covariates: child age, child sex, adult age, adult sex, treatment arms, and treatment sessions. Weighted predictor includes balancing time-varying covariates through inverse probability weighting of parent attendance to the treatment sessions.

[d.] Cumulative effect sizes by phases.