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Behavioral and Psychological Predictors of BMI Reduction in Children Seeking Treatment at a Hospital Clinic's Family-Based Pediatric Weight Management Program

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Abstract

The rate and occurrence of childhood obesity is concerning and sets young people on a trajectory of lifetime physical health and psychological problems. Although randomized controlled trials have demonstrated the effectiveness of family-based pediatric lifestyle modification interventions, there is still a dearth of research evaluating behavioral and psychological predictors of treatment outcome under real-world practice settings.

Objective: To address this gap, we explored demographic, behavioral, and psychological predictors of treatment success in a family-based pediatric weight management program in a hospital-based clinic.

Methods: For 662 consecutively-treated children with overweight/obesity, we conducted four linear regressions examining demographic, psychological and behavioral predictors of post BMI z-scores (z-BMI), controlling for pre-treatment BMI z-scores.

Results: Overall there was a significant decrease in z-BMI from pre to post-treatment. Linear regressions revealed that participants who began treatment at a younger age, lower BMI (<99th percentile), and who, at pre-treatment, were more likely to have externalizing problems (CBCL) had a lower z-BMI at post treatment, after controlling for pre-treatment z-BMI. Results also indicated that those who attended more visits, specifically more visits with an exercise specialist, and who achieved more behavioral goals in treatment had a lower z-BMI at post treatment, after controlling for pre-treatment z-BMI.

Conclusion: Our findings provide modest support for the effectiveness of family-based pediatric lifestyle modification interventions in hospital-based clinics. We suggest the need for health care providers to identify and prepare children and their families to enter treatment at a younger age and lower BMI, to emphasize sessions with exercise specialists, and treatment engagement/goal achievement at home.

Keywords: Pediatric obesity; Predictors; Treatment outcome; Family-based treatment

Introduction

Current research indicates that 33.4% of United States youth (ages 2-19) are overweight (Body Mass Index [BMI] in the 85th-94th percentile) or obese (BMI ≥ 95th percentile), with 17.2% of those being obese and 5.8% categorized as extremely obese [1,2]. Childhood obesity rates nearly doubled in children from 1980 to 2000 and have remained high for the last decade [2]. Childhood obesity prevalence is deeply concerning because it sets young people on a trajectory for a lifetime of physical and psychological health problems [3,4].

Given the adverse effects of pediatric obesity, identifying effective methods for treatment is imperative. Meta-analytic research indicates that family-based lifestyle modification interventions for children with overweight/obesity are effective [5-7]. In particular, lifestyle modification programs that incorporate parental involvement and behavioral therapy techniques into structured dietary and physical activity treatment guidelines [5-7] can produce significant and clinically meaningful weight reduction [8] where positive outcomes are sustained in youth with overweight/obesity for at least a year [5,9].

Randomized controlled trials (RCTs) have demonstrated the effectiveness of family-based pediatric lifestyle modification interventions [5] and evaluations of these interventions in routine practice settings have also demonstrated a modest reduction in BMI or z-BMI [10-20]. However, given that clinical trials are typically equipped with more research personnel to encourage attendance (e.g., personally calling participants to attend treatment and complete assessments; more flexibility to cater to patients' schedules for appointments) and external funding to compensate participants for participation (e.g., financially incentivizing assessment completion and/or not charging for treatment), more research on weight management programs as an element of routine practice at hospital-based clinics is warranted, especially when more patients are and will be treated in these and similar practice settings. More specifically, there is still a dearth of research evaluating how well these RCT findings generalize to real-world, non-research-funded practice settings and under what conditions or for whom these treatments are most effective in achieving weight loss.

Several studies have evaluated demographic and treatment attendance variables as predictors of weight loss in routine pediatric practice settings and report mixed findings. These studies have variously found that greater BMI reduction was associated with a longer treatment duration [17,18], shorter time between treatment sessions [12], longer time between medical visits [13], greater frequency of dietitian visits per month [13], more follow-up visits [16], a younger age at treatment onset [16,17], a higher z-BMI at treatment onset [16], a lower BMI at treatment onset [15], being male [17], being female [15] and no parental history of obesity [17]. In addition, only one known study [15] has examined behavioral (other than treatment attendance) and psychological predictors of successful weight management in routine practice settings. Madsen et al. [15], in a sample of 156 children and adolescents participating in a clinic-based pediatric lifestyle intervention, found that less sugar-sweetened beverage consumption at pre-treatment and more frequent breakfast consumption at pre-treatment predicted a greater reduction in z-BMI after treatment but that pre-treatment parental BMI, days exercised, hours/day of TV, or quality of life were not significantly associated with BMI reduction.

Our study builds on existing research and specifically on Madsen's et al. study [15] by examining associations between z-BMI at post-treatment and both behavioral change during treatment (e.g., sedentary activity change and treatment goal achievement) and psychological variables at pre-treatment measures (e.g., Child Behavior Checklist) in addition to demographic predictors (age, gender, race/ethnicity and obesity status). More specifically, the current study examines demographic, behavioral, and psychological predictors of treatment success in New Impact (NI), a children's hospital-based clinic in South Carolina. We hypothesized that more sessions attended, more behavior goal achievement, greater reduction in screen time, and fewer behavior problems on the CBCL, would be associated with lower post-z-BMI. This study adds to the literature by evaluating the effectiveness of these real-world applications, by shedding light on current mixed findings regarding demographic predictors and by providing additional information on behavioral and psychological predictors of treatment success in routine practice settings.

Method

We used an intent-to-treat approach with a single group pre-post design similar to Madsen et al. [15] and Serodio et al. [18]. A medical chart review was conducted for all NI patients beginning treatment between January 2011 and October 2014. This period was chosen because no changes to the treatment protocol were made during this time. Study was approved by all authors' institutions' Internal Review Boards.

Participants

Participants were 662 children and adolescents with a z-BMI from 0.92-4.28 (M=2.41 ± 0.39), who either independently sought treatment at NI or were referred by a physician. The majority of the patients (99.5%) had a BMI percentile greater than or equal to 85%, with the exception of three patients, who had a BMI percentile under 85% (82.2, 82.6, 84.0%) but were treated at NI and so were retained in the study sample. Participants were not eligible for treatment at NI if the clinical psychologist's initial assessment determined active psychosis, suicidal ideation, or an eating disorder. Participants with any serious medical condition affecting treatment for weight management (e.g., Prader-Willi Syndrome) were removed from the dataset (n=5). The majority presented as female (56.9%) and ethnically diverse, as White (47.7%); Black (31.1%) and Hispanic (19.2%) participants were represented.

New impact program

NI provides a family-focused pediatric weight management program structured according to the Obesity Care Model [21,22] and utilizes an interdisciplinary treatment team consisting of an exercise specialist, a registered dietitian, a psychologist, and a pediatrician. NI's one-year program comprised a pre-treatment visit with an initial psychological and medical screening, an 8-session active treatment phase, a post-treatment visit with a psychological and medical follow-up assessment, and three maintenance follow-up appointments with the physician. During active treatment, the initial visit was scheduled with the dietitian and exercise specialist, and subsequent hour-long visits alternated weekly between dietitian visits and exercise specialist visits. The dietitian utilized the We Can! "Go-Slow-Whoa" [23], Let's Go! 5210 (letsgo.org), and MyPlate.gov programs to educate families about nutrition, meal patterns, menu planning, portion control, sugary beverages, calorie-dense foods, nutrient dense foods, and distinguishing between emotional and physical hunger. Participants received motivational counseling, feedback on food logs, and set nutrition goals both individually and as a family. Exercise specialist visits included education and motivational counseling on incorporating physical activity and reducing sedentary behavior into daily routines, feedback on exercise logs, and help in setting individualized physical activity goals.

Participants were provided a 2-month YMCA family membership and were given the option to attend up to four individualized counseling sessions with the clinical psychologist to address any BMI-related depression, parent-child conflict, attention deficit hyperactivity disorder (ADHD), or anxiety.

Participants earned small prizes for attendance and meeting goals.

Measures

Anthropometric, behavioral, and psychological measures were assessed by clinical staff and recorded in the patients' medical record. Data were retrieved from eClinicalWorks, patient charts, and patient progress reports by a team of trained research assistants under the lead author's supervision.

Demographic variables were age, gender, race/ethnicity, and extreme obesity status (BMI percentile ≥ 99%) [2]. In order to have moderately-large, equal sample sizes between Whites and other racial backgrounds, participants who were Black, Hispanic, Asian, Biracial or "Other" were grouped into one category.

BMI z-scores and BMI percentiles were calculated from height and weight measurements taken at each visit based on the Centers for Disease Control and Prevention growth charts (2000) using the NutStat model of EpiInfo 2000 [24]. We conducted intent-to-treat analyses with last observation carried forward for missing post-z-BMI scores. We had an attrition rate of 33%, which is consistent with other pediatric weight management studies [25].

Behavioral variables included number of treatment sessions attended, screen time (hours/day), and behavior goal achievement. Number of treatment sessions by treatment type was determined via medical chart review. Screen time was assessed at pre- and post-treatment sessions by the exercise specialist. Behavior goal achievement was coded on a 3-point scale from 0 (not at all achieved), to 2 (full achievement). A goal achievement score for each nutrition and exercise goal set during treatment was recorded by the dietitian or exercise specialist, respectively, and then averaged across all goal achievement scores recorded during the first four weeks of treatment for an overall behavioral goal achievement.

Psychological variables were measured with the Child Behavior Checklist (CBCL) [26], a 120-item caregiver-report, assessing internalizing and externalizing behaviors along eight dimensions: 1) anxious/depressed, 2) withdrawn/depressed, 3) somatic complaints, 4) social problems, 5) thought problems, 6) attention problems, 7) rule-breaking behavior, 8) aggressive behavior, as well as competence in activities, socialization, and school. The median test-retest reliability as reported by the manual is .89 for scale scores, total score and competence scores, with correlations between the total score on the CBCL and the total score on related instruments ranging from .71 to .92 [26].

Statistical Analyses

Except for z-BMI score calculations, all analyses were performed using SPSS software (version 23). We conducted intent-to-treat analyses with last observation carried forward whenever pre-treatment data were available. There were missing data for variables due to participant attrition and/or failure to measure and record outcome variables by clinical staff, resulting in a smaller sample size for several predictor variables. Data missing at pre-treatment were not imputed. When there was a question about treatment attendance, instead of assuming that the number of sessions was zero, we treated those data as missing.

We conducted analyses of variance (ANOVAs) to examine demographic differences in z-BMI at pre-treatment. We conducted analyses of covariance (ANCOVAs), controlling for pre-z-BMI scores, to examine demographic differences in z-BMI at post-treatment. To address heterogeneity of variance for analysis comparing obesity status on z-BMI at post-treatment, we conducted a t-test using a pre-to-post z-BMI change score (negative numbers indicating z-BMI reduction) and reported results for equal variances not assumed. To examine correlations between age and z-BMI, we conducted a Pearson Bivariate correlation at pre-treatment and a partial correlation at post-treatment, controlling for pre-z-BMI. We assessed pre-to-post z-BMI change using a paired samples t-test. To test our hypotheses and examine associations between predictor variables and post z-BMI, we grouped predictor variables and conducted a series of four linear regressions with pre z-BMI entered in the first step as a covariate, and predictor variables entered simultaneously in the second step, using pairwise deletion where there were missing data.

Results

Table 1 presents sample demographics. Overall there was a significant reduction in z-BMI from pre-to-post (pre-z-BMI M=2.41 ± 0.39; post-z-BMI M=2.37 ± 0.40; t (661)=10.29, $p<0.001$, d=0.404), indicating a small-to-medium effect size. A majority of participants (n=387; 57.1%) had a reduction in z-BMI; 130 participants (19.6%) maintained their z-BMI; and 145 participants (23.3%) had an increase in z-BMI.

Table 1: Sample demographics and demographic differences in pre-treatment and post-treatment z-BMI.

	N	%	Pre z- BMI	Pre z-BMI Differences (ANOVA)			Post z- BMI	Post z-BMI Differences (ANCOVA)		
			M (SD)	F(df)	p	η_p^2	M (SD)	F(df)	p	η_p^2
Gender										
Female	377	56.9	2.37 (0.38)	10.17 (1, 661)	0.001	0.015	2.33 (0.39)	0.067 (1, 661)	0.796	0.000

Male	285	43.1	2.46 (0.40)				2.42 (0.41)			
Race/Ethnicity										
White	316	47.7	2.40 (0.36)	0.54 (1, 661)	0.463	0.001	2.36 (0.37)	0.06 (1, 661)	0.807	0.000
Non-White	346	52.3	2.42 (0.41)				2.38 (0.43)			
Black	206	31.1	2.52 (0.43)				2.49 (0.43)			
Hispanic	127	19.2	2.25 (0.31)				2.18 (0.34)			
Asian	3	00.5	2.33 (0.48)				2.36 (0.53)			
Other	10	01.6	2.56 (0.42)				2.54 (0.42)			
Obesity Status										
Non-Extreme Obesity	257	38.8	2.04 (0.25)	871.18 (1, 661)	0.000	0.569	1.99 (0.26)	-2.805[a] (405.52)	0.005	0.196[b]
Extreme Obesity	405	61.2	2.64 (0.26)				2.61(0.26)			
	M (SD)	**Range**		**r**	*p*			**r**[p]	*p*	
Age	11.87 (3.29)	4.2-19.8		-0.051	0.192			0.155	0.001	

Non-Extreme Obesity (<99.0%); Extreme Obesity (≥ 99.0%); ANCOVA controlling for pre-z-BMI; Partial correlation, controlling for pre-z-BMI; [a]Independent samples t-test, equal variances not assumed, comparing obesity status on pre-to-post z-BMI change, with negative numbers indicating z-BMI reduction: Non-Extreme Obesity M(SD)=-0.05(0.12); Extreme Obesity M(SD)=-0.03(0.08); [b]Cohen's d effect size.

Boys had significantly higher z-BMI scores than girls at pre-treatment, but there was no difference at post-treatment. There were no differences by race/ethnicity at pre- or post-treatment. Patients with a higher obesity status at pre-treatment had less reduction in z-BMI at post-treatment than those with a lower obesity status. Age was not significantly correlated with z-BMI at pre-treatment but was significantly correlated with z-BMI at post-treatment, after controlling for pre-z-BMI scores. On average, participants completed 2.62 ± 1.90 sessions with an exercise specialist, 2.75 ± 1.63 sessions with a dietitian, 0.68 ± 1.51 sessions with the clinical psychologist for a total of 6.44 ± 3.83 sessions (includes visits with physician). On a scale from 0 (no goal achievement) to 2 (full goal achievement), participants' overall mean goal achievement was 1.24 ± 0.59, with 8% never achieving a behavior goal, 40% reaching only partial goal achievement, 30.4% reaching some partial and some full goal achievement, and 21.6% reaching full goal achievement on all recorded goals.

Demographic, behavioral and psychological predictors

Linear regression results with demographic variables (**Table 2**) indicated that a younger age and lower obesity status at pre-treatment was associated with lower post-z-BMI scores after controlling for pre-z-BMI scores.

Table 2: Linear regression with demographic variables predicting post-treatment z-BMI (N=662).

Model	Predictor	R	R^2	F(df), *p*	Beta	t	*p*	CI
1	**Pre z-BMI**	0.969	0.939	10156.54 (1, 660), 0.000	0.97	100.78	0.000	0.98, 1.02
2	**Pre z-BMI**	0.971	0.942	2140.91 (5, 656), 0.000	0.92	64.140	0.000	0.92, 0.98
	Age				0.04	3.934	0.000	0.00, 0.01
	Gender				0.00	0.134	0.893	-0.01, 0.02
	Race				0.01	0.880	0.379	-0.01, 0.02
	Obesity Status				0.06	4.444	0.000	0.03, 0.08

Non-Extreme Obesity (<99.0%); Extreme Obesity (≥ 99.0%)

In partial support with our hypotheses, linear regression results with type of treatment attendance (**Table 3**) indicated that attending more treatment sessions with an exercise specialist was significantly associated with lower z-BMI at post-treatment after controlling for pre-z-BMI.

Table 3: Linear regression with number and type of treatment visits predicting post-treatment z-BMI.

Model	Predictor	n	R	R^2	F(df), *p*	Beta	t	*p*	CI
1	**Pre z-BMI**	662	0.969	0.939	19987.26 (1, 649), 0.000	0.97	099.94	0.000	0.98, 1.02
2	**Pre z-BMI**	662	0.970	0.941	2603.90 (4, 646), 0.000	0.97	101.13	0.000	0.98, 1.02
	#Exercise Visits	654				-0.05	-3.40	0.001	-0.02, -0.01
	#Dietitian Visits	656				0.00	-0.05	0.961	-0.01, 0.01
	#Counseling Visits	656				0.00	-0.04	0.967	-0.01, 0.01

Consistent with our hypotheses, linear regression results with variables assessing behavior during treatment (**Table 4**) indicated that attending more treatment sessions overall as well as achieving more of treatment goals were significantly associated with lower z-BMI at post-treatment after controlling for pre-z-BMI. Inconsistent with our hypothesis, linear regression results with CBCL subscales (**Table 5**) indicated that externalizing problems significantly predicted higher post-z-BMI.

Table 4: Linear regression with behavior during treatment predicting post-treatment z-BMI.

Model	Predictor	n	R	R^2	F(df), *p*	Beta	t	*p*	CI
1	**Pre z-BMI**	662	0.969	0.939	5124.43 (1, 333), 0.000	0.97	71.59	0.000	0.97, 1.03
2	**Pre z-BMI**	662	0.971	0.942	1345.85 (4, 330), 0.000	0.97	72.81	0.000	0.97, 1.03
	#Treatment Sessions	662				-0.05	-3.69	0.000	-0.01, -0.00
	#Behavior Goal Achievement	402				-0.03	-2.14	0.033	-0.04, 0.00
	#Change in Screen Time	458				0.00	-0.02	0.988	-0.02, 0.02

Behavior Goal Achievement (0-no goal achievement to 2-full goal achievement); Change in Screen Time (hours/day of screen time at post-treatment minus hours/day screen time at pre-treatment)

Table 5: Linear regression with child behavior checklist (CBCL) subscales at pre-treatment predicting post-treatment z-BMI.

Model	Predictor	n	R	R^2	F(df), *p*	Beta	t	*p*	CI
1	**Pre z-BMI**	662	0.969	0.939	6971.08 (1, 453), 0.000	0.97	77.75	0.000	0.97, 1.02
2	**Pre z-BMI**	662	0.970	0.941	591.18 (12, 454), 0.000	0.97	81.96	0.000	0.98, 1.03
	Activities	522				0.01	1.21	0.344	0.00, 0.00
	Socialization	511				0.01	0.89	0.287	-0.00, 0.00
	School	476				0.01	0.54	0.340	-0.00, 0.00
	Anxiety/Depression	542				-0.01	-0.65	0.563	-0.00, 0.00

	Withdrawn/Depression	542				0.03	1.19	0.191	-0.00, 0.00
	Somatic Complaints	542				0.02	1.37	0.278	0.00, 0.00
	Social Problems	542				0.03	1.93	0.088	0.00, 0.00
	Thought Problems	542				0.01	0.81	0.577	-0.00, 0.00
	Attention Problems	542				0.02	0.52	0.274	-0.00, 0.00
	Internalizing Problems	542				-0.02	-1.22	0.494	-0.00, 0.00
	Externalizing Problems	542				-0.03	-2.10	0.043	-0.00, 0.00

Discussion

Our goal is to expand the knowledge about weight management in routine practice settings for comparison purposes with other clinics, to provide information to pediatricians and other health care professionals who need to determine for whom a weight management referral would be helpful, and to inform future intervention research. Overall, participants had a significant reduction in z-BMI from pre-to-post treatment. Our findings indicate that starting treatment at a younger age and lower z-BMI was significantly associated with a lower post-z-BMI.

The average reduction in z-BMI w as 0.04 with a small-to-moderate effect size, which is consistent with pediatric obesity, lifestyle-based interventions [5,6]. Although statistically significant, the reduction in BMI z-scores may not seem meaningful to patients and their parents. Our findings should be placed in the context of weight gain trajectories. Previous research and current healthcare guidelines suggest that children who are on a weight gain trajectory or steeper weight gain velocity benefit from maintaining their current weight as they grow taller in order to stabilize or reduce their BMI [6,27]. Sustained weight maintenance over one year has the potential to decrease risks of a myriad of physical health issues [5].

Our results that a younger age at pre-treatment was associated with a lower z-BMI at post-treatment and that a lower BMI at pre-treatment was associated with greater z-BMI reduction from pre-to-post-treatment are consistent with previous research [9,16,17,28] and with the push for early intervention of a child's environment and behavior to change his/her overweight trajectory [29]. Perhaps those with a higher BMI at pre-treatment are more set in behaviors contributing to obesity and experience more enabling factors in their lives assisting them with these obesogenic behaviors [30], making it more difficult for them to engage in the recommended weight management behaviors. However, our findings that a higher BMI at pre-treatment was associated with less z-BMI reduction from pre-to-post-treatment are inconsistent with some research [31]. A study by Knop et al. [32] found that children with extreme obesity at or under the age of 10 demonstrated greater reduction in BMI after treatment but those children with extreme obesity over the age of 10 demonstrated less reduction in BMI after treatment. Although we did not test for an interaction be tw een ag e (ranging 4-20 y/o in our sample) and obesity status on z-BMI reduction, an interaction between age and obesity status may help explain our findings and should be explored further. Collectively, our findings suggest that clinicians should not wait to refer patients to weight management clinics and support a treatment model that emphasizes family-based over individually-focused change.

Reduction in z-BMI was further associated with goal achievement, suggesting that when participants actively work toward their treatment goals, even if they only meet partial goal achievement, they are more likely to experience z-BMI reduction. This suggests that patient's commitment to and engagement in treatment and potentially family's commitment to treatment make the treatment more successful, which is consistent with previous research on child and parent adherence to treatment [33].

Our results also confirm the important role of exercise in pediatric weight management [34,35]. While we do not propose that participation in exercise sessions serve as a proxy measure for daily exercise; it does serve as another indicator of child and parent adherence to treatment.

It is unclear why more externalizing problems (delinquent and aggressive behaviors) were associated with lower z-BMI at post-treatment. There is evidence that behavioral problems are more common among female adolescents with overweight status than among normal weight peers [36], and a recent meta-analysis found a moderate effect for a positive association between impulsivity (associated with delinquent and aggressive behaviors) and pediatric obesity [37]. It is possible that, in this study, the physical activity and nutrition structure and/or attention provided by the program were particularly helpful for those with more externalizing problems. However, our findings are in contrast with Nederkoorn and colleagues [38] who found that more impulsivity was associated with less weight reduction after treatment. Future research should explore this association.

Strengths and limitations

There are several limitations to our study. First, this was not a randomized controlled trial (RCT), so we have no comparison group and acknowledge that the improvement in z-BMI and other treatment outcomes may be due to the passage of time or initial medical attention. Despite not having a comparison group and not being able to randomize participants to two different treatment conditions, we believe that regular evaluation and reporting of clinic-based treatments is essential for improving health care and treatment outcomes and for understanding the generalizability of RCT outcomes to routine practice settings.

Second, our study is limited by an uneven distribution of participants from diverse backgrounds, which precluded more fine-tuned analysis of racial and ethnic differences. A third of participants (33%) stopped attending treatment before session 4; however, attrition in this sample is consistent with other studies [25]. Consistent with non-research settings, clinicians are less likely to have time or motivation to administer all pre-treatment and post-treatment measures, which resulted in fewer post-treatment outcome measures.

Last, our study is limited by having a short follow-up time period. Research emphasizes the importance of longevity in weight intervention studies, especially among children [39]. In addition, our small sample and inclusion of participants who did not complete all eight active treatment sessions precludes the assessment of treatment mediators [7]. However, our program sheds light on predictors of treatment success in routine practice settings, which, we believe, increases generalizability beyond findings from randomized controlled trials.

Clinical implications

With these limitations in mind, we offer the following conclusions. Our findings suggest that clinicians should recommend patients for treatment early (at a younger age and lower BMI), should work to prepare families for treatment and to be supportive of their child's lifestyle changes, and should emphasize that making changes in the home is key to treatment success. In conjunction with previous research on treatment attendance [12,40,41], our findings suggest that exploring ways to improve treatment attendance is important but that engagement with treatment outside clinic may be equally if not more critical. Future research should examine goal achievement as predictors of treatment success to corroborate our findings. Future research evaluating tertiary-care, hospital-based weight management clinics might also consider partnering with local researchers to conduct program evaluations and expand on these findings.

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