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Association between the Family Nutrition and Physical Activity Screening Tool and obesity severity in youth referred to weight management

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Summary
Background: The Family Nutrition and Physical Activity Screening Tool (FNPA) evaluates family behavioural and environmental factors associated with pediatric obesity, but it is unknown if FNPA scores differ among youth across obesity severities. Our aim was to determine the association between the FNPA and obesity severity in youth referred to weight management.
Methods: Upon initiating treatment, height, weight, and the FNPA were collected according to standard procedures. Cut-points for overweight/obesity, severe obesity (SO) class 2, and SO class 3 were calculated. FNPA scores were compared across weight status groups using analysis of covariance, and odds of SO across FNPA quartiles were evaluated with multiple logistic regression.

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Results: Participants included 564 5–18 year old who initiated treatment and completed the FNPA. After adjustment, FNPA scores differed by weight status with higher/healthier scores in youth with overweight/obesity (56.6 ± 8.5) when compared to those with SO class 2 (55.0 ± 7.1; p = 0.015) or SO class 3 (53.6 ± 9.0; p < 0.001). Compared to those in the highest FNPA quartile, youth in the 2nd quartile had 1.8 (95% CI: 1.1, 2.9) times higher odds of SO, and those in the lowest FNPA quartile had 2.1 (95% CI: 1.3, 3.4) times higher odds of SO. Youth with SO had unhealthier subscale scores among 6 of 10 constructs, including nutritional, physical activity, sedentary, and sleep behaviours.

Conclusions: Results suggest a consistent inverse relationship between the FNPA and adiposity among youth presenting for weight management. The FNPA is a useful metric for programs and clinicians targeting family behaviours and the home environment to combat obesity.

Introduction

Childhood obesity is a major public health concern given the number of youth it affects and its adverse consequences. Currently, 18% of U.S. youth are obese and another 17% are overweight [1–3]. Among this high prevalence of overweight and obesity, a troublesome pattern has been observed in the increasing rates of severe pediatric obesity (body mass index percentile >99th age- and sex-specific percentile). Recent data have shown severe obesity to be the fastest increasing category of obesity among youth, with prevalence rates in the US reported to be between 4% and 6% [1–5]. This growing upward shift is of great concern due to severe obesity being associated with serious short-term and long-term health consequences [6]. Compared to youth with overweight or obesity, youth with severe obesity have more adverse levels of blood pressure, triglycerides, oxidative stress, high-density lipoprotein cholesterol, inflammation, and higher prevalence of prediabetes and impaired glucose tolerance [6]. In addition, the Bogalusa Heart Study has shown that excess adiposity and associated cardiometabolic risk factors track from childhood to adulthood [7]. Because of the serious short- and long-term consequences of severe obesity, it is vital that this population receive treatment as early as possible.

Over two-thirds of children's hospitals in the U.S. now provide services through a pediatric obesity clinic or weight-management program [8,9]. Patient assessment is a critical component within the chronic care model [10]. The behavioural assessment often includes gathering information on the components of energy balance—diet, sedentary behaviour and physical activity. Beyond assessment of the *amount* of physical activity (e.g. minutes of moderate-to-vigorous physical activity), sedentary behaviour (e.g. screen time), and caloric intake, it is also necessary to consider the *context* of these behaviours. Hence, understanding how the home and family environments influence these behaviours is essential [11,12].

A variety of surveys have been developed for potential use in the clinical screening of obesity and energy balance components, including the Patient-Centred Assessment and Counselling for Exercise [13], Family Nutrition and Physical Activity Screening Tool (FNPA) [14], Healthy Home Survey [15], and the Comprehensive Home Environment Survey [16]. The FNPA combines information from a variety of behaviours (e.g. family meals, TV in bedroom, parental modelling of physical activity) related to child obesity to evaluate family environments, and has potential for use by pediatric health professionals for assessing a child's family and home environment related to obesity. Studies evaluating the validity of the FNPA screening tool have shown it to be significantly associated with baseline prevalence of overweight [14], one-year change in BMI [17], cardiovascular disease risk factors [18], and acanthosis nigricans [19]. However, the utility of the FNPA screening tool in pediatric obesity treatment programs has not been investigated, nor has it been compared among youth across levels of obesity severity. Therefore, the purpose of this study

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was to determine the association between the FNPA and adiposity among youth with overweight and obesity referred to pediatric weight management.

Methods

Patient population and referral process

Participants in this study included youth who were seeking treatment at FitKids360, a 7-week, multi-component, stage 2 pediatric weight management program between 2011 and 2015 [20]. Program inclusion criteria required youth to be referred by a physician, between 5 and 18 years of age, and have a body mass index (BMI) ≥85th percentile based on age and sex. The FitKids360 model is designed to be family based with at least one parent or guardian accompanying and actively participating with the referred child to each weekly class, and siblings are encouraged to attend. The program primarily treats underserved youth, with approximately 85% of participating families enrolled in Medicaid. Session sizes often include up to a dozen families depending on the site's capacity and the number of available staff. Participants for the current study included referred youth enrolled in one of 57 FitKids360 classes conducted between November 2011 and April 2015 in Northern and Western Michigan, Detroit, and Butte, Montana.

Measures

The primary goal of FitKids360 is to improve the health habits of youth and their families, including nutrition, physical activity, sleep, and sedentary behaviours. A secondary purpose of the program is to reduce the level of adiposity of the referred youth. To evaluate health behaviours and other obesogenic risk factors within the home, the FNPA Screening Tool is administered during the initial orientation visit of the program. Anthropometry is also assessed during the orientation visit and includes height, weight, and body composition estimates.

FNPA

The current FNPA survey is comprised of 20 questions that cover ten behavioural domains, including family meal patterns, family eating habits, food choices, beverage choices, restriction and reward, screen time behaviour and monitoring, healthy home environment, family activity involvement, child activity involvement, and sleep routine. During the development of the FNPA, these factors were identified in a comprehensive evidence analyses as being positively associated with overweight and obesity [14]. Item responses range from one to four based on the frequency of engaging in each behaviour (i.e. ''almost never'', ''sometimes'', ''usually'', or ''almost always'') resulting in a total possible score between 20 and 80, with lower total scores indicating an adverse, obesogenic family environment. Previous studies have demonstrated the validity of the FNPA for differentiating the prevalence of overweight cross-sectionally [14] and for prospectively predicting 1-year change in BMI after accounting for baseline BMI, parent BMI, and other demographic variables [17].

During the orientation visit, the FNPA was provided in English or Spanish based on each family's preference. For patients <11 years, parents were asked to complete the FNPA based on their home environment and the behaviours of their referred child. When ≥11 years of age, referred youth and their parents were asked to complete the FNPA questions together. Trained FitKids360 staff members were available throughout the administration of the survey to help families as needed (e.g. clarify survey items, read questions aloud), and to review each completed survey for potential errors.

Anthropometry

Height and weight were measured using a standardised protocol [21] by FitKids360 staff members who had completed anthropometry training led by an expert technician (JT). After shoes and excess clothing had been removed, height was measured in duplicate to the nearest 0.1 cm using a Shorr board stadiometer (*Shorr* Production, Olney, MD). A third measure was taken if the first two differed by 0.4 cm or more, and the average of the measures was used to index standing height. Body mass was measured to the nearest 0.1 kg and percent body fat (%BF) was estimated using a foot-to-foot bioelectric impedance scale (Tanita BC-534/BC-539 Plus, Tokyo, Japan; US Service Centre Arlington Heights, IL). Two consecutive weight and %BF measures were taken and the mean of each was used to estimate weight and %BF, respectively.

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared, and age- and sex-specific BMI percentiles were calculated using CDC SAS growth software [22]. In addition, percent of the 95th BMI percentile was calculated in order to classify obesity severity as has been recommended [23], with 100%, 120%, and 140% of the 95th BMI percentile representing cutpoints for obesity, class II obesity, and class III obesity, respectively. Youth with class II or class

Table 1 Characteristics of the total sample and by sex.

Anthropometry	N	Total N = 599		Males N = 238		Females N = 361	
		Mean	SD	Mean	SD	Mean	SD
Age (year)	599	10.4	2.9	10.4	2.8	10.5	3.1
Height (cm)	599	147.6	16.2	149.0	16.6	146.7	15.9
Weight (kg)	599	65.9	26.1	66.4	26.4	65.6	26.0
BMI (kg/m^2)	599	29.1	6.6	28.8	6.5	29.2	6.7
BMI % of 95th percentile	599	126.1	23.0	128.0	24.1	124.9	22.2
Percent body fat (%)	537	38.8	8.5	36.4*	9.6	40.5*	7.2
Waist to height ratio	404	0.60	0.10	0.60	0.11	0.60	0.09
Overweight (%)	62	10.4		8.8		11.4	
Obesity (%)	211	35.2		35.3		35.2	
Obesity class 2 (%)	188	31.4		29.4		32.7	
Obesity class 3 (%)	138	23.0		26.5		20.8	
FNPA (total)	564	55.4	8.3	55.6	8.4	55.3	8.3

FNPA, Family Nutrition and Physical Activity Survey.
* Significant difference ($p < 0.05$) between males and females.

III obesity were identified as having severe obesity (BMI ≥120% of 95th percentile).

Abdominal adiposity was estimated via waist circumference in FitKids360 through the spring of 2014, which included participants from 37 (65%) of the classes in the current sample. Waist circumference was assessed in duplicate using a Gullick tape to the nearest 0.1 cm at the superior border of the iliac crest. When consecutive waist measures differed by more than 0.5 cm the assessment was repeated and the mean of the two closest values were used to estimate waist circumference. Waist-to-height ratio was calculated as waist circumference divided by standing height.

Data analyses

Descriptive characteristics of the sample were calculated as frequencies, means, and standard deviations for the combined sample and by sex. Mean differences between sexes and subsamples with missing body composition and FNPA data were compared using independent t-tests. Associations between FNPA and adiposity measures were assessed as continuous variables using simple and multiple linear regression for unadjusted and age- and sex-adjusted models, respectively. FNPA scores and sub-scale scores were compared between weight status categories using analysis of covariance in order to adjust for potential confounders, and follow-up pairwise comparisons were assessed using least square means. Participants were also divided into quartiles based on FNPA scores, after which logistic regression was used to compare the odds of having severe obesity across FNPA quartiles. In addition, logistic regression was used to test odds of having FNPA scores below the highest quartile when comparing participants grouped by obesity severity (i.e. overweight/obesity, class II obesity, and class III obesity). Alpha was set at 0.05, and all statistical analyses were conducted using SAS 9.4.

Results

Demographic characteristics of the sample are presented in Table 1. A total of 599 participants (60.3% female) with a mean (±SD) age of 10.4 ± 2.9 years were enrolled into the program and participated in the anthropometric screening. Of these, 563 (94%) completed the FNPA screening and 537 (90%) had percent body fat assessed. Participants with missing FNPA or BF% data did not differ statistically in age or BMI from those with complete data. All participants were affected by overweight or obesity (BMI ≥85th percentile), and over half had severe obesity (BMI ≥120% of 95th percentile), including 188 youth (31.4%) with class II obesity, and 138 (23.0%) with class III obesity. When sexes were compared, males and females did not differ in age, height, weight, BMI, or FNPA scores. However, %BF was lower among males (36.7 ± 11.6%) than females (40.8 ± 8.1%) ($p < 0.001$).

Multiple linear regression showed a negative association between age- and sex-adjusted FNPA scores and all adiposity measures, including BMI, percent of 95th BMI percentile, %BF, and waist to height ratio (Table 2). Beta estimates indicated that, after adjusting for age and sex, a one point increase in FNPA total score was associated with a 0.12 kg/m^2 lower BMI ($p < 0.001$), a 0.51 percentile point lower percent of 95th BMI percentile

Table 2 Association between FNPA and adiposity estimates in total sample and by sex: coefficients from linear regression models.

Anthropometry	Unadjusted			Age-adjusted			Age- & sex-adjusted		
	β	95% CI	p Value	β	95% CI	p Value	β	95% CI	p Value
BMI (kg/m^2)	−0.22	−0.28, −0.15	<0.001	−0.12	−0.17, −0.07	<0.001	−0.12	−0.17, −0.07	<0.001
BMI % of 95th percentile	−0.49	−0.71, −0.26	<0.001	−0.51	−0.74, −0.27	<0.001	−0.51	−0.74, −0.28	<0.001
Percent body fat (%)	−0.21	−0.30, −0.13	<0.001	−0.18	−0.27, −0.09	<0.001	−0.17	−0.26, −0.09	<0.001
Waist to height ratio	−0.002	−0.003, −0.001	0.003	−0.001	−0.003, −0.000	0.038	−0.001	−0.003, −0.000	0.039

($p < 0.001$), a 0.17% point lower %BF ($p < 0.001$), and a 0.001 reduction in waist to height ratio ($p = 0.039$).

After adjusting for age and sex, FNPA scores differed significantly across weight status categories (omnibus $F = 7.0$; $p = 0.001$). Post hoc tests revealed greater FNPA means among participants with overweight/obesity (56.6 ± 8.5) when compared to participants with class 2 obesity (55.0 ± 7.1) ($p = 0.015$) and class 3 obesity (53.5 ± 9.0) ($p < 0.001$). Among FNPA subscales, participants with severe obesity had lower scores for family meal patterns ($p = 0.008$), food choices ($p = 0.007$), screen time ($p = 0.009$), healthy environment ($p = 0.010$), child activity ($p = 0.003$), and sleep routine ($p = 0.006$) (Fig. 1).

When compared to participants with overweight/obesity, youth with severe obesity were more likely to have survey scores in the lowest 3 FNPA quartiles (Table 3). Specifically, youth with class 2 obesity had 1.4 times greater odds of lower FNPA scores and those with class 3 obesity had 2.0 times higher odds ($p < 0.001$) of low FNPA scores when compared to overweight/obese participants after adjusting for potential covariates. Similarly, when compared to participants in the highest (4th) FNPA quartile, participants in the 2nd quartile had 1.8 times higher odds of having severe obesity (class II + class III) ($p = 0.017$), and those in the lowest (1st) FNPA quartile had 2.1 times higher odds of having severe obesity ($p = 0.003$).

Discussion

The current study demonstrates a consistent inverse association between FNPA scores and adiposity among youth with overweight and obesity who present for weight management treatment. Though absolute differences in FNPA scores between weight status groups were relatively small, this is to be expected in a sample limited to youth with overweight and obesity. The FNPA tool was originally validated using a sample of 854 first graders, of which 36.4% of males and 35.3% of females had overweight or obesity [14]. When divided into tertiles based on FNPA scores, Ihmels et al. showed that those in the lowest tertile had 1.7 times higher odds of having overweight or obesity when compared to those in the highest FNPA tertile. Despite the wider age range, we found similarly increased odds of severe obesity when comparing youth in the lowest two quartiles for FNPA scores to those in the highest quartile. These findings, when combined with previous FNPA research [14],

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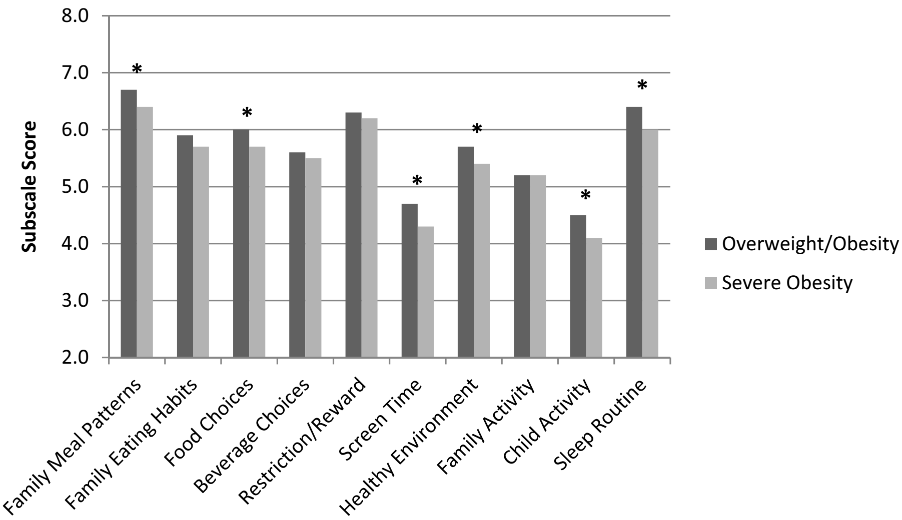

Figure 1 Comparison of mean age- and sex-adjusted subscale scores between patients with overweight/obesity and severe obesity (class 2 + class 3). Each subscale score is a composite of two questions such that scores range from 2 (unhealthiest) to 8 (healthiest). *Significant difference ($p < 0.05$).

Table 3 Odds ratios for FNPA quartiles associated with weight status.

Anthropometry	Unadjusted			Age-adjusted			Age- & sex-adjusted		
	OR	95% CI	p Value	OR	95% CI	p Value	OR	95% CI	p Value
Predictor: FNPA below 4th quartile									
Overwt/obesity	1	—	—	1	—	—	1	—	—
Obesity class 2	1.31	0.93—1.85	0.121	1.43	1.01—2.02	0.043	1.43	1.01—2.02	0.044
Obesity class 3	1.98	1.35—2.89	<0.001	2.00	1.36—2.93	<0.001	2.01	1.37—2.95	<0.001
Predictor: severe obesity (class 2 + class 3)									
Q4 FNPA (>61)	1	—	—	1	—	—	1	—	—
Q3 FNPA (56—61)	1.38	0.86, 2.22	0.182	1.40	0.87, 2.25	0.169	1.41	0.87, 2.27	0.161
Q2 FNPA (51—55)	1.76	1.09, 2.84	0.020	1.77	1.10, 2.85	0.020	1.79	1.11, 2.90	0.017
Q1 FNPA (<51)	1.92	1.19, 3.09	0.007	2.08	1.27, 3.39	0.004	2.08	1.28, 3.40	0.003

FNPA, Family Nutrition and Physical Activity Survey.

suggests the survey correlates with higher levels of adiposity across the spectrum of youth weight statuses, from normal weight through severe obesity. In addition, the significant relationship shown between continuous FNPA scores and body composition in the current study, suggests an inverse linear trend between adiposity and the health behaviours targeted within the FNPA, even among youth who already have obesity.

While construction of the FNPA survey questions was guided by an evidence analysis linking specific health behaviours to overweight or obesity, these identified behaviours do not necessarily differ between youth with overweight/obesity vs. severe obesity. For example, it is possible for both groups to consume sugar-sweetened beverages at similar rates, but more often than their normal weight peers. Yet, we found significantly unhealthier scores among participants with severe obesity in 6 of the 10 subscales, with a seventh approaching significance (Family Eating Habits (eating fast food & eating while watching TV), $p = 0.066$). Subscales that differed between weight status groups included a range of diverse factors, including nutritional, physical activity, sedentary, and sleep behaviours. Youth with severe obesity ate breakfast and family meals less often (Family Meal Patterns), and reported eating ready-to-eat foods more often and fruits and vegetables less often (Food Choices). These youth also had fewer screen time limits (Screen Time Monitoring), and were more likely to watch TV in their bedroom (Healthy Environment). Physical activity differences included less frequent enrollment in sports, less activity during free time (Child Activity), and fewer family opportunities to be active (Healthy Environment). Lastly, bedtime routines and adequate sleep duration (Family Routine) were less frequent among youth with severe obesity.

In addition to associations with adiposity, recent evidence has also linked FNPA scores to both cardiometabolic health and parenting behaviours. Among 119 10-year olds, Yee et al. found an inverse relationship between FNPA scores and a continuous cardiovascular risk score that included blood cholesterol, blood pressure, and waist circumference measures [18]. Another study by this group also showed associations between FNPA and acanthosis nigricans among 6—13 year old youth [19]. The current study showed similar associations between the FNPA and abdominal adiposity, as measured by waist to height ratio, which has been associated with increased odds of cardiometabolic risk factors among U.S. children and adolescents [24].

When examining parenting, Johnson et al. [25] demonstrated a link between parenting styles and FNPA scores, with lower FNPA scores found in households that used parenting styles categorised as Authoritarian (i.e. strict obedience, disciplinary strategies) and Permissive (i.e. tolerance/acceptance of behaviour, ignore misbehaviour), and higher FNPA scores in families that incorporated Authoritative styles (warmth, involvement, reasoning, joint participation) [26]. These associations are consistent with several studies that link permissive parenting with greater child adiposity [27—29] and authoritative styles with lower BMIs [30,31].

The current study is not without limitations. Our sample consisted of youth who were presenting for treatment for their weight, which may not be generalizable to other samples of youth with overweight and obesity. However, it does provide utility for similar weight management programs. In addition, the cross-sectional nature of our study precludes causal inferences from the findings. For example, low FNPA scores are a marker of obesogenic behaviours, which likely lead to increased obesity severity; however, it is also possible that having severe obesity promotes these obesogenic behaviours, thereby depressing FNPA scores. To date, one prospective study has shown that the FNPA can predict changes in BMI percentile over a 1-year period [17]. Additional longitudinal research is needed in order to evaluate the potential for the FNPA to detect improvements in health behaviours, and determine the subsequent impact on adiposity and related risk factors.

Despite its brevity, the FNPA has shown moderate agreement ($r = 0.37$; $p < 0.01$) with more in-depth behavioural evaluations, including the Comprehensive Home Environment Survey, a 181-item questionnaire with 18 subscales that evaluate nutrition, physical activity, and sedentary behaviours in the home [16]. In addition, research that incorporated the FNPA as an interventional component found high patient acceptability when administering the survey [32]. These findings, when combined with the body of growing research demonstrating step-wise associations with obesity and related risk factors across a wide range of youth, suggest that the FNPA holds promise as a screening tool for both preventing and treating obesity. For example, primary care providers and clinicians may improve pediatric care by incorporating the FNPA into well-child visits in order to detect adverse obesogenic home environments in youth with normal weight, while also providing a guide for initiating behavioural treatment strategies among youth with overweight or obesity.

In summary, the current study found significant associations between FNPA scores and obesity severity among treatment-seeking youth, which adds to the evidence supporting the potential utility of the survey as a screening tool for obesity-related behaviours in the home. Future research is needed in order to optimise treatments designed to increase FNPA scores through improvements in the familial environment, and to determine their impact on reductions in adiposity and prevention of excess weight gain throughout a child's growth and maturation.

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