Prevention and Treatment of Childhood Obesity: A *Strategy Involving Children and the Family for Improved Body Composition*

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Abbreviations:

PAK	ProActive Kids
BMI	Body mass index
FFM	Free fat mass
CDC	Centers for Disease Control

Table of Contents Summary

The article describes an intervention used to improve body composition and includes an analysis of children between 5-17 years of age who participated.

What's Known on This Subject

Pediatric obesity is a significant health problem. An increased trend in pediatric obesity has been observed in recent decades and currently exists in spite of efforts toward prevention. Additional strategies to improve pediatric body composition are currently warranted.

What This Study Adds

ProActive Kids, Inc. designed an effective strategy to improve pediatric body composition (weight, percent fat, fat mass and BMI) in children of all ages. By involving the family and the environment in which the child resides, long-term sustainability of improved body composition is feasible.

Introduction: Approximately one in six children and adolescents in the U.S. are currently overweight or obese. This trend has increased in the last four decades in spite of this known significant health problem. Strategies to prevent pediatric obesity have not improved the current incidence.

Methods: We analyzed body composition from participants of the ProActive Kids Foundation between 2010 to 2017. Baseline and final body composition measurements were analyzed in 884 children between the ages of 5 to 17 years. The outcomes were analyzed using a mixed model, ANCOVA and paired t-test analysis.

Results: Body composition improved in the majority of children irrespective of age, gender or county of residence. Children were tabulated into three groups according to age, revealing significant improvements in weight, percent body fat, and BMI following the intervention. Fat free mass did not improve in children who were older than 13 years. Age, county of residence and time significantly impacted weight, body fat, fat free mass and BMI. The mixed model revealed gender had no impact on the average change of weight or BMI.

Conclusion: The ProActive Kids Foundation designed an effective intervention to improve body composition in children between 5 to 17 years of age. By incorporating the family and the environment in which the child resides, significant improvements in body composition were observed in nearly all children. The incorporation of lifestyle changes for improved body composition will result in long-term changes that are likely sustainable. Strategies employed in similar settings to treatment this ongoing epidemic are currently warranted.

Introduction

Childhood obesity is at epidemic proportions on a global scale [Centers for Disease Control and Prevention (CDC), 2017; Bhupathiraju and Hu, 2016). An estimated 1 in 6 U.S. children and adolescents, or 12.7 million youth between 2-19 years of age are currently overweight or obese (CDC, 2017; Ogden et al., 2015). In spite of substantial efforts toward prevention, a recent upward trend has been observed in certain age subgroups (Cockrell Skinner et al., 2018) indicating marginal, if any improvement in incidence. During the period 2011-2014, 1 of every 5 (20.5%) adolescents between 12-19 years and ~17% of all youth were obese (~32% were overweight or obese (CDC, 2017). This trend parallels that of such complex metabolic health problems as diabetes and cardiovascular disease (Bhupathiraju and Hu, 2016) contributing to costs for treatment and complications, far outpacing other diseases (Dielman et al., 2016), and for children, currently exceeding $254 billion (Mozaffarian, Benjamin, Go et al., 2015). Moreover, the subsequent manifestations continue into adulthood. The progression to the development of childhood obesity is for the most part, preventable.

Pediatric obesity involves the complex interplay between genetic, environmental, physiological, and psychosocial factors (Bhupathiraju and Hu, 2016; Johnson III & Johnson, 2015). Those most disparaged seem to be at greatest risk; a disproportionate incidence has been observed in lower socioeconomic groups from barriers to access healthy foods (Bhupathiraju and Hu, 2016). The incidence is typically irrespective of gender but not race with the exception of non-Hispanic Asians; racial and ethnic disparities were observed in Hispanic (21.9%) and non-Hispanic blacks (19.5%) who report greater incidence than non-Hispanic whites (14.7%) or non-Hispanic Asian youth (8.6%) (CDC, 2017). Participation in physical activity from outdoor play or physical education has progressively declined in children. Only 27.1% of high school students

engage in the minimum requirements of at least 60 minutes of daily physical activity (USDHHS, 2008; ACSM, 2018) and many are not physically active outside of the school environment (Moyers et al., 2005). Nutritional habits, food options and parental cooking in the home (Chin & Ludwig, 2013; Mareno, 2014; Moyers et al., 2005) impact pediatric weight, in addition to nutritional options in the school setting (Ling, Robbins, Hines-Martin, 2016; Mareno, 2014; Moyers, Bulge, & Jackson, 2005). Research has demonstrated somewhat surprisingly, that parental perception of their child's weight may be skewed (Eckstein et al., 2006). Consideration of social status and the happiness of the child has also been identified as a more important concern, by some parents (Newson et al., 2013).

Regardless of strategies employed to combat the ongoing increased incidence, pediatric obesity remains a significant societal problem. The strategy employed by [ProActive Kids Foundation (PAK), 2018]), however, demonstrates significant improvement in all measures of body composition, such as, weight, percent body fat, FFM and BMI. By involving the child in addition to the family, these measures improved in nearly all children. Children along with parentes were also educated on topics as fitness, nutrition, and lifestyle habits. In this paper, we present the unique methodology designed by PAK to treat and prevent childhood obesity by incorporating a holistic approach of fitness, nutrition and lifestyle education. The outcomes were analyzed according to age, gender and Illinois county of residence.

Methods

Data

We used a dataset obtained from PAK involving 884 children between the ages of 5 to 17 years, who resided in either Cook, DuPage, Kane or Will Counties in Illinois between 2010 and 2017. The Proactive Kids Foundation was founded by Tony Burke in 2008 as an early

intervention and nonprofit organization with a mission of improving body composition, physical strength, endurance and self-esteem in children. (PAK, 2018). According to Burke, 'kids alone can't turn their lives around; hence, family involvement is key for lifestyle changes in children.

PAK uses a three-tiered approach in which the child along with the family receive an education on the topics of lifestyle, nutrition and fitness for the purpose of changes that are sustainable on a long-term basis. The duration of the program is eight weeks with mandatory attendance in which the child attends sessions alone on Mondays and Wednesdays (90 minutes) and with a caregiver on Fridays (120 minutes). Each session involves a 45-minute workout in addition to an educational session in which nutritional topics such as, healthy dietary options, portion control, interpreting food labels or grocery shopping are presented, as well as an open dialogue (45 minutes) with the caregiver. Topics for the open dialogue session include coping, communication techniques, confidence and self-esteem, body image and bullying (PAK, 2018).

Measures

Age groups

Demographic data was obtained from the parent or caregiver during the final visit by paper survey. For purposes of analyses, we stratified the children into three groups according to the age of the child. Group 1 involved children who were less than 8.9 years of age; Group 2 children were between 9 and 12.9 years and; Group 3 children, 13 years of age and older. Children were required to be enrolled by a parent or caregiver, although the age and weight validated by a healthcare provider. Requirements for participation in PAK included: a) body mass index (BMI) of at least 85 percent according to age (CDC, 2018); b) residence in Cook, DuPage, Will or Kane County in Illinois; c) ages 5 to 17 years. PAK established collaborative partnerships with a hospital or healthcare organization; thus, participation is of no cost to the

family (PAK, 2018). All participants consented for involvement in PAK and data was de-identified and therefore exempt from review by the IRB.

Body composition

Height (inches), weight (pounds), body fat (percent), fat free mass (FFM) and BMI and were obtained during week 1 and week 8. BMI is as an indicator of body composition and represents the body mass in relation to stature (CDC, 2018). BMI in children is interpreted with consideration to children of the same age and gender according to a gender-specific growth chart established by the CDC (CDC, 2015). A normal BMI is between the 5^{th} and 85^{th} percentile in children and adolescents (2 to 19 years), overweight is defined by a BMI between the 85th and 95th percentile, and obesity as a BMI >95th percentile for age and gender (CDC, 2015; Ogden et al., 2010). While BMI is not recommended for diagnostic purposes to identify excess weight from fat, it is recommended to screen for excess weight (CDC, 2015; American Academy of Pediatrics). BMI values greater than normal require additional measurements of fatness, such as percent body fat and FFM, as obtained in the PAK measurements at week 1 and week 8.

Statistical Approach

Pre-established growth charts with separate weight categories were used to compare children according to age and gender. Demographic and baseline data of the study sample are presented as mean ± SD for continuous variables and the categorical variables are presented as percentages. We employed ANCOVA analysis to identify body composition changes by county of residence. The mean change in weight, percent body fat, FFM, and BMI were obtained between the initial visit (week 1) and final visit (week 8) amongst the four counties, with county as a factor and the week 1 measurement as a covariate. Paired t-test analyses were employed to compare pre- and post- body composition measurements. Changes from week 1 through week 8

were examined for the variables, weight, percent body fat, FFM and BMI. All statistical tests were 2-tailed with an adopted significance level of $p < 0.05$. Correcting for multiple comparisons was conducted using the Bonferroni method. All statistical analyses were performed using SAS® software version 9.4 (2013, SAS Institute Inc., Cary, NC, USA).

We then used linear mixed model analyses to predict variables of body composition according to demographic variables. The model included child as a subject, and a structured covariance matrix to determine whether weight, percent body fat, FFM, and BMI were able to be predicted by age, county of residence or gender. The missing values of the data were replaced by the imputed values via MCMC option using SAS PROC MI with random seed 54321 used. Changes for the body composition measurements of weight, percent body fat, fat free mass, and BMI which were not clinically meaningful were removed from the analysis. For example, 3 subjects (487, 915 and 985) demonstrated a change in BMI greater than 20% between week 1 and week 8 that is not clinically meaningful and were removed from the dataset for, BMI change analysis.

Results

Demographic data

The dataset included slightly more female (51.1%) than male children, and the majority were between 9-12.9 years of age (Group 2, 55.3%), followed by children younger than 8.9 years (Group 1, 29.1%) and the least number of the children 13 years of age or older (Group 3, 15.6%). Most of the children were white Caucasian (48.39%), followed by Hispanic (29.64%), and black children (21.97%). The majority resided in DuPage (51%) or Cook County (46%), with only 3% who lived in Kane or Will County (2% and 1%, respectively). DuPage, Kane and Will Counties are each ranked as the top 100 wealthiest US counties according to mean household income.

DuPage County is ranked as 1 of 102 healthiest counties in which to reside; Kane and Will Counties rank 7th and 9th, respectively, and Cook County is ranked 59th (County Health Rankings, March 14, 2018). Participation for PAK is at no cost to the family; the average income for PAK participants ranged from $25,000 to $49,999 and only 58.37% had health insurance (PAK, 2018). A post-program survey revealed the majority (82.23%) of children were enrolled by their mother and resided in families in which the parents were married (67%).

Body composition

We tabulated body composition measurements (weight, percent body fat, FFM and BMI) into three groups according to age, and subdivided by gender. These findings are presented in Table 1. Females in Group 3 demonstrated the greatest fat content and BMI while males in Group 3 demonstrated the greatest weights.

The BMI indicates normal, overweight or obese status for children according to gender and age. The highest within a category for normal weight BMI is 85%. A normal BMI for female children through 8.9 years of age is equivalent to ~ 19 kg/m^2 (CDC, 2015).

Table 1. Body Composition Change According to Age and Gender

	Group 1 5-8.9 yr (M±SD)		**Group 2** 9-12.9 yr (M±SD)		**Group 3** 13+yr (M±SD)		**Combined** (M±SD)	
	Female (n=124)	**Male (n=134)**	**Female (n=237)**	**Male (n=253)**	**Female (n=79)**	**Male (n=59)**	**Female (n=440)**	**Male (n=446)**
Weight week 1	123.13 ±32.22	126.72 ±37.65	140.93 ±40.86	151.67 ±47.24	190.06 ±49.35	198.15 ±47.57	144.73 ±46.16	150.32 ±49.54
Weight week 8	122.84 ±32.40	125.91 ±37.71	140.34 ±40.60	150.47 ±46.83	186.42 ±50.10	196.17 ±47.41	143.68 ±45.65	149.14 ±49.16
Body Fat week 1	0.41 ±0.07	0.39 ±0.10	0.41 ±0.07	0.40 ± 0.10	0.438 ±0.08	0.39 ±0.099	0.41 ±0.07	0.397 ±0.10
Body Fat week 8	0.39 ± 0.08	0.37 ± 0.10	0.39 ± 0.07	0.39 ± 0.09	0.43 ±0.08	0.37 ±0.10	0.40 ± 0.07	0.378 ± 0.09
FFM week 1	71.26 ±15.30	75.46 ±20.89	81.22 ±17.10	87.27 ±22.08	102.40 ±15.71	117.26 ±24.57	82.21 ±19.35	87.69 ±25.42
FFM week 8	72.48 ±15.58	77.62 ±21.65	82.17 ±17.12	89.56 ±22.87	102.71 ±16.03	118.05 ±31.81	83.13 ± 19.31	89.74 ± 26.81

BMI week 1	28.40 ± 4.98	28.51 ± 5.86	28.86 ± 5.79	30.12 ± 6.41	33.70 ± 7.30	33.54 ± 7.29	29.60 ± 6.18	30.09 ± 6.54
BMI week 8	27.96 ± 5.04	27.70 ± 5.75	28.43 ± 5.72	29.62 ± 6.39	33.18 ± 7.34	33.00 ± 7.39	29.15 ± 6.15	29.49 ± 6.54

All body composition measurements improved significantly as a result of the intervention in Group 1 and the Combined Groups, according to paired t-test analyses as shown in Table 2; weight ($p < 0.0001$), percent body fat ($p < 0.0001$) FFM ($p < 0.0001$), and BMI ($p < 0.0001$). No significant improvement in FFM was found in Group 3 children ($p = 0.591$).

Table 2. Body Composition Change According to Age* and Combined Groups using Paired T-Test Analyses

Baseline to Post-Program (week 1 to week 8)	**Age Group 1** (Mean ± SE, *p*-Value)	**Age Group 2** (Mean ± SE, *p*-Value)	**Age Group 3** (Mean ± SE, *p*-Value)	**Combined Groups** (Mean ± SE, *p*-Value)
Weight	0.561 ± 0.176, 0.0017	0.9017 ± 0.153, <.0001	2.934 ± 0.788, 0.0003	1.119 ± 0.159, <.0001
Body Fat	0.014 ± 0.002, <.0001	0.015 ± 0.002, <.0001	0.015 ± 0.002, <.0001	0.015 ± 0.001, <.0001
FFM	-1.712 ± 0.254, <.0001	-1.641 ± 0.205, <.0001	-0.513 ± 0.952, 0.5914	-1.490 ± 0.201, <.0001
BMI	0.628 ± 0.063, <.0001	0.462 ± 0.052, <.0001	0.526 ± 0.071, <.0001	0.520 ± 0.036, <.0001

*Groups by Age: Group 1, 0-8.9 years; Group 2, 9-12.9 years; Group 3, 13 years and older

We analyzed the mean change in week 1 to week 8 body composition according to county of residence using analysis of covariance (ANCOVA). County was the factor and week 1 as covariate. The pairwise comparison amongst the four counties revealed statistically different changes between Cook vs DuPage Counties for weight and body fat; only weight differed significantly across all four counties (Cook vs. DuPage, $p = <.0001$; Kane vs Will, $p = 0.0018$; Global, $p = <.0001$, Table 3). Body fat ($p < 0.0001$) improved significantly in Cook vs. DuPage Counties and in the Global group (body fat, $p < 0.0001$) as indicated in Table 3. However, no significance difference was observed in body fat ($p = 0.2720$) in Kane vs. Will Counties. FFM

and BMI demonstrated insignificant differences in all counties (Global, $p = 0.1560$ and $p = 0.1669$, respectively). For the insignificant global test, pairwise comparisons were not performed.

Table 3. Body Composition from Baseline to Post-Study for the four counties (Cook, DuPage, Kane and Will) using ANCOVA Models

Difference (week 1 – week 8)	Global (P-Value)	Cook vs. DuPage (P-Value)	Kane vs. Will (P-Value)
Weight	<.0001	<.0001	0.0183
Body Fat	<.0001	<.0001	0.2720
FFM	0.1560	NA	NA
BMI	0.1669	NA	NA

* Considering the sample sizes from these four counties are highly unbalanced with most of subjects from Cook and DuPage, pairwise comparisons between Cook and DuPage and between Will and Kane were conducted.

We used mixed model analyses to predict the main effect of the variables age, county of residence, and time, on weight, BMI, body fat, or FFM (Table 4). *Time* refers to the difference between baseline and the end of the study (week 1 to week 8). The changes in body composition measure reflect potential effects of the outcomes of the strategy used by Proactive Kids, for children observed in this study. The fixed-effects estimates indicate the improvement of these four body composition measures from baseline to the end of the study. The fix-effects parameter estimates revealed that weight and BMI were significantly impacted by age ($p < 0.0001$) and county of residence ($p < 0.0001$) but were not impacted by gender ($p = 0.9708$ and 0.8069, respectively). Gender, age and county of residence significantly impacted percent body fat (gender, $p = 0.0004$; age, $p = 0.0006$; county of residence, $p = 0.0009$; time, $p < 0.0001$) and FFM (gender, $p = 0.0003$; age, $p < 0.0001$; county of residence, $p < 0.0001$; time, $p < 0.0001$).

Table 4. Mixed Model Analysis to Determine Tests of Fixed Effects involving Age, County, and Gender on Obesity-related variables (Weight, Body Fat, Fat Free Mass and BMI.

Dependent Variable	Effect Estimate	Estimates	P-Value
Weight	Gender	Female 0.0751	0.9708
		Male reference	
	Age	2.8435	<.0001
	County	Cook 9.6833	<.0001
		DuPage -1.6833	
		Will 14.421	
		Kane reference	
	Time	Pre 1.1130	<.0001
		Post reference	
Body Fat	Gender	Female 0.0217	0.0004
		Male reference	
	Age	0.0400	0.0006
	County	Cook 0.0256	0.0009
		DuPage 0.0021	
		Will 0.0054	
		Kane reference	
	Time	Pre 0.0140	<.0001
		Post reference	
FFM	Gender	Female -4.5949	0.0003
		Male reference	
	Age	1.8982	<.0001
	County	Cook 1.8790	<.0001
		DuPage -3.8998	
		Will -4.5413	
		Kane reference	
	Time	Pre -1.6410	<.0001
		Post reference	
BMI	Gender	Female -0.0836	0.8069
		Male reference	
	Age	0.3642	<.0001
	County	Cook 0.9913	<.0001
		DuPage -0.6878	
		Will 0.2015	
		Kane reference	
	Time	Pre 0.5289	<.0001
		Post reference	

Discussion

The most important outcome of our study is the effectiveness of the intervention used by PAK to decrease pediatric obesity. All measures of body composition, weight, body fat, FFM, and BMI, improved in children who were between the ages of 5 to 17 years, and the findings were irrespective of gender, age, or county of residence.

Pediatric obesity is an ongoing epidemic that continues in spite of substantial efforts in recent decades. The intervention designed by PAK improved body composition and the health of children. Childhood obesity results from lifestyle and other environmental factors, therefore, the intervention is aimed at the variables that contribute to the etiology of obesity and are therefore, more likely to be effective.

The geographic residence of all children is one of four Illinois' counties near Chicago. The sample was diverse and included largely representative of the US population. DuPage and Cook Counties differ substantially in the ethnicity socioeconomic background of the population, although, DuPage, Kane and Will Counties are relatively homogenous.

Weight

The recent trend of increased pediatric weight parallels the increased incidence of obesity in adults. Weight improved across all categories for each gender. Weight is the most reliable measurement of body composition and easiest to interpret. Weight and body fat improved most in children residing in DuPage or Cook Counties where the majority of the children resided and the findings were impacted by sample size. Males lost more weight than females in Groups 1 and 2, while females in Group 3 demonstrated the greatest improvement in weight of any subgroup. Group 3 represents children aged 13 years and older are experiencing increasing hormone levels that may impact their weight. Of all groups, males in Group 3 demonstrated the highest baseline

weight, and Group 3 females had the highest percentage of body fat. Although the weights of females in Group 3 improved, body fat and FFM demonstrated only negligible improvements. Males older than 13 years of age demonstrated the highest weights likely due to growth.

BMI

BMI is an alternative measurement of body fat and has been found to correlate with skinfold measurements, underwater weighing (densitometry) and dual energy x-ray absorptiometry (DXA Scan) (Barlow, 2007; Cote & Harris, 2013; Whitlock et al., 2010). BMI measurements are recommended for screening, and since BMI is specific to age and gender, it is an important baseline measurement for PAK participation.

The BMI improved in all participants by study completion at week 8 although all BMIs exceeded the 95th percentile (CDC, 2015). Continued PAK lifestyle interventions are recommended. The PAK interventions target long-term strategies to improve body composition.

The impact of age, county of residence, and time on weight, BMI, body fat and FFM were analyzed using mixed model analysis. These findings revealed nearly all measures of body composition to improve in all children. Gender, age, and county of residence significantly influenced body fat and FFM. Weight and BMI were significantly affected by age and county of residence but not by gender which needs more exploration. Note that county of residence significantly affected all four obesity-related variables, including weight, body fat, FFM, and BMI. These encouraging outcomes suggest the usefulness of this intervention strategy. The demographics in the counties included in this study are highly variable. The influence of gender on body fat and FFM and lack of influence on weight takes into account hormonal differences.

Limitations

The data was obtained from the PAK Program intervention with a different objective than the aims of this analysis. Limitations exist with the use of a secondary data set. The heterogeneous applicability of outcomes varied between Cook County and DuPage County, as they comprise a highly different demographic. The majority of children resided in these two counties. Irrespective of these outcomes, Cook County includes an estimated 50% minorities, therefore, is relatively representative of the U.S. population. The research conducted met the intended objections of the Proactive Kids program, however, a lack of control over data quality was a limitation in this study.

Conclusion

Childhood obesity remains a significant health problem on a global scale in spite of efforts towards prevention. The ProActive Kids Foundation designed a successful strategy to improve all measures of body composition in children by incorporating lifestyle changes that are likely to be effective on a long-term basis. All measures of body composition improved in a heterogeneous sample of children in four Illinois counties. The unique intervention designed by ProActive Kids involves the child's environment, parents or caregivers to impact and improve a child's weight. These findings implicate a cumulative impact on the epidemic of childhood obesity. Further analyses of PAK participants over a longer duration, including follow-up of the current intervention are also warranted. Strategies modeling the PAK intervention may elucidate the various etiology of the increasing trend in pediatric weights.

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