Dietary Composition and Weight Change Among Low-Income Preschool Children

P. K. Newby, ScD, MPH, MS; Karen E. Peterson, ScD, RD; Catherine S. Berkey, ScD; Jill Leppert, BS; Walter C. Willett, MD, DrPH; Graham A. Colditz, MD, DrPH

Objective: To examine the relation between dietary composition and weight change among children. We tested several hypotheses considering intake of nutrients (total fat and fiber) and predefined food groups (breads and grains, “fat foods,” fruits, and vegetables) used in the North Dakota Special Supplemental Nutrition Program for Women, Infants, and Children (WIC Program).

Design: Prospective study.

Subjects: We collected dietary, anthropometric, and sociodemographic data from 1379 children aged 2 to 5 years participating in the North Dakota WIC Program on 2 visits ranging from 6 to 12 months apart.

Main Outcome Measure: Annual change in weight.

Results: In multiple regression analyses, no significant relations were found between total intake of fat, fiber, fruits, or vegetables and weight change. There was a 0.16-kg lower weight change per year (95% confidence interval [CI], −0.20 to −0.12 kg; \( P < .01 \)) with each additional daily serving of breads and grains, and a 0.05-kg greater weight change per year (95% CI, 0.1-0.09 kg; \( P < .05 \)) for each additional serving of fat foods in a model adjusting for sex, age, baseline weight, change in height, and sociodemographic variables.

Conclusions: Intake of North Dakota WIC Program–defined fat foods, but not dietary fat per se, significantly predicted weight gain, whereas intake of North Dakota WIC Program–defined breads and grains, but not fiber per se, significantly predicted weight loss in preschool children.


Approximately 1 in 4 children and adolescents in the United States is overweight.1 Although several reports have assessed the prevalence of overweight among older children,1-4 fewer studies have targeted preschool children.5,6 Dramatic increases in obesity during the past several decades suggest the predominance of environmental factors over genetic factors.7,8 Clearly obesity is the result of a positive balance between energy intake and expenditure. Dietary composition, which can be modified, may be related to energy imbalance, given the different effects of macronutrients on hunger, satiety, food intake, and substrate utilization.9

The percentage of energy derived from fat has decreased and that from carbohydrates has increased among children aged 2 to 17 years from 1989-1991 to 1994-1995.10 Increases in carbohydrate intake may be related to obesity, although the effect of carbohydrates on appetite and weight depends in part on fiber content.11 Daily total fiber intake among children aged 2 to 5 years significantly decreased from 1977-1978 to 1987-1988, although fiber intake from cereals increased and fiber intake from fruits and vegetables declined.12

We are not aware of any studies that have specifically examined the relation between intake of fiber or fiber-rich foods such as fruits, vegetables, or breads and grains and obesity among young children.

The objective of this study was to examine prospectively the relation of intake of selected nutrients (total fat and fiber) and predefined food groups (breads and grains, “fat foods,” fruits, and vegetables) with weight change among low-income preschool children.

Methods

Subjects

The data analyzed herein were provided by the North Dakota Special Supplemental Nutrition Program for Women, Infants, and Children (WIC Program) for children aged 2 to 5...
years seen between January 1, 1993, and June 30, 1998, originally including data from 17,232 visits to the WIC clinics. The mission of the federally funded WIC Program is to safeguard the health of low-income women, infants, and children up to 5 years of age by providing nutritious foods, information on healthy eating, and health care referrals.13

We excluded children with only 1 clinic visit (n = 7834) because they provide no data on weight change and children who reported implausible energy intakes (<800 or >3500 kcal) (n=447). A statistical program from the Centers for Disease Control and Prevention14 was used to exclude children with biologically implausible measures of weight for height, weight for age, or height for age (n = 532) or children who were underweight (less than the fifth percentile for age- and sex-specific body mass index [BMI; calculated as weight in kilograms divided by the square of height in meters]) (n = 686).

From the remaining 7733 observations, we created a data set of 4328 children with at least 2 clinic visits and excluded 2842 observations for which the second visit was less than 6 months or greater than 12 months from the first; this time interval (mean, 9.1 months) was selected with the rationale that intervals outside this range might obscure the diet-weight relation. Children seen more frequently than the 6-month period required for WIC Program recertification could have a sickness affecting dietary intake and/or body mass. Visits separated by longer than 12 months were thought to provide data on diet too distant from commensurate growth, as the diet changes frequently during preschool years.

Because few children had greater than 2 clinic visits (n = 36), we restricted analysis to data from the first 2 visits. Of these, 71 were excluded because of an implausible change in BMI (a reduction or increase in BMI ≥4), leaving 1379 children for the analysis.

MEASUREMENTS

Dietary and anthropometric data were collected by WIC Program staff at each visit. Staff were trained to measure height and weight and were routinely observed to ensure data quality. Scales were regularly calibrated. Height was measured without shoes, socks, or jackets to the nearest one-third centimeter using a wall-mounted measuring board, and weight was recorded without shoes and coat to the nearest 0.1 kg using a standard floor-model beam scale.15 The WIC records provided sociodemographic data on birth weight, years of maternal education, race/ethnicity, residence, and federal poverty level.

Dietary data were collected using a semiquantitative food frequency questionnaire (FFQ). The FFQ is a reproducible instrument16 that has been modified and validated in this population in North Dakota.17 The child’s parent or guardian completed the questionnaire to reflect the child’s usual eating habits during the past 4 weeks. The FFQ contains 84 foods, which were selected on the basis of the most common food sources, and consumption categories were created on the basis of median portion sizes for low-income women and children as reported in the 1985 Continuing Survey of Food Intake for Individuals.18 The 9 frequency categories ranged from never in the past 4 weeks to greater than 6 times per day; categories were converted to obtain daily serving measurements (eg, 1 serving/wk = 0.14 serving/d). Daily food servings were used in the creation of food groups and the derivation of nutrients.

The food grouping scheme was developed by a nutrition committee consisting of representatives from several statewide WIC programs and academic experts at the beginning of the project in 1992. Nutritionists at the North Dakota WIC Program further modified the food groups for state-specific use, and these predefined food groups (hereafter referred to as ND food groups) were used in this study. The ND food groups are similar to the categorization scheme used in the US Department of Agriculture (USDA) Food Guide Pyramid,19 which was not developed when this project began. The ND food groups are not related to the WIC Program federal food package and are not federally defined food groups. The groups were created for nutrition education purposes and are used in nutrition counseling at North Dakota WIC Program clinics. In this study, we considered 4 ND food groups as our main food exposures (ND breads and grains, ND fat foods, ND fruits, and ND vegetables). We analyzed the ND fruits group with and without fruit juices because fruit juice may be positively related to obesity.20

Nutrient intakes were derived from the 1993 USDA Nutrient Database for Standard Reference,21 supplemented by information from Holland et al22 and Paul and Southgate.23 Fat intake was treated as a percentage of total energy, and fiber intake was treated as absolute grams, adjusted for energy using the nutrient residual approach.24

STATISTICS

We calculated sample means and frequencies at the first clinic visit. The percentage of children who were at risk of overweight at baseline was calculated on the basis of the age- and sex-specific 85th percentile of BMI using reference growth curves developed from the National Health and Nutrition Examination Survey data.25

Our outcome variable was calculated by subtracting weight at visit 1 from weight at visit 2, dividing by the time interval (in months), and multiplying by 12 months to estimate an annual change in weight. Dietary measures reported at visit 1 were used to predict change in weight between visits 1 and 2. We tested the hypotheses that intake of dietary fat, ND fat foods, and ND breads and grains would be directly related to weight change, whereas intake of dietary fiber, ND fruits, and ND vegetables would be inversely related, adjusting for baseline weight, change in height during the time interval, age, sex, total energy intake, and sociodemographic covariates.

We used linear regression analysis to estimate the associations of diet with weight change and performed the analysis separately for nutrients and food groups owing to the collinearity between foods and nutrients. One set of models included all nutrients and another set included all food groups. Three models were fit for each dietary predictor. In the first analysis, we adjusted for sex and baseline measurements of age, weight, and total energy and change in height during the time interval. The second analysis further adjusted for birth weight, maternal education, race/ethnicity, residence, and poverty level; those subjects who were missing data on demographic variables were retained in the analysis by using missing indicator variables. For the last analysis, we adjusted for all these variables but removed total energy from the equation, with the rationale that total energy intake is a mechanism through which nutrients and foods may affect weight. Thus, it could be argued that total energy intake should not be included in the model. We also examined the independent relation between total energy intake and weight change.

We performed all statistical analyses using SAS for Unix software.26

RESULTS

At the first clinic visit, 18% of girls and 23% of boys were at risk of overweight, defined by age- and sex-specific BMI of at least the 85th percentile (Table 1). Few subjects of African American, Hispanic, or Asian ethnicity were included in the study. Few differences were seen in dietary intake at baseline between girls and boys (Table 2).
Of the individual ND food groups tested, we observed a 0.19-kg lower weight change per year (95% confidence interval [CI], −0.22 to −0.15 kg; \(P<.001\)) with each additional serving of ND breads and grains, a 0.07-kg greater weight change per year (95% CI, 0.03-0.11 kg; \(P=.003\)) for each additional serving of ND fat foods, and a 0.09-kg greater weight change (95% CI, 0.05-0.13 kg; \(P=.02\)) for each additional serving of vegetables in multivariate, energy-adjusted models (Table 3). When all food groups were considered together in a single model, there was a 0.16-kg lower weight change per year (95% CI, −0.20 to −0.12 kg; \(P<.001\)) with each additional daily serving of ND breads and grains and a 0.05-kg greater weight change per year (95% CI, 0.01-0.09 kg; \(P=.03\)) for each additional serving of ND fat foods in a multivariate adjusted model, and ND vegetable intake was no longer significantly related to weight change. Intake of ND fruits was not significantly related to weight change in any model tested, and this finding remained when fruit juices were excluded from the analysis.

Total fat and fiber intake were not significantly related (\(P>.05\)) to weight change in any of the analyses (Table 4). Total energy was not independently related to weight change (data not shown). Findings from all regression analyses were similar when repeated using only subjects with complete data for all sociodemographic variables (n=628) (data not shown).

**COMMENT**

Childhood obesity continues to rise around the world.\(^{27}\) In this study, we found that 18% of girls and 23% of boys were at risk of overweight based on the 85th percentile of age- and sex-specific nationally representative BMI growth curves;\(^{32}\) similar to the findings from the Pediatric Nutrition Surveillance System, which reported 22% based on the 85th percentile of weight for height.\(^{3}\) There is little scientific consensus surrounding the dietary etiology of the disease.

Findings between dietary fat intake and body fat have been inconsistent among children, whether fat is considered as a percentage of total energy\(^{38-31}\) or as a food group.\(^{32}\) Data on dietary determinants of obesity among children aged 2 to 5 years are sparse. Two cross-sectional studies among preschool children found no relation between fat as a percentage of total energy and body composition.\(^{35,36}\) In a longitudinal study, children aged...
3 to 7 years who had increased their sum of 7 skinfolds by 1.5 SDs had a higher intake of total grams of fat. In this study, we found a positive and significant relation between fiber consumption and body weight, relative to other aspects of diet. Although fiber intake was not related to weight change, intake of ND breads and grain was the strongest predictor of weight change in this study. Although the percentage of carbohydrate intake has increased alongside the growing prevalence of obesity in recent decades, in our study consumption of breads and grains was associated with weight loss, not weight gain. However, the ND breads and grain groups include foods that differ in macronutrient and fiber content, including macaroni and cheese, spaghetti with tomato sauce, cereals, and rice. Likewise, the ND fat foods group contains many salty and sweet snacks and fried foods that also differ in nutrient content. That total fat and fiber intake were not related to weight change suggests other aspects of the ND breads and grains and ND fat foods groups (eg, energy density and micronutrients) beyond fat and fiber may be responsible for the weight change we observed. In light of inconsistent findings on the relation between weight and dietary fat and carbohydrate, whether measured as nutrients or as foods, more research is clearly needed.

A major strength of our study is its prospective design. Cross-sectional studies considering diet and weight are potentially affected by reverse causation, in which diet is changed because of weight. For example, a mother

### Table 3. Food Group Intakes and Annual Weight Change Among 1379 Children Participating in the North Dakota WIC Program

<table>
<thead>
<tr>
<th>Regression Models</th>
<th>Change in Weight, kg/y, β (SE)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ND breads and grains only (model 1), servings per day</td>
<td>Adjusted for age and sex† -0.18 (0.04) &lt;.001</td>
<td></td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ -0.19 (0.04) &lt;.001</td>
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<tr>
<td></td>
<td>Without energy§ -0.13 (0.03) &lt;.001</td>
<td></td>
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<tr>
<td>ND “fat foods,” only (model 2), servings per day</td>
<td>Adjusted for age and sex† 0.10 (0.02) &lt;.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multivariate adjusted‡ 0.07 (0.02) .003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Without energy§ 0.05 (0.02) .01</td>
<td></td>
</tr>
<tr>
<td>ND fruits only (model 3), servings per day</td>
<td>Adjusted for age and sex† 0.02 (0.03) .54</td>
<td></td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ 0.04 (0.03) .17</td>
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<tr>
<td></td>
<td>Without energy§ 0.03 (0.03) .32</td>
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</tr>
<tr>
<td>ND vegetables only (model 4), servings per day</td>
<td>Adjusted for age and sex† 0.11 (0.04) .005</td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ 0.09 (0.04) .02</td>
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<tr>
<td></td>
<td>Without energy§ 0.06 (0.03) .06</td>
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</tr>
<tr>
<td>All food groups together (model 5)</td>
<td>Adjusted for age and sex† -0.14 (0.04) &lt;.001</td>
<td></td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ -0.16 (0.04) &lt;.001</td>
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<td></td>
<td>Without energy§ -0.15 (0.03) &lt;.001</td>
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### Table 4. Nutrient Intakes and Annual Weight Change Among 1379 Children Participating in the North Dakota WIC Program

<table>
<thead>
<tr>
<th>Regression Models</th>
<th>Change in Weight, kg/y, β (SE)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat only (model 1), % energy per day</td>
<td>Adjusted for age and sex† -0.02 (0.01) .13</td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ -0.02 (0.01) .07</td>
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<td></td>
<td>Without energy§ -0.02 (0.01) .07</td>
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<tr>
<td>Fiber only (model 2), g/d</td>
<td>Adjusted for age and sex† 0.008 (0.02) .66</td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ 0.01 (0.02) .53</td>
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<td></td>
<td>Without energy§ 0.01 (0.02) .52</td>
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</tr>
<tr>
<td>Fat and fiber (model 3)</td>
<td>Fat, % energy per day</td>
<td>Adjusted for age and sex† -0.02 (0.01) .14</td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ -0.02 (0.01) .08</td>
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<td></td>
<td>Without energy§ -0.02 (0.01) .08</td>
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<tr>
<td>Fiber, g/d</td>
<td>Adjusted for age and sex† -0.001 (0.02) .96</td>
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<tr>
<td></td>
<td>Multivariate adjusted‡ 0.001 (0.02) .97</td>
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<tr>
<td></td>
<td>Without energy§ 0.001 (0.02) .97</td>
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### Abbreviations:
- ND food groups: food groups for state-specific use by the North Dakota WIC Program.
- WIC Program: Special Supplemental Nutrition Program for Women, Infants, and Children.
- All models are adjusted for baseline weight and change in height.
- Adjusted for age, sex, and energy.
- Adjusted for age, sex, and energy, as well as sociodemographic variables (ethnicity, residence, level of poverty, maternal education, and birth weight).
- Adjusted for age, sex, and the sociodemographic variables above. Energy is omitted from the model.

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may feed her overweight child a low-fat diet in an attempt to help her child lose weight. Comparison of findings and interpretation of results across studies must therefore consider study design.

An additional strength of our study is that we included all nutrients in one model and all food groups in another model to adjust for potential confounding among dietary predictors. Inconsistent findings from nutritional studies may be due in part to inadequate control of dietary confounders. We found that estimates (and significance) of all individual ND food groups were altered when considered together in multivariate models, suggesting confounding among foods. We built multivariate-adjusted models that included and omitted total energy intake. Energy reflects body size, metabolic efficiency, and physical activity and is normally controlled for in epidemiological research because it is often a confounder of nutrient and/or food intake. Energy can also produce extraneous variation because energy is correlated with most nutrient and food intakes. However, the biological relation between specific foods and/or nutrients and body weight may be mediated through their impact on within-meal or subsequent-meal energy intake; thus, including energy in a model would in effect be overcontrol by including a variable in the causal pathway of this relation. The inclusion or exclusion of total energy mildly altered our findings. These changes may have been due to an effect of confounding, reduction in measurement error, overcontrol, chance, or some other reason.

Our study has several limitations with regard to sample size and dietary assessment. Of the 4328 children available for prospective analysis, multiple exclusions were performed to create an analytic data set, including restricting the time interval between diet and weight change to a range of 6 to 12 months. A shorter or longer time interval might have been more appropriate to observe the relation, or no time interval restriction might have been required at all; more research is needed to examine how time should be handled in prospective studies of diet and weight.

In addition, dietary intake was measured using an FFQ completed by the child’s mother. Mothers may not have complete knowledge of what their children consume in a given day (eg, if the child attends day care), or they may not accurately report serving size or account for food discarded by the child. It is also possible that mothers may have altered their responses to please the interviewer (eg, underreported unhealthy foods). Also, we chose to consider dietary intake only from visit 1 because, although averaging dietary intake from visits 1 and 2 would have provided a more precise estimate of diet, diet changes rapidly during preschool years. However, dietary intake at visit 1 may not be a good representation of intake over the entire follow-up period. Since the FFQ inquires only about intake during the past month, our data do not provide information on total food intake between the 2 visits, which may be more strongly related to weight change during the study period.

Inconsistent findings across studies may also be explained by inadequate adjustment for confounders such as parental BMI, sex, birth weight, physical activity, and television viewing.

Increases in childhood obesity during the past few decades suggest the predominance of environmental factors such as diet in the etiology of obesity. Although many studies among children and adolescents have been performed, most of these studies are cross-sectional in design. Few studies have examined prospectively the etiology of obesity or weight change among children, and no studies have examined prospectively the relation between multiple food and nutrient intakes and weight change among low-income preschool children participating in the North Dakota Special Supplemental Nutrition Program for Women, Infants, and Children. Our results suggest that limiting the intake of fat foods, such as sweet and salty snacks, processed meats, and fried foods, and replacing them with breads and grains could reduce excess weight gain and, hence, the development of childhood obesity.

Race/ethnicity, income, and place of residence have also been associated with obesity. In this study, we were able to adjust for some, but not all, potential confounders, notably parental BMI and television viewing or other indicators of caloric expenditure. In a 4-year longitudinal study of prepubertal children, Maffeis and colleagues found that fat intake was rejected from the final model when parental BMI and television viewing were included. In a case-control study of children aged 8 to 10 years, consumption of high-fat foods was not an independent predictor of obesity, but there was a 38% increase in risk of obesity when high-fat food consumption was combined with low physical activity.

Conclusions

Intake of ND fat foods, but not dietary fat per se, was significantly related to weight gain in this study of preschool children, whereas intake of ND breads and grains, but not dietary fiber per se, was significantly related to weight loss. More research is needed to assess the relative importance of dietary intake (energy input) in tandem with physical activity (energy output) to further elucidate the complex etiology of positive energy balance that results in childhood obesity.

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Corresponding author: P. K. Newby, ScD, MPH, MS, Jean Mayer US Department of Agriculture Human Nutrition Research Center on Aging at Tufts University, 711 Washington St, 9th Floor, Boston, MA 02111 (e-mail: pknewby@post.harvard.edu).

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