

Citation:

Cheng G, Karaolis-Danckert N, Libuda L, Bolzenius K, Remer T, Buyken AE. Relation of dietary glycemic index, glycemic load, and fiber and whole-grain intakes during puberty to the concurrent development of percent body fat and body mass index. *Am J Epidemiol.* 2009 Mar 15;169(6):667-77.

PubMed ID: [19126582](#)

Study Design:

Prospective Cohort Study

Class:

B - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To examine prospectively whether change in dietary glycemic index (GI), glycemic load (GL), fiber intake, or whole-grain intake during puberty is associated with concurrent change in percentage of body fat (%BF) or BMI.

Inclusion Criteria:

- Adolescents who had complete anthropometric and nutritional data around the time of age at takeoff (the earliest mark of puberty onset) from the Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) Study, and information on potential confounders.
- Boys had to possess height measurements from age 6 years onwards and girls from age 5 years onwards

Exclusion Criteria:

Excluded if not included above.

Description of Study Protocol:

Recruitment : The subjects were part of DONALD study and the analyses were based on observations made between 1988 and 2007.

Design: Prospective cohort study

Blinding used (if applicable): not applicable

Intervention (if applicable): not applicable

Statistical Analysis:

- Student's t test and McNemar test were used to compare anthropometric and nutritional intake data around age at takeoff (baseline) and 4 years after age at takeoff (endpoint)
- Linear mixed-effects regression models (PROC MIXED in SAS), including both fixed and random effects were used to construct longitudinal models of either percent body fat or BMI SD score trajectories between baseline and endpoint. Dietary GI, GL, intakes of fiber and whole-grain, and time (age, age²) were the principal fixed effects, and family was included as a random effect. These analyses yielded three regression coefficients: 1) cross-sectional estimate; 2) prospective estimate; and 3) concurrent estimate
- Energy-adjusted residual of dietary GI and fiber intake at baseline were grouped into tertiles for illustration of their cross-sectional association with general characteristics and other nutritional intake data
- All dietary variables were expressed as sex- and age- specific SD scores (mean=0; SD, 1). This approach allowed comparison of all unadjusted models with the respective energy-adjusted models
- The fixed effects of sex, maternal overweight (BMI ≥ 25), maternal education (≥ 12 years of schooling), household smoking status, birth year, full breastfeeding for at least two weeks, meal frequency during the first two years after age at takeoff, and physical activity (active, moderately active, or inactive at age 9 years) were also considered, as well as intakes of energy, protein, and added sugar and dietary GI (in the fiber model) or fiber intake (in the GI and GL models)
- Intake at baseline, intake at baseline X time, and change in intake during the study period were considered
- Multivariate analysis were done on variables that substantially modified the association of the principal dietary variables with percent body fat or BMI SD score in the basic models or significantly predicted the outcome variable or improved the fit statistic (Akaike's Information Criterion)
- All analyzes were performed with the significance level set at $P < 0.05$, except for the analysis of interaction, where $P < 0.1$ was considered significant.

Data Collection Summary:

Timing of Measurements: The weighted 3-day dietary records and anthropometric data included in this study were collected at puberty onset (defined by age at takeoff) and over the subsequent four years, endpoint (1988-2007). Ninety-four percent of the participants had the maximum of five measurements. Details on study protocol was published elsewhere.

Dependent Variables

- Development of percent body fat during puberty was calculated using the equations of Slaughter et al. The skinfold thicknesses were measured from age 6 months onwards.
- BMI during puberty: sex- and age-independent SD scores were calculated using the German Reference curves for BMI. Overweight was defined according to the International Obesity Task Force BMI cutoffs for children, which correspond to an adult BMI of 25.
- The parameter age at takeoff, that is age at minimal height velocity, as estimate using the Preece and Baines formula, was used to define the onset of puberty. All the participants attained peak height velocity within 4 years after puberty onset; so all of them reached an

advanced stage of puberty within the study period.

Independent Variables

- Dietary glycemic index: each carbohydrate-containing food recorded in the dietary record was assigned a dietary glycemic index value (based on glucose as the reference food) according to a standardized procedure. Foods were assigned either to a published glycemic index, the dietary glycemic index of a close match, or the dietary GI calculated from the glycemic indexes of the food's ingredients, using recipes available in the in-house database. The carbohydrate content of the food was the principal consideration when matching a particular food with one listed in the tables
- Glycemic load
- Fiber: dietary fiber content was calculated using the LEBTAB database
- Whole-grain: the intake was estimated by assigning whole-grain content in grams to each carbohydrate-containing food recorded in the dietary record, using both recipes and ingredient information. The mean daily intake of fiber or whole grain was the sum of the fiber or whole-grain content of all foods consumed
- Food consumption was assessed using weighed 3-day dietary records. Mean energy and nutrient intakes were calculated using the in-house nutrient database LEBTAB.

Control Variables

- Gender
- Age
- Physical activity
- Full breastfeeding for at least two weeks
- Maternal BMI and education
- Meal frequency during the first 2 years after age at takeoff

Description of Actual Data Sample:

Initial N: 376

Attrition (final N): 215 (99 boys; 116 girls)

Age: mean of 9.4 years at baseline; 13.4 years at endpoint

Ethnicity: not reported

Other relevant demographics: Boys had takeoff later than girls, with the mean ages at baseline and endpoint of 10.3 to 14.3 years in boys and 8.7 to 12.7 years in girls.

Anthropometrics: Mean BMI SD scores were close to 0 at both baseline and the endpoint, indicating that the participants' BMI was comparable to that of the German reference population at both time points.

Location: Dortmund, Germany

Summary of Results:

Key Findings

- Neither changes in dietary GI, GL, fiber intake, nor whole-grain intake were associated with concurrent changes in %BF throughout puberty; change in %BF: -0.03 (standard error (SE), 0.11) per standard deviation (SD) increase in GI (P=0.8); -0.01 (SE, 0.11) per SD increase in GL (P=0.9); 0.02 (SE, 0.14) per SD increase in fiber intake (P=0.9) and 0.09 (SE, 0.13) per SD increase in whole-grain intake (P=0.5). Similarly, no concurrent associations were observed between these dietary factors and BMI SD scores.
- A cross-sectional association on higher fiber intake with higher levels of percent body fat and BMI SD score was observed; %BF 1.26 (SE, 0.447) per SD increase in fiber intake (P=0.005), and BMI 0.2 (SE, 0.06) per SD increase in fiber intake (P=0.003)
- Among overweight adolescents higher dietary glycemic index at baseline tended to be associated with higher percent of body fat (P=0.05) and BMI SD score (P=0.01) at baseline, while no association was observed for normal-weight adolescents. There was a suggestion of effect modification by overweight status in the concurrent association; P for interaction: 0.03 for percent body fat and 0.08 for BMI SD score

Other Findings

- At baseline, higher energy-adjusted levels of dietary glycemic index tended to be associated with a lower prevalence of overweight, while higher energy-adjusted levels of dietary glycemic index was associated with higher prevalence of overweight (P>0.04)
- At baseline, higher fiber intake was associated with higher paternal educational levels (P>0.03)
- A higher energy-adjusted dietary glycemic index was associated with a higher dietary glycemic load (P<0.006) and higher intake of added sugar (<0.0001), as well as with lower intakes of protein (P=0.009) and fiber (P=0.003)
- However, a higher energy-adjusted fiber intake was related to higher intakes of protein (P=0.006) and whole grain (<0.0001), a lower dietary glycemic index ((P=0.001), and lower intakes of added sugar (P<0.0001), fat (P=0.03), and saturated fatty acids (P=0.0008)

Characteristics of participants at baseline and endpoint

	Baseline mean (SD) or Median (IQR)	Endpoint mean (SD) or Median (IQR)	P value
Anthropometric data			
BMI	17.2 (2.4)	19.9 (3.3)	<0.0001
BMI SD score	0.06 (0.94)	0.12(1.02)	0.5
Sum of 4 skinfolds, mm	37.8 (19.3)	43.4 (23.8)	0.008
Median body fatness, %	16.3 (12.6-22.6)	17.5 (13.7-23.7)	0.1
Overweight (%)	17.2	17.2	1.0
Nutritional data			
Glycemic index	55.7(3.4)	56.5 (3.7)	0.03
Glycemic load, g	120.1 (29.7)	151.8 (42.8)	<0.001
Glycemic load, g/1,000 kcal	71.1(9.2)	73.6 (10.6)	0.009

Carbohydrate intake, % of energy	51.0 (5.7)	52.1 (6.4)	0.06
Added sugar intake, % energy	13.6 (5.6)	14.6 (6.5)	0.09
Fiber intake, g/day	18.2 (5.3)	21.3 (7.0)	<0.0001
Fiber intake, g/1,000 kcal	10.9 (2.7)	10.5 (2.9)	0.1
Whole-grain intake, g/day	62.4 (28.9)	71.6 (34.4)	0.003
Whole-grain intake, g/ 1,000 kcal	34.3 (16.2)	35.4 (15.9)	0.2
Fat intake, % of energy	35.9 (5.3)	34.6 (5.9)	0.02
Saturated fatty acid intake % of energy	15.8 (2.8)	15.0 (3.1)	0.006
Protein intake, % energy	13.1 (2.1)	13.2 (2.1)	0.4
Total energy intake, kcal/day	1,690 (355)	2,061 (503)	<0.0001

Author Conclusion:

Dietary glycemic index, glycemic load, and intakes of fiber and whole grain do not appear to be relevant to the development of percent body fat or BMI during puberty, at least in healthy, free-living adolescents. Therefore, the study does not support the common view that carbohydrate quality may be implicated in the current obesity epidemic.

Reviewer Comments:

Limitations reported by the authors:

- *The design of DONALD study produces a relatively small study sample characterized by participants of high socioeconomic status, who may not resemble an "at-risk" population*
- *Percent body fat was estimated from skinfold-thickness measurements, which are known to be more susceptible to measurement error than are specialized research-based techniques*
- *Glycemic index values had to be calculated for approximately 36% of the carbohydrate-containing foods from the glycemic index values of their ingredients; this is a controversial procedure*
- *Weighed 3-day dietary records may not be representative of habitual dietary intake*
- *Adjustment for physical activity did not explain the findings; however, this is probably attributable to the fact that only a very crude measure of physical activity was available*

Participants selection for this ancillary study was part of a longitudinal study

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	N/A
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	N/A

Validity Questions

1.	Was the research question clearly stated?	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	Was the selection of study subjects/patients free from bias?	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	No
3.	Were study groups comparable?	N/A
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	N/A
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	N/A
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A

3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	Was method of handling withdrawals described?	No
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	No
4.4.	Were reasons for withdrawals similar across groups?	???
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	Was blinding used to prevent introduction of bias?	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A

6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	Were outcomes clearly defined and the measurements valid and reliable?	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	N/A
8.	Was the statistical analysis appropriate for the study design and type of outcome indicators?	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	Are conclusions supported by results with biases and limitations taken into consideration?	Yes
9.1.	Is there a discussion of findings?	Yes

9.2.	Are biases and study limitations identified and discussed?	Yes
10.	Is bias due to study's funding or sponsorship unlikely?	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes

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