Is intake of dietary fat associated with adiposity in children?

Conclusion

Moderate evidence from prospective cohort studies suggests that increased intake of dietary fat is associated with greater adiposity in children. However, there were no studies conducted under isocaloric conditions.

Grade: Moderate

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades,click here.

Evidence Summary Overview

The Dietary Guidelines Advisory Committee (DGAC) conducted a full Nutrition Evidence Library (NEL) search to evaluate the association between dietary fat intake and adiposity in children. Results of this review were supplemented by the findings of prospective studies included in an earlier evidence review conducted by the American Dietetic Association (ADA). This conclusion was based on 28 peer-reviewed articles which addressed the research question, 21 studies from the earlier ADA review; and seven studies from the subsequent NEL review. This included four randomized controlled trials (RCTs) (Caballero, 2003; Hakanen, 2006; Lauer, 1995; Niinikoski, 2007); and 24 longitudinal studies (21 from the ADA review and three from the NEL review) (Alexy, 2004; Johnson, 2008b; Karaolis-Danckert, 2007; Alexy, 1999; Berkey, 2000; Bogaert, 2003; Boulton, 1995; Carruth, 2001; Davison, 2001; Eck, 1992; Francis, 2003; Gazzaniga, 1993; Klesges, 1995; Lee, 2001; Maffeis, 1998; Magarey, 2001; Newby, 2003; Robertson, 1999; Rolland-Cachera, 1995; Scaglioni, 2000; Shea, 1993; Skinner, 2003; Skinner, 2004; Wang, 2003). Fourteen of the studies were conducted in the US.

Of the 24 longitudinal studies, 15 found a positive association between total fat intake or intake of high-fat foods and adiposity in all or a sub-sample of the population studied (Carruth, 2001; Davison, 2001; Eck, 1992; Francis, 2003; Gazzaniga, 1993; Johnson, 2008a; Karaolis-Dankert, 2007; Klesges, 1995; Lee, 2001; Magarey, 2001; Newby, 2003; Robertson, 1999; Skinner, 2003; Skinner, 2004; Wang, 2003). The varied results between studies were a product of using multiple measures of adiposity within the same study, conducting analyses stratified by different variables (e.g., sex, weight status) or dietary fat measured in both absolute terms (total grams) as well as a percent of energy intake. Nine other longitudinal studies found no association between total fat intake and adiposity in children (Alexy, 1999; Alexy, 2004; Berkey, 2000; Bogaert, 2003; Boulton, 1995; Maffeis, 1998; Rolland-Cachera, 1995; Scaglioni, 2000; Shea, 1993). A greater proportion of the studies that found a positive association between dietary fat and adiposity, however, used multiple measures of adiposity, such as skinfold measures and body composition by dual energy X-ray absorptiometry (DEXA), rather than only body mass index (BMI), which provides a poor estimate of actual body fat (Freedman, 2009).

Three of the four RCTs found no association between percent energy from dietary fat and adiposity. In the Special Turku Coronary Risk Factor Intervention Project for Children (STRIP) clinical trial, which tested the effects of a fat-modified diet from seven months of age (Hakanen, 2006) reported less obesity among intervention girls compared with control girls at age 10 years, but no differences for boys; while at age 14 years, Niinikoski et al, (2007) found no difference in obesity between treatment groups, for either males or females. Caballero et al, (2003) reported no change in percent body fat in a three-year school-based nutrition and physical activity intervention among 1,704 Native American children, who were age seven years at baseline. Results showed that percent body fat and BMI did not differ by treatment group at study end. However, children in the intervention group reported lower total energy intake (1,892 vs. 2,157kcal per day)

and percent energy from total fat (31.1% vs. 33.6%) compared with the control group, and percent energy from fat was lower in the intervention school lunches compared to the control schools (28.2% vs. 32.0%). Finally for the Dietary Intervention in Children (DISC) trial (Lauer, 1995), which tested the safety and efficacy of lowering dietary intake of fat and cholesterol in children with elevated low-density lipoprotein cholesterol (LDL-C), analyses of growth patterns showed no difference in BMI, height or weight between the lower-fat, lower saturated fat intervention groups vs. controls. It should be noted, however, that in this trial, great effort was taken to assure that energy intake would not decrease and growth would be maintained, since the goal was to show that lipids could be improved *without a deleterious effect on growth.*

In summary, the combination of evidence from methodologically strong studies in the NEL and ADA reviews supports a conclusion that dietary fat and adiposity in children are positively associated. Methodological differences between studies, however, were significant, especially with respect to dietary assessment procedures, identification of implausible energy intake reports, choice of anthropometrics, and statistical approaches. Despite these methodological differences and limitations, collectively the studies tended to find either a positive association or no significant (NS) association between dietary fat and adiposity with the weight of evidence leaning towards a positive association. Additional prospective studies that assess both the amount and type of fat in relation to changes in childhood adiposity are warranted, however.

Evidence Summary Paragraphs

Randomized Controlled Trials (4)

Caballero et al, 2003 (positive quality) conducted a randomized, controlled, school-based intervention trial (The Pathways Study) in American Indian third graders to evaluate the effectiveness of a school-based, multi-component intervention for reducing percentage body fat. The study included 1,409 children, with a mean age of mean age 7.6±0.6 years at baseline. Attrition rate was 17%. This study tested a four-part intervention: Change in diet (reduction in energy density in school meals via fat reduction and increased fruits and vegetables), increased physical activity, classroom curriculum, family involvement and the primary outcome variable was percent body fat (%BF). Dietary intake was assessed by direct observation of school lunch at baseline and three-year follow-up, and a 24-hour dietary recall was taken at the three-year follow-up. Physical activity was measured by motion sensor and self-reported questionnaire. Body mass index was calculated using measured height and weight and %BF was measured using bioelectric impedance. Results showed that %BF and BMI did not differ between intervention groups at the end of the study. The 24-hour diet recall showed a significantly lower total energy intake (1,892 vs. 2,157kcal per day) and percent of energy from total fat (31.1% vs. 33.6%) in the intervention group compared with the control group. School lunch observation at follow-up was similar in total energy content (683 vs. 688kcal) in the intervention compared with control schools; however, percent energy from fat was lower in the intervention school lunches compare to the control schools (28.2% vs. 32.0%).

Hakanen et al, 2006 (positive quality) analyzed data from a cohort of subjects from Finland to evaluate the impact of nutrition counseling on the prevalence of overweight. This study was a part of the Special Turku Coronary Risk Factor Intervention Project for Children (STRIP), which is a prospective, randomized trial aimed at reducing the exposure of the intervention children to the known risk factors of atherosclerosis. Children were followed from seven months to 10 years of age. Intervention participants were counseled to consume 30% of energy from fat (30-35% between one and two years), with a ratio of 2:1 for unsaturated fat to saturated fat. Height and weight of the children were measured, BMI was calculated, and weight status was determined. Children were classified as overweight or obese if their weight for height was >20% or at least 40% above the mean weight for height of healthy Finnish children, respectively. Analyses were adjusted for study group, birth weight, age, mother's BMI, father's BMI and pubertal status at 10 years. The final sample included 585 children. Results showed that there were continuously fewer overweight girls in the intervention group than in the control group. At the age of 10 years, 10.2% of the intervention girls and 18.8% of the control girls were overweight (P=0.0439), whereas 11.6% of the intervention boys and 12.1% of the control boys were overweight (P=1.00). However, the study group was not a statistically significant predictor of overweight in the model. Mean fat intake levels for the intervention and control groups were not

reported in this manuscript.

Lauer et al, 1995 (positive quality) conducted a six-center RCT in the US to assess the effects of lowering dietary intake of total fat, saturated fat and cholesterol on weight in children. The intervention group received counseling on a diet containing 28% energy from total fat, less than 8% energy from saturated fat, up to 9% energy from polyunsaturated fat, and <75mg/100kcal per day of cholesterol (not to exceed 150mg per day). The intervention was given over a one year period, with follow-up occurring through year three. The control group received usual care. Dietary intake was assessed using three 24-hour recalls. Height and weight were measured to calculate BMI, skinfold thickness was measured and waist and hip circumference were measured. The final sample included 334 children in the intervention group and 329 children in the control group (ages eight to 10 years at baseline). Mean percentage of energy from fat decreased in both groups (33% in the control and 28.6% in the intervention at year three), through more so in the intervention groups. Mean percent energy from saturated fat (10% in the intervention and 12% in the control at year three) and cholesterol (95mg in the intervention and 113mg in the control group at year three) decreased in the intervention group, with little change in the control group. There were NS differences in mean weight, BMI or skinfold thickness between the groups.

Niinikoski et al, 2007 (positive quality) analyzed data from a cohort of subjects from Finland to evaluate the effect of low-saturated fat, low-cholesterol dietary counseling on fat intakes, growth, serum cholesterol values and pubertal development in children and adolescents. This study was a part of the Special Turku Coronary Risk Factor Intervention Project for Children (STRIP). Children were followed from seven months to 14 years of age. Intervention participants were counseled to consume 30% of energy form fat (30-35% between one and two years), with a ratio of 2:1 for unsaturated fat to saturated fat. Height and weight of the children were measured and BMI and weight status were determined. The final sample included 585 children. Intervention children had significantly lower intake of total fat and saturated fat compared to control children (P<0.001), but mean intake levels for each study group are not reported. The two study groups showed no difference in growth, BMI, pubertal development or age at menarche.

Cohort Studies (24)

Alexy U et al, 1999 (positive quality) analyzed data from a prospective cohort study (the DONALD study) in Germany in order to evaluate the effects of dietary intake, including fruit juice intake, on prevalence of obesity over a three year period. Children were followed from age three to five years. Dietary fat intake was determined using data collected from three-day weighed diet records, and weight status was determined using measured height and weight. The final sample includes 205 children (105 boys, 100 girls). Subjects were split into groups based on juice consumption, with low juice consumers consuming 33% of energy from fat, and high juice consumer consuming 38% energy from fat. Results showed that children's BMI correlated positively with energy intake (r=0.18; P<0.05), but not with intake fat (percent of energy intake).

Alexy et al, 2004 (positive quality), analyzed data from a prospective cohort study (the DONALD study) in Germany to evaluate the influence of long-term dietary fat intake on BMI. Children were followed from age two to 18 years. Dietary fat intake was determined using data collected from three-day weighed diet records, and weight status was determined using measured height and weight. The final sample included 228 children (114 boys, 114 girls). A cluster analysis revealed four fat intake patterns: Constant (38% energy from fat), Medium (36% energy from fat), High (40% energy from fat) and Low (32% energy from fat). The clusters did not differ on any of the measured subject characteristics or mean energy intake. However, energy density was lowest in the Low cluster (P<0.0001). The High and Constant clusters consumed more meat/fish/eggs and fats/oils (P<0.0001), while the Low and Medium clusters consumed more fruits/vegetables (P<0.0001). Differences in BMI by fat cluster were not seen at the beginning or end of the study; however, during the study period, mean BMI differed significantly between clusters, with the highest BMI in the low fat intake cluster (0.26(0.70); P<0.05), followed by the Medium cluster (0.11(0.85), High cluster (0.06(0.88) and Constant cluster (-0.30(0.79).

Berkey CS et al, 2000 (positive quality) used data from a prospective cohort study in the US to examine the role of dietary patterns on annual weight changes among preadolescents and adolescents. Subjects were from

the Growing Up Today Study, and were nine to 14 years old and were followed for one year. Dietary fat intake was determined using a food-frequency questionnaire (FFQ), and fat intakes were energy-adjusted. Adiposity was assessed using BMI, based on self-reported height and weight. All models controlled for race/ethnic group, baseline BMI, annual change in height, menstrual history in girls, Tanner stage, and age. The follow factors were entered into the models: Total energy intake, fat intake, fiber intake, number of gym classes per week, hours of physical activity and hours of tv or video games. The final sample included 6,149 girls and 4,620 boys. For both girls and boys, dietary fat intake was not predictive of one-year change in BMI.

Bogaert N et al, 2003 (neutral quality) used data from a prospective cohort study in Australia to examine whether measures of energy intake predict excessive weight gain over time in children. Children were between the ages of six and nine years, and were followed for one year. Dietary fat intake was assessed using a three-day food record. Body mass index z-score was calculated using measured height and weight, and body composition was assessed using bioelectrical impedance analysis. The final sample included 41 children (mean age=8.6 years). Mean fat intake was as follows: 34% for boys under age eight years, 32% for girls under age eight years, 38% for boys over age eight years and 34% for girls over age eight years. There was no relationship between dietary fat intake and BMI z-score change from baseline to one year.

Boulton TJC et al, 1995 (neutral quality) analyzed prospective cohort data from Australia to assess the relationship between food energy and nutrient intake on children's growth. Subjects were participants in the Adelaide Nutrition Study, and were followed from age three months to eight years. Percent energy from fat was determined using seven-day (up to two years), three-day (four years), and four-day (six and eight years) food records. Subjects were split into tertiles of fat intake, <30%, 30-34.9%, and >35% in order to test the association between fat intake and body weight/fatness. Body weight was measured and body fatness was determined by the sum of four skinfold measurements. The final sample included 140 children. Median fat intake was 44% at three months, and declined to 36% at six months, and remained at a similar level until eight years. There were no differences between the fat intake groups in body weight or fatness, except at three months ($P<0.05$), when those in the median fat intake group were heavier and had a higher percent body fat than those in the high fat group.

Carruth BR et al, 2001 (positive quality) used data from a prospective cohort study in the US to examine the association between pre-school children's dietary intake and body composition. Subjects were followed from two months to eight years. Fat intake (g) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. Body composition was measuring using DEXA. The final sample included 53 children. Mean fat intake over time was 30-33% of energy. Higher mean longitudinal intake (24-60 months) of monounsaturated fat was associated with lower body fat at 70 months ($P=0.02$). However, higher mean longitudinal intake of total dietary fat was positively associated with body fat at 70 months ($P=0.02$).

Davison KK et al, 2001 (positive quality) analyzed data from a prospective cohort in the US to assess predictors of change in girls' BMI between ages five and seven years. Children were participants in the Girls Needs Study. Percent energy from fat was determined using three 24-hour recalls from the girls' mother and BMI was calculated using measured height and weight. Regression models included physical activity, dietary intake, family income, parent education, BMI at age five years, family risk of overweight, parental change in BMI, parent physical activity, parents' dietary intake. The final sample included 192 girls. Mean percent energy from fat at five years was 31%. Girls with greater increased in BMI between ages five and seven had a higher percentage of energy from fat at age five years ($P<0.02$), though level of fat intake is not reported.

Eck LH et al, 1992 (neutral quality) examined familial risk of obesity, dietary intake and weight status using data from a group of children in the US. Children were followed for a one-year period from age four to five years. Children were divided into two groups based on parental weight status; the high-risk group had children with one or two overweight parents, while the low-risk group had children with no overweight parents. Percent energy from fat was determined using a FFQ. Children's weight was measured at baseline and a one-year follow-up. The final sample included 187 subjects (92 high-risk, 95 low-risk). The high-risk

group consumed a mean of 34% energy from fat, which was significantly higher than the low-risk group, who consumed a mean of 32% energy from fat (P=0.0004). The relationship between dietary fat intake and one-year weight change was not tested.

Francis LA et al, 2003 (positive quality) analyzed data from a prospective cohort in the US to assess whether consumption of high fat, energy dense snacks were associated with weight status. Children were participants in the Girls Needs Study, and were followed from age five to nine years. Percent energy from fat was determined using three 24-hour recalls from the girls' mother, and BMI was calculated using measured height and weight. The model included tv viewing, snacking while watching TV, snacking frequency, fat intake from high energy density (ED) snack foods, increase in BMI from age five to nine years, while controlling for child BMI and family income. Girls were also divided into groups based on parental weight status. The final sample included 173 girls. Fat intake from energy-dense snacks was significantly positively associated with change in BMI between ages five years and nine years (P<0.05), however, fat intake levels are not reported.

Gazzaniga JM and Burns TL, 1993 (positive quality) analyzed prospective cohort data from the US to examine the relationship between diet composition and body fatness. Subjects were from the Muscatine Coronary Risk Factors Project and were identified for two study groups, either non-obese or obese. Dietary intake data was collected using three 24-hour diet recalls. Height and weight were measured and body composition was determined using skinfold thickness measurements. The final sample included 48 children (25 girls, 23 boys). Percentage body fat was positively correlated with intakes of total (P<0.0001), saturated fat (P<0.01), monounsaturated fat (P<0.0001) and polyunsaturated fat (P<0.01). After adjustment for study group, energy intake, resting energy expenditure (REE) and physical activity, the association remained for total, saturated and monounsaturated fat.

Johnson et al, 2008 (positive quality), conducted a longitudinal, observational cohort study in the United Kingdom to test the relationship between dietary energy density and fat mass in early adolescence. Subjects were from Children in Focus, a sub-sample of the Avon Longitudinal Study of Parents and Children (ALSPAC), and children were followed from age five to age nine years. Dietary intake was assessed using three-day diet diaries, and body fat mass at age nine was measured using DEXA. The final sample included 521 children with five and nine-year data available and 682 children with seven and nine-year data available. Pattern score at ages five and seven years was correlated with dietary energy density (r=0.8), fiber density (r= -0.7) and percentage of energy intake as fat (r= 0.5), and a one SD-increase in pattern score was associated with a 0.15 kg (95% CI: -0.1 to 0.45kg) and a 0.28kg (95% CI: 0.05 to 0.53kg) higher fat mass at age nine years. The adjusted odds of excess adiposity at age nine years for the highest quintile compared to the lowest quintile of dietary pattern score were 2.52 (95% CI: 1.13 to 6.08) at five years of age and 4.18 (95% CI: 2.07 to 9.38) at seven years of age.

Karaolis-Danckert et al, 2007 (positive quality) analyzed data from a prospective cohort study (the DONALD study) in Germany to examine the interaction between rapid weight gain and nutrition in infancy and early childhood and their effect on percent body fat (%BF) trajectories. Children were followed from age two to five years. Dietary fat intake was determined using data collected from three-day weighed diet records. Weight status was determined using measured height and weight and rapid growers were identified as those children with an increase in weight SDS of 0.67 between birth and 24 months of age. The final sample included 249 children (51.4% girls). There was no relationship between a consistently high fat intake at 12 and 18-24 months and rapid weight gain at two years, but rapid growers who had a consistently high fat intake (>35% energy) at both 12 and 18-24 months, did not show the expected physiologic decrease in %BF between two to five years that was seen in rapid growers with an inconsistent or consistently low fat intake at these time points (0.73±0.26 percent per year; P=0.006). Conversely, normal growers with a consistently high fat intake at both 12 and 18-24 months had a significantly greater decrease in %BF between two to five years then when fat intakes were inconsistent or consistently low.

Klesges RC et al, 1995 (positive quality) analyzed data from a prospective cohort study in the US to determine the dietary predictors of weight change in children. Subjects were followed for a two-year period from age three to five years. Percent energy from fat was determined using a FFQ and BMI was calculated

using measured height and weight. Analyses were adjusted for the following factors: baseline BMI, gender, age, family risk ofoverweight, gender by family risk interaction, baseline percent energy as fat, aerobic activity, change in percent energy from fat, change in leisure activity time. The final sample included 146 subjects. Baseline and change in fat intake were related to increases in BMI. A 5% higher percent calorie intake at baseline predicted a 0.168 increase in BMI; a 5% recent increase in fat intake predicted a 0.201 increase in BMI.

Lee Y et al, 2001 (positive quality) analyzed data from a prospective cohort in the US to compare the diet quality and weight status of girls consuming diets meeting the recommendation of the American Academy of Pediatrics for dietary fat with those consuming >30% energy from fat. Children were participants in the Girls Needs Study, and were followed from age five to seven years. Percent energy from fat was determined using three 24-hour recalls from the girls' mother. Body mass index was calculated using measured height and weight and body fatness was measured using triceps and subscapular skinfold thickness measures. Subjects were divided into two groups: High-fat was >30% fat (55% of subjects) and low-fat was <30% fat (45% of subjects). The final sample included 192 girls. Girls on high-fat and low-fat diets did not differ inBMI at either five or seven years of age, but change in BMI between five and seven years was greater for girls consuming high-fat diets, even when controlling for BMI at five years ($P<0.05$). Change in the sum of skinfold thickness measured was also higher in the high-fat group compared to the low-fat group, such that girls consuming a higher fat diet at age five years had greater body fatness increases between age five and seven years ($P<0.05$).

Maffeis C et al, 1998 (positive quality) analyzed prospective cohort data from Italy to assess the relationship between diet, body composition, and adiposity in children. Subjects were followed for a four-year period, starting when children were eight years of age. Dietary intake data was collected through an interview with mothers and children regarding their usual weekly meal and snack intakes and food intake at school was assessed by reviewing the school's menu with the children and asking which meals were consumed. Weight and height were measured and BMI was calculated. Analyses were controlled for age, gender, energy intake, percent energy intake as fat,protein, carbohydrate, parents' BMI, TV viewing time, and time spent on vigorous physical activity. The final sample included 112 children (mean age at baseline=8.6 years). Children's mean percent energy intake from fat was 32% at baseline. Mutivariate analyses showed that dietary fat intake was not associated with children's BMI at age 12 years.

Magarey AM, et al 2001 (positive quality) analyzed data from a prospective cohort study from Australia to investigate the relationship between food energy and macronutrient intake and body fatness. Children were participants in the Adelaide Nutrition Study and were followed from age two to age 15 years. Fat intake (g) and percent energy from fat were determined using three-day (ages two, four and six years) and four-day (ages eight, 11, 13, 15 years) food records. Body mass index was calculated using measured height and weight and measures of subscapular skinfold thickness were taken. Analyses were adjusted for total energy intake, sex and parental body fat. The final sample included 243 subjects. Mean percent energy from fat decreased from 38% at two years, to 35% at ages four to 13 years, to 33-34% at 15 years. At six years, fat intake was positively associated with BMI-SDS at eight years ($P<0.05$). Fat intake at two years was positively associated with subscapular skinfold thickness at 15 years ($P<0.05$). Fat intake was NS associated with triceps skinfold thickness at any time point, nor was it associated with BMI or subscapular skinfold thickness at any other time-point.

Newby PK et al, 2003 (positive quality) analyzed prospective cohort data from the US to examine the relationship between dietary composition and weight change in children. Children were participants in the North Dakota Women, Infants and Children program (WIC), and were followed for two visits ranging from six to 12 months apart. Dietary intake data was collected using a semiquantitative FFQ, from which percent energy from fat was determine, and food groups were determined based on the North Dakota WIC program (referred to as ND food groups). Height and weight were measured. Analyses were adjusted for baseline weight, change in height during the time interval, age, sex, total energy intake, sociodemographic covariates (birth weight, maternal education, race/ethnicity, residence, poverty level). The final sample included 1,379 children (mean age; three years). Mean fat intake among this cohort of children was 34% of energy. Results showed a 0.07kg greater weight change per year for each additional serving of ND fat foods (95% CI

0.03-0.11kg; P=0.003). When all food groups were considered in a single model, each additional serving of ND fat foods was associated with a 0.05kg greater weight change per year (95% CI 0.01-0.09kg; P=0.03). However, total fat intake (percent energy from fat) was NS related to weight change. The authors concluded that high fat foods, but not total dietary fat per se, significantly predicted weight gain over a one-year period.

Robertson SM et al, 1999 (neutral quality) analyzed prospective cohort data from the US to compare diet between a group of children who had increased their sum of seven skinfold measures by 1.5 SD or more since the previous year and those who had not. Subjects were three or four year old children enrolled in a four-year longitudinal study. Food intake was assessed through observation during the school day by trained observers, and reported by parents for the time periods before and after school, and percent energy from fat was determined. Body fatness was determined by taking the sum of seven skinfold thickness measures. Children were grouped by change in adipose tissue over the previous year, those who were 1.5 SD above the mean for the previous year's value were study subjects and control subjects were matched to the study subjects on gender, ethnicity and age. The final sample included 48 subjects (15 study subjects, 33 controls; mean age; three years at baseline). Mean dietary fat intake was 37% (75g) for study subjects and 34% (58g) for control subjects. A significant difference between study subjects and control subjects was found for fat grams(P=0.02), while the difference between groups for percent energy for fat was borderline significant (P=0.06).

Rolland-Cachera MF et al, 1995 (positive quality) analyzed prospective cohort data from France to test the relationship between early nutrient intake and adiposity development. Children were followed from two to eight years of age. Dietary interviews were conducted to ascertain percent energy from fat and adiposity was assessed via BMI, which was calculated using measured height and weight, and skinfold thickness measurements. The final sample included 112 children. The relationship between dietary fat intake at age two was not associated with adiposity at age eight years.

Scaglioni S et al, 2000 (positive quality) analyzed prospective cohort data from Italy to examine the influence of macronutrient intake in early on the development of overweight in children. Subjects were assessed at birth, one year and five years of age. Dietary intake data was collected via FFQ. Body weight was measured and BMI was calculated to determine children's weight status. Adjustments were made for infant's gender, weight and length at birth and one year of age and parental age. Dietary fat intake at age one years was not associated with children's weight status at age five years and was approximately 35% of energy.

Shea S et al, 1993 (positive quality) analyzed prospective cohort data from the US to determine whether a moderately reduced fat diet affects growth in preschool children. Children were aged three to four years at baseline, and were followed for a mean of two years. Dietary intake was assessed using four 24-hour recalls and three FFQs administered to mothers over the one year baseline period. Height and weight were measured and BMI was calculated. Adjustments were made for age at the first 24-hour recall, sex, race/ethnicity and total energy intake. The final sample included 215 children (105 boys, 110 girls). Mean total fat intake was 32.5% based on the 24-hour recall data and 33.4% based on the FFQ data. Children were split into quintiles of dietary fat intake, I (27%), II (30%), III (32%), IV (35%) and V (38%). There were no differences in height, weight, or BMI across quintiles of total fat or saturated fat intake and there were no differences in growth parameters between children consuming <30% energy as fat compared to those consuming >30% energy from fat.

Skinner JD et al, 2003 (positive quality) used data from a prospective cohort study in the US to examine the association between pre-school children's dietary intake and body composition. Subjects were followed from two months to eight years. Fat intake (grams) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. Body composition was measuring using DEXA. The following variables were included in the model: mother's percent body fat, mother's BMI, father's BMI, gender, sedentary activity, dietary intake (calcium, energy, protein, carbohydrate, fat, saturated fat, polyunsaturated fat, monounsaturated fat). The final sample included 52 children. Mean intake was 59g for boys, 54g for girls, or 32% of energy. Polyunsaturated fat was inversely associated with children's body fat (P<0.02). However, total dietary fat and saturated fat intake were positively associated with body fat

(P<0.01 and P<0.003).

Skinner JD et al, 2004 (positive quality) used data from a prospective cohort study in the US to examine the association between pre-school children's dietary intake and body composition. Subjects were followed from two months to eight years. Fat intake (grams) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. Body mass index was calculated using measured height and weight. The final sample included 70 children (37 boys, 33 girls). The following variables were included in the model: Gender, birth weight, breastfeeding duration, age that cereal was introduced, BMI at age two years, estimated AR, longitudinal energy and macronutrient intake, perception of child as a picky eater at age six years, number of foods liked at age eight years, screen time, and dietary variety score. The final sample included 70 children. Average longitudinal percent energy from fat was 32%. Dietary fat (longitudinal intake in grams and longitudinal percent energy from fat) was positively related to BMI at eight years (P<0.01).

Wang Y et al, 2003 (positive quality) analyzed prospective cohort data from China to examine the influence of dietary intake on adiposity in children. Children ages six to 13 years at baseline were participants in the China Health and Nutrition Survey and were followed over a two-year period. Dietary intake data were collected for three consecutive days via 24-hour recalls and was reported by mothers for children under 10 years. Measures of weight, height, triceps skinfold thickness and arm circumference were taken. The final sample included 95 children (51 boys, 44 girls; mean age at baseline; nine years). Subjects were overweight at baseline and follow-up consumed significantly more energy from fat (24%) compared to those who were not overweight (19%). Overweight children who had a high-fat diet (>30% energy from fat) were more likely to remain overweight at follow-up (P<0.01).

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Author, Year, Study Design, Class, Rating	Participants and Study Description	Methods	Outcomes
Alexy U, Sichert-Hellert W et al, 1999 Study Design: Prospective Cohort Study Class: B Rating:	N=205 (105 boys, 100 girls). Age: Three to five years. Location: Germany. Dortmund Nutritional and Anthropometric Longitudinal Designed Study (DONALD), 1990-1997.	Children were followed from age three to five years and annual assessments were taken. Dietary fat intake was determined using data collected from three-day weighed diet records. Weight status was determined using measured height and weight.	Results showed that children's BMI correlated positively with energy intake (r=0.18; P<0.05), but not with intake fat (percent of energy intake).
Alexy U, Sichert-Hellert W et al, 2004 Study Design: Prospective Cohort Study	N=228; enrolled at birth. Subjects with at least 10 diet records were included. Age: two to 18 years. Location: Germany.	Weight measured annually with electronic scale (SECA); Height measured annually with a stadiometer; BMI and BMI z-score calculated.	Between clusters, there were significant differences in Energy Density, as well as percent E from all macronutrients: Energy Density by diet

Class: B Rating:	Dortmund Nutritional Anthropometric Longitudinally Designed Study (DONALD): 1985-2002.	Dietary intake assessed by annual three-day weighed diet (completed for younger children by parent). Dietary Energy Density (DED) calculated as kJ per gram, including all beverages.	cluster: 3.7 (0.4), Low fat intake cluster 4.0 (0.4), Medium fat intake 4.1 (0.4), High fat intake cluster 4.1 (0.3), Constant cluster 3.9 (0.4), All subjects. No differences in BMI z-score were found between clusters of diet intake either at the first or last examination per subject. Mean BMI during the study period differed significantly, with the highest BMI in the low fat, low energy density cluster.
Berkey CS, Rockett HRH, et al 2000 Study Design: Prospective Cohort Study Class: B Rating:	N=6,149 girls and 4,620 boys. Age: Nine to 14 years at baseline. Location: United States. Growing Up Today Study (children of nurses from the Nurses' Health Study II).	Children from all over US returned questionnaires in the fall of 1996 and a year later in 1997. Each child self-reported his or her current height and weight. Dietary intake was assessed using an FFQ.	For both girls and boys, dietary fat intake was not predictive of one-year Δ in BMI.
Bogaert N, Steinbeck KS et al 2003 Study Design: Cohort design (prospective) Class: B Rating:	N=41 (21 boys, 20 girls). Age: Six to nine years. Location: Australia.	Children were followed for one year. Dietary fat intake was assessed using a three-day food record. BMI z-score was calculated using measured height and weight and body composition was assessed using bioelectrical impedance analysis.	There was no relationship between dietary fat intake and BMI z-score Δ from baseline to one year.

Boulton TJC & Magarey AM. 1995 Study Design: Cohort study Class: B Rating:	N=140 Location: Australia. Adelaide Nutrition Study (ANS).	Subjects were were followed from age three months to eight years. Percent energy from fat was determined using seven-day (up to two years), three-day (four years), and four-day (six and eight years) food records. Subjects were split into tertiles of fat intake, <30%, 30-34.9% and >35% in order to test the association between fat intake and body weight/fatness. Body weight was measured and body fatness was determined by the sum of four skinfold measurements.	There were no differences between the fat intake groups in body weight or fatness, except at three months ($P<0.05$), when those in the median fat intake group were heavier and had a higher percent BF than those in the high fat group.
Caballero et al 2003 Study Design: Randomized Controlled Trial Class: A Rating:	N=1,704 American Indian school children in grade three at baseline. Mean ageL 7.6 (±0.6) years. Duration: Three years. Location: United States. The Pathways Study.	This study tested a four-part intervention: Δ in diet; increased physical activity; classroom curriculum; family involvement. Diet assessment by direct observation of school lunch at baseline and three-year follow-up; 24-hour diet recall at three year follow-up only. Weight measured by digital scale; Height measured by stadiometer; BMI calculated. Percent body fat measured by bioelectric impedance.	Percent Body Fat measures (as well as BMI and skin-fold measures) did not differ between intervention groups at the end of the study. The 24-hour diet recall showed significantly ↓ percent energy from total fat (31.1% vs. 33.6%) in the intervention group, compared with the control group. School lunch observation at follow-up was similar in mean energy content in intervention compared with control schools, however mean percent E from fat in the intervention school lunches was ↓ than in control schools (28.2% vs. 32.0%).

Carruth BR, Skinner JD 2001 Study Design: Cohort Study Class: B Rating: 	N=53 pre-school children (29 boys, 24 girls). Location: United States.	Subjects were followed from two months to eight years. Fat intake (g) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. Body composition was measuring using DEXA.	↑ mean longitudinal intake (24-60 months) of MUFA was associated with ↓ body fat at 70 months (P=0.02). However, ↑ mean longitudinal intake of total dietary fat was positively associated with body fat at 70 months (P=0.02).
Davison and Birch, 2001 IJO Study Design: Longitudinal cohort Class: B Rating: 	N=192 girls. Age: 5.4±0.4 years at baseline. Location: United States	Girls were followed from age five to seven years. Girls' dietary intake was assessed using three, 24-hour recalls. BMI was calculated using measured height and weight.	Mean percentage energy from fat was 31%. Girls with greater ↑ in BMI between ages five and seven had a higher percentage of energy from fat at age five years (P<0.02), though level of fat associated with ↑ BMI was not reported.
Eck LH, Klesges RC, et al. 1992 Study Design: Cohort Study Class: B Rating: 	N=187 (92 high-risk, 95 low risk). Age: Three to four years at baseline. Location: United States.	Children were followed for a one-year period from age four to five years. Children were divided into two groups based on parental weight status; the high-risk group had children with one or two overweight parents, while the low-risk group had children with no overweight parents. Percent energy from fat was determined using a FFQ. Children's weight was measured at baseline and a one-year follow-up.	High-risk group consumed a mean of 34% energy from fat, which was significantly ↑ than the low-risk group, who consumed a mean of 32% energy from fat (P=0.0004). Relationship between dietary fat intake and one-year weight Δ was not tested.

Francis LA, Lee Y, Birch LL 2003 Study Design: cohort study Class: B Rating:	N=173 girls. Age: 5.4 years at baseline. Location: United States.	Girls were followed from age five (time one; mean 5.4 years [summer before kindergarten), seven (time two) and nine (time three) years. Percent energy from fat was determined using three 24-hour recalls from the girls' mother. BMI was calculated using measured height and weight.	Higher fat intakes from energy dense snack foods in girls from overweight families (4.6 vs. 3.0g). Fat consumed from energy-dense snacks was significantly correlated with BMI (five to seven years) (R^2=0.26).
Gazzaniga JM & Burns TL. 1993 Study Design: Prospective Cohort Study Class: B Rating:	N=48 (23 boys, 25 girls). Age: Nine to 11 years. Location: United States. Muscatine Coronary Risk Factors Project.	Dietary intake data was collected using three 24-hour diet recalls. Height and weight were measured and body composition was determined using skinfold thickness measurements.	Percentage body fat was positively correlated with intakes of total (P<0.0001), SFA (P<0.01), MUFA (P<0.0001) and PUFA (P<0.01). After adjustment for study group, energy intake, REE and physical activity, the association remained for total, SFA and MUFA.
Hakanen M, Lagstrom H et al, 2006 Study Design: Randomized Controlled Trial Class: A Rating:	N=1,062. Age: Five months at recruitment; Seven months at randomization-baseline; 10 years at this follow-up study. Duration: 15 or more years (ongoing as of 2010). Location: Finland. The Special Turku Coronary Risk Factor Intervention Project for Children (STRIP).	Children were randomly assigned to either a dietary counseling intervention aimed at reducing SFA and cholesterol intake, or to usual care. Dietary intake goal for intervention group: Total Fat 30-35% E age one to two years; Total Fat 30% E after two years, with PUFA:MUFA:SFA ratio of 1:1:1. Weight and height (or length) measured at one to three-month intervals to age two-year; then semi-annually thereafter; BMI and BMI z-score	After two years of age, there were continuously fewer overweight girls in the intervention group vs. the control group. At 10 years of age, 10.2% of intervention girls and 18.8% of control girls were overweight (P=0.0439), whereas 11.6% of intervention boys and 12.1% of control boys were overweight (P=1.00). Only three intervention children were obese at some age point vs. 14 control children. Intervention children had

		BMI and BMI Z-score calculated. Dietary Intake assessed by semi-annual three or four-day food records (completed for younger children by parent or caregiver).	significantly ↓ total fat and SFA intakes (both P<0.001) and ↑ PRO and CHO intakes (both P<0.001), compared with control children.
Johnson et al 2008; Am J Clin Nutr Study Design: Prospective Cohort Study Class: B Rating: 	N=521 at five and nine years. N=682 at seven and nine years. Location: United Kingdom. Avon Longitudinal Study of Parents and Children (ALSPAC).	Reduced rank regression (RRR) derived a dietary pattern with the use of dietary energy density (DED), dietary fiber density (FD) and dietary fat intake (percent Energy) as intermediate variables. Low Pattern Score=higher intake fruits and vegetables; high fiber bread and cereal; boiled or baked potatoes (healthy pattern). High Pattern Score=more chips, chocolate, candy, low fiber bread and cereal, cakes, biscuits, processed meats (less healthy pattern). Fat mass measured at age nine years by DEXA. Dietary Intake assessed by three-day diet diaries at age five and seven years (completed for child by parent).	Pattern score at five and seven years was correlated with DED (r=0.8); FD (r= -0.7); and percent energy from fat (r=0.5). An ↑ of one SD of pattern score at ages five and seven years, respectively was associated with a 0.15kg and a 0.28kg ↑ fat mass at nine years after controlling for confounders. The adjusted odds of excess adiposity at nine years for children in the (less healthy) Quartile (Q)5 (higher DED, lower dietary fiber, higher dietary fat) vs. the (healthier) Q1 (lower DED, higher dietary fiber, lower dietary fat) of diet pattern score at ages five and seven years, respectively, were 2.52 and 4.18 (both statistically significant). The percent energy from fat was significantly ↑ for Q5 (40%), compared with Q1 (32%). Percent Energy from Fat (age five years): • Q1=33±4; Q2=35±4 • Q3=36±4; Q4=37±4 • Q5=40±4 (P<0.001). Percent Energy from Fat (age seven years):

			• Q1=34±4; Q2=35±4 • Q3=36±4; Q4=38±4 • Q5=40±4 (P<0.001). Thus, higher pattern scores, which included significantly ↑ percent E from dietary fat, were prospectively associated with ↑ fat mass and ↑ odds of adiposity at age nine years. Children in Q5 of pattern score at seven years were more than four times more likely to have excess adiposity at nine years vs. Q1.
Karaolis-Danckert et al. 2007 Study Design: Longitudinally open-cohort study Class: B Rating:	N=249 infants. Birth cohort: Enrolled full term infants, with weight appropriate for gestational age. This report: Data on subjects for three year period, between two and five years of age. Location: Germany. Dortmund Nutritional Anthropometric Longitudinally Designed Study (DONALD): 1985-2002.	Weight measured annually with an electronic scale (SECA). Length measured annually to age two years; then standing height, with stadiometer. BMI and BMI z-score calculated. Dietary Intake assessed by annual three-day weighed diet (completed for younger children by parent).	Rapid growers who had a consistently ↑ fat intake (>35% energy) at both 12 and 18-24 months, did not show the expected physiologic ↓ in percent BF between two and five years seen in those rapid growers with an inconsistent or consistently ↓ fat intake at these time points (P=0.006). Conversely, among normal growers, a consistently ↑ fat intake at both 12 and 18-24 months resulted in a greater ↓ in percent BF between two and five years than when fat intakes were inconsistent or consistently ↓.
Klesges RC, Klesges LM et al, 1995 Study Design: Cohort Study Class: B	N=146 pre-school children. Age: Two to five years at baseline. Location: United States.	Subjects were followed for a two-year period from age three years to five years. Measurements of height and weight were taken on parents and children by trained research assistants.	Baseline intakes of kcal from fat as well as (Δ) ↓ in fat intake were related to ↓ in BMI. Higher baseline levels of percent of calories as fat were associated with greater ↑ in BMI (0.168kg/m^2 per

Rating:		Dietary intake was assessed with FFQ revised for use with children.	5%) as were recent ↑ (year two to year three) in the percentage of intake as fat (0.201kg/m^2 per 5% Δ).
Lauer RM, Obarzanek E et al, 1995 Study Design: Randomized Controlled Trial Class: A Rating:	N=663, randomized into intervention group (N=334) and usual care group (N=329). N=334 (179 boys and 155 girls) were assigned to the intervention group and N=329 (183 boys and 146 girls) to the usual care group. Mean age: 9.7 years for boys and 9.0 years for girls. Duration: Three or more years (ongoing six-center trial as of 1995). Location: United States. The Dietary Intervention Study in Children (DISC).	Children were randomly assigned to one of two treatment groups: Behavioral intervention or usual care aimed at promoting adherence to a diet providing 28% energy from total fat, <8% from SFA, up to 9% from PUFA and <75mg per 4,200kJ (1,000kcal) per day of cholesterol (not to exceed 150mg per day). Primary efficacy measure was the mean LDL-C level at three years; measured height and weight and BMI were secondary outcomes. Dietary Intake assessed by three non-consecutive 24-hour dietary recalls within two weeks of clinic.	Mean percentage of energy from fat ↓ in both groups (33% in control and 28.6% in intervention at year three), through more so in the intervention groups. Mean percent energy from SFA (10% in intervention and 12% in control at year three) and cholesterol (95mg in intervention and 113mg in control group at year three) ↓ in the intervention group, with little Δ in the control group. There were NS differences in mean weight, BMI or skinfold thickness between the groups.
Lee Y, Mitchell DC, et al, 2001 Study Design: Prospective Cohort Study Class: B Rating:	N=192 girls. Age: Five years at baseline. Location: United States.	Children were were followed from age five to age seven years. Percent energy from fat was determined using three 24-hour recalls from the girls' mother. BMI was calculated using measured height and weight and body fatness was measured using triceps and subscapular skinfold thickness measures. Subjects were divided into two groups: • High-fat (HF) >30% fat (55% of subjects)	45% of girls consumed diets with <30% of energy from fat (LF) (N=84) vs. HF (>30% kcal) (N=108). Girls on HF and LF diets did not differ in BMI at either five or seven years of age, but Δ in BMI between five and seven years was greater for girls consuming HF diets, even when controlling for BMI at five years (P<0.05). Δ in sum of skinfold thickness measured was also ↑ in HF group compared to LF group, such that girls consuming a

		• Low-fat (LF) <30% fat (45% of subjects).	higher fat diet at age five years had higher body fatness ↑ between age five and seven years (P<0.05).
Maffeis C, Talamini G, et al 1998 long Study Design: Prospective Cohort Study Class: B Rating:	N=112. Age: 8.7±1.1 years at baseline and 12.3±1.0 years at follow-up. Location: Italy.	Subjects were followed for a four-year period, starting when children were eight years of age. Dietary intake data was collected through an interview with mothers and children regarding their usual weekly meal and snack intakes. Food intake at school was assessed by reviewing the school's menu with the children and asking which meals were consumed. Weight and height were measured and BMI was calculated.	Children's mean percent energy intake from fat was 32% at baseline. Mutivariate analyses showed that dietary fat intake was not associated with children's BMI at age 12 years.
Magarey AM, Daniels LA, et al 2001 Study Design: Cohort Study Class: B Rating:	N=243. Location: Australia. Adelaide Nutrition Study (ANS).	Subjects in ANS were first selected by birth order from healthy term infants born at Queen Victoria Hospital, Adelaide, South Australia between November 1975 and June 1976 and were followed from age two years to 15 years. Anthropometric measurements of height, BMI and triceps (TC) and subscapular (SS) skinfold thicknesses were taken at at each age two, annually from age four to eight and at 11, 13 and 15 years of age. Dietary intake was estimated from a three-day weighed food record at	Fat intake was NS associated with triceps skinfold thickness at any time point, nor was it associated with BMI or subscapular skinfold thickness at any other time-point.

		ages two, four and six years and a four-day weighed food record at eight, 11, 13 and 15 years of age. Energy/nutrient intakes were expressed as kJ per g per day.	
Newby PK, Peterson KE et al, 2003 Study Design: Cohort study (longitudinal, prospective) Class: B Rating: 	N=1,379. Age: Two to five years. Location: United States. The Dietary Intervention Study in Children (DISC).	North Dakota WIC participants with two visits six to 12 months apart (if >two visits, the study used the first two). Measurement of height and weight. Dietary Intake assessed by a FFQ. Dietary intake examined specific WIC target foods using the following *"Food group scheme*": Breads and grains, fat foods, fruits, vegetables.	Multivariate, energy-adjusted models showed a 0.07kg greater weight Δ per year (CI 0.03 to 0.11kg, P=0.003) for each additional serving of fat foods. Fat foods included: Ice cream, mayonnaise, potato chips, cookies, cakes, pie, chocolate, hot dogs, bologna, butter, margarine, fried chicken, fried fish, sausage, donuts, sweet rolls and fries. In all groups as a single model (multivariate adjusted): A 0.05kg greater weight Δ per year (CI 0.01 to 0.09kg, P=0.03) for each additional serving of fat foods. Total fat was not related to weight Δ.
Niinikoski H, Lagstrom H et al, 2007 Study Design: Prospective Cohort Study Class: B Rating: 	N=1,062. Age: Five months at recruitment; Seven months at randomization-baseline; 14 years at this follow-up study. Duration: 15 or more years (ongoing as of 2010). Location: Finland. The Special Turku	Children were randomly assigned to either a dietary counseling intervention aimed at reducing SFA and cholesterol intake, or to usual care. Dietary intake goal for intervention group: • Total Fat 30-35%E age one to two years • Total Fat 30%E	SFA intakes were lower (P<0.001) in the intervention than in control children during the 14 years. However, at 14 years of age, BMI, overall growth and pubertal development did not differ significantly between intervention and control groups.

	Coronary Risk Factor Intervention Project for Children (STRIP).	after two years, with PUFA:MUFA:SFA ratio of 1:1:1. Weight and height (or length) measured at one to three-month intervals to age two-year; then semi-annually thereafter; BMI and BMI z-score calculated. Dietary Intake assessed by semi-annual three or four-day food records (completed for younger children by parent or caregiver).	
Robertson SM. et al. 1999 Study Design: Longitudinal case-control Class: B Rating:	N=48 (15 study subjects, 33 controls). Mean age: Three years at baseline. Location: United States.	Subjects were three or four-year old children enrolled in a four-year longitudinal study. Food intake was assessed through observation during the school day by trained observers and reported by parents for the time periods before/after school and percent energy from fat was determined. Body fatness was determined by taking the sum of seven skinfold thickness measures. Children were grouped by Δ in adipose tissue over the previous year. Those who were 1.5 SD above the mean for the previous year's value were study subjects and control subjects were matched to the study subjects on gender, ethnicity, and age.	Mean dietary fat intake was 37% (75g) for study subjects and 34% (58g) for control subjects. A significant difference between study subjects and control subjects was found for fat grams (P=0.02), while the difference between groups for percent energy for fat was borderline significant (P=0.06).

Rolland-Cachera MF, Deheeger M et al, 1995 Study Design: Cohort Study Class: B Rating:	N=112. Age: Two years at baseline. Location: France.	Children were followed from two to eight years of age. At ages six and eight years, the dietitian visited the families at home. Dietary interviews and anthropometric measurements were recorded by the same well-trained investigator in all subjects. A 45-minute "dietary history" was used to assess nutrient intake at age two, then verified at the end of the interview with a 24-hour recall.	Relationship between dietary fat intake at age two years was not associated with adiposity at age eight years.
Scaglioni S, Agostoni C, et al, 2000 Study Design: Cohort study. Class: B Rating:	N=147 (80 boys and 67 girls). Age: One year at baseline; Five years at follow-up. Location: Italy.	Subjects were assessed at birth, one year and five years of age. Dietary intake data was collected via FFQ. Body weight was measured and BMI calculated to determine children's weight status.	Fat intake (percent of total kcal) was comparable and slightly lower than 35% in both groups Dietary fat intake at age one year was not associated with children's weight status at age five years and was ~35% of energy.
Shea S, Basch CE et al, 1993 Study Design: Cohort Study Class: B Rating:	N=215 children (105 males, 110 females). Age: Three to four years at baseline. Location: United States	Families were recruited during 1985 and 1986 and were followed for at least 12 months, had at least five measures of height/weight and completed the first four 24-hour recalls and the first FFQ. Stature: Height, weight and BMI at baseline, calculated as means of all measurements occurring between first and fourth diet recalls in the first year of the study.	Mean total fat intake was 32.5% of total calories based on 24-hour recalls and 33.4% of total calories based on the FFQ. Children were split into quintiles of dietary fat intake, I (27%), II (30%), III (32%), IV (35%) and V (38%). No differences in height, weight or BMI across quintiles of total fat or SFA intake. N[illegible]

		Food Intake: Determined by four 24-hour recalls and three FFQs.	No differences in growth parameters between children consuming <30% energy as fat, compared to those consuming >30% energy from fat.
Skinner JD, Bounds W et al 2003 Study Design: Cohort study (longitudinal, prospective) Class: B Rating:	N=52 (25 boys, 27 girls). Mean age:8.1±0.1 years. Location: United States.	Subjects were followed from two months to eight years. Fat intake (g) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. Body composition was measuring using DEXA.	PUFA was inversely associated with children's body fat (P<0.02). Total dietary fat and SFA intake were positively associated with body fat (P<0.01 and P<0.003).
Skinner JD, Bounds W et al 2004 Study Design: Cohort (longitudinal, prospective) Class: B Rating:	N=70 boys and girls . Location: United States.	Subjects were followed from two months to eight years. Fat intake (g) and percent energy from fat was determined using three-day diet records taken six times between age two months and eight years. BMI was calculated using measured height and weight.	Average longitudinal percent energy from fat was 32%. Dietary fat [longitudinal intake (g) and longitudinal percent energy from fat] was positively related to BMI at eight years (P<0.01).
Wang Y, Ge K, Popkin BM, 2003 Study Design: Cohort (longitudinal, prospective) Class: B Rating:	N=95. Mean age: Nine years at baseline. Location: China. China Health and Nutrition Survey.	Children ages six to 13 years at baseline and were followed over a two-year period. Dietary intake data were collected for three consecutive days via 24-hour recalls and reported by mothers for children <10 years. Measures of weight, height, triceps skinfold thickness and arm	Subjects were overweight at baseline and follow-up consumed significantly ↑ energy from fat (24%), compared to those who were not overweight (19%). Overweight children who had a high-fat diet (>30% energy from fat) were more likely to remain overweight at follow-up (P<0.01).

		circumference were taken.	

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Alexy U, Sichert-Hellert W, Kersting M, Manz F, Schoch G. Fruit juice consumption and the prevalence of obesity and short stature in German preschool children: results of the DONALD study. *Journal of Pediatric Gastroenterology & Nutrition* 1999; 29: 343-249.

Alexy U, Sichert-Hellert W, Kersting M, Schultze-Pawlitschko V. Pattern of long-term fat intake and BMI during childhood and adolescence--results of the DONALD Study. *Int J Obes Relat Metab Disord.* 2004 Oct; 28(10): 1,203-1,209.

Berkey CS, Rockett HRH, Field AE, Gillman MW, Frazier AL, Camargo CA, Colditz GA. Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics* 2000; 105: 1-9.

Bogaert N, Steinbeck KS, Baur LA, Brock K, Bermingham MA. Food, activity and family--environmental vs biochemical predictors of weight gain in children. *Eur J Clin Nutr*. 2003 Oct;57(10):1242-9.

Boulton TJC & Magarey AM. Effects of differences in dietary fat on growth, energy and nutrient intake from infancy to eight years of age. *Acta Paediatrica* 1995; 84: 146-50. *Adelaide Nutrition Study.*

Caballero B, Clay T, Davis SM, Ethelbah B, Rock BH, Lohman T, Norman J, Story M, Stone EJ, Stephenson L, Stevens J; Pathways Study Research Group.Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren. *Am J Clin Nutr*. 2003 Nov;78(5):1030-8.

Carruth BR, Skinner JD. The role of dietary calcium and other nutrient in moderating body fat in preschool children. *International Journal of Obesity* 2001; 25: 559-566.

Davison KK, Birch LL. Child and parent characteristics as predictors of change in girls' body mass index. *Int J Obes* 2001; 25: 1,834-1,842.

Eck LH, Klesges RC, et al. Children at familial risk for obesity: an examination of dietary intake, physical activity and weight status. *International Journal of Obesity* 1992: 16: 71-78.

Francis LA, Lee Y, Birch LL. Parental weight status and girls' television viewing, snacking, and body mass indexes. *Obes Res* 2003;11:143-51.

Gazzaniga JM & Burns TL. Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *Am J Clin Nutr* 1993; 58: 21-8.

Hakanen M, Lagström H, Kaitosaari T, Niinikoski H, Näntö-Salonen K, Jokinen E, Sillanmäki L, Viikari J, Rönnemaa T, Simell O. Development of overweight in an atherosclerosis prevention trial starting in early childhood. The STRIP study. *Int J Obes* (Lond). 2006 Apr; 30 (4): 618-626.

Johnson L, Mander AP, Jones LR, Emmett PM, Jebb SA. Energy-dense, low-fiber, high-fat dietary pattern is associated with increased fatness in childhood. *Am J Clin Nutr.* 2008 Apr;87(4):846-54.

Karaolis-Danckert N, Günther AL, Kroke A, Hornberg C, Buyken AE. How early dietary factors modify the effect of rapid weight gain in infancy on subsequent body-composition development in term children whose birth weight was appropriate for gestational age. *Am J Clin Nutr.* 2007 ;86(6):1700-8.

Klesges RC, Klesges LM, Eck LH, Shelton ML. A longitudinal analysis of accelerated weight gain in preschool children. *Pediatrics* 1995; 95: 126-130.

Lauer RM, Obarzanek E, Kwiterovich PO, Kimm SYS, Hunsberger SA, Barton BA, Van Horn L, Stevens VJ, Lasser NL, Robson AM, Franklin FA, Simonson-Morton DG. Efficacy and safety of lowering dietary intake of fat and cholesterol in children with elevated low-density lipoprotein cholesterol. *JAMA.* 1995; 273: 1,429-1,435.

Lee Y, Mitchell DC, Smickiklas-Wright H, Birch LL. Diet quality, nutrient intake, weight status, and feeding environments of girls meeting or exceeding recommendations for total dietary fat of the American Academy of Pediatrics. *Pediatrics* 2001; 107: e95.

Maffeis C, Talamini G, Tato L. Influence of diet, physical activity and parents' obesity on children's adiposity: A four-year longitudinal study. *Int J Obes.* 1998; 22: 758-764.

Magarey AM, Daniels LA, Boulton TJC, Cockington RA. Does fat intake predict adiposity in healthy children and adolescents aged 2-15 y? A longitudinal analysis. *Eur J Clin Nutr* 2001; 55: 471-481.

Newby PK, Peterson KE, Berkey CS, Leppert J, Willett WC, Colditz GA. Dietary composition and weight change among low-income preschool children. *Arch Pediatr Adolesc Med.* August 2003;157(8):759-64.

Niinikoski H, Lagström H, Jokinen E, Siltala M, Rönnemaa T, Viikari J, Raitakari OT, Jula A, Marniemi J, Näntö-Salonen K, Simell O. Impact of repeated dietary counseling between infancy and 14 years of age on dietary intakes and serum lipids and lipoproteins: The STRIP study. *Circulation.* 2007 Aug 28; 116 (9): 1,032-1,040.

Robertson SM, Cullen KW, Baranowski J, Baranowski T, Hu S, de Moor C. Factors related to adiposity among children aged 3 to 7 years. *J Am Diet Assoc* 1999; 99: 938-943.

Rolland-Cachera MF, Deheeger M, Akrout M, Bellisle F. Influence of macronutrients on adiposity development: a follow up study of nutrition and growth from 10 months to 8 years of age. Int *J Obes Relat Metab Disord* 1995; 19: 573-578.

Scaglioni S, Agostoni C, De Notaris R, Radaelli G, Radice N, Valenti M, Giovannini M, Riva E. Early macronutrient intake and overweight at five years of age. *Int J Obes.* 2000; 24: 777-781.

Shea S, Basch CE, Stein AD, Contento IR, Irigoyen M, Zybert P. Is there a relationship between dietary fat and stature or growth in children three to five years of age? *Pediatrics.* 1993; 92: 579-586. *Columbia University Study of Childhood Activity and Nutrition.*

Skinner JD, Bounds W, Carruth BR, Ziegler P. Longitudinal calcium intake is negatively related to children's body fat indexes. *J Am Diet Assoc*. 2003 Dec;103(12):1626-31.

Skinner JD, Bounds W, Carruth BR, Morris M, Ziegler P. Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2-8 y. *Int J Obes Relat Metab Disord*. 2004 Apr;28(4):476-82.

Wang Y, Ge K, Popkin BM. Why do some overweight children remain overweight, whereas others do not? *Public Health Nutr.* 2003 Sep;6(6):549-58.