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The Relationship Between BMI and Intake of Energy and Fat in Australian Youth: A Secondary Analysis of the National Nutrition Survey 1995

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Abstract

Objectives: To explore the association between overweight or obesity and the intake of energy and fat in Australian children and adolescents.

Design: Secondary data analyses were conducted on children and adolescents participating in the Australian National Nutrition Survey in 1995. Dietary information had been obtained by 24-hour dietary recalls conducted on participants by qualified nutritionists. The participants were regrouped into age groups of seven to nine, ten to 12 and 13-15. The participants' body mass index (BMI) was categorised into non-overweight, overweight and obesity using a new international standard definition.

Subjects: Boys and girls aged seven to 15 years (n 1581).

Setting: Data had been collected by household interview (61.4% response rate) for children and adolescents across all states and territories of Australia.

Main outcome measures: Body mass index derived from measured height and weight. Intakes of total energy, fat and percentage of energy from fat.

Statistical analyses: Mean nutrient intakes for each body mass index category were compared using a one-way ANOVA (analysis of variance) in boys and girls.

Results: The average intake of energy and fat in obese boys aged 13 to 15 years was lower than that in non-overweight boys (P = 0.03). The percentage of energy from fat in obese girls aged 13 to 15 years was also lower than that of non-overweight girls (P = 0.006). However, after considering the effect of multiple testing (i.e. a Bonferroni correction), these differences were not statistically significant.

Conclusion: This study did not provide evidence that there were statistically significant differences in the average intake of energy and fat, and percentage of energy from fat between non-overweight and overweight or obese boys and girls. Although they provide many logistic challenges, longitudinal studies that also include measures of energy expenditure, would help to better define the relationship between energy intake and overweight or obesity in children and adolescents.

Keywords: nutrient intake; BMI; overweight; obesity; children; adolescents.

Introduction

The prevalence of overweight or obesity in children and adolescents has increased in recent decades in developed countries (1,2). Magarey, Daniels and Boulton (3) revealed in 2001 that overall 20% of boys and 21.5% of girls aged seven to 15 years in Australia were overweight or obese, while in 1985 the figures were 10.7% of boys and 11.8% of girls in the same age group. This study (3) is based on a secondary data analysis of the 1995 Australian National Nutrition Survey (NNS) data using new international BMI cut-off points for overweight and obesity in children and adolescents (4). The most significant long-term consequence of childhood obesity is its persistence into adulthood, along with the numerous associated health risks (5). Overweight or obese children and adolescents are at higher risk for long-term mortality and morbidity, as well as for psychological problems (5,6). Therefore, both effective prevention and treatment for overweight or obese children are essential.

There have been a number of risk factors identified as contributing to the prevalence of overweight and obesity in children. The increased prevalence of overweight and obesity in Australian children may be attributed to decreasing activity, increasing food energy intake, or a combination of these factors (3). Some studies have suggested that the increased incidence

of obesity could be the result of an increase in the consumption of foods that are high in fat (7,8). There is no published data on the relationship between overweight or obesity, and dietary intake or physical activity, in Australian children and adolescents.

The 1995 NNS provides the most current nationally representative data on nutrient intake and height and weight measurement of Australians. The selected highlights from the NNS showed the average energy intake of adults classified as overweight or obese was lower than that recorded for adults whose weight was in the acceptable range (9). In this study, we examined the data from the NNS for Australian children and adolescents to explore the association between overweight or obesity and the intake of energy and fat, and percentage of energy from fat (% Fat), in Australian youth.

Methods

Subjects and dietary intake methodology

The NNS was conducted between February 1995 and March 1996 using a sub-sample of respondents in the National Health Survey. The survey provides detailed data on food and nutrient intake, food habits and attitudes, and selected physical measurements for people aged two years or more (10). Selected participants of the National Health Survey gave consent to be re-contacted for the NNS. Sampling for the NNS was based on a multi-stage sample of households, including urban and rural areas across all States and Territories of Australia. Two people per household in urban areas and three per household in rural areas were randomly selected to take part. A total of 22 562 individuals aged two years or over was selected from the NHS to participate in the NNS and 17 326 individuals initially agreed to participate. Finally, 13 858 individuals completed the NNS with an overall response rate of 61.4%. The proportion of individuals who initially agreed to participate in the NNS among the groups four to seven years, eight to 1 1 years and 12 to 15 years was 86.4%, 84.8% and 80.4%, respectively (10). A total of 1585 children and adolescents aged seven to 15 years completed the NNS, of which 1581 (844 boys, 737 girls) had data for both dietary intake, and measurements of weight and height.

Participants aged seven to 15 years were selected to be the target population in this analysis in order to make the data comparable with another Australian National Dietary Survey of school children aged 10 to 15 years in 1985 (11), as well as to explore the relationship between BMI and nutrient intake in younger Australian children.

In the NNS, total daily food and beverage intake was collected based on a 24-hour recall of food items consumed on the day prior to interview. The 24-hour food intakes reported by participants were converted into nutrient intakes using a nutrient composition database developed by the Australian and New Zealand Food Authority (ANZFA). The primary source of information for foods in this database was the Composition of Foods Australia(10). Total intake of each nutrient and percentage of energy from fat for the 24-hour recall period were available as pre-calculated variables on the NNS data set.

Data on the participants were regrouped into seven to nine, ten to 12 and 13 to 15 age groups. These divisions enabled the relationship of children (seven to nine years) to be clearly separated from adolescents (13 to 15 years). The ten to 12- years-old group is regarded as a transition group between childhood and adolescence. The analyses presented in this study apply to three variables for which there is a close relationship with overweight or obesity, namely intake of total energy, intake of fat and percentage of energy from fat (% Fat) (3,7,8). Data on energy underreporting were also analysed to determine if they impacted on the association. To identify an underreporter, the ratio of energy intake to basal metabolic rate (EI:BMR) was used. This was a pre-calculated variable on the NNS data set for children and adolescents aged 10 to 15 years in this study. A cut-off of 0.90 in the EI:BMR ratio was used for assessing those underreporting (12). The proportion of underreporters in the overweight and obese ca tegories was calculated for ten to 15 years of age. The associations between

intake of energy, fat and % Fat with overweight and obesity were recalculated excluding underreporters.

Body mass index (BMI) in children and adolescents

In the NNS, portable digittal scales (Tanita model 1597) were used for the measurement of weight, and a stadiometer and the stretch stature method was used to measure height. Weight and height were measured with subjects wearing light clothes and without shoes. The precision of weight and height measurement was to the nearest 0.1 kg and 0.1 cm, respectively (10). BMI was a pre-calculated variable in the NNS data set. Recently developed criteria for overweight and obesity among children and adolescents provide BMI values for males and females aged two to 18 years in six-month age brackets (4). The new international standard definition was applied to the BMJ categorisation. For each age, the cut-off point at the midyear value was applied (eg, for those aged 7 years, the cutoff at 7.5 years was used). Children and adolescents aged seven to 15 years were categorised into groups of non-overweight, overweight, obese and combined overweight/obese for this study.

Data management and analysis

The SPSS for Windows statistical package (SPSS Inc, Chicago, SPSS for Windows, version 10.0 2000) was used for all NNS data management and statistical analyses. The NNS data were used with the permission from Australian Bureau of Statistics. All data files were obtained from the 1995 NNS Confidentialised Unit Record File (CURF) (13). Before all analyses, a subject weighting factor (e.g. main survey weight in the NNS CURF) was applied to account for a person's chance of selection in the sample from their region with adjustment for age, sex, part of State level and other factors that affected response. The normality of all continuous variables was tested. Square root transformation was applied to those variables, which were not normally distributed. The prevalence of each overweight or obesity classification, and corresponding intake of nutrients, was tabulated separately by gender and by age. The linear association of mean nutrient intake and age was explored by a chi-square test for trend. To establish the as sociation between overweight or obesity and nutrient intake a one-way ANOVA was used. These analyses were followed with Tukey's procedure for multiple comparisons to compare pairwise differences between means of nutrient intake in one BMI group with another. A series of stratified analyses was performed to explore associations between overweight or obesity and nutrient intake by age and by gender. An ANOVA was used to determine these relationships. Statistical significance was defined at an overall $P < 0.05$ level (two-tailed). However, individual critical P values were defined using Bonferroni corrections for multiple comparisons.

Results

Proportion of overweight or obese children and adolescents and nutrient intake

The ranges of prevalence of overweight combined with obesity for seven to years, ten to 12 years and 13 to 15 years of age were 15.6%, 19.8% and 22.5% in boys, and 25.1%, 25.8% and 15.6% in girls, respectively. The percentage of energy from fat (% Fat) remained similar by gender at about 33% for all age groups (Table 1). Average energy and fat intake increased with age in boys ($P < 0.01$) while there was no significant linear association between the intake of energy and fat and age in girls.

Comparison of energy intake in the NNS 1995 with earlier data

When comparing the energy intake in Australian children and adolescents aged 10 to 15 years based on the data in 1985 (11), the results suggested that the average increase of energy intake

in the ten-year interval ranged from 0.6 to 2.2 MJ in boys and from 0.2 to 1.3 MJ in girls (Table 2). Generally the percentage increase was greater in younger children.

Association between BMI and nutrient intakes

The results of a one-way ANOVA did not provide evidence that there were statistically significant differences in average intakes of energy and fat and of % Fat between non-overweight and overweight or obese boys and girls aged seven to years and ten to 12 years, respectively (Tables 3 and Table 4). However, the energy intake of obese boys aged 13 to 15 years was lower when compared with their non-overweight counterparts (P = 0.03, Table 3) while % Fat in obese girls aged 13 to 15 years was also lower than that of non-overweight girls (P = 0.006, Table 4). When adjusting for multiple testing using Bonferroni corrections, these above differences were no longer statistically significant.

Underreporting

Overall 7.0% of boys and 11.1% of girls were identified as underreporting their energy intake. Further calculation showed that 16.2% of overweight boys and girls, and 31.4% of obese boys and girls were underreporters whereas only 6.0% in the non-overweight category of boys and girls underreported. There were statistically significant differences in the proportion of underreporters between non-overweight and overweight children, and between non-overweight and obese children and adolescents aged ten to 15 years in the NNS. However, when the energy underreporters were excluded from this study, there was still no association found between intake of energy and fat and of % Fat with overweight or obesity in children and adolescents.

Discussion

The study reported here focused on exploring the relationship between overweight or obesity, and the intake of energy and fat, by looking at the dietary records for children and adolescents. There were no significant differences in the intake of energy and fat and % Fat between overweight or obese and non-overweight boys and girls. This study showed significant difference in underreporting between non-overweight and overweight/obese children and adolescents. However, removal of the underreporters did not impact on the lack of association. It was not possible to explore the gender differences in underreporting in this analysis due to the small numbers in some groups. There were very limited studies that addressed the characteristics of underreporters in children and adolescents in the NNS data. Giskes et al. revealed that a higher proportion of boys from low-income households under-reported their energy intakes compared with boys in higher income households (14).

The selected highlights from the NNS revealed that a higher proportion of overweight and obese men and women were on special diets, including both weight-reduction and fat-modified diets than that of non-overweight counterparts (7). When comparing the status of 'special way of eating' (e.g. vegetarian, weight-reduction diet, diabetic diet, fat modified diet, to low blood fat diets and others) among children and adolescents in the NNS in this study, the result suggested that the proportion of 'no special way of eating' remained constant at about 87% for boys and girls in all age groups. However, a higher proportion of older obese girls consumed fat-modified diets compared with older non-overweight girls while there was no significant difference between overweight or obese and non-overweight boys on such diets. Some body image studies have revealed even primary school girls are more likely to have low body satisfaction and prefer a thinner body compared with boys (15-19), this study did not found the significan ce in younger girls.

A number of previous epidemiological studies have also examined the relationship between energy intake and percentage of energy from fat, and obesity in children, however the results of these previous studies were inconsistent. Obarzanek et al (20) revealed that body

fatness is related to energy intake and expenditure in both black and white girls aged nine to ten years, while other studies have shown no relationship (21,22). Also, some studies (23,24) have reported a significant relationship between obesity and percent of energy from fat, while in the current study no such relationship was established.

In general, excess weight is the outcome of a long-term imbalance of energy intake from food and of energy expenditure for the maintenance of normal physiological processes and for physical activity. Simply, it is the consequence of an energy imbalance where energy intake exceeds energy output (25). When comparing energy intake in this study with that in another Australian national survey in 1985 (11), the results revealed that the mean energy intake of Australia children and adolescents aged ten to 15 years has increased by 0.6 to 2.2 MJ (i.e. increased by 5% to 25%) in boys and 0.2 to 1.3 MJ (i.e. increased by 3% to 17%) in girls, in the 10-year interval. Another comparison of this study with the data of Magarey et al. (26) in the late 1980s among eight-year-old Australian children, also suggested that the mean daily energy intake increased by 1.8 MJ (increased by 24.3%) in boys and 1.6 MJ (increased by 24.6%) in girls.

There is increasing evidence to suggest that physical activity among the youth in the US has declined over the past decades, thus, the increasing levels of obese children may be the direct result of declining physical activity levels of obese children in American society (27). An Australian study on the comparison of physical activity in children from 1985 to 1997 suggested that there was a decrease in physical activity over this period (28). Unfortunately, no data on physical activity of Australian youth under 15 years was collected in the NNS data. Therefore, further studies of the relationship between physical activity and overweight or obesity in children and adolescents would be needed to explore these issues related to childhood obesity in Australia.

As the NNS was a cross-sectional survey, it does not provide any longitudinal data on food and energy intake and trends in the relationship to BMI. There are also other limitations of this study, which make definitive conclusions difficult. The response rate of the NNS (61.4%) was low compared with other Australian national surveys. This may be a consequence of asking people to participate in two surveys, i.e. the National Health Survey as well as the NNS. The non-respondents were most likely to come from households where parents were unmarried, unemployed or earned high incomes (29). The dietary patterns of these non-respondents may affect the degree to which this study is representative. Additionally, the data collection instrument, a 24-hour dietary recall, particularly in relation to within-person variation and self-reported dietary data, also has limitations regarding individual dietary intake. Furthermore, the low sample size in the categories of overweight or obesity would be associated with low statis tical power and hence may prevent some relationships between dietary intake and overweight or obesity in children and adolescents from attaining statistical significance. Finally, there may also be some reporting bias of food and nutrient intakes related to age and gender. For example, some studies have suggested that the bias of underestimation of energy increase with age in adolescents (30,31). However, there is no report addressing such issues for the NNS data set.

Overall, in spite of the limitations in the NNS data, it is the most current, comprehensive and nationally representative data available on the food and nutrient intakes of Australians. Longitudinal studies would also help to better define the relationship between energy intake and overweight or obesity in youth as well as enabling conclusions on causality to be drawn. However, in such studies it would also be necessary to include measures of energy expenditure. The common measures of energy expenditure, i.e. use of a diary, or a pedometer, in such large-scale surveys have limited validation in the younger age groups. Therefore, measuring energy expenditure, in itself, provides many challenges.

In conclusion, the present study provides further baseline data on the relationship between BMI categories and intake of energy and fat in Australian children and adolescents based on a representative national nutrition survey in Australia. The results did not provide

evidence that there were significant differences in average intake of energy and fat and % Fat between non-overweight and overweight or obese boys and girls.

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TABLE 1. BMI (body mass index) categories and nutrient intakes of girls and boys aged seven to 15 years

		Boys	
	7-9 years	**10-12 years**	**13-15 years**
Number	301	268	275
BMI categories (a) (%)			
Overweight	10.6	16.1	16.0
Obese	5.0	3.7	6.5
Overweight combined obese	15.6	19.8	22.5
Nutrient intakes (b)			
% Fat (c)			
Mean	32.9	33.2	33.5
95% CI (d)	(32.2,33.6)	(32.4,34.0)	(32.7,34.3)
Energy (MJ)			
Geometric mean	8.8	10.1	11.5
95%CI	(8.5,9.1)	(9.7,10.5)	(11.0,12.0)
Fat (g) Geometric mean	78.5	89.9	103.0
95%CI	(75.1,81.9)	(85.3,94.5)	(97.7,108.4)
		Girls	
	7-9 years	**10-12 years**	**13-15 years**
Number	251	268	218
BMI categories (a) (%)			
Overweight	17.9	20.9	11.0
Obese	7.2	4.9	4.6
Overweight combined obese	25.1	25.8	15.6
Nutrient intakes (b)			
% Fat (c)			
Mean	34.0	33.3	32.8
95% CI (d)	(33.2,34.8)	(32.4,34.2)	(31.8,33.8)
Energy (MJ)			
Geometric mean	7.7	8.3	8.1
95%CI	(7.4,8.0)	(8.0,8.7)	(7.8,8.5)
Fat (g) Geometric mean	70.8	74.8	71.8
95%CI	(67.2,74.5)	(70.9,78.9)	(67.4,76.4)

a) BMI categories were defined using the international standard (4)
b) Pre-calculated values and refer to mean daily intake based on 24-hour recall in the NNS
c) % Fat, percentage of energy from fat
d) 95%CI = mean [+ or -] 1.96 * SE

TABLE 2. The comparison of energy intake (MJ) in Australian children and adolescents aged ten to 15 years based on the published data in 1985 (11) and the NNS 1995

	1985 (MJ)	**1995 (MJ)**	**Increased by MJ**	**%**
Boys				
10 years	8.14	9.96	1.92	23.9
11 years	8.52	10.27	1.75	20.5
12 years	8.84	11.04	2.20	24.9
13 years	9.87	11.88	2.01	20.4
14 years	10.75	11.45	0.70	6.5
15 years	11.71	12.30	0.59	5.0
Girls				
10 years	7.03	8.15	1.12	15.9
11 years	7.40	8.66	1.26	17.0
12 years	7.69	8.84	1.15	14.9
13 years	7.66	8.26	1.08	14.1
14 years	7.92	8.15	0.23	2.90
15 years	7.60	8.85	1.25	16.4

TABLE 3. Comparison of energy and fat intake and percentage energy from fat between different BMI categories in Australian boys using one-way ANOVA

			Boys		
	Non-overweight	**Overweight**	**Obesity**	**F**	**P**
7-9 years					
n	254	32	15		
% Fat (a)					
Mean	32.9	33.0	32.8	0.01	0.99
(95%CI) (b)	(32.1,33.4)	(30.6,35.4)	(30.2,35.4)		
Energy (MJ)	8.8	9.2	9.2	0.48	0.62
Geometric mean (95% CI)	(8.4,9.1)	(8.4,10.0)	(8.0,10.5)		
Fat (g)					
Geometric mean	77.9	81.4	81.5	0.26	0.77
(95%CI)	(74.2,81.7)	(71.5,92.1)	(67.4,96.9)		
10-12 years					
n	215	43	10		
% Fat					
Mean	33.2	33.0	32.8	0.03	0.97
(95%CI)	(32.3,34.1)	(30.8,35.2)	(29.3,36.3)		
Energy (MJ)					
Geometric mean	10.0	9.8	8.5	1.41	0.25
95%CI	(9.8,10.7)	(9.0,10.8)	(6.1,11.3)		
Fat (g)					
Geometric mean	90.9	88.3	74.7	0.96	0.38
95%CI	(85.9,96.0)	(76.3,101.2)	(52.8,100.4)		
13-15 years					
n	213	44	18		
% Fat					
Mean	33.3	34.4	33.0	0.51	0.60
(95%CI)	(32.3,34.2)	32.5,36.3	31.1,35.0		
Energy (MJ)					
Geometric mean	11.7	11.2	9.2(c)	3.29	0.04
(95%CI)	(11.2,12.3)	10.0,12.5	7.4,11.1		
Fat (g)					
Geometric mean	104.8	103.4	81.4	2.50	0.08
(95%CI)	(98.7,111.1)	91.3,116.1	65.0,99.7		

a) % Fat, percentage of energy from fat
b) 95%CI = mean (+ or -) 1.96*SE
c) $P < 0.05$ comparing with non-overweight boys

TABLE 4. Comparison of energy and fat intake and percentage energy from fat between different BMI categories in Australian girls using one-way ANOVA

			Girls		
	Non-overweight	**Overweight**	**Obesity**	**F**	**P**
7-9 years					
n	188	45	18		
% Fat (a)					
Mean	34.1	33.0	35.1	0.79	0.46
(95%CI)(b)	(33.2,35.0)	(31.0,35.1)	(31.7,38.5)		
Energy (MJ)	7.5	8.1	8.9	3.32	0.04
Geometric mean (95%CI)	(7.2,7.9)	(7.4,8.9)	(7.4,10.6)		
Fat (g)					
Geometric mean (95%CI)	69.3 (65.4,73.3)	72.1 (63.2,81.6)	84.8 (65.9,106.1)	2.17	0.12
10-12 years					
n	199	56	13		
% Fat					
Mean (95%CI)	33.0 (32.0,34.0)	33.8 (31.6,36.0)	36.0 (30.5,41.6)	1.13	0.32
Energy (MJ)					
Geometric mean (95%CI)	8.4 (8.1,8.8)	7.9 (7.1,8.8)	9.0 (7.6,10.5)	1.09	0.34
Fat (g)					
Geometric mean (95%CI)	74.8 (70.5,79.2)	72.4 (62.9,82.6)	87.2 (65.5,111.9)	0.99	0.37
13-15 years					
n	184	24	10		
% Fat					
Mean (95%CI)	33.3 (32.3,34.3)	32.4 (28.7,36.1)	25.9 (c) (20.5,31.3)	4.77	0.01
Energy (MJ)					
Geometric mean (95%CI)	8.3 (7.9, 8.7)	6.9 (6.0, 7.8)	8.6 (6.7, 10.8)	2.77	0.07
Fat (g)					
Geometric mean (95%CI)	74.2 (69.3,79.2)	59.0 (49.5,69.4)	61.5 (38.8,89.6)	2.89	0.06

a)% Fat, percentage of energy from fat
b)95% CI = mean [+ or -] 1.96*SE
c)P < 0.01 comparing with non-overweight girls