Meal patterns and childhood obesity

Bernadeta Patro and Hania Szajewska

Department of Paediatrics, The Medical University of Warsaw, Warsaw, Poland

Correspondence to Hania Szajewska, MD, Department of Paediatrics, The Medical University of Warsaw, Dzialdowska 1, Warsaw, Poland
Tel: +48 22 452 33 09; fax: +48 22 452 33 09; e-mail: hania@ipgate.pl

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Purpose of review

To summarize the literature concerning the relationship between meal patterns and childhood obesity. Literature searches of *MEDLINE* and the *Cochrane Library* were performed in October 2009 for studies published in the last 18–24 months.

Recent findings

Available data indicate that not only meal composition but also some components that form a specific meal pattern can promote childhood obesity. Reducing meal and snack frequency, especially breakfast skipping, seem to be such components. On the contrary, limiting consumption of sugar-sweetened beverages and snack foods (defined as high-fat, energy-dense foods) may be associated with a reduction in the risk of obesity.

Summary

There is still much to be learned about specific aspects of the association between meal patterns and obesity. Although current knowledge does not allow one to draw any definitive conclusions, it provides a solid basis for further research.

Keywords

breakfast, diet, eating, overweight

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Introduction

Worldwide, the frequency of obesity has risen dramatically in recent years, stimulating research to identify factors that affect energy balance. Although it is clear that genetic factors are important in determining body weight, other factors such as behavioral and environmental may also contribute. It has been suggested that alterations in meal patterns could be one of the responsible factors. Although there is no standard definition of a meal, it could be defined as 'a certain amount of food eaten at a specific time'. In defining 'meal pattern', one should consider not only the composition of a particular meal but also the meal frequency, source of the meal (home, school, restaurant, etc.), number of eating episodes, and meal time span. Eating occasions can be divided into breakfast, other main meals (lunch, dinner), and snacks. Although the meal is universal, clearly meal patterns vary considerably among societies, cultural and social classes, age groups, and individuals. Obviously, over time, meal patterns of different populations undergo alterations. These changes in children's eating habits may be associated with current trends toward overweight and obesity. The purpose of this review is to summarize the literature on some aspects of meal patterns and overweight and obesity in the pediatric population, primarily in developed countries. *MEDLINE* and the *Cochrane Library* were searched in October 2009 for key articles published primarily in the last 18–24 months that assessed the effect of meal patterns on body weight in children and adolescents. The reference lists of identified studies and key review articles, including previously published reviews, were also searched. Only English-language publications were included.

Breakfast consumption

Breakfast is commonly considered a key component of a healthy diet. However, it is estimated that a substantial number of children and adolescents (8–12 and 20–30%, respectively) skip breakfast. The risk of skipping breakfast is higher in female students, children from lower socioeconomic backgrounds, and older children and adolescents [1]. Recognized barriers to eating breakfast include a lack of time, not feeling hungry in the morning, and weight concerns [2]. In recent years, a number of studies aimed at determining the health effects of breakfast skipping in children and adolescents have been published [3•,4•,5,6•–8•]. These were cross-sectional or cohort studies. Participants were children and adolescents from European countries such as Croatia, Czech Republic, Denmark, Finland, Greece, The Netherlands, Norway, Portugal, Spain, Sweden, and the UK. The participants were aged 7–21 years and were from different socioeconomic backgrounds. A definition of breakfast was provided in only some of the studies. Although almost all of the studies provided criteria for breakfast skipping, there were variations in those criteria. In some

studies, the authors used 'breakfast frequency' (number of days with eaten breakfast) to define breakfast skipping. In other studies, breakfast skipping was defined according to the number of breakfasts eaten or skipped weekly. The definition of overweight/obesity also varied across the studies. Collectively, the data from observational studies carried out in Europe have consistently shown that children and adolescents who eat breakfast have a reduced risk of becoming overweight or obese and have a lower BMI compared with those who skip breakfast. These results are in line with previous results from cross-sectional studies and several, small, prospective cohort studies carried out outside of Europe [9•,10,11]. They are also in line with the results of a systematic review published in 2005 [12]. The authors of this review found that although breakfast eaters consumed more daily calories, they were less likely to be overweight. However, it was noted that not all studies associated breakfast skipping with being overweight.

Meal frequency

Data from the cross-sectional Bogalusa Heart Study [13] show a tendency toward a decrease in the number of eating episodes among 10-year-old children ($n = 1584$) in the USA between 1973–1974 and 1993–1994. During this period, total eating episodes decreased from 6.6 to 5.2 ($P < 0.0001$). According to the American Dietetic Association (ADA) evidence analysis from 2006, based on the available data (the authors assessed the results from a total of five observational studies – six separate analyses: one longitudinal study, two nationally representative cross-sectional studies, and three other cross-sectional studies), it is not likely that the frequency of eating is associated with adiposity [14]. However, the authors emphasized difficulty in comparing results of identified studies due to various definitions of a meal and an eating episode. The conclusion from the ADA analysis is in contrast to the results of almost all later published studies, which demonstrate an inverse association between meal frequency and the prevalence of overweight and obesity in children. All identified studies were observational ones: two longitudinal studies [15,16•], one cohort study [17], and five cross-sectional studies [6•,18•,19•,20,21]. Participating children, aged 3–19 years, were mostly European, but some were from South America (Brazil) and North America (USA). The most probable reasons for the discrepancy between the results of the ADA analysis and those of later studies are differences in populations, a lack of universal definitions for meals and overweight/obesity, and a lack of statistical power. However, these recent findings on meal frequency and its relation to body composition are consistent with those from similar studies conducted in adults [21]. Possible biological mechanisms that may explain the observed association between the number of meals and the prevalence of overweight and obesity are increased daily thermogenesis after consumption of more meals, different levels of physical activity between nibblers and gorgers, and the influence of the number of meals on insulin metabolism [21].

Beverage consumption

An increase in the consumption of sugar-sweetened beverages (SSBs) over the past several decades is considered to be related to the risk of overweight and obesity [22•]. However, the evidence supporting this relationship is not so clear. There are a large number of studies and reviews on this topic, but the conclusions raised are inconsistent. We identified a total of nine reviews that had evaluated the link between SSBs consumption and weight gain. The earliest ones (published from 2005 to 2007) found the evidence to be 'not conclusive', 'equivocal', 'probable' or 'strong' [23••]. One of the recent reviews by Wolff and Dansinger [24•], although supporting the hypothesis that SSBs consumption causes weight gain, suggests the need for larger and longer interventional trials to clarify the effects of SSBs intake on body weight. A meta-analysis by Forshee *et al.* [25••], which evaluated only studies involving children, found that the association between SSBs consumption and BMI was near zero. In her paper, Harrington [26•] focused on SSBs intake and its relation to an increased glycemic index; she concluded that, pending additional clinical trials, limiting SSBs consumption should be implemented. Finally, the most up-to-date review by Gibson [23••] estimated the effect of SSBs intake on excess body weight as small (except in susceptible individuals or at high levels of intake). However, the author emphasized the methodological weaknesses of the analyzed studies. Recently, eight additional cross-sectional studies related to this issue were published. Six of these cross-sectional studies [27•–32•] and one longitudinal study [33•] revealed a positive association between SSBs intake and weight gain; however, the remaining two cross-sectional studies [34•,35•] and one cohort study [36] demonstrated no significant association between these variables. Only a few intervention studies, which provide the highest level of evidence, have been conducted. Three randomized controlled trials (RCTs) [37,38,39••] that were incorporated in previous reviews suggest some beneficial effect of the avoidance of SSBs consumption on body weight, although there was no significant difference in BMI values between the treatment and control groups. A recent RCT by Albala *et al.* [40••], which estimated the effect of replacing habitual consumption of SSBs with milk, demonstrated beneficial effects on lean body mass and growth in children, despite no changes in percentage body fat. Another RCT that evaluated the outcomes of a cognitive behavioral therapy program showed a greater reduction in the intake of SSBs as a

percentage of total energy in the experimental group than in the control group, which was related to reductions in weight, BMI, and waist circumference [41••]. In summary, methodological weaknesses of existing studies and the paucity of good-quality intervention studies that adequately assess diet, lifestyle, and effect size make it hard to provide a definitive answer regarding whether SSBs intake is significantly implicated in weight gain [23••]. However, for now it seems to be reasonable to support the recommendations of known scientific bodies (ADA 2006, AAP 2004, AHA 2009) suggesting limiting SSBs consumption.

Snacking

What is called a 'snack' remains unclear. This lack of a consistent definition is the main issue when the effects of snacking are considered. Eating between meals and eating certain types of food – that is, snack food (usually defined as a high-fat, energy-dense, salty, savory, or sweet food) – are examples of often-mentioned definitions. The approach to snacking pattern assessment is either to quantify snacking frequency or to evaluate the quality of a snack food.

The available data show that the snacking frequency among children tends to increase concurrently with the prevalence of overweight [42,43]. Due to their composition, snacks contribute to greater intake of fat, sugars, and energy. However, according to the ADA evidence analysis, snacking frequency or snack food intake is not likely to be associated with adiposity in children [43]. This statement cannot be clearly supported by the results of current studies. We identified three cross-sectional studies that showed that more frequent snack intake is associated with a smaller risk of overweight in children [44•,45•,18•]. In the study by Aounallah-Skhiri *et al.* [45•], this effect was observed only in boys. Another cross-sectional study assessed the type and number of snacks consumed weekly by a large sample of 8–10-year-old children [46•]. It showed no significant difference between the number of snacks consumed by obese and nonobese children. However, obese children preferred more energy-dense snacks, especially those with a salty taste. The authors concluded that salty snack intake independently increased the likelihood of children becoming obese. In a study by McDonald *et al.* [47•], the prevalence of overweight was positively associated with snack food intake (e.g., candy, ice cream, packed fried snacks, soda, sugar-sweetened fruit-flavored drinks). Finally, in one case–controlled study, frequent snack consumption by the child in commercial establishments was found to be a risk factor for obesity [48]. In conclusion, the new data suggest that there is some correlation between snacking and childhood overweight. However, methodological limitations of the conducted studies must be considered when interpreting these inconsistent results.

Conclusion

As dietary factors play an important role in energy balance, dietary interventions may help reduce or prevent overweight and obesity in children. Available data indicate that not only meal composition but also some components that form a specific meal pattern can promote childhood obesity. Reducing meal and snack frequency, especially breakfast skipping, seem to be such components. On the contrary, limiting SSBs and snack food (defined as high-fat, energy-dense food) intake may have a beneficial effect. Although current knowledge does not allow one to draw any definitive conclusions, it provides a solid basis for further research.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 352–353).

1 Siega-Riz AM, Popkin BM, Carson T. Trends in breakfast consumption for children in the United States from 1965–1991. Am J Clin Nutr 1998; 67:748S–756S.

2 Reddan J, Wahlstrom K, Reicks M. Children's perceived benefits and barriers in relation to eating breakfast in schools with or without Universal School Breakfast. J Nutr Educ Behav 2002; 34:47–52.

3 • Fabritius K, Rasmussen M. Breakfast habits and overweight in Danish school-children. The role of socioeconomic positions. Ugeskr Laeger 2008; 170: 2559–2563.
The results of this cross-sectional study indicate that skipping breakfast is associated with overweight among Danish adolescents.

4 • Henríquez Sánchez P, Doreste Alonso J, Lainez Sevillano P, *et al.* Prevalence of obesity and overweight in adolescents from Canary Islands, Spain. Relationship with breakfast and physical activity. Med Clin 2008; 130:606–610.
A cross-sectional study that estimated the prevalence of obesity and overweight in Canary adolescents and its association with breakfast intake and physical activity. An inverse relationship between breakfast intake and its quality and obesity was found.

5 Dialektakou KD, Vranas PB. Breakfast skipping and body mass index among adolescents in Greece: whether an association exists depends on how breakfast skipping is defined. J Am Diet Assoc 2008; 108:1517–1525.

6 • Mota J, Fidalgo F, Silva R, *et al.* Relationships between physical activity, obesity and meal frequency in adolescents. Ann Hum Biol 2008; 35:1–10.
The data from this study indicate that increased meal frequency may have a beneficial effect on reducing the BMI. Breakfast skipping was not identified as a predictor of being overweight/obese.

7 • Harding S, Teyhan A, Maynard MJ, Cruickshank JK. Ethnic differences in overweight and obesity in early adolescence in the MRC DASH study: the role of adolescent and parental lifestyle. Int J Epidemiol 2008; 37:162–172.
In this study, skipping breakfast was associated with obesity and other poor dietary practices.

8 • Croezen S, Visscher TL, Ter Bogt NC, *et al.* Skipping breakfast, alcohol consumption and physical inactivity as risk factors for overweight and obesity in adolescents: results of the E-MOVO project. Eur J Clin Nutr 2009; 63:405–412.
The data from this cross-sectional electronic health survey (E-MOVO) show that skipping breakfast, alcohol consumption, and physical inactivity are associated with overweight in Dutch adolescents.

9 • Duncan JS, Schofield G, Duncan EK, Rush EC. Risk factors for excess body fatness in New Zealand children. Asia Pac J Clin Nutr 2008; 17:138–147.
This cross-sectional study (conducted in New Zealand) identified three lifestyle risk factors related to fat status: low physical activity, skipping breakfast, and insufficient sleep on weekdays.

10 Dubois L, Girard M, Potvin Kent M. Breakfast eating and overweight in a preschool population: is there a link? Public Health Nutr 2006; 9:436–442.

11 Utter J, Scragg R, Schaaf D, *et al.* Correlates of body mass index among a nationally representative sample of New Zealand children. Int J Pediatr Obes 2007; 2:104–113.

12 Rampersaud GC, Pereira MA, Girard BL, *et al.* Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. J Am Diet Assoc 2005; 105:743–760.

13 Nicklas TA, Morales M, Linares A, *et al.* Children's meal patterns have changed over a 21-year period: the Bogalusa Heart Study. J Am Diet Assoc 2004; 104:53–61.

14 American Dietetic Association. Childhood Overweight Evidence Analysis Project. Updated 2006. http://www.adaevidencelibrary.com/topic.cfm?cat=4159. [Accessed 28 September 2009]

15 Thompson OM, Ballew C, Resnicow K, *et al.* Dietary pattern as a predictor of change in BMI *z*-score among girls. Int J Obes (Lond) 2006; 30:176–182.

16 • Franko DL, Striegel-Moore RH, Thompson D, *et al.* The relationship between meal frequency and body mass index in black and white adolescent girls: more is less. Int J Obes (Lond) 2008; 32:23–29.
Ten-year, longitudinal, observational study that revealed an adverse association between meal frequency and BMI in 9–19-year-old US girls.

17 Zerva A, Nassis GP, Krekoukia M, *et al.* Effect of eating frequency on body composition in 9–11-year-old children. Int J Sports Med 2007; 28:265–270.

18 • Lioret S, Touvier M, Lafay L, *et al.* Are eating occasions and their energy content related to child overweight and socioeconomic status? Obesity 2008; 16:2518–2523.
In this cross-sectional study, overweight was found to be inversely correlated to the number of eating episodes and to the contribution of snacking episodes to energy intake.

19 • Prochnik Estima Cde C, da Costa RS, Sichieri R, *et al.* Meal consumption patterns and anthropometric measurements in adolescents from a low socioeconomic neighborhood in the metropolitan area of Rio de Janeiro, Brazil. Appetite 2009; 52:735–739.
In this study, higher values for BMI and waist and hip circumferences were observed among Brazilian adolescents with an unsatisfactory meal pattern (defined as less frequent meal consumption).

20 Kosti RI, Panagiotakos DB, Mihas CC, *et al.* Dietary habits, physical activity and prevalence of overweight/obesity among adolescents in Greece: the Vyronas study. Med Sci Monit 2007; 13:CR437–CR444.

21 Toschke AM, Küchenhoff H, Koletzko B, von Kries R. Meal frequency and childhood obesity. Obes Res 2005; 13:1932–1938.

22 • Wang YC, Bleich SN, Gortmaker SL. Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents. Pediatrics 2008; 121:e1604–e1614.
This study documents the increasing consumption of SSBs among US youth during 1988–2004.

23 •• Gibson S. Sugar-sweetened soft drinks and obesity: a systematic review of the evidence from observational studies and interventions. Nutr Res Rev 2008; 21:134–147.
The most up-to-date (July 2008) systematic review evaluating the link between SSBs consumption and weight gain in adults and children. It estimated the effect of SSBs intake on excess body weight as small.

24 • Wolff E, Dansinger ML. Soft drinks and weight gain: how strong is the link? Medscape J Med 2008; 10:189.
This review supports the hypothesis that consumption of SSBs causes weight gain in adults and children. The authors emphasize the need for larger and longer interventional trials to clarify this effect.

25 •• Forshee RA, Anderson PA, Storey ML. Sugar-sweetened beverages and body mass index in children and adolescents: a meta-analysis. Am J Clin Nutr 2008; 87:1662–1671.
A quantitative meta-analysis and qualitative review that indicated the association between SSBs consumption and BMI was near zero. Only studies involving children were evaluated.

26 • Harrington S. The role of sugar-sweetened beverage consumption in adolescent obesity: a review of the literature. J Sch Nurs 2008; 24: 3–12.
A review that focuses on SSBs intake and its relation to an increased glycemic index in adolescents.

27 • Hirschler V, Buzzano K, Erviti A, *et al.* Overweight and lifestyle behaviors of low socioeconomic elementary school children in Buenos Aires. BMC Pediatr 2009; 24:17.
This small cross-sectional study showed that drinking sweet beverages and skipping breakfast are predictive variables for childhood overweight/obesity.

28 • Downs SM, Marshall D, Ng C, Willows ND. Central adiposity and associated lifestyle factors in Cree children. Appl Physiol Nutr Metab 2008; 33:476–482.
The aim of this small study was to determine whether lifestyle factors were associated with central adiposity in Canadian Cree children. SSBs intake was positively correlated with waist circumference in children with central adiposity.

29 • Kleiser C, Schaffrath Rosario A, Mensink GB, *et al.* Potential determinants of obesity among children and adolescents in Germany: results from the cross-sectional KiGGS Study. BMC Public Health 2009; 9:46.
In this large cross-sectional study, high intakes of beverages were significantly associated with overweight and obesity.

30 • Denova-Gutiérrez E, Jiménez-Aguilar A, Halley-Castillo E, *et al.* Association between sweetened beverage consumption and body mass index, proportion of body fat and body fat distribution in Mexican adolescents. Ann Nutr Metab 2008; 53:245–251.
A cross-sectional analysis of data from Mexican adolescents that supports the hypothesis that the consumption of SSBs increases the risk of overweight and obesity.

31 • Mahmood M, Saleh A, Al-Alawi F, Ahmed F. Health effects of soda drinking in adolescent girls in the United Arab Emirates. J Crit Care 2008; 23:434–440.
A small cross-sectional study that showed the association between soda drinking and higher risk of obesity in adolescent girls in the United Arab Emirates.

32 • Linardakis M, Sarri K, Pateraki MS, *et al.* Sugar-added beverages consumption among kindergarten children of Crete: effects on nutritional status and risk of obesity. BMC Public Health 2008; 8:279.
A cross-sectional study with results that indicate that high intake of SSBs by kindergarten children in Greece is associated with an increased risk for developing obesity.

33 • Lim S, Zoellner JM, Lee JM, *et al.* Obesity and sugar-sweetened beverages in African-American preschool children: a longitudinal study. Obesity (Silver Spring) 2009; 17:1262–1268.
A small longitudinal study that revealed an increased risk for obesity among African–American children with high consumption of SSBs.

34 • Laurson K, Eisenmann JC, Moore S. Lack of association between television viewing, soft drinks, physical activity and body mass index in children. Acta Paediatr 2008; 97:795–800.
In this cross-sectional and longitudinal study, correlations between physical activity, screen time, diet, and BMI were low and nonsignificant among US children.

35 • Gómez-Martínez S, Martín A, Romeo J, *et al.* Is soft drink consumption associated with body composition? A cross-sectional study in Spanish adolescents. Nutr Hosp 2009; 24:97–102.
In this cross-sectional study, no association was present between SSBs consumption and obesity in Spanish adolescents.

36 Kral TV, Stunkard AJ, Berkowitz RI, *et al.* Beverage consumption patterns of children born at different risk of obesity. Obesity (Silver Spring) 2008; 16:1802–1808.

37 James J, Thomas P, Cavan D, Kerr D. Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomised controlled trial. BMJ 2004; 328:1237.

38 Ebbeling CB, Feldman HA, Osganian SK, *et al.* Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. Pediatrics 2006; 117:673–680.

39 •• Sichieri R, Paula Trotte A, de Souza RA, Veiga GV. School randomised trial on prevention of excessive weight gain by discouraging students from drinking sodas. Public Health Nutr 2009; 12:197–202.
The results of this RCT indicate that decreasing SSBs intake significantly reduces BMI among overweight children.

40 •• Albala C, Ebbeling CB, Cifuentes Mds, *et al.* Effects of replacing the habitual consumption of sugar-sweetened beverages with milk in Chilean children. Am J Clin Nutr 2008; 88:605–611.
This RCT estimated the effect of replacing habitual consumption of SSBs with milk and demonstrated beneficial effects on lean body mass and growth in children, despite no changes in percentage body fat.

41 •• Tsiros MD, Sinn N, Brennan L, *et al.* Cognitive behavioral therapy improves diet and body composition in overweight and obese adolescents. Am J Clin Nutr 2008; 87:1134–1140.
This RCT evaluated the outcomes of a cognitive behavioral therapy program and revealed that a greater reduction in the intake of SSBs in the experimental group was associated with reductions in weight, BMI, and waist circumference.

42 Kerr MA, Rennie KL, McCaffrey TA, *et al.* Snacking patterns among adolescents: a comparison of type, frequency and portion size between Britain in 1997 and Northern Ireland in. Br J Nutr 2009; 101:122–131.

43 Davis MM, Gance-Cleveland B, Hassink S, *et al.* Recommendations for prevention of childhood obesity. Pediatrics 2007; 120 (Suppl 4):S229–S253.

44 Vader AM, Walters ST, Harris TR, Hoelscher DM. Television viewing and • snacking behaviors of fourth- and eighth-grade schoolchildren in Texas. Prev Chronic Dis 2009; 6:A89.
In this study, it was observed that more frequent snack intake is associated with a smaller risk of overweight in US school children.

45 Aounallah-Skhiri H, Romdhane HB, Traissac P, *et al.* Nutritional status of • Tunisian adolescents: associated gender, environmental and socio-economic factors. Public Health Nutr 2008; 11:1306–1317.
A cross-sectional study that assessed the nutritional status of Tunisian adolescents and associated factors showed that more frequent snack intake is associated with a smaller risk of overweight in boys.

46 Maffeis C, Grezzani A, Perrone L, *et al.* Could the savory taste of snacks be a • further risk factor for overweight in children? J Pediatr Gastroenterol Nutr 2008; 46:429–437.
In this large cross-sectional study, no significant difference between the number of snacks consumed by obese and nonobese children was found. However, salty snack intake independently increased the likelihood of children becoming obese.

47 McDonald CM, Baylin A, Arsenault JE, *et al.* Overweight is more prevalent than • stunting and is associated with socioeconomic status, maternal obesity, and a snacking dietary pattern in school children from Bogota, Colombia. J Nutr 2009; 139:370–376.
In this study, the prevalence of overweight was positively associated with snack food intake.

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