Original Article

Associations Between Artificially Sweetened Beverages and Obesity Among UK Children

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ABSTRACT

Objective: to examine the association between artificially sweetened beverage (ASB) consumption and obesity/overweight in a large, nationally representative sample of UK children.
Study Design: Observational / cross-section study.
Place and Duration of Study: This study was conducted at Avicenna Medical & Dental College, Lahore December 2017 to February 2018.
Materials and Methods: Data came from the UK Millennium Cohort Study sweep 5. The sample included 13,287 children aged 10-12 years. Multinomial regression models were run to examine the associations between ASB consumption and obesity, after adjusting for socio-demographic factors and physical activity.
Results: A significant association between ASB consumption and obesity was detected in multinomial regression models. After adjusting for socio-demographic factors and physical activity, children who frequently consumed ASB had a 59% (CI: 1.36-1.85) increased relative risk of being overweight and a 2.39 times (CI: 1.82-3.13) greater relative risk of being obese than those with no ASB consumption.
Conclusion: ASB consumption was found to be significantly associated with obesity. Further research is needed on the role of added sugars and artificial sweeteners in beverages for childhood obesity. A further comprehensive research with intervention design is recommended.
Key Words: Artificially Sweetened Beverages, Obesity, Obesity among children, Childhood Obesity, Weight Gain in childhood.

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INTRODUCTION

Obesity is a world-wide phenomenon[1] and a major public health problem[2]. It is a huge burden on the worldwide economy, affecting a significant proportion of the world population. The harmful aspects of obesity also affect overall general health, quality of life of individuals, as well as the economy of communities and countries[3]. The global rise in obesity is universal in high income, middle income and many low income countries[4].

Childhood obesity is also becoming a major problem and a pandemic.Sugar is one of the major causes of obesity and sugar added into commercial beverages are thought to pose a risk to obesity and weight gain[5]. The role of Artificially Sweetened Beverages (ASB) on health and weight status has so far been controversial and the evidence on the association between obesity and ASB is inconsistent in its findings. This study will therefore examine the role played by the consumption of artificially sweetened beverages in childhood overweight and obesity.

Artificially sweetened beverages (ASB) have emerged as a substitute to Sugar-sweetened Beverages (SSB) with the aim of providing the appetency of sweetness without adding calories. But, their role still remains questionable.

Epidemiological studies and large-scale surveys, reviewing on metabolic effects of artificial sweeteners in young people have found associations between artificial sugar intake and weight gain[6].

Some of the studies have reported that ASB consumption was positively associated with obesity in epidemiological studies but no association was found in interventional studies[7]. Some Studies concluded a strong cross-sectional association between diet soda consumption and weight gain in young adults[8]. Consumption of sugar containing beverages is a behaviour influenced by socio-economic determinants[9]. Socio-economic factors like maternal education, family income, child's ethnicity, social class play important role in developing hazardous behaviours for health[10, 20]. Moreover, physical activity is an important confounder to be considered. These socio-demographic and

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confounding covariates were not always included in previous studies.

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MATERIALS AND METHODS

This study is based on the secondary data analysis of data from the Millennium Cohort Study (MCS). The MCS is housed by the Centre for Longitudinal Studies (CLS).

The data used in this study came from the 5th sweep (MCS5), when the children were 11 years old.

The total number of cohort members[11] was 13,469 but after taking out those with missing values, total number of study participants were 13,287.

In MCS, data were collected through house-hold questionnaire along with face-to-face interviews. The outcome measure among children was Obesity having 3 categories namely not overweight (including underweight), overweight and obese. Exposure to the outcome was frequency of ASB consumption. It has 7 categories: More than once a day, once a day, 3-6 days a week, 1-2 days a week, less often but at least once a month, Less than once a month, Never. The association between the risk and outcome was adjusted for age, sex, ethnic background, education level of mothers, socio-economic status and physical activity.

The statistical analyses were carried out using STATA 12.0 (StataCorpLP).

Multinomial regression was used to examine the associations with overweight and obesity, a variable with 3 categories. Relative Risk Ratios (RRR) for being overweight/obese with 95% confidence intervals were estimated for association of obesity with ASB consumption using multinomial regression models. The regression analysis had 3 models. Model A showed unadjusted or crude association. Model B showed adjusted results only with demographic and socio-economic association. Model C was fully adjusted model with socio-demographic and confounding factors.

RESULTS

The sample characteristics are shown in Table 1. Of 13,287 total participants, 51% were males.

Most of the children in the sample (67%) were 11 years old. Of all children, 21% were overweight and 7% were obese. In relation to the consumption of artificially sweetened drinks (ASB), 20% of children reported no ASB consumption. About 35% of mothers in the sample had a university degree or higher, while 14% of mothers reported no educational qualifications. The majority of the sample (83%) belonged to White ethnicity. 23% of children reported no regular physical activity while 9% of children recorded physical activity of 5 or more days a week.

Table No. 1. Sample characteristics N: 13,287

Variable	N	%
Sex: Male	6,713	50.52
Female	6,574	49.48
Missing	0	
ASB Consumption: Never	2,654	19.97
<Once a month	860	6.47
Once a month at least	1,074	8.08
1-2 days/week	1,900	14.30
3-6 days/week	1,135	8.54
Once a day	2,268	17.07
>Once a day	2,743	20.64
Missing	653	4.91
Child's Age		
10 Years	4,378	32.95
11 Years	8,843	66.55
12 Years	66	0.50
Obesity Flag		
Not overweight+ under-weight	9,294	69.95
Over-weight	2,717	20.45
Obese	860	6.47
Missing	416	3.13
Mother's Education		
Level 5	1,053	7.93
Level 4	3,627	27.30
Level 3	1,146	8.62
Level 2	3,883	29.22
Level 1	1,214	9.14
Overseas only	449	3.83
None of above	1,865	14.04
Missing	50	0.38
Child Ethnicity		
White	10,992	82.73
Mixed	383	2.88
Indian	340	2.56
Pakistani & Bangladeshi	948	7.13
Black	431	3.24
Other Ethnic groups	190	1.43
Missing	3	0.02
Equivalised Income Quintiles		
Top Quintile	2,366	17.81
2nd Quintile	2,578	19.40
3rd Quintile	2,751	20.70
4th Quintile	2,778	20.91
Bottom Quintile	2,814	21.18
Parental Social Class (Current job)		
Managerial & Professional	3,351	25.22
Intermediate	2,014	15.16
Small employer	797	6.00
Low Supervisory & Technical	266	2.00
Semi-routine & routine	2,135	16.07
Missing	4,724	35.55
Frequency of Physical Activity		
5 or more days/week	1,101	8.29
4 days/week	1,001	7.53
3 days/week	1,932	14.54
2 days/week	2,564	19.30
1 day/week	2,776	20.89
<1 day/week	247	1.86
Not at all	3,024	22.76
Missing	642	4.83

Table 2. Multinomial Regression Analysis for ASB consumption and overweight/obesity. (No. of observations = 12,205)

Variables	Model A	Model B	Model C
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
	Baseline Outcome = not overweight (Ref RRR: 1)		
	Overweight		
ASB Consumption: Never	Ref RRR: 1	Ref RRR: 1	Ref RRR: 1
<Once a month	1.02 (0.80-1.30)	1.05 (0.82-1.35)	1.07 (0.83-1.37)
Once a month	1.16 (0.94-1.43)	1.21 (0.98-1.49)	1.21 (0.98-1.50)
1-2 days/week	1.38 (1.16-1.64)***	1.41 (1.18-1.68)***	1.42 (1.19-1.70)***
3-6 days/week	1.45 (1.17-1.79)***	1.45 (1.16-1.80)***	1.45 (1.16-1.81)***
Once a day	1.38 (1.16-1.65)***	1.42 (1.18-1.70)***	1.41 (1.18-1.70)***
>Once a day	1.55 (1.33-1.80)***	1.58 (1.35-1.85)***	1.59 (1.36-1.85)***
Sex: Male		Ref RRR: 1	Ref RRR: 1
Female		1.28 (1.14-1.43)***	1.24 (1.11-1.39)***
Child age: 10 years		Ref RRR: 1	Ref RRR: 1
11 Years		0.93 (0.83-1.04)	0.93 (0.83-1.03)
12 Years		1.60 (0.71-3.59)	1.66 (0.74-3.73)
Mother's Education: Level 5		Ref RRR: 1	Ref RRR: 1
Level 4		1.04 (0.84-1.28)	1.04 (0.84-1.29)
Level 3		1.35 (1.04-1.74)*	1.33 (1.02-1.72)*
Level 2		1.40 (1.11-1.78)**	1.38 (1.08-1.75)**
Level 1		1.36 (1.04-1.78)*	1.31 (1.00-1.72)
Overseas only		1.27 (0.87-1.88)	1.25 (0.85-1.85)
None of above		1.39 (1.06-1.81)*	1.34 (1.02-1.75)*
Child's Ethnicity: White		Ref RRR: 1	Ref RRR: 1
Mixed		1.34 (0.99-1.82)	1.32 (0.98-1.80)
Indian		1.36 (0.99-1.88)	1.30 (0.95-1.79)
Pakistani & Bangladeshi		1.50 (1.23-1.83)***	1.43 (1.18-1.74)***
Black		1.97 (1.50-2.60)***	1.91 (1.45-2.52)***
Other Ethnic groups		1.03 (0.57-1.83)	0.97 (0.54-1.74)
Equivalised Income Quintiles			
Top Quintile		Ref RRR: 1	Ref RRR: 1
2nd Quintile		1.03 (0.86-1.23)	1.03 (0.86-1.22)
3rd Quintile		1.09 (0.91-1.30)	1.07 (0.90-1.27)
4th Quintile		1.10 (0.91-1.33)	1.06 (0.87-1.28)
Bottom Quintile		0.87 (0.71-1.08)	0.84 (0.68-1.04)
Parental Social Class			
Managerial & Professional		Ref RRR: 1	Ref RRR: 1
Intermediate		0.88 (0.73-1.05)	0.87 (0.72-1.05)
Small employer		1.09 (0.85-1.41)	1.08 (0.84-1.39)
Low Supervisory & Technical		1.09 (0.72-1.65)	1.08 (0.71-1.62)
Semi-routine & Routine		1.04 (0.86-1.25)	1.02 (0.84-1.23)
Missing		1.04 (0.89-1.21)	1.02 (0.87-1.18)
Frequency of Physical Activity			
5 or more days/week			Ref RRR: 1
4 days/week			0.99 (0.75-1.30)
3 days/week			1.08 (0.86-1.37)
2 days/week			1.08 (0.87-1.34)
1 day/week			1.46 (1.20-1.78)***
<1 day/week			1.70 (1.14-2.52)**
Not at all			1.33 (1.08-1.63)**
Constant	0.22 (0.20-0.25)***	0.11 (0.09-0.15)***	0.10 (0.07-0.14)***
	Obese		
ASB Consumption: Never	Ref RRR: 1	Ref RRR: 1	Ref RRR: 1

<Once a month	0.73 (0.44-1.24)	0.76 (0.45-1.29)	0.77 (0.46-1.31)
Once a month	1.26 (0.86-1.84)	1.43 (0.97-2.10)	1.41 (0.96-2.09)
1-2 days/week	1.77 (1.25-2.51)***	1.83 (1.29-2.60)***	1.86 (1.31-2.64)***
3-6 days/week	1.76 (1.17-2.64)**	1.71 (1.16-2.53)**	1.71 (1.15-2.52)**
Once a day	1.95 (1.45-2.63)***	2.04 (1.50-2.77)***	2.03 (1.49-2.76)***
>Once a day	2.41 (1.86-3.13)***	2.40 (1.84-3.14)***	2.39 (1.82-3.13)***
Sex: Male		Ref RRR: 1	Ref RRR: 1
Female		1.18 (1.00-1.39)*	1.12 (0.95-1.33)
Child age : 10 Years		Ref RRR: 1	Ref RRR: 1
11 Years		0.89 (0.74-1.09)	0.90 (0.74-1.09)
12 Years		0.93 (0.29-3.05)	0.98 (0.30-3.16)
Mother's Education: Level 5		Ref RRR: 1	Ref RRR: 1
Level 4		1.09 (0.70-1.70)	1.08 (0.69-1.69)
Level 3		1.17 (0.68-2.00)	1.14 (0.66-1.95)
Level 2		1.57 (0.95-2.60)	1.52 (0.92-2.52)
Level 1		2.32 (1.35-3.96)**	2.17 (1.26-3.72)**
Overseas only		1.74 (0.89-3.41)	1.72 (0.89-3.35)
None of above		2.13 (1.23-3.71)**	2.00 (1.15-3.50)**
Child's Ethnicity: White		Ref RRR: 1	Ref RRR: 1
Mixed		1.85 (1.19-2.87)**	1.81 (1.17-2.80)**
Indian		0.87 (0.44-1.72)	0.82 (0.42-1.61)
Pakistani & Bangladeshi		1.61 (1.18-2.20)**	1.51 (1.10-2.07)*
Black		3.39 (2.10-5.49)***	3.25 (2.01-5.24)***
Other Ethnic groups		0.85 (0.30-2.45)	0.79 (0.27-2.29)
Equivalised Income Quintiles			
Top Quintile		Ref RRR: 1	Ref RRR: 1
2nd Quintile		1.10 (0.76-1.58)	1.08 (0.75-1.56)
3rd Quintile		1.45 (0.97-2.16)	1.39 (0.94-2.06)
4th Quintile		1.81 (1.20-2.74)**	1.68 (1.10-2.55)*
Bottom Quintile		1.17 (0.77-1.76)	1.09 (0.72-1.65)
Parental Social Class			
Managerial & Professional		Ref RRR: 1	Ref RRR: 1
Intermediate		0.95 (0.68-1.33)	0.95 (0.68-1.32)
Small employer		1.48 (1.00-2.20)	1.44 (0.97-2.14)
Low Supervisory & Technical		1.30 (0.71-2.38)	1.25 (0.68-2.28)
Semi-routine & Routine		1.02 (0.73-1.42)	1.00 (0.71-1.39)
Missing		1.21 (0.90-1.62)	1.17 (0.87-1.57)
Frequency of Physical Activity			
5 or more days/week			Ref RRR: 1
4 days/week			1.25 (0.70-2.23)
3 days/week			1.25 (0.76-2.03)
2 days/week			1.71 (1.06-2.78)*
1 day/week			2.03 (1.29-3.17)**
<1 day/week			2.88 (1.53-5.41)***
Not at all			2.02 (1.26-3.23)**
Constant	0.05 (0.04-0.07)***	0.02 (0.01-0.03)***	0.01 (0.00-0.02)***

*p<0.05 **p<0.01 ***p<0.001

Table 2 presents the multinomial regression models for the association between ASB consumption and overweight/obesity. Total observations in this model were 12,205 after excluding observations with missing data.

In model A, the frequency of ASB consumption was associated with overweight and obesity risk. Children consuming ASB more than once a day were 55% more likely to be overweight as compared to non-consumers (RRR=1.55; CI: 1.33-1.80). Further, more than once a day ASB consumption was associated with a more than 2 times increased risk of being obese (RRR=2.41; CI: 1.86-3.13). The association with obesity was linear and with overweight almost linear, meaning that the risk of being overweight or obese increased the more frequently ASB were consumed.

Model B adjusted for demographic and socioeconomic factors. Adjustment for aforementioned factors did not lead to any substantial changes in the association between ASB consumption and overweight/obesity. As before, being female, low maternal education, Pakistani, Bangladeshi and Black ethnicities were significantly associated with both overweight and obesity risks.

Model C additionally adjusted for the frequency of physical activity, which as before was associated with both overweight and obesity. However adjusting for physical activity did not affect the association with ASB consumption.

DISCUSSION

This study analysed data from UK's Millennium Cohort study to explore the association between beverages' consumption and obesity. The survey gathered the information about the frequency of drinking artificially sweetened beverages among UK children. This study provided evidence of an association between ASB consumption and overweight/obesity. After adjustment for socio-demographic variables and physical activity, children who consumed ASB more than once a day had a 1.59 times increased risk of being overweight and a 2.39 times increased risk of being obese, compared to non-consumers. These findings are consistent with previous studies on the effects of artificial sugars[6, 17]. This association is attributed to multiple plausible behavioural mechanisms such as sweet taste dissociation from caloric consumption may enhance appetite resulting in increased food consumption and weight gain[4,18]. Moreover, poor diet quality is associated with raised uptake of added caloric sweeteners[12,13]. Multinomial models of ASB consumption showed that females were more susceptible to be overweight and obese and this phenomenon is observed and confirmed by other studies as well[19]. Mother's education appeared to be a significant protective factor in all multinomial analyses. Children whose mothers had no qualifications were at higher risk of being overweight or obese compared to those with high maternal education. The analyses showed that children doing physical activity for less than one day a week had an almost 3 times higher risk of being obese than those involved in physical activity of 5 or more days. This impact was supported by evidence from other studies[14, 15, 16].

Strengths of this study was analysis on a large study data and adjustment and controlling for confounding factors that play important role in the development of various unhealthy behaviours among children. This study used a large sample from Millennium cohort study sweep 5 which included nationally representative data of UK children. The sampling methods were standardized so that every region of the country shows equalized representation. Weaknesses of this study include cross-sectional study design that is insufficient to make an inference between exposure and outcome. This study also did not look at the dietary habits of the children that may act as a confounding factor in being over-weight/obese. Further research is recommended on the associations between artificially sweetened beverages and obesity among children as well as adults.

CONCLUSION

Analyzing UK children at the age of 11, this study provided evidence of a significant association between artificially sweetened beverages and obesity keeping in consideration the confounding factors like Socio-economic status, maternal education and physical activity.

Author's Contribution:

Concept & Design of Study:	Muhammad Bilal Arshad
Drafting:	Sabina Nayab
Data Analysis:	Muhammad Bilal Arshad
Revisiting Critically:	Muhammad Behzad Salahuddin
Final Approval of version:	Muhammad Bilal Arshad

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