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Original Article

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Association between artificially sweetened beverages consumption and changes in body mass index among children

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ABSTRACT

BACKGROUND & OBJECTIVE: Poor food quality and choices are a major concern in the modern life style and increased consumption of sweetened and artificially sweetened beverages have been implicated as contributing factors for obesity. The objective of this study is to determine the association between the consumption of artificially sweetened beverages and changes in body mass index among children.

METHODOLOGY: Data on the consumption of artificially sweetened beverages consumption and BMI for 13,287 children was analyzed for exposure and outcome from Millennium Cohort Study (MCS). The association between frequency of ASB consumption and BMI was quantified using demographics and linear regression analysis. The linear regression analysis was done adjusting demographic, socioeconomic variables and confounding factors of frequency of physical activity. Regression analysis was conducted using survey weights to account for the complex sampling design.

RESULTS: Adjusted linear regression for demographical and socioeconomic variables showed that more frequent consumption of ASB was associated with a significant increase in BMI. As the frequency of ASB increased, BMI significantly increased by 0.69-1.06 units in categories ($p<0.01$). Regression analysis adjusted for frequency of physical activity also showed an increase of BMI by 0.36 units ($p<0.01$) with the highest frequency of ASB consumption.

CONCLUSION: Higher consumption of artificially sweetened beverages causes an increase in BMI among UK children.

KEYWORDS: Artificially sweetened beverages, Artificial sweeteners, BMI, Childhood obesity, Obesity.

INTRODUCTION

Obesity is defined as" A medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems" [1]. Obesity has become a phenomenon and public health problem observed worldwide and its ever-increasing global prevalence has made it a pandemic [2,3,4]. An adult is considered to be obese if the BMI (Body Mass Index), which is calculated as weight/height2, overpasses 30kg/m2. A BMI of between 25kg/m2 and 30kg/m2 is classified as overweight [5]. Overweight and obesity in children are measured by different criteria. These include BMI adjusted for both age and sex, a measure that has become more popular recently in assessing childhood obesity. Other measures are bio-impedance, skinfold thickness, waist to hip ratio, waist circumference, and a simple weight for height index which was used in the past and does not consider a child's age [6,7]. Obesity in children is defined using percentiles of BMI in growth reference charts. Children's BMI is classified as overweight or obese utilizing thresholds that change according to child's age and sex [8]. Beverages with artificial sweeteners gained popularity as substitutes to regular soft drinks, sugar sweetened juices and energy drinks [9]. However, the role of artificial sugars added to beverages as healthy alternatives have been very controversial [10]. Findings from systematic reviews and meta-analysis have shown a close association between artificial sweeteners and metabolic derangements among children leading to the increase in BMI and waist circumferences

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[11]. The main contributors towards increased consumption of sugars and artificial sweeteners are addictive behaviors as sugar packed foods and drinks are more palatable, fulfilling and satisfying [12]. However, it is pertinent to mention that where observational and cross-sectional studies have shown hefty associations between artificial sweeteners and obesity, randomized controlled trials didn't find any significant causal relationship between the two [13,14]. This research was aimed to look into the controversial role of Artificially Sweetened Beverages (ASB) in increasing/decreasing BMI among growing children of the UK.

METHODOLOGY

Our study performed secondary analysis of data from Millennium Cohort Study (MCS). The MCS is a prospective cohort study of UK children, following the lives of over 19,000 children born from 1st September 2000 till 31st August 2001 in Wales and England, and from 23rd November 2000 till 11th January 2002 in Northern Ireland and Scotland. Ethical clearance from Research Ethical Committee (REC) was obtained for both the pilot surveys and the main surveys. The data were retrieved for secondary analysis from the UK Data Service. This data is freely available for academic use, which does not require additional permission for that purpose. According to the Copyright, Designs and Patents Act 1988 UK, original literary work is protected by copyrights, while this study is done on data from MCS, which is made public and isn't governed by copyrights [15]. This study included the data from 5th sweep of MCS when the children were at the age of 11. The sample size of MCS was 13,469 but after the removal of missing values, total number of study participants was 13,287. Respondents' BMI was the outcome variable which is a continuous variable. The beverages consumed by the respondents were largely comprised of containing artificial sweeteners like Aspartame, Saccharin and Sucralose. The frequency of ASB consumption was the exposure (Independent Variable) which had 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. Gender, child age, ethnicity, income quintiles, maternal education level and physical activity of cohort members were taken as covariates. Taking BMI (continuous variable) as main outcome variable, a linear regression was conducted to see the impact of variables independently. Adjustment of all covariates was carried out in linear regression analysis. The regression analysis was conducted using survey weights to account for the complex sampling design. Statistical analysis was done using STATA 12.0, and the significance level was set at 5% (p-value <0.05) for the statistical analysis.

RESULTS

The sample characteristics are shown in Table-I of 13,287 total participants, 51% were males. The mean BMI of the cohort members in the sample was 19.25 kg/m2. About 20% of the participants reported that they never consumed ASB in their lives. However, 21% of the participants reported the highest frequency of ASB consumption i.e., more than once per day.

Table-I: Characteristics of study participants

Total Observations: N: 13,287 Variable	n(%)
Gender	
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 BMI: Mean (S.D)	19.25 (3.68)
Child's Age	
10 Years	4,378 (32.95)
11 Years	8,843 (66.55)
12 Years	66 (0.50)
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)

Table-II shows linear regression analysis of the association between ASB consumption and BMI.

The analysis adjusted the association for socioeconomic, demographic variables and confounding factors i.e., frequency of physical activity. Linear regression analysis showed the significant increase in BMI as the frequency of ASB consumption increases, with the increase of 1.06 Kg/m2 (CI: 0.83-1.30, P-Value: <0.001) of BMI with the highest frequency of ASB consumption i.e. More than once a day. On average, females had a higher BMI than males (0.40, CI 0.24-0.55). Black children also had significantly greater BMI compared to White children (1.48, CI: 0.80-2.16). Mothers' education and Parental social class appeared to be a non-significant factor against BMI increase. Poorer children tended to have a higher BMI: the BMI increased in a linear fashion from the top quintile to the 4th quintile of household income. However, the BMI of children in the bottom quintile did not differ significantly from those in the top quintile. The analysis also exhibited that less than one

Table-II: Linear Regression analysis of ASB consumption and BMI.
(Number of observations after dropping the missing values from included variables= 12,205).

Variables	Model-A
	Coef. (95% CI)
ASB Consumption	
Never	Ref Coef
<Once a month	-0.08 (-0.40-0.24)
Once a month	0.39 (0.14-0.65) **
1-2 days/week	0.69 (0.41-0.96) ***
3-6 days/week	0.77 (0.47-1.07) ***
Once a day	0.68 (0.44-0.93) ***
>Once a day	1.06(0.83-1.30) ***
Sex	
Male	Ref Coef.
Female	0.40 (0.24-0.55) ***
Child age	
10 Years	Ref Coef.
11 Years	0.22 (0.06-0.39) **
12 Years	1.20 (0.09-2.32) *
Mother's Education	
Level 5	Ref Coef.
Level 4	-0.12 (-0.38-0.14)
Level 3	-0.04 (-0.38-0.29)
Level 2	0.31 (-0.01-0.64)
Level 1	0.39 (-0.02-0.80)
Overseas only	0.40 (-0.08-0.89)
None of above	0.41 (-0.03-0.85)
Child's Ethnicity	
White	Ref Coef.
Mixed	0.54 (0.01-1.08)
Indian	-0.03 (-0.50-0.43)
Pakistani & Bangladeshi	0.37 (0.08-0.67) *
Black	1.48 (0.80-2.16) ***
Other Ethnic groups	-0.56 (-1.36-0.25)
Equivalised Income Quintiles	
Top Quintile	Ref Coef.
2nd Quintile	0.05 (-0.16-0.27)
3rd Quintile	0.29 (0.05-0.53) *
4th Quintile	0.45 (0.17-0.72) ***
Bottom Quintile	-0.15 (-0.48-0.18)
Parental Social Class	
Managerial & Professional	Ref Coef.
Intermediate	-0.13 (-0.37-0.11)
Small employer	0.20 (-0.18-0.58)
Low Supervisory & Technical	-0.03 (-0.62-0.56)
Semi-routine & Routine	0.05 (-0.20-0.30)
Missing	0.07 (-0.14-0.28)
Frequency of Physical Activity	
5 or more days/week	Ref Coef.
4 days/week	-0.11 (-0.46-0.24)
3 days/week	-0.03 (-0.34-0.27)
2 days/week	0.17 (-0.11-0.45)

Table continued..

1 day/week	0.41 (0.13-0.69) **
Never	0.36 (0.05-0.67) **
Constant	17.28 (16.88-17.68) ***

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

day of physical activity per week was associated with higher BMI as compared to the activity of 5 or more days (0.36, CI: 0.05-0.67).

DISCUSSION

This study performed secondary analysis of data to contemplate an association between frequency of consumption of artificially sweetened beverages and its effects on BMI of UK children and provided evidence of an association between the two factors.

In line with these findings, the BMI of children consuming ASB more than once a day was increased by 1.11 kg/m2 compared to children who did not consume ASB's in the fully adjusted model. This very trend among children has previously been noted among past studies [16,17,18]. This association between frequent consumption of ASB and higher BMI among children can be explained by the decreased satiety and altered glucose homeostasis caused by ingredients used in beverages such as Aspartame and Saccharin [19, 20]. Previously done studies also have attributed the association between ASP consumption and BMI increase to various plausible behavioral and psychological phenomenon indicating appetite enhancement consequent to sweet taste dissociation from caloric consumption. This ultimately leads to increased consumption of food and weight gain [21]. Additionally, poor diet quality is also considered to trigger the increased uptake of added caloric sweeteners [22].

The impact of equivalized family income showed an interesting trend. The risk of having greater BMI increased proportionally from the top to the 4th income quintile. However, children in the bottom quintile did not have a higher risk than children in the top quintile. Similar trends were detected in Health Survey for England 2016 where top income quintiles were least likely to be obese, but bottom quintiles showed a little deviation from the trend [23].

The Strengths of this study are as follows. The strengths of this study were a large sample size from Millennium cohort study sweep 5 that comprised of nationally representative data of UK children and standardization of sampling methods by incorporation of statistical weights to equalize the representation from all regions of the country. The element of cross-sectional observational design was one of the weaknesses of this study. Further experimental investigation is recommended to look into the association between ASBs' consumption and BMI not only among children but also among adults.

CONCLUSION

This study concluded that a strong positive association between the frequency of artificially sweetened beverages and BMI increase was found among UK children in in Millennium Cohort Study. Maternal education and frequency of physical activity were found protective factors against the increase in BMI of UK children.

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Muhammad Bilal Arshad: Conception, design, and acquisition of data.
Muhammad Usman Sheikh: Statistical analysis and interpretation of data.
Muhammad Afzal: Critical review of article and methodology.
Aneela Amjad: Data compilation and manuscript drafting.
Shahzeb Patoli: Acquisition of data and literature review.
Muhammad Behzad Salahuddin: Manuscript drafting and final approval of the version.

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