Original Research

The Association between Soft Drink Consumption and Body Fat in Females Age 16 to 24

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ABSTRACT

Int J Exerc Sci 3(4) : 189-196, 2010. American soft drink consumption (SDC) has increased since the 1960's surpassing all other kinds of beverage consumption. In recent years, the scientific literature has suggested that SDC has been linked to the rising epidemic of obesity in children and adolescents. However, there is lack of information in scientific literature on the effects of SDC on body fat (BF%) in young females. The purpose of this study was to determine the association between SDC and BF% in young women, ages 16-24 years. Sixty-six females were asked to complete a 3-day food record, food frequency questionnaire, and an assessment BF% by dual-energy x-ray absorptiometry (DXA). Overall, participants consumed 29.44 ± 44.68 fl oz/day of soft drinks. There were significant positive associations between SDC and BF% ($r = 0.24$, $p < 0.05$). Due to the large standard deviation in SDC, secondary analysis compared moderate SDC (MSDC: < 32 fl oz/day) to high SDC (HSDC: ≥ 32 fl oz/day). Results suggested HSCD had significantly greater BF% than MSDC. Therefore, limiting the consumption of soft drinks is suggested in order to maintain a healthy BF%.

KEY WORDS: Body composition, Obesity, Late Adolescents

INTRODUCTION

Americans are ranked as the world's leading consumers of soft drinks with an increase in consumption since the 1960's. Soft drink consumption currently exceeds all other kinds of beverage intake such as water, milk, beer, or coffee (11). This increasing amount of soft drink consumption has recently been linked to the rising epidemic of obesity in children and adolescents (1,4,10,15). Therefore, the health risks associated with soft drink consumption have become an important public health issue.

Scientific research has found that during the same time period that obesity began its incline, so did the intake levels of high fructose corn syrup (HFCS), a simple sugar found in soft drinks (1,4,22). HFCS, made by enzymatic isomerization of fructose was introduced to the United States in 1967 as HFCS-42 (42% fructose) and introduced as HFCS-55 (55% fructose) in 1977 (4). Since its introduction, the total consumption of dietary fructose has increased by approximately 30%. This caloric sweetener is inexpensive to develop and now represents 42% of all added caloric sweeteners in the American diet (4,22).

The increase in consumption of soft drinks sweetened by HFCS has been linked to overconsumption of these beverages without decreases in subsequent food or beverage intake, resulting in increased daily energy intake (4,9,15,19). DiMeglio et al (9) found that participants were more likely to consume additional calories when on a fluid diet compared to participants on a solid food diet. The increase in soft drink consumption may also be a significant contributor to the obesity epidemic due to its low satiety levels and high caloric value (1,15,16). Most soft drinks are high in caloric value, but do not provide a feeling of fullness, hence, individuals tend to increase daily caloric intake when they consume soft drinks, which can lead to increased body fat. With an increase in body fat, individuals are placed at a greater risk of health problems including but not limited to type 2 diabetes, heart attack, stroke, and cancer (16).

Several studies have investigated the association of body fat and the intake of soft drinks among children and adolescents (1,15,16,22). Investigations completed by Malik et al. (16), Bawa et al. (1), and Ludwig et al. (15) all found positive associations between soft drinks and weight gain and obesity. However, there is a lack of information in the scientific literature relating to young women's dietary habits (specifically intake of soft drinks) as it relates to body composition. Therefore, the primary aim of this investigation was to determine the association between soft drink consumption and body fat in young women, ages 16 to 24 years. Specifically, it was hypothesized that a larger consumption of soft drinks is associated with increased percent body fat.

METHODS

Subjects

A convenience sample of 66 university females between 16 and 24 years agreed to participate in the current study (Table 1). Approval from the University of Nebraska at Kearney Institutional Review Board was obtained prior to subject recruitment, and written informed consent was obtained from each subject.

Table 1. Descriptive Characteristics of Participants (n=66)

Variable	Mean ± SD
Age (y)	20 ± 2
Mass (kg)	65.00 ± 11.37
Height (cm)	166.51 ± 6.35
Body Mass Index (kg $\cdot$ m^{-2})	23.50 ± 4.29
Body Fat (%)	33.20 ± 8.53

Three Day Dietary Analysis

Three-day food record measurements are an accurate and reliable method of measuring habitual food intake when compared to doubly labeled water (r = 0.71) (14). Therefore, participants were instructed to record brand name, portion size, method of preparation, and ingredients of all foods consumed, including liquids, for three consecutive days, including two week days and one weekend day, and each dietary analysis was reviewed with the participant using example portion sizes and food models to clarify incomplete responses.

Energy and nutrient intake were analyzed using Nutritionist PRO™ nutritional software by the principle investigator. All food and drink items were entered into the nutritional software by brand and amount, this allowed for quantitative analysis of each record. For each record, a full diet record nutrient analysis summary from which we obtained average intakes of energy (kilocalories/day), sugar (g/day), and soft drink consumption (fl oz/day). All other micronutrient and macronutrient intake values were archived to be used in later studies. A soft drink was defined as any non-alcoholic carbonated beverage, including both diet and non-diet choices.

Food Frequency Questionnaire

To capture habitual nutritional intake during the past year, participants completed a self-administered Block 2000-Brief Food Frequency Questionnaire (Block Dietary Data Systems, Berkeley, CA). The questionnaire requests information about the frequency of 70 food items, which are based on the National Health and Nutrition Examination Survey using a guide with, photographs of food portions (2,3,5). The abbreviated version of this questionnaire has been previously validated by comparison to multiple food records and full-length Block Food Frequency Questionnaire (3). A Women's Health Trial Validation study completed by Block et.al, (1990) compared the abbreviated version of the Block Food Frequency Questionnaire to the full-length version to analyze dietary intakes in similar populations. Validity is indicated between the two versions, when looking at overall macronutrients and micronutrients ($r = 0.6$-0.8) (3).

All completed questionnaires were sent to Block Dietary Data Systems, Berkeley, California for decoding and analysis of the responses given. For analysis, an index was created from data on frequency of non-diet soft drinks, milk, and juice consumption reported over twelve months. The frequency was calculated by how often participants consumed these beverages, multiplied by how many servings they consumed during each time. Options of frequency included never, a few times per year, once per month, two to three times per month, once per week, twice per week, three to four times per week, five to six times per week, or every day. For example, if participants consumed soft drinks less than two to three times per month they were considered low consumers and received a zero. If participants consumed soft drinks between once to twice per week, they were classified as moderate consumers and received a two. And if participant consumed between three to four time per week to everyday, they were classified as high consumers and received a five. This classification was then multiplied by how many servings of the beverage they reported consuming during each time frame. This food frequency questionnaire was utilized to evaluate habitual beverage choices of our population.

Body Composition

Body mass was determined using a Befour Platform Scale (PS6600), Befour Inc., Saukville, WI), accurate to 0.1 kg. Height was assessed using a standard wall mounted stadiometer, measured to the nearest 0.5 cm. Both body mass and height were measured without shoes, wearing only t-shirt, shorts, and undergarments.

To determine body composition, a whole body scan was performed using General Electric Prodigy Advance Plus dual energy x-ray absorptiometry (DXA) in conjunction with Encore 2002 software (GE Medical Systems Lunar, Madison, WI, USA). This method permits for the direct measurement and differentiation of three compartments of the body in one precise measurement, including: fat mass, fat-free mass, and bone mineral content (20). DXA provides regional assessment of the three compartments and is safe, non-invasive,

and convenient for the patient (6). DXA has been shown to be a precise method for assessing body composition (17).
Statistical Analysis.

Pearson correlation coefficients were calculated using SAS Statistical software for Windows (SAS Institute, Cary, NC). The correlation coefficients were computed to identify the association between soft drink consumption and body fat percent. ANOVAS were computed between high, moderate and no soft drink consumers for dependent variables to determine statistical differences between groups. Descriptive characteristics are presented as means ± standard deviations. A p-value of less than 0.05 was considered to be statistically significant.

RESULTS

The body mass index of participants was 23.50 ± 4.29 kg m^{-2}, placing them in normal ranges for females in this age group (7). Body fat was 33.20 ± 8.53%, when compared to females of the same age; our population was above average for percent body fat (21). Pearson correlation coefficients indicated a significant positive associations between soft drink consumption and body fat ($r = 0.24$, $p \le 0.05$, Figure 1).

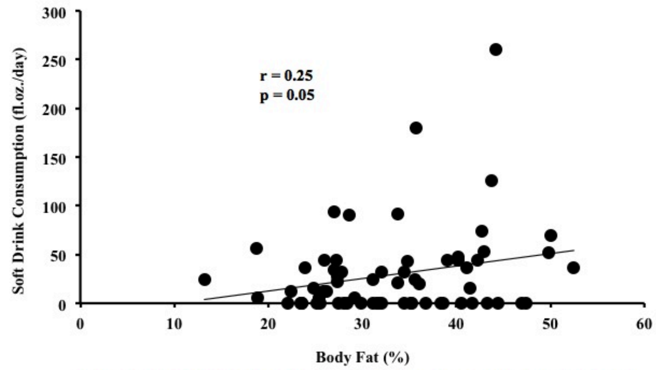

Figure 1. Association between Soft Drink Consumption and Percent Body Fat

The frequency of non-diet soft drink consumption was quite low (1.68 ± 3.11 out of 20 possible). Surprisingly, participants reported consuming milk more frequently (5.35 ± 4.63) than both non-diet soft drinks (1.68 ± 3.11) and juice (2.12 ± 2.83). Daily energy intake was 1764.0 ± 540.7 kilocalories, which is below average for females this age (13).

Due to the high standard deviation in soft drink consumption (29.44 ± 44.68 fl oz/day) of the entire group, the participants were divided into two groups: those who consumed soft drinks moderately (< 32 fl oz/day) and those who consumed high

Table 2. Overall Beverage Consumption

Variable	Mean ± SD
Soft Drink Consumption (fl oz/day)	29.44 ± 44.68
Milk Consumption (oz/day)	24.49 ± 24.27
Energy Intake (kcals/day)	1764.63 ± 540.74
Frequency of Non-diet Soft Drink Consumption [a]	1.68 ± 3.11
Frequency of Milk Consumption [a]	5.35 ± 4.63
Frequency of Juice Consumption [a]	2.12 ± 2.83
Sugar (g)	81.46 ± 35.31

[a] Frequency as calculated by how often participants consumed each beverage, multiplied by how many servings they consumed during each time as measured by Block Food frequency questionnaire

Table 3. Comparison Statistics for Moderate versus High Soft Drink Consumers

Variable	Moderate Soft Drink Consumers (<32 fl oz) N = 41	High Soft Drink Consumers (≥32 fl oz) N = 25
Age (Years)	19.73 ± 2.39	20.08 ± 1.66
Mass (kg)	62.85 ± 8.26	68.53 ± 14.68
Height (cm)	166.26 ± 6.12	166.91 ± 6.82
Body Mass Index (g/cm^2)	22.80 ± 3.25	24.65 ± 5.47
Body Fat (%)	31.35 ± 7.81	36.24 ± 8.94*
Soft Drink Consumption (fl oz/day)	6.05 ± 9.19	67.80 ± 52.91*
Milk Consumption (oz/day)	25.10 ± 22.08	23.00 ± 27.59
Energy Intake (kcals/day)	1721.18 ± 544.97	1804.37 ± 552.94
Frequency of Non-diet Soft Drink Consumption [a]	1.00 ± 1.57	3.00 ± 4.25*
Frequency of Milk Consumption [a]	6.00 ± 4.53	4.00 ± 4.48*
Frequency of Juice Consumption [a]	1.00 ± 1.99	3.00 ± 3.60*
Sugar (g)	79.05 ± 28.90	84.67 ± 43.90

Values are Mean ± SD *Significant differences between moderate soft drink consumers and high soft drink consumers ($p < 0.05$). [a] Frequency as calculated by how often participants consumed each beverage, multiplied by how many servings they consumed during each time

amounts of soft drinks (≥ 32 fl oz/day). This cut-point was set because of the average consumption for all participants and consideration of typical fluid ounce consumption amounts commercially available (Table 2).

No significant differences between groups were found for body mass index, caloric intake, or sugar intake (Table 3). However, there were significant differences ($p \leq 0.05$) between groups for soft drink consumption and body fat. Soft drink consumption of high consumers was 91.1% greater than that of the moderate consumers, while body fat was 13.5% greater. Frequency of beverage choices of high soft drink consumers indicated that they drank significantly less milk and significantly more non-diet soft drinks and juice compared to moderate soft drink consumers (Table 3).

Pearson correlation coefficients for soft drink consumption and body fat were computed for the moderate consumer and high soft drink consumer groups; there was no significant association between soft drink consumption and body fat for either the moderate soft drink consumer or the high soft drink consumer groups ($p > 0.05$). However, a significant association was found for all sixty-six participants ($p < 0.05$).

DISCUSSION

The purpose of the current investigation was to determine the association between soft drink consumption and body fat. It has been previously suggested that soft drink consumption is associated with increased body fat in children and adolescents (4,8,9). Our data with young healthy females ages 16 to 24 years indicates a significant positive association between soft drink consumption and body fat ($r = 0.24$, $p \leq 0.05$). Although the correlation is low, it may be driven by the large discrepancy in soft drink consumption from none, to 260 fl oz per day.

Our study population was a convenience sample and may have been healthier than a random sample. Overall soft drink consumption was 29.44 ± 44.68 fluid ounces per day. Others have indicated that approximately 25% of children and adolescents in the United States consume more than 26 fluid ounces of soft drinks per day (12) while 39.4% of our participants reported consuming more than 26 fluid ounces per day. This indicates that our participants may be at a greater risk of encountering the negative effects of soft drinks than a younger population.

Due to the large standard deviation in amount of soft drinks consumed and high percent of participants that reported not consuming any soft drinks (39.4%) we choose to reanalyze our aims with moderate soft drink consumers and high soft drink consumers. Moderate consumers are those participants who consume less than 32 fluid ounces of soft drinks per day, and high consumers are those who consume greater than or equal to 32 fluid ounces of soft drinks per day. There were no significant differences between non-soft drink consumers and moderate soft drink consumers for any dependent variable; hence, they were combined into one group for comparison.

In a study by Ludwig et al. (15), it was estimated that children who consumed one sugar-sweetened beverage per day had a 1.6 times greater chance of becoming obese in adulthood. Although low associations were found between soft drink consumption and body fat ($r = 0.24$, $p \leq 0.05$), high soft drink consumers had a significantly higher percent body fat (36.24 ± 8.94%) when compared to moderate soft drink consumers (31.35 ± 7.81%). High soft drink consumers are consuming 8.4% less milk and 91.1% more soft drinks in their diet than that of moderate soft drink consumers. In addition, the high consumer's frequency of milk intake is lower and non-diet soft drink and juice intakes are higher. These are indications that our high soft drink consumers may be replacing more nutrient dense beverages with soft drinks, which may lead to unhealthier lifestyle choices which effect body fat.

In several studies, researchers have indicated that soft drink consumption increases the total daily caloric intake (1,9,8,12,18). This is due to the lack of adjustment in caloric intake made in subsequent meals increasing total body fat. Among our participants, there was not a statistically significant association between soft drink consumption and caloric intake ($r = 0.23$, $p > 0.05$), however, the positive trend suggests those with higher soft drink consumption were indeed consuming more calories. There was no statistical significant difference in caloric intake between the moderate consumer (1721.18 ± 544.97 kcals/day) and high soft drink consumer groups (1804.37 ± 552.94 kcals/day, $p > 0.05$) with only a 83 kcal per day difference.

Accurate measurement of dietary intake and balance of calories in and calories out is important for the maintenance of stable body mass. An excessive amount of caloric consumption has been linked to products high in simple sugar, or high fructose corn syrup (1,4). With the increasing soft drink consumption in young females, there is an increase in intake of high fructose corn syrup. For our participants who reported consuming soft drinks, the amount of non-diet soft drinks consumed ranged from 5 to

260 fluid ounces per day. On average, each 12 fluid ounces of non-diet soft drink contributes 40 to 50 grams of sugar. Therefore, the soft drink consumers may be taking in anywhere from 16.7 grams to 1083.3 grams of sugar per day. The American diet is high in sugar and soft drinks are not the sole contributor to sugar intake, however, they can significantly enhance the potential intake of sugar.

Some of the limitations of our study must be acknowledged. First, the sample size was relatively small (n=66). This cross sectional study was not population based and participants were chosen by a convenience sample. Participants were predominately white Americans which may limit our ability to generalize the results to non-whites. Second, the food frequency questionnaire that was used did not evaluate the intake of diet soft drinks. And third, the study did not take lifestyle into consideration. Therefore, future studies should use a larger random sample, should consider better methods to quantify diet versus non-diet soft drinks and should add a questionnaire to evaluate habitual lifestyle behaviors.

Conclusion

This study highlights the possible repercussions of soft drink consumption to overall health in young females by examining the associations between soft drink consumption and body fat. Sixty-two percent of participants reported consuming less than 32 fluid ounces of soft drinks per day (including those who did not consume any soft drinks), while 38% of participants reported consuming greater than or equal to 32 fluid ounces per day. There were significant differences in percent body fat between the moderate consumer and high consumer groups. Our findings suggest with the increase in the obesity epidemic in the United States, recommendations to limit or eliminate soft drink consumption may be recommended.

REFERENCES

1. Bawa S. The role of the consumption of beverages in the obesity epidemic. J of the Royal Soc for the Promo of Health 125: 124-128, 2005.

2. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data- based approach to diet questionnaire design and testing. Am J of Epi 124: 453-469, 1986.

3. Block G, Hartman AM, Naughton D. A reduced dietary questionnaire: Development and validation. Epidemiology 1: 58-64, 1990.

4. Bray GA, Nielsen SJ, Popkin BM. Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. Am J of Clin Nut 79: 537-543, 2004.

5. Brehm B, Gates D, Singler M, Poeppelman A, Succop P, D'Alessio D. Prevalence of obesity and cardiovascular risk factors among manufacturing company employees in Kentucky. Am Assoc for Occ Health Nurses J 55: 397-406, 2007.

6. Brownbill RA, Ilich JZ. Measuring body composition in overweight individuals by dual energy x-ray absorptiometry. Bone Mineral Content Med Imaging 5:1, 2005.

7. Centers for Disease Control and Prevention (Internet). About BMI for Adults; cited 2009 Jan 27. Atlanta, GA, Centers for Disease Control and Prevention.

8. Dhingra R, Sullivan L, Jacques PF, Wang TJ, Fox CS, Meigs JB, D'Agostino RB, Gaziano JM, Vasan RS. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. Circulation 116: 408-488, 2007.

9. DiMeglio DP, Mattes RD. Liquid versus solid carbohydrate: effect on food intake and body weight. Int J of Ob 24: 794-800, 2000.

10. Fitzpatrick L and Heaney RP. Got Soda? J of Bone and Min Research 18:1570, 2004.

11. Garcia-Contreras F, Paniagua R, Avila-Diaz M, Cabrera-Munoz L, Martinez- Muniz E, Foyo-Niembro E, Amato D. Cola beverage consumption induces bone mineralization reduction in ovarectimized rats. Arch of Med Research: 31, 360-365, 2000.

12. Harnack L, Stang J, Story M. Soft drink consumption among US children and adolescents: nutritional consequences. J of Am Dietetic Assoc 99: 436-441, 1999.

13. Heyward V. Advanced Fitness Assessment and Exercise Prescription. Champaign, IL: Burgess Publishing Company, 2006.

14. Hise ME, Sullivan DK, Jacobsen DJ, Johnson SL, Donnelly JE. Validation of energy intake measurements determined from observer-recorded food records and recall methods compared with the doubly labeled water method in overweight and obese individuals. Am J of Clin Nut 75: 263-267, 2002.

15. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: A prospective, observational analysis. The Lancet 357: 505-508, 2001.

16. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: A systematic review. Am J of Clin Nut 84: 274-288, 2006.

17. Mazess, RB; Barden, HS; Bisek, JP, Hanson, J. Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. Am J of Clin Nut 51(6): 1106-1112, 1990.

18. Mrdjenovic G, Levitsky D. Nutritional and energetic consequences of sweetened drink consumption in 6- to 13-year-old children. J of Ped 142: 604-610, 2003.

19. Raben A, Vasilaras TH, Moller AC, Astrup A. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. Am J of Clin Nut 76: 721-729, 2002.

20. Reid IR. Relationships among body mass, its components, and bone. Bone 31: 547-555, 2002.

21. Williams JE, Wells JC, Wilson CM, Haroun D, Lucas A, Fewtrell MS. Evaluation of Lunar Prodigy dual-energy X-ray absorptiometry for assessing body composition in healthy persons and patients by comparison with the criterion 4-component model. Am J Clin Nut 83: 1047-1054, 2006.

22. Wolff E, Dansinger ML. Soft drinks and weight gain: how strong is the link? Medscape J of Med 10: 189, 2008.