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Research Article
Consumption of Sugar-Sweetened Soft Drinks Among Saudi Adults: Assessing Patterns and Identifying Influencing Factors Using Principal Component Analysis

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Abstract

Background and Objective: Previous studies showed that the Saudi population is one of the largest consumers of soft drinks in the Middle East. However, most of these studies explored patterns with very little focus on the factors that influence soft drink consumption. The present study aimed to identify factors associated with sweetened soft drink consumption in Saudi adults and the association between different factors using principal component analysis (PCA). **Materials and Methods:** A cross-sectional study was performed from July-September 2016 in Saudi Arabia, in which 1,194 eligible adult Saudi participants answered an online questionnaire. Data were collected on the amount and frequency of soft drinks consumed and factors that can influence consumption. All responses were categorized using a 5-points Likert scale. Statistical analysis was performed using SPSS and PCA was performed using orthogonal rotation with a varimax option to identify influencing factors. **Results:** Sixteen percent of the participants reported that they consumed soft drinks daily or frequently (3-6 times/week). The correlation coefficient between frequency and quantity of consumption was $R^2 = 0.39$ ($p<0.0001$). Barlett's test was significant and the KMO test was 0.8. PCA revealed two components with approximately 56.1% combined variance: 14.7% constituted "individual" grouping factors of eating at home and watching TV/electronic device use and 41.4% were attributable to "social-environmental" grouping factors, such as availability, affordability, advertising and social gathering. **Conclusion:** Patterns of sweetened soft drinks consumption in adult Saudis were complex and influenced by socio-environmental and individual factors. A comprehensive approach focusing on these factors is needed to limit soft drink consumption.

Key words: Obesity, principal component analysis, Saudi adults, Saudi Arabia, sweetened soft drinks

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sweetened soft drinks are a major source of added simple sugars in the human diet[1]. Several epidemiological studies demonstrated that these drinks are one of the main contributors to obesity and related health problems globally[1-3]. Indeed, a clear association was demonstrated between soft drink intake and increased energy intake, body mass index (BMI) and diabetes worldwide[3]. Saudi Arabia is the country with the largest soft drink consumption in the Middle East region according to a 2015 Euromonitor International report[4]. This high consumption could be explained by the hot climate, which demands cool drinks, a large youth market and the adoption of food products that are produced and consumed in the Western world. Notably, there has been a corresponding rise in the rates of obesity and diabetes in Saudi Arabia. Saudi Arabia is among the top 10 countries of the prevalence of obesity and diabetes, with overall rates of 33.7 and 23.7%, respectively[5-7]. To address this menace, the Saudi government launched the National Transformation Program in 2016 to enhance the health status of the Saudi population, with a priority of reducing the obesity incidence by 1% by 2020[8]. Sweetened soft drinks were subjected to selective taxation as an additional measure with the goal of decreasing the population's consumption of these drinks. However, dietary behaviours are the result of the influence of various independent factors and their synergic interactions[9]. For instance, factors such as availability, affordability, food preference and lifestyle, may affect the quantity and frequency of sweetened soft drink consumption[10-11]. Therefore, evaluations of dietary patterns should be performed as a broader picture instead of a single factor effect. Consistent with this suggestion, current research focusing on nutrition and behaviour is shifting from a classical approach to exploratory approaches based on statistical dimension-reduction methods to examine dietary patterns[12]. Principal component analysis (PCA) is the most-used dimension-reduction method to derive dietary patterns[12].

The effects of different factors on a specific dietary pattern vary between communities and nations[13-15]. Therefore, successful interventions for optimal changes to a given dietary pattern should be tailored to the target populations. Few studies examined the consumption of sweetened soft drinks in Saudi Arabian adults and most studies are descriptive with very little focus on factors that influence consumption[16-19]. Therefore, the present study identified these factors and assessed associations of different factors on the frequency or amount of sweetened soft drinks consumed in Saudi adults. The PCA method was used as a dimension-reduction analysis to provide an in-depth exploration on how these factors should be considered.

Methods

Study design and subjects:

A cross-sectional study was performed from July-September 2016 as a countrywide survey using an online questionnaire. A total of 1,348 eligible Saudi adults (1,037 females and 311 males) aged 20-60 years were recruited using the snowball technique. Participants who were diabetic, diagnosed with osteopenia and/or osteoporosis, under specific diets to lose weight, or residing outside Saudi Arabia did not participate in the study. Information on the objective of the research study, the nature of expected participation and the eligibility criteria were made available to the respondents. They were also informed of their right to accept or refuse participation and the ability to withdraw at any time while answering the questionnaire. Only participants who gave consent were allowed to answer the survey questions. All responses were confidential and all data analyses were performed anonymously. Any participant with incomplete answers was excluded (n = 154) from the study.

Research instrument: The online questionnaire was comprised of the following sections:

- Socio-demographic information including age, sex, monthly income, marital status and educational level.
- Sweetened soft drink consumption patterns: This contained information on the quantity and frequency of consumption. The quantity at each instance of soft drink consumption was determined as ½ can, 1 can, 2 cans or more than 2 cans. Frequency of consumption was estimated using a 5-score scale. A score of 1 indicated no consumption and a score of 5 indicated everyday consumption.
- Factors influencing soft drinks consumption patterns were availability, affordability, social gathering, TV/electronic device use, advertising and eating outside or inside the home. These factors were identified as probable causes in previous studies[15,20-21]. Participants were asked to score on a scale of 1-5 how much they agreed or disagreed that a given factor increased the likelihood or frequency of soft drink consumption. The response categories used a 5-point Likert scale: (1) I strongly disagree, (2) I disagree, (3) I neither disagree nor agree, (4) I agree and (5) I strongly agree[22].

- Before performing the large-scale online survey, the questionnaire was tested using two focus groups of 20 individuals each to guarantee its simplicity and clarity for the respondents. The questionnaire reliability was demonstrated using Cronbach's coefficient alpha ($\alpha = 0.72$) (CI: 95%).

Ethical approval: Ethical approval was obtained in May 2016 from the Research Ethics Committee of College of Health and Rehabilitation Sciences (REC-CHRS) (Ethics number Z-F002) at Princess Nourah University (Riyadh, KSA).

Statistical analysis: Sample characteristics were described using means and standard deviation (SD) for continuous variables and percentages for categorical variables. One-way ANOVA was used to assess differences between groups based on frequency of consumption and the scoring of the factors. The chi-square test was applied to assess correlations between different parameters. A p-value of <0.05 was used as the significance cut-off.

The studied factors were entered into a principal component analysis (PCA) procedure using orthogonal rotation with a varimax option to drive the optimal non-correlated components. The correlation matrix of the standardized factors was considered to agree on the number of components to retain based on eigenvalue >1.0 and interpretability. Before running the PCA, the Barlett's test and the Kaiser-Meyer-Olkin (KMO) test were used to evaluate the relevance of the data for PCA. The obtained components were interpreted based on the included factors. All statistical analyses were performed using SPSS software (version 24.0).

RESULTS

A total of 1,348 Saudi adults participated in the survey and 1,194 participants (~89%) completed the questionnaire. Demographic characteristics and patterns of sweetened soft drink consumption of the studied population is presented in Table 1. Nearly 75% were women and more than half were aged between 20-29 years. Fifty percent of the participants were single and 46.3% were married. Most of the participants had university degrees (71.9%) and approximately 10% had postgraduate degrees. Different levels of economic status were observed in the study sample, in which 41.3% reported a monthly income less than 5000 Saudi Riyals (SR), which is equivalent to US $1,333/month.

A total of 85.8% of the participants in this study reported consumption of sweetened soft drinks and only 14.2% reported no consumption. Analysis of the frequency of consumption found that 6% consumed soft drinks daily and 26.8% consumed soft drinks at least once weekly. A total of 38.7% of the participants reported drinking one can of soft drink and only 4% of participants consumed two cans or more each time. Correlation analyses between the frequency and quantity of consumption revealed a significant moderate positive correlation between these factors ® = 0.39, p<0.0001). The next analyses determined how and what factors influenced the consumption of soft drinks among the participants. The most common factor was influenced the consumption when eating outside of the home, followed by habit and affordability (38.5, 25.8 and 24.1%, respectively). Notably, the lowest percentages for consumption were

Table 1: Demographic characteristics and patterns of sweetened soft drink consumption of the studied population

Parameters	Percentage (n =1194)
Sex	
Female	76.5
Male	23.5
Age (years)	
20-29	58.0
30-39	24.9
40-49	12.9
50-59	4.2
Marital status	
Single	50.4
Married	46.3
Divorced	2.8
Widow	0.5
Educational level	
Primary	1.1
Secondary	16.8
University	71.9
Master/PhD or equivalent	10.2
Monthly income (SAR)*	
<5000	41.3
5000-10000	29.4
11000-20000	22.5
>20000	6.8
Frequency of soft drink consumption	
Never	14.2
Rarely (1-3 times per month)	41.5
Sometimes (1-2 times per week)	26.8
Frequently (3-6 times per week)	11.5
Daily	6.0
Quantity of soft drink consumed each time	
Less than 1 can	57.2
1 can	38.7
2 cans	3.4
More than 2 cans	0.8

Correlation between frequency and quantity of consumption* $R^2 = 0.39$, p<0.0001, SAR: Saudi Riyals, *Correlation was calculated using Chi-squared test

Table 2: Factors influencing sweetened soft drink consumption among participants (n = 1194)

	I strongly disagree	I disagree	I neither disagree nor agree	I agree	I strongly agree
Availability	15.2	13.3	24.8	25.6	21.1
Affordability	20.6	13.0	21.3	21.0	24.1
Advertising	25.3	14.5	23.3	16.6	20.3
Habit	16.8	10.1	22.4	25.0	25.7
Eating out	12.6	8.7	16.4	23.8	38.5
Eating at home	30.0	22.1	25.5	12.1	10.3
TV watching/using electronic devices	30.1	17.8	26.0	14.5	11.6
Social and family gatherings	14.6	10.1	27.3	31.3	16.7

Results are presented as percentage of the total population for each factor. Response categories used a 5-point Likert scale

Table 3: Correlation ® between different factors influencing sweetened soft drink consumption among participants (n = 1194)

	Frequency of consumption	Social gathering	Availability	Affordability	Advertising	Habits	Out of home eating	At home eating	TV/electronic device use
Frequency of consumption	1.000								
Social gathering	0.182	1.000							
Availability	0.196	0.501	1.000						
Affordability	0.155	0.364	0.558	1.000					
Advertising	0.071	0.240	0.324	0.386	1.000				
Habits	0.178	0.405	0.490	0.386	0.446	1.000			
Out of home eating	0.178	0.461	0.456	0.421	0.355	0.571	1.000		
At home eating	0.295	0.111	0.123	0.171	0.087	0.016	NA	1.000	
TV/electronic device use	0.188	0.230	0.199	0.213	0.274	0.224	0.200	0.434	1.000

All correlations are significant ($p<0.05$), except at home eating with habits. Correlations were assessed using Pearson's test

observed when eating at home and watching TV/using electronic devices (10.3 and 11.6%, respectively). Affordability, availability and advertising were almost equally distributed amongst the different scorings (Table 2).

The present study also observed a correlation between the frequency of consumption of sweetened soft drinks and its related factors (Table 3). All factors positively correlated to consumption frequency and this correlation was statistically significant for all factors. The strongest correlation was observed for eating at home, followed by availability and TV/electronic device use R = 0.295, R = 0.196 and R = 0.188, respectively). Notably, strong correlations between the other factors were also detected, including habits and eating outside of the home R = 0.571), affordability and availability R = 0.558) and availability and social gathering R = 0.501).

The next analyses used principal component analysis (PCA) of the factors that influenced soft drink consumption in Saudi adults to identify the major components (Fig. 1). The Kaiser-Meyer-Olkin measurement of sampling adequacy was 0.8, which indicates that the patterns of correlations were relatively compact and the factor analysis will yield distinct and reliable components. Bartlett's Test of Sphericity was highly significant (p = 0.000), which indicated that PCA was appropriate for this study. PCA identified two components that were related to sweetened soft drink consumption. The first component (Component-1) was characterized by high factor loadings for social gathering, availability, affordability, advertising, habits and eating outside of the home, which were labelled as "socio-environmental factors". The second component (Component-2) identified by PCA was characterized by high factor loadings for eating at home and TV/electronic device use, which were labelled "Individual factors". Together, these components explained 41.3 and 16.4% of the variations in sweetened soft drink consumption, respectively.

DISCUSSIONS

The present study examinee factors that affected sweetened soft drink consumption in Saudis adults using PCA-based one-dimension reduction analysis. This analysis provided a comprehensive understanding of how different factors collectively caused Saudi adults to become excessive consumers of these drinks. The present study demonstrated that 85.8% of adults in Saudi Arabia consumed sweetened soft drinks and 43% consumed one can (330 mL) or more each time. This finding supports the evidence that Saudi Arabia is the largest consumer of soft drinks in the Middle East region[4]. This consumption is occurring despite the well-established association of sweetened soft drink consumption with serious health problems, such as increased risk of type 2 diabetes mellitus, dental caries, metabolic syndrome and cardiovascular diseases[23-25]. A previous study suggested that each can of soft drink consumed per day increased the risk of obesity by 60%[26].

The present study demonstrated a significant positive correlation between the frequency of consumption of

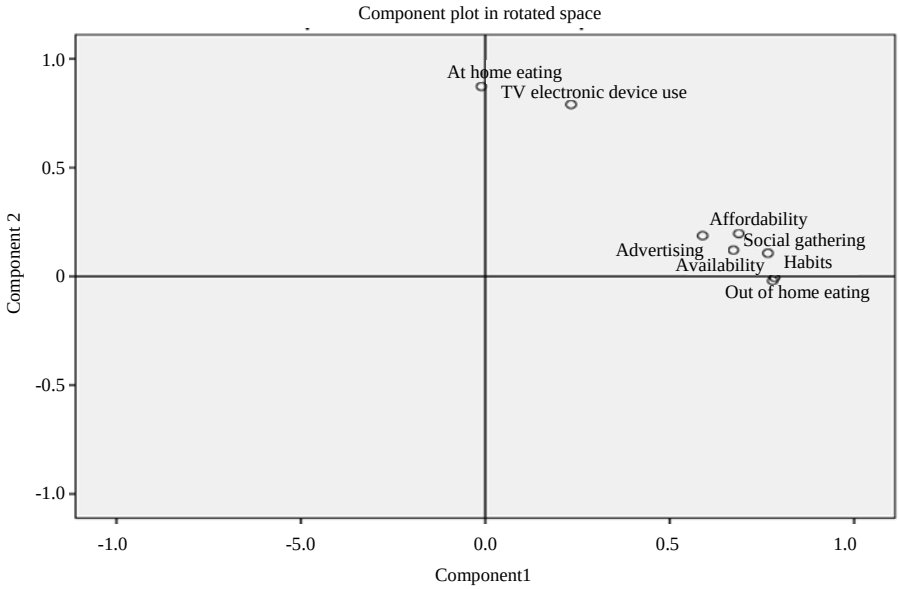

Fig. 1: Results of principal component analysis of factors influencing sweetened soft drink consumption in adult Saudis

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Kaiser-Meyer-Olkin Measure of Sampling Adequacy: 0.802, p-value: 0.000, Component 1 was labelled "socio-environmental factors" and component 2 was "Individual factors". These components explained 41.3 and 16.4% of variation in sweetened soft drink consumption, respectively

sweetened soft drinks and the amount consumed each time. This result suggests that reducing the frequency of consumption should be targeted, rather than quantity, to reach an overall substantial decrease in consumption. Therefore, attempts to decrease sweetened soft drink consumption among adults in Saudi Arabia requires the investigation of possible related factors that affect consumption frequency. Potential factors influencing consumption frequency in adults in this study were investigated using PCA, which reduced the multiple variables included as determinants of soft drink consumption into major components. The results of the analyses identified two main components, which were labelled as individual factors and socio-environmental factors. Individual factors included personal lifestyles, such as eating at home and TV/electronic devise use and socio-environmental factors included social gathering, availability, affordability, advertisements, habits and eating outside of the home. The socio-environmental factors explained 41.3% of the overall variance and the individual factors explained only 14.6% of the overall variance. Socio-environmental factors were more strongly correlated to the consumption frequency of sweetened soft drinks than individual lifestyle factors. These socio-environmental factors may have appeared due to the rapid social evolution in the last three decades in Saudi Arabia towards a Western lifestyle, which includes access to supermarket beverages, eating outside of the home, social norms related to the consumption of unhealthy beverages and the widespread advertisement of soft drinks[27]. This finding suggests that attempts to limit sweetened soft drink consumption by adult Saudis should primarily focus on the modification of socio-environmental factors in addition to changes in personal lifestyle. Efforts to tackle soft drink consumption frequency should primarily concentrate on socio-environmental factors using governmental policies and regulations to control availability, advertising and cost. Individual factors should also be targeted using nutrition education campaigns as complementary efforts to help curb soft drink consumption.

The present study demonstrated that soft drink availability and affordability were significantly associated with an increased frequency of consumption. Bere *et al.*[28] reported that the availability of soft drinks at home was associated with increased consumption, which is consistent with our finding. They stated that increased distance to a shop tended to reduce the odds of drinking regular and diet soft drinks[28]. Van Der Horst *et al.*[29] revealed an inverse correlation between soft drink consumption and a 200-300 m distance to the nearest store. This result suggests that availability is an important determinant in the modification of soft drink consumption. The affordability of soft drinks positively correlated with a high consumption of soft drinks in secondary school students in

Australia[25], which is consistent with our results. Students who had at least $40 AU per week to spend on themselves were more likely to consume a high amount of soft drinks than those who had less than $10 AU. Similar findings were reported in children aged 13-14 years, in whom the cost and availability of soft drinks were significantly associated with increased consumption[26]. For advertising, food marketing is known to stimulate individuals' purchase requests[20]. The present study demonstrated that advertisements significantly correlated with the consumption frequency of soft drinks. Scully *et al.*[25] documented that advertisements encouraging soft drink consumption were the second-most effective way to influence adolescent's ability to control their behaviour in USA[25], which is consistent with the results of the present study.

The present study confirmed a positive association between watching TV and increased frequency of soft drink consumption. Watching TV for more than two hours per day was associated with high soft drink consumption in secondary school students[25], which is consistent with the result of the present study.

CONCLUSION

In conclusion, the present research confirmed that sweetened soft drink consumption among Saudi adults was high and demonstrated that consumption frequency and quantity were significantly associated. The results of the current study also revealed that these patterns of consumption were influenced by two main categories of components obtained by PCA: socio-environmental and individual. Therefore, nutrition education campaigns alone are not sufficient to tackle the high sweetened soft drink consumption frequency in Saudi adults and these efforts should be combined with governmental efforts and regulations that target the availability, affordability and advertising of soft drinks. Increasing alternative healthy food is needed to further reduce sweetened soft drink consumption among Saudis.

SIGNIFICANCE STATEMENT

The present study, first time, identified the socio-environmental and individual factors that influence sweetened soft drink consumption, which was not explored in previous studies. Therefore, new policies on reducing the high consumption of sweetened soft drinks in Saudi adults may be formulated and implemented.

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