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ORIGINAL CONTRIBUTION

# Dietary intakes, sources, and determinants of free sugars amongst Lebanese children and adolescents: findings from two national surveys

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## Abstract

**Purpose** To determine the intake levels, dietary sources, and determinants of free sugars (FS) consumption amongst Lebanese children and adolescents.

**Methods** This study is based on data collected by two national cross-sectional surveys conducted on representative samples of Lebanese children: survey 1 (under-five years (U5) children) ($n=899$) and survey 2 (5–18 years-old children) ($n=1133$). Multi-component questionnaires were used for data collection. Dietary intakes were assessed using one 24 h dietary recall. Median daily intakes of FS, and percent contribution of various food groups to FS intake were compared between sex and age groups. Logistic regressions were conducted to explore the determinants of high FS intake (> 10% energy intake/d), as per the WHO recommendations.

**Results** Median contribution of FS to daily energy intake was 8.5% in U5 children and 11.9% amongst those aged 5–18 years old. The top contributors to FS in both surveys were sugar-sweetened beverages and biscuits and chocolates. The proportion of children and adolescents exceeding WHO upper limits for FS was estimated at 43 and 62% in survey 1 and survey 2, respectively. Regression models showed females, higher household monthly incomes and higher parental educational levels were associated with significantly lower odds of exceeding the WHO upper limit for FS.

**Conclusion** The study showed that a high proportion of Lebanese children and adolescents exceeded the WHO upper limit for FS intake, while also documenting a socioeconomic gradient in FS intake. Findings call for devising food system-based interventions to help reduce FS intake in this nutritionally vulnerable age group.

**Keywords** Free sugars · Dietary intakes · Food sources · Children · Adolescents · Lebanon

## Abbreviations

| | |
|---|---|
| 24-h | 24-H recalls |
| AOR | Adjusted odds ratio |
| CI | Confidence interval |
| EI | Energy intake |
| ELNAHL | Early Life Nutrition and Health |
| EMR | Eastern Mediterranean Region |
| FS | Free sugars |
| L-FANUS | Lebanese Food and Nutrition Security Survey |
| OR | Odds ratio |
| SE | Standard error |
| SSBs | Sugar sweetened beverages |
| U5 | Underfive |
| WHO | World Health Organization |

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## Introduction

Similar to other countries of the Eastern Mediterranean Region (EMR), Lebanon is witnessing the nutrition transition, with its characteristic shifts in diet, lifestyle, and body composition [1]. One of the hallmarks of the nutrition transition is an increase in sugar intake and the consumption of

sweetened processed foods [2]. The population group that may be the most vulnerable to the ongoing nutrition transition and the concurrent shifts in diet and eating practices are children and adolescents [3]. This is a public health concern given that excessive sugar intake has been suggested as a potential driver for weight gain and cardiometabolic diseases in the pediatric population [4, 5].

Sugars can be found naturally in foods, such as fruits, vegetables, and milk, but may also be added to foods during processing and preparation [5]. Different terminologies have been suggested to differentiate between the various types of sugar. While the term "Total Sugars" comprises all mono- and disaccharides present in foods, the term "Added Sugars" is used to designate sugars that were intentionally added to foods and beverages to sweeten the flavor, improve palatability, or preserve and confer functional attributes [5]. The World Health Organization (WHO) uses the term "Free Sugars" (FS), which is defined as "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer (i.e. added sugars), plus sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates (i.e. non-milk extrinsic sugars)" [6]. The FS term is therefore used to describe sugars that may have physiological consequences different from those related to intrinsic sugars that are encapsulated within intact plant cell walls or lactose, which is naturally present in milk [5, 7].

High consumption of FS has been associated with poor overall dietary quality, and was suggested to contribute to excessive energy intake (EI) and unbalanced energy expenditure [8–10]. In children and adolescents, FS intake was associated with the development of overweight and obesity [11, 12], insulin resistance [13], and high levels of low-density lipoproteins and triglycerides [14]. In addition, FS are recognized as the most important dietary cause of dental caries in children and adolescents [15]. In 2015, the WHO updated sugar dietary guidelines and recommended reducing the intake of FS to less than 10% EI as a 'strong recommendation' [6], based on moderate quality evidence from observational studies of dental caries [6].

Previous studies conducted in different parts of the world have documented high intakes of FS in children and adolescents. In Europe, the contribution of FS to total daily EI was reported to range between 14 and 21% in children and adolescents [16–20], while estimates ranged between 16 and 26% in the USA, New-Zealand, Canada, and Australia [21–26]. Studies investigating FS intake are lacking in the EMR, despite the fact that the region harbors one of the highest burdens of pediatric obesity worldwide [3]. This study aims to determine the intake levels of FS amongst Lebanese children and adolescents, identify their main dietary sources, and investigate the socioeconomic and demographic determinants of FS intake amongst the study population.

## Materials and methods

### Study design

This study is based on data collected by two national cross-sectional surveys conducted in Lebanon. The first survey, "*Early Life Nutrition and Health*", (ELNAHL), was conducted in 2011–2012 and included a representative sample of Lebanese children aged 0–5 years [27, 28]. The second survey, "*Lebanese Food and Nutrition Security Survey"* (L-FANUS), was conducted in 2014–2015, and included a representative sample of Lebanese households with 4–18 year old children and adolescents [29, 30]. The two surveys were conducted using similar designs, data collection methods, dietary assessment approach and questionnaires for demographic and socioeconomic indicators. Detailed descriptions of the surveys' protocol were published elsewhere [27–30].

In brief, in both surveys the primary sampling unit was the household. The selection of households was based on a stratified cluster sampling strategy: the strata were the six governorates of Lebanon and the clusters were selected further at the level of districts. In each district, the selection of households was based on a probability proportional to size approach, with a higher number of participating households being drawn from more populous districts; the selection of households in districts was conducted using systematic sampling [28].

Sample size calculation for survey 1 (ELNAHL) was based on a prevalence of 13% of overweight and obesity [31]. Accordingly, a sample of 1,030 under-five children (U5) was needed, with a 2% error and a 95% confidence interval (CI). To be eligible to participate in survey 1, households had to include a mother and a child aged 5 years or below. Of the 1194 eligible households that were contacted, 1029 participated in the survey (response rate 86%). Children and their mothers were not included if children were of non-Lebanese nationality, were born preterm (< 37 weeks), or suffered from any chronic illness, inborn errors of metabolism, or physical malformations that may alter normal dietary intake.

For survey 2, sample size calculation was based on a prevalence of 10.9% of obesity amongst children aged 6–18 years [32]. Accordingly, a minimum sample of 1200 children was needed with a 1.8% margin of error and a 95% CI. For a household to be eligible for survey 2, it should include a Lebanese mother and her child between the ages of 4 and 18 years, both mother and child should be present at the time of the interview and do not have medical conditions or chronic diseases that may affect growth or nutritional status. A total of 4076 households were approached and 3147 agreed to participate (response

rate 77%). Of these, 1221 households met the eligibility criteria, of which 1209 completed the interview. Details about the survey are published elsewhere [29].

For the purpose of the present study, data related to children aged 6 months–5 years were included from survey 1, and data pertinent to 5–18 years old children were included from survey 2.

## Ethical considerations

Both surveys were performed according to the guidelines laid down in the Declaration of Helsinki and were approved by the Institutional Review Board of the American University of Beirut (NUT.LJ.03 and NUT.LN.13). Written informed consent was obtained from mothers prior to enrollment in the study and assent was obtained from children above 6 years of age.

## Data collection

In both surveys, data was obtained through face-to-face interviews. For children aged less than 10 years, the interview was conducted with the mother, as a proxy, in the presence of the child. For children aged 10 years or above, the interview was conducted directly with the child, in the presence of the mother for assistance. Interviews were held in the household setting and lasted for approximately one hour. Trained nutritionists collected data, using age-specific multi-component questionnaires covering information on demographic, socioeconomic, and dietary intakes. Demographic characteristics consisted of the following: sex of the child, age of the child and age of his/her mother (years). Socioeconomic indicators included mother's and father's educational levels (primary school or less; intermediate/high school/technical diploma; or university degree), maternal employment status (employed vs not employed) and household's monthly income (< 1,000,000 Lebanese pounds; 1,000,001–3,000,000 L.L.; > 3,000,000 L.L.), which are amongst the commonly utilized indicators of socioeconomic status (SES) [33]. In addition for children participating in survey 2, physical activity was evaluated using the modified version of the Children and Youth Physical Activity questionnaire [34]. Children were categorized as meeting or not meeting the recommendations if they engaged or not in 420 min/week of moderate-to-vigorous activities, respectively, as per the WHO recommendations of physical activity in young individuals [35].

## Dietary intake assessment

For the present study, dietary assessment in both surveys, was based on single multiple pass 24-h recalls (24-h), which were conducted using the USDA multiple pass five-step approach [36]. While collecting the dietary data, specific attention was made to obtain information about foods consumed at daycare or school. For young children, and in case another caretaker shared the responsibility of feeding the child, the mother directly consulted with him/her for further information pertinent to the dietary interview.

The Nutritionist Pro software (version 5.1.0, 2014, First Data Bank, Nutritionist Pro, Axxya Systems, San Bruno, CA, USA) was used for the analysis of dietary intake data. Within the Nutritionist Pro, the USDA database was selected for analysis. This allowed for the estimation of the intake of energy (kcal), carbohydrates, and total sugars in grams per day (g/day); and thereafter the calculation of FS intake (g/day) [7]. As data for lactose were available in the database, lactose intake was subtracted from total sugars. Free sugar intake was calculated based on the 10-step methodology proposed by Kibblewhite et al. (2017) and which consists of a modification of the method of Louie et al. [37, 38] that was originally developed for added sugar calculation. As per the definition of the WHO, sugars naturally present in unsweetened fruit juice, syrups, and honey were included in FS estimation [6, 7], while whole fruits and vegetables were assigned a value of zero for free sugar [38, 39]. To determine the relative importance of various dietary sources to FS intake, foods were grouped into 12 food groups based on similarities in their composition and culinary use, as well as relative consistency with previously published studies [7, 40]. Appendix 1 shows examples of food items included in each of the food groups.

## Data analysis

Data from both national surveys were entered and analyzed into one database using the Statistical Package for Social Sciences 25.0. Descriptive statistics were reported as means with standard errors (SE) (for continuous normally distributed variables), median and interquartile ranges (for continuous non-normally distributed variables) and as frequencies (n) and proportions (%) for categorical variables. The results in the present study were weighted to account for the effect of the cluster sampling technique [29].

Normality of the variables were evaluated using the Shapiro–Wilk test of normality. If test was statistically significant, this indicated that the variables of interest did not follow a normal distribution. Mann–Whitney U tests were used to chart comparisons for non-normal continuous variables, such as daily intakes of energy (kcal), carbohydrates, total sugars, FS (g/day), and the percent contribution of FS to total EI. Independent t tests were used to chart comparisons for normally distributed variables.

The contribution of selected food groups to total daily FS intake (g/day) was also examined, per capita and per consumer. Per capita analysis included all respondents, and thus

represented the mean intake of the population. Per consumer analysis included only subjects who reported the consumption of food items within the food groups tested, and thus represented the mean intake amongst consumers only. Per capita and per consumer daily intakes of FS (g/day) from selected food groups were stratified by sex and age groups (6 months–2 years *vs* 2–5 years for survey 1 and 5–10 years *vs* 10–18 years for survey 2).

Simple and multiple logistic regression analyses were conducted to explore the associations of demographic, socioeconomic and lifestyle characteristics of the study sample with the odds of high FS intake (i.e. > 10% EI as per WHO recommendation [6]). Multicollinearity between the independent demographic and socioeconomic variables was checked, using the variance inflation factor (VIF), and a VIF < 10 was considered to show no collinearity between the variables used in the model. All variables that were found significant in the simple logistic models were entered in the final multiple logistic regression models as independent variables. Results from the logistic regression analyses were expressed as odds ratios (OR) or adjusted odds ratio (AOR) with 95% CI. A $p$-value < 0.05 was considered statistically significant in all analyses.

## Results

A total of 899 infants and young children (aged 6 months-5 years) from survey 1 and 1133 children and adolescents (aged 5–18 years) from survey 2 had complete dietary data and were included in the present study.

As shown in Table 1, comparable demographic and socioeconomic characteristics were noted between the two study samples. The majority of mothers and their spouses had intermediate/high school level education or higher in both survey 1 (85 and 79%) and survey 2 (78 and 72%). Employment rate of mothers in surveys 1 and 2 were 17 and 24%, respectively. In terms of monthly income, 42% of households in both surveys reported earning less than 1,000,000 L.L. (~ 663 US dollars), while only 10% of households in survey 1 and 8% of households in survey 2 reported earning more than 3,000,000 L.L. (~ 2000 US dollars) per month.

Median intake values for daily energy (kcal/day), carbohydrates, total sugars, and FS (g/day and % EI) are shown in Table 2, by survey and by sex. Overall, median daily EIs were 1238 (IQR: 774) kcal in survey 1 and 1735 (IQR: 1024) kcal in survey 2. Approximately half of the participants' daily EI was provided by carbohydrates (median = 49.5% in U5 children and 49.7% in school-aged children and adolescents). Median total sugars intake represented 23.5% EI in U5 children, and 17.2% EI in school-aged children and adolescents. In contrast, median FS intakes was lower amongst U5 children compared to older children and adolescents (8.5% EI vs 11.9% EI, respectively). Amongst U5 children (survey 1), boys had significantly higher intakes of carbohydrates and FS (g/day) compared to girls. Amongst school-aged children and adolescents, boys had significantly higher intakes of energy, total carbohydrates, total sugars and FS.

The food groups that contributed at least 1% of FS intake (in boys or girls) are displayed in Fig. 1, by survey and sex. In both surveys, the main contributor was "sugar sweetened beverages" (SSBs) estimated at 29.3% in boys and 25.8% in girls amongst U5 children and at 43.5% in boys and 34.3% in girls amongst school-aged children and adolescents. "Biscuits and chocolates" ranked as the second contributor in both surveys, followed by "breads and pies" in survey 1 and "syrups, jams and honey" in survey 2 as the third contributor. Significant differences by sex were observed for most food groups and in both surveys. For instance, amongst U5 children, while the contribution of SSBs, and "biscuits and chocolates" to FS was significantly higher in boys, the contributions of "breads and pies" and "syrups, jams and honey" were significantly higher in girls compared to boys.

**Table 1** Demographic, socioeconomic and physical activity characteristics of Lebanese children and adolescents, based on two nationally representative surveys

| Demographic and socioeconomic characteristics | Survey 1 ($n = 899$) | Survey 2 ($n = 1133$) |
|---|---|---|
| Child's age (years) | 2.4 ± 0.04 | 11.3 ± 0.11 |
| Mother's age (years) | 31.7 ± 0.21 | 39.9 ± 0.23 |
| Mother's education | | |
| ≤ Primary school or less | 136 (15.1) | 245 (21.6) |
| Intermediate/ high school/Technical diploma | 577 (64.2) | 668 (59.0) |
| ≥ University degree | 186 (20.7) | 220 (19.4) |
| Father's education* | | |
| ≤ Primary school or less | 188 (21.2) | 312 (27.9) |
| Intermediate/high school/Technical diploma | 568 (64.1) | 654 (58.4) |
| ≥ University degree | 130 (14.7) | 153 (13.7) |
| Mother's employment status (employed) | 152 (16.9) | 269 (23.8) |
| Household monthly income (Lebanese pounds)* | | |
| < 1,000,000 (< $US 663) | 311 (42.6) | 467 (42.0) |
| 1,000,001–3,000,000($ US 666–2,000) | 346 (47.4) | 554 (49.8) |
| > 3,000,000(> $US 2,000) | 73 (10.0) | 92 (8.3) |
| Physical activity‡ | | |
| Not meeting recommendations | | 534 (47.1) |
| Meeting recommendations | | 599 (52.9) |

Continuous variables are presented as means and SE and categorical variables are presented as frequencies and proportions (%)

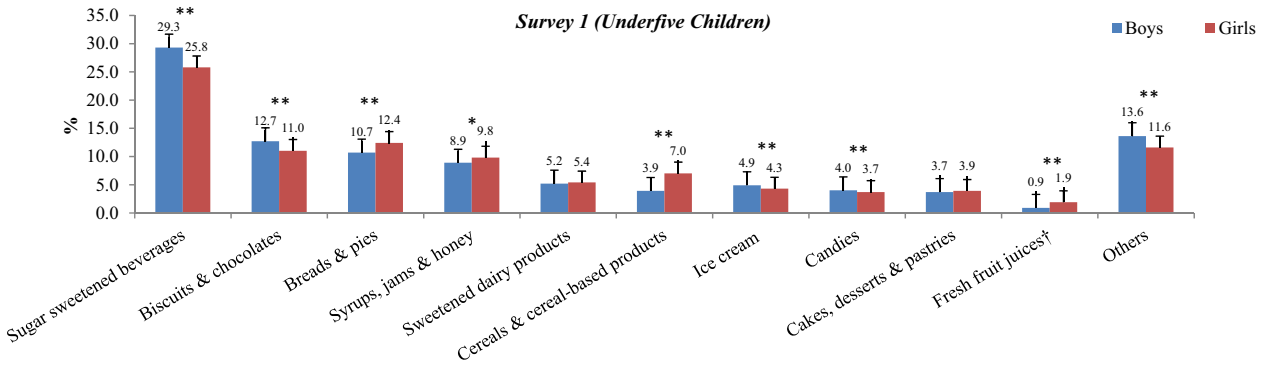
*Numbers may not add up to the total $N$ due to missing data (i.e. father's education in both surveys and income in survey 1)

‡Meeting physical activity requirements of 420 min per week of moderate to vigorous activities as per the WHO [35]

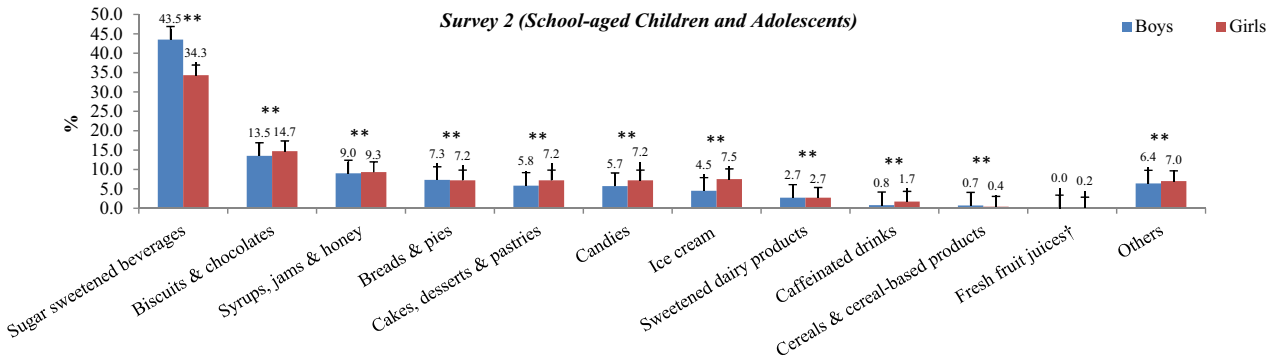
**Table 2** Median daily intakes of energy, carbohydrates, total sugars and free sugars of Lebanese children and adolescents, by sex, based on two nationally representative surveys

| | Survey 1<br>6 months-5 years<br>Median (IQR) | | | Survey 2<br>5–18 years<br>Median (IQR) | | |
|---|---|---|---|---|---|---|
| | Total sample ($n=899$) | Boys ($n=460$) | Girls ($n=439$) | Total sample ($n=1133$) | Boys ($n=460$) | Girls ($n=439$) |
| Energy (kcal/day) | 1238 (774) | 1236 (809) | 1243 (736)** | 1735 (1024) | 1941 (1223) | 1597 (865)** |
| Total CHO (g/day) | 155.7 (96.2) | 157.8 (102.7) | 155.5 (92.4)** | 212.8 (136.5) | 236.0 (147.2) | 196.7 (113.2)** |
| Total sugars (g/day) | 69.0 (47.7) | 67.0 (47.8) | 68.3 (45.8)** | 71.6 (58.8) | 77.2 (61.1) | 64.9 (53.4)** |
| Free sugars (g/day) | 26.5 (43.9) | 28.3 (48.7) | 24.1 (39.8)** | 49.5 (50.7) | 54.8 (60.0) | 45.1 (49.1)** |
| Energy from CHO (%) | 49.5 (11.4) | 49.6 (11.6) | 49.4 (11.4)** | 49.7 (11.0) | 49.7 (11.0) | 50.1 (11.1) |
| Energy from total sugars (%) | 23.5 (13.5) | 23.5 (12.9) | 23.5 (13.8) | 17.2 (10.8) | 17.2 (10.3) | 17.1 (12.1)** |
| Energy from free sugars (%) | 8.5 (11.1) | 8.5 (11.9) | 8.5 (9.6) | 11.9 (10.2) | 12.3 (10.3) | 11.5 (10.0)** |

Sex differences were examined using Mann–Whitney *U* test (*significant at $p<0.05$; **significant at $p<0.001$)




ᵗ Survey 1 was conducted amongst Lebanese children aged 6 months to 4 years in 2012. † Percent contribution to free sugar intake is below 1%. *Differences in means by sex were statistically significant at p<0.05 (*); p<0.01 (**).




ᵗ Survey 2 was conducted amongst Lebanese children aged 5 to 18 years in 2014-2015. † Percent % contribution to free sugar intake is below 1%. *Differences in means by sex were statistically significant at p<0.05 (*); p<0.01 (**).

*Percent contribution was calculated based on per capita intake data

**Fig. 1** Percent contribution* of selected food groups to total daily intake of free sugars in Lebanese children and adolescents, by sex, based on two nationally representative surveysᵗ

Tables 3 and 4 present per capita and per consumer daily intakes of FS (grams per day), by sex, for survey 1 and survey 2, respectively. For SSBs, "biscuits and chocolates", "ice cream" and "fresh fruit juice", per capita and per consumer intakes of FS were significantly lower in girls, compared to boys in survey 1 ($p<0.001$). As for survey 2, per capita

**Table 3** Per capita and per consumer daily intake of free sugars (grams/day) from selected food groups consumed by Lebanese under-five children, by sex, based on Survey 1

| Free sugars from selected food groups (grams/day) | Per capita[¥] | | Per consumer[¤] | | | |
|---|---|---|---|---|---|---|
| | | | Consumers *n* (%)[¶] | | Mean intake | |
| | Boys (*n* = 460) | Girls (*n* = 439) | Boys (*n* = 460) | Girls (*n* = 439) | Boys (*n* = 460) | Girls (*n* = 439) |
| Sugar sweetened beverages (SSBs) | 18.1 ± 0.05 | 15.7 ± 0.06** | 233 (50.7) | 191(43.5)* | 33.4 ± 0.06 | 32.2 ± 0.06** |
| Biscuits and chocolates | 5.7 ± 0.03 | 3.7 ± 0.02** | 190 (41.3) | 181 (41.2) | 13.1 ± 0.04 | 11.8 ± 0.04** |
| Breads and pies | 1.2 ± 0.00 | 1.5 ± 0.01** | 348 (83.5) | 363 (82.7) | 1.6 ± 0.00 | 1.9 ± 0.01** |
| Syrups, jams and honey | 2.9 ± 0.01 | 3.7 ± 0.02 | 122 (26.5) | 104 (23.7) | 10.3 ± 0.04 | 11.7 ± 0.04** |
| Sweetened dairy products | 1.1 ± 0.01 | 1.6 ± 0.01** | 298 (64.8) | 279(63.6) | 2.5 ± 0.02 | 2.7 ± 0.02** |
| Ice cream (dairy and non-dairy) | 3.1 ± 0.02 | 2.0 ± 0.02** | 73 (15.9) | 61 (13.9) | 15.0 ± 0.05 | 13.6 ± 0.05** |
| Candies | 1.8 ± 0.02 | 1.8 ± 0.02** | 62 (13.5) | 45 (10.3) | 14.7 ± 0.09 | 15.7 ± 0.06** |
| Cakes, desserts and pastries | 1.8 ± 0.01 | 2.3 ± 0.02 | 70 (15.2) | 60 (13.7) | 15.8 ± 0.06 | 14.7 ± 0.08** |
| Cereals, cereal-based products | 0.5 ± 0.00 | 1.2 ± 0.01** | 151 (32.8) | 180 (41.0)* | 1.8 ± 0.01 | 2.7 ± 0.02** |
| Fresh fruit juices | 0.6 ± 0.01 | 0.5 ± 0.01** | 13 (2.8) | 16 (3.6) | 18.4 ± 0.08 | 17.1 ± 0.06** |

Continuous variables are presented as means and SE

[¥]Per capita analysis included all respondents. It represents the mean intake of the population

[¤]Per consumer analysis included only subjects who reported the consumption of food items in the food groups tested

[¶]Percentage of consumers (boys and girls) of the food group tested

*Sex differences using Mann–Whitney *U* test for continuous variables at $p < 0.05$

**Sex differences using Mann–Whitney *U* test for continuous variables at $p < 0.001$

**Table 4** Per capita and per consumer daily intake of free sugars (grams/day) from selected food groups consumed by Lebanese school-aged children and adolescents, by sex, based on Survey 2

| Free sugars from selected food groups (grams/day) | Per capita[¥] | | Per consumer[¤] | | | |
|---|---|---|---|---|---|---|
| | | | Consumers *n* (%)[¶] | | Mean intake | |
| | Boys (*n* = 548) | Girls (*n* = 585) | Boys (*n* = 548) | Girls (*n* = 585) | Boys (*n* = 548) | Girls (*n* = 585) |
| Sugar sweetened beverages (SSBs) | 31.6 ± 0.08 | 22.9 ± 0.08** | 434 (79.2) | 380 (65.0)** | 40.9 ± 0.07 | 35.2 ± 0.08** |
| Biscuits and chocolates | 10.5 ± 0.05 | 7.4 ± 0.03** | 237 (43.2) | 247 (42.2) | 22.2 ± 0.06 | 17.8 ± 0.05** |
| Syrups, jams and honey | 4.4 ± 0.03 | 3.7 ± 0.02** | 198 (36.1) | 192 (32.8) | 12.4 ± 0.05 | 11.9 ± 0.04** |
| Breads and pies | 2.7 ± 0.01 | 1.9 ± 0.01** | 528 (96.4) | 546 (93.3)* | 2.9 ± 0.01 | 2.0 ± 0.01** |
| Candies | 4.4 ± 0.03 | 5.8 ± 0.04** | 94 (17.2) | 110 (18.8) | 28.0 ± 0.11 | 30.4 ± 0.09** |
| Cakes, desserts and pastries | 3.9 ± 0.03 | 3.7 ± 0.03** | 119 (21.7) | 144 (24.6) | 18.7 ± 0.11 | 20.6 ± 0.09** |
| Ice cream (dairy and non-dairy) | 2.0 ± 0.02 | 3.1 ± 0.02** | 105 (19.2) | 112 (19.1) | 14.9 ± 0.06 | 14.7 ± 0.04** |
| Sweetened dairy products | 1.6 ± 0.02 | 2.0 ± 0.03** | 355 (64.8) | 375 (64.1) | 3.5 ± 0.03 | 4.0 ± 0.05** |
| Caffeinated drinks | 0.5 ± 0.01 | 0.7 ± 0.01** | 163 (29.7) | 209 (35.7)* | 1.7 ± 0.02 | 2.4 ± 0.02** |
| Cereals, cereal-based products | 0.2 ± 0.01 | 0.1 ± 0.01** | 44 (8.0) | 27 (4.6)* | 2.4 ± 0.01 | 2.1 ± 0.02** |
| Fresh fruit juices | 0.03 ± 0.01 | 0.00 ± 0.00 | 3 (0.50) | 2 (0.30) | 15.0 ± 0.27 | 22.8 ± 0.17** |

Continuous variables are presented as means and SE

[¥]Per capita analysis included all respondents. It represents the mean intake of the population

[¤]Per consumer analysis included only subjects who reported the consumption of food items in the food groups tested

[¶]Percentage of consumers (boys and girls) of the food group tested

*Sex differences using Mann–Whitney *U* test for continuous variables at $p < 0.05$

**Sex differences using Mann–Whitney *U* test for continuous variables at $p < 0.001$

and per consumer intakes of FS were significantly lower in girls, compared to boys, for the majority of the studied food groups, except for "candies", "cakes, desserts and pastries", "sweetened dairy products" and "caffeinated drinks" ($p < 0.001$). In both surveys, the percentage of consumers was the lowest for "fresh fruit juices" (0.30–3.6%), and the highest for "breads and pies" (82.7–96.4%) (Tables 3 and 4).

Table 5 further compares per capita and per consumer daily intakes of FS (grams/day) by age group within the U5 study population: 6 months–2 years vs 2–5 years. It shows that per capita FS intakes from all studied food groups were significantly higher in 2–5 year old children compared to younger ones except for "sweetened dairy products" and "cereal and cereal-based products". Per consumer analyses showed that FS intakes from "sweetened dairy products", "cakes, desserts and pastries", and "cereal and cereal-based products" were significantly higher amongst 6 months–2 year old children compared to those aged 2–5 years.

Table 6 compares mean daily intakes of FS (grams per capita and per consumer) by age group within 5–18 year old population: 5–10 years vs 10–18 years. It shows that per capita FS intakes from "biscuits and chocolates", "candies", "ice cream", "sweetened dairy products" and "cereals and cereal-based products" were significantly higher amongst 5–10 years children compared to those aged 10–18 years ($p < 0.01$). Per consumer analyses showed that FS intakes from the majority of the studied food groups were significantly higher in 10–18 year old children compared to younger ones except for "candies", "ice cream", and "fresh fruit juices", which were higher amongst the 5–10 year olds.

The proportion of children and adolescents exceeding the WHO maximal intake level for FS (10% EI) was estimated at 43.0% amongst U5 children and at 62.0% in school-aged children and adolescents. Table 7 presents the associations of demographic, socioeconomic and lifestyle characteristics with the odds of high FS intake (exceeding 10% EI) amongst children in surveys 1 and 2. For U5 children, results from the multiple logistic regression model showed that FS intake increased with age (AOR 1.88; 95% CI 1.84, 1.91). Children with highest parental educational levels were significantly less likely to have high FS consumption compared to those with low or intermediate parental educational levels (AOR 0.53; 95% CI 0.48, 0.59 and AOR 0.76; 95% CI 0.70, 0.83). Highest household monthly income remained significantly associated with lower odds of high FS intake (AOR 0.59; 95% CI 0.31, 0.37), even after adjusting for other factors. For school-aged children and adolescents, results of the multiple logistic regression showed that belonging to the older age group (10–18 years), females and those with highest household monthly income had significantly lower odds of exceeding the WHO limit compared to their counterparts (AOR 0.95, 95% CI 0.93, 0.96; AOR 0.90, 95% CI 0.81, 0.99; AOR 0.57, 95% CI 0.47, 0.68; respectively). Interestingly, children and adolescents meeting physical activity recommendations were more likely to have high FS intakes compared to those who do not engage in regular physical activity (OR 1.17; 95% CI 1.04, 1.32), even after adjusting for other significant correlates.

## Discussion

This study is the first to examine the intakes, sources, and determinants of FS amongst children and adolescents in the EMR. Based on two recent national surveys conducted in Lebanon, the study showed that the contribution of FS to daily EI increased from 8.5% in U5 children to 11.9% in school-aged children and adolescents (aged 5–18 years). Importantly, the study identified the major food sources of FS in the study population, highlighting "SSBs and "biscuits and chocolates" as the top two contributors in both age groups. More than 40% of U5 children were found to exceed the WHO upper limit for FS intake (10% EI), while this proportion increased to 62% in older children and adolescents. The study findings documented sex-based disparities in FS intakes and showed that a higher SES (based on parental education and income) was associated with lower FS intake.

Although the international recommendations in relation to sugar consumption refer to a reduction in FS intake, studies investigating FS consumption based on the WHO definition are scarce in the literature and completely lacking in the EMR. Since total sugars levels can be analytically assayed in foods, these values are commonly included in most food composition databases and hence, the majority of studies investigating sugar consumption have reported on total sugars intakes [41, 42]. In the present study, total sugars contribution to EI was estimated at approximately 23% in U5 children, and 17% in school-aged children and adolescents. Despite the well-recognized difficulties of comparing results between studies due to discrepancies in dietary assessment methods and differences in age groups under investigation, our results are within the range reported in the literature [4, 41, 43] (Table 8). The fact that, in our study, total sugars intake was higher in U5 children compared to older children and adolescents (5–18 years old), is also in line with findings reported by previous studies. A review of data from 18 different countries suggested that total sugars as a percentage of EI were the highest in infants and young children and tended to decrease over the lifespan [42]. Based on a national survey in Portugal, total sugars intake was found to decrease from 28% EI in U5 children, to 22.7% EI and 20.2% EI in 5–9 year old children and 10–17 year old adolescents, respectively [4].

In our study, median FS intake contributed 8.5% EI in U5 children, which falls within values reported by previous

**Table 5** Per capita and per consumer daily intake of free sugars (grams/day) from selected food groups consumed by Lebanese under-five children, by age, based on Survey 1

| Free sugars from selected food groups (grams/day) | Per capita[¥] | | Per consumer[¤] | | | |
|---|---|---|---|---|---|---|
| | | | Consumers *n* (%)[¶] | | Mean intake | |
| | 6 months–2 years (*n* = 376) | 2–5 years (*n* = 523) | 6 months–2 years (*n* = 376) | 2–5 years (*n* = 523) | 6 months–2 years (*n* = 376) | 2–5 years (*n* = 523) |
| Sugar sweetened beverages (SSBs) | 7.7 ± 0.05 | 22.9 ± 0.05** | 111 (29.5) | 313 (59.8)** | 25.4 ± 0.08 | 35.5 ± 0.05** |
| Biscuits and chocolates | 1.9 ± 0.02 | 6.6 ± 0.03** | 120 (31.9) | 251 (48.0)** | 6.7 ± 0.04 | 16.4 ± 0.04** |
| Breads and pies | 1.0 ± 0.00 | 1.6 ± 0.00** | 263 (69.9) | 484 (92.5)** | 1.7 ± 0.01 | 1.9 ± 0.00** |
| Syrups, jams and honey | 1.7 ± 0.02 | 4.2 ± 0.02** | 55 (14.6) | 171 (32.7)** | 9.3 ± 0.06 | 11.4 ± 0.03** |
| Sweetened dairy products | 2.3 ± 0.02 | 0.7 ± 0.01** | 248 (66.0) | 329 (62.9) | 4.0 ± 0.03 | 1.7 ± 0.01** |
| Ice cream (dairy and non-dairy) | 0.6 ± 0.01 | 3.8 ± 0.02** | 19 (5.1) | 115 (22.0)** | 9.4 ± 0.03 | 16.0 ± 0.04** |
| Candies | 1.4 ± 0.01 | 2.1 ± 0.02** | 32 (8.5) | 75 (14.3)** | 13.2 ± 0.07 | 16.0 ± 0.08** |
| Cakes, desserts and pastries | 1.1 ± 0.01 | 2.6 ± 0.02** | 28 (7.4) | 102 (19.5)** | 21.5 ± 0.14 | 13.9 ± 0.05** |
| Cereals, cereal-based products | 1.1 ± 0.01 | 0.6 ± 0.01** | 178 (47.3) | 153 (29.2)** | 2.7 ± 0.02 | 2.0 ± 0.01** |
| Fresh fruit juices | 0.2 ± 0.00 | 0.8 ± 0.01** | 2 (0.5) | 27 (5.2)** | 10.7 ± 0.02 | 18.7 ± 0.05** |

Continuous variables are presented as means and SE

[¥]Per capita analysis included all respondents. It represents the mean intake of the population

[¤]Per consumer analysis included only subjects who reported the consumption of food items in the food groups tested

[¶]Percentage of consumers (boys and girls) of food items in the food group tested

*Age differences using Mann–Whitney *U* test for continuous variables at $p < 0.05$

**Age differences using Mann–Whitney *U* test for continuous variables at $p < 0.001$

**Table 6** Per capita and per consumer daily intake of free sugars (grams/day) from selected food groups consumed by Lebanese school-aged children and adolescents, by age, based on Survey 2

| Free sugars from selected food groups (grams/day) | Per capita¥ | | Per consumer¤ | | | |
|---|---|---|---|---|---|---|
| | | | Consumers *n* (%)¶ | | Mean intake | |
| | 5–10 years (*n* = 452) | 10–18 years (*n* = 681) | 5–10 years (*n* = 452) | 10–18 years (*n* = 681) | 5–10 years (*n* = 452) | 10–18 years (*n* = 681) |
| Sugar sweetened beverages (SSBs) | 23.7 ± 0.10 | 28.9 ± 0.07** | 321 (71.0) | 493 (72.4) | 34.4 ± 0.08 | 40.9 ± 0.07** |
| Biscuits and chocolates | 9.3 ± 0.05 | 8.6 ± 0.04** | 207 (45.8) | 277 (40.7) | 19.8 ± 0.06 | 20.2 ± 0.05** |
| Syrups, jams and honey | 2.9 ± 0.02 | 4.7 ± 0.03** | 154 (34.1) | 236 (34.7) | 9.6 ± 0.03 | 13.9 ± 0.05** |
| Breads | 2.2 ± 0.01 | 2.3 ± 0.01* | 439 (97.1) | 635 (93.2)* | 2.3 ± 0.01 | 2.5 ± 0.01** |
| Candies | 6.7 ± 0.04 | 4.2 ± 0.03** | 99 (21.9) | 105 (15.4)* | 30.6 ± 0.10 | 27.8 ± 0.09** |
| Cakes, desserts and pastries | 3.5 ± 0.04 | 4.0 ± 0.03 | 115 (25.4) | 148 (21.7) | 18.3 ± 0.12 | 20.6 ± 0.09** |
| Ice cream (dairy and non-dairy) | 3.4 ± 0.02 | 2.1 ± 0.01** | 99 (21.9) | 118 (17.3) | 16.0 ± 0.06 | 13.7 ± 0.05** |
| Sweetened dairy products | 2.0 ± 0.02 | 1.7 ± 0.02** | 318 (70.4) | 412 (60.5)* | 3.6 ± 0.03 | 3.9 ± 0.05** |
| Caffeinated drinks | 0.09 ± 0.00 | 0.9 ± 0.01** | 113 (25.0) | 259 (38.0)** | 0.40 ± 0.01 | 2.9 ± 0.02** |
| Cereals, cereal-based products | 0.32 ± 0.00 | 0.08 ± 0.00** | 38 (8.4) | 33 (4.9)* | 2.3 ± 0.02 | 2.3 ± 0.01 |
| Fresh fruit juices | 0.0 ± 0.0 | 0.02 ± 0.00** | 2 (0.40) | 3 (0.40) | 23.3 ± 0.12 | 14.1 ± 0.27** |

Continuous variables are presented as means and SE

¥Per capita analysis included all respondents. It represents the mean intake of the population

¤Per consumer analysis included only subjects who reported the consumption of food items in the food groups tested

¶Percentage of consumers (boys and girls) of food items in the food group tested

*Age differences using Mann–Whitney *U* test for continuous variables at $p < 0.05$

**Age differences using Mann–Whitney *U* test for continuous variables at $p < 0.001$

studies on this age group (Table 8) [4, 20, 44–46]. The proportions of Lebanese U5 children exceeding the maximum level recommended by the WHO (43%) was relatively similar to that reported from Australia (38%) [44], while being lower than estimates from Ireland (75%) [20]. Unlike the observation regarding total sugars, the intake of FS was found to be higher in 5–18 year-old children and adolescents (11.9% EI) compared to U5 children in our study. Similar observations have been reported by previous studies [4, 41, 42]. For instance, in Portugal, school-aged children and adolescents had the highest percentage of total EI from FS (7.4–9.8% EI) compared to U5 children (8.2% EI) [4]. This may reflect the decrease in the intake of naturally present sugars from milk feedings and fruits, and the increase in the intake of FS from nutrient-poor, energy-dense processed foods amongst school-aged children and adolescents, when compared with younger age groups [4]. The observed level of FS intake amongst Lebanese school-aged children and adolescents (11.9% EI), is also in line with estimates described by previous studies (Table 8). The proportion of Lebanese school-aged children and adolescents exceeding the WHO upper limit (62%) in the present study was lower than that observed in the HELENA study (94%) [7], while exceeding the estimate reported for 10–12 years old Greek children (44.2%) [40]. It is important to mention that comparison of FS estimates with those generated by other studies may be limited by differences in dietary assessment methods (Table 8), as well as the use of different food composition databases or distinct approaches in estimating FS intake. Similarly to our study, some investigations have adopted the modified version of the method described by Louie et al. for the estimation of FS intake [7, 20, 37, 46], while others have used other approaches for such calculations [8, 40, 45, 47].

The present study has also investigated dietary sources of FS and showed that, even amongst children aged less than 5 years, SSBs were the highest contributors to FS in the diet (25.8% in U5 girls and 29.3% in boys). Although other studies conducted on young children and preschoolers have also reported SSBs as one of the contributors to FS intake [4, 20, 44, 46], none has reported SSBs as the first highest contributor to FS in this age group. Of concern is the fact that 43.5% of U5 girls and 50.7% of U5 boys consumed

**Table 7** Associations of socio-demographic and lifestyle characteristics with high free sugars (FS) consumption amongst Lebanese children and adolescents, based on two nationally representative surveys

| | Survey 1<br>6 months–5 years ($n=899$) | | Survey 2<br>5–18 years ($n=1113$) | |
|---|---|---|---|---|
| | High FS consumption<br>(> 10% of energy intake) | | High FS consumption<br>(> 10% of energy intake) | |
| | OR[†] (95% CI) | AOR[‡] (95% CI) | OR[‡] (95% CI) | AOR[§] (95% CI) |
| Child's age (years) | **1.87 (1.84, 1.91)** | **1.88 (1.84, 1.91)** | **0.95 (0.94, 0.97)** | **0.95 (0.93, 0.96)** |
| Child's sex | | | | |
| Male | 1.0 | 1.0 | 1.0 | 1.0 |
| Female | **0.91 (0.88, 0.94)** | 1.05 (1.00,1.09) | **0.85 (0.77, 0.93)** | **0.90 (0.81, 0.99)** |
| Mother's age (years) | 1.00 (0.69, 0.83) | – | **0.99 (0.98, 0.99)** | 1.01 (1.00, 1.02) |
| Mother's education | | | | |
| ≤ Primary school or less | 1.0 | 1.0 | 1.0 | – |
| Intermediate/ high school/Technical diploma | **0.51 (0.48, 0.53)** | **0.60 (0.55, 0.65)** | 0.92 (0.79, 1.07) | – |
| ≥ University degree | **0.40 (0.36, 0.42)** | **0.53 (0.48, 0.59)** | 0.97 (0.82, 1.15) | – |
| Father's education | | | | |
| ≤ Primary school or less | 1.0 | 1.0 | 1.0 | 1.0 |
| Intermediate/ high school/Technical diploma | **0.80 (0.76, 0.84)** | **0.68 (0.64, 0.72)** | 0.97 (0.86, 1.09) | 0.95 (0.84, 1.07) |
| ≥ University degree | **0.71 (0.66, 0.75)** | **0.76 (0.70, 0.83)** | **0.79 (0.67, 0.93)** | 0.84 (0.70, 1.02) |
| Mother's employment status (employed) | 0.98 (0.93, 1.0) | - | 0.92 (0.83, 1.02) | – |
| Household monthly income (Lebanese pounds) | | | | |
| < 1,000,000 (< $US 663) | 1.0 | 1.0 | 1.0 | 1.0 |
| 1,000,001–3,000,000($US 666–2000) | **1.08 (1.03,1.13)** | **1.10 (1.04,1.16)** | 1.08 (0.96,1.22) | 1.11 (0.99,1.24) |
| > 3,000,000(> $US 2000) | **0.57 (0.53, 0.61)** | **0.59 (0.31, 0.37)** | **0.50 (0.43, 0.58)** | **0.57 (0.47, 0.68)** |
| Physical activity[‡] | | | | |
| Not meeting recommendations | | | 1.0 | 1.0 |
| Meeting recommendations | | | **1.29 (1.14, 1.44)** | **1.17 (1.04, 1.32)** |

Significant results are shown in bold

[†]ORs of the dependent variable (below vs above 10% of energy intake) were presented with 95% CI using simple logistic regression

[‡]Adjusted odds ratios (AORs) were presented with 95% CI using multiple logistic regression analysis. The model was adjusted for socio-demographic characteristics found to be significant correlates of the dependent variable (child's age, mother and father education, and household monthly income)

[§]AORs were presented with 95% CI using multiple logistic regression analysis. The model was adjusted for socio-demographic and lifestyle characteristics found to be significant correlates of the dependent variable (child's age and sex, father education, and income and physical activity)

[‡]Meeting physical activity requirements of 420 min per week of moderate to vigorous activities as per the WHO [35]

SSBs during the 24-h preceding the dietary interview. This high proportion of consumers may explain the fact that SSBs' contribution to FS intake in Lebanese U5 children exceeded that reported by studies conducted in other countries such as Australia (16% in 2 year old children) [44], Japan (18.4% in 3–6 year old children) [46] and Portugal (5.8% in U5 children) [4]. As for older school-aged children and adolescents, our findings are in agreement with those reported by the HELENA study amongst European adolescents [7] and by Amoutzopoulos et al. amongst adolescents in the UK [47], where SSBs were the highest contributors to FS intake. These beverages, which include carbonated soft drinks and sweetened fruit juices, were found to contribute 35.2% and 40.9% of FS intake in Lebanese 5–18 years old girls and boys, respectively. These values were also close to those reported amongst 11–18 years old teenagers in the UK (33.6%) [47], but exceed values reported by a multicenter cohort study amongst 2–9 year old European children (25%) [41], and by the HELENA study amongst European adolescents (26%) [7]. Interestingly, in our study, fresh fruit juice had a minimal contribution to FS intake in both age groups, being estimated at 0.9–1.9% in U5 children and less than 1% in school-aged children and adolescents. These estimates are lower than values reported from Japan (6.2%) [46] and Greece (12.4%) [40].

In our study, "biscuits and chocolates" ranked as the second contributor to FS intake in both age groups, while "cakes, desserts and pastries" were also featured amongst

**Table 8** Contribution of total and free sugars to percent total energy intake (% EI) in Lebanese children and adolescents, in comparison with the literature

| Country | Dietary assessment | Age group | Total sugars intake (% EI) | Free sugars intake (%EI) |
|---|---|---|---|---|
| Under-five Children | | | | |
| Lebanon (present study) | Single 24 h | 6 months-4 years | Mean: 23.9<br>Median: 23.5 | Mean: 9.5<br>Median:8.5 |
| Portugal [4] | Two-day food diary | < 5 years | Mean: 28<br>Median: 27.3 | Mean: 8.2<br>Median: 7.4 |
| Ireland [20] | Four-day semi-weighed food diary | < 3 years | Mean: 26.9<br>Median: 26.9 | Mean: 14.1<br>Median: 13.5 |
| UK [45] | Four-day food diary | 1.5–3 years | – | Mean: 12.2 |
| Japan [46] | Three-day food diary | 3–6 years | Mean: 16.3 | Mean: 7.8 |
| Australia [44] | Semi-quantitative FFQ | 2 years | – | Mean: 10.4<br>Median: 8.0 |
| School-aged children and adolescents | | | | |
| Lebanon (present study) | Single 24 h | 5–18 years | Mean: 17.6<br>Median: 17.2 | Mean: 12.6<br>Median: 11.9 |
| Europe [7, 41] | Single 24 h | 2–9 years | Mean: 23 | Mean: 18 |
| | Two-day 24 h | 12.5–17.5 years | Mean: 23.6 | Mean: 19 |
| Portugal [4] | Two-day food diary | 5–9 years | Mean: 22.7<br>Median: 22.3 | Mean: 10.6<br>Median: 9.8 |
| | Two-day food diary | 10–17 years | Mean: 20.2<br>Median: 19.8 | Mean: 10.5<br>Median: 9.8 |
| Spain [8] | Three-day food diary | 9–12 years | Mean: 18.8 | Mean: 9.8 |
| UK [45, 47] | Four-day food diary | 4–10 years | – | Mean: 13.4 |
| | Four-day food diary | 11–18 years | – | Median: 13 |
| Australia [61] | Single 24 h | 9–13 years | Mean: 22.2 | Mean: 13.8 |
| Greece [40] | Semi-quantitative FFQ | 10–12 years | – | Mean: 11.2 |

*24 h* 24 h dietary recall, *FFQ* food frequency questionnaire

the main dietary contributors of FS. In line with our findings, sweetened cereal products such as sweet biscuits, cakes, muffins have been reported by several other studies as major sources of FS in the diet of children and adolescents [4, 47]. Of interest is the fact that breakfast cereals (i.e. cereals and cereal-based products) had a negligible contribution to FS in school-aged children and adolescents (0.4–0.7%), reflecting the culture-specific food consumption practices in Lebanon. Indeed, the percentage of school-aged children and adolescents reporting to consume breakfast cereals was very low, ranging between 4.6% of girls and 8% of boys. The third contributor to FS intake differed between the two age groups, being "breads and pies" in U5 children and "syrups, jams and honey" in school-aged children and adolescents. The fact that "syrups, jams and honey" featured amongst the most important contributors to FS intake is in line with findings reported by several other studies [7, 46, 47]. The major contribution of "breads and pies" to FS intake is no surprise given that bread is the most common staple food in Lebanon and dough-based pies are amongst the traditional snacks that are heavily consumed in the country [48, 49]. The study findings have shown that 82.7–83.5% of U5 girls and boys, respectively, are consumers of "breads and pies" and this proportion increased to 93.3–96.4% amongst older children and adolescents. It could be argued that foods such as breads and pies may be perceived as healthy dietary choices, despite the amount of FS they may contain. These findings highlight the importance of interventions targeting food labelling, by including and clarifying information on added and FS, and by educating caregivers, children, and adolescents on hidden sources of FS [4]. The fact that processed and ultra-processed foods (SSBs, "biscuits and chocolates", "breads and pies", and "syrups, jams and honey") were the main contributors to FS intakes calls for a food system approach, addressing the food supply, food environment, as well as consumer education and behavior to impact FS consumption amongst children and adolescents. Lebanon is still lagging behind in terms of food policy development and there is an imminent need for food policies targeting the reformulation of sugar content in manufactured foods, the taxation of SSBs, the enhancement of food labelling, and the regulation of the advertisement and availability of high sugar foods and beverages

in settings attended by children and adolescents, such as daycares, schools, playgrounds, and sports facilities. These interventions ought to be acknowledged as a priority in a country like Lebanon, where pediatric and adolescent obesity have increased by two-fold during the past decade [32] and where the nutrition transition and the westernization of dietary patterns have been unfolding [48].

In agreement with findings observed amongst European children and adolescents [7, 41], sex differentials in FS intake were observed. Girls had significantly lower intakes of FS (g/day) in both age groups, and this difference persisted in school-aged children and adolescents, when the contribution to EI was considered. In addition, girls had significantly lower odds of exceeding the WHO upper limit for FS. A limited number of studies have reported on such sex disparities, with available evidence being equivocal. A study conducted amongst Australian 12–14 months children showed that boys were more likely to exceed the WHO upper limit for FS [50], while amongst Greek 10–12 year old children, no significant differences were observed in the proportions of boys and girls exceeding the recommended cut-off [40].

Our study findings indicate a socioeconomic gradient in FS intake in both age groups. Children and adolescents belonging to the highest income bracket had significantly lower odds of having high FS intake. In addition, maternal and paternal education levels were associated with lower FS intake, particularly in younger children. Similar findings were reported by Marinho et al. in Portugal [4] and Devenish et al. in Australia [44, 50], highlighting the important role of socio-economic attributes in modulating the consumption of FS by children and adolescents. Previous studies conducted in Lebanon have identified maternal education as a significant determinant of dietary patterns in children and adolescents [28, 51], with lower education amongst mothers predicting higher adherence to the Western pattern, the latter being rich in processed foods and hence FS. As education is a crucial determinant of nutrition knowledge [52], it is possible that parents with lower education levels are not well-informed about potential sources of FS or about the evidence linking high FS intake with chronic disease risk [53]. Taken together, the study findings highlight the role of parental education levels as key modulators of the family's environment and dietary habits, while also supporting the conclusions reported by Darmon and Drewnowski, suggesting that higher quality diets are usually consumed by better educated individuals [54]. Alternatively, the higher intake of FS amongst children and adolescents from lower education and income brackets may reflect an economic obstacle to the adoption of healthier dietary habits and hence lower intake of FS [54]. Previous studies have suggested that it is less expensive to consume a diet that is rich in processed foods and hence FS, suggesting food cost as a prohibitive factor to lower sugar diets [54].

In the present study, data about physical activity was available for school-aged children and adolescents, and the findings showed that children and adolescents meeting physical activity recommendations were more likely to have high FS intakes compared to those who do not. This may contrast with findings reported by other studies, where healthier behavioral characteristics were associated with lower intakes of FS [4]. This discrepancy may be attributed to the potentially higher consumption of beverages, including SSBs, amongst physically active children [55, 56]. A previous study conducted amongst 4–13-year-old Lebanese children showed that physically active children had significantly higher total water intake from beverages, such as soft drinks, energy drinks, milk and milk alternatives (milk-shakes, flavored yoghurts, and hot chocolate) compared to inactive children. These findings also corroborate with another study conducted amongst 12–17-year-old adolescents in Spain showing that beverage consumption was positively associated with physical activity, with the highest consumption of energy and sport beverage drinkers being reported amongst active adolescents compared to their inactive counterparts [56]. These study findings highlight the need for nutrition education interventions to improve the knowledge and perceptions of adolescents towards the high FS content of beverages, such as soft drinks, sports drinks and energy drinks that are heavily promoted amongst this age group, yet can have serious adverse health consequences.

This study has several strengths. First, the study is based on national food consumption surveys that were carried out on representative samples of U5 children (survey 1) and school-aged children and adolescents (survey 2). In both surveys, similar methods were adopted in data collection, dietary assessment, and analysis. However, the results of the study ought to be considered in light of the following limitations. First, like other studies where dietary intake was evaluated by means of self-exposure, dietary assessment conducted in our study may be prone to reporting errors [57]. Second, dietary information was assessed based on the collection of one 24-h, which may not be representative of usual dietary intake at the individual level. However, despite its well-acknowledged limitations, such as reliance on memory and possible day-to-day variation, the 24-h may provide accurate estimates of dietary intake at the population level [58]. It is important to mention that in both surveys, the 24-h were administered by trained nutritionists, who received extensive training to enhance data accuracy and minimize social desirability bias. In addition, the 24-h were conducted using the USDA multiple pass five-step approach [36], which has consistently showed attenuation in the limitations of the 24-h [59]. Third, given the lack of local food composition

databases, we have used the USDA database within the Nutritionist Pro for dietary intake analysis. To analyze composite, mixed and traditional Lebanese dishes, we have added recipes to the Nutritionist Pro software using single food items. Fourth, though every effort was exerted to ensure the representativeness of the sample, a comparison of the study sample distribution based on socioeconomic indicators with available national estimates showed a few discrepancies. For instance, in survey 1, the proportions of employed mothers (16.9%) was lower than the national estimate of 23.5% [60]. This may be explained by the fact that mothers in survey 1 had young children (U5) and hence may have opted for staying at home. Such discrepancies may limit the generalizability of the study findings. Finally, the estimation of FS intake in U5 children as well as older children and adolescents was based on two separate cross-sectional surveys with different samples. The observed differences in FS intake and sources between the surveys could therefore be at least partly due to a birth cohort effect, highlighting the need for further studies on FS intake amongst children and adolescents in Lebanon.

## Conclusion

In conclusion, the study findings documented high intakes of FS in the pediatric population of Lebanon, with 43% of U5 children and 62% of school-aged children and adolescents exceeding the WHO upper limit. Male sex and lower socioeconomic status were identified as independent correlates of high FS intake in the study population. Importantly, the study has identified the major food sources of dietary FS in Lebanese children and adolescents, showing that SSBs, "biscuits and chocolates" as well as "breads and pies", and "syrups, jams and honey" are amongst the top contributors. Of concern was the fact that SSBs were the first highest contributor to FS in the study population, even amongst children aged less than 5 years, an observation that appears to be unique to the Lebanese setting. Our study findings call for devising food system-based interventions to help reduce FS intake amongst this nutritionally vulnerable age group and limit the adverse health consequences of high FS consumption on the short and long-term.

**Author contributions** LN conceptualized the research question, drafted the manuscript, and contributed to the interpretation of the data. LJ critically reviewed the manuscript and contributed to the interpretation of the data. LN is the principal investigator on survey 1. LJ is the principal investigator on survey 2. MDH and FC conducted data analysis. SK assisted and supervised the statistical analyses. SH contributed to data analysis, in partial fulfillment of the requirements for MSc in Nutrition at the Department of Nutrition and Food Sciences at the American University of Beirut. All authors read and approved the final manuscript.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethics approval** The study has been approved by the Institutional Review Board at the American University of Beirut and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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