Short Communication

nutrition and health

Nutrition and Health
2020, Vol. 26(4) 277–283

DOI: 10.1177/0260106020944299
journals.sagepub.com/home/nah

Frequency of fruit juice consumption and association with nutrient intakes among Canadians

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Abstract

Background: In Canada, studies on consumption of 100% fruit juice and nutrient intakes are limited. **Aim:** This study aimed to evaluate nutrient intakes and adequacy of intake by frequency of fruit juice consumption. **Methods:** Individuals ≥1 year ($n = 34{,}351$) participating in the Canadian Community Health Survey, 2004 with a 24-hour dietary recall and reported usual frequency of fruit juice consumption (assumed to be 100% juice) were categorized by frequency of consumption as <0.5, ≥0.5 to <1.5, or ≥1.5 times/day. **Results:** More frequent consumption of fruit juice (≥0.5 times/day) was associated with higher intakes of total fruits and vegetables, whole fruits, energy, total sugars, vitamin C and potassium. More frequent consumption of fruit juice was associated with improved intake adequacy of vitamin C for adults. **Conclusions:** Fruit juice consumption contributes to increased intakes of vitamin C and potassium as well as energy and total sugars, thus presenting a trade-off for consumers to balance.

Keywords

Dietary intakes, fruit juice, dietary surveys, nutrient adequacy, Canadian Community Health Survey, cross-sectional analysis

Introduction

In Canada, studies on consumption of 100% fruit juice and nutrient intakes are limited despite the availability of nationally representative dietary data for over a decade. Cross-sectional studies in the USA have indicated that consuming 100% fruit juice may contribute to higher intake and adequacy of commonly under-consumed nutrients as well as higher intake of whole fruits, but may also contribute to higher intake of total sugars and higher intake of energy (O'Neil et al., 2011, 2012).

In the 2019 updated nutrition guidance, Health Canada recommends that all beverages that are sources of sugar, including 100% fruit juice, be avoided and encourages consumers to instead drink water or eat whole fruit (Health Canada, 2019). There is an overall public health concern around the impact of fruit juice on sugar and caloric intake, though associations between 100% fruit juice consumption and diet quality among Canadians have not been investigated. The purpose of this study was to determine and compare usual intake and adequacy of intake of select micronutrients typically found in fruit juice, as well as total sugars, energy and dietary fiber, among Canadians categorized by usual frequency of fruit juice consumption.

Methods

Data source and study population

The data source for this assessment was the Canadian Community Health Survey 2.2 (CCHS 2.2), a cross-sectional, nationally representative survey of the Canadian population conducted by Statistics Canada consisting of a general health questionnaire and a 24-hour dietary recall with data collected between January 2004 and January 2005 (Health Canada, 2006; Statistics Canada, 2008). Ethical approval was based on the authority of the Statistics Act of Canada. Approval to conduct the analyses presented

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in this paper was received from the Statistics Canada Research Data Centre Program. From a total sample of 35,107 in CCHS 2.2, the analysis in this paper excluded pregnant and breastfeeding women, infants, children consuming breastmilk, and individuals with invalid (as identified by Statistics Canada) or missing dietary recalls or a response on consumption of fruit juice in the questionnaire, resulting in a final analysis sample of 34,351 individuals.

Respondents were categorized into population groups aligning with the age- and sex-specific life-stage groups used by the Institute of Medicine for derivation of Dietary Reference Intakes. Population characteristics also include the prevalence of weight status classified as overweight/obese based on body mass index calculated from measured height and weight in 62% of the sample.

Categorization of fruit juice consumption

The CCHS 2.2 included a questionnaire that gathered information on the frequency of fruit and vegetable consumption (Health Canada, 2006). Respondents were asked to describe usual consumption as number of times (frequency) they consumed fruit juice such as orange, grapefruit or tomato; fruit excluding juice; green salad; potatoes excluding French fries, fried potatoes and potato chips; and carrots. Respondents were asked to describe their usual consumption of other vegetables in terms of number of servings. For each question, respondents reported frequency of intake as the number of times or servings per day, week, month or year. The questionnaire survey data files provide derived frequencies of fruit juice and whole fruit (excluding juice) consumption (0.0 to 20.0 times per day per fruit type), and the percent of individuals reporting consumption of fruits and vegetables five or more times per day.

For this study, we assumed that the questionnaire reflects the consumption of 100% fruit juice because it specifically refers to juices that are typically 100% juice (i.e. orange, grapefruit or tomato). Based on daily fruit juice consumption, respondents were categorized into one of three categories of daily frequency of consumption: <0.5, 0.5 to <1.5, or ≥1.5 times per day. Within these frequency categories, mean fruit juice consumption was 0.1 to 0.2, 1.0, and 2.4 to 2.8 times/day, respectively, across age–sex groups.

The 2015 CCHS-Nutrition survey provides updated dietary recalls, though it did not include a module on fruit and vegetable consumption (Health Canada, 2017). Thus the 2004 survey uniquely provides information to categorize typical frequency of fruit juice consumption and examine nutrient intakes.

Estimates of usual nutrient intakes and nutrient adequacy

The CCHS 2.2 included a 24-hour dietary recall component in which data were collected by a trained interviewer using a modified version of the 5-step Automated Multiple-Pass Method with a second 24-hour dietary recall from approximately 30% of the respondents (Statistics Canada, 2008). The dietary recalls were processed by Statistics Canada using compositional data available at the time of the survey (Health Canada, 2001; Statistics Canada, 2008). In this study, estimates of mean usual energy intake and mean usual nutrient intakes adjusted for energy were calculated by the frequency category of fruit juice consumption. Usual intake estimates were derived with the software for Intake Distribution Estimation (PC-SIDE). The prevalence of inadequate nutrient intakes was examined using the Estimated Average Requirement (EAR) cut-point method (Institute of Medicine, 2000). For nutrients without an EAR (potassium and dietary fiber), the proportion of each age–sex group with usual intake above the Adequate Intake (AI) at the time of the analysis was determined.

Statistical analysis

Analysis of demographic variables was completed with Stata 12 using survey weights to adjust for differential probabilities of selection, non-response, season and day of the week. Bootstrap SVY commands in Stata were used to calculate the standard errors (SE) and confidence intervals for body weight status and usual frequency of intakes. Balanced repeated replication methods were used to create variance and SE estimates of usual intakes. PC-SIDE analyses included ratio adjustments for weekend versus weekday and energy (Dodd, 1996). Statistical significance was set at $p<0.05$ and a Bonferroni adjustment was applied to account for multiple comparisons.

Results

Population characteristics

The sample was categorized by reported usual frequency of fruit juice consumption classified as <0.5 times/day, including non-consumers ($n = 13{,}832$); ≥0.5 to <1.5 times/day ($n = 13{,}485$); or ≥1.5 times/day ($n = 7034$). Frequency of fruit juice consumption varied among age–sex groups: the predominant frequency of fruit juice consumption was ≥1.5 times/day among young children 1–3 years (46% of respondents); ≥0.5 to <1.5 times/day among children 4–8 years and boys and girls 9–13 and 14–18 years (39–42% of respondents); and <0.5 times/day for Canadian adults 19 years and older (46–55%). Across all age–sex groups, 15% of individuals reported never consuming fruit juice. Proportions of Canadians classified as overweight or obese did not significantly differ by frequency of fruit juice consumption category of <0.5, ≥0.5 to <1.5, or ≥1.5 times/day among children 4–17 years ($28 \pm 1.5\%$, $28 \pm 1.4\%$, and $25 \pm 1.4\%$, respectively) or adults ≥19 years ($62 \pm 1.3\%$, $59 \pm 1.4\%$, and $57 \pm 2.7\%$, respectively).

Increased frequency of fruit juice consumption was associated with higher proportions of Canadians consuming fruits and vegetables five or more times per day, and the most frequent (≥1.5 times/day) consumption of fruit juice

Table 1. Fruit and vegetable intake and usual intake of energy and total sugars among Canadians categorized by reported frequency of fruit juice consumption, CCHS, Cycle 2.2.

	Frequency of fruit juice consumption*								
	<0.5 times/day (n = 13,832)			≥0.5 to <1.5 times/day (n = 13,485)			≥1.5 times/day (n = 7034)		
Population by sex and age	Mean	SE		Mean	SE		Mean	SE	
Whole fruit intake (excluding juice), mean times/day									
M/F, 1–3 years	1.56	± 0.10	b	1.53	± 0.05	b	1.84	± 0.05	a
M/F, 4–8 years	1.17	± 0.05	c	1.38	± 0.04	b	1.56	± 0.05	a
M, 9–13 years	0.86	± 0.05	c	1.06	± 0.04	b	1.44	± 0.07	a
F, 9–13 years	1.11	± 0.06	b	1.21	± 0.04	b	1.50	± 0.06	a
M, 14–18 years	0.75	± 0.08	c	0.97	± 0.05	b	1.27	± 0.07	a
F, 14–18 years	0.83	± 0.05	c	1.01	± 0.04	b	1.32	± 0.08	a
M, 19–50 years	0.84	± 0.04	b	1.04	± 0.04	a	1.19	± 0.07	a
F, 19–50 years	1.13	± 0.04	b	1.28	± 0.06	ab	1.47	± 0.09	a
M, ≥51 years	1.09	± 0.05	b	1.15	± 0.03	b	1.56	± 0.13	a
F, ≥51 years	1.39	± 0.04	b	1.35	± 0.04	b	1.71	± 0.08	a
Total fruit and vegetable intake (including fruit juice), % reporting ≥5 times per day									
M/F, 1–3 years	25.7	± 3.4	c	38.5	± 2.9	b	81.5	± 1.9	a
M/F, 4–8 years	12.4	± 2.5	c	33.5	± 1.9	b	70.2	± 2.2	a
M, 9–13 years	6.5	± 1.4	c	21.9	± 2.2	b	65.6	± 2.8	a
F, 9–13 years	20.4	± 3.2	b	28.4	± 2.7	b	78.2	± 2.5	a
M, 14–18 years	8.4	± 2.4	c	17.9	± 2.0	b	62.6	± 3.2	a
F, 14–18 years	10.6	± 1.5	c	23.1	± 2.5	b	68.6	± 3.1	a
M, 19–50 years	9.3	± 1.1	c	25.1	± 2.2	b	67.6	± 3.2	a
F, 19–50 years	22.4	± 1.6	c	38.2	± 2.3	b	71.7	± 3.4	a
M, ≥51 years	17.0	± 1.5	c	37.9	± 2.0	b	75.6	± 3.9	a
F, ≥51 years	27.4	± 1.6	c	44.1	± 1.7	b	83.5	± 2.7	a
Energy (kJ)									
M/F, 1–3 years	5397	± 213	c	6104	± 159	b	6657	± 167	a
M/F, 4–8 years	7611	± 222	b	7766	± 142	ab	8209	± 151	a
M, 9–13 years	9837	± 339	ab	9205	± 276	b	10652	± 343	a
F, 9–13 years	8180	± 297		8242	± 192		8837	± 251	
M, 14–18 years	11510	± 351	b	11719	± 444	ab	12598	± 368	a
F, 14–18 years	8012	± 243	b	8368	± 222	ab	8950	± 289	a
M, 19–50 years	10272	± 243	b	10954	± 230	b	12276	± 410	a
F, 19–50 years	7414	± 167	b	7912	± 163	ab	8184	± 301	a
M, ≥51 years	8560	± 188	b	8920	± 197	ab	9556	± 385	a
F, ≥51 years	6602	± 121	b	6832	± 109	ab	7309	± 276	a
Total Sugars (g)									
M/F, 1–3 years	79.3	± 4.2	c	90.8	± 2.6	b	110.0	± 3.0	a
M/F, 4–8 years	109.2	± 3.6		115.2	± 2.2		124.0	± 6.9	
M, 9–13 years	121.9	± 5.7	b	130.4	± 6.2	ab	161.2	± 16.8	a
F, 9–13 years	108.1	± 4.2	b	119.2	± 4.2	ab	141.8	± 14.0	a
M, 14–18 years	148.6	± 7.7	b	150.8	± 5.6	b	179.4	± 6.2	a
F, 14–18 years	101.1	± 3.8		109.3	± 4.1		131.5	± 15.0	
M, 19–50 years	104.7	± 3.5	c	120.9	± 3.9	b	147.7	± 7.3	a
F, 19–50 years	80.5	± 2.3	c	96.4	± 2.7	b	122.3	± 7.4	a
M, ≥51 years	84.5	± 2.1	c	95.9	± 2.6	b	131.1	± 8.0	a
F, ≥51 years	71.8	± 1.6	c	84.8	± 1.7	b	104.6	± 5.4	a

[a, b, c] Mean values within a row with unlike superscript letters are significantly different (p<0.05; Bonferroni-adjusted p<0.0167)

*Fruit juice assumed to be 100% juice

†Usual mean intakes and proportions below the EAR were estimated using PC-SIDE (Department of Statistics, Iowa State University) with balanced repeated replication methods and ratio adjustment for intake day, categorized as weekend/weekday, and energy intake.

Sample sizes by frequency category (<0.5, ≥0.5 to <1.5, or ≥1.5 times/day) in each age–sex group: M/F, 1–3 years (447, 740, 1006); M/F, 4–8 years (707, 1361, 1273); M, 9–13 years (566, 840, 743); F, 9–13 years (550, 867, 626); M, 14–18 years (752, 946, 697); F, 14–18 years (803, 948, 594); M, 19–50 years (2347, 1655, 640); F, 19–50 years (2618, 1641, 505); M, ≥51 years (2181, 1733, 409); F, ≥51 years (2861, 2754, 541).

Table 2. Micronutrient intakes and proportions with usual intakes below the estimated average requirement (EAR) among Canadians categorized by reported frequency of 100% fruit juice intake, CCHS, Cycle 2.2.

	Usual intake*									Proportions with usual intakes below the EAR*,†								
	<0.5 times/day			≥0.5 to <1.5 times/day			≥1.5 times/day			<0.5 times/day			≥0.5 to <1.5 times/day			≥1.5 times/day		
Nutrient	Mean	SE		Mean	SE		Mean	SE		Mean	SE		Mean	SE		Mean	SE	
Vitamin C (mg)																		
M/F, 1–3 y	70	6.4	c	124	6.0	b	180	6.2	a	<1%	0.49	-	0	0	-	0	0	-
M/F, 4–8 y	99	7.0	c	126	4.8	b	180	6.6	a	<1%	0.82	-	<1%	0.05	-	0	0	-
M, 9–13 y	102	6.9	b	113	8.0	b	209	12.5	a	7.6	2.75	a	<1%	0.62	b	<1%	0.04	b
F, 9–13 y	94	7.9	c	127	8.5	b	193	10.4	a	<1%	1.78	-	<1%	0.14	-	<1%	0.11	-
M, 14–18 y	91	6.7	c	149	8.7	b	243	14.2	a	24.0	7.66	a	4.1	2.32	b	<1%	0.45	b
F, 14–18 y	96	6.5	c	144	7.8	b	205	11.1	a	11.2	6.16		2.4	1.60		<1%	0.30	
M, 19–50 y	89	4.4	c	155	6.9	b	224	14.4	a	45.6	4.58	a	8.7	2.41	b	4.1	2.08	b
F, 19–50 y	84	3.5	c	137	5.3	b	209	14.2	a	33.4	3.44	a	2.3	1.45	b	<1%	14.04	b
M, ≥51 y	92	4.7	c	135	4.9	b	251	22.7	a	45.5	3.54	a	13.4	2.36	b	1.3	1.06	c
F, ≥51 y	89	3.2	c	131	3.6	b	164	10.9	a	30.8	2.87	a	5.0	1.10	b	<1%	0.69	c
Vitamin A (mcg RAE)																		
M/F, 1–3 y	476	24.9		546	25.5		518	20.2		5.5	2.27		<1%	0.37	-	<1%	0.22	-
M/F, 4–8 y	580	26.9		582	19.2		593	19.9		2.7	1.27		1.3	0.92		1.3	0.85	
M, 9–13 y	664	47.3		669	26.9		663	33.7		17.9	5.89		13.6	3.85		12.5	4.52	
F, 9–13 y	569	35.7		572	32.1		648	38.8		18.6	8.24		21.6	5.89		14.4	5.20	
M, 14–18 y	615	47.1		695	30		673	41.5		60.1	7.96		39.7	8.75		46.6	10.46	
F, 14–18 y	507	27.2		513	25.6		584	48.5		49.7	8.06		49.7	5.53		42.5	7.91	
M, 19–50 y	638	35.4	b	705	40.2	b	857	54.7	a	58.6	4.46	a	40.4	11.41	ab	25.4	8.60	b
F, 19–50 y	598	34.2		588	24.5		685	69.0		42.7	4.81		37.5	5.10		23.0	14.98	
M, ≥51 y	766	89.4		757	38.4		784	76.3		53.6	3.47		41.4	5.48		33.5	9.71	
F, ≥51 y	612	24.7		645	24		689	62.6		42.3	4.08	a	22.9	7.80	b	28.5	9.00	ab
Vitamin D (mcg)																		
M/F, 1–3 y	6.8	0.32		6.5	0.28		6.2	0.23		97.6	11.91		89.8	2.53		90.9	1.85	
M/F, 4–8 y	6.0	0.31		6.1	0.22		5.6	0.20		90.9	3.05		94.8	1.73		99.1	9.93	
M, 9–13 y	7.2	0.43	a	7.3	0.29	a	6.3	0.31	b	83.5	3.93	a	86.1	3.00	a	96.4	1.66	b
F, 9–13 y	5.6	0.38		5.4	0.30		5.6	0.30		95.2	2.38		95.9	2.30		98.7	0.89	
M, 14–18 y	7.3	0.43		7.5	0.38		6.2	0.48		84.1	4.32		81.1	3.89		90.9	3.79	
F, 14–18 y	4.9	0.33		4.8	0.54		4.4	0.27		96.9	1.87		96.6	2.50		>99%	9.90	
M, 19–50 y	4.8	0.21	b	6.1	0.43	a	6.3	0.43	a	96.4	1.10		93.8	10.08		92.4	10.13	
F, 19–50 y	4.4	0.24		4.8	0.25		4.9	0.43		98.1	0.77		96.9	1.23		97	1.91	
M, ≥51 y	6.2	0.47		7.6	0.80		6.9	1.02		87.4	3.53		73.3	8.83		84.3	6.95	
F, ≥51 y	4.5	0.31		5.1	0.29		5.4	0.38		95.1	10.78		94.2	1.85		95.6	2.42	
Calcium (mg)																		
M/F, 1–3 y	1060	48.8		1025	35.2		1004	29.6		3.9	1.22		2.1	0.91		2.2	0.69	
M/F, 4–8 y	1043	43.2		1008	22.6		1002	24.4		22.0	3.99		14.5	3.87		22.2	3.58	
M, 9–13 y	1160	50.9		1165	43.4		1135	43.0		49.5	5.33		43.9	6.05		47.4	6.27	
F, 9–13 y	936	43.3		920	31.0		1009	40.9		75.7	5.86		79.2	4.49		66.6	6.67	
M, 14–18 y	1141	50.5		1237	44.1		1162	56.5		47.6	6.71		36.9	5.15		41.3	12.6	
F, 14–18 y	852	36.7		827	29.0		863	35.8		81.5	3.84		89.4	3.85		84.8	4.70	
M, 19–50 y	834	24.4	c	956	30.5	b	1138	54.3	a	51.1	3.48	a	29.8	5.37	b	14.8	4.36	c
F, 19–50 y	749	20.4		788	25.1		818	42.9		62.7	3.44		55.7	4.87		50.8	7.78	
M, 51–70 y	779	26.9		822	29.9		750	51.0		59.6	4.45		52.1	4.48		65.6	11.6	
M, ≥71 y	617	28.1	c	719	30.4	b	936	81.8	a	94.1	2.06	a	87.3	3.19	ab	62.0	13.9	b
F, ≥51 y	653	17.4	b	705	14.9	a	752	40.3	a	94.0	1.59		90.4	1.66		84.7	4.89	
Magnesium (mg)																		
M/F, 1–3 y	198	7.3	b	213	5.2	ab	221	5.5	a	<1%	0.03	-	0	0	-	0	0	-
M/F, 4–8 y	240	7.5		250	4.9		251	5.4		<1%	0.14	-	0	0	-	0	0	-
M, 9–13 y	289	9.7		286	7.1		310	9.3		3.2	1.53		2.2	1.30		<1%	0.28	-
F, 9–13 y	240	10.0		258	8.1		268	9.2		20.6	6.89	a	7.3	3.47	ab	4.4	2.53	b

(continued)

Table 2. (continued)

	Usual intake*									Proportions with usual intakes below the EAR*,†								
	<0.5 times/day			≥0.5 to <1.5 times/day			≥1.5 times/day			<0.5 times/day			≥0.5 to <1.5 times/day			≥1.5 times/day		
Nutrient	Mean	SE		Mean	SE		Mean	SE		Mean	SE		Mean	SE		Mean	SE	
M, 14–18 y	308	9.5	b	340	9.1	a	354	11.1	a	73.1	5.70	a	51.3	9.35	ab	41.1	10.70	b
F, 14–18 y	245	7.4		261	6.4		265	8.7		87.4	3.66		79.8	3.93		77.4	7.77	
M, 19–30 y	325	11.3	b	357	12.4	ab	400	23.3	a	56.1	7.43	a	36.4	7.22	ab	19.8	8.12	b
F, 19–30 y	264	9.0		290	11.1		286	15.1		45.7	7.70		19.1	12.9		29.5	13.0	
M, 31–50 y	340	9.8	b	356	10.2	ab	403	20.1	a	63.2	4.83	a	51.4	6.50	a	16.7	9.88	b
F, 31–50 y	286	7.5		306	8.9		279	11.5		41.8	4.15		27.8	9.17		38.0	11.90	
M, ≥51 y	318	6.2	b	342	6.7	a	368	15.0	a	70.9	3.11	a	58.5	3.79	b	41.8	9.26	b
F, ≥51 y	268	4.8	b	280	4.8	ab	297	10.0	a	51.4	3.27	a	43.6	3.06	ab	31.7	5.53	b

EAR: Estimated Average Requirement; F: female; M: male.

[a, b, c] Mean values within a row with unlike superscript letters are significantly different ($p<0.05$; Bonferroni-adjusted $p<0.0167$)

* Fruit juice assumed to be 100% juice; usual mean intakes and proportions below the EAR were estimated using PC-SIDE (Department of Statistics, Iowa State University) with balanced repeated replication methods and ratio adjustment for intake day, categorized as weekend/weekday, and energy intake.

† "-" indicates statistical comparisons were not conducted.

Sample sizes by frequency category (<0.5, ≥0.5 to <1.5, or ≥1.5 times/day) in each age–sex group: M/F, 1–3 years (447, 740, 1006); M/F, 4–8 years (707, 1361, 1273); M, 9–13 years (566, 840, 743); F, 9–13 years (550, 867, 626); M, 14–18 years (752, 946, 697); F, 14–18 years (803, 948, 594); M, 19–50 years (2347, 1655, 640); F, 19–50 years (2618, 1641, 505); M, ≥51 years (2181, 1733, 409); F, ≥51 years (2861, 2754, 541).

was associated with the highest intake of whole fruit in age–sex groups other than females 9–13 years (Table 1).

Energy and sugars intake

Energy intake was higher among the most frequent (≥1.5 times/day) compared with the least frequent (<0.5 times/day) consumers of fruit juice for all age–sex groups other than boys and girls 9–13 years, and total sugars intake were higher with increased frequency of fruit juice consumption in age–sex groups other than children 4–8 and girls 14–18 years (Table 1).

Usual micronutrient intakes and prevalence of inadequate intakes

Within all age–sex groups, mean daily vitamin C intake was significantly higher with increased frequency of fruit juice consumption (Table 2). The proportions of boys 9–13 and 14–18 years and all adults with vitamin C intake below the EAR were lowest among moderately frequent and the most frequent juice consumers (≥0.5 times/day). More frequent consumption of fruit juice was associated with higher intake of magnesium and lower prevalence of inadequate magnesium intake among the most versus least frequent consumers of fruit juice in children age 1–3 years, older women and subpopulations of males 14 years and older. Few differences in intake or adequacy of intake of vitamins A and D and calcium were observed (Table 2).

Fiber intake was significantly higher with increased frequency of fruit juice consumption among populations of children and men (Figure 1(a)) and potassium intakes were higher with increased frequency of fruit juice consumption in all age–sex groups (Figure 1(b)), though proportions of individuals exceeding the fiber and potassium AIs did not substantially differ (data not shown).

Discussion

The current study examined select nutrient intakes and adequacy of intakes among Canadians categorized by frequency of consumption of fruit juice assumed to be 100% fruit juice, and thus begins to provide information on nutrient adequacy associated with 100% fruit juice intake. Results show that more frequent consumption of fruit juice is associated with more frequent consumption of total fruits and vegetables across all age–sex groups, and higher usual intakes of vitamin C and potassium adjusted for energy. Moderate or more frequent consumption of fruit juice (≥0.5 times/day) was also associated with improved nutrient adequacy for vitamin C among adults.

The small but increased nutrient intakes with more frequent fruit juice consumption observed in this study are consistent with findings from research on dietary intakes by children and adults from 2003–2006 in the USA and more recently from adults in France (Bellisle et al., 2017; O'Neil et al., 2011, 2012), as are the findings of decreased prevalence of nutrient inadequacy (O'Neil et al., 2011, 2012). It is important to note, however, that the higher nutrient intakes among more frequent consumers of fruit juice may be attributed in part to small but statistically significant increases in the frequency of whole fruit intake and intake of total fruits and vegetables. Analyses in the USA also show that consumers of fruit juice have higher intakes of whole fruit compared with non-consumers, although consumption of total vegetables did not differ between juice

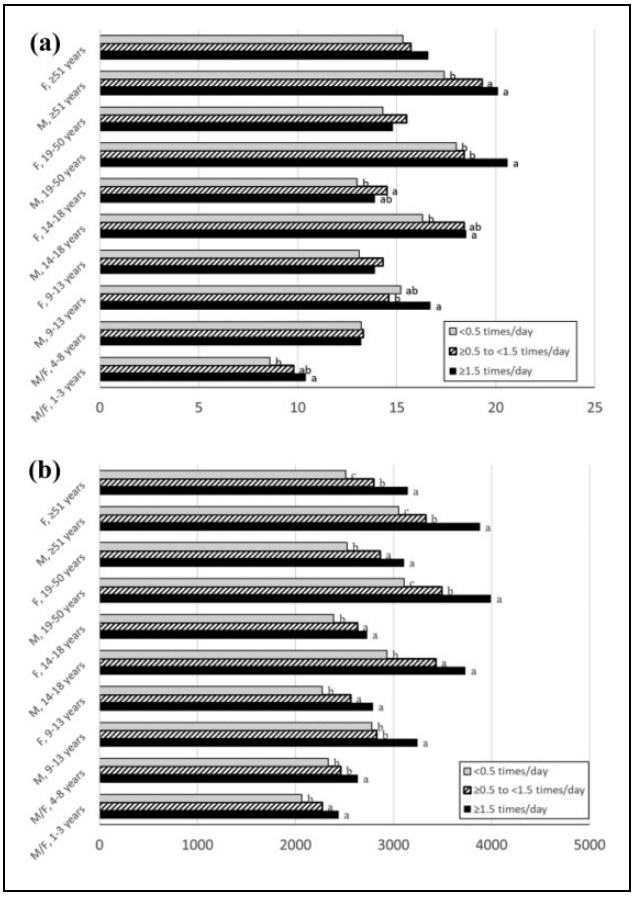

Figure 1. Fiber (a) and potassium (b) intake among Canadians categorized by reported frequency of fruit juice consumption, CCHS, Cycle 2.2 (Mean values of intake). Fruit juice assumed to be 100% juice; usual mean intakes were estimated using PC-SIDE (Department of Statistics, Iowa State University) with balanced repeated replication methods and ratio adjustment for intake day, categorized as weekend/weekday, and energy intake.
[a, b, c] Bars within an age–sex group with unlike superscript letters are significantly different ($p<0.05$; Bonferroni-adjusted $p<0.0167$). Sample sizes by frequency category (<0.5, ≥0.5 to <1.5, or ≥1.5 times/day) in each age–sex group: M/F, 1–3 years (447, 740, 1006); M/F, 4–8 years (707, 1361, 1273); M, 9–13 years (566, 840, 743); F, 9–13 years (550, 867, 626); M, 14–18 years (752, 946, 697); F, 14–18 years (803, 948, 594); M, 19–50 years (2347, 1655, 640); F, 19–50 years (2618, 1641, 505); M, ≥51 years (2181, 1733, 409); F, ≥51 years (2861, 2754, 541).

consumers and non-consumers (O'Neil et al., 2011, 2012). The current study did not quantify contributions of fruit juice to total nutrient intakes or total fruit and vegetable intakes. The differences in nutrient intakes observed by frequency of fruit juice consumption, although small, may nonetheless be relevant given that many Canadians have inadequate intakes of several micronutrients in fruit juice such as vitamin C and magnesium (Health Canada, 2016). In fact, reported increases in the prevalence of inadequate intakes of vitamin C among adults between 2004 and 2015 have been attributed to declines in the consumption of fruit juice (Garriguet, 2019).

In addition to higher intakes of some nutrients, however, increased frequency of fruit juice consumption was also associated with higher intake of energy and total sugars, which is also consistent with previous studies (Bellisle et al., 2017; O'Neil et al., 2011) and of potential concern. Recommendations to limit or reduce the intake of sugars are widely supported, though specific guidance varies (Mela and Woolner, 2018). Many 100% fruit juices are good sources of nutrients including vitamin C, but juice is also energy-dense (Rampersaud, 2007), and given its potential for contributing to higher energy intake, moderating intake is important. The trade-off of modest portions of 100% fruit juice to help bridge the gap of inadequate total fruit and vegetable consumption and meet requirements for vitamin C and to a small extent magnesium while increasing intake of potassium therefore appears to be higher intakes of energy and total sugars.

Major strengths of the current analysis include use of a large nationally representative sample of Canadians and use of frequency data in combination with intake data. Categorization based on reported frequency of fruit juice consumption provided a means to distinguish among frequency of intake over a period of time (per day, week, month or year), thus minimizing the potential for misclassification based on a single recall. As previously noted, the 2004 survey uniquely provides information to categorize typical frequency of fruit juice consumption and examine nutrient intakes, as the 2015 CCHS-Nutrition survey did not include a module on fruit and vegetable consumption (Health Canada, 2017).

It is also important to consider limits of this study. As a cross-sectional data analysis, it is not possible to examine causal effects. The questionnaire used to categorize frequency of fruit juice consumption does not account for each respondent's portion size, and consequently frequency data may not reflect the total amount of fruit juice consumed. Misclassification by frequency of intake was possible if responses included intake of products containing less than 100% fruit juice, such as fruit drinks or fruit punch. The food consumption data were self-reported and therefore prone to recall bias. In addition, consumption of fruit juice by Canadians has declined since 2004 as a result of smaller quantities consumed and a smaller proportion of the population consuming fruit juice (Garriguet, 2019; Tugault-Lafleur and Black, 2019), therefore the frequency of intake distributions may not reflect current consumption patterns.

In summary, results from this focused study show that among Canadians, more frequent consumption of fruit juice (assumed to be 100% juice) independent of caloric intake was associated with higher usual intakes of vitamin C and potassium, and improved intake adequacy of vitamin C for adults. More frequent consumption of fruit juice was also associated with higher mean intakes of whole fruit and total vegetables and fruit. Along with increased intake of select nutrients, more frequent consumption of 100% fruit juice is a source of higher energy and total sugars, thus presenting a trade-off for consumers to balance.

Acknowledgements

The authors thank Carmina Ng and Dave Haans at the Statistics Canada Toronto Region Research Data Centre for support in accessing the CCHS 2.2 data, and Brenda Sims, Professor (retired), of the University of North Texas for editorial assistance.

Authors' contributions

TDB conceived the study question. MMM and LMB drafted the study protocol with input from TDB and AMD. MMM, LMB and AMD completed all data analyses with LMB overseeing all statistical analyses. All authors contributed to interpretation of the findings. MMM prepared a first draft of the manuscript with input from all authors. All authors read, critically reviewed, edited, and approved the final manuscript.

Availability of data and materials

The CCHS 2.2 data used to complete this analysis were accessed at the Statistics Canada Toronto Region Research Data Centre. Approval to conduct the analyses presented in this paper was received from the Statistics Canada Research Data Centre Program.

Declaration of conflicting interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: MMM and LMB are employees of Exponent, Inc.; PepsiCo, Inc. is a client of Exponent, Inc. TDB is an employee of PepsiCo. AMD has no conflicts.

Ethical approval

Ethical approval was based on the authority of the Statistics Act of Canada.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by PepsiCo R&D; the opinions in this study are those of the authors and do not necessarily represent the opinions or policies of PepsiCo, Inc.

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Supplemental Material

Supplemental material for this article is available online.

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