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Knowledge and Perceptions of Carbohydrates among Nutrition-Major and Nutrition-Elective Undergraduate Students in Canada

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ABSTRACT

Objective: The purpose of the study was to assess knowledge and perceptions related to carbohydrates, including sugars, among Canadian nutrition-major undergraduates compared to those enrolled in elective nutrition courses (i.e., "nutrition-elective students").

Methods: Cross-sectional surveys were distributed during class time at eight Canadian universities, which included 32 questions on demographics, knowledge and perceptions of carbohydrates and sugars. Descriptive analyses were performed. Differences between groups were tested by Chi-squared statistics.

Results: A total of 1207 students (60% nutrition-majors) participated in the survey (January 2016–February 2017). Internet-based sources accounted for one-third of the sources where students obtained nutrition information. About 61% of internet-bases sources were "online" or "website" with no qualifiers, and about a quarter was from social media. A higher percentage of nutrition-majors correctly answered knowledge questions of carbohydrates compared with nutrition-elective students ($p < 0.01$); no difference was observed for sugars-related knowledge questions. The perceptions of sugars were generally negative and did not differ between groups.

Conclusions: Several knowledge gaps and common perceptions on topics related to carbohydrates and sugars were identified; nutrition-major students performed better than nutrition-elective students on carbohydrate knowledge questions, but not sugars. These results highlight the importance of identifying methods to help students bridge knowledge gaps and develop skills to critically evaluate nutrition information from various resources and challenge personal biases.

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Carbohydrate; sugar; knowledge gap; perception; nutrition education

Introduction

Media coverage of scientific studies should effectively bridge the information gaps that exist between academia and the general public, in order to facilitate the transfer of current information on nutrition-related research discoveries. However, sensational headlines and over-simplification of complex research designs that omit cautionary facts and limitations of such studies can lead to misleading messages made available to the public (1, 2).

An increased focus by the media to report on scientific results that concern topics on foods containing sugars and carbohydrates have arisen due to the potential relationships between diet and chronic diseases. Single studies reporting associations between sugars intake and obesity or other chronic diseases have been popularized in the media to often imply causal relationships, which have not been supported by systematic reviews required to examine the totality of available scientific evidence (3). In the meantime, the internet has been increasingly used as a source of medical, nutrition and dietary information especially among young adults (4–6), although the quality of information is not always reliable (7–9). Previous research among Canadian dietitians has shown certain knowledge gaps related to sugars which were likely due to miscommunicated information (10). Undergraduate nutrition students preparing to become future food and nutrition professionals are exposed to the plethora of media headlines and online information as they acquire science-based professional training. To encourage critical thinking and evidenced-based communication in this area, it is essential to gain an understanding of their

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knowledge and perceptions on carbohydrates and sugars containing foods and the metabolism of these nutrients with respect to relationships with human health and wellness. It was hypothesized that students receiving formal academic training in nutrition are less susceptible to sensationalized popular media compared to other students with an interest in gaining nutrition knowledge. The objectives of this study were to assess the knowledge, attitudes and perceptions related to carbohydrates (including sugars), metabolism and health, among undergraduate students specifically enrolled in a nutrition program (referred to as "nutrition-major students"), as compared to those taking a nutrition course as an elective but not enrolled in a nutrition program (referred to as "nutrition-elective students"). The study also attempted to determine whether there were differences in student understanding on these topics during their progression of university nutrition education.

Methods

Study population and procedure

Undergraduate students enrolled in food science or nutrition courses were invited to participate in the cross-sectional survey offered to eight Canadian universities. Printed questionnaires were administered to students between January 2016 and February 2017 during classes. No personally identifiable information was collected. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Research Ethics Board of all participating universities. Written informed consent was obtained from all subjects.

Questionnaire

The questionnaire was composed of 32 questions (Supplementary Material 1) on student demographic information, the sources from which the students obtained nutrition information, basic knowledge points on carbohydrates and sugars that are usually covered in nutrition courses, and attitudes and perceptions on carbohydrates and sugars based on a 5-point Likert scale (Strongly Agree, Somewhat Agree, Undecided, Somewhat Disagree, Strongly Disagree). The responses to knowledge questions were analyzed based on the percentage of students who selected the correct answer(s); responses to attitude and perception questions were grouped based on the degree of agreement with each statement at a 3-point level: Agree, Undecided, Disagree. The last question (Question 32) was designed to measure each participant's level of nutrition education by indicating the number of nutrition courses completed from a list of nutrition courses specific to each university (See Statistical Analysis). The questionnaire was pre-tested among a focus group comprised of 10 undergraduates (nutrition-major and nutrition-elective) at a participating University to ensure acceptability of the questionnaire in terms of length and language clarity and was amended based on feedback. The questionnaire was tested among a small group of dietetic interns to ensure internal repeatability. The questionnaire was written in English and was translated to French for administration at a French-speaking University.

Statistical analyses

Analyses were performed using IBM SPSS Statistics for Windows, Version 22 (IBM Corp., Armonk, NY, USA) and Stata 14/MP (College Station, TX: Stata Press). Two collaborators (Chung and Gurcan) not privy to the hypotheses or objectives performed all the analyses. The differences between nutrition-major and nutrition-elective students were tested using chi-squared statistics. Based on *a priori* power calculations that considered multiple testing, a lower *p*-value (less than 0.01) was considered a statistically significant difference in order to reduce the risk of false significance. The differences in the number of correctly answered knowledge questions by the number of credible sources were analyzed using one-way ANOVA with Tukey's *pos-thoc* testing. The differences in the number of correctly answered knowledge questions by internet sources were analyzed using a two-tailed unpaired t-test. A *p*-value of <0.01 was considered significantly different between groups.

The level of nutrition education for each student was quantified using the Nutrition Class Scores (NCS) based on responses to Question 32, which reflect both the number of courses completed and the advancement of each course. For each student, a total NCS was calculated by summing up scores for courses a student was taking or had completed at the time of the survey (Supplementary Table S1). The higher total scores correspond to a higher number of nutrition courses taken by the students and more advanced knowledge of course contents, thus representing more highly developed student nutrition training. Since the distributions of total NCS were skewed toward lower scores, the Wilcoxon/Mann-Whitney rank-sum test was used to compare the NCS between students who answered correctly and those who were unsure or gave incorrect answers to the knowledge questions. Nutrition-major and nutrition-elective students were analyzed separately.

Results

Participant demographics

A total of 1207 undergraduate students participated in the survey between January 2016 and February 2017 at eight participating universities, 60.4% of whom were nutrition-majors (Table 1). The majority of the surveyed participants were female (81.7% among all participants and 88% among nutrition-major students), generally reflective of the gender distribution of Canadian dietitians with 95% being female (11).

Distribution of the NCS is presented in Supplementary Figure S1. The majority (91%) of nutrition-elective students had scored less than 10, suggesting that the nutrition-elective students had completed fewer nutrition courses than nutrition-major students. Among the 9% of nutrition-elective students with NCS greater than 10, over 60% were

enrolled in a Biology, Kinesiology or Health Sciences program; excluding answers from this small group of nutrition-elective students with more nutrition knowledge did not change the overall observed differences between nutrition-majors and nutrition-electives (data not shown).

Table 1. Demographic characteristics of participating undergraduate students from eight Canadian universities.

Demographic characteristics	Frequency Distribution ($n = 1207$)
The year of University program enrolled in when completing the questionnaire	
1st	18.1%
2nd	31.9%
3rd	14.5%
4th and above	34.7%
Currently Enrolled in a Nutrition Degree Program	
Yes	60.4%
No	39.6%
Gender	
Female	81.7%
Male	18.1%
Age Range	
15–19 years	26.4%
20–24 years	61.6%
25–29 years	8.0%
30–34 years	2.2%
35 years and above	1.5%

Sources of nutrition information

Students were asked to provide, in no particular order, the top three sources where they obtained nutrition-related information (Figure 1). Internet-based sources were listed 32% of the time. Academic sources such as scientific journals, research publication databases and libraries ranked second at approximately 27%; nutrition-major students were more likely to use academic sources as compared to nutrition-elective students (Figure 1, 32% for nutrition-major and 19% for nutrition-elective students, $p < 0.001$). Among internet-based sources, 61% included "internet", "online", "website" without specific qualifiers, and 27% were social media sources such as Twitter, YouTube and Facebook. Students who indicated more credible sources in the top three answers had a higher number of carbohydrate-related knowledge questions (i.e., Questions 9, 10, 11, 12, 13, 16-1/3/4, 17-2) and total knowledge questions (i.e., Questions 9–20) answered correctly (Table 2). No difference was observed for sugars-related knowledge questions (i.e., Questions 14, 15, 16-2, 17-1, 18, 19, 20). Similarly, those who included internet-based sources as one of the top 3 sources of nutrition information had a lower number of carbohydrate-related knowledge questions and total knowledge questions answered correctly, but not sugars-related knowledge questions (Table 2).

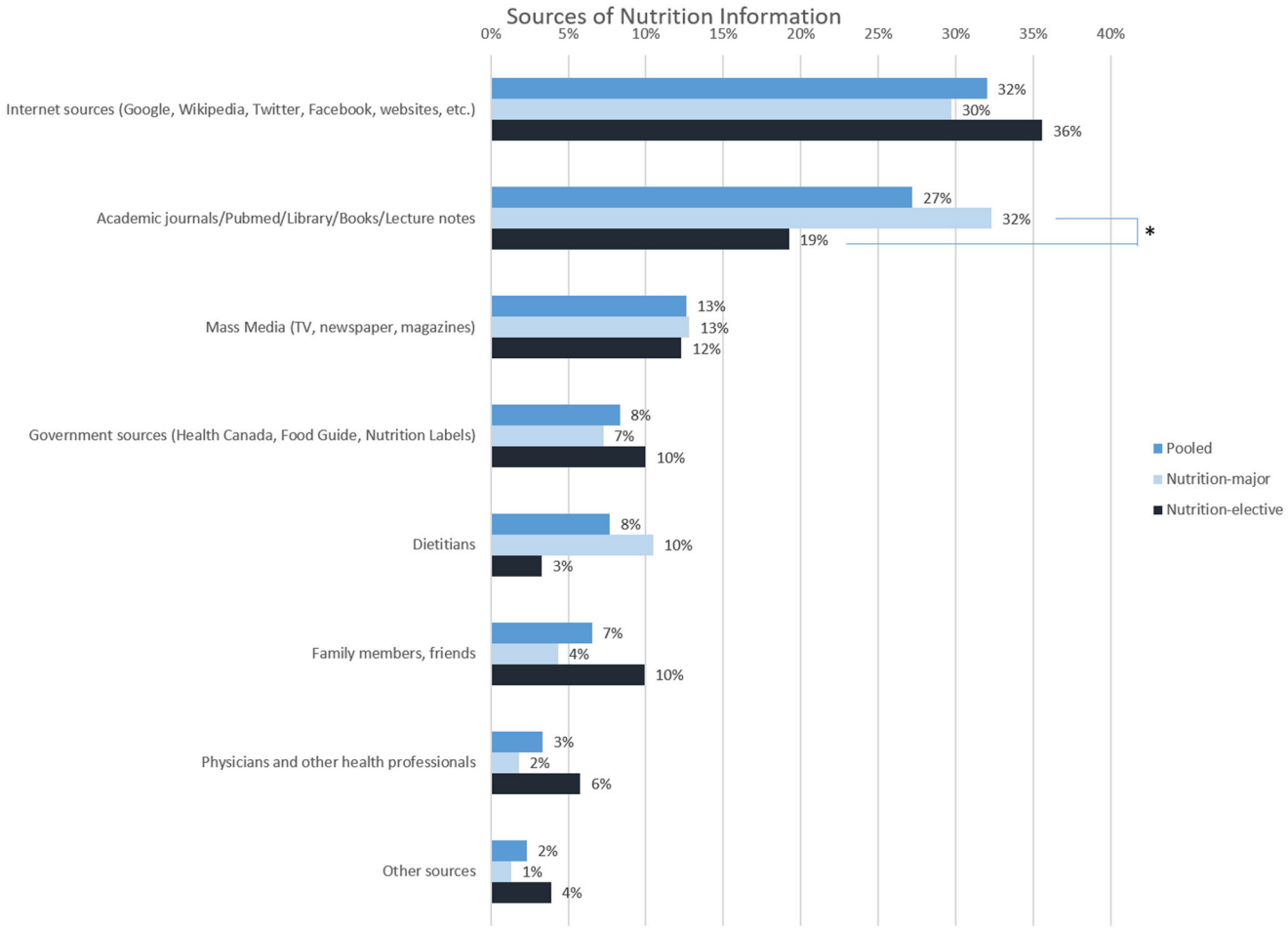

Figure 1. Top sources of nutrition information among all students as well as the subgroups of nutrition-major and nutrition-elective students. *$p < 0.001$ between nutrition-major and nutrition-elective students.

Table 2. The number of knowledge questions correctly answered (Mean ± SD) based on the number of credible sources and whether or not internet-based sources were included in the top 3 sources of nutrition information (Question 8).

	Number of credible sources[1]					Internet[2] included as one of the sources		
	0 ($n = 388$)	1 ($n = 415$)	2 ($n = 240$)	3 ($n = 118$)	p[3]	Yes ($n = 879$)	No ($n = 328$)	p[4]
Carbohydrate knowledge questions	4.0 ± 1.8^{a}	4.3 ± 1.8^{ab}	4.5 ± 1.8^{b}	5.1 ± 1.6^{c}	<0.0001	4.1 ± 1.8	4.6 ± 1.8	<0.0001
Sugars knowledge questions	2.1 ± 1.1^{a}	2.1 ± 1.2^{a}	2.1 ± 1.1^{a}	2.3 ± 1.1^{a}	0.3622	2.1 ± 1.2	2.2 ± 1.1	0.3237
Total knowledge questions	7.8 ± 3.4^{a}	8.3 ± 3.4^{ab}	8.6 ± 3.4^{b}	9.8 ± 3.0^{c}	<0.0001	8.1 ± 3.4	8.9 ± 3.4	0.0003

[1]Credible sources include academic journals/PubMed/library/books/lecture notes, government sources, dietitians, physicians and other health professionals.
[2]Internet-based sources include Google, "internet", "website", "online" and social media sources.
[3]One-way ANOVA with Tukey's multiple comparisons, means without a common superscript (a,b,c) differ, $p < 0.01$.
[4]Two-tailed unpaired t-test, $p < 0.01$.

Table 3. Percentage frequency of students who answered knowledge questions correctly[a,b].

Questions	All (%) ($n = 1207$)	Nutrition-major Students (%) ($n = 729$)	Nutrition-elective Students (%) ($n = 478$)	p
Q9. What is the main source of energy normally used by the brain?	93.1	95.9	89.5	0.001
Q10. Which of the following is (are) considered soluble fiber? Please check all that you think is (are) correct.	32.1	27.6	38.9	<0.001
Q11. Which of the following has the highest Glycemic Index (GI)?	32.6	33.9	30.5	0.047
Q12. The following statement is in regard to Glycemic Index (GI). Please check all that you think is (are) correct.	29.7	36.8	19.0	<0.001
Q13. The Acceptable Macronutrient Distribution Range (AMDR) for carbohydrates was determined, by the Institute of Medicine, based on decreasing risk of chronic disease and providing adequate intake of other nutrients. What is the AMDR for carbohydrates?	64.2	80.5	39.3	<0.001
Q14. Statistics Canada reports that Canadians on average consume 26 teaspoons of sugars per day (1 teaspoon = 4 grams). Which of the following are considered sugars by Statistics Canada in the assessment of sugars intake? Please check all that you think is (are) correct.	18.2	16.5	20.9	0.047
Q15. The naturally-occurring sugars in fruits and vegetables include _____. Please check one.	29.8	30.3	29.1	0.122
Q16. How many Calories per gram do the following provide?				
16-1. Starch	57.4	70.2	37.9	<0.001
16-2. Sugars	63.9	73.7	49.0	<0.001
16-3. Soluble fiber	7.4	10.0	3.3	<0.001
16-4. Insoluble fiber	33.2	40.3	22.4	<0.001
16-5. Alcohol	47.0	67.6	15.5	<0.001
16-6. Protein	71.3	82.7	53.8	<0.001
16-7. Fat	72.9	82.7	57.9	<0.001
Q17. In the small intestine,				
sucrose is broken down to _____,	57.5	63.6	48.1	<0.001
and starch is broken down to ____.	59.7	69.8	44.4	<0.001
Q18. People may be at risk of inadequate micronutrient intake when added sugars intakes are _____.	29.0	24.1	36.4	<0.001
Q19. Added sugars consumption in Canada has been_____ over the past 20 years.	5.1	4.7	5.6	0.717
Q20. The average consumption of added sugars in Canada (excluding sugars naturally occurring in fruits and vegetables) is estimated to be approximately _____ of the total daily Caloric intake.	8.5	9.5	7.1	0.071

[a]Values represent mean percent. $p < 0.01$ indicates a significant difference between nutrition-major and nutrition-elective students after accounting for multiple testing.
[b]See Supplementary Material 1 for detailed multiple choices.

Knowledge questions

Carbohydrate-related knowledge questions

Nutrition-major students had better knowledge of carbohydrate-related concepts compared with nutrition-elective students (Table 3). When asked to select the type of food with the highest glycemic index (GI) (Question 11), only 33.9% of nutrition-major students and 30.5% of nutrition-elective students chose the correct answer of "white bread". A greater percentage of students from both groups incorrectly selected "table sugar" compared to other options (Figure 2). Interestingly, there was a 5-fold difference in the percentage between those who chose "table sugar" compared to those who chose "honey", despite that honey falls within the same medium GI category as table sugar. When asked about statements pertaining to the definition and factors affecting the

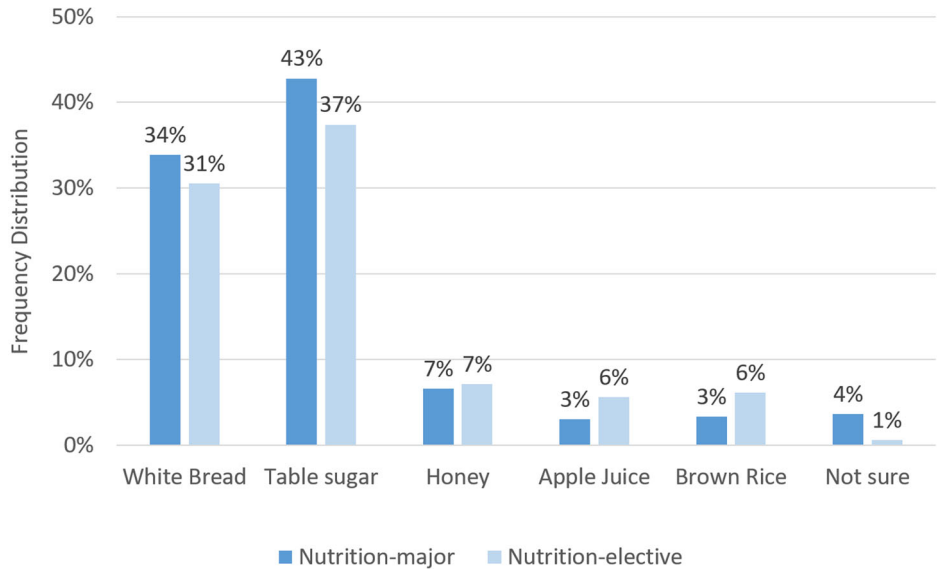

Figure 2. Percentage frequency distribution of nutrition-major and nutrition-elective students who answered Question 11: Which of the following has the highest Glycemic Index.

GI (Question 12), 36.8% of nutrition-major students provided correct answers, as compared to 19.0% of nutrition-elective students ($p < 0.001$).

Table 4. Percentage frequency distribution of perceptions of carbohydrates among pooled students. No differences were observed between responses from nutrition-major and nutrition-elective students.

Questions	Agree (%)	Undecided (%)	Disagree (%)
Carbohydrate-related perceptions			
Question 23. Low-carbohydrate diets are effective weight-loss strategies for the general public	37	9	54
Question 25. The intake of tuber vegetables such as potatoes that are composed predominantly of starches should be avoided because they cause rapid spikes in blood glucose levels.	25	13	62
Question 28. Dietary fibers that occur naturally in foods have greater health benefits than functional fibers added to foods	60	20	20
Question 30. Carbohydrate is preferred over protein or fat as an efficient energy source to support intensive physical activity.	78	6	16
Sugars-related perceptions			
Question 22. Sugars found naturally in fruits and vegetables are metabolized similarly by our bodies to sugars added to foods.	58	5	37
Question 24. Added sugars are more likely to contribute to weight gain than other Caloric sources in your diet	72	8	20
Question 26. Consumption of sugar-sweetened food and beverages can lead to changes in mood and hyperactive behaviors in Children	72	10	18
Question 27. Sugars are addictive and make people crave more sugars-containing food, leading to overeating and weight gain.	83	11	6
Question 29. In addition to sugars, other fermentable carbohydrates (such as starches) contribute to dental caries (tooth decay) formation.	58	23	19
Question 31. Fructose, in comparison to glucose, is more likely to be converted to fat and stored in the liver.	31	32	37

Sugars-related knowledge questions

When knowledge questions (Questions 14, 15, 18, 19, and 20) related to sugars were asked, there was no difference between nutrition-majors and non-majors (Table 3). For example, in Question 14, when asked about the types of sugars included in the 26 tsp average Canadian consumption of sugars (i.e., total sugars) reported by Statistics Canada, the percentage of nutrition-major students that gave the correct answer was not different from nutrition-elective students ($p = 0.047$, Table 3). As many as 28% of nutrition-major students and 12% of nutrition-elective students did not believe that naturally-occurring sugars, such as those in milk and fruits, were included (Supplementary Table S2). This apparent misunderstanding implies an unclear understanding of whether the term "sugar" refers to either "total sugars" or "added sugars".

The relationship between nutrition class scores and knowledge of carbohydrates and sugars

Nutrition-major students who correctly answered carbohydrate-based questions (e.g., Questions 9, 10, 12, 13) had higher NCS (as a measure of higher levels of nutrition education) than those who did not answer the questions correctly ($p < 0.01$) (Supplementary Figure S2). Similar findings were observed among nutrition-elective students for two of the four carbohydrate-based questions. In contrast, the levels of nutrition education did not seem to be different between nutrition-major or nutrition-elective students who answered sugars-based knowledge questions correctly and those who did not (e.g., Questions 14, 15, 18, 19, 20).

Perception questions

Similar distributions of answers on the grouped 3-point Likert scale were observed between nutrition-major and nutrition-elective students for all perception questions; as a result, pooled data are presented (Table 4). Overall, students

had negative attitudes toward sugars. Over 70% of students thought that added sugars contribute more to weight gain than other dietary sources of calories (Question 24). The majority of students thought that sugars lead to hyperactivity in children (72%, Question 26) and that sugars are addictive, leading to overeating and weight gain (83%, Question 27). A modest majority of students recognized the role that all fermentable carbohydrates have on the development of tooth decay (58%, Question 29).

Discussion

Our study is the first in Canada to report on the basic knowledge, attitudes and perceptions of carbohydrates and sugars in students majoring in nutrition (60.4%) and non-major students enrolled in elective nutrition courses. This allowed for comparisons between students who were studying to obtain a nutrition degree and those students who had an interest in nutrition but were not nutrition-majors. Results from this study suggest that internet-based sources are a major channel that students use to source their nutrition information. Interestingly, those who relied more on credible sources (such as academic journals and government websites) and relatively less on internet-based sources displayed a comparatively better knowledge about carbohydrate-related, but not necessarily sugars-related facts. Similarly, compared to nutrition-elective students, nutrition-major students generally displayed a better knowledge of carbohydrates compared to sugars. Both groups displayed generally negative attitudes toward sugars, many of which were similar to common views reported in the media. These data support the crucial role of formal academic training, supported by credible curriculum teaching materials, which enabled obtaining knowledge that was more accurate and moreover, was in part protective against the potential influence of misinformation obtained from some media sources.

Our results identify knowledge gaps related to dietary carbohydrates and sugars information. For example, GI is a key measurement used to categorize carbohydrate-containing foods and is commonly included in the nutrition curriculum. GI depicts the blood glucose response after consuming a standard amount of food in proportion to consuming a piece of white bread or consuming the same amount of glucose in solution. However, only about one-third of nutrition-major students and a comparable proportion of nutrition-elective students correctly identified that white bread had the highest GI among a list of examples of carbohydrate-containing foods and beverages. A higher proportion of both nutrition-major and nutrition-elective students incorrectly selected table sugar over white bread. Another important indicator of knowledge on GI is that the glycemic response in individuals after consuming certain foods can change depending on food preparation methods or when other foods are consumed concurrently (12–14). However, only 37% of nutrition-major students understood this concept, and this score was lower among students that were enrolled in an elective nutrition course. These data suggest that understanding of the GI concept and the factors that influence GI values and glycemic response after consuming different types of foods is lacking and should be improved.

The study also assessed whether the Nutrition Class Score (NCS), as a measure of the level of nutrition education, was associated with overall knowledge of carbohydrates and sugars. The results indicate that the NCS of the nutrition-major students who answered carbohydrate-based questions correctly were higher than those who did not answer the questions correctly. In contrast, the NCS did not differ between students who correctly answered sugars-based knowledge questions and those who did not, regardless of whether students were nutrition-major or nutrition-elective students, and the percentages of correct answers to these questions were generally low. These results show that students did not have an accurate understanding of sugars-based knowledge questions, and the higher level of nutrition education that they received did not help increase their sugars-based knowledge. Information about the health effects of sugars in the public domain may have strongly influenced students' perceptions or potentially influenced the nutrition curriculum, highlighting the need to strengthen course materials that cover these topics of interest.

With the transition from traditional mass media to internet-based communications, the channels through which students obtain information has expanded to include easily accessible but unvetted information on the internet. Such a transition is reflected by the findings of this study where internet-based sources accounted for about 33% of the total sources, with a majority (about 60% for both nutrition-major and nutrition-elective students) being "online" or "websites" without specific qualifiers to inform the credibility of the information. While the traditional channel of academic journals and libraries remains a top source of information frequently mentioned, it represented just 27% of the total sources reported. The rising trend of consumers seeking health information on the internet has been well documented over 15 years ago (15).

Although it can be argued that credible information can also be found through the internet via the websites of academic journals, professional associations and government, it was expected that the undergraduate students, if they did seek information from these sources, would refer to them with specific source names when answering this question, rather than using generic terms like "online" or "websites". The authors applaud the easily accessible information from reputable sources but also caution a lack of peer review, quality control or credibility for other internet sources accessible through generic search engines and social media channels (7–9).

Some media articles tend to sensationalize or exaggerate research findings, especially those obtained from discovery-oriented studies, leading to an unbalanced perspective on the potential consequences of the finding. Woloshin and colleagues (2006) analyzed the content of scientific publications reported in major media outlets (e.g., newspapers, television, radio, etc.) and found that news articles written on materials derived from scientific conference presentations often omitted basic study facts and failed to use cautionary statements

(1). A recent comparison of 75 clinically-oriented media articles in the top five American newspapers showed that newspapers were more likely to cover observational studies of inferior quality more so than randomized controlled studies that were of higher quality (2). Bubela and Caulfield (2004) found that both scientific studies and newspaper articles overemphasized benefits and under-represented risks or costs associated with the research findings (16). Inaccurate or misrepresented information about health-related research conveyed in the news should not occur if researchers are actively involved in fact-checking the reported information (17, 18), and the quality of press releases has been shown to correspond to the quality of the corresponding news articles (19). Given the inconsistent quality of studies reported, and difficulties in accurate translation of scientific findings related to advances in nutritional science by the media, it is of vital importance for students to develop the skills needed to scrutinize and critically appraise the information received from various nonacademic sources.

Our results not only identified that students obtained a greater proportion of nutrition information from internet sources, but also indicate that popular media coverage may influence the understanding and attitudes of students toward sugars and health. For example, over 70% of students from both groups thought that added sugars are more likely to contribute to weight gain than other caloric sources present in the diet. This has been a very controversial topic and may have contributed to mixed opinions prior to completing the questionnaire. A majority of nutrition-major (63%) and an even higher proportion of nutrition-elective (84%) students believed that sugar-sweetened food and beverages lead to hyperactive behaviors in children. Although this is a common message reported in the media, the concept has not been proven by scientific studies (20, 21). Similarly, the majority of students (79% and 88% for nutrition-major and nutrition-elective students, respectively) believed that sugars are addictive and will lead to overeating and weight gain, a belief often stated in media reports but one that remains highly debatable within the scientific community (22). Although it is not possible to assert any direct connection between popular media influence on student perceptions of sugars-related health topics, our findings do show the need to implement training for students to develop critical thinking skills on popular issues such as the exposure to nutrition information from a wide variety of sources that may vary in both accuracy and objectivity.

The surveys were focused on knowledge points or perceptions that were related to carbohydrates or sugars only. It would also be worthwhile to further explore whether the findings we obtained are specific to sugars, or whether there may be similar findings for knowledge and perception gaps for other nutrients, such as saturated fat, animal proteins or the gluten-free diet controversy.

We acknowledge that there are limitations to our study. First, for questions related to perceptions of carbohydrates and sugars, it was difficult to differentiate whether those students that selected "I don't agree or disagree" was because they either did not know the answer or because they were very knowledgeable on the subject and were of the opinion that the current scientific evidence remains inconclusive. Although a pre-testing of the questionnaire was conducted, the accuracy may be improved between groups if the questionnaire's repeatability was verified among nutrition-elective students. The cross-sectional design of the study also only provided a one-time observation. We wish to use this information as a baseline to monitor trends, in particular those related to perceptions on carbohydrates and sugars over time with additional surveys that could be conducted in the future.

Conclusions

This cross-sectional survey of Canadian undergraduate students identified a number of knowledge gaps related specifically to carbohydrates and sugars nutrition. Students that were enrolled in a nutrition degree program with the advantage of taking more nutrition courses possessed greater knowledge on carbohydrate-related issues, but this was not the case for responses on sugars topics. Internet-based sources including the media have emerged as a major source of nutrition information for students; however, the quality and credibility are variable, may not clearly identify strengths and limitations of information sources, and may produce a negative influence on overall student perceptions toward sugars. The knowledge gaps identified in this study and the negative perceptions reported are likely linked to popular internet and media information sources, which can be improved by encouraging student critical thinking during their study of food science and nutrition. An enhanced focus on basic food chemistry and metabolism principles of carbohydrates and sugars in the classroom is important to enabling students to critically scrutinize the scientific merits of nutrition studies reported by the media.

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Disclosure statement

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Authorship

YW, NB, DK, HTO, CD, LP, SM contributed to the study design, NB, DK, HTO, DWLM, MS, BL contributed to the conduct of the study,

MC, AG contributed to the analysis of data, all authors contributed to the interpretation and preparation of the manuscript.

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