Underestimating a serving size may lead to increased food consumption when using Canada's Food Guide

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Abstract: It is unclear whether Canadians accurately estimate serving sizes and the number of servings in their diet as intended by Canada's Food Guide (CFG). The objective of this study was to determine if participants can accurately quantify the size of 1 serving and the number of servings consumed per day. White, Black, South Asian, and East Asian adults (n = 145) estimated the quantity of food that constituted 1 CFG serving, and used CFG to estimate the number of servings that they consumed from their 24-h dietary recall. Participants estimated 1 serving size of vegetables and fruit (+43%) and grains (+55%) to be larger than CFG serving sizes ($p \leq 0.05$); meat alternatives (–33%) and cheese (–31%) to be smaller than a CFG serving size ($p \leq 0.05$); and chicken, carrots, and milk servings accurately ($p > 0.05$). Serving size estimates were positively correlated with the amount of food participants regularly consumed at 1 meal ($p < 0.001$). From their food records, all ethnicities estimated that they consumed fewer servings of vegetables and fruit (–15%), grains (–28%), and meat and alternatives (–14%) than they actually consumed, and more servings of milk and alternatives (+26%, $p \leq 0.05$) than they actually consumed. Consequently, 68% of participants believed they needed to increase consumption by greater than 200 kcal to meet CFG recommendations. In conclusion, estimating serving sizes to be larger than what is defined by CFG may inadvertently lead to estimating that fewer servings were consumed and overeating if Canadians follow CFG recommendations without guidance. Thus, revision to CFG or greater public education regarding the dietary guidelines is warranted.

Key words: dietary guidelines, nutrition, portion sizes, dietary intake, food estimation, eating, ethnic, diet.

Résumé : On ne sait pas très bien si les Canadiens ont une estimation précise des portions et du nombre de ces portions dans leur régime selon le Guide alimentaire canadien (CFG). Cette étude se propose de vérifier si les participants peuvent déterminer précisément la grosseur d'une portion et le nombre de portions consommées en une journée. Des adultes blancs, noirs et originaires de l'Asie du Sud et de l'Est (n = 145) déterminent la quantité d'aliments dans une portion selon le CFG et se servent du guide pour déterminer le nombre de portions consommées telles que consignées dans leur carnet alimentaire des 24 dernières heures. Selon l'estimation des participants, la portion de fruits et légumes et celle de grains est respectivement 43 % et 55 % plus grosse que la portion définie dans le CFG ($p \leq 0{,}05$); la portion de substituts de la viande et de fromage est respectivement 33 % et 31 % plus petite que la portion définie dans le CFG ($p \leq 0{,}05$); la portion de poulet, de carottes et de lait est égale à la portion définie dans le CFG ($p > 0{,}05$). Les estimations des portions sont positivement corrélées à la quantité d'aliments consommés chaque jour par les participants ($p < 0{,}001$). D'après les carnets alimentaires, tous les groupes ethniques consomment selon eux moins de portions de fruits et légumes (–15 %), de grains (–28 %), de viandes et de substituts (–14 %) qu'en réalité, mais plus de portions de lait et de produits laitiers (+26 %, $p \leq 0{,}05$) qu'en réalité. En conséquence, 68 % des participants pensent qu'ils doivent accroître leur apport alimentaire de 200 kcal pour se conformer au CFG. Surestimer une portion alimentaire lorsque comparée à celle définie dans le CFG peut aboutir à sous-estimer le nombre de portions et à se suralimenter, si les Canadiens se conforment au CFG sans aide. Il y a donc lieu de réviser le CFG ou d'améliorer l'éducation du public en ce qui concerne les recommandations alimentaires.

Mots-clés : directives alimentaires, nutrition, portion, apport alimentaire, estimation de l'apport, se nourrir, ethnie, régime alimentaire.

[Traduit par la Rédaction]

Introduction

Canada's Food Guide (CFG) is an educational tool that was created to provide guidance to Canadians about healthy eating (Health Canada 2007*c*; Katamay et al. 2007; Bush et al. 2007). It recommends that Canadians consume a specific number of servings each day from the 4 food groups to meet nutrient and energy requirements necessary for optimal health (Katamay et al. 2007; Bush et al. 2007). A "serving" corre-

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sponds to a reference portion amount that is meant to help Canadians understand the quantity of food that should be consumed from the 4 food groups each day (Bush et al. 2007; Health Canada. 2007*d*). CFG serving sizes vary depending on the type of food (Katamay et al. 2007; Bush et al. 2007), but have largely remained the same since the 1977 CFG (Health Canada 2007*a*, 2007*b*).

Previous research has demonstrated that serving size reference amounts are not analogous to the actual portion sizes commonly consumed (Rolls 2003; Young and Nestle 1995). The portion sizes of food consumed have increased since the 1970s (Rolls 2003; Young and Nestle 1995, 2002, Wansink and van Ittersum 2007; Smiciklas-Wright et al. 2003; Nielsen and Popkin 2003), and it has been demonstrated that larger portion sizes are associated with greater food consumption (Wansink and van Ittersum 2007; Diliberti et al. 2004; Ello-Martin et al. 2005; Young and Nestle 2003; Rolls et al. 2004). From 1984 to 2004, the average muffin size has increased from 1.5 to 4 oz (42.5 to 113.4 g) (167% increase) and a portion of spaghetti and meatballs has increased from 1 to 2 cups (250 to 500 mL) (100% increase) (Rolls 2003; National Heart, Lung, and Blood Institute 2004). This finding is problematic when comparing commonly served portion sizes to serving sizes in the CFG. For example, a bagel commonly weighs 113 g, 26% larger than the 90-g serving size for a bagel in the CFG (Health Canada 2007*b*; The Great Canadian Bagel 2010). Similarly, a portion of Sirloin steak at a steakhouse is generally 8 to 12 oz (226.8 to 340.2 g), 220% to 380% larger than the 2.5 oz (75.0 g) serving size in the CFG (Health Canada 2007*b*; The Keg Steakhouse and Bar 2011). Although, Canadians may consume more than a single serving during each meal, even a single 8-oz (226.8 g) steak already exceeds the CFG's maximal daily allowance for meat and alternatives (3 servings = 7.5 oz (225.0 g)) (Health Canada 2007*b*; The Keg Steakhouse and Bar 2011). These societal practices may make it more challenging for Canadians to understand and conceptualize a CFG serving size correctly (Wansink and van Ittersum 2007).

Approximately 20% of Canada's total population has immigrated to Canada and 43% of Toronto's total population is from visible minority groups (Statistics Canada 2009, 2010*a*). After Whites, South Asians and East Asians are the largest ethnic groups in Canada followed by Blacks (Statistics Canada 2010*b*). The CFG has attempted to accommodate some of the ethnic differences in dietary habits by including serving size examples for ethnic specific foods (Katamay et al. 2007; Bush et al. 2007; Health Canada 2007*b*). However, people of different ethnicities may even interpret the word "serving" differently (Paisley et al. 2005).

Given the importance of dietary habits in determining health status and body weight regulation, and that the CFG is the most common dietary information tool utilized by health professionals, it is important to examine how the messages in the CFG are understood. Thus, the purpose of this study was to examine the accuracy in estimating serving sizes and the number of servings consumed among Canadians of different ethnic backgrounds.

Materials and methods

A total of 145 White, Black, East Asian, and South Asian men and women from the Greater Toronto Area, ranging in age from 25 to 75 years, were included in these analyses. Participants were recruited from a physician's office and through flyers and posters distributed in areas of Toronto with an ethnically diverse population. Participants were excluded if they did not self-identify as White, Black, East Asian, or South Asian, or had missing demographic or serving size information. Participants provided written informed consent prior to participation and all procedures were approved and conducted in accordance with the ethical guidelines of the York University Institutional Review Board.

Information regarding demographics, lifestyle habits, education, self-rated nutrition knowledge (poor, average, and good), self-rated dietary habits (poor, average, and good), awareness of the CFG (yes, no), and previous use of the CFG (yes, no) were assessed by questionnaire. Participants were also asked to complete an assessment of their serving size knowledge and to use their 24-h dietary recall and the CFG to assess the number of servings that they consumed. Self-rated frequency of food consumption for the foods used in the serving size knowledge test was categorized as often, sometimes and rarely consumed. Body mass index (BMI) was calculated using measured height and weight and was categorized into either underweight–normal (UW–NW) or overweight–obese (OW–OB) groups using standard ($<$ or $\geq$25 kg·m^{-2}) (World Health Organization (WHO) 2000) and Asian BMI cutoffs ($<$ or $\geq$23 kg·m^{-2}) (WHO Expert Consultation 2004).

Assessment of serving sizes

Before being provided with CFG, participants were given actual food and asked to physically portion out the amount of food that they believed constituted 1 serving as defined by the CFG (estimated serving size). A study investigator then measured the food portion to determine how accurately participants estimated the serving sizes as compared with what is defined in the CFG. The food items that were tested included food from each of the 4 food groups: vegetables and fruit (carrots, lettuce, and oranges), grain products (bread (Country Harvest brown bread and bakery white bread)), cereal (Post Original Shreddies) and rice (white), milk and alternatives (milk and cheddar cheese), and meat and alternatives (chicken breast, eggs, and tofu). Food items were selected to include a range of foods that are more and less often consumed by the ethnic groups examined in this study and were foods that were used as examples in the 2007 CFG (Bush et al. 2007; Health Canada 2007*c*). Participants were again shown the actual food items and were asked to portion out how much of each food they would regularly consume at each sitting or meal, after which a study investigator measured this portion. After the serving size assessment, participants rated how frequently they consumed each food on a 5-point Likert scale (very often, often, sometimes, rarely, or never). These were then collapsed into 3 categories: often (very often or often), sometimes, and rarely (never or rarely).

Assessment of the number of servings consumed

With assistance from a study investigator, participants completed a 24-h dietary recall using measurement tools, such as measuring cups, drinking glasses, and examples of

food items, to improve accuracy. Participants were then asked to use the CFG and their 24-h dietary recall to estimate the number of servings that they consumed from each of the 4 food groups (estimated number of servings). For each food group, the participants were asked if they thought that they consumed too much, too little, or just enough to meet recommendations. If participants thought they did not meet the guidelines, they were then asked how they should theoretically modify their food intake (theoretical food modification) to meet CFG recommendations, and if those food modifications were realistic. A study investigator then re-examined the 24-h dietary recall, calculated the actual number of servings that participants consumed according to the CFG (actual number of servings), and determined if they actually met CFG recommendations.

Dietary analysis

Differences between the estimated serving size and regular consumption of the selected food items were categorized as no difference (regular consumption equals participant's serving size estimate), larger (participant's serving size is larger than their regular consumption), or smaller (participant's serving size is smaller than their regular consumption).

The 24-h dietary recalls and theoretical food modifications were analyzed for caloric and macronutrient intake using a nutrition analysis program (version 10.6; Esha Food Processor SQL, Salem, Ore., USA). The theoretical food modifications in calories were divided into the following: increase ($\geq$200 kcal), decrease ($\leq$–200 kcal), or no modification in calories ($\pm$200 kcal), wherein 200 kcal represents the 33rd percentile for all theoretical food modifications in calories. This means that 33% of the sample believed that they needed to eat less, not change, or theoretically increase their food consumption by less than 200 calories, and 67% believed that they needed to theoretically increase their food consumption by greater than 200 calories. The theoretical food modifications were summed with the actual food intake to determine the theoretical caloric and macronutrient intake.

Terminology

Estimated serving size: The amount of food participants believed was equal to 1 serving.

CFG serving size: The amount of food that is equal to 1 serving as defined by CFG.

Regular consumption: The amount of the selected food that participants normally consume at a sitting or meal.

Frequency of consumption: How often participants consume the selected food items.

Estimated number of servings: The number of servings participants estimated they consumed from their 24-h dietary recall.

Actual number of servings: The number of servings a study investigator determined was actually consumed from the 24-h dietary recall.

CFG recommended number of servings: The number of servings that are recommended in the CFG, based on age and sex.

Theoretical food modification: How participants believe they needed to change their food consumption to meet CFG recommendations.

Actual food intake: The amount of food participants consumed in their 24-h dietary recall.

Theoretical food intake: Participants' actual intake summed with their theoretical food modifications.

Statistical analyses

All analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, N.C., USA) and the level of statistical significance was set at $p \leq 0.05$. Frequencies and means ($\pm$SD) were used to describe sample characteristics. ANOVA with Tukey post hoc comparisons and χ^2 were used to determine ethnic differences in participant characteristics and frequency of consumption of tested food items. Pearson and Spearman correlations were used to examine associations between the dietary variables. Independent t tests were used to compare group differences. Paired t tests were used to compare the estimated and actual dietary values; and the theoretical changes in food intake after using the CFG.

General linear models were used to examine the association between the difference in the estimated and actual serving sizes and number of servings consumed with ethnicity. Model 1 was adjusted for sex and age. Model 2 was further adjusted for BMI, born inside or outside Canada, previous use of the CFG, nutrition knowledge, and frequency of consumption (frequency of consumption was only included in the models predicting serving sizes). Since no significant sex interactions were observed, all analyses were collapsed across men and women.

Results

Participant characteristics

Participant characteristics are presented in Table 1. There were similar proportions of men and women from each ethnicity with the exception of East Asians where there were significantly more women than men ($\chi^2 = 5.23$, $p \leq 0.05$). Approximately 57% of the sample had a BMI in the overweight or obese range.

Estimated versus CFG serving sizes

On average, participants estimated 1 serving of vegetables and fruit (lettuce and oranges) and of grains to be larger (43% and 55%, respectively) than what is defined in the CFG ($p \leq 0.05$). Cheese servings were 31% and meat alternative servings were 33% smaller than what is defined in the CFG ($p \leq 0.05$). Carrots, chicken, and milk servings were accurately estimated ($p > 0.05$) (Fig. 1). Participants who had used the CFG before this study were no better at estimating serving sizes than those who had never used the CFG, except in the case of estimating the size of a serving of rice, wherein those who had previously used the CFG were more accurate in estimating a serving of rice ($p < 0.01$).

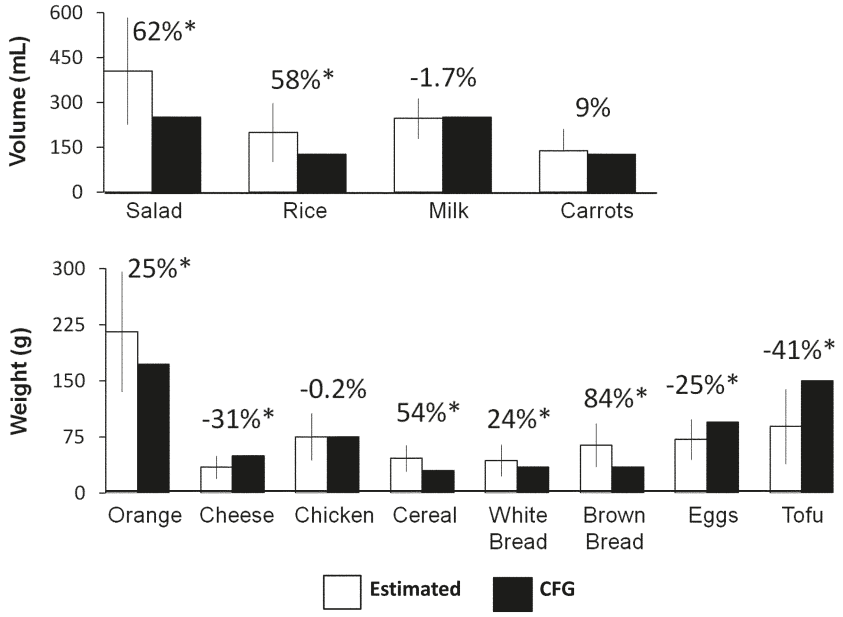
Using standard BMI cut-offs, OW–OB estimated a serving size of chicken to be 12% larger than what is defined in the CFG ($p \leq 0.05$), while UW–NW estimated a chicken serving size to be 15% smaller than what is defined in CFG ($p \leq 0.05$). A serving size of cereal was significantly larger than a CFG serving size for all participants, but OW–OB estimated the size of a serving of cereal (67%) to be significantly larger

Table 1. Participant characteristics.

	White	South Asian	Black	East Asian
Total sample (*n*)	35	33	34	43
Male (%)	60.0	54.6	44.1	32.6
Age (y)	51.0±12.8	46.1±12.1	51.0±12.1	52.7±8.2
BMI (kg·m^{-2})	28.2±6.5d	25.2±3.7c	29.3±6.1bd	23.6±4.0ac
Aware of CFG (%)	85.7	63.6	79.4	67.4
Used CFG (%)	45.7	27.3	35.3	30.2
Desire to use CFG after serving assessment (%)	57.1	65.6	80.7	79.5
Self-reported good nutrition knowledge (%)	17.1	6.1	23.5	18.6
Born in Canada (%)	60.0bcd	3.0a	8.8a	2.3a
Self-reported good current diet (%)	51.4	42.4	32.4	32.6

Note: Data are presented as means ± SD or by prevalence (%). Letters indicate the following differences: a, differs from White; b, differs from South Asian; c, differs from Black; d, differs from East Asian ($p \leq 0.05$) (Tukey adjustments). BMI, body mass index; CFG, Canada's Food Guide.

Fig. 1. The difference between estimated and actual Canada's Food Guide (CFG) serving sizes for the selected food items. *, Significant difference ($p \leq 0.05$). Data are presented as means ± SD.



than UW–NW (38%, $p \leq 0.05$). There were no significant differences in participants' serving size estimates for the other food items by BMI category.

Using Asian BMI cut-offs, similar differences in chicken serving size estimates were observed between Asian participants. In addition, a serving size of brown bread was significantly larger than a CFG serving size for all Asian participants, but Asian OW–OB estimated a serving size of brown bread to be larger than Asian UW–NW ($p \leq 0.05$).

There were significant ethnic differences in serving size estimation for rice, tofu, chicken, cereal, salad, bread, glass of milk, and eggs, adjusted for sex and age (Table 2; model 1). With additional adjustment for BMI, born inside or outside of Canada, previous use of the CFG, nutrition knowledge, and consumption, ethnic differences in serving size estimation for rice ($p < 0.02$), tofu ($p < 0.01$), chicken ($p < 0.01$), and cereal ($p < 0.01$) remained significant, but not for salad, bread, glass of milk, and eggs ($p > 0.05$) (Table 2; model 2).

Frequency of and regular consumption and serving size estimation

Participants with larger serving size estimates tended to consume the selected food items more frequently, and those with smaller serving size estimates consumed those food items less frequently. Specifically, the frequency of consumption was significantly and positively correlated with participants' estimated serving size for oranges ($r_s = 0.35$), chicken ($r_s = 0.20$), carrots ($r_s = 0.19$), cereal ($r_s = 0.32$), and tofu ($r_s = 0.31$), all at $p \leq 0.05$.

Participants' serving size estimates were also positively correlated with the amount of food they regularly consumed at 1 sitting for carrots ($r = 0.80$), oranges ($r = 0.55$), salad ($r = 0.55$), rice ($r = 0.52$), cereal ($r = 0.66$), brown bread ($r = 0.48$), white bread ($r = 0.53$), milk ($r = 0.56$), cheese ($r = 0.49$), chicken ($r = 0.61$), eggs ($r = 0.37$), and tofu ($r = 0.71$), $p < 0.001$). Greater than 50% of participants believed that a serving size was equal to the amount that they regularly consumed. This finding is problematic as partici-

Table 2. Error in quantifying serving sizes in different ethnic groups.

	White		South Asian		Black		East Asian	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Salad (mL)	185.49*	162.99	97.81*	110.13	169.99*	129.98	162.76*	182.19
Orange (g)	29.11	28.28	42.78	43.73	45.52	46.76	56.17	54.57
Carrots (mL)	15.56	11.20	–13.61	–17.27	29.64	25.38	14.30	20.15
Rice (mL)	28.56*bc	37.39*c	104.30*a	88.23*	103.13*a	108.00*a	61.70*	50.77*
Cereal (g)	19.57*b	14.04*	18.72*ad	21.07*d	23.26*d	22.66*d	6.47*bc	10.00*bc
Brown bread (g)	24.75*	27.37	34.04*	31.02	38.80*d	38.41	22.04*c	21.28
White bread (g)	5.06*	4.52	9.25*	7.15	16.53*	13.43	4.47*	4.00
Cheese (g)	–15.67	–18.51	–16.56	–14.46	–10.41	–9.92	–18.90	–17.58
Milk (mL)	5.42*	23.11	5.42*	–9.88	20.99*	20.85	–24.04*	–22.73
Chicken (g)	6.64*d	0.78*	–4.45*c	–1.70*	14.96*bd	14.71*d	–14.99*ac	–11.39*c
Eggs (g)	–13.62*b	–9.46	–30.94*a	–25.33	–20.28*	–18.77	–28.37*	–24.80
Tofu (g)	–66.29*d	–67.51*	–89.53*d	–87.35*d	–72.42*d	–63.04*	–29.29*abc	–37.17*b

Note: Values are least squared adjusted mean errors in estimating serving sizes (estimated – CFG serving size). Zero means they estimated serving sizes accurately, a positive number means they estimated a serving size to be larger than a CFG serving size, and a negative number means that they estimated a serving size to be smaller than a CFG serving size. Model 1, adjusted for sex and age; model 2, adjusted for sex, age, body mass index, born inside or outside of Canada, previous use of CFG, nutrition knowledge, and consumption. CFG, Canada's Food Guide. *, Significant main effect of ethnicity ($p \leq 0.05$). Letters indicate the following differences: a, differs from White; b, differs from South Asian; c, differs from Black; d, differs from East Asian.

pants regularly consumed more than 1 serving at each sitting. On average, participants indicated that they would regularly consume 1.6 servings of vegetables, 1.4 servings of fruit, 2.0 servings of grains, 0.9 servings of milk and alternatives, 1.3 servings of meat, and 0.8 servings of meat alternatives at 1 sitting.

Estimated versus actual number of servings consumed

Analysis of participants' food records revealed that all 4 ethnic groups inaccurately estimated the number of servings consumed in a day from all food groups. On average, participants underestimated the number of servings that they consumed per day for vegetables and fruit by 1.0 serving, grain products by 2.1 servings, and meat and alternatives by 0.4 servings, and overestimated the number of servings of milk and alternatives that they consumed by 0.3 servings, even after being given the food guide ($p \leq 0.05$). No ethnic differences were observed in how accurately participants were able to quantify the number of servings consumed in a day with or without adjusting for sex and age. Thirty-eight percent of participants underestimated the number of servings of grains that they consumed, 29% underestimated the number of servings of meat and alternatives consumed, 18% underestimated the number of servings of vegetables and fruit, and 15% overestimated the number of servings of milk and alternatives that they consumed.

Relationship between caloric and macronutrient intake and meeting recommendations

A total of 68% of participants believed that they needed to increase their food intake by more than 200 kcal to meet CFG recommendations, while only 9% believed that they did not need to modify their intake and 23% believed that they needed to decrease their consumption by more than 200 kcal after using the CFG. On average, each ethnic group believed that they needed to increase their food intake by 283 to 479 kcal per day. The magnitude of these theoretical food modifications was not related with BMI.

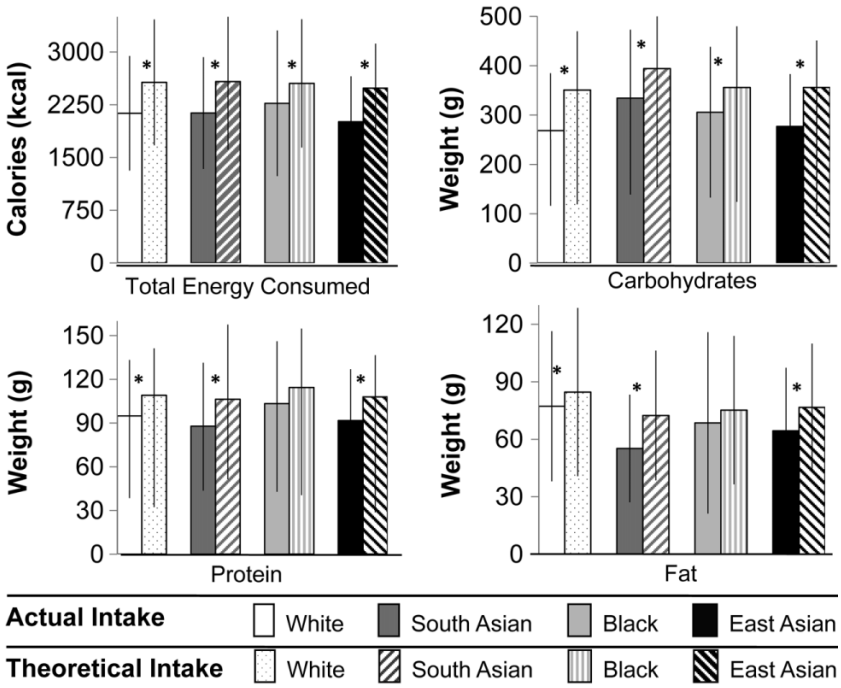
On average, participants chose foods that would theoretically increase their carbohydrate intake by 70 g (24%; range of –202 to 371 g), protein intake by 14 g (13%; range of –84 to 102 g), and fat intake by 9 g (14%; range of –61 to 68 g) per day (Fig. 2). Whites (82 g) and Blacks (79 g) had the largest theoretical increase of carbohydrates, while South Asians had the largest increase of protein (19 g) and fat (17 g) per day. The increase in food did not materially modify the proportion of calories from carbohydrates, protein, and fat in the diet. On average, 72% of participants said that they could realistically make these modifications to their diet to meet CFG recommendations. Specifically, more East Asians (84%) and South Asians (85%) believed that they could realistically make these modifications than Whites (60%) and Blacks (59%). The magnitude of the theoretical food modifications were not associated with the participants' belief of whether these modifications were realistic ($p > 0.05$).

Discussion

The most novel findings of this study suggest that Canadians of different ethnic backgrounds and weight status do not estimate serving sizes accurately. Participants often overestimated the size of a serving and underestimated the number of servings that they consumed. Consequently, the majority of participants inaccurately perceived that they needed to increase food consumption to meet CFG recommendations.

The 2007 revision of the CFG included more pictorial serving size examples of ethnically diverse foods and narrowed the recommended range for servings (Katamay et al. 2007; Bush et al. 2007). Some Canadian health professionals suggest that serving sizes are confusing (Kondro 2006). In addition, understanding and conceptualizing a CFG "serving" may be even more compromised among diverse ethnic groups as they may be less familiar with the term "serving" (Paisley et al. 2005; Teufel 1997). The current study supports the concerns that servings are not well understood. In fact,

Fig. 2. Theoretical versus actual calorie and macronutrient intake between ethnicities. *, Significant difference between theoretical and actual intake ($p \leq 0.05$). Data are presented as means ± SD.



participants who had previously used the CFG were no better at estimating serving sizes than those who had not previously used the CFG. These findings are similar to an American study that determined that serving sizes in the American Food Guide Pyramid are not estimated accurately for most of the tested food items (Britten et al. 2006). In fact, people have been reported to overestimate the size of a serving of grains by 1.5 to 2 times (Hogbin and Hess 1999). This may partially be due to the variability in serving sizes on nutrition labels that are not analogous with food guide servings (Britten et al. 2006; Hogbin and Hess 1999). Further, CFG serving sizes also vary between different types of food, as even a serving size of cold cereal differs from hot cereal (Health Canada 2007*b*).

Serving size definitions in the CFG have stayed relatively constant in the 1977 to 2007 CFG (Health Canada 2007*a*, 2007*b*). Meanwhile, there has been a steady growth in the portion sizes available in restaurants, at home and in the supermarket (Health Canada 2007*a*, 2007*b*; Rolls 2003; Wansink and van Ittersum 2007; Nielsen and Popkin 2003). An American study reports that participants believe that a reference serving size was an official recommended amount to eat at one time (Britten et al. 2006; Hogbin and Hess 1999), and we observed that serving size estimates were often analogous to the amount people consumed at one time. Interestingly, OW–OB participants in our study had significantly larger estimated serving sizes for some food items than UW–NW. Further, in our study serving size estimates were often larger for foods that participants consume more regularly and thus the larger serving size estimates by OW–OB participants may be compounded with their greater habitual consumption, all of which may contribute to the higher energy intake reported in obese populations (Langlois et al. 2009).

Observed ethnic differences in estimating serving sizes may in part be due to variations in how ethnicities understand the term "serving" (Paisley et al. 2005; Teufel 1997). For example, there is no direct word for "serving" in the Chinese language, and the word in the Chinese version of the CFG is more closely translated to "portion" (Health Canada 2007*b*), and our participants were often unsure what the term "serving" meant. East Asians also do not commonly use a measuring cup to measure their food intake, though it is a standard unit in the CFG to measure 1 serving of a food item (Health Canada 2007*b*; Paisley et al. 2005). Nevertheless, ethnic differences in serving size estimates appear to be more related to differences in habitual food consumption and less related to differences in understanding of the term "serving" as it appears that all ethnic groups in the current study do not estimate servings very well.

Inaccurate estimation of serving sizes may lead to further problems when determining the total number of servings consumed in a day. In an American study, it was reported that it was difficult for participants to gauge their food intake in reference to the recommended intake (Britten et al. 2006). This verdict is concordant with our findings that most participants underestimated the number of servings that they consumed. This problem may be because participants often overestimated the size of a CFG serving, which led to the false perception that fewer total servings were consumed. Despite differences in ethnic food traditions, all ethnic groups and individuals across the range of BMIs similarly underestimated the number of servings that they consumed. This issue is a potential problem that may lead to weight gain if participants inaccurately believe they need to increase their food intake to meet CFG recommendations

This study has answered some practical and relevant questions about serving size understanding. Few studies to date

have examined CFG use and understanding among diverse ethnic groups. However, limitations of this study should be mentioned. The 24-h dietary recall is subject to self-report recall bias. Further, we did not adjust or control for hunger. Hunger may have affected the amount of food that they thought was equal to a serving size and may have adjusted the amount that they reported on their 24-h dietary recall (Nederkoorn et al. 2009). Finally, the findings are limited to the ethnic groups examined in this study and may not be generalizable to the Canadian population as this sample was recruited only within the Toronto area.

In summary, these findings suggest that simply providing individuals the CFG in its current form may not be appropriate given that servings are not well understood by individuals of differenct ethnicities and weight status. Some researchers have suggested that larger and more culturally appropriate serving sizes should be used to help improve people's accuracy in quantifying the amount of food consumed (Paisley et al. 2005; Teufel. 1997; Harnack et al. 2004). If the CFG continues to be used in its current form, more public health initiatives are needed to help educate Canadians on serving sizes.

Authors' contributions

S.L.A., J.I.R., M.J.H., and J.L.K. designed research; S.L.A., J.I.R., C.P.R., and V.K.J. conducted research; S.L.A. analyzed data and wrote the manuscript; J.L.K. and M.J.H. had primary responsibility for final content. The authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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