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SURVEY

The utility of serving size in the measurement of soft drink consumption

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ABSTRACT

Background Many studies examining population differences in soft drink consumption or the association it has with fatness have not included serving size in its assessment. It is not clear what effect this has on their findings and our study aimed to investigate this by comparing the relationships that days (serving size unaccounted for) and cans/day (serving size accounted for) of consumption have with ethnicity/country and fatness.

Methods Daily nutrient intakes were calculated from a self-administered food frequency questionnaire from a cross-sectional health screening study. Participants were Pacific (n=954) and New Zealand European (n=1,745) people aged 35 to 74 years.

Results Compared to Australian youth, NZ Pacific youth consumed soft drinks more frequently but a larger difference was observed for cans/day. In a dose-dependent manner, FMI was positively associated with days (P=0.015) and cans/day (P=0.024) of consumption. However, cans/day showed a stronger relationship, with a standardised regression coefficient of 0.066, compared to 0.033 for days of consumption.

Conclusions It is useful to include serving size in the assessment of soft drink consumption. Excluding it leads to underestimation of both ethnic/country differences in daily volume of intake and associations with fatness.

Key words: *Soft drink, obesity, serving size, measurement error*

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Introduction

Sugary drink consumption has been shown to be a risk factor for obesity[1]. Many previous studies that have assessed the association that it has with fatness have estimated intake using frequency of consumption[1-4]. This approach does not account for variation in serving size and thus do not accurately measure volume of beverage consumed each day since the latter is dependent on both frequency and serving size. The resulting measurement error could be particularly notable when dealing with population groups whose food portion sizes vary greatly. For example, the fact that Pacific people consume larger food servings sizes than those from other ethnic groups[5,6] suggests that, for a given sugary drink consumption frequency, they may consume a greater daily volume than non-Pacific people. This could mean that, in studies that have examined sugary drink-fatness associations across Pacific and non-Pacific populations using frequency for measurement of sugary drink intake[2,4], it is difficult to compare effect sizes across ethnic groups.

In addition, accurate assessment of differences in soft drink consumption between these groups would better quantify disparities in obesity risk factors for informing targeted interventions aimed at reducing soft drink consumption in populations most in need of these initiatives. This is particularly important for Pacific groups, in which, relative to non-Pacific groups, obesity prevalence[7,8] and soft drink intake (as assessed by frequency of consumption)[7,8] are both high and foods consumed are large in size[5,6].

In view of this, it seems warranted to assess the relative strength of associations that daily volume of soft drinks consumed (serving size accounted for) and frequency of their consumption (serving size unaccounted for) have with ethnicity/country and fatness in the same dataset, as this would help to clarify and quantify the value of including serving size in the assessment of soft drink consumption. However, this has not been previously examined in studies of Pacific people. Therefore, we aimed to compare associations that soft drink consumption adjusted and unadjusted for serving size have with ethnicity/country and fatness.

Table 1. Characteristics of participants, by country and ethnic group

		New Zealand				Fiji		Tonga	Australia	All
		Pacific	Maori	Asian	European	Indigenous Fijian	Fijian Indian	Tongan	Australian	All
N		770	348	134	233	611	832	1019	1673	5620
Sex	**Male**	374 (48.6)	150 (43.1)	61 (45.5)	116 (49.8)	270 (44.2)	388 (46.6)	471 (46.2)	1006 (60.1)	2836 (50.5)
	Female	396 (51.4)	198 (56.9)	73 (54.5)	117 (50.2)	341 (55.8)	444 (53.4)	548 (53.8)	667 (39.9)	2784 (49.5)
Days of soft drink consumption (in last 5 school days)	**Mean†**	2.85±0.03a	2.85±0.08a	2.64±0.09a	2.15±0.13a	2.57±0.13a	2.85±0.09a	2.19±0.08a	1.72±0.09	2.33±1.67
	0	119 (15.5)	73 (21.0)	39 (29.1)	98 (42.1)	154 (25.2)	173 (20.8)	325 (31.9)	904 (54.0)	1885 (33.5)
	1-3	401 (52.1)	158 (45.4)	64 (47.8)	92 (39.5)	306 (50.1)	387 (46.5)	463 (45.4)	558 (33.4)	2429 (43.2)
	4-5	250 (32.5)	117 (33.6)	31 (23.1)	43 (18.5)	151 (24.7)	272 (32.7)	231 (22.7)	211 (12.6)	1306 (23.2)
Soft drink serving size (cans)	**Mean†**	1.99±0.11a	1.89±0.08a	1.27±0.09a	1.27±0.21a	1.76±0.09a	1.69±0.09a	1.93±0.05a	0.69±0.05	1.43±1.61
	0	119 (15.5)	73 (21.0)	39 (29.1)	98 (42.1)	154 (25.2)	173 (20.8)	325 (31.9)	904 (54.0)	1885 (33.5)
	>0-2	453 (58.8)	192 (55.2)	73 (54.5)	110 (47.2)	321 (52.5)	483 (58.1)	465 (45.6)	665 (39.8)	2762 (49.1)
	>2	198 (25.7)	83 (23.9)	22 (16.4)	25 (10.7)	136 (22.3)	176 (21.2)	229 (22.5)	104 (6.3)	973 (17.3)
Cans/day of soft drink consumption*	**Mean†**	1.27±0.06a	1.23±0.06a	0.82±0.04a	0.69±0.15	0.98±0.09a	1.09±0.07a	0.93±0.05a	0.41±0.04	0.85±1.29
	0	119 (15.5)	73 (21.0)	39 (29.1)	98 (42.1)	154 (25.2)	173 (20.8)	325 (31.9)	904 (54.0)	1885 (33.5)
	>0-2	508 (66.0)	216 (62.1)	79 (59.0)	117 (50.2)	373 (61.1)	537 (64.5)	562 (55.2)	703 (42.0)	3095 (55.1)
	>2	143 (18.6)	59 (17.0)	16 (11.9)	18 (7.7)	84 (13.8)	122 (14.7)	132 (13.0)	66 (4.0)	640 (11.4)
Age (years)		14.9±1.5	14.8±1.4	15.2±1.6	15.4±1.5	15.5±1.3	15.4±1.2	15.1±2.0	14.6±1.4	15.0±1.5
FMI (kg/m2)		8.1±4.5	7.6±4.6	4.6±2.6	5.6±3.3	4.6±2.4	4.4±2.2	5.2±2.8	5.6±2.3	5.7±3.2

*Categorical data are cited from reference 13; †Adjusted for sex and age, with values expressed as mean±standard error; aSignificantly different from Australian (P<0.05); FMI = Fat mass index; Values are sample size (column %) or mean±standard deviation for age and FMI.

Table 2. Relationship between average daily soft drink consumption (days of consumption in last 5 school days, and cans per day) and fat mass index[a]

		New Zealand					Fiji			Tonga	Australia	All
	Group	Pacific	Maori	Asian	European	All New Zealand	Indigenous Fijian	Fijian Indian	All Fiji	Tongan	Australian	All
		(N=770)	(N=348)	(N=134)	(N=233)	(N=1485)	(N=611)	(N=832)	(N=1443)	(N=1019)	(N=1673)	(N=5620)
	Days											
Mean FMIb	0	8.24 (0.41)	7.40 (0.54)	4.70 (0.19)	5.36 (0.16)	7.20 (0.32)	4.64 (0.21)	4.34 (0.15)	4.45 (0.12)	4.79 (0.16)	5.55 (0.08)	5.53 (0.09)
Difference in FMIc	1-3	-0.22 (0.46)	0.03 (0.60)	-0.31 (0.24)	0.26 (0.38)	-0.03 (0.36)	-0.16 (0.17)	0.08 (0.21)	-0.01 (0.13)	0.52 (0.12)‡	-0.02 (0.14)	0.13 (0.11)
	4-5	-0.17 (0.43)	0.48 (0.38)	0.40 (0.37)	0.97 (0.68)	0.25 (0.33)	-0.02 (0.24)	-0.04 (0.14)	0.00 (0.12)	0.88 (0.16)‡	0.03 (0.14)	0.33 (0.12)†
	Cans per day											
Mean FMIb	0	8.24 (0.41)	7.40 (0.55)	4.69 (0.19)	5.36 (0.16)	7.20 (0.33)	4.64 (0.21)	4.35 (0.15)	4.45 (0.12)	4.79 (0.16)	5.55 (0.08)	5.52 (0.09)
Difference in FMIc	>0-2	-0.21 (0.44)	-0.24 (0.49)	-0.21 (0.19)	0.26 (0.34)	-0.07 (0.33)	-0.21 (0.16)	0.07 (0.17)	-0.02 (0.11)	0.52 (0.13)‡	-0.02 (0.12)	0.13 (0.10)
	>2	-0.19 (0.59)	1.92 (0.80)*	0.57 (0.41)	1.97 (1.03)	0.69 (0.57)	0.27 (0.34)	-0.16 (0.24)	0.07 (0.21)	1.14 (0.14)‡	0.10 (0.22)	0.56 (0.20)†

Adjusted for age and sex. "New Zealand All", "Fiji All" and "All countries" were further adjusted for ethnicity; bAdjusted mean followed by standard error in parentheses; cCompared to "0 cans per day" (reference category). Standard error in parentheses; FMI = Fat mass index (kg/m2); *P<0.05; †P<0.01; ‡P<0.001.

Subjects and Methods

Participants

The current study is an analysis of the baseline data collected in the Obesity Prevention In Communities (OPIC) study, a community-based obesity intervention study with follow-up that compared changes in fatness between participating intervention and comparison sites in New Zealand (NZ), Australia, Fiji and Tonga. The participating sites were: in NZ, 7 schools in South Auckland with a high percentage of Pacific Island students; in Australia, 12 schools in East Geelong and the Barwon-South Western region of Victoria; in Fiji, 18 schools in Viti Levu; and, in Tonga, 4 districts in Tongatapu and Vava'u. The overall response rate (based on the number of students on the school roll) was 61% (varying from 49% to 74% by country) and a total of 17,185 participated[9]. For further information, the sampling method of the OPIC study is described in more detail elsewhere[10]. All baseline data were collected between 2005 and 2006.

Ethics approval was obtained from the University of Auckland Human Participants Ethics Committee (in NZ), the Deakin University Human Research Ethics Committee (in Australia), National Health Research Council (NHRC) (in Fiji), the Fiji National Research Ethics Review Committee (FNRERC) Ethics Committee (in Fiji) and the Tonga National Health Ethics Research Committee (TNHERC) (in Tonga). All participants gave informed consent.

Measurements

All measurements were carried out by trained staff using a standardised protocol. Height (±0.1 cm) was measured with a stadiometer at maximum inspiration. Impedance (±1 Ω) and body weight (±0.1 kg) were measured in light clothing (school uniform) and no socks or stockings on a Tanita BC-418 BIA device (Tanita Corp., Tokyo, Japan). Total fat mass (TFM) was calculated using equations developed in Pacific Island, Maori, Asian and European adolescents[11]. Fat mass index (FMI) was calculated as TFM (kg)/height (m)^2. This is an index of fatness that adjusts TFM for differences in height[12]. In this paper, we have focused on this measure of fatness as its association with soft drink consumption has not been previously examined in our study population.

Demographic and soft drink consumption data were collected via questionnaires administered through hand-held computers (personal digital assistants; PDAs) and via paper. Ethnicity was defined by self-identification from a multiple-choice question. Only a single choice was possible as answers where entered into PDAs.

Soft drink frequency was assessed by the question, "In the last 5 school days (including time spent at home), on how many days did you have regular (non-diet) soft drinks?" Soft drink serving size was assessed by the question, "On the last school day, how many glasses or cans of soft drinks did you have?" Each can corresponded to 300mL of soft drink. Average daily volume of soft drinks consumed (cans/day) was calculated as (number of days of soft drink consumption times consumption on the previous day)/5 days. The amounts (cans per day) were categorised into three groups: 0, >0-2 and >2 cans/day.

Weight-change attempts were assessed by asking each

participant what he/she was doing about their weight. Students answered, "trying to lose weight", "trying to gain weight", "trying to stay at my current weight" or "not doing anything about my weight". For the analyses, the first two and last two categories were combined into "change weight" and "not change weight" categories, respectively.

Statistical analysis

In order to correct standard errors for design effects from clustered sampling, SUDAAN (version 10.0) was used for all analyses. Statistical significance was set at P<0.05. All continuous variables were examined for normality.

We have previously justified restricting analysis to those not trying to change weight in the current dataset[13]. In brief, this circumvents the issues of reverse causation and measurement error associated with including in analysis those who are trying to diet. This is supported by noting that associations between soft drink consumption and fatness weaken or exist in unexpected directions when including in analyses those who are making attempts to change their weight[13]. Restriction may decrease external validity, but increases internal validity - which is the approach currently preferred by epidemiologists[14]. Therefore, all analyses performed for this paper were carried out only among those who not trying to change weight.

Associations between soft drink variables and FMI were examined by multiple linear regression. All models were adjusted for sex and age. Models for country-specific analyses and for all ethnic groups combined were additionally adjusted for ethnicity. Ethnic/country differences in continuous soft drink consumption variables were examined using ANCOVA (adjusted for sex and age). Our chosen reference group, Australians, was an appropriate one because this population had a large sample size and had notably smaller soft drink serving sizes than all other groups (Table 1), which would enhance our ability to observe a potential benefit of including portion size in the assessment of soft drink consumption. The Wald F-test was used to assess whether associations were dose-dependent (that is, whether there were stepwise differences in fatness outcomes with stepped differences in exposure). Standardised regression coefficients were calculated to compare effect sizes of different measures of soft drink consumption; these are unitless and thus allow the strength of associations with different independent (consumption) variables to be directly compared[15].

Results

Table 1 shows characteristics of the participants, those who were not trying to change weight (n=5620). Individuals were aged between 12 and 22 years and were categorised into 8 ethnic groups: Pacific Island, Maori, Asian and European (all four from NZ), Australian (from Australia), Tongan (from Tonga) and Indigenous Fijian/iTaukei and Fijian Indian (both from Fiji).

Ethnic differences in soft drink consumption

Compared to Australians, NZ Pacific youth consumed larger serving sizes (P<0.0001) and had soft drinks on more days in the last 5 school days (P<0.0001): on average, 2.85 days for the NZ Pacific group, while 1.72 days for Australians (Table 1). In other words, NZ Pacific adolescents had drinks on 1.6 times as many days; this represents about a 65% increment over the consumption days for Australians. However, a notably larger difference for cans/day was observed (Table 1). That is, those of NZ Pacific ethnicity had a consumption level (1.19 cans/day) of almost 200% more than or nearly three-fold that of Australians (0.40 cans/day).

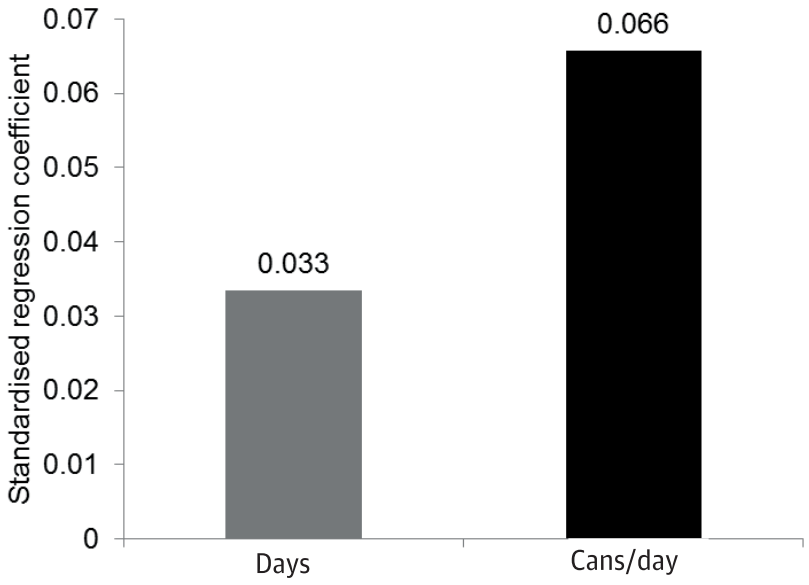

Figure 1- Standardised regression coefficients for associations that days (in last 5 school days) and cans/day of soft drink consumption have with fat mass index (FMI) among all ethnic groups combined

Unstandardised associations between soft drink variables and FMI

Unstandardised associations of soft drink consumption variables with FMI - by ethnic group and country, and among all ethnic groups combined - are shown in Table 2. Among all ethnic groups combined, soft drink consumption had positive and dose-dependent associations with FMI, when measured by cans/day (P=0.024) or number of days consumed in the last 5 school days (P=0.015). For FMI differences between highest and lowest soft drink consumption categories, the number of ethnic-specific positive or significant relationships were slightly greater for cans/day of consumption.

Standardised associations between soft drink variables and FMI

To compare the strength of soft drink consumption-fatness associations when accounting for and not accounting for serving size, standardised effect sizes were calculated in two steps. Firstly, regression coefficients (in kg/m2) for all ethnic groups combined (Table 2) were divided by the mean number of days in the last 5 school days or cans/day in the corresponding

exposure category. For instance, for the >0-2 cans/day category, the effect size was 0.13 kg/m2 (Table 2) and the mean cans/day were 0.76 (data not tabulated) and this corresponds to a slope of 0.17 kg/m2 per cans/day. This gave unstandardised effect sizes of 0.06 kg/m2 (1% of the average FMI tabulated in Table 1) for each day-increment (unadjusted for serving size) in consumption and 0.17 kg/m2 (3% of the average FMI) for each cans/day increment (adjusted for serving size) in consumption. In the second step, these effect sizes were expressed as standard deviations of FMI per standard deviation (SD) of consumption (effect per SD increment in consumption as a proportion of the SD of FMI). That is, 0.06 kg/m2 was multiplied by the SD of days of consumption (1.67 days) divided by the SD of FMI (3.24 kg/m2), and 0.17 kg/m2 was multiplied by the SD of cans/day of consumption (1.29 cans/day) divided by the SD of FMI – to give standardised regression coefficients. These are illustrated in Figure 1 and show that cans/day had a stronger association with FMI compared to days of consumption (0.066 versus 0.033).

Discussion

NZ Pacific youth consumed more frequent and larger servings of soft drinks than Australians, but a larger difference was observed for cans/day. Both soft drink cans/day and frequency had strong, positive, dose-dependent associations with FMI. However, their relationships differed in magnitude and consistency, with soft drink cans/day having a larger effect size (stronger association) and slightly more consistent (positive) relationships.

Cans/day is numerically equal to the product of frequency and serving size. Therefore, for a given frequency, a higher serve size indicates more cans/day. In this study, Pacific groups consumed larger serving sizes than non-Pacific groups. Therefore, it makes sense for ethnic differences in frequency to underestimate differences compared with cans/day and our findings showed this to be the case. Further, both volume and frequency of consumption influence soft drink-related energy intake, which increases body fat stores. As this energy intake depends on volume at a given frequency, it is plausible for weaker and less consistent associations with fatness to be observed with days of consumption (out of past 5 school days) and this is what was found in the present study.

Of interest is the sizes by which both the ethnic differences increased and the associations with fatness strengthened when consumption was measured with cans/day instead of frequency. Knowledge of this is important as it would quantify the value of including serving size in the measurement of soft drink intake. Compared to Australians, NZ Pacific youth consumed soft drinks 66% more often (a ratio of 1.66); but almost 200% more cans/day (a ratio of approximately three), which is notably larger (Table 1). For the association with FMI among all ethnic groups combined, the standardised regression coefficient for cans/day of consumption was double that of days of consumption (Figure 1). The magnitude of each of these differences is large and this supports the inclusion of serving size in the measurement of soft drink intake in future studies.

Also of interest was the magnitude of the FMI relationships among all ethnic groups combined. Compared to those who consumed soft drinks on 0 days, those who consumed on 4-5 days had 0.33 kg/m2 more FMI (Table 2), which is 6% of the average FMI (Table 1). Further, compared to those whose consumption was 0 cans/day, those whose consumption was >2 cans/day had 0.56 kg/m2 more FMI (Table 2), which is 10% of the average FMI (Table 1). These effect sizes are notable, particularly for cans/day.

Our findings have important implications for studies that rely on frequency only to assess soft drink consumption. Some studies have reported differences in frequency between Pacific and non-Pacific groups[7,8] and our work indicates that, in those studies, the differences in cans/day would be wider. Further, there are many studies which have examined associations that soft drink frequency has with fatness[1], a few of which have involved Pacific groups[2-4]. In these studies[1-4], it is likely that stronger associations and larger effect sizes would have been observed had serving size been included in the measurement of soft drink intake.

In this study, random measurement error arising from day-to-day variation in soft drink consumption habits and imperfect memory to recall these would have weakened associations, in which case we would expect their sizes to be larger than what we observed them to be. Another study limitation is that the findings would have limited applicability to those who were trying to change weight as these individuals were excluded from our analyses. However, our findings have at least some applicability to these individuals because they probably would have previously tried not to change weight[13].

Conclusions

In summary, because soft drink serving size varies between Pacific and non-Pacific groups, frequency of intake underestimates differences in consumption (volume per unit time) across these ethnic groups. Including serving size in the assessment of soft drink intake improves measurement of the latter and strengthens the association that it has with fatness. This suggests that studies that do not account for the volume of drink consumed on each occasion underestimate the effect of sugary drink intake on obesity. This supports the inclusion of serving size in the assessment of soft drink consumption in future studies.

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