Relationship of Average Daily Glycemic Index and Glycemic Load with Body Mass Index among Filipinos in the Rural Setting

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Abstract

Introduction: While the relationship between obesity and caloric intake is widely accepted, the role of glycemic index (GI) and glycemic load (GL) to body mass index (BMI) remains equivocal. This study seeks to determine the daily glycemic index (GI) and glycemic load (GL) of usual diet of rural-dwelling Filipinos, and their relationship with body mass index (BMI).

Methods: This is a cross-sectional study reviewing the data of 139 adults from San Juan, Batangas. Average daily GI and GL were calculated from two-day food recall questionnaires. Spearman's rank test was used to determine correlation of daily GI and GL with BMI; the mean BMI was compared among GI and GL tertiles using one-way ANOVA. Partial least squares regression was used to determine the contribution of food items to daily GI and GL.

Results: No overall correlation was observed between daily GI or GL and BMI using Spearman's rank. However, BMI was higher with increasing GI tertiles ($p<0.0001$) and GL tertiles ($p=0.0108$) among the males, but not females. Bread, coffee-mix and sweets were major contributors to daily GI, while rice, bread/pastries and sweetened beverages were to daily GL. Leafy vegetables negatively contributed to both.

Conclusion: There is a positive relationship observed between daily GI and BMI, and daily GL and BMI among the men, but not women, in this population. Staple food with high GI like bread/pastries and sweetened beverages contributed most to both daily GI and GL, with the addition of rice for daily GL. Among Filipinos with marginal daily caloric intake, optimizing carbohydrate quality (low GI or GL) rather than limiting its quantity may be more appropriate. Future studies of prospective design and using objective methods of food intake reporting are recommended.

Keywords: glycemic index, glycemic load, body mass index, obesity

Introduction

The alarming growth of the obesity pandemic has inevitably driven research agenda towards preventive measures and nutritional interventions.[1] One particular point of interest was the relationship of obesity with consumption of food with high glycemic index (GI) and glycemic load (GL). GI can be defined as the ratio of the blood glucose response over time from a certain food item against the same quantity of available carbohydrate in a reference such as a glucose drink; while glycemic load refers to the estimated amount of available carbohydrate in the quantity of a food item consumed multiplied by its GI.

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The implication of GI or GL in energy assimilation and expenditure appears to be broad. In human models, consumption of low-GI diet can enhance glycogen reserve in trained athletes, may lessen voluntary food intake and increase counter-regulatory hormone levels in teenage boys, can increase protein retention among hyperinsulinemic men, and even may attenuate weight gain during pregnancy.[2] Studies have demonstrated that the GI of mixed meals is consistent with mean GI for individual food items, and average daily GI can be estimated by adding the products of the GI of each particular food and its carbohydrate content and the number of servings, and dividing this sum the total carbohydrate intake.[3] In a metaanalysis examining low-GI diets among diabetic individuals, an absolute reduction of 0.43% points in A1c is observed favoring low GI diets.[4] Despite limited evidence, most international authorities in diabetes worldwide like American Diabetes Association (ADA) and even local guidelines advocate limiting intake of food with high GI and replacing them with those with low GI. However, how GI or GL relates to measures of obesity in the general population is uncertain.

Although the idea of higher GI or GL predicting a higher body mass index (BMI) is popular and seemingly intuitive, the available evidence does not unanimously support this. On one hand, some studies have found that BMI is positively correlated with both daily glycemic index and load.[5-6] On the other hand, more recent investigations involving Spanish and Italian cohorts concluded the relationship is inverse.[7-8] Whether these patterns are confounded by unaccounted variables, or are simply specific to the particular population being observed is unclear.

In Southeast Asia, a study in Singapore looked into the GI of the most commonly consumed food and beverages in the region and found that nine out of fifteen items included were of medium to high GI.[9] In the Philippines, however, no previous studies have assessed the relationship of GI or GL with BMI to our knowledge. Like that of its neighboring countries, the Filipino cuisine is largely based on carbohydrates, particularly with high GI sources like rice that is staple for most regions in the country as seen in the report by the World Food Programme.[10] Because previous investigations have determined that Asians are at risk for metabolic disorders at lower BMI, tend to develop post-prandial hyperglycemia earlier on, and have more profound beta cell dysfunction,[11] dietary interventions are of utmost importance among Asian population, including Filipinos. In order to make appropriate recommendations on dietary modifications in terms of GI and GL, it is important to examine its relationship with markers of obesity in this population in order to understand its impact on the increasing prevalence of metabolic diseases like diabetes and other non-communicable diseases (NCD).

Objectives

- To determine the average daily GI and GL of the usual carbohydrate intake of Filipinos living in a rural community
- To determine the relationship of average daily GI and GL with BMI among Filipinos living in a rural community
- To determine the relative contribution of specific food items and food groups to average daily GI and GL

Methods

The study follows a cross-sectional analytic design. The investigators utilized the baseline data gathered in the original study by Sandoval and colleagues[12], entitled An Intensive Community-Based Lifestyle intervention Program for the prevention of type II diabetes mellitus among Some Filipinos in San Juan, Batangas, Philippines. In its preliminary phase (phase IVA), 139 rural residents were selected using stratified random sampling of the adult (>18 years old) population grouped according to geographical clusters (different villages or barangays), age group and sex. The subjects selected were relatively healthy, non-pregnant individuals. In the original study, they were interviewed by trained nutritionists and physicians using a standard two-day, 24-hour food recall, verified by a food frequency questionnaire with amount recall for the previous two weeks. This study included all 139 respondents after verifying completeness of needed data.

Using NCSS-PASS 2013, the minimum sample size needed to determine relationship of BMI and GI/GL was calculated to be 112 based on r=0.2615 with alpha level= 5% and power= 80%, with a final estimate of 134 to account for incomplete data.

Clinical data (age,sex) and anthropometric measurements (weight, height, and body mass index) were recalled from the electronic database of the original study and recorded for analysis. The participants were classified using BMI (kg/m^2) criteria of World Health Organization Asia Pacific Perspective (WHO-APP) as underweight (less than 18.5), normal (18.5-22.9), overweight (23-24.9), obese I (25-29.9), or obese II (30 and above).[13] For purposes of analysis, the last three categories were grouped into a single entity (overweight/obese).[12] The level of physical activity (in Metabolic Equivalents (MET)-min/week) was determined in the original study using International Physical Activity Questionnaire, and participants were classified as having either low, moderate or high physical activity.

Dietary Assessment

The accomplished two-day, 24-hour food recall forms of each participant were reviewed. The total caloric intake together with specific macronutrient composition, dietary fiber content and alcohol consumption were duly noted. Using the book Glycemic index of commonly consumed carbohydrates foods in the Philippines published by the Food and Nutrition Research Institute (FNRI) as a guide, the glycemic index of each carbohydrate consumed was identified.[14] For food items not listed in mentioned source, reliable international publications were consulted, and if none was available, the GI of the most similar food item identified was appropriated. To calculate for the average daily GI (GId), the following formula was used:[7] GId = {Σ(GIf x (CHOf x nf)/CHOT)}; where GIf is the identified GI of food item, CHOf is the amount of carbohydrates per serving of food item in grams, nf is the number of servings of food item consumed per day, and CHOT is the total daily carbohydrate intake in grams. This was done for all food items consumed containing at least three grams of carbohydrates. Likewise the daily glycemic load (GLd) was calculated by multiplying the GId by the CHOT and dividing the product by 100.

Identification of underreporters

An underreporter (UR) was defined as an individual who selectively reports caloric intake that is less than the minimum amount required to maintain one's present weight. The ratio of reported daily energy intake to basal metabolic rate (EI:BMR) was calculated for this purpose. The Mifflin-St Jeor

Equation (MSJE) as used to estimate the basal metabolic rate.[15] The cut-off for underreporting (Goldberg-Black cut-off) was based on the proposed lower limit for EI:BMR by Goldberg and Black as follows: among men, 1.06, 1.19 and 1.33 for assumed low, moderate and high physical activity levels (PAL), respectively; for women, 1.06, 1.11 and 1.23, respectively. These limits have a sensitivity of 0.74 in men and 0.67 in women, and specificity of 0.97 in men and 0.98 in women for detection of underreporting.[16] Participants with EI:BMR less than the designated cut-off were identified as UR.

Statistical Analysis

Data encoding was done in MS Excel, while data analysis was performed in Stata SE version 13 and SAS version 9. Normally distributed quantitative variables were summarized as mean ± SD, and non-normally distributed quantitative variables as median and inter-quartile range. Categorical variables were tabulated as frequency and percentage. Spearman's rank correlation was used to analyze overall relationship of daily GI and GL with BMI. Comparison of characteristics between males and females were performed using Wilcoxon rank sum test for continuous variables, and Fisher's exact test for categorical variables. Comparison of the daily GI and GL across BMI classification was performed using one-way ANOVA. The data for each gender was then divided into tertiles based on the GI and GL. Comparison of different characteristics across GI and GL tertiles were analyzed using kruskal wallis test for continuous variables and fisher's exact test for categorical variables. Partial least squares (PLS) regression, a special type of regression wherein several variables are analyzed and regressed while ranking was done to identify contribution of various food items to daily GI and GL. Level of significance was set at five percent.

Ethical Consideration

The study was conducted in accordance to the stipulations of Declaration of Helsinki and Good Clinical Practice. The protocol was reviewed and duly approved by the University of the Philippines Regulatory Ethics Board (UPM-REB) in April 2016. Confidentiality was maintained. Original documents were secured under lock and key, while electronic databases were password-protected.

Results

The clinical characteristics and dietary parameters were as summarized in Table I. The sample was relatively young ($\bar{x}$=39 years) and lean (BMI 21.5=males; 22=females). Average total caloric intake and fiber intakes were low. Majority of participants have at least moderate level of physical activity (92.8%=males; 88.4%=females). Average daily GI was 63 (male and female), while average daily GL was 182g and 144g for males and females respectively.

Table I. Clinical characteristics of study participants

Characteristics (mean ± SD)	Men (n=70)	Women (n=69)	*p*-value
Age (year),	39 ± 26	39 ± 16	0.638
BMI (kg/m^2)	21.5 ± 5.2	22.1 ± 5.1	0.510
Underweight, n (%)	14 (20)	11(16)	0.798
Normal, n (%)	32 (45.7)	29(42)	
Overweight/Obese, n (%)	24 (34.3)	29 (42)	
Average Total Calories (Kcal/day)	1666.5 ± 975.0	1336.0 ± 515.0	<0.001
Average Carbohydrate Intake (g/day)	73.9 ± 12.6	71.7 ± 11.4	0.121
Average Protein intake (g/day)	12.6 ± 5.1	12.7 ± 5.0	0.601
Average Fat Intake (g/day)	10.4 ± 11.0	15.8 ± 9.6	0.001
Fiber intake (g/1000 kcal),	6.2 ± 2.4	8.1 ± 2.8	<0.001
Leisure time physical activity (LTPA) (Metabolic equivalents [MET]-min/week), median (interquartile range)	3840 (280-33,012)	2422 (28-19,146)	0.006
Low n (%)	5 (7.2)	8(11.6)	0.184
Moderate, n (%)	22 (31.4)	39(56.5)	
High, n (%)	43 (61.4)	22(31.9)	
Underreporters n (%)	44 (62.8) † 20 (28.7)‡	29 (42.0) † 11(15.7) ‡	
Glycemic index	64±2.2	64.0±4.5	0.902
Glycemic load (g/day)	195.2±61.4	152.4±41.8	<0.001

†Using physical activity level (PAL) specific cut-offs,
‡Using universal cut-off for EI:BMR (<0.9)

Using Spearman rank test, rho coefficient of 0.0348 (*p*=0.6839) and 0.1537 (*p*=0.0708) were obtained when correlating GI with BMI and GL with BMI of all participants, respectively. After the participants were classified into three BMI groups (underweight, normal, overweight/obese), the mean daily GI and GL were compared across categories relationship showing non-significant differences for both (Table II).

Due to lack of accepted cut-off for daily GI and GL (unlike that for individual food item, i.e. low GI <55) and the likelihood of observing a non-linear relationship, earlier studies have used tertiles or quintiles to describe the distribution of variables in specific populations.[7-8] Participants were grouped into tertiles according to their average daily GI and GL. The mean BMI, age, daily GI, total daily caloric intake and macronutrient distribution, fiber intake and level of physical activity were compared across tertiles. BMI was observed to be higher with increasing GI tertiles in males (*p*=<0.0001) but not in females; age varied significantly among GI tertiles in females (see Table III). Among the GL tertiles, significant differences were noted in the mean total energy intake in

Table II. Comparison of daily GI and GL among BMI categories

N=139	Underweight n=25	Normal n=61	Overweight/ Obese n=53	*p*-value
Daily GI (mean)	64.4 ± 3.1	63.9 ± 2.6	63.9 ± 3.8	0.741†
Daily GL (mean)	157.2 ± 51.5	172.8 ± 59.9	182.9 ±57.9	0.0954†

†Using one-way ANOVA

both males and females, while the percentage of energy reported from carbohydrate intake differed significantly among females only. As in the case of GI tertiles, BMI of males was noted to be higher with increasing glycemic load tertiles, while age was higher in the lower GL tertiles (Table IV). No such pattern was seen among the female participants. This suggests that as men get older, their GLd decreases. Since GLd was computed by adding up the products of GI and the available carbohydrates in a food item, it is expected that as the GLd tertile increases, total energy intake and the intake of carbohydrate in relation to total calories would also increase. Among females, the percentage fat intake was observed to decrease with increasing GL tertile.

The underreporting rates using the Goldberg-Black cut-offs were higher than expected (52.5% overall), compared to prior reports (19.7-24.7%).[5,7] However, utilizing a lower universal cut-off that was used in a Korean survey (<0.9),[17] the UR rate approximated the earlier reports (22.3%).

The relative contributions of the different food items to both daily GI and GL were evaluated by assigning a factor (PLS) to each item to that indicated the vector of influence. A factor closer to one signified a greater impact on the whole, the weight diminishing as value approaches zero; while a negative sign indicates the direction of influence is inverse (i.e. predicts lower daily GI or GL). The results are summarized in Table V. Bread, sweets and coffee mixes contributed to higher daily GI in both males and females. The analysis was unable to define the contribution of rice to daily GI due to the narrow range of the daily GI values and because the entire sample consumed said food item, rendering its influence neutral (GI values are fixed despite the amounts consumed). On the contrary, intake of nuts/ legumes, pasta, root crops and chocolate are associated with lower daily GI for both sexes, with the addition of fruits for men. As expected, rice contributed most to daily GL due to the large amounts consumed, followed by bread, pastries, fruits, corn and coffee mixes, with nuts and soda as added contributors in women. Among the negative contributors to daily GL are leafy vegetables for both sexes and nuts/ legumes for males only.

Discussion

To our knowledge, this is the first study to explore the relationship of GI and GL with BMI among Filipinos. A positive relationship was observed between GI and BMI, and GL and

Table III. Glycemic index tertiles in relation to clinical and dietary parameters

	Men			*p*	Women			*p*
	1st tertile GI (n= 37)	2nd tertile GI (n=10)	3rd tertile GI (n=23)		1st tertile GI (n= 24)	2nd tertile GI (n=23)	3rd tertile GI (n=22)	
Mean daily Glycemic Index	61.7 (61.4,62.0)	63.3 (63.2,63.5)	66.6 (65.8,67.3)		60.3 (59.1,61.5)	63.5 (63.2,63.8)	67.8 (66.9,68.7)	
Body mass index (kg/m²)	21.4 (19.9, 23.0)	22.5 (20.6,24.5)	24.0 (19.9,28.0)	<0.0001†	23.1 (20.9,25.2)	22.4 (20.3,24.5)	22.3 (20.7,23.9)	0.8026
Age (years)	40.6 (30.9,50.2)	41.3 (35.2,47.4)	44.3 (38.4,50.2)	0.8487†	39.8 (34.3,45.3)	37.8 (31.3,44.3)	47.9 (42.3,53.5)	0.0321
Total Energy (kcal/day)	1817.1 (1453.8, 2180.3)	1830.9 (1592.1,2069.8)	1567.0 (1307.8,1826.1)	0.3823†	1347.2 (1188.6,1505.8)	1478.2 (1290.9,1665.5)	1279.5 (1154.1,1405.0)	0.2145
Carbohydrates (%)	70.3 (63.5,77.1)	74.6 (71.3,77.9)	70.4 (63.5,77.2)	0.7043†	69.8 (66.7,72.9)	73.1 (69.0, 77.3)	71.9 (69.2,74.7)	0.3304
Protein (%)	15.9 (10.8,21.1)	12.4 (11.3,13.5)	16.7 (11.1,22.4)	0.1011†	13.2 (11.6,14.8)	12.4 (11.1, 13.7)	14.6 (12.5,16.6)	0.4051†
Fat (%)	11.7 (8.0,15.4)	11.1 (8.2,14.0)	11.5 (8.2,14.9)	0.9226†	17.0 (14.4,19.6)	14.5 (10.9, 18.1)	13.5 (11.3,15.6)	0.1415†
Fiber (g/1000 Kcal)	6.6 (5.3,7.9)	6.4 (5.5,7.4)	6.7 (5.6,7.9)	0.8191†	8.7 (7.7,9.8)	7.8 (6.5, 9.2)	9.1 (7.3,10.8)	0.5954†
LTPA (MET-min/week)	6958.2 (2777.8,11138.6)	6756.5 (4036.9, 9476.1)	5992.2 (3137.1,8847.4)	0.9377†	2646.4 (1886.3,3406.4)	3391.9 (2154. 1,4629.7)	3301.9 (1795.1,4808.7)	0.5303†

One-way ANOVA was used to analyze the differences among tertiles except marked (†) where Kruskal Willis test was used; significant differences are in bold letters. Values are expressed in median with interquartile range in parentheses.

Table IV. Glycemic load tertiles in relation to clinical and dietary parameters

	Men			*p*	Women			*p*
	1st tertile GL (n=17)	2nd Tertile GL (n=19)	3rd tertile GL (n=34)		1st tertile GL (n=29)	2nd Tertile GL (n=28)	3rd tertile GL (n=12)	
Glycemic Index	119.9 (112.0,127.7)	162.9 (156.8,169.0)	251.0 (237.3, 264.7)		116.6 (109.7,123.5)	160.9 (155.3,166.6)	218.9 (200.1,237.8)	
Body Mass Index (kg/m^2)	19.9 (18.0,21.9)	22.3 (20.3,24.2)	24.4 (21.5,27.2)	**0.0108**	22.6 (20.7, 24.5)	22.5 (20.7,24.3)	23.0 (21.1,24.9)	0.7392
Age (year)	49.3 (40.4,58.2)	47.8 (40.6,55.0)	35.3 (30.6,40.0)	**0.0030**	44.7 (38.6, 50.8)	42.8 (37.7,47.8)	36.6 (30.7,42.5)	0.3442
Total Energy (kcal)	1005.6 (910.2,1100.9)	1544.3 (1390.4,1698.2)	2217.9 (20135.6,2400.1)	**<0.0001**	1055.5 (969.0,1142.0)	1499.5 (1391.0,1607.9)	1719.2 (1600.6,1837.9)	**<0.0001**
Carbo-hydrates (%)	77.5 (74.3,80.7)	66.0 (57.5,74.5)	72.9 (69.2,76.5)	0.0813	69.4 (67.2,71.6)	71.1 (67.9,74.3)	77.1 (72.8,81.3)	**0.0082†**
Protein (%)	14.4 (12.9,15.9)	18.8 (10.7,27.0)	12.6 (11.6,13.6)	0.1008	13.5 (12.1,14.9)	14.3 (12.3,16.2)	11.9 (10.3,13.5)	0.3008
Fat (%)	8.2 (5.7,10.8)	12.8 (9.0, 16.6)	12.1 (9.3,14.9)	0.1561	17.1 (15.1,19.1)	14.6 (12.1,17.2)	11.0 (7.1,15.0)	**0.0151†**
Fiber (g/ 1000 Kcal)	7.0 (5.2,8.8)	6.2 (5.6,6.7)	6.6 (5.7,7.5)	0.9932	9.1 (7.4,10.7)	8.4 (7.4,9.5)	8.2 (6.5,10.0)	0.9063
LTPA (MET-min/week)	7166.3 (3040.8,11291.8)	7174.5 (3196.0,11153.0)	5907.7 (3702.1,8113.4)	0.9014	2794.8 (1986.2,3603.3)	3188.8 (2341.3,4036.4)	3490.8 (204.6,6777.1)	0.5085

Kruskal Wallis test was used to analyze the differences among tertiles except marked (†) where one-way ANOVA was used; significant differences are in bold letters. Values are expressed in median with interquartile range in parentheses.

BMI, but among male participants only; that may be due to differences in dietary patterns between sexes. Commonly consumed food items like bread contributed largely to both GI and GL, while rice was most implicated for GL.

Traditionally, each carbohydrate source can be described in terms of its ability to affect blood glucose level after consumption known as its GI. Food items whose GI is less than 55 are considered low GI foods, while those with GI of 55-69 and ≥70 are moderate and high GI food, respectively.[13] In a practical sense, this concept was devised to simplify the notion of "available carbohydrates" that it may be easily applied to evaluate and likely optimize dietary patterns; and therefore, identify which food item one should "eat less of" due to higher glucose content. Its application to lifestyle intervention among diabetics is supported by observed modest improvement in glycemic control and is reflected in the ADA guidelines.

The investigations of Lau (2006) and Murakami (2007) both reported positive correlation of BMI with GI and GL;[5-6] however, other studies have opposite results.[7-8] Those that support a positive correlation hypothesize that this may be related to hyperinsulinemia that promoted fat oxidation and greater carbohydrate oxidation. Satiety may also play a role, as it has been postulated by Lavin that low GI diets may not only dampen glycemic excursion but may also bring about a more sustained stimulation of the gut due to slower digestion and release of nutrients, thereby producing a prolonged activation of satiety centers in the brain.[18] Our investigation found a positive relationship for both daily GI and daily GL with BMI among men. The fiber intake in females in the study is higher on average by a little more than two gram per 1000 kcal of energy intake (p=<0.001). This may mask the influence of daily GI to BMI, as shown in the study by Murakami where dietary fiber was negatively correlated to obesity.[6] The finding of higher percentage of fat intake among lower GL in women may also suggest that higher relative fat intake may decrease the drive for consumption of more glucose in the diet, although this cannot be confirmed at the moment as without additional data. Physical activity level did not vary among the GI and GL groups. Since majority of study population have moderate to high physical activity, low-activity subjects are under-represented that may render its effect difficult to observe.

The nutritional status of this population markedly differed from the data provided by the latest National Nutrition and Health Survey (NNHeS) in 2013, where the combined prevalence of obese/overweight in the Philippines was 31.1% (overall population). The survey used the WHO definition of overweight and obesity (BMI 25-29.9 and ≥30, respectively) rather than the WHO-APP definitions used in this study. Applying WHO definitions, the combined prevalence of overweight/obese for this study was only 20% (38% using WHO-APP criteria). Similarly, it was lower than the estimates for CALABARZON region (33.5%) where San Juan, Batangas was located. Conversely, the overall rates of chronic energy

Table VIII. Factor loading for GI and GL diet pattern scores (regression coefficients)

Food items	Glycemic index pattern factor loading		Glycemic load pattern factor loading	
	Men	Women	Men	Women
Grains & cereals				
Rice	0.00001	0.00001	0.98203*	0.84992*
Rice products	0.08618	0.18127	0.05747	0.18923
Pasta/noodles	-0.10596‡	-0.12052‡	0.07591	0.14416
Root crops	-0.27414‡	-0.39342‡	0.063	0.04221
Corn	-0.0443	0.05456	0.09884*	0.09996*
Bread/crackers	0.29297*	0.16750*	0.22187*	0.33222*
Pastries/cakes	0.12573	-0.04638	0.14153*	0.24291*
Junk food/chips	0.09903	-0.27756	0.05023	-0.01591
Fruits & Vegetable				
Fruits	-0.27441‡	-0.06258	0.10703*	0.16526*
Leafy vegetables	-0.07151	0.01074	-0.00490‡	-0.01866‡
Starchy vegetables	-0.12787	0.08149	0.03761	0.01882
Nuts/legumes	-0.33762‡	-0.34131‡	-0.01642‡	0.14606
Dairy products				
Milk/yogurt	0.02125	-0.04427	-0.00094	0.0053
Chocolate	-0.14658	-0.19422	0.02102	0.06651
Ice cream	-0.05786	0.00693	0.05092	-0.00967
Creamer	-0.00038	-0.00666	0.01069	0.04245
Simple sugars				
Table sugar	0.18283	-0.17245	0.066	0.07388
Candy/sweets/syrup	0.17170*	0.23240*	0.00258	0.02713
Beverages				
Juices	0.04696	-0.08142	0.04497	0.09215
Soda	-0.06001	0.18206	0.04015	0.19396
Coffee mix	0.42292*	0.19081*	0.09526*	0.20897*

*Major positive contributors to GI and GL, ‡the major negative contributors.

deficient or underweight individuals were higher in our study than that of national and regional (18% vs. 10% vs. 9.85%, respectively).[19]

The distinctiveness of this population from that of earlier reports was not limited to differences in nutritional status. As emphasized earlier, the sample population was relatively leaner (BMI $\bar{x}$=22.6) with a lower obesity rate (20%). The participants were also relatively young and more physically active. Compared to the reports by Lau, Mendez or Rossi,[5,7,8] the participants of this study reported a markedly lower daily caloric intake ($\bar{x}$=1547 kcal/day) and a higher percentage of carbohydrates consumption (ranging 63-77% of total calories). This pattern offers a rare perspective to the consequence of the carbohydrate quality (GI, GL) to obesity in a population that consumes high carbohydrate diets and where caloric excess is uncommon. Understandably, these differences may have important implications regarding the dietary recommendations for such individuals. Intervention involving caloric restriction may have limited role here given the higher prevalence of energy deficient individuals, and dietary advice reasonably should emphasize quality of food choices over actual quantity. This highlights the importance of a tailored medical nutrition therapy to suit individual needs.

Underreporting as described by Lau in his study is a potential yet often undervalued source of bias.[5] In this group, overall UR rate using Goldberg-Black criteria was 52.5% (62.8=male; 42.0=female), higher than that reported by Lau (24.7%),[5] which included more than 12,000 participants. As previously indicated, when a universal cut-off was applied, the number is reduced to 22.3% (male =28.7; female=15.7%). However, the former criteria were based on observations among Caucasians,[20-22] and has not been validated for Filipinos. A similar sex bias for underreporting was seen in an earlier study which noted more male participants underestimating their caloric intake.[23] A lower cut-off then may be more fitting but needs validation. Likewise, method of basal metabolic rate (BMR) estimation has its inherent limitations that can only be overcome by calorimetric measurement, and its use among Asians is likely to overestimate values. Hence, further investigation is needed to verify these cut-offs in order to draw more meaningful conclusions with their use.

As expected, the food items that predicted higher daily GI (bread, pastries, coffee mixes, soda/sweets) were naturally food items with high individual GI (>55), while items with low GI (<55) like nuts/legumes, pasta/noodles and root crops are associated with lower daily GI. Similarly, food items with the greatest relative contribution to daily GL were of high GI. These results reflect the typical diet of Filipinos, with rice, corn and root crops as staple foods, breads and pastries as snacks, and abundance of tropical fruits and vegetables. The Batangas province in particular was known for its flourishing coffee plantations during the Spanish era, and coffee drinking is commonplace among its dwellers to this day. However, many of the residents of San Juan have favored instant mixes over brewed coffee. Dietary modifications for weight management in this population would likely include cutting down on servings of rice, bread and pastries, and replacing them with items of lower GI, as well as moderation on intake of sweetened beverages, coffee mixes and fruits.

There are several limitations to this study. In the calculation of daily GI and GL, a few necessary assumptions were made with regards to assigning corresponding GI values to food items that did not appear in the local resource. The authors had consulted international resources to resolve this issue. Also, it was assumed that the reported dietary information was accurate and represented the usual dietary intake. Thirdly, the study was limited to evaluating association between daily GI or GL and BMI, and not causality. Fourth, BMI was used as the sole measure of obesity; it would be interesting to see if similar patterns would be observed when other parameters such as waist circumference or waist-to-hip ratio (WHR) are used to define obesity. Lastly, underreporting rate using Goldberg-Black criteria was determined to be high, but the applicability of such criteria to this population is uncertain.

Conclusions

The results of this investigation suggest that there is likely a positive relationship between daily GI and BMI, and between daily GL and BMI among the males in this population. This relationship was not seen in the female population, although differences between the dietary patterns between the sexes particularly dietary fiber or fat intake may have influenced the results. Majority of the food items that are considered staple this population are of high GI and contribute to higher daily GI and GL.

Recommendations

Although the study has its limitations, it paves the way for further research that explores this subject. Further investigations are needed to determine applicability of Goldberg-Black criteria among Filipinos and to set relevant cut-offs for its use. A prospective study employing reliable methods of energy reporting is also ideal. Likewise, we recommend a study focusing on urban population, as there are likely to be differences in nutritional status and dietary patterns.

Acknowledgements

Special thanks to Dr. Cecilia Jimeno for a comprehensive technical review of this protocol and to Ms. Dolores Santos for her help with the SAS program.

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