Nutrient Analysis of the Guamanian Diet: Acceptable Energy Distribution with Inadequate Nutrient Quality

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Note: data collection for the project was conducted when RSP was on the faculty at the College of Agriculture and Life Sciences, University of Guam, Mangilao, Guam.

Abstract

Nutrition-related diseases are now a major health problem and cause of mortality on Guam. The purpose of this study is to document the nutrient content of the diet of adults on Guam with ethnic and sex differences. The subjects were 400 adults residing on Guam selected to reflect the population distribution of the island for ethnicity and gender. A 24-hour dietary recall was administered via telephone using two-dimensional food models. The diets were analyzed for nutrient content using the Food Intake Analysis System. T-tests were used to compare the mean nutrients and a Kruskal – Wallis test was used to compare the median for the two genders. Analysis of variance was used to compare mean nutrient intakes among the ethnic groups. Results show a generally appropriate intake of energy with energy distribution of carbohydrate, protein and fat within guidelines established by the National Academy of Sciences (U. S.). Nutrients that likely exceed recommendations for good health include saturated fat, cholesterol, and sodium with mean (± SD) intake at 10.5 ± 4.1of kcals, 352 ± 256 mg/d, and 3226 ± 1901 mg/d, respectively. Fiber, vitamin A, C, and E, folate, and magnesium are at levels that suggest inadequacy because large proportions of the sample, 96%, 48%, 56%, 83%, 85%, and 74%, respectively, were below the Estimated Adequate Intake (EAR) for these nutrients. Median intake is exceptionally low for calcium, 360 mg /d, and potassium, 2169 mg /d, and large proportions of the sample, 92% and 96%, are below the Adequate Intake (AI) level for calcium and potassium, respectively. This nutrient profile is associated with increased risk for chronic disease. (PHD, 2005 Vol 12 No 2 Pages 65 - 77)

Introduction

Guamanians are experiencing a health transition and a combination of infectious and chronic diseases are prevalent.[1,2] Nutrition-related diseases are a major health problem and cause of mortality. [2, 6] Focus group results from Guam indicate that community members percieve “unhealthy lifestyles” including “overeating,” as one of the key health problems on the island.[7] Over the last 50 years Guam has increasingly adopted the mainland diet of the United States (U. S.), with emphasis on processed foods that are high in fat, sodium, and refined carbohydrates including sugar, but low in fiber.[5,6,8] A number of studies since 1958 have shown suboptimal food and nutrient intake in both children and adults. [9-16] However, none of the earlier studies detailed the nutrient content of diets of a representative sample of the adult population on the island.

Health data for Pacific Islanders is frequently aggregated in the United States. Because of cultural influences on food intake[8] it is important to explore nutrient differences between the many ethnic groups that make up the population of Guam which include Chamorros, Asians, Filipinos, Whites, Blacks, and those from other Pacific Islands. Further, statistics on the micronutrient status of women is not readily available globally except in well developed countries. [17] The purpose of this study is to document the nutrient content of the diet of a representative sample of adults on Guam with sex and ethnic differences.

Methods

Study design

This study describes the investigation of the dietary intake of adults on Guam using a telephone survey. The telephone survey included three steps. First, a call was made to select subjects based on a multistage sampling protocol. If subjects agreed to participate then appointments were made to complete the full diet assessment survey. Second, two-dimensional food models [18] were mailed to each participant’s home address to help with estimating food portions. Third, a call was made to complete a 24-hour food recall interview.

Local residents trained by the principal investigator (RSP), a registered dietitian, conducted the 24-hour

recall using a script to maintain consistency. The 40-hour training session included 24 hour recall methodology, food descriptions, quantification of amounts eaten, and cultural sensitivity issues. The interviewers maintained a log, and were monitored by the principal investigator. The research assistants were bilingual and interviews were conducted in English, Chamorro, or Tagalog, according to the preference of the respondent. The interviewer explained the purpose of the study and received oral informed consent from the participants. This study was approved by the Human Subjects Committees at the University of Guam and Bowling Green State University.

Subjects

The subjects were 400 adults residing on Guam during the study period. A multistage sampling protocol was used for subject selection in a two-stage process. First, households were selected from the 1993 Guam Telephone Directory. To do this a random number was selected for the first phone number to call and then every sixth residential listing after that was selected for a call. Secondly, subjects were randomly selected from within the household using a method described by Czaja et al.[19] Briefly, the person who answered the phone was asked how many adults 18 years old or older were in the household and how many of these were women. A chart was used to select the person within the household who should be interviewed (i.e., the oldest male, the youngest adult female, etc). Interviewers requested to speak to this person and asked them to self report their ethnicity. Participants were recruited in this manner until the final sample reflected Guam's population as distributed by ethnicity and sex.[20] The final sample (Table 1) included 36.7% Chamorros, 4.8% other Pacific Islanders (including Carolinian, Palauan, Chuukese, Kosraean, Marshallese, Pohnpeian, Yapese, and other), 1.5% Chinese, 22.2% Filipinos, 1.7% Japanese, 3% Korean, 0.75% other Asians, 14.2% Whites, 2.2% Blacks, and 1.5% other single ethnic groups. Mixed ethnicity participants included 5.7% Chamorro and other ethnic groups, and 5.5% Asian (mostly Filipino) and other groups. There were 214 males and 186 females in the study.

To recruit the 400 subjects, 647 people were contacted; 247 declined participation, 39 of those because of a language barrier, four because of impairment (i.e., hearing) resulting in an acceptance rate of 62%.

Data Collection and Analysis

A 24-hour dietary recall with the multiple pass technique was administered via telephone using two-dimensional food models[18] to aid in portion size quantification.[21] The 24-hour dietary recall interview is recognized as the most complete self-reported method to gather information about an individual's diet.[22] In the multiple pass method the interviewer asks a respondent to search his or her memory several times to increase retrieval of the types and amounts of foods consumed the previous 24-hours to improve accuracy of the recalls.[23] When administered by telephone, the 24-hour recall provides a valid estimate of dietary intake of mean and distributions of nutrient intake.[24,25] Additional benefits of the telephone

Table 1: Ethnic and sex distribution of adults on Guam completing the diet assessment.

Ethnic Group	Female n	Male n	Total n
Chamorro	76	73	149
Other Pacific Islander			
Palauan	8	2	10
Pohnpeian	1	1	2
Other Pacific Islander	9	3	12
Asian			
Chinese	2	3	5
Japanese	5	2	7
Korean	5	6	11
Other Asian	2	3	5
Filipino	45	47	92
Other Single Ethnic			
White	21	34	55
Black	3	4	7
Other Single Ethnic	3	5	8
Multiple Ethnic			
Chamorro and other	9	11	20
Asian and other	9	11	20
Total Sample	189	211	400

24-hour recall are reducing the logistical and personnel time constraints associated with a nutrition survey while increasing personal security and reducing the burden of the respondents.[25]

The diet recalls were analyzed for nutrient content using the Food Intake Analysis System (FIAS) version 3.0 (The University of Texas-Houston Health Science Center School of Public Health-Human Nutrition Center and the United States Department of Agriculture Research Service, 1996, Houston, Texas). The FIAS includes nutrient values of approximately 10,250 food items commonly consumed by people in the United States. Substitutions for local foods not found in the data base were few but when required were made based on an estimation of the nutrient content of similar foods and from information on food labels. In this study, one additional food, Calrose rice (unpublished data, USDA Human Nutrition Center, San Francisco) was added to the FIAS database as it is a staple of the diet on Guam and differed in nutrient composition from the other rice choices. Salt or soy sauce added to food while eating is difficult to quantify accurately and for this reason was not added to the food recalls. Thus the sodium content of the diet is an underestimation of actual intake.

Statistical Analysis

Statistical analyses were performed using the Statistical Analysis System.[26] Descriptive statistics were used to report the mean, median, and standard deviation of all nutrients (in gram and milligram) and the energy distribution and nutrient densities. Comparisons were also made by gender, and ethnicity. T-tests were used to compare the mean nutrients, and length of years on Guam for the two genders. A Kruskal – Wallis test was used to compare the median for the two genders.

For analysis, some ethnic groups were combined where related groups contained too few subjects resulting in six ethnic groupings: Chamorro, other Pacific Islanders, Asian (excluding Filipino), Filipino, Other Single Ethnic groups (including Whites and Blacks), and those of mixed Chamorro/Other ethnicity. Analysis of variance was used to compare the mean nutrients among the ethnic groups. Tukey's multiple comparison procedure was used to find where differences exist among the different ethnic groups. The level of significance used for all tests was alpha equal to 0.05.

Results

The mean ± standard deviation (SD) age for the subjects was 38.5 ± 14.9 years. Age ranged from 18 to 83 years. The average length of residence on Guam was 22 ± 14.9 years with a range of one month to 83 years. There were no statistical differences between the ethnic groups based on length of residency on Guam.

Nutrient Intake

Nutrient intake is reported for the total sample and by sex (Table 2) as are the relevant Dietary Reference Intakes (DRIs) including the Estimated Average Requirements (EARs) recently established by the National Academy of Sciences.[27-32] The DRI is an umbrella term that includes four standards: 1) the traditional Recommended Dietary Allowances (RDA) which is no longer used to assess groups, 2) the Adequate Intake (AI) which is used when there is not enough information to establish a RDA, 3) the Upper Limit (UL) which is a level that should not be exceeded, and 4) the Estimated Average Requirement (EAR) which represents the estimated median requirement for healthy individuals.

The EAR cut off method is the most appropriate technique when analyzing diets of a group for adequacy. In this method, the proportion (%) of the group below the EAR reflects the proportion of the population that does not meet their nutrient requirement and is at risk for deficiency.[33,34] Thus, if 20% of a population falls below the EAR for a particular nutrient, then the risk for deficiency in that population is 20% for that nutrient. United States (U. S.) DRI standards are used in this study because of the political associations between Guam and the U. S. and because the DRIs are formulated for people of broad cultural and ethnic diversity.[33]

Both saturated fat and cholesterol should be "as low as possible while consuming a nutritionally adequate diet

With the new EAR cut off method it is desirable to get an estimate of day to day variation (within-person variability) by assessing more than one day of intake or by using another dataset in order to calculate usual diet.[33,34] If only one day of dietary data is used, as in this study, the results tend to overestimate the proportion of the sample at risk for deficiency. Unfortunately no other report of dietary intake has been published for Guamanians and the study was conducted before the improvements in dietary assessment methodology were recommended by the U. S. Institute of Medicine. Thus the actual risk for deficiency noted in this study may be lower than our results suggest.

Macronutrients

Mean (± SD) energy intake for the sample was 2066 ± 948 kcals (1 kcal = 4.18 kJ). Energy requirements are highly individualized but this average and the median of 1938 kcals fall within the range of recommendations[31] for these subjects. Mean energy distribution was 47.9 ± 12.3 % from carbohydrate, 18.4 ± 6.0 % from protein, and 32.9 ± 12.3% from fat (Table 2). The Accepted

Table 2: Dietary intake of energy and macronutrients of adults on Guam (n=400) for total sample and by sex

Nutrient	Total Sample (n = 400)		DRI[1]	Sample < EAR[2]	Females (n=189)	Males (n=211)		Females (n=189)	Males (n=211)	
	Mean ± SD[3]	Median		%	Mean ± SD	Mean ± SD	p	Median	Median	p
Macronutrients										
Energy, kcal[4]	2066 ± 948	1938	1255 - 3600[5]	-	1797 ± 745	2307 ± 1042	0.0001**	1708	2187	0.000**
Carbohydrate, g	243 ± 118	223	100[2]	6.25	216 ± 94	267 ± 132	0.0001**	203	238	0.000**
% of energy	47.9 ± 12.3	47.9	45 - 65[6]	-	48.9 ± 12.0	47.0 ± 12.7	0.1103	48.7	46.0	0.058
Protein, g	95 ± 51	86.6	38 - 46[2]	11.5	80.2 ± 39.8	108.3 ± 55.4	0.0001**	73.9	95.8	0.000**
% of energy	18.4 ± 6.0	17.4	10 - 35[6]	-	17.8 ± 5.3	19.0 ± 6.5	0.0461*	17.0	17.8	0.093
Total Fat, g	79 ± 48	71.9	-	-	68.9 ± 41.4	87.6 ± 52.1	0.0001**	60.6	80.0	0.000**
% of energy	32.9 ± 12.3	32.8	20 - 35[6]	-	32.9 ± 10.2	32.9 ± 10.5	0.9793	32.6	33.1	0.644
Saturated Fat, g	25 ± 16	22.2	-	-	21.8 ± 13.7	27.9 ± 17.7	0.0001**	19.2	23.3	0.000**
% of energy	10.5 ± 4.1	10.1	As low as possible[7]	-	10.4 ± 4.0	10.6 ± 4.2	0.8177	10.2	10.1	0.856
Monounsaturated fat, g	30 ± 19	25.8	-	-	25.3 ± 13.7	27.9 ± 17.7	0.0001**	22.9	30.0	0.000**
% of energy	12.3 ± 4.3	12.2	-	-	12.0 ± 4.1	12.6 ± 4.4	0.1947	11.9	12.6	0.108
Polyunsaturated fat, g	17 ± 14	13.1	-	-	15.8 ± 12.9	18.5 ± 14.4	0.0392*	11.9	14.7	0.012*
% of energy	7.1 ± 4.0	6.4		-	7.4 ± 4.4	6.8 ± 4.0	0.1271	6.7	6.2	0.276
Alcohol, g	2.7 ± 14.1	0.0	-	-	0.9 ± 5.9	4.2 ± 18.6	0.0129*	0	0	0.210
% of energy	0.8 ± 4.1	0.0	-	-	0.3 ± 2.2	1.1 ± 5.1	0.5352	0	0	
Cholesterol, mg	352 ± 256	302	As low as possible[7]	-	306 ± 242	394 ± 261	0.0005**	224	335	0.000**
Density	169 ± 111	149	-	-	123 ± 9	171 ± 99	0.7416	136	157	0.126
Dietary Fiber, g	12.2 ± 8.4	10.5	26 – 38[8]	95.5[9]	12.1 ± 8.4	12.4 ± 8.4	0.7408	9.6	11.2	0.379
Density	6.4 ± 4.3	5.4	-	-	7.3 ± 5.1	5.6 ± 3.2	0.0001**	6.2	4.9	0.000**
Micronutrients – Vitamins										
Vitamin A, μg-RE	896.6 ± 1344.5	600.2	485 - 625[2]	48.0	914.3 ± 1759.3	880.7 ± 814.5	0.8032	554.4	620.4	0.253
β Carotene, μg-RE	503.3 ± 637.9	261.7	-	-	490.3 ± 595.7	514.9 ± 674.7	0.7011	261.1	262.2	0.709
Vitamin C, mg	101.1 ± 124.0	58.6	56 - 75[2]	56.25	95.1 ± 106.8	106.6 ± 137.7	0.3552	54.8	63.1	0.732
Vitamin E, mg	8.1 ± 8.6	6.6	12[2]	82.75	7.3 ± 9.0	8.7 ± 8.2	0.0960	5.9	7.3	0.001**
Thiamin, mg	1.9 ± 1.1	1.6	.9 - 1[2]	16.25	1.6 ± 0.89	2.1 ± 1.3	0.0001**	1.4	1.9	0.000**
Riboflavin, mg	1.6 ± 0.95	1.4	.9 – 1.1[2]	25	1.4 ± 0.94	1.7 ± 0.94	0.0034**	1.3	1.6	0.000**

Niacin, mg	28.0 ± 15.8	24.8	11 - 12[2]	9.75	24.0 ± 14.3	31.5 ± 16.4	0.0001**	22	28.2	0.000**
Vitamin B_6, mg	1.8 ± 1.1	1.6	1 – 1.4[2]	32.5	1.6 ± 1.1	2.0 ± 1.1	0.0003**	1.3	1.7	0.000**
Folate, μg	208.5 ± 191.6	158.9	320 - 330[2]	85.25	194.1 ± 179.3	221.4 ± 201.6	0.1549	144.0	167.7	0.049*
Vitamin B_{12}, μg	6.3 ± 13.0	4.1	2.0[2]	23.5	6.0 ± 16.9	6.8 ± 6.8	0.3956	3.6	4.8	0.001**
Micronutrients – Mineral										
Calcium, mg	488.5 ± 415.7	359.7	1,000 – 1,300[18]	92.25[9]	451.9 ± 386.8	521.2 ± 438.4	0.0964	346.8	386.7	0.099
Phosphorous, mg	1150.5 ± 575.0	1080.2	580 - 1055[2]	14.25	1011.9 ± 500.2	1274.6 ± 609.5	0.0001**	946.2	1213.7	0.000**
Magnesium, mg	250.7 ± 148.8	222.4	255 - 350[2]	74.25	226.0 ± 150.6	272.8 ± 144.0	0.0017*	203.3	246.5	0.000**
Iron, mg	16.7 ± 10.5	14.5	5 – 8.1[2]	10.75	14.9 ± 10.0	18.3 ± 10.7	0.0010**	13.1	16.7	0.000**
Zinc, mg	12.3 ± 8.2	10.9	6.8 – 9.4[2]	31.75	10.8 ± 8.0	13.6 ± 8.2	0.0007**	9.3	11.7	0.000**
Copper, mg	1.2 ± 0.8	1.0	.685 - .700[2]	24	1.1 ± 1.1	1.2 ± 0.7	0.2067	0.9	1.1	0.001**
Sodium, mg	3226 ± 1901	2843	1,200 – 1,500[10]	12.75[10]	2879 ± 1483	3536 ± 2167	0.0004**	2516	3134	0.003**
Potassium, mg	2376 ± 1297	2169	4,700[8]	96[9]	2116 ± 1038	2609 ± 1454	0.0001**	2030	2390	0.000**

[1] Dietary Reference Intakes (DRIs) is an umbrella term that includes the Recommended Dietary Allowances for Individuals (RDAs), Adequate Intake (AI), Estimated Average Requirements for Groups (EAR), Tolerable Upper Intake Levels (UL), Acceptable Macronutrient Distribution Ranges (AMDR), and Estimated Energy Requirements (EER). The DRI's are based on age and sex, thus they are presented in the range appropriate for subjects in this sample.

[2] The Estimated Average Requirements for Groups (EAR) is used for assessing adequacy of population intakes by estimating the proportion of the group who fall below this requirement. Not all nutrients have an EAR established. The percent of the population falling below the EAR was based on the specific EAR for the age and gender of each person in the sample.

[3] Standard Deviation (SD)

[4] 1 kcal = 4.18 kJ

[5] Estimated Energy Requirements for Mean and Women, broadest range of recommended energy intake for this sample based on sex and an estimated minimum and maximum physical activity level.

[6] Acceptable Macronutrient Distribution Ranges (AMDR)

[7] DRI: Additional Macronutrient Recommendations for Saturated fatty acids and cholesterol are "as low as possible while consuming a nutritionally adequate diet.

[8] Adequate Intake (AI) as no EAR is established for this nutrient. The AI is believed to cover the needs of all individuals in the group, but lack of data prevent being able to specify with confidence the percentage of individuals covered by this intake.

[9] The proportion of those falling below the AI can be reported, but no assessment of adequacy can be made when mean intake of a group is below the AI.

[10] The Tolerable Upper Intake Levels (UL) for sodium ranges from 2200 – 2300 mg/d for this group, 65% of the sample exceed the UL for sodium.

* Significant at α = .05; ** Significant at α = .01;.; Sex differences 7

Table 3: Dietary mean intake for nutrients and nutrient density per 1,000 kcals by ethnicity for adults on Guam

Nutrient	Chamarro (n=149)	Asian (n=28)	Mixed Asian/Chamarro (n=40)	Filipino (n=92)	Other Single Ethnic groups (n=70)	Other Pacific Islanders (n=21)	p- value
Energy (kcal)	2101[a]	1885[a]	2065[a]	2111[a]	2006[a]	1952[a]	0.8557
Carbohydrate (g)	235.7[a]	228.3[a]	241.4[a]	259.0[a]	242.7[a]	238.8[a]	0.7513
% of kcal	45.1[a]	50.7[a]	48.0[a]	49.4[a]	49.5[a]	51.9[a]	0.0202*
Protein (g)	98.1[a]	95.2[a]	93.7[a]	93.5[a]	91.9[a]	91.5[a]	0.9512
% of kcal	19.1[a]	19.2[a]	18.0[a]	17.6[a]	18.3[a]	18.1[a]	0.5042
Total Fat (g)	83.8[a]	66.7[a]	77.3[a]	78.7[a]	75.0[a]	68.7[a]	0.4430
% of energy	35.1[a]	29.6[a]	32.6[a]	31.9[a]	31.9[a]	29.0[a]	0.0185*
Saturated Fat (g)	27.3[a]	19.4[a]	24.1[a]	23.0[a]	25.7[a]	23.0[a]	0.4194
% of energy	11.5[a]	8.6[b]	10.2[ab]	9.5[b]	10.9[ab]	9.8[ab]	0.0005**
MUFA (g)	31.9[a]	25.0[a]	30.0[a]	28.4[a]	27.9[a]	27.1[a]	0.4194
% of energy	13.2[a]	11.0[a]	12.6[a]	11.6[a]	12.0[a]	11.2[a]	0.0167*
PUFA (g)	17.3[a]	15.8[a]	16.4[a]	20.5[a]	14.7[a]	12.1[a]	0.0563
% of energy	7.3[ab]	7.3[ab]	6.9[ab]	8.0[a]	6.2[ab]	5.2[b]	0.0174*
Cholesterol (mg)	377.9[a]	297.8[a]	315.6[a]	353.7[a]	317.3[a]	376.0[a]	0.4213
Density	186.1[a]	149.2[a]	144.3[a]	166.2[a]	153.3[a]	172.9[a]	0.1673
Dietary Fiber (mg)	10.5[a]	14.0[a]	12.5[a]	12.4[a]	15.3[a]	10.5[a]	0.0031*
Density	5.4[b]	8.1[a]	6.6[ab]	6.2[ab]	8.0[a]	6.4[ab]	0.0003**
Alcohol	2.7[a]	1.0[a]	6.1[a]	2.5[a]	1.4[a]	3.1[a]	0.6606
% energy	0.7[a]	0.4[a]	1.3[a]	1.1[a]	0.3[a]	1.0[a]	0.7832
Density	0.7[a]	0.4[a]	1.3[a]	1.1[a]	0.3[a]	1.0[a]	0.7832
Vitamin A-IU	5033[b]	10182[a]	5570[ab]	6448[ab]	7235[ab]	3392[b]	0.0030*
Density	2621.1[b]	6132.2 [a]	2729.0[b]	3060.1[b]	4426.6[ab]	2151.1[b]	0.0005**
Vitamin A-RE (μg)	839.3[a]	1209.0[a]	778.6[a]	997.3[a]	963.0[a]	489.2[a]	0.4696
Density	422.1[a]	722.0[a]	385.0[a]	469.3[a]	561.7[a]	289.9[a]	0.2415
Carotene RE	382.6[b]	944.3[a]	445.7[b]	560.7[ab]	620.3[ab]	264.3[b]	0.0001**
Density	197.9[a]	579.3[a]	216.8[a]	252.3[a]	399.2[a]	177.8[a]	0.0001**
Thiamin (mg)	1.9[a]	1.8[a]	1.9[a]	1.9[a]	1.5[a]	1.8[a]	0.3386
Density	0.9[a]	1.0[a]	0.9[a]	0.9[a]	0.8[a]	1.0[a]	0.0747

Riboflavin (mg)	1.6[a]	1.5[a]	1.5[a]	1.5[a]	1.6[a]	1.3[a]	0.3083
Density	0.8[a]	0.8[a]	0.7[a]	0.8[a]	0.9[a]	0.7[a]	0.2280
Niacin (mg)	29.4[a]	26.9[a]	28.0[a]	27.4[a]	27.3[a]	25.4[a]	0.8316
Density	14.3[a]	14.3[a]	13.9[a]	13.7[a]	13.4[a]	13.4[a]	0.8980
Vitamin B_6 (mg)	1.7[a]	1.8[a]	1.6[a]	1.8[a]	1.9[a]	1.9[a]	0.5638
Density	0.8[a]	1.0[a]	0.8[a]	0.9[a]	1.0[a]	1.0[a]	0.1185
Folate (μg)	193.3[a]	240.3[a]	186.9[a]	224.1[a]	243.7[a]	128.7[a]	0.1170
Density	92.9[a]	137.9[a]	102.4[a]	109.3[a]	126.1[a]	69.7[a]	0.0090**
Vitamin B_{12} (μg)	6.7[a]	5.2[a]	7.0[a]	6.7[a]	5.2[a]	4.2[a]	0.9028
Density	3.2[a]	2.6[a]	3.5[a]	3.4[a]	2.4[a]	1.9[a]	0.8551
Vitamin C (mg)	94.7[a]	122.7[a]	69.6[a]	111.5[a]	119.3[a]	66.9[a]	0.1853
Density	3.2[a]	2.7[a]	3.5[a]	3.4[a]	2.4[a]	1.9[a]	0.0161*
Vitamin E (mg)	7.5[a]	7.8[a]	8.0[a]	9.7[a]	7.5[a]	7.0[a]	0.4918
Density	3.6[a]	4.1[a]	3.9[a]	4.6[a]	3.9[a]	3.9[a]	0.6976
Calcium (mg)	438.4[b]	470.2[ab]	460.3[ab]	458.8[b]	685.6[a]	347.5[b]	0.0005**
Density	215.9[b]	249.4[ab]	235.7[ab]	226.3[b]	342.2[a]	180.5[b]	0.0001**
Phosphorous (mg)	1132.5[a]	1112.4[a]	1136.3[a]	1130.3[a]	1260.2[a]	1035.2[a]	0.5838
Density	550.9[a]	583.0[a]	556.0[a]	555.7[a]	626.5[a]	530.4[a]	0.0297*
Magnesium (mg)	226.8[a]	268.4[a]	248.1[a]	268.2[a]	281.6[a]	218.7[a]	0.0934
Density	112.4	149.4	121.1	133.7	146.0	118.8	0.0015**
Iron (mg)	16.1[a]	16.6[a]	16.3[a]	18.0[a]	17.3[a]	13.4[a]	0.5235
Density	7.8[a]	9.0[a]	8.5[a]	8.5[a]	8.6[a]	7.1[a]	0.3768
Zinc (mg)	12.4[a]	11.8[a]	11.4[a]	12.4[a]	12.9[a]	10.3[a]	0.8231
Density	5.9[a]	6.3[a]	5.7[a]	5.9[a]	6.3[a]	5.0[a]	0.6270
Copper (mg)	1.0[a]	1.2[a]	1.2[a]	1.4[a]	1.3[a]	1.0[a]	0.0705
Density	0.5[b]	0.7[ab]	0.6[ab]	0.7[ab]	0.7[a]	0.6[ab]	0.0157**
Sodium (mg)	3242.3[a]	3754.9[a]	3297.0[a]	2979.4[a]	3296.1[a]	2719.3[a]	0.3762
Density	1533.0[b]	2010.4[a]	1641.4[ab]	1481.4[b]	1678.6[ab]	1415.0[b]	0.0050**
Potassium (mg)	2193.3[b]	2673.7[ab]	2212.7[ab]	2355.1[ab]	2757.3[a]	2351.6[ab]	0.0459*
Density	1093.2[c]	1434.4[ab]	1125.8[bc]	1154.1[bc]	1449.7[a]	1301.2[abc]	0.0001**

* Significant at α=0.05; ** Significant at α=0.01; Means with the same letter superscript within each row are not significantly different.

Macronutrient Distribution Ranges (AMRDs) for adults are 45 to 65% for carbohydrates, 10 to 35% for protein, and 20 – 35% for fat.[31] The type of fat distribution for the sample averaged 10.5 ± 4.1% from saturated fats, 12.3 ± 4.3% from monounsaturated fats, and 7.1 ± 4.0% from polyunsaturated fats. Mean cholesterol intake was 352 ± 111 mg/day. Both saturated fat and cholesterol should be "as low as possible while consuming a nutritionally adequate diet"[31] and both are at levels higher than is suggested to prevent chronic disease, i.e., fewer than 7 - 10% of kcals from saturated fat and less than 300 mg/d of cholesterol. Dietary fiber, the nondigestible carbohydrates and lignin that are intrinsic and intact in plants, intake was 12.2 ± 8.4, just under half of the U.S. Institute of Medicine's recommendation of 26 to 38 grams of total fiber a day.[31]

Sex Differences

The mean energy intake for males (2,307 kcal) was higher (t =-5.6657, p = 0.0001) than for females (1,797 kcal). Men generally had significantly higher intake of macronutrients when expressed as weight but when macronutrients were calculated as nutrient density there were no difference between men and women except for protein and fiber. The men had a higher (t =-2.0003, p = 0.0460) mean percentage of kilocalories from protein (19.0%) than women (17.8%), but when median values were compared this difference did not hold (p = 0.093). Women had higher (p = 0.0001) fiber density than men, 7.3 versus 5.6 g/1,000 kcal, respectively, but both were low.

There were also ethnic differences in the types of fat

Ethnic Differences

Protein as a percent of energy was similar for all ethnic groups (Table 3) but there was a significant difference (F=2.17, p=0.0202) and (F=2.75, p=0.0185) found among the ethnic groups for the mean percentage of energy from carbohydrate and fat, respectively. There were also ethnic differences in the types of fat. The mean percentage of energy for saturated fat for the Chamorros (11.5%) was higher (p = 0.0005) than it was for the Asians (8.6%) and Filipinos (9.5%). There was a significant difference (F=2.80, p=0.0167) for the percentage of energy from monounsaturated fats and the percentage of energy from polyunsaturated fats which was higher for the Filipinos (8.0%) (p=0.0174) than for the Pacific Islanders (5.2%). There was a significant difference (F=3.65, p=0.0031) found among the ethnic groups for dietary fiber as well (Table 3).

Alcohol intake on average was 2.7 ± 14.1 g (Table 2) with few differences by sex or ethnicity. The mixed Asian/Chamorro group had a higher mean percentage of energy (1.3%) from alcohol than the other groups (0.3% to 1.1%) (Table 3). Participants who were 25-50 years of age had mean intake of alcohol (3.7 g) and mean percentage of energy (1.1%) from alcohol that was higher than those aged 24 and under and those aged 51 and older (data not shown).

Micronutrients

There is considerable risk for nutrient deficiency in this sample because there was a large proportion of the sample with intakes below the EAR for the vitamins and minerals (Table 2). While this is likely an overestimate because only one day of dietary data were collected[34] nonetheless, proportions of the sample below the EAR are very large for vitamin A (48% below EAR), vitamin C (56% below EAR), vitamin E (83% below EAR), folate (85% below EAR), and magnesium (74% below EAR).

For those nutrients which do not have an EAR established, such as calcium and potassium, the AI is used for evaluation. Both mean and median intake for calcium and potassium are well below their AI recommendation (Table 2). When mean intakes are below the AI it is technically not possible to make any assumptions about the prevalence of inadequacy.[33,34] However, the proportion of the sample below the Adequate Intake (AI) is exceptionally high for both calcium (92%) and potassium (96%), thus there is cause for concern.

Sodium intake is above the AI, thus inadequacy is unlikely according to the logic described by the U.S. Institute of Medicine. In this sample it is more likely that there is excessive sodium intake as the group mean, 3226 ± 1901 mg/d, is above the Tolerable Upper Intake Levels (UL) which ranges from 2200 – 2300 mg/d for the age and genders in this sample. Furthermore, 65% of the sample exceeded the UL even though the sodium levels reported are an underestimate of actual intake as salt and soy sauce added at the table were not included in the analysis.

Sex Differences

While significant differences existed between males and females in the amount of several vitamins and minerals (thiamin, riboflavin, niacin, Vitamin B_6, folate, magnesium, phosphorous, potassium, iron, and sodium), nutrient averages were not significantly different when compared by nutrient density (data not shown). This implies that the nutrient amounts are related to the difference in energy intake between the men and women. There was no significance difference between men and women by any of the measures for Vitamin B_{12}, vitamin E, vitamin A, or calcium. In the few exceptions that were found, women had higher ($p < .05$) nutrient density than men for beta-carotene, vitamin C, and copper.

Ethnic Differences

For the vitamins and minerals, no differences were observed by ethnicity (Table 3) for thiamin, niacin, Vitamin B_6, B_{12}, vitamin C, vitamin E, vitamin A, iron, magnesium, or phosphorous. There was a significant difference found among the ethnic groups for the mean density for folate (F=3.12, p=0.0090).

For the minerals, some ethnic differences are noted for calcium, potassium, and sodium (Table 3). The mean calcium intake for the Other Pacific Islanders (347.5 mg) and Chamorros (438.4 mg) was lower (F=4.53, p=0.0005) than mean calcium intake for the mixed Asian/Chamorro group (685.6 mg). The Other Single Ethnic group's (mainly Whites) mean potassium intake (2,757.3 mg) was significantly higher (F=2.28, p=0.0459) than for the Chamorro subjects (2,193.3 mg). The same was true (F=7.35, p= 0.0001) for potassium density (1449.7 mg), for the mixed Asian/Chamorro group compared to the Chamorro subjects (1093.2 mg). Using Turkey's multiple comparison test (α=0.05), a statistically significant difference was (F=3.41, p= 0.0050) observed between the Asian and mixed Asian/Chamorro. Mean sodium density was higher for the Asian (2,010.4 mg) than for the Chamorro (1,533.0 mg), Filipino (1,481.4 mg), or the Other Pacific Islander (1,415.0 mg) groups.

The relatively low level of fiber intake is a further nutritional risk factor for chronic disease. Fiber has many healthful functions; it aids in laxation, promotes satiety which may help reduce risk of obesity

Discussion

Overall, the results of this nutrient analysis of diets on Guam show an appropriate intake of energy with energy distribution of carbohydrate, protein and total fat within guidelines established by the U. S. National Academy of Sciences, Institute of Medicine.[31] Nutrients that likely exceed recommendations for good health include saturated fat, cholesterol, and sodium. Nutrients that are at levels that suggest inadequacy include fiber, vitamin A, vitamin C, vitamin E, folate, and magnesium. Calcium and potassium intake may be too low and should be investigated further. This nutrient profile is associated with increased risk for chronic disease.

While energy intake fell within normal ranges for this sample, energy requirements are highly influenced by activity levels. In addition self reports of energy intake are prone to underreporting by as much as 13%.[23] The last reported Behavioral Risk Factor Surveillance System (BRFSS) survey on Guam found the prevalence of overweight, expressed as a Body Mass Index (BMI) of 25 or higher, to be 61%, with higher levels for men, 67.7%, than women, 53.6%.[35] In the same BRFSS report, over a quarter, 27%, of Guamanians reported no leisure time physical activity. This combination of high levels of overweight and low physical activity suggest either underreporting in the current study, or very low energy needs based on sedentary lifestyles. Energy intake above energy expenditure results in obesity which is a risk factor for many of the chronic diseases. While cultural attitudes about large body size[36,37] should be respected it is imprudent to ignore the health effects of obesity. In 2002 on Guam, 42.5% of the population died from disease of the heart, cerebrovascular disease and diabetes.[4]

There is strong evidence suggesting that high intakes of saturated fat and cholesterol, such as those observed in this study, especially for males, increase blood cholesterol concentrations which are a risk factor for coronary heart disease. Although it is difficult to completely eliminate these dietary fats they should be included in the diet at levels "as low as possible" while consuming a diet nutritionally adequate in all required nutrients.[31,38] Approximately one third of adults on Guam reported being told by a health professional their blood cholesterol was high according to the BRFSS.[35] Eating less saturated fat should be a key public health message especially for Chamorros, those of mixed Asian and Chamorro ethnicity, Whites, and the other Pacific Islanders on Guam.

The relatively low level of fiber intake is a further nutritional risk factor for chronic disease. Fiber has many healthful functions; it aids in laxation, promotes satiety which may help reduce risk of obesity, and attenuates blood glucose and cholesterol concentrations which reduce the risk of coronary heart disease. The criterion for adequacy is set to achieve the lowest risk for coronary heart disease. [31,38] Low amounts of fiber in the diet are associated with consumption of refined foods and meats, typical of modern diets. One strategy for increasing fiber intake is to call for a return to traditional diets. For example, heritage retention has been shown to be positively correlated with fiber intake in Hispanic mothers in the United States.[39] The traditional foods of most of the cultural groups on Guam are more fiber rich than many of the processed and refined foods available on the island today.[6,8-15]

Discretionary salt use (i.e., salt added at the table or while cooking) and soy sauce is not included in our nutrient estimate because of issues related to accurate quantification. On average, the natural salt content of food accounts for about 10% of total intake, while approximately 75% is derived from salt added by manufacturers in processed foods. Discretionary salt

use generally provides approximately 5 to 10% of total intake.[40] Thus, at least 65% of the sample probably exceeded the Upper Limit (UL) for sodium. The UL is the highest average daily nutrient intake level likely to pose no risk of adverse health effects for almost all individuals in the general population but the risk for adverse effects increase as intake rises above the UL.[33,34] For sodium the adverse health effects are hypertension, increased risk of cardiovascular disease, and stroke. Potassium blunts the effect of sodium on blood pressure but only 4% of the sample had potassium intake above the level that is considered to be adequate (AI).[32] With this nutrient profile, it is not surprising that according to the BRFSS, 24.5% of Guamanians have been told by a health professional they had high blood pressure.[35]

Alcohol is included mainly to account for the contribution to energy intake, and a complete discussion of alcohol is beyond the scope of this report. Alcohol consumption was higher for men than for women. This gender difference is similar to a finding in the BRFSS that more men, 29%, than women, 6.1%, on Guam binge drink. Binge drinking is defined as having consumed 5 or more drinks at one time on more than one occasion in the last month.[35] Health risks of excessive alcohol consumption include increased risk for high blood pressure, heart disease, stroke, cancer, liver disease, and motor vehicle fatalities.[41]

Vitamin deficiencies are a world wide problem and are known to affect health outcomes

Vitamin deficiencies are a world wide problem and are known to affect health outcomes. The social and economic costs of micronutrient deficiencies are likely to be considerable wherever they are found.[42] In this study, a large proportion of the sample fell below the EAR for vitamin A, vitamin C vitamin E and folate.

The EAR for vitamin A is based on the assumption of adequate liver stores.[17] Vitamin A has a role in maintaining immune function, normal vision, and reproduction; deficiencies result in not only abnormal vision and xerophthalmia but also increased morbidity and mortality.[30] Results of the present study add to the concern about inadequate vitamin A intake in the Pacific region as a major problem.[43]

The EARs for both vitamins C and E are related to their antioxidant roles. Oxidative stress is related to cancer, cardiovascular disease, cataracts, age-related macular degeneration, central neurodegenerative diseases, and diabetes.[29] It has been shown that cigarette smoking increases the need for vitamin C,[29] and the prevalence of smoking on Guam, 31.2%, is higher than any other U.S state or territory.[35] Results of our diet assessment indicate that 56% of the adult population is at risk for vitamin C deficiency, but the actual number at risk may be higher because of the high rates of smoking on the island. The evaluation of the high proportion of the sample that did not meet the EAR for vitamin E should be tempered by the knowledge that estimates of vitamin E are difficult due to a propensity to underreport fat intake which serves as a major carrier for vitamin E.[29] Thus, unlike vitamin C, it is possible that even less than the 83% estimated in our analysis are at risk for deficiency.

The EAR requirement for folate is based on roles in preventing neural tube defects, the inverse relationship with homocysteine (high levels of homocysteine are related to vascular disease and thrombosis), an association with colorectal cancer, and possible links with neuropsychiatric disorders.[28] It is likely that the folate levels reported in this study are an underestimate of current intake because data were obtained before folate fortification of grains was required.

Mineral deficiencies, like vitamins, are prevalent world wide. Iron is a common nutrient deficiency, but does not appear to be as large a problem on Guam as elsewhere,[42] especially compared to magnesium and calcium intake. Magnesium has many metabolic roles and is implicated in heart disease, hypertension, postmenopausal osteoporosis, diabetes, and poor obstetric performance. The EAR for magnesium is based on the assumption that the best current indicator of adequacy is for an individual to maintain total body magnesium over time as opposed to being in negative magnesium balance.[27]

The criterion for adequacy (AI) is set to maintain desirable rates of calcium retention for bone mineral density. There is no EAR established for calcium because of concerns related to the intricacies of accounting for variations in retention and absorption in metabolic studies of calcium, the lack of concordance between observational and experimental data (mean intakes are lower than experimentally derived values), and the lack of longitudinal data that can be used to verify intake and retention with bone-loss and fracture.[27] The mean calcium intake of Guamanians in this present study ranged from only 488 - 521 mg and similarly low intakes of calcium were observed in children[14] and pregnant adolescents on Guam in previous studies.[16] When interpreting the Guamanians' diet to determine the adequacy for calcium, other factors need to be considered, such as whether fish bones are consumed as part of the diet, or what contribution to calcium intake, if any, is made by the powdered limestone used with leaf to wrap the betel nuts consumed by some

residents of Guam. More research is needed to clarify the relationship between low calcium intake and health effects on Guam.

Many investigators note energy and nutrient differences between the sexes[10,17,42] but there were relatively few in our study. Females had a lower energy intake in this study, as well as in other studies but they also have lower requirements and are more likely to underreport energy consumption.[44,45] Men had higher protein intake, but women had adequate levels of protein and men were within recommended amounts. The higher fiber intake and higher nutrient density for carotene, vitamin C and copper by women indicate that the women consume a slightly better diet than men, but improvement is needed for both groups. Given the few ethnic differences in the diet, public health messages can promote consistent recommendations for a healthy diet for all people on Guam. Saturated fat reduction can be stressed for Chamorros, as can sodium reduction for Asians. Following a balanced diet while staying within energy requirements is recommended for both men and women of all ethnic backgrounds on Guam.

Limitations of this study are that only one day of dietary intake was collected resulting in higher variability than would be expected if the data were corrected for usual intake.[33] Under-reporting or over-reporting consumption by participants is an issue in all dietary assessment studies which may especially affect energy intake estimates.[23,44,45] Strengths of this study are that the sample selection methods allow the results to be generalized to the adult population on Guam. In addition, interviewers were local residents and were bilingual. This report provides specific nutrient information that can be used as a baseline for future research and identifies key nutrients for public health intervention programs.

Guam residents would benefit from changes in diet to lower saturated fat, cholesterol, and sodium and increase vitamins, minerals, and fiber

Recommendations

Guam residents would benefit from changes in diet to lower saturated fat, cholesterol, and sodium and increase vitamins, minerals, and fiber. These suggestions are in accordance with Guam's Dietary Guidelines. Education and skill building is seen as an effective community action to improve health on Guam[7] and these efforts should be continued. Yet education is not enough and good diet is not solely an individual responsibility. Issues related to costs, availability, and environment also play a role in food choices thus efforts to improve diet on Guam should be pursued at many levels. Island leaders should develop a national strategy that follows the guidelines promoted in the World Health Organization's *Global Strategy on Diet, Physical Activity and Health*.[46] This strategy encourages the promotion of health and the reduction of chronic disease through healthful diets and physical activity brought about by creating an effective strategy, defining goals, mobilizing social and economic groups, creating a favorable environment, considering international trade agreements, and avoiding unintended negative consequences on vulnerable populations. Sustainable action at the individual, community and national levels can lead to reduced death and disease rates related to unhealthy diet and physical inactivity.

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The path of progress is strewn with the wreck of nations; traces are everywhere to be seen on the hecatombs of inferior races, and victims who found not the narrow way to greater perfection
(Karl Pearson – 1900)