Obesity, bone status and dietary intake of Palauan elderly congregating in a Senior Citizen's Center.

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Abstract

A health survey of obesity and bone density measured by an Achilles Ultrasound bone densitometer (Lunar, USA) and nutritional intake was carried out for 15 male and 30 female Palauan elderly persons congregating in a Senior Citizens' Center.

The subjects had high obesity values with mean BMI of 27.0 in males and 28.9 in females, and with mean body fat % of 22.3 in males and 39.8 in females ($p<0.01$). The females showed a great decline in bone density from 60 to 70 years of age, with mean Stiffness index of 65.0 compared with that of 80.0 for males of the same age group.

The subjects have all undergone a certain acculturation in their dietary habits, influenced by traditional Palauan, East-Asian, and Western food and dietary patterns. While all subjects had high carbohydrate intakes, and males had significantly greater intakes of energy, protein, calcium, phosphorus, iron, vitamin B1 and niacin than females.

To determine the association of nutritional intake with obesity and Stiffness index, principal component analysis was carried out for amounts of intake of each food group. Correlation analysis between the scores of each principal food component and the body fat %, the BMI and the stiffness index was done. The score of the fourth principal component named "greater variety of food intake" was found to have significant positive correlation with body fat %. However, between the nutritional intake and body fat % , only a relationship could be identified. The findings indicate a need develop appropriate nutrition education and, particularly to address the problem of obesity. (PHD, 2005 Vol 12 No 1 Pages 22 - 32)

Introduction

A high prevalence of elevated body mass index (BMI) values and a change to Westernized dietary pattern due to rapid development and modernization of lifestyle have been reported by population studies of Micronesia [1-5]. Most of those studies evaluated adults of other Micronesia areas. There have been few studies on the health status of Palauan elderly. Palauan elderly have a unique historical and cultural background. It is a mixture of traditional, Japanese , and Western influences. In 1996, the life expectancy at birth of Palauans was 69 years for males and 73 years for females. Life expectancy is expected to increase as the society ages [6].

Since 1992, one of our co-researchers has been evaluating the health of Palauan elderly citizens congregating in a Senior Citizens' Center at Koror, the capital of the Republic of Palau. When he measured obesity based on body mass index (BMI) and body fat percentage (%) of twenty of those Palauan elderly citizens in 1995, eighty to ninety percent were categorized as obese [7]. Based upon high prevalence of obesity among this population, we conducted a further investigation in this group to clarify the association between obesity and nutritional intake. With a view to preventing osteoporosis with aging, we also measured bone density using an Achilles ultrasound densitometer (Lunar Corporation, Madison, WI, U.S.A.). We also examined the relationship between bone density and nutritional intake in order to develop long-term objectives for improving the health or quality of life of Palauan elderly.

Methods

Background

The Republic of Palau ,located in Micronesia, consists of approximately 340 small islands situated 7 degrees north and 135 degrees east in the western part of the Pacific Ocean. Palau is 722 mi southwest of Guam and 500 mi southeast of the Philippines. Historically, Palau had been occupied by Spain (1885-1889), Germany (1899-1914), and Japan (1914-1944). After World War II, it was placed under the trusteeship of the United States until it became independent in 1994 as the Republic of Palau [8]. The population in 1995 was 17,225, according to the official census taken in 1995. The top five leading causes of death in 1994 were injury, cancer, cardiovascular disease, hypertension/stroke and respiratory diseases [9].

This survey was conducted on Palauan citizens aged fifty-five and older who had been congregating at the Senior Citizens' Center. This survey was administered by the Agency for Aging in Koror, the capital of the Republic of Palau during March 1996. This Senior Citizens' Center was funded by the United States and provides many services under Title III and Title V programs. The services include provision of meals, an opportunity to meet old friends and make new ones, and participation in activities such as watching TV, choir singing, hand-made folk crafts, and building canoes. The Center also exists to inform and refer citizens to other social service agencies, to provide a venue for citizens to sell their own crafts and produce, and to enable them to participate in educational programs [10]. About 100 eligible Palauans are brought to this center by a government bus around ten o'clock in the morning. They eat the provided lunch, participate in activities, and return home around two o'clock in the afternoon on most weekdays.

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Subjects and methods

Forty-five subjects (15 males, 30 females) participated in this study as shown at Table 1. The average age of participants was 66.1 ± 9.5 years for males and 69.4 ± 8.8 years for females. Each participant was subjected to (i)a physical examination that included anthropometry (height and weight), body fat percentage and bone density, (ii) a dietary survey, (iii) social and health-related questionnaires, and (iv) measurement of the subjects' capacity for physical activities in daily living. This paper reports the results of (i) and (ii). One of our co-researchers is preparing a paper about the results of (iii) and (iv).

Body fat % was measured by the bioelectric impedance analysis method (BIA)using a body fat analyzer [11-13]. As indicators for obesity, body mass index (BMI) [(weight in kg)/(height in meters)^2], and body fat % were considered. BMI states three categories of obesity for males and females, as per WHO's definition: obesity class I: a BMI of equal to or greater than (>=) 25 and that of less than (<) 30, obesity class II: BMI of equal to or greater than (>=) 30 and that of less than (<) 40, and obesity class III: BMI of equal to or greater than (>) 40. Body fat % , based on standard formulas applied to Japanese population, states a percentage of equal to or greater than (>=) 30 for males and (>=) 25 for females [11,14].

Ultrasound densitometry has been suggested as an alternative method of assessing bone density. In theory, it measures the physical properties of bone including structure, elasticity, and density [15, 16]. The speed of sound (SOS) and broadband ultrasound attenuation (BUA) values have clinical significance because they correlate highly with bone mineral density (BMD)(r~0.9) [17-20]. Results on the heel using the Achilles bone densitometer (Luna Corporation, Madison, WI, USA) have been shown to correlate highly with BMD of the heel [16]. The Achilles system combines SOS and BUA values to express the ultrasound results in a new clinical index called Stiffness. Stiffness provides better effective precision than either SOS or BUA, improves the correlation with BMD, maximizes diagnostic sensitivity, and provides clinicians with ease of interpretation. Thus, Stiffness indicates the subject's bone density by using an Achilles ultrasound bone densitometer.

The protocol for measuring Stiffness was as follows. An alcohol swab was used to scrub both sides of the heel before placing it in the waterbath. The foot was fixed in the proper position and placed in a waterbath (37 °C) for about 7 to 10 minutes. The ultrasound signal was sent from a fixed transducer through the waterbath with the heel placed in it. The signal was received by a second transducer located on the opposite side

Table 1. Study population

Age group	Total	Males		Females	
(years)	(n)	(n)	(%)	(n)	(%)
< 60	5	3	20	2	6.7
60-69	24	7	46.7	17	56.7
70-79	11	4	26.7	7	23.3
80 +	5	1	6.7	4	13.3
Total	45	15		30	

of the heel, and SOS and BUA were measured through the trabecular region of the os calcis. The formula for Stiffness is :
Stiffness = 0.67 BUA + 0.28 SOS-420

This index differs from biomechanical term stiffness used to describe the slope of bone strength with increasing load [16,21]. When Stiffness, SOS and BUA were recorded, the % Young Adult value (or T-score; the value comparing a subject's Stiffness value with the expected values for a 20-year-old subject of the same sex and nationality) and the % Aged-Matched value (or Z-score; the value comparing the subject's Stiffness value with the expected Stiffness values for a reference Japanese group of the same age and sex) were also calculated [21, 22]. A reduction of T score of 2 standard deviation (SD) is a commonly used diagnostic criterion for osteopenia and underlines the concept of a "fracture threshold" [23], and a Z score, a value for bone mineral density, more than 1 S.D. below the young adult mean but less than 2.5 S.D. below this value, is considered as 'osteopenia (low bone mass)', which corresponds to the WHO general diagnostic categories of 'osteoporosis' [24]. The highest left or right stiffness value was used for data analysis.

The dietary survey was carried out by (i) 24-hour recall, and (ii) a semi-quantitative food frequency questionnaire consisting of 214 kinds of East Asian, traditional Palauan and, Western foods. The semi-quantitative food frequency questionnaire was adapted and modified from the U.S.A. HANES III)[25], and it was suitably modified again in consultation with Palauan staff members. Nutrient intake was calculated by several food composition books from Japan, U.S.A. and East-Asia [26-28]. Each person was interviewed showing with a visual food portion book, which visually represents one portion size for each type of food, in conjunction with a semi-quantitative food frequency questionnaire [29]. Trained Palauan nurses and Japanese staff members (sociologist, physical educator and nutritionist) administered the research protocol.

Data Analysis

Groups were compared statistically using the Welch's t-test with two-sided statistical testing. The Chi-square test was used for testing statistical significance between proportions. In order to identify relationships between nutritional intake and BMI, body fat % values ,and Stiffness index, principal component analysis and correlation analysis were done by using a statistical package [30]. First, principal component analysis was used to characterize the relationships among subjects' intake amounts of each food group per week. The principal components were computed as the standardized linear combination of the explanatory variables in the order of their relative contribution, which corresponded to the eigenvalue. After interpreting the relationships among the intake amounts of each food group by the principal component analysis, correlation analysis was conducted between principal component scores and BMI, body fat %, and Stiffness in order to identify the relationships.

Results

1. Socio-economic characteristics

All participants were born in Palau, of Palauan parents. More than 50% of subjects spoke Japanese and English as well as Palauan, and the majority had learned Japanese for three to five years at primary school. More than 80% of subjects had already retired from formal employment. Half had spouses, and more than 50% lived with their children's families in the same house

Table 2. Body mass index (BMI) and body fat % by sex

	Males			Females		
	Total	< 70 yrs.	>=70 yrs.	Total	< 70 yrs.	>=70 yrs.
	(n=15)	(n=10)	(n=5)	(n=30)	(n=19)	(n=11)
BMI(mean ± s.d.)	27.0±3.8	26.9±4.3	27.1±2.7	28.9±5.6	30.6±5.5	26.0±4.6
Obesity class I (%)*	60.0	60.0	60.0	30.0	21.1	45.5
Obesity class II(%)*	20.0	20.0	20.0	33.3	47.4	9.1
Obesity class III(%)*	0.0	0.0	0.0	6.7	10.5	0.0
Body fat %	22.3±7.4	24.3±8.0	18.1±3.8	39.8±9.3	42.0±8.3	35.9±10.0
Obesity (%)b	26.7	40.0	0.0	86.7	94.7	72.7

* p<0.05 ; ** p<0.01
* The percentage of obesity class I(25<=BMI<30), obesity class II(30<=BMI<40) and obesity class III(BMI>=40).
b The percentage of obesity(>=25% in males and >=30% in females) by body fat % criteria.

although in separate rooms. The average number of family members was 5.9 and the average number of children was 5.9.

2. Obesity and bone status characteristics

As shown in Table 2, male subjects had a BMI of 27.0 ± 3.8 (mean ± s.d.) and female subjects had a BMI of 28.9 ± 5.6. Females younger than seventy years were significantly fatter than those equal to or older than seventy ($p<0.05$). Based on BMI criteria, 80 % of males and 70% of females were categorized as obese. In obesity class II, the percentage of younger females age group (younger than 70 years) was higher than the percentage in the older group (more than 70 years). Whereas, in obesity class I, the older

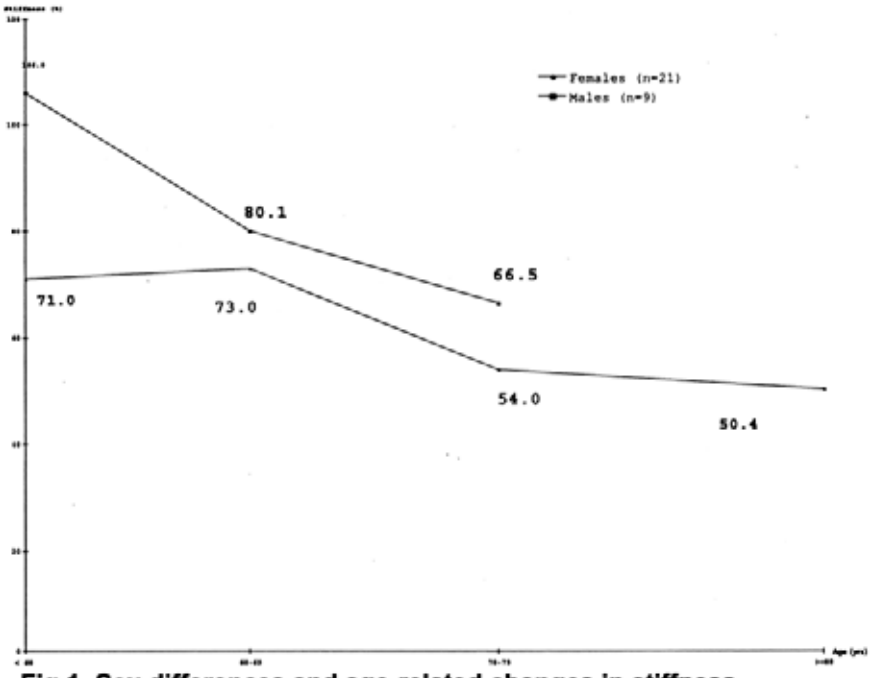

Fig 1. Sex differences and age-related changes in stiffness

Table 3. Age-related changes in SOS, BUA, and Stiffness by sex

	SOS (m/s)	BUA (dB/MHz)	Stiffness (%)
Males(n=9)			
< 60 yrs.(n=1)	1575±0	128±0	106.0±0.0
60-69 yrs.(n=6)	1517±39	113±15	80.1±20.6
70-79 yrs.(n=2)	1487±0	105±0	66.5±0.0
>=80 yrs.(n=0)	NA*	NA*	NA*
Total	1514±41	113±14	80.0±20.5
Females(n=21)			
< 60 yrs.(n=2)	1502±0	106±0	71.0±0.0
60-69 yrs.(n=14)	1505±17	107±6	73.0±7.9
70-79 yrs.(n=6)	1470±12	94±6	54.0±7.3
>=80 yrs.(n=4)	1465±17	90±8	50.4±9.9
Total	1491±24	101±9	65.0±12.5
NA*: Non applicable			

Fruits	32	8.3	345.1	Banana (86.5)	Papaya (42.4)	Coconut (31.1)
Fish /Shellfish	12	3.5	178.9	Sea fish (116.3)	Canned tuna (18.1)	Canned sardine (13.5)
Meat	11	2.9	82.4	Chicken (23.6)	Corned beef (15.3)	Ham (10.3)
Eggs	1	0.8	23.9	Egg (26.2)		
Bean /Bean products	7	3.1	150.1	Miso soup (52.7)	Lentils (31.1)	Green beans (23.4)
Milk /Milk products	8	1.4	62.5	Whole milk (21.8)	Cheese (4.5)	Low fat milk (2.9)
Fats /Oil	14	3.2	153.7	Vegetable oil (20.6)	Coconut oil (18.7)	Peanut butter (14.0)
Green /Colored vegetables	9	3.6	193.7	Water convolvulus (56.8)	Carrot (32.6)	Broccoli (25.8)
Yellow vegetables	16	5.6	287.2	Onion (90.6)	Cabbage (45.9)	Cucumber (45.3)
Desserts /Sweets	17	4.2	79.3	Ice cream (16.0)	Doughnuts (13.6)	Cookies (8.8)
Beverages	14	2.7	183.8	Coffee (63.1)	Mineral water (46.7)	Chocolate milk (22.3)
Seasoning	14	2.6	190.7	Salt (58.4)	Soy sauce (54.3)	Jam (23.4)
Total	179	50.2	2433.6	White rice (128.0)	Sea fish (116.3)	Taro (95.9)

group showed a percentage much higher than that of the younger group. In reference to obese males, the percentage of obesity classified as obesity class I was higher than that of obesity class II, regardless of age. The body fat percentages (mean ± s.d.) were 22.3 ± 7.4 for males and 39.8±9.3 for females. Females were significantly fatter than males ($p<0.01$). The percentage of obese male subjects based on body fat % was 26.7, which was significantly lower than that based on BMI which was 80.0 (obesity class I percentage plus obesity class II percentage) ($p<0.01$).

Bone density, SOS, BUA, and Stiffness values decreased with age as shown in Table 3, Fig. 1, particularly from 60 years to 70 years of age for females. Males had greater Stiffness than females, however, the sample size of males was small. Females less than 70 years old (n=18) had a T score of -1.94 (mean) and Z score of -0.02 (mean), and those aged 70 years and over(n=7), had a T score of -3.92 and Z score of -1.11.

3. Daily nutrient intake

Food intake frequency by food group is shown in Table 4. The most popular foods within each food group were white rice, taro, banana, sea fish, chicken, egg, miso soup, whole milk, vegetable oil, water convolvulus (swamp cabbage or "kangkum" in the Palauan language), onion, ice cream, coffee, and salt. With regards to the variety of foods chosen by individuals, fruits had the highest number of selection with 8.3 kinds per person. Yellow vegetables were second, with 5.6 kinds per person. Of the total 179 different foods that were consumed by the participants within the 100-day period of the study, the top 20 most consumed foods, as indicated by reported number of times they were eaten during the periods, were as follows: white rice(128), sea-fish(116.3), taro(95.9), onion(90.6), banana(86.5), coffee(63.1), bread (62.8), salt(58.4), "kangkum"(56.8), soy sauce(54.3), mineral water(46.7), cabbage (45.9), sweet potatoes(46.9), cucumber(45.3), papaya (42.4), tapioca (36.1), whole milk (21.8), carrot (32.6) and lentil beans at (31.1),each. Of the top five foods, three (fish, taro and banana) are traditional foods, the other two(rice and onion) are imported.

Vit. B1	mg	2.63±1.93*	1.38±0.60*
Vit. B2	mg	2.58±2.20	1.57±0.97
Vit. C	mg	393±271	246±143
Niacin	mg	36.8±27.6*	20.8±10.8*
* p<0.05			

Table 6. Eigenvalues and eigenvectors of the correlation matrix of the intake of food amounts per week by food group for females (n=21).

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
1. Milk and milk products	0.127	-0.008	-0.114	*0.360*	0.248	0.235
2. Tofu, fermented soy bean products	0.229	-0.197	0.063	0.283	-0.009	*0.323*
3. Bean & bean products	*0.405*	0.022	-0.045	0.085	-0.225	0.059
4. Processed meat products	0.111	0.090	0.174	-0.242	*0.456*	-0.100
5. Meats	0.210	0.118	0.198	-0.287	0.123	-0.240
6. Canned fish	-0.050	*-0.377*	*0.314*	0.064	-0.052	-0.065
7. Fish and seafood	0.187	0.241	*0.315*	0.147	-0.200	-0.075
8. Eggs	0.275	-0.075	-0.082	0.197	0.133	0.239
9. Tropical fruits such as guava, papaya, banana, plantains, pineapple, mango, soursap, coconut et.al.	-0.224	-0.016	0.083	0.116	*-0.384*	-0.043
10. Fruits excluded tropical fruits	*0.338*	0.146	-0.131	0.171	0.094	-0.045
11. Yams,taros and tapioca	*0.341*	-0.020	-0.079	0.137	-0.203	*-0.344*
12. White, sweet and other potatoes	0.046	*-0.359*	0.105	0.245	0.048	0.082
13. Rice, glutinous rice, rice noodle, udon and instant noodle	-0.112	*0.372*	0.056	0.000	-0.154	0.145
14. Bread, cereals, spaghetti and baked goods	0.071	-0.036	0.278	-0.157	*-0.311*	*0.306*
15. Vegetable oil and fat	0.007	-0.104	*0.496*	0.019	0.263	-0.072
16. Animal oil and fat	-0.158	0.222	0.251	*0.397*	0.069	-0.022
17. Yellow vegetables	0.029	0.202	0.276	-0.163	-0.196	*0.438*
18. Green vegetables	-0.071	-0.228	0.234	0.091	-0.166	-0.274
19. Carbonated beverages	0.141	*0.388*	0.117	0.083	0.203	-0.022
20. Asian type snacks such as rice, crackers, rice cake and sweet bean bread	*0.323*	0.119	-0.054	-0.053	*-0.314*	-0.275
21. Western type snacks such as cookies, doughnut et.al.	0.231	-0.114	*0.324*	0.030	0.074	-0.102
22. Sugar and jam	-0.205	0.055	-0.047	*0.373*	-0.004	*-0.315*
23. Salt and salty seasoning	-0.217	*0.329*	0.152	0.299	0.025	-0.025
Eigenvalue	3.886	3.449	2.697	2.346	2.281	1.727
Proportion(%)	16.9	15	11.7	10.2	9.9	7.5
Cumulative proportion(%)	16.9	31.9	43.6	53.8	63.7	71.2

The energy and nutrient intake by sex is shown in Table 5. Overall, the intakes for males were significantly greater than that of females for total energy, protein, calcium, phosphorus, iron, vitamin B1, and niacin ($p<0.05$). Females, however, tended to derive a greater percentage of their total energy from carbohydrates.

Table 7. Correlation coefficients between the score of each principal component obtained the intakes of food amounts in 23 food groups and BMI, body fat % and stiffness values for females (n=21).

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
BMI[a)]	-0.028	0.265	0.313	0.325	-0.015	-0.044
Body fat %	-0.025	0.409	0.102	0.445*	-0.062	-0.089
Stiffness	-0.083	0.043	0.265	-0.194	-0.067	-0.163

a) BMI;Body Mass Index, * $p<0.05$

4. Associations of nutritional intake with obesity and bone mineral density.

We analyzed only the female data because females seemed to have more risk factors than males, i.e. higher body fat % and lower Stiffness index.

As shown in Table 6, by using the average of intake amounts per week of 23 food groups, 6 principal components (factors) which had an eigenvalue above 1 were extracted, and the cumulative contribution ratio of the 6 components was determined to be 71.2 %.

Correlation coefficients equal to and greater than 0.3 are marked by a single line and those equals to and less than -0.3 by double lines. The component loadings of the first principal component were positive for 'canned bean', 'fruits except tropical fruits', 'Asian type snacks' and 'taro, yam and tapioca', which are rich in dietary fiber. Thus, factor 1 was characterized as "the pattern of intakes of dietary fiber rich foods". The component loadings of the second principal component were negative for 'canned fish', 'white and sweet potatoes' and positive for 'rice, glutinous rice and noodle', 'carbonated beverages', and 'sugar and jam', which are high-calorie foods. Thus, factor 2 was characterized as negative for "the pattern of intakes of protein source food" and as positive for "the pattern of the intakes of energy source food". The component loadings of the third principal component were positive for 'canned fish', 'fish and seafood', 'vegetable oil' and 'Western type snacks'. So, factor 3 was characterized as positive for "the pattern of intakes of fish and other energy-source foods". Factor 4 was characterized as negative for "less variety of food intake" and positive for "greater variety of food intake" because the component loadings of factor 4 were positive rather than negative for "greater variety of foods".

Correlation analysis was performed between the scores of each principal component and BMI, body fat %, and Stiffness values as shown in Table 7. Regarding the correlation coefficients between the scores of each principal component, the only significant positive correlation coefficient noted was between the fourth principal component (food variety) and body fat % values. No significant correlation coefficient was noted between the scores of each principal component and Stiffness values.

Discussion

In our study, it is possible to see that a greater percentage of males were obese by BMI indicator rather than by body fat % indicator. A possible explanation for this could be to assume that excessive body weight of males was mainly derived from muscle tissue rather than from fat tissue due to the fact that males tend to be engaged in physical activities such as fishing and farming. Whereas, a greater percentage of females were obese when both indicators (BMI and body fat %) were combined.

In our study, it is possible to see that a greater percentage of males were obese by BMI indicator rather than by body fat % indicator.

It is uncertain whether obesity among the subjects is related or not to their weight at younger ages because the body weight histories were unknown. However, in comparison to body weight at the age of twenty, a high proportion of females (8 out of 30 females) reported a gain in body weight of more than 10 kg , while a high proportion of males (5 out of 15 males) reported constant or even loss in body weight. Thus, it seems that females gradually gained body weight with aging more than males did. In reference to body fat %, it declined with aging for both sex, Regarding body fat % of females, in all age groups were categorized as obese. As can be observed in Table 2., females subjects younger than seventy years old were fatter than those of subjects equal to or greater than seventy years of age. According to the mean of BMI by sex and age groups, females younger than seventy years old were significantly fatter than those of equal to or greater than seventy years old. Whereas,

a significant difference regarding age was not seen in males. Out of the present study, it is possible to suggest that health education for obesity needs to be developed and implemented in this elderly population, in particular, for females younger than 70 years. The high prevalence of obesity in our study is similar to other population studies in Micronesia [1-2, 31].

Data showed males to have a gradual decline in Stiffness with age and, in general, females had less Stiffness than males in each age group. The largest decrease in Stiffness in the females is seen for those between 60 and 70 years of age. It is difficult to draw a clear conclusion on whether the bone density of our subjects indicates a high rate of osteoporosis or not because there are no reference values of Stiffness in the normal Micronesian population and because of the small size of the study population. However, it may be useful to compare the Stiffness of Micronesian subjects with that of normal Japanese as a reference population in order to calculate the T score and Z score. The Stiffness of the normal Japanese female population has been reported to be lower than that of normal Caucasian American women [32]. Thus, this study showed that females subjects, particularly, those older than 70 years, may be susceptible to osteopenia because the average T score of such females (n=8) was -3.92 and the average Z score was -1.11. Regarding the correlation coefficients between Stiffness values and body weight, and BMI for females, it was consistently shown that weight gain is associated with higher bone mass. There were statistically significant positive correlations between Stiffness values and body weight($r=0.55767$, $p<0.05$) and BMI ($r=0.49415$, $p<0.05$), whereas, stiffness declined with age along with the decline of body weight and BMI [33].

The supplanting of the traditional diet by the intake pattern of "East-Asian/ Western" food groups such as rice and bread, is at least partly due to participants planting less taro and tapioca in their gardens

With respect to food frequency patterns and nutrient intakes, participants were consuming a diet rich in carbohydrates due to the intake of high in starch foods such as white rice and taro. Traditional Palauan foods, East-Asian foods and Western foods were frequently eaten and were commonly integrated into the diet of the Palauan elderly. This was evident by the variety of foods in each food group. As a staple food, taro, which is part of the traditional Palauan diet, had the highest frequency in the potato and starch group. However, rice had even a higher frequency than taro. The supplanting of the traditional diet by the intake pattern of "East-Asian/ Western" food groups such as rice and bread, is at least partly due to participants planting less taro and tapioca in their gardens, as it is difficult for the elderly to dig out taro and tapioca without any assistance. Additionally, availability of taro and tapioca in the markets depends on the weather and farm output. Finally, increased demands for local foods have driven their prices up. Therefore, rice is more frequently eaten than taro due to its greater availability in the stores. The higher intake of rice could also be the result of the influence of Japanese eating habits that became established when the Republic of Palau was occupied by Japan for thirty years before World War II. Finally, preparation of rice for meals is both fast and convenient.

As the main protein source, sea-fish showed the highest intake. Sea-fish is typically eaten raw, in soup, or baked. Eggs, chicken, milk and milk products, and processed canned foods such as tuna, sardine, corned beef, and spam also had high intakes, while pork and beef intakes were lower. The consumption of processed canned foods is expected to increase as imports of these Western foods have increased, making them readily available, more convenient and cheaper than fresh fish. Also, the fish market is difficult to reach for elderly people because there is no organized transportation system.

The participants ate a variety of vegetables and fruits. The most frequently used vegetables and fruit were grown locally, in home gardens and at local farms. For example, onions, water convolvulus, bananas, papayas, and coconuts are commonly grown year round.

For desserts and sweets, ice cream, doughnuts, and popcorn were ranked as the top three most frequently eaten foods, while coffee, mineral water, and chocolate milk were the top three beverages. These all reflect the influence of Western dietary habits and the wide availability of these foods in the markets.

In fact, all Palauan elderly in our study indicated that they frequently eat indigenous Palauan, East-Asian, and Western foods, particularly, taro and rice. Fresh fish, eggs and chicken were among the traditional Palauan and Western protein-source foods while water convolvulus(swamp cabbage or "kangkum"), bananas and papayas comprised the main locally grown traditional Palauan vegetables and fruits. Coffee, ice cream and doughnuts were the main beverages and snacks consumed.

Regarding energy and nutrient intake by sex , most of energy was derived from carbohydrates: 60.5% in males and 65.5% in females. As shown in Table 4., rice, taro, banana, and white bread, all carbohydrate-rich foods, were consumed in large quantities. In comparison to the recommended energy intake of macronutrient in Japan

and in North America, the percentage of energy derived from carbohydrate was higher than the recommended amount of 50-55 % in USA and 55-60% in Japan. The percentages of energy derived from protein and fat were within appropriate ranges. The higher percentage of energy derived from carbohydrate was due to the consumption of large quantities of carbohydrate-rich foods , rather than to the percentage of energy derived from fat. The average carbohydrate intake of Japanese is 273 gram per day, while the elderly in this study population tended to eat large quantities of carbohydrate-rich foods. Traditional staple food is taro and yam in Palau. However, the combination of the influence of indigenous Palauan eating habits with that of multicultural eating habits such as having rice and bread could have induced Palauans to an increase in the consumption of large quantities of carbohydrate-rich foods. According to data collected along 24-hour food record, most of subjects ate more than one kind of staple food in each meal. Hence, mixing original Palauan staple foods(taro and yam) with cultural staple foods(rice and bread) together with the intake of more than one kind of staple food in each meal could imply over consumption of carbohydrates, resulting in the high obesity rate of this study population. It could be advisable eating Palauan staple foods rich in dietary fiber and selecting only one staple food in each meal in order to prevent this study population from over-eating large quantities of carbohydrates.

Palauans basically consumed a relatively low fat, high carbohydrate diet with increasing intakes of Western foods such as sugar and cola in the 1970's

Males tended to have greater nutrient intake than females. In particular, males had significantly greater nutrient intake of energy, protein, calcium, phosphorus, iron, vitamin B1, and niacin that was due to the frequent eating of protein rich foods such as meat and canned foods.

There have been several studies on elderly populations in Micronesia. In the 1970's, Hankin et al.[34] carried out a dietary survey on Palauans aged over 20 years, and in the study population, 18 elderly subjects (11 males, 7 females) over years of age after sixty were included. Those elderly subjects had diets with a high percentage of energy derived from carbohydrate: 66.8% for males and 61.9% for females. The percentage of energy derived from protein and fat was appropriate for both sexes. The dietary intake pattern of Hankin's study [34] indicated meat, poultry and dairy products were not readily available, whereas taro, cassava and lean fish were plentiful. Intakes of sugar, cola beverages, and salt were high. Consequently, Palauans basically consumed a relatively low fat, high carbohydrate diet with increasing intakes of Western foods such as sugar and cola in the 1970's. Other population studies of Palauans by Hankin et al., Reed et al., and Labarthe et al.[35-37] only reported about younger adults. All those studies also showed high intake of carbohydrate rich foods; and the percentage of energy derived from carbohydrate ranged from 60.8 to 65%, while that from protein ranged from 15 to 17.7%, and that from fat ranged from 19.1 to 22%.

Data from elderly participants were not available. In the same studies, energy intake ranged from 1651 kcal to 2520 kcal per day for both sexes [34-37]. In nutrition studies in other areas of Micronesia in the 1980's and 1990's, the distribution of total calories by macronutrient in populations older than 20 years was as follows: the percentage of energy derived from protein ranged from 14 to 18%, from fat 25 to 35%, and from carbohydrate 46 to 66% [36, 38-40]. In comparison with other studies in Palau and other areas of Micronesia in the 1970's, 1980's, and 1990's, data shows that the elderly in our study population had a higher total daily intake of fat than those in the previous studies while the percentage contribution of carbohydrate rich foods to the total energy intake tended to remain the same.

To determine how the pattern of food intake was associated with obesity and Stiffness, principal component analysis and correlation analysis were carried out. Only the data for females were analyzed by these methods because the study population of males was too small for such methods, and females seemed to have more risk factors such as high prevalence rate of obesity and low Stiffness values. From the results, only the relationship between food intake pattern and body fat % could be identified statistically for females. Correlation analysis between scores of the fourth principal component (food variety) and body fat % showed a statistically significant positive correlation shown at Table 7. In the principal component analysis, it also seems that Factor 4 was associated with a high intake of dairy products, animal oil and fat and sugar and jam, being this factor able to explain the increase of obesity.

The component loadings of Factor 4 were positive rather than negative for a greater variety of foods. In Factor 4 shown in Table 6., correlation coefficients of equal to and greater than 0.1 and less than 0.3 were eight component loadings, and those of greater than zero and less than 0.1 were six component loadings. Hence, those subjects who had a high intake of dairy products, animal oil and fat, and sugar and jam also tended to have an over-intake of other foods such as shown in correlation coefficients equal to and greater than 0.1, and this combination could be related to the increase of obesity risk. Even

so, according to the correlation coefficients between obesity indexes and nutrition intake for females, high positive correlation coefficients were found between the intake of animal oil and fat and BMI ($r=0.565$, $p<0.01$) and body fat % ($r=0.577$, $P<0.01$) and between the intake of sugar and jam and BMI ($r=0.584$, $p<0.01$) and body fat %($r=0.678$, $p<0.01$). This was also reflected in the differences in nutrient intakes between obese and non-obese groups. The obese female group based on both BMI and body fat % had a tendency towards over-intake of energy and all nutrients, particularly fat.

Regarding the relationship between nutritional intake and Stiffness in females, our study showed low correlation coefficients between the scores of each principal component and Stiffness as given in Table 6.

Based upon the results of longevity studies of Palauan elderly , we can suggest the kind of health education that would be needed for Palauan elderly congregating in this Senior Citizens' Center. The diet of very old Palauans in longevity studies suggests that they eat basic foods of the traditional diet such as taro and tapioca (which are high carbohydrate and fiber), fish, little canned and processed foods, and much less salt, sugar, coffee and tea.

The lifestyles of very old Palauans also included little consumption of alcohol and tabacco, involvement in useful social roles and active participation in social and cultural networks and activities a lot of which also physical in nature [41-42]. Based on the longevity factors in the diet of very old Palauans in the previous studies, our study suggests that a nutrition education targeting the elderly population addressing such issues as selection of healthy food, preparation of balanced meals, obesity, and others, should be developed, implemented and evaluated as a strategy to improve their quality of life. It should be noted that the elderly in the Senior Citizen Center that where the study took place enjoyed recreational activities such as dancing, singing, and basket weaving and making other traditional arts and crafts. All of these could contribute to prevention of obesity. Additional activities that the elderly can do and enjoy such as stretching to music, simple aerobic exercises could be considered towards obesity reduction. While our study indicates that Palauan continue to consume their traditional foods, it also showed that consumption of foods high in salt and fat contents such as canned fish, spam, ham and foods high in sugar content is increasing. This suggests that most Palauan elderly's eating habits have been influenced by the Westernized dietary patterns, perhaps exerted by the young generation. This makes it imperative that any nutrition education should include and command cooperation by all member of the family.

In conclusion, our study of the Palauan elderly people at the Senior Citizen Center in Koror showed that obesity is a common health risk among them, the females more than the males. Based on the dietary assessment of the subjects, the study indicates that a nutrition education, targeting on the elderly population and addressing such issues as nutritional contents of foods, food selection, balanced meal preparation and especially obesity as a health risk factor would contributed to improvement of quality of life for them. In order to ensure the effectiveness of such a health education nutrition program for the elderly, three main strategy areas should be addressed: recruitment and involvement family and social support (manpower); use of media and other communication network (community base); and compulsory food and nutrition polices which include the processes of assessment and planning, policy development and documentation, implementation, surveillance, monitoring and evaluation (government and community base) [43-44].

Based on the longevity factors in the diet of very old Palauans in the previous studies, our study suggests that a nutrition education targeting the elderly population addressing such issues as selection of healthy food, preparation of balanced meals, obesity, and others, should be developed

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While our study indicates that Palauan continue to consume their traditional foods, it also showed that consumption of foods high in salt and fat contents such as canned fish, spam, ham and foods high in sugar content is increasing

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In conclusion, our study of the Palauan elderly people at the Senior Citizen Center in Koror showed that obesity is a common health risk among them, the females more than the males.

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Do not fear going forward slowly. Fear only to stand still
(Chinese Wisdom)