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Nutritional Assessment of the Elderly of San Pedro Ayampuc, Guatemala: Evaluation of Anthropometry, Biochemistry, and Helminthic Infection

Author
King, Jane E

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Nutritional Assessment of the Elderly of San Pedro Ayampuc, Guatemala:
Evaluation of Anthropometry, Biochemistry, and Helminthic Infection

By

Jane Elizabeth King

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THESIS

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Doris Howes Calloway ....

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TABLE OF CONTENTS

INTRODUCTION

In the realm of scientific research, as well as in many other arenas, the elderly are a population which has been too long overlooked. Each year, elderly folk comprise an increasingly large number and proportion of our population, and yet we remain relatively ignorant as to their basic life situations - not to mention their needs and wants.

In the developing world, more so than in industrialized countries such as the U.S. or those that exist is western Europe, emphasis is consistently placed on the percentage of the population under fifteen years of age. Investigators seem to operate on the widely held belief that the elderly populations of the tropical, pre-industrialized nations are small and relatively unimportant. However, these populations are growing rapidly, at a much faster rate than in the aforementioned industrialized nations. This growth rate will allow even less time for adaptation and adjustment of infrastructure to meet the needs of the burgeoning elderly population.

In 1988, it was reported that 4.4% of the population of Latin America was 65 or older (22). The World Health Organization predicts that from 1950 to 2025, life expectancy in Latin American and the Caribbean will have increased by slightly more than 20 years, from 51.2 years to

71.8 years. By 2025, an estimated 10.8% of the people of the region will be over 60 years of age (66). Thus, both in absolute number and as a percentage of the population of the developing countries in the Western Hemisphere, the elderly are increasing.

In an effort to address these changes, the Agency for International Development (AID) has announced three immediate priorities on its global agenda for aging: "(1) the development of data on aging in developing countries in cooperation with those countries; (2) the development of initiatives which improve the quality of life of the aging; (3) the creation of productive opportunities for the aging that will enable them to be providers as well as recipients of development programs" (23). Scientific research may help to advance all three of these goals.

The risk factors for nutritional deficiency in the elderly are myriad, ranging from psychosocial to physiologic and pathologic changes. They include depression, isolation, cognitive impairment, decreased physical activity, idiosyncratic food preferences, dental changes, decreased taste and smell, decreased appetite, alcoholism, drug-nutrient interactions, and recurrent infections, to name just a few (31).

However, nutritional assessment of the aged is a relatively recent undertaking, particularly in the developing world. Even in analyses of the elderly in industrialized countries, there are biases in knowledge based on extrapolation of data from younger persons, or because the great majority of data is derived from samples in nursing homes, due to ease of access.

There are many ways to assess nutritional status, foremost among them the use of anthropometric and biochemical indices. Body size and composition may reflect the many interactions between and among genetic factors, physical activity levels, nutrient intakes and disease states (47). In this context, comparative nutritional evaluation of elderly groups from different socioeconomic conditions and geographic environments, with distinct life-long dietary patterns and activity levels, might provide insights concerning any protective or harmful effects of life-long dietary patterns on nutritional and health status in the later years.

However, there may also be pitfalls in attempting comparison of population groups whose environments are so radically different from one another. For example, in a well-nourished population, public health interest might be focused on individuals above the 95th percentile of weight for height for suspicion of obesity, while in a less well nourished group, those individuals above the 95th percentile of weight for height would be of considerably less public health interest. On the contrary, those below the 5th percentile of weight for height in both population groups would be more carefully studied as likely to suffer from malnutrition, and/or benefit from an intervention program (38). It should also be noted that differences in indices of nutritional status, whether anthropometric or biochemical, are not in themselves 'bad'. *Functional* indicators of nutritional status, such as morbidity, mortality, activity & work capacity, and social performance, may be far more appropriate indices to use in planning actual intervention strategies (2). Furthermore, it must be remembered that persons who have grown and developed in different environments may be well-adapted to their respective situations and that an interventional attempt to make them more similar to one another may, in fact, cause a maladaptation to the environment in which they actually live.

This descriptive study looks at a group of rural elderly in the Republic of Guatemala, a country in which approximately 6% of an estimated 8.2 million inhabitants are thought to be over 60 years of age. As noted above, differences in dietary patterns and lifestyle may affect morbidity and mortality, and this group of Guatemalan elders have a different diet and lifestyle from most of the elders that have been studied in other societies.

This study is cross-sectional and descriptive, so that its goal is to describe and understand the current condition of this elderly population, without reference to testing specific hypotheses regarding their nutritional and health status. Not only will this research pave the way for initiatives which might improve quality of life for these elders, but it may serve as a foundation for future research by generating new hypotheses about nutrition and health in the elderly. The purpose of the current study, then, is to survey and describe the general health and nutritional status of an elderly rural population in Guatemala, with particular attention to variations in body composition and biochemical indices with age, to correlations between body composition and biochemical indices, and finally, to the prevalence and intensity of parasitism and its potential interactions with body composition and biochemical parameters of nutritional status.

The present study was undertaken as a portion of a multiphasic survey involving clinical evaluations and anthropometric measurements, visual acuity testing, hearing acuity testing, ocular and dental examinations, stool examinations for parasites, and biochemical and hematological studies of blood samples. The project was carried out under the auspices of and with the financial and technical support of the Center for Studies of Sensory Impairment, Aging, and Metabolism, the research arm of the National Committee for the Blind and Deaf of Guatemala, in collaboration with the U.S.D.A. Human Nutrition Research Center on Aging at Tufts University.

SUBJECTS

In the rural countryside, large, extended family households are still the norm, and elders remain fully integrated participants in family life. Our study population was derived from San Pedro Ayampuc, a town in the Department (state) of Guatemala, situated 1,250 meters above sea-level, with an estimated 7000 inhabitants. The town lies in a river valley and enjoys a temperate climate. The annual rainfall falls chiefly during a rainy season which lasts from mid-May to mid-September.

Although San Pedro Ayampuc lies but 22 kilometers north of the national capital, Guatemala City, on a well-traveled dirt and gravel road, many of the townspeople have never visited that city. There is a water system which serves some of the town's houses, although many families do not have access to running water. Solid waste is burned by individual family units, and sometimes dumped or buried behind their homes. Sanitation facilities vary widely, from none at all to flush toilets (see census data, below).

The majority of the population dedicate themselves to agricultural pursuits; principal crops include maize, black beans, coffee and tomatoes. A selection of fruits and vegetables, limited both in quantity and quality, are brought daily from produce markets in the capital and offered for sale in the newly-constructed town marketplace. As elsewhere in rural Guatemala, the diet is based primarily on beans, corn tortillas and coffee, supplemented with eggs, dairy products, fruits and vegetables. Meat, poultry and fish are consumed infrequently by the rural poor.

Health services include both a network of traditional midwives (comadronas) and healers (curanderos), a rural government health center staffed by a doctor, nurse and auxiliary staff, and an occasionally-present private physician. The most common causes of morbidity and mortality in the community, as elsewhere in Guatemala, are gastrointestinal disorders, upper respiratory infections, and malnutrition (76). Of 67 deaths registered in San Pedro in 1986, 52% involved persons four years of age or younger.

The protocol for this study was approved by the Committee on Human Subjects of the Center for Studies of Sensory Impairment, Aging, and Metabolism, and the project was discussed with influential leaders of the community. After an initial census of the elderly population, the nature, inconvenience and potential benefits of the study were explained to each resident in the appropriate age range. Verbal informed consent for the specific procedures, e.g. anthropometric measurement, blood draw, was obtained at the time of measurement/procedure, in the presence of witnesses.

A door-to-door census of the San Pedro population, further described below, revealed a population of 280 persons over the age of 60 years. Of these, 64% are of indigenous and 36% of ladino ancestry[1]. Two hundred and sixty five persons provided us with census information, 205 were subjects of anthropometric study, 164 were subjects of biochemical study, and 89 provided stool samples for examination.

TABLE 1
DESCRIPTIVE STATISTICS FOR THE ELDERLY SAN PEDRO AYAMPUC POPULATION, GROUPED BY DATA SET

ANTHROPOMETRICS:

	WOMEN	MEN	TOTAL
G1	66	50	116 (56.6%)
G2	31	31	62 (30.2%)
G3	12	15	27 (13.2%)
TOTAL	109	96	205

BIOCHEMICAL INDICES:

	WOMEN	MEN	TOTAL
G1	53	36	89 (54.3%)
G2	27	30	57 (34.8%)
G3	9	9	18 (11.0%)
TOTAL	89	75	164

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[1] Indigenous refers to persons who primarily define their heritage as being that of the Mayan Indians; ladino to persons who identify more strongly with their Spanish ancestry.

PARASITIC INFESTATION:

	WOMEN	MEN	TOTAL
G1	35	19	54 (60.7%)
G2	17	11	28 (31.5%)
G3	3	4	7 (7.9%)
TOTAL	55	34	89

Although participation levels in the study were high, the possibility remains that the sample is biased by virtue of characteristics shared by those who continued throughout all phases of the study, versus some potentially different attributes shared by those who entered the study initially and later declined to continue. These traits could be based on psychosocial, behavioral, physiologic, and/or pathologic conditions and thus may have complex effects on the final data set. It was impossible to determine any specific characteristics about the individuals who did not complete the full study. As a general proxy, however, mean anthropometric indices were compared across the three subgroupings for whom anthropometric data was collected, and no significant differences were found.

The following summary statistics refer to the 205 subjects with anthropometric data: the sample included 109 women ranging in age from 60 to 88 years, with a mean age of 68.5 $\pm$ 7.3 y and a median age of 67 y, and 95 men ranging in age from 60 to 96 years, with mean and median ages of 70.1 $\pm$

7.9 and 69 years, respectively. The age distribution by gender is shown in Table 1. For the purposes of analysis the population was divided into three age groups. Sixty-six women (60%) and 50 men (52%) were between the ages of 60 and 69 years, and are classified as Group 1 (G_1). Group 2 (G_2) includes the 31 women (29%) and 31 men (32%) between the ages of 70 and 79 y, and Group 3 (G_3) includes the 12 women (11%) and 15 men (16%) who were 80 y and older. All subjects are identifiable by code number only.

METHODS

Census: A door-to-door census of the San Pedro population was conducted over a two week period in September and October, 1987. The author walked to each house and questioned for the presence of any person over age sixty; if the answer was affirmative, and cooperation was offered, a full questionnaire was completed by the author at that time. In some cases, the presence of persons over 60 was ascertained, but they choose not to participate in any phase of the study. In other cases, individuals elected to participate in the study, but did not answer the questionnaire at that time, doing so on the occasion of a visit for other data collection. In all cases, the author questioned subjects individually and recorded responses herself. A copy of the census questionnaire and a translation of same are presented in Figure 1.

FIGURE 1 - CENSUS FORM USED (SPANISH)

NOMBRE:____________________________ M F CODIGO:_______
FECHA DE NACIMIENTO:________________________ EDAD:__________

ESTADO CIVIL: SOLTERO___ CASADO/UNIDO___ VIUDO___
CANTON________

LADINO INDIGENA AÑOS DE VIVIR EN SPA:____________
lugar de nacimiento, si no SPA___________

Estado ambulatorio/general:
___ puede sentarse
___ puede pararse
___ puede caminar (si no, dirección de la casa______________)
___ puede extender los brazos
___ está actualmente enfermo

Oficios/trabajos:
___ sigue haciendo oficio en la casa?
___ todavía va al monte?
___ otros:____________________________

Sabe Ud. leer?

Llega Ud. al Centro de Salud?
___ nunca
___ entre veces
___ de 6 - 12 veces al año
___ >1 vez al mes

Hay otro lugar en donde busca servicios de salud o curación?

Cuántas personas viven con Ud. en su casa? ________________
En cuántos cuartos? __________ incluya # y relación

La casa en donde vive Ud.: (∅ = no, ✓ = sí)
es alquilada ___ propia ___
está hecha de blok ___ adobe ___ caña ___
tiene piso de cemento ___ tierra ___
tiene agua ___
de pozo ___ de chorro ___
tiene luz eléctrica ___
tiene letrina ___ baño ___

Tiene Ud. en su casa?
mesa para comer? ___
camas ___ si hay camas, cuántas? ___
sofa ___
sirvienta/muchacha ___
radio ___
televisión ___

FIGURE 1 - CENSUS FORM (ENGLISH TRANSLATION)

NAME:________________________________ M F CODE # ______

DATE OF BIRTH:______________________ AGE: _________

MARITAL STATUS: SINGLE ___ MARRIED ___ WIDOWED ____

NEIGHBORHOOD ____________ LADINO INDIGENOUS

YEARS LIVING IN SPA:____ birthplace, if not SPA____________

General/ambulatory state:

- ___ can sit
- ___ can stand
- ___ can walk (if not, location of house ______________)
- ___ can extend the arms
- ___ is currently ill

Chores/work:

- ___ continues working in the home
- ___ still goes to the fields/woods
- ___ other:____

Do you know how to read?

Do you ever go to the health center?
- ___ never
- ___ occasionally
- ___ 6 - 12 times/year
- ___ >once/month

Do you seek health services in any other locale?

How many people live in your house? _______________________
in how many rooms? _________ include # & relationship

The house you live in: (Ø = no, √ = yes)
- you rent ___ you own ___
- is made of cinderblock ___ adobe ___ cane ___
- has a cement ___ dirt ___ floor
- has water ___
  - well ___ faucet ___
- has electricity ___
- has a latrine ___ toilet ___

Do you have?
- a table to eat on ___
- beds ___ if there are beds, how many? ___
- a sofa ___
- a housekeeper/kitchen helper ___
- radio ___
- television ___

Anthropometry: Measurements taken included weight, height, armspan, mid-upper arm circumference (MAC) and triceps skinfold thickness (TSF). The subjects were weighed barefoot and in light indoor clothing on a Metro bathroom scale accurate to 0.25 pounds. The scale was standardized each morning with a twenty-five pound weight. Weight was recorded to the nearest 0.5 lbs and later converted to kilograms. Notably, the traditional clothing worn by the indigenous women is significantly heavier than the western garb of the ladina women. To correct for this variation, the mean difference in weight between the two attires, 0.72 kg, was subtracted from the recorded weight of each indigenous woman before the data were analyzed.

Height was measured, again in bare feet, with a two meter graduated bar made especially for this purpose. With the subject's heels and buttocks touching the wall and the head upright, we used a carpenter's right angle to read height to the nearest 0.5 cm. Armspan was measured with the same two meter bar placed behind the subject at shoulder level. With the arms in full lateral extension we measured the distance between the tips of the longest fingers on each hand. In subjects with any impaired range of motion that might affect their armspan, we measured the distance from the mid-sternum to the tip of the longest finger of the unimpaired arm and multiplied by two, thus estimating total armspan, again to the nearest 0.5 cm.

Mid-upper arm circumference was measured using the method of Bishop et al. (5), modified by using the left arm and a tailor's plastic measuring tape calibrated in millimeters. Circumference values were recorded to the nearest 0.1 centimeter. Triceps skinfold thickness, also determined by the method of Bishop et al., was measured with a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, MD, USA). Three consecutive measurements were taken to the nearest 0.5 mm, and the mean of the three was recorded as the subject's skinfold thickness. While it is well known (25, 43) that measurement with calipers compresses subcutaneous tissues, and thus underestimates actual subcutaneous fat thickness, it has not been shown that taking skinfold compression into account makes any significant difference in the estimation of body fatness.

From the five basic measurements I calculated height-armspan ratio, body-mass index, mid-arm muscle and fat areas, percentage of mid-upper arm area as fat and muscle, and percentage of total body fat (TBF) as calculated from triceps skinfold thickness. Skinfold thicknesses are highly correlated with body fat as estimated by densitometry (80). Various workers (43, 25, 35) have shown that while multiple skinfold thicknesses -biceps, triceps, subscapular, and supra-iliac- are more accurate for estimating body fatness from skinfold thickness, if just one measurement is utilized, it is the triceps skinfold which will most accurately predict the body fatness measured by hydrostatic weighing.

Comparison and determinations of adequacy were made based on values in the literature for these derived indices. All equations and references are presented below:

Quetelet's body mass index = weight/height^2 = kg/m^2

from Frisancho (35):

mid-arm muscle circumference = MAC - π (TSF/10)

brachial area = MAC^2/4π

mid-arm muscle area (MAMA) =

(mid-arm muscle circumference^2)/4π

mid-arm fat area (MAFA) = brachial area - MAMA

from Siri, Durnin & Womersley (70,25):

percent total body fat (TBF) =

[(4.95/density) - 4.5] x 100

density for women > 50 = 1.1160 - (0.0762 log TSF)

density for men > 50 = 1.1027 - (0.0662 log TSF)

The equations for mid-arm muscle and fat areas approximate the arm as cylindrical, and do not compensate for the contribution to arm volume made by the humerus. Although these equations have been shown to overestimate bone-free arm muscle area (42), they are widely used in the anthropometric literature and thus serve as useful measures by which to compare this population with others studied in the past.

Blood samples/Biochemistry: A non-fasting venous blood sample was obtained from each subject. The samples were centrifuged for 15 minutes to separate the plasma. The erythrocyte fraction was washed with saline, spun 15 more minutes, washed again with saline and centrifuged a final 15 minutes. They were then stored on ice at -70° C degrees for transport to Guatemala City. They were transported to Tufts University and remained frozen at -70° C until their eventual analysis by the Nutrition Evaluation Laboratory of the U.S.D.A. Human Nutrition Research Center on Aging at that university. All analyses were carried out under the supervision of Dr. Frank D. Morrow. A brief description of methodologies follows, quoted from a memo written by Dr. Morrow.

> Retinol and alpha-tocopherol were determined simultaneously using an automated modification of the reverse-phase high performance liquid chromatography of Bieri et al. (4). Fat soluble vitamins were extracted into n-hexane following ethanol precipitation of plasma proteins. The hexane extract was evaporated under reduced lighting using a stream of high-purity nitrogen and immediately re-dissolved in a mixture of methanol/diethyl-ether (75:25, v/v). Sample extracts were injected onto an octadecylsilane column (4.6 mm x 10 cm) with a 5 µm packing (Biorad Laboratories, La Jolla, CA) using a WISP model 710B auto-injector (Waters Associates, Milford, MA). All sample preparations steps were performed in

duplicate using a precise robotic liquid handling system (SPD-3000, Dynatech Laboratories, Inc., Chantilly, VA). Recovery of retinol and tocopherol was monitored using retinyl acetate as an internal standard. Results are expressed as µmol/L. Total carotenoids were quantitated [sic] in the same hexane extract by their absorption at 450 nm using a molar extinction coefficient E1% of 2550 (67). Thiamin, riboflavin, and pyridoxine status were determined by the method of Williams et al (78) as automated on a centrifugal analyzer (Cobas Fara II, Roche Diagnostics, Montclair, NJ). Hemolysate enzymes were quantitated [sic] before and after addition of the vitamin cofactor (thiamin pyrophosphate, flavin adenine nucleotide, and pyridoxal-5-phosphate, respectively). Specimens from subjects with marginal or deficient vitamin status demonstrate higher Activity Coefficients (AC) than subjects with normal vitamin status. The concentration of retinol binding protein in the plasma samples was also measured on the Cobas Fara using an automated immunoturbidimetric procedure. Each sample was diluted 1:21 in polyethylene glycol buffer, centrifuged to remove lipoproteins, and reacted with sheep anti-human polyclonal RBP anti-serum (Behring Diagnostics. La Jolla, CA). Standardization was accomplished using a serum calibrator of known RBP concentration also supplied by Behring Diagnostics. The concentration of prealbumin was quantitated in the same samples using a similar immunoturbidimetric procedure using antiserum supplied by Atlantic Antibodies, Inc., Scarborough, ME. All specimens on a given subject were analyzed in a single analytical run to eliminate inter-assay variation.

Plasma B12 and folate were performed by a commercially available competitive protein binding assay ("Magic B12/folate," Ciba-Corning, Medfield, MA) based on affinity-purified hog stomach intrinsic factor and milk folate binding proteins, respectively.

Hematocrit was determined by the microcapillary method.

Stool samples/Parasites: Stool samples were collected from willing subjects early in the morning and transported to Guatemala City within three hours. Stool was processed by the Kato Katz method (33). With this method, one is able to count the number of helminth eggs seen in ten central low-power microscopic fields, and from that, calculate the number of eggs contained in each gram of stool. The prevalence of helminth eggs and their intensity, in eggs per gram of stool, is thus determined. Specifically, the current investigation pursued analysis of eggs of Ascaris lumbricoides and Trichuris trichuria.

Statistical analyses: Initial anthropometric calculations and analyses were performed on a Tandy 1000 microcomputer (Tandy Corp., Fort Worth, TX, USA) using Systat (Systat Inc., Evanston, IL, USA) and Statgraphics (Plusware, Rockville, MD, USA) statistical software packages.

Further analyses of the anthropometric data and analyses of all remaining portions of the data set were performed on an

IBM-compatible PC using SPSS/PC+ (SPSS Inc., Chicago IL). Summary statistics were calculated for all variables. Comparisons between gender were made using the student's t-test for independent samples, while comparisons between age groups but within gender were computed using the one-way analysis of variance (ANOVA) with the Tukey method for testing of intergroup differences. Correlations were computed via the Pearson correlation coefficient, regressions performed by the least squares method. In all cases, a significance level of $p < 0.05$ was considered worthy of reporting.

RESULTS AND DISCUSSION

Census:

Census data are presented for the overall elderly population in Table 2. Unfortunately, whereas these data were collected individually and coded by subject identification number, only the present summary is available for use in this paper. Thus, no comparisons or correlations could be analyzed across data sets, e.g. potential association between prevalence of parasites and access to water or sanitation facilities.

For an elderly population, this one was found to be a young group, with a median age of 68 years. Ninety-one percent of these elders still consider themselves to be active, carrying out chores either at home or in the fields. In a

TABLE 2
SAN PEDRO AYAMPUC ELDERS: CENSUS INFORMATION

	% OF WOMEN	% OF MEN	% OF TOTAL
INDIGENOUS	69	60	65
LADINO	31	40	35
WIDOWED	47	31	39
MARRIED	53	69	60
SINGLE (never married)	0	2	1
STILL DOES CHORES	83	74	78
DOES A FEW CHORES	9	16	13
DOES NO CHORES	8	10	7
LITERATE	14	31	22
ILLITERATE	82	59	71
READS A LITTLE (name)	4	10	7
NO WATER			40
WELL			19
FAUCET			41
ELECTRICITY			44
NO ELECTRICITY			56
FLUSH TOILET			6
BLIND LATRINE			60
NO SANITARY FACILITIES			34
DIRT FLOOR			72
CEMENT FLOOR			28
HAS RADIO			42
DOES NOT HAVE RADIO			58
SOMETIMES USES HEALTH CENTER	50	28	39
NEVER USES HEALTH CENTER	50	72	61
SEEKS HEALTH CARE IN CAPITAL CITY	24	26	25

population divided almost equally between women and men, 64% identified themselves as indigenous and 36% as ladino. Although there were more older men than women, 48% of the women but just 30% of the men were widowed. Eighty-two percent of the women and fifty-nine percent of the men were illiterate.

With regard to their homes, I obtained information from just 105 of the elders in San Pedro Ayampuc. Fifty-four percent enjoy the use of electricity; 37% have no access to water in or near their homes while 20% have blind wells and 43% have a cold water faucet. Thirty percent of the elders report that they have no sanitary facilities, 63% utilize blind latrines, and 7% have flush toilets. Seventy percent of this population live in homes with dirt floors and 30% in homes with cement floors. Fifteen percent have a television to watch and 43% have and listen to a radio.

Of the 124 persons questioned about use of health care facilities, 39% occasionally utilize (llegan entre veces) San Pedro's local health center, and 61% state that they never do so. Twenty-five percent of the total seek health care in the capital city, whether in a hospital, private clinic or pharmacy.

Anthropometry:

Table 3 presents descriptive statistics by gender for each anthropometric index measured or calculated. As expected, women were found to be both lighter in weight and shorter of stature than their male counterparts. Mean weight for women was 44.5 ± 8.5 kg, and for men 49.9 ± 8.2 kg, a difference of 5.5 kg; mean heights were 141.5 ± 6.4 and 155.1 ± 5.7 cm for the respective gender groups, a difference of 14.4 cm.

TABLE 3
ANTHROPOMETRIC INDICES OF SAN PEDRO AYAMPUC ELDERS BY GENDER*

	WOMEN		MEN	
	X ± S.D.	MEDIAN	X ± S.D.	MEDIAN
WEIGHT (kg)	44.5 ± 8.5	44.2	49.9 ± 8.2	48.1
HEIGHT (cm)	141.5 ± 6.4	141.0	155.1 ±5.7	155.0
ARMSPAN (cm)	144.1 ± 7.4	143.5	160.3 ±6.6	160.6
BODY MASS INDEX (kg/m^2)	22.2 ± 3.7	21.9	20.7 ± 2.5	20.1
MID-ARM CIRCUMF. (cm)	25.9 ± 3.2	25.5	25.6 ± 2.7	25.2
TRICEPS SKINFOLD (mm)	13.6 ± 5.8	12.0	6.0 ± 5.5	5.5
MID-ARM MUSCLE AREA (cm^2)	37.6 ± 7.4	36.5	45.0 ± 9.3	43.3
% ARM AREA AS MUSCLE (%)	70.7 ± 8.9	71.9	85.9 ± 5.2	86.7
MID-ARM FAT AREA (cm^2)	16.6 ± 8.4	13.9	7.5 ± 3.6	6.6
% ARM AREA AS FAT (%)	29.3 ± 8.9	28.1	14.1 ± 5.2	13.3
% TOTAL BODY FAT (%, from triceps)	29.4 ± 6.7	28.8	20.0 ± 5.2	19.8

* P value for women vs. men < .001 in all cases except for mid-arm circumference, for which the difference was insignificant.

Compared to the median heights of a reference United States population at peak adult height from the NCHS survey (62), 100% of both women and men fall below the respective median NCHS levels, and 92.6 and 91.6%, respectively, fall below the tenth percentile values.

Armspan was assessed as a surrogate measure for the peak attained adult height (7,24) and as an indicator of senile loss of stature when compared with current height. It has been shown (Albright, in 7) that the normal individual tends to have a span equal to his or her height, and that in most adults armspan and height will be within 2 inches (5 cm) of each other. Loss of height with aging is largely due to changes in the spinal column, including flattening of both the vertebral bones themselves and the intercartilaginous discs. Armspan, because it reflects length of long bones, in which there is no loss of length due to age, can thus be used on a population level to estimate peak adult height and, from that, height loss secondary to aging. The mean value for armspan for women was 144.1 $\pm$ 7.4 cm, indicating an average decline of 2.6 cm (1.7% of their initial peak height) to the present. The armspan averaged 160.3 $\pm$ 6.6 cm for elderly men, indicating a mean decline of 5.2 cm (3.1%) since young adulthood. That this population is of short stature is confirmed by comparing armspan to the NCHS reference standard. Even using this latter index as an estimation of maximal adult stature for each individual, 97.4% of women and 100% of men fell below the above-mentioned respective median NCHS values, and 92.6 and 91.6%, respectively, fell below the tenth percentile values.

Returning to the data summarized in Table 3, highly significant differences across gender were noted for every measure and index, except mid-arm circumference. Not surprisingly, women were found to possess greater proportions of fat, and men greater proportions of lean tissue. Mean mid-arm muscle area (MAMA) and percentage of cross-sectional arm area as muscle (%M) for women were 37.6 $\pm$ 7.4 cm^2 and 70.7 $\pm$ 8.9%. Comparable values for men were 45.0 $\pm$ 9.3 cm^2 and 85.9 $\pm$ 5.2%. Mean values for estimation of percent total body fat derived from triceps skinfold thickness (25) were 29.4 $\pm$ 6.7% and 20.2 $\pm$ 5.2 for females and males, respectively. Mean body mass index, or weight/height^2, was 22.2 $\pm$ 3.7 kg/m^2 in women and 20.7 $\pm$ 2.5 kg/m^2 in men.

Differences in body composition were noted with advancing age. These findings, however, must be interpreted with caution. Our population has an age distribution shifted to the younger decade, with relatively small percentages in the 70-79 and 80 and over groups; this limits the representativeness of our population for the oldest segments of the rural population in Guatemala. More importantly, however, conclusions about age-dependent trends derived from a cross-sectional study may be confounded by processes operating on a given birth cohort, and the fact that any group of elderly subjects represents only the surviving segment of a given population (71).

Table 4 shows the comparison of the various indicators of body composition across age groups, along with the ANOVA estimate of difference. Generally, age-related trends were seen, but they differed in timing and magnitude for women and men. While arm circumferences showed a steady decrease across the age groups for both females and males, women demonstrated a precipitous decline in mean skinfold thickness from the seventh (G_1) to the eighth (G_2) decade of life ($p<0.01$). With little decrease in the MAMA with increasing age in women, it is logical that we would find the percentage of mid-arm area as fat (%F) to decrease and the %M to increase in that gender group. Percent body fat also decreased in women across the decades from 31.2% to 26.6% ($p<0.01$). For men, on the other hand, no significant changes in triceps skinfold thickness was seen across the decades: this lack of change is consistent with the findings of Czajka-Narins et al. (21) in elderly Missourians, as is the noticeable decrease in triceps skinfold thickness with age in women. Among men, the mean MAMA declined from 48.4 to 42.0 cm^2 from G_1 to G_2 ($p<0.01$). This was associated with a fairly constant relative partition of the upper arm composition between fat and muscle. The percent of body fat mass also remained constant in men with increasing age in this rural sample. Body mass index showed no significant differences across age groups for women, whereas a significant decrease was noted for men between G_1 and G_3 ($p<0.02$).

TABLE 4
MEAN ANTHROPOMETRIC INDICES BY GENDER COMPARED ACROSS AGE GROUPS*

		WEIGHT (kg)	HEIGHT (cm)	ARMSPAN (cm)	BMI (KG/M^2)
F	G1	46.2 ± 7.4a	142.8 ± 6.2a	145.5 ± 7.5a	22.6 ± 3.2a
	G2	42.1 ± 9.0b	139.7 ± 6.6b	141.9 ± 7.3b	21.6 ± 4.4a
	G3	41.1 ± 11ab	139.6 ±5.5ab	142.0 ±5.5ab	20.9 ± 4.1a
M	G1	51.4 ± 8.0a	155.1 ± 5.2a	160.2 ± 5.7a	21.3 ± 2.6a
	G2	49.3 ± 7.7ab	156.0 ± 5.7a	161.2 ± 6.8a	20.2 ±2.2ab
	G3	46.3 ± 8.6b	153.2 ± 6.8a	158.9 ± 9.2a	19.6 ± 2.3b

		MID-ARM CIRC (cm)	TRICEPS SKINFLD (mm)	MAMA (cm^2)	MAFA (cm^2)
F	G1	26.5 ± 2.9a	15.0 ± 5.6a	38.2 ± 7.0a	18.4 ± 7.9a
	G2	25.3 ± 3.5ab	11.6 ± 5.6b	37.6 ± 7.8a	14.2 ± 8.7b
	G3	24.2 ± 4.0b	11.6 ± 5.9ab	34.0 ± 8.0a	13.7 ±9.0ab
M	G1	26.4 ± 2.3a	6.0 ± 2.3a	48.4 ± 8.0a	7.7 ± 3.3a
	G2	24.7 ± 2.8b	6.0 ± 3.0a	42.0 ± 9.9b	7.2 ± 4.0a
	G3	24.3 ± 2.8b	6.3 ± 3.0a	40.1 ± 8.7b	7.5 ± 4.0a

		% AREA AS MUSCLE (%)	% AREA AS FAT (%)	TOTAL BODY FAT (%)	
F	G1	68.5 ± 8.8a	31.5 ± 8.8a	31.2 ± 8.8a	
	G2	74.3 ± 8.1b	25.7 ± 8.1b	26.9 ± 6.8b	
	G3	73.4 ± 9.0ab	26.7 ± 9.0ab	26.6 ± 8.1b	
M	G1	86.4 ± 4.4a	13.6 ± 4.4a	20.0 ± 4.8a	
	G2	85.6 ± 6.2a	14.4 ± 6.2a	19.7 ± 5.6a	
	G3	84.8 ± 5.9a	15.2 ± 5.9a	20.2 ± 5.8a	

* G1 = 60 - 69 years, G2 = 70 -79 years, G3 = 80 or more years

Within any given column and gender, values accompanied by different letters are significantly different ($p<.05$)

Table 5 demonstrates that there are also significant differences in body composition by ethnic heritage. Although not presented in tabular form, gender specific means were also calculated; these show that the body composition differences by ethnic heritage are more pronounced for men than for women.

TABLE 5
ANTHROPOMETRIC INDICES OF SAN PEDRO AYAMPUC ELDERS BY ETHNIC HERITAGE

	INDIGENOUS N=115		LADINO N=50		
	X ± SD	MEDIAN	X ± SD	MEDIAN	P
WEIGHT (kg)	45.6 ± 8.3	46.1	51.0 ± 9.5	49.6	.001
HEIGHT (cm)	146.5 ± 8.7	146.5	152.3 ± 8.7	153.5	.000
ARMSPAN (cm)	151.7 ±10.7	151.0	150.6 ±13.7	151.0	NS
BODY MASS INDEX (kg/m^2)	21.2 ± 3.1	20.8	22.0 ± 3.5	21.3	NS
MID-ARM CIRCUMF. (cm)	25.3 ± 2.9	25.0	26.9 ± 3.9	27.0	.012
TRICEPS SKINFOLD (mm)	10.3 ± 6.0	8.0	11.0 ± 6.9	9.0	NS
MID-ARM MUSCLE AREA (cm^2)	39.5 ± 8.2	39.0	45.3 ± 10.9	44.3	.001
% ARM AREA AS MUSCLE (%)	77.4 ± 10.9	79.5	77.2 ± 13.0	78.2	NS
MID-ARM FAT AREA (cm^2)	12.3 ± 7.9	10.0	14.7 ± 12.4	11.5	NS
% ARM AREA AS FAT (%)	22.6 ± 10.9	20.5	21.7 ± 10.7	21.6	NS
% TOTAL BODY FAT (%, from triceps)	25.1 ± 7.6	24.5	25.5 ± 8.0	24.6	NS

Among the women, only height and percent total body fat were significantly different, whereas among the men, ladinos had significantly greater means for weight, height, mid-arm circumference, and arm-muscle area, and there was no significant difference in percent total body fat.

In general, the indigenous persons are shorter and lighter than ladino persons. However, neither body mass index nor percent arm area as muscle or fat are significantly different between the two groups, suggesting that while the absolute numbers are dissimilar, relative proportions of lean body mass and fat are quite similar.

Comparison of this rural Guatemalan population with groups of elderly adults of other races, geographic locations and life-styles, who live under vastly different socioeconomic conditions, may help to identify patterns of age-related changes in the composition of the human body. On the other hand, the differences in ancestries and living conditions themselves may confound clear interpretations of the findings.

Anthropometric data were gathered by other investigators (71) at the Center for Studies of Sensory Impairment, Aging, and Metabolism from three institutions for the aged in Guatemala City. One hundred and sixty-six subjects were studied in two San Vicente de Paul Homes and in the Center for Blind Elderly for an Independent Life; all of these subjects had some degree of chronic illness and their ambulatory state ranged from bedridden to fully independent. To summarize, differences in anthropometric characteristics between the urban Guatemala City population and the present rural group, although similar across genders, were found to be greater and more significant in men than women. This is true for weight, height, body mass index, triceps skinfold thickness, and arm muscle area. In each case the rural men were substantially leaner and more muscular than their urban compatriots. While it is likely that men in the countryside would be more physically active than the urban institutionalized group, it is not obvious why so little difference is noted in size and indicators of body composition in female counterparts, for rural women are certainly more active than their institutionalized companions. An alternate explanation would need to address the issue of food intake <u>and</u> activity levels in the two groups.

In another Guatemalan study (45), 87 sugarcane cutters, ages 20-55, were seen to have anthropometric values similar to, although slightly larger than, the elderly men of San Pedro. Their mean height was found to be 159.6 cm, mean weight 53.1 kg, and mid-upper arm circumference 25.5 cm. Interestingly, if armspan can be used as a good proxy for peak adult height, then the sugarcane cutters are no taller than the Sampedranos were in their youth. In comparing these two groups, however, one must consider each of the differing racial, geographic and lifestyle factors, in addition to the possibility of secular trends, as potential confounders of conclusions.

By international standards, the population of 205 elderly examined here, with their respective median heights for women and men of 141 and 155 cm., is exceedingly short of stature. The median weights also suggest that the population of elderly is light, as well as short. Table 6 shows a compilation and comparison of anthropometric data from reports on elderly from various nations[2] (12,18,20,25,29,30,63,66,80). Rural Guatemalan elderly in the current study are, in general, a full twenty kilograms lighter in weight and ten centimeters shorter in stature than their elderly counterparts in more industrialized countries.

Focusing of the adequacy of weight-for-height, the traditional indicator of current energy nutriture, mixed interpretations are generated. It was noted above that the elders of both genders are shorter than North American adults. When compared to the same NCHS population with the weights adjusted for actual heights and age (62), 96.3% of the studied women fall below the median 60.4 kg value for elderly U.S. women of height equal to the Guatemalan women's median height, and 76.2% fall below the tenth percentile of the same. For men, the corresponding comparative values are 95.8% below 67.3 kg, which is the U.S. median weight at the Guatemalan men's median height adjusted for age, and 86.5% below the tenth percentile of same. This comparison would indicate that

[2] Each of these studies was done in persons over 60, with group mean ages of approximately 73. Numbers of individuals studied ranged from as few as 75 to as many as the thousands of the U.S. NHANES; most studies averaged around 400 subjects.

Guatemalans are light not only by virtue of their short stature, but are also underweight for their height, as compared to North Americans in the U.S. Such a conclusion, however, is subject to the criticism that the reference U.S. population may itself be generally overweight. For this reason, I also compared the San Pedro population to an alternative standard, the computer-smoothed, weight-for-height, normative curve of Geissler and Miller (36), proposed as a gender- and age-independent international reference standard. It is interesting to note, then, that with respect to the Geissler and Miller standard, 88% of the San Pedro elderly women and 66% of the men have a weight above the 50th percentile for their individual heights, that is, had a weight-for-height adequacy of greater than 100%. This is in diametrical contrast to the comparison with NCHS, and provides support to the notion that the Guatemalans of the current study may not be underweight, but that the U.S. population of the NCHS survey may be overweight for their height, by international standards.

The Quetelet body mass index (BMI) is the other indicator derived from weight and height data. The median values for BMI for our rural elderly population, 21.9 kg/m^2 and 20.1 kg/m^2 for women and men respectively, are also low in comparison with elders from developed countries (Table 6). Elderly women from more industrialized countries had median BMIs that ranged from 23.7 to 28.0 kg/m^2. Our female median BMI most closely approximates the 23.7 kg/m^2 of elderly Boston women (44), but is still 8% lower. Aged men from European and North American

TABLE 6
ACROSS POPULATION COMPARISON OF SELECTED ANTHROPOMETRIC INDICES IN THE ELDERLY

	WOMEN			MEN			
	WEIGHT (kg)	HEIGHT (cm)	BODY MASS INDEX (kg/m^2)	WEIGHT (kg)	HEIGHT (cm)	BODY MASS INDEX (kg/m^2)	source
SAN PEDRO	44	141	22	48	155	20	--
OREGON[1]	66	159	26	77	172	26	80
SF,CA (wh)[1]	61	155		74	169		63
SF,CA (asian)[1]	55	151		62	161		63
OHIO (wh)[2]			25			26	18
BOSTON, MA[1]	59	154	27	66	166	27	69
SCOTLAND[1]	80	161		80	172		25
WALES[2]			26			24	12
HOLLAND[1]	70	160	27	76	172	26	54
GERMANY[1]	62	157	25	74	172	25	55
NAPLES	67	152	28	70	165	26	20
N. ITALY[2]	64	154	27	72	166	26	65
ITALY[1]	62	149	27	67	161	26	29
ITALY[2]	65	151		69	162		30
CHINA[2]			23			22	79

[1] Values for these populations are expressed as means; medians were not available.

[2] These are weighted medians as calculated from the original data using the San Pedro Ayampuc age distribution as the weight factor.

TABLE 7 - ACROSS POPULATION COMPARISON OF SELECTED ANTHROPOMETRIC INDICES IN THE ELDERLY

	WOMEN					MEN					
	MID-ARM CIRCUMF (cm)	TRICEPS SKINFLD (mm)	MAMA (cm^2)	MAFA (cm^2)	% TBF (%)	MID-ARM CIRCUMF (cm)	TRICEPS SKINFLD (mm)	MAMA (cm^2)	MAFA (cm^2)	% TBF (%)	source
SAN PEDRO	26	12	36	14	29	25	6	43	7	20	--
OREGON[1]		20					12				80
SF, CA (wh)		20					12				63
SF, CA (asian)		20					13				63
NHANES	30	23				31	11				5
NHANES	30	24	40	31		31	11	57	16		35
OHIO (wh)[2]			44					56			18
SCOTLAND[1]		25			39		11			28	25
WALES[2]	26	17	33			24	8	41			12
HOLLAND[1]					40					30	55
NAPLES			36	31	39			42	19	26	20
N. ITALY[2]			42	17	39			50	11	24	65
ITALY[1]					39					26	29
CHINA	20				18	22				16	79

[1] Values for these populations are expressed as means; medians were not available.
[2] These are weighted medians as calculated from the original data using the San Pedro Ayampuc age distribution as the weight factor.

populations had median BMIs that ranged from 24.3 to 26.2 kg/ ^{2}. Our male median BMI is closest to that of Welsh elders (12), although 23% below the North American group. In Rome, Italy, Ferro-Luzzi et al. (30) classified elderly subjects into the categories of underweight, normal, overweight and obese, using criteria based on BMIs. Using this scheme, 25% of our Guatemalan rural elderly women would be classified as underweight and 11% would be classified as overweight or obese. Among our men, 73% would be considered as underweight, and none would be considered either overweight or obese. By contrast, in the Italian elderly sample 3.2% and 79.8% of the women and 7.6% and 53.8% of the men were categorized as underweight and either overweight or obese, respectively.

As chronic energy deficiency is known to result in decreased body mass and decreased fat mass (26), it behooves one to examine indices of body composition in our Guatemalan elders. This requires the intercession of indicators derived from skinfolds and circumferences. In comparison with other reported elderly populations from the more industrialized nations, one again finds consistently smaller median values for Guatemalans in mid-upper arm circumference, triceps skinfold thickness, mid-upper arm muscle area, mid-upper arm fat area, and percents of cross-sectional arm area as muscle or fat than are found for European and North American elderly (Table 7). Difference of up to 16 cm^2 are seem in mid-arm fat areas between Guatemalan elderly women and their industrialized nation counterparts. There were corresponding differences of up to 10 cm^2 for the elderly men. For percent total body weight as fat, the San Pedro women had a median of 28.8%, while the median for men was 19.8%. This compares to, for example, medians of 39 and 26%, respectively, for Neapolitan women and men (20).

Biochemical values:

Table 8 presents descriptive statistics of the biochemical indices evaluated in the elders of San Pedro Ayampuc. When compared to criteria of subadequacy[3] for the various vitamins (provided by the Nutrition Evaluation Laboratory, where the samples were analyzed), striking patterns of subadecuacy are noted.

Riboflavin stands out for a major inadequacy, with 70% of all individuals having an activity coefficient greater than 1.29. It is interesting to note that it occurs in a fairly isolated way, that is, largely in the absence of major inadequacies of the other B vitamins. By way of comparison, activity coefficients for B1 and B6 were representative of subadequacy (greater than 1.29 and 2.15) in two and zero persons, respectively.

[3] Below this cut-off value, levels are considered to be low, although not necessarily deficient.

TABLE 8
BIOCHEMICAL NUTRIENT INDICES OF SAN PEDRO AYAMPUC ELDERS

	X ± S.D.	MEDIAN	RANGE	CRITERIA FOR SUB-ADEQUACY	% OF PERSONS W/SUB-ADEQUATE VALUES
RETINOL (µg/dl)	40.4 ± 14.3	39.2	0.4 - 85.1	< 30	21%
CAROTENE (µg/dl)	58.7 ± 28.2	54	5 - 126	< 40	30%
α-TOCOPHEROL (µg/dl)	821 ± 317	783	251 - 2146	<500	15%
RETINOL BINDING PROTEIN (mg/dl)	4.1 ± 1.3	4.0	1.2 - 9.8	<3.5	35%
PREALBUMIN (mg/dl)	20.6 ± 6.2	20.4	5.2 - 38.2	< 10	4%
VITAMIN B12 (pg/ml)	344 ± 354	234.5	27 - 2341	<200	38%
FOLATE (ng/ml)	5.2 ± 2.1	4.8	0.8 - 12.5	< 3	9%
THIAMIN (a.c.)	1.1 ± 0.1	1.0	0.77 - 1.33	>1.29	1%
RIBOFLAVIN (a.c.)	1.4 ± 0.2	1.4	1.01 - 1.85	>1.29	70%
VITAMIN B6 (a.c.)	1.6 ± 0.2	1.6	1.03 - 1.99	>2.15	0%
HEMATOCRIT (%)	40.3 ± 4.7	41	21 - 52	<37 (F) <39 (M)	18%

Presentation of biochemical indices by gender is shown in Table 9. A few significant differences by gender are noted.

TABLE 9
BIOCHEMICAL INDICES OF SAN PEDRO AYAMPUC ELDERS BY GENDER

	WOMEN		MEN		
	X ± SD	MEDIAN	X ± SD	MEDIAN	P <
RETINOL (μg/dl)	38.0 ± 12	37.0	43.3 ± 16	42.0	.02
CAROTENE (μg/dl)	58.2 ± 28	54.0	59.4 ± 29	52.0	NS
α-TOCOPHEROL (μg/dl)	864 ± 344	820	769 ± 289	773	.05
RETINOL BINDING PROTEIN (mg/dl)	3.8 ± 1.1	3.8	4.5 ± 1.4	4.4	.001
PREALBUMIN (mg/dl)	19.1 ± 5.2	19.8	22.4 ± 7	22.1	.001
VITAMIN B12 (pg/ml)	344 ± 330	242	344 ± 384	232	NS
FOLATE (ng/ml)	5.3 ± 2.2	4.9	5.0 ± 2.0	4.6	NS
THIAMIN (a.c.)	1.0 ± 0.08	1.05	1.0 ±0.09	1.04	NS
RIBOFLAVIN (a.c.)	1.4 ± 0.17	1.33	1.4 ±0.15	1.37	NS
VITAMIN B6 (a.c.)	1.6 ± 0.16	1.61	1.6 ±0.16	1.66	NS
HEMATOCRIT (%)	39.3 ± 4.5	40	41.4 ±4.7	42	.004

Women have lower mean values for retinol, retinol binding protein, α-tocopherol, prealbumin and hematocrit. Table 10 displays the biochemical nutrient indices by ethnic heritage, that is to say, divided according to self-identification as either indigenous or ladino. In all cases, the trend was that indigenous people had lower mean and median values than the ladinos. This variation may be explained by differences in

TABLE 10
BIOCHEMICAL INDICES OF SAN PEDRO AYAMPUC ELDERS BY ETHNIC HERITAGE

	X ± SD	MEDIAN	X ± SD	MEDIAN	P <
RETINOL (μg/dl)	39.5 ± 14	38.5	42.6 ± 15	40.5	NS
CAROTENE (μg/dl)	56.7 ± 28	51.5	63.7 ± 28	62.0	NS
α-TOCOPHEROL (μg/dl)	777 ± 275	772	921 ± 381	805	.02
RETINOL BINDING PROTEIN (mg/dl)	3.9 ± 1.2	4.0	4.4 ± 1.4	4.2	.04
PREALBUMIN (mg/dl)	20.0 ± 6.2	20.0	22.1 ± 6	22.2	.04
VITAMIN B12 (pg/ml)	301 ± 273	234.5	441 ± 481	248.5	NS
FOLATE (ng/ml)	5.2 ± 2.1	4.6	5.3 ± 1.9	4.9	NS
THIAMIN (a.c.)	1.0 ± 0.08	1.05	1.0 ±0.11	1.02	NS
RIBOFLAVIN (a.c.)	1.4 ± 0.14	1.37	1.3 ±0.19	1.33	NS
VITAMIN B6 (a.c.)	1.6 ± 0.16	1.63	1.6 ±0.18	1.65	NS
HEMATOCRIT (%)	39.4 ± 4.7	40	42.4 ±4.2	42	.000

socioeconomic standing and education noted in the census section above. Again, significant differences were observed for retinol binding protein, α-tocopherol, prealbumin, and hematocrit. Differences were noted, but did not quite achieve significance, for vitamin B12 and riboflavin ($p < 0.06$ for both). Given that there is a higher percentage of women (59%) in the indigenous group and a higher percentage of men (56%) in the ladino group, one might conclude that the disparities seen in Table 10 are explained by gender, and not by ethnic background. Analysis by ethnic group within gender supports this in the case of retinol binding protein and prealbumin, but not in the case of tocopherol or hematocrit. α-tocopherol levels are significantly different between indigenous and ladino women, but not between men; t-testing shows the p value for hematocrit to be less than 0.01 for differences between indigenous and ladino women and men, whether taken separately or as a group.

The various biochemical indices are not presented in tabular form by age group. The trend is toward lower values with increasing age for retinol, carotene, retinol binding protein, and prealbumin and to higher values with increasing age for folate and B12. However, the only significant differences by age group are seen with carotene, prealbumin and thiamin. For carotene, the younger elders (60-69 y) had a mean value of 65 $\pm$ 27 µg/dl, while those in the 70-79 group had a mean value of 51 $\pm$ 28 µg/dl ($p < 0.007$). The younger elders had a mean prealbumin value of 22.4 $\pm$ 6.2 mg/dl, as compared to 18.6 $\pm$ 5.6 and 18.7 $\pm$ 5.1 for the 70-79 year and 80 and over groups, respectively ($p < 0.0005$ in both cases). In the case of thiamin, the 70-79 year old group had a mean activity coefficient of 1.0 $\pm$ 0.09, significantly different from those of the other two groups ($p < 0.02$), who had values indicative of poorer B1 nutriture.

Finally, indices of vitamin nutriture were analyzed by tertiles of body mass index (Table 11). For this purpose, the

TABLE 11
BIOCHEMICAL INDICES BY TERTILES OF BODY MASS INDEX (BMI)

	BMI kg/m²	RETINOL µg/dl	CAROTENE µg/dl	RBP mg/dl
BMI 1	18.2 ± 1.2a	36.3 ± 13.4a	50.2 ± 23.8a	3.8 ± 1.3a
BMI 2	21.0 ± 0.8b	42.5 ± 15.5b	59.4 ±30.9ab	4.1 ± 1.3ab
BMI 3	25.0 ± 2.5c	43.1 ± 13.3b	66.7 ± 26.9b	4.4 ± 1.3b

	VITAMIN E µg/dl	PREALBUMIN mg/dl	FOLATE ng/ml	VITAMIN B12 pg/ml
BMI 1	665 ± 240a	18.4 ± 6.4a	5.3 ± 2.3a	286 ± 267a
BMI 2	802 ± 238b	21.6 ± 6.3b	4.7 ± 1.6a	277 ± 185a
BMI 3	1001 ± 377c	22.2 ± 5.3b	5.5 ± 2.2a	449 ± 490b

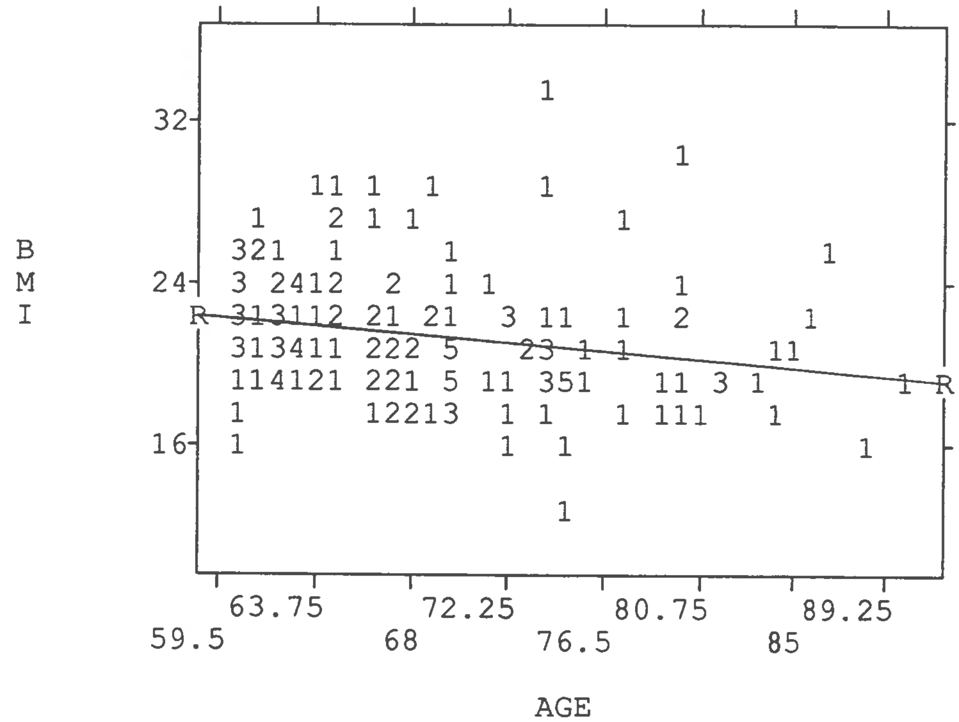
	THIAMIN a.c.	RIBOFLAVIN a.c.	VITAMIN B6 a.c.	HEMATOCRIT %
BMI 1	1.04 ±.08ab	1.40 ± 0.15a	1.64 ± 0.14a	39.2 ± 4.3a
BMI 2	1.06 ±0.10a	1.37 ± 0.16ab	1.62 ± 0.18a	40.0 ±5.4ab
BMI 3	1.02 ±0.08b	1.31 ± 0.17b	1.62 ± 0.18a	41.8 ± 4.3b

Within any given column and nutrient index, values accompanied by different letters are significantly different (p<.05)

population was divided according to body mass index, with those with the lowest values in the bottom third, and those with the highest values in the top third. Mean body mass index for the three groups were 18.2 ± 1.2, 21.0 ± 0.8, and 25.0 ± 2.5 kg/m^2 respectively. Notably, this is a fairly small range of body mass indices (see, for example, comparisons with other group of elders in Table 6). As seen in Table 11, the general tendency is to higher values with higher levels of body mass index. To see any sort of trend in this relatively homogenous group indicates that the tendency must be strong. Significant differences are seen for every nutrient but folate and pyridoxine.

As seen in Figure 2 below, body mass index is significantly and negatively correlated with age, although the correlation is not a particularly strong one.

FIGURE 2
PLOT OF BMI WITH AGE



158 cases plotted.
Correlation -.22764
y = -0.1(age) + 28.6
$p < 0.004$

Multiple regressions of the biochemical indices which show variations with body mass index grouping were therefore performed on independent variables body mass index and age to correct for the possibility that the trend seen might merely be a mask for age effects. For retinol, retinol binding protein, riboflavin, and hematocrit, the results of regression indicated that age could be dropped from the equation, that is to say, that the effect seen was due to the change in body mass index, and not any age effect. Results of regression indicated that both age and body mass index were significant determinants of carotene and prealbumin levels, although in each of these cases, the coefficient of the body mass index variable was more than twice as large as that for age. Last of all, it was shown that alpha-tocopherol levels varied strongly and significantly with age, but that body mass index had no relationship to this change.

Although many authors have studied both biochemical and anthropometric indices of nutritional status in their assessments (cf Ferro-Luzzi, Mensink and Arab, Sayhoun et al., and Woo), it is rare to attempt any correlation between the two type of indices. Woo et al. in China are among the very few who have done so, in their case evaluating the relationship between either prealbumin or retinol binding protein and corrected arm muscle area (79). Describing prealbumin and retinol binding protein as indices of protein status (a claim which has certainly been disputed), they found that both of those measures correlated well with arm muscle area, thus concluding that protein depletion is well reflected

TABLE 12A - PEARSON CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS OF ANTHROPOMETRIC WITH BIOCHEMICAL INDICES[a]: WOMEN

	WEIGHT	HEIGHT	CIRCUM	SKINFOLD	ARMUSC	ARFAT	%MUSC	%FAT	BMI	%TBF
AGE	-.2385 .027	-.2240 .038	-.2927 .006	-.1668 .122	-.2187 .042	-.0761 .483	.1235 .254	-.2244 .038	-.1693 .119	-.2646 .014
RETINOL	.3454 .001	.1443 .185	.3276 .002	.1303 .229	.3459 .001	.0920 .397	-.0734 .499	.1454 .182	.3214 .003	.2377 .028
TOCOPHERO L	.4325 .000	.1956 .071	.3777 .000	.2592 .015	.3729 .000	.2541 .018	-.1750 .105	.2063 .057	.3899 .000	.2908 .007
CAROTENE	.2223 .042	.0793 .473	.2415 .026	.0728 .477	.2733 .011	.0790 .472	-.0160 .885	.0545 .662	.2029 .064	.1083 .328
RBP	.3225 .002	.0653 .550	.2732 .010	.1237 .254	.2824 .008	.0859 .429	-.0799 .462	.1411 .195	.3414 .001	.2088 .054
PREALBUMI N	.4096 .000	.1774 .102	.3880 .000	.2000 .063	.3576 .001	.1337 .217	-.1298 .231	.2265 .036	.3755 .000	.3078 .004
B12	.1614 .138	.1939 .074	.1858 .085	.1064 .327	.1673 .121	.0957 .378	-.0623 .566	.1006 .357	.0809 .459	.1391 .202
FOLATE	.0512 .640	.1624 .135	.0026 .981	.0362 .739	-.0016 .988	.0476 .662	-.0274 .801	.0140 .898	-.0282 .796	.0074 .946
THIAMIN	-.1445 .195	-.0797 .477	-.1892 .087	-.1625 .142	-.0871 .434	-.1110 .318	.1199 .280	-.1813 .103	-.1210 .279	-.2032 .067
RIBOFLAVI N	-.2291 .038	-.2288 .039	-.1774 .109	-.1944 .078	-.1293 .244	-.1866 .091	.1501 .176	-.1604 .150	-.1389 .213	-.1702 .126
B6	-0456 .684	.0545 .627	-.0365 .743	-.0973 .382	.0402 .718	-.0440 .693	.0955 .391	-.1390 .213	-.0842 .452	-.1043 .351
HCT	.2993 .006	.2276 .037	.3385 .002	.1438 .076	.3552 .001	.1941 .075	-.1131 .303	.1451 .188	.2246 .040	.2339 .032

[a] Upper line is r value, lower is significance (p).

TABLE 12B - PEARSON CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS OF ANTHROPOMETRIC WITH BIOCHEMICAL INDICES*: MEN

	WEIGHT	HEIGHT	CIRCUM	SKINFOLD	ARMUSC	ARFAT	%MUSC	%FAT	BMI	%TBF
AGE	-.2306 .051	-.0228 .849	-.2637 .025	.0736 .539	-.3218 .006	.0098 .935	-.1515 .204	.1515 .204	-.3079 .009	.0567 .636
RETINOL	.1134 .343	.0167 .889	.2455 .038	-.1115 .351	.3068 .009	-.0571 .634	.1887 .112	-.1887 .112	.1315 .271	-.0977 .414
TOCOPHEROL	.4095 .000	-.0411 .732	.5225 .000	.2398 .043	.5105 .000	.3458 .003	-.0922 .441	.0921 .442	.5563 .000	.2243 .058
CAROTENE	.2028 .088	.0295 .806	.2840 .016	.0439 .714	.2996 .011	.1102 .357	.0432 .718	-.0433 .718	.2491 .035	.0569 .635
RBP	.2132 .072	.0042 .972	.3182 .006	.0941 .432	.3240 .005	.1497 .209	.0253 .833	-.0253 .833	.2790 .018	.0629 .600
PREALBUMIN	.2541 .031	.0423 .724	.4094 .000	.0276 .818	.4431 .000	.1094 .360	.1179 .324	-.1179 .324	.3171 .007	-.0033 .978
B12	.2737 .020	.2286 .053	.1228 .304	-.0030 .980	.1211 .311	.0514 .668	.0423 .724	-.0424 .724	.1761 .139	-.0408 .734
FOLATE	.0254 .832	.0243 .840	.0284 .813	.2785 .018	-.0524 .662	.2215 .061	-.3144 .007	.3147 .007	.0301 .802	.3040 .009
THIAMIN	-.1390 .244	-.1328 .266	-.0276 .818	-.2293 .053	.0174 .884	-.2095 .077	.2238 .059	-.2239 .059	-.1026 .391	-.1929 .105
RIBOFLAVIN	-.1935 .103	-.0123 .918	-.1262 .291	-.1419 .234	-.1030 .389	-.1653 .165	.1085 .364	-.1085 .364	-.2474 .036	-.1040 .385
B6	.0443 .712	.0477 .691	.0747 .533	-.0885 .460	.0870 .467	-.0531 .658	.1268 .288	-.1268 .288	-.0102 .932	-.1100 .358
HCT	.4206 .000	.2036 .086	.4997 .000	.1114 .351	.5104 .000	.2277 .054	.0127 .916	-.0128 .915	.4474 .000	.1535 .198

* Upper line is r value, lower is significance (p).

by muscle wasting. On the other hand, the authors make no mention of the effect of age on arm muscle area or on prealbumin and retinol binding protein levels, and as seen above, age may have more to do with the noted correlation than not.

In the present study, similar correlations were noted (Tables 12a & b). However, many significant correlations were noted amongst anthropometric and biochemical indices, not all of which appear to have any grounding in specific aspects of physiology or nutritional biochemistry.

As with the anthropometry data, it is worthwhile to compare the biochemical values discovered for the elders of San Pedro Ayampuc with those of other elders studied around the world[4]. Tables 13 & 14 show some of these comparisons.

In each population studied, the retinol levels for both men and women were found to be substantially higher than those of the San Pedro Ayampuc population. Unfortunately, most of the other studies did not evaluate retinol binding protein and carotenes at the same time. In Yearick's study (80), the ratio of mean carotenes to mean retinol is approximately 1.6, in Mensink's and Arab's work (55), the ratio is 2.2; here, the ratio is found to be just 1.4, and this in the context of

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[4] Again, these studies were done in persons over 60, with group mean ages of approximately 75. Numbers of subjects ranged from as low as 136 to as many as the thousands of the U.S. HHANES; most of the studies averaged about 400 subjects.

TABLE 13 - ACROSS POPULATION COMPARISON OF MEAN BIOCHEMICAL INDICES IN THE ELDERLY

	WOMEN				MEN				
	RETINOL (µg/dl)	CAROTENES (µg/dl)	RBP (mg/dl)	TOCOPHEROL (µg/dl)	RETINOL (µg/dl)	CAROTENES (µg/dl)	RBP (mg/dl)	TOCOPHEROL (µg/dl)	source
SAMPEDRANOS	38.0 ± 12	58.2 ± 28	3.8 ± 1.1	864 ± 344	43.3 ± 16	59.4 ± 29	4.5 ± 1.4	769 ± 289	
OREGONIANS[1]	89.8 ± 19.3	143.6 ± 69			89.9 ± 23.8	134.4 ± 61			80
BOSTONIANS[2]	67.8 ± 18.9			1248 ± 439	72.9 ± 18.0				46
BOSTONIANS	67.5 ± 21.4		5.7 ± 2.4	1020 ± 320	61.0 ± 19.8		5.0 ± 1.4	890 ± 280	69
MEXICAN AMERICANS[2]	48.0 ± 0.9				53.5 ± 0.9				53
CUBAN AMERICANS[2]	50.6 ± 0.9				58.6 ± 0.9				53
PUERTO RICANS[2]	49.2 ± 0.6				56.1 ± 1.1				53
GERMANS	54 ± 2	160 ± 9		1467 ± 72	54 ± 3	116 ± 6		1204 ± 41	55
DUTCH	37.2 ± 11.4				40.0 ± 14.3				54
ITALIANS	31.9 ± 12.8				31.9 ± 13.0				29

[1] More than half of the Oregon subjects were taking vitamin supplements

[2] Values were converted from published figures as follows:
retinol: µmol/l x 28.6 = µg/dl
α-tocopherol: µmol/l x 43 = µg/dl

TABLE 14 - ACROSS POPULATION COMPARISON OF MEAN BIOCHEMICAL INDICES IN THE ELDERLY

	WOMEN					MEN					
	FOLATE (ng/ml)	VITAMIN B12 (pg/ml)	THIAMIN (a.c.)	RIBOFLAVIN (a.c.)	VITAMIN B6 (a.c.)	FOLATE (ng/ml)	VITAMIN B12 (pg/ml)	THIAMIN (a.c.)	RIBOFLAVIN (a.c.)	VITAMIN B6 (a.c.)	Source
SAMPEDRANOS	5.3 ± 2.2	344 ± 330	1.0 ± .09	1.4 ±.15	1.6±.16	5.0 ± 2.0	344 ± 384	1.0 ± .09	1.4 ±.15	1.6 ±.16	
OREGONIANS	6.9 ± 5.5					6.9 ± 5.5					80
BOSTONIANS[1]	8.8 ± 4.3	402 ± 223			1.8 ±.20	8.2 ± 3.9	374 ± 186			1.8 ±.19	46
BOSTONIANS	10.5 ± 7.3	479 ± 327	1.1 ±.09	1.1 ±.10	1.8 ±.17	9.3 ± 5.9	529 ± 747	1.1 ±.09	1.1 ± .11	1.8 ±.21	69
GERMANS		390 ± 27	1.1 ±.01	1.0 ±.02			340 ± 24	1.1 ±.01	1.0 ±.02		55
DUTCH	3.2 ± 1.1	361 ± 193	1.71 ± .21	1.09 ± .10		2.9 ± 1.1	389 ± 186	1.7 ± .21			54
NEAPOLITAN[2]			1.07	1.04				1.07	1.11		20
ITALIANS			1.1 ±.06	1.2 ±.16				1.1 ± .06	1.2 ±.16		32
ITALIANS	9.0 ± 4.4			1.2 ±.12		8.6 ± 4.1			1.2 ±.14		29
CENTRAL AMERICANS	10.0 ± 3.6	361 ± 153				10.5 ± 3.6	292 ± 102				77
CHINESE				1.5 ±.16					1.5 ±.11		13

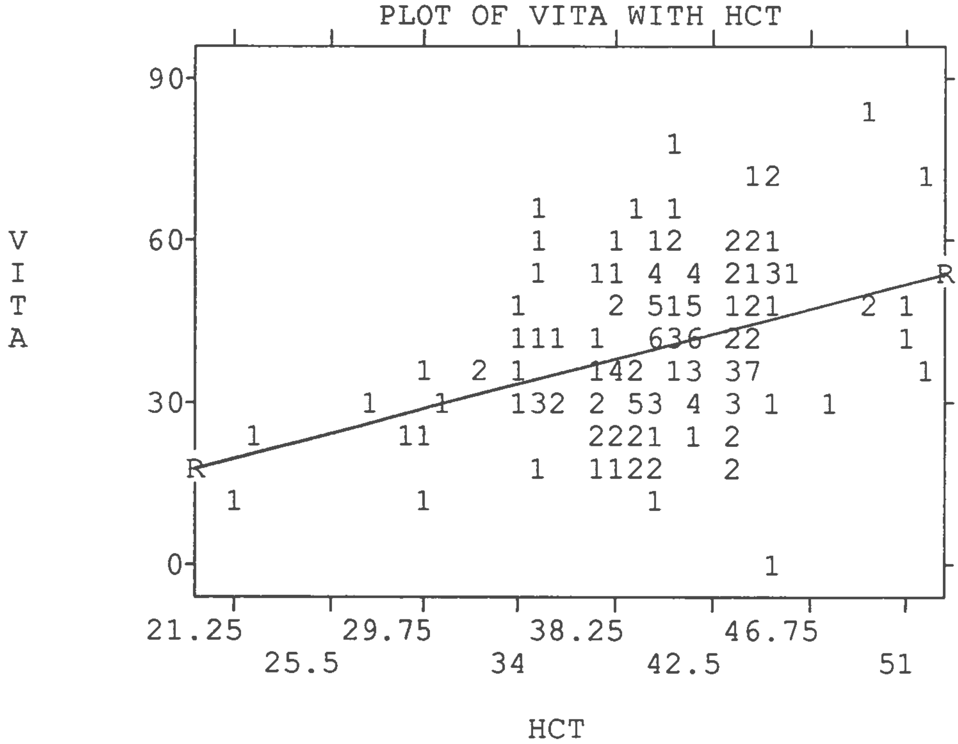
[1] Values were converted from published figures as follows:
folate: nmol/l x 0.44 = ng/ml
B12: pmol/l x 1.35 = pg/ml
[2] Median values; means were not available.

substantially lower values of both indices. In a study of vitamin A status and potential regulation of retinol binding protein, Mourey et al. (58) noted that, with each index expressed as μmol/l, the ratio of retinol to retinol binding protein was well under unity in children with deficiency (0.62 $\pm$ 0.31), and close to or greater than unity (1.09 $\pm$ 0.14) in other children. That relationship was not found to hold in the current study, in which the ratios were calculated to be 0.70 in elderly persons with retinol levels below 30 μg/dl, and 0.75 in elderly persons with adequate levels of retinol.

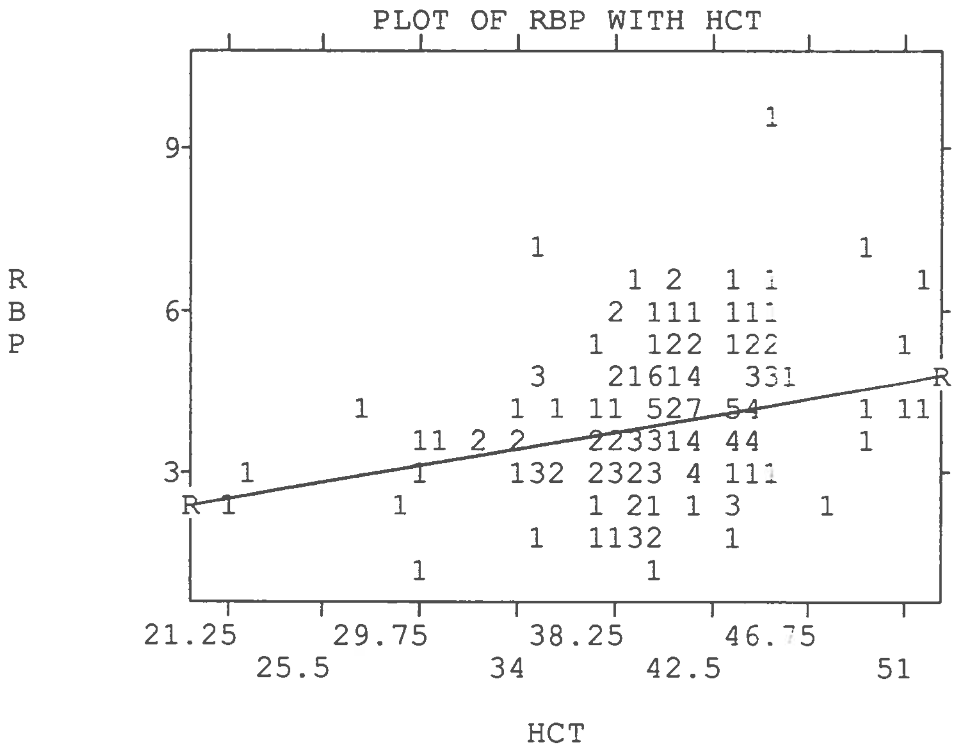
Other workers have attempted to elucidate some relationship between vitamin A and iron status (6), based on observations of many authors in the literature. In a cross-sectional study of Thai children, Bloen et al. determined that there is a relationship between biochemical indicators of vitamin A and iron status. Although they also studied more appropriate indices of iron nutriture (e.g. serum iron, transferrin, ferritin), this group did find significant associations between hematocrit and both retinol and retinol binding protein. Those findings are supported in the current study, in which linear regression of retinol and retinol binding protein on hematocrit produced r values of 0.3544 and 0.3099 respectively, with significance levels in both cases less than 0.0005 (Figure 3). Bloen et al (6) suggest that vitamin A enhances hematopoiesis and the availability of serum iron by depleting iron stores, and conversely, that a lack of vitamin A may immobilize iron stored in the reticuloendothelial system. Even excluding those subjects from the present study who have a hematocrit level below 34%, i.e. those who are frankly anemic, the correlation coefficients are 0.2583 and 0.2506, respectively ($p < .002$). This latter analysis indicates that the correlation may indeed be due to nutritional deficiency, as opposed to an effect exerted solely by the individuals who are anemic by virtue of a chronic disease or other condition.

FIGURE 3

PLOT OF VITA WITH HCT



161 cases plotted.
y = 1.1(hct) - 2.9
r = 0.3544
p < 0.0005



161 cases plotted.
y = 0.1(hct) + 0.6
r = 0.3099
$p < 0.0005$

Mean alpha-tocopherol levels in Sampedranos are also well below those of other populations studied; the mean and median levels for women are 864 ± 344 and 820 µg/dl, and those for men are 769 ± 289 and 773 µg/dl respectively. This compares to mean values of 1248 and 1111 µg/dl and 890 and 1020 µg/dl in two studies (46,69) of elder Bostonian women and men, and 1467 and 1204 µ/dl in older Germans. These reduced levels may be associated with lower tocopherol and/or fat intakes in Guatemala, a dietary characteristic that has been noted in numerous less-industrialized countries (43).

While mean folate levels in Sampedranos are well below others in Table 14, and specifically are only about 55% of those described as "normal" in the Central American population over 50 years of age, relatively few Sampedranos show an actual deficiency in folate. The minimum acceptable level of 3 ng/ml is not achieved by just 9% of the population. B12 levels are much more similar to levels found in the other population groups than are any of the other vitamins. This observation is consistent with the rarity of dietary deficiency of vitamin B12 (43).

Lastly, analysis of thiamin and riboflavin activity coefficients highlights that, as noted above, Sampedranos suffer from an isolated deficiency of riboflavin. And in fact, as can be seen from Table 14, both the mean and range of activity coefficients observed are well above those of the other populations studied. Activity coefficients for thiamin, however, are not substantially different from those seen in elders from other countries. Although I have no information on dietary intake to compare with the elders mentioned, the generally lesser consumption of meat, milk and dairy products (primary dietary sources of riboflavin) and the generally greater consumption of grains and legumes (primary dietary sources of thiamin) in elder Guatemalans *could* explain their variation in B1 and B2 nutriture.

Parasitic infestation:

Ascaris lumbricoides, Trichuris trichuria, and hookworm are the three most prevalent helminths to infect human beings worldwide (8,10,72,73). These three infections often occur concurrently, as they have similar predispositions, environmentally and individually[5]. In the present study, prevalence and intensity of just trichuris and ascaris were assessed. Stool specimens were examined for estimation of the number of helminth eggs per gram of feces. This has been validated as the most practical method for estimation of the intensity of infection in community-based surveys (33). The evaluation of infection intensity over mere prevalence is critical as many individuals may be lightly infected, whereas just a few may be predisposed to heavy infection which is more likely to result in clinical illness (8,9).

Ascariasis, like trichuriasis, is prevalent in warm, moist areas. The frequency of infection with ascaris, like that of trichuris, rises in areas with poor sanitation (73). The eggs are passed in human feces to the soil; infective eggs, passed from the soil to food and water, are ingested by other humans. In the human, the life cycle is complex, with larvae migrating from the duodenum to liver, heart, lungs, and trachea, where the 'cough and swallow' phenomenon places them back into the small intestine. In the small intestine, two to

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[5] It should be noted, however, that hookworm infection is unlikely to be prevalent in San Pedro Ayampuc because of its high altitude.

three months after initial ingestion, the larvae mature and produce eggs, up to 200,000 per day by a single female.

In areas where humans defecate indiscriminantly, or where human feces are used as manure, the soil becomes polluted with helminth ova and larvae. The fecal-oral route of infection is thus crucial in the persistence and recurrence of A. lumbricoides infections in humans. In endemic areas, A. lumbricoides ova and larvae can be demonstrated on commonly eaten raw fruits and vegetables (64). These foods serve as vehicles of ascaris infection, in the absence of careful preparation with uncontaminated water. Ascaris ova can also be transferred directly from fingers to mouth, although this tends to be less of a problem in the elderly population, due to better hygienic habits.

Trichuris infection also results from ingesting the infective eggs, either directly or indirectly via the soil. Different from ascaris, trichuris eggs require two to three weeks of embryonization in the soil before they become pathogenic to humans (28). The life cycle in the human is similar except that the trichuris larvae do not migrate from the small intestine.

Recently, a number of investigators (e.g. Forrester, Scott, Bundy, Cooper, Golden) have begun to look at potential predisposition to ascaris and trichuris infections, both at the individual and family level. In a study of trichuriasis in children, Bundy and Cooper concluded that predisposition may be determined by differential immunocompetence secondary to nutritional status, and by differential exposure to infection, secondary to sanitation. Furthermore, in analyzing results from children in a village community versus those in an institution, they concluded that heterogeneity in infection exposure is a more important determinant of predisposition than is heterogeneity in susceptibility (11).

In a study in Mexico (34), Forrester et al. found that persons heavily infected with ascaris or trichuris tend to become heavily reinfected after treatment, and that these people tend to be clustered in particular households. From this, the authors conclude that not only certain individuals, but certain households are predisposed to heavy infection. This finding is particularly important for the current study, as one attempts to explain prevalent helminthic infection in the elderly. In another study, this one in the West Indies, investigators (9) found that individuals intensely infected during their first observation period tended, after adequate treatment, to reacquire heavy worm burdens during the subsequent seventeen month period, whereas those persons initially lightly infected tended to re-acquire light infections. Standardizing for age, they conclude that individual predisposition to heavy of light T. trichuris infection is independent of host age; however, their study population included persons from two to merely fifteen years old and thus, this conclusion cannot be directly extrapolated to older adults. Infection predisposition does argue, though, for the existence of determinants of helminth infection success that are associated with characteristics specific to an individual host. These characteristics, as seen above, may range from differences in susceptibility secondary to individual nutritional or immune status, to variations in environmental exposure.

A study of helminth infestation in persons 1 to 90 years old in the marginal zones of Trujillo, Venezuela (56) is notable for its finding that there was no significant difference in the number of eggs per gram of feces between youngsters under the age of 15 and all adults over 15 years of age. The investigators suggest that this is a characteristic phenomenon in communities with high prevalence of helminth infection. Furthermore, they substantiate the idea of predisposition, noting that in each age group, there are heavily infected individuals who are responsible for the bulk of the environmental contamination.

As noted in a previous section, stool samples were collected from just 89 individuals, 55 women and 34 men. This small subsample may create a bias in results, as those persons aware of or concerned about gastrointestinal symptoms may have been more likely to participate in this phase of the study. Of the persons studied, 58 were infected with either Ascaris lumbricoides, Trichuris trichuria, or both. Of these 58, 26 were infected with both helminths (Table 15). Infection with either trichuris, ascaris, or both was more prevalently in women than in men, and in indigenous persons than in those of ladino identification.

TABLE 15
PREVALENCE OF HELMINTHIC INFECTION BY GENDER, ETHNIC HERITAGE AND AGE GROUP

	NOT INFECTED	ASCARIS ONLY	TRICHURIS ONLY	ASCARIS & TRICHURIS
WOMEN	15	6	14	20
MEN	16	6	6	6
INDIGENOUS	14	9	13	18
LADINO	17	3	7	8
60-69 YEARS	14	11	14	15
70-79 YEARS	14	0	4	10
80 YEARS & OVER	3	1	2	1
TOTAL	31	12	20	26

Due to large variation in infestation levels, median values are used to compare the various subgroups; those persons parasitized with both helminths had higher median infestation levels than those with either just ascaris or just trichuris. Strengthening the finding of higher prevalence of parasitization by gender, women are also more heavily *infested* with both parasites. Although this is not reflected by a significant difference between the means - due to a large standard deviation - the median values differ greatly. A similar tendency is seen between the ethnic groupings, where median infestation levels are more than three times as high for indigenous persons.

TABLE 16
INTENSITY OF HELMINTHIC INFECTION IN SAN PEDRO AYAMPUC ELDERS

	ASCARIS LOAD (eggs/g feces) (x ± s.d./median/range)	TRICHURIS LOAD (eggs/g feces) (x ± s.d./median/range)
INDIV. WITH ASCARIS INFECTION ONLY	5000 ± 4074 3900 600 - 13400	---
INDIV. WITH TRICHURIS INFECTION ONLY	---	673 ± 702 400 20 - 2600
INDIV. WITH BOTH ASCARIS AND TRICHURIS INFECTION	11183 ± 12224 7000 80 - 40600	784 ± 763 500 20 - 3000

TABLE 17
INTENSITY OF INFECTION BY GENDER, ETHNIC HERITAGE AND AGE GROUP

	ASCARIS INTENSITY x ± s.d.	ASCARIS INTENSITY median	TRICHURIS INTENSITY x ± s.d.	TRICHURIS INTENSITY median
WOMEN	6739 ± 10385	2600	642 ± 699	400
MEN	4511 ± 7973	1700	452 ± 755	150
INDIGENOUS	9948 ± 11136	6000	965 ± 787	800
LADINO	7469 ± 9796	2600	261 ± 177	200
60-69 YEARS	5455 ± 8544	2600	688 ± 760	400
70-79 YEARS	7811 ± 13309	1500	387 ± 622	200
80 YEARS & OVER	5800 ± 6856	4900	225 ± 206	250

For both helminths, median infection intensity was greater in the 60-69 age group than in the 70-79 year olds, although no statistical difference could be established between the means.

Few studies of parasitism in elderly people have been undertaken, and fewer still have examined, either cross-sectionally or longitudinally, any associations or interrelations of parasite prevalence and burden with indices of nutritional status. In a Nigerian study (1), 44% of the overall study population of 487 persons was found to be infected with A. lumbricoides, and 31% with T. trichuria. The proportion in the subgroup of 102 adults over 51 years of age was quite similar, 43 and 31% respectively. Prevalence of infection for women and men was almost identical for both parasites, contrary to my findings.

Kan, in West Malaysia, investigated the prevalence of soil-transmitted helminthiases among the inhabitants of a plantation (48). Of a total 819 individuals, 34% were infected with ascaris and 36% with trichuris. However, in this study, the subgroup of 86 adults over 51 years of age showed a lower prevalence of infection, 14% with ascaris and 16% with trichuris. And, as seen with the Sampedrano elders, a greater proportion of women were parasitized as compared to the men in the older age groups, although that finding did not reach statistical significance for the Malaysians. Among the older plantation inhabitants, 57% of the infected elders had single infections, 24% had double infections, and 19% were infected with all three helminths studied. The parasitized San Pedro elders had a comparable single infection proportion of 55%, and a double infection proportion, with ascaris and trichuris both, of 45%. We did not examine for hookworm, a helminth of quite low prevalence at the altitude of San Pedro Ayampuc, so it is impossible to compare the double and triple infection distributions.

As mentioned above, few studies of parasitism in elders have been undertaken, and the remainder of the studies mentioned here were done in children. In a review of trichuriasis in children, Bundy (8) found that the ten percent of most heavily infected children had significant growth deficits, seen as height for age, compared to the remainder of the children. The same association was not seen with intense A. lumbricoides infection, leading him to conclude that the association is not with worm burden in general, but with trichuriasis in particular. "The facts that reduced height-for-age is more strongly associated with trichuriasis than weight-for-age, and that mid-upper arm circumference is not affected at all," states Bundy, "argue for a chronic inhibition of growth rather than for an acute wasting disease" (8, pg 709). While from the present study of elders in San Pedro Ayampuc it certainly cannot be concluded that these same individuals have been infected with trichuris since childhood, it is remarkable to note analogous associations. With data dichotomized into groups of individuals with trichuris infection and those without, both mean height and mean weight are seen to be significantly greater in the group that is not infected. Simple linear regression of intensity of trichuris infection on height reveals an r value of -0.2179 at $p < 0.043$ whereas the same exercise with ascaris intensity shows no significant association. At the same time, there is a slightly stronger negative correlation ($r = -0.2245$, $p < 0.037$) between intensity of trichuris infection and weight, but no significant association between infection intensity and mid-upper arm circumference.

TABLE 18
MEAN WEIGHT AND MEAN HEIGHT BY TRICHURIS INFECTION STATUS

	TRICHURIS POSITIVE	TRICHURIS NEGATIVE	P VALUE <
MEAN WEIGHT (kg)	45.4 ± 8.2	50.4 ± 9.0	.008
MEAN HEIGHT (cm)	145.8 ± 8.5	149.9 ± 9.2	.033

Taren et al. (75) studied three to six year olds in the Republic of Panama, and determined that plasma levels of vitamin A and carotenes were significantly lower in ascaris-infected as compared to uninfected children, as was the percent hematocrit. These authors report similar findings in a number of other of studies of children, both in Panama and India. In the present study, no such difference was noted. In a study of twelve Chilean school children parasitized with A.

lumbricoides, Krause et al. (51) reported a significant increase ($p< 0.001$) in hematocrit and plasma vitamin A levels after appropriate treatment with mebendazole. This study lends support to the notion that ascaris infection may impair vitamin A absorption. The finding of increased hematocrit may harken back to the proposal by Bloen et al. (see above) that vitamin A increases the availability of serum iron and enhances hematopoiesis.

In summary, women, and indigenous persons as a whole, are more prevalently and more heavily parasitized than are men, or ladino individuals as a group. These observations may be due to gender and ethnic heritage serving as markers for educational and/or socioeconomic characteristics, to differential exposure to infection for women and men, or to as yet unexplored factors.

Persons with both infections tended to be more heavily parasitized than those with just one helminthic infection. Again, it is difficult to draw conclusions without concrete data, but one may postulate a differential in efficiency of immune mechanisms, or merely a synergistic effect of dual parasitization.

No differences in biochemical indices of nutritional status could be discerned on the basis of grouping by helminthic infection. From this, one may conclude that there is no relationship between the nutrients studied and parasitization prevalence or intensity. Finally, the present descriptive study does provide indirect support for the notion that there exists an individual predisposition to helminthic infection.

SUMMARY AND GENERAL CONCLUSIONS

In conclusion, this descriptive study of the over 60 population of San Pedro Ayampuc, Guatemala presents data about a sector of the world population that has long been overlooked, the elderly of a developing Latin American republic. Data are presented regarding socioeconomic factors, body size and composition, biochemical nutrient levels, and prevalence and degree of helminthic infection.

Limitations of the data set include the fact that it was drawn from a cross-sectional study, and that the San Pedro Ayampuc population is not necessarily representative, either in age or in other characteristics, of the elderly Guatemalan population as a whole. On the other hand, this descriptive data is useful in that it provides a foundation to which other investigators may compare their own correlations and a springboard from which they may derive further relationships to be examined.

Without a doubt, this population of rural elderly are both shorter in stature and substantially leaner than their counterparts in more industrialized nations. This may be due to chronic energy malnutrition in the early years combined with continuing active lifestyles in the later years of life. Highly significant differences across gender were noted for every anthropometric index except for mid-arm circumference, women being lighter, shorter, and having a greater proportion of fat mass than their male counterparts.

In terms of biochemical assessment, fewer differences were noted among genders, age and ethnic groups within the Sampedrano population than were noted in the anthropometric assessment. Indices of vitamin nutriture were found to vary significantly by tertiles of body mass index, with a tendency to higher values with higher levels of body mass index.

Compared to other groups of elders, studied in industrialized nations, biochemical nutrient levels in this group were substantially lower. However, riboflavin was the only vitamin which stood out for a strong dietary deficiency. This may be due to the generally low consumption of meat, milk and other dairy products by these Guatemalan elders.

Helminthic infestation was found to be both more prevalent and more intense in women and indigenous persons than in men or ladinos. While gender and ethnic heritage may serve as markers for certain characteristics, and while women and men may have different exposures to infection, the true basis for the above observation was not discovered in the current study. Lastly, although no differences in biochemical indices of nutritional status were found on the basis of grouping by helminthic infection, support is provided for the existence of individual predisposition to helminthic infection.

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