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A COMPARISON OF ANTHROPOMETRICS, BIOCHEMICAL VARIABLES AND NUTRIENT INTAKE BETWEEN YOUNG AND ELDERLY RURAL PAKISTANI MEN

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Abstract: Aging health is associated with nutritional changes which are not well understood or investigated in developing countries, and were therefore evaluated in this study by comparing the nutritional status of elderly with young subjects in Peshawar, Pakistan. *Subjects:* The participants in this study were young and elderly men (n=50 each), represented by each of the four BMI categories (obese, overweight, normal weight, underweight). *Methods:* Anthropometrics (height, weight, body mass index (BMI), percent body fat (%BF) were measured; nutrient intake was assessed by 24 hr Dietary Recall (24-hr DR); clinical chemistry variables (albumin, total protein, triglycerides, CRP, ferritin) in plasma were analyzed on a Modular Analytics SWA automated analyzer. *Results:* Our results show no significant differences in mean weight, waist circumference (WC) and waist to hip ratio (WHR) between young and elderly ($p \geq 0.005$). Mean %BF of elderly was significantly ($p=0.02$) higher than young. Of the sample, 10% and 34%, respectively, of the elderly fall either in high risk categories of WC (HR-WC) or WHR (HR-WHR). Intake of almost all nutrients studied was significantly higher in young compared to elderly ($p < 0.005$). There were differences in plasma factors but only the mean plasma CRP level was significantly higher in the elderly ($p=0.0376$). With increasing age, there was a significant increase in % BF and CRP ($p=0.0160$ and 0.0222, respectively) but decrease in energy intake ($p= 0.0001$). BMI decreased with age but not significantly ($p=0.5821$). *Conclusions:* The elderly had relatively poor nutritional status as compared to the young. Great variations existed in WC, WHR, %BF and nutrient intake within different BMI categories of young and elderly. These results suggest almost the same poor nutritional status of elderly as reported in most developed and developing countries.

Key words: Nutritional status, elderly, anthropometry, body fat.

Introduction

The numbers of elderly people, potentially the most vulnerable group for malnutrition (1), are increasing in developing countries like Pakistan (2, 3). Poor dentition (2), neuropsychological problems and decreased mobility at older age directly affect nutritional status (4). Poor health and disability (5) are linked to nutritional risk indicators, which often lead to poor nutritional status in old age.

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The prevalence of malnutrition (both under- and overnutrition) is increasing in many countries in the elderly population (6, 7). Obesity is associated with increased mortality, metabolic and cardiac disorders (8) and contributes to functional decline and disability in the elderly (9). At the same time, a significant number of older individuals are reported to suffer from underweight (10) and to be at higher risk for acute illness and death.

Anthropometry and clinical chemistry variables are good indicators of nutritional status (11). Body mass index (BMI), waist circumference (WC) and waist-to-hip ratio (WHR) are simple anthropometric indices for assessing the amount and distribution of body fat (12-14), which additionally can help in risk assessment for many health problems. Low BMI is indicative of chronic energy deficiency and malnutrition, and is associated with compromised immune function, increased susceptibility to infections, and reduced survival among the elderly (8). In addition, there are well-documented links between adiposity, measured by WC and/or WHR, and the risks of obesity-related conditions including type-II diabetes, hypertension and coronary heart disease (CVD). These links may remain intact even once BMI is adjusted for age and other variables, demonstrating that measures of central adiposity are independent predictors of future obesity-related diseases (15-18). It is customary to categorize individuals in various risk categories for these diseases based on WC as: low risk (WC<89 cm), moderate risk (WC=90–99 cm) and high risk (WC≥100 cm). For WHR, these risk categories are usually defined as: low risk (WHR< 0.89), moderate risk (WHR= 0.90 – 0.94) and high risk (WHR ≥ 0.95) (17, 18).

Similar to other developing countries, Pakistan can be expected to experience the impact of an increasingly aged population over the next few decades. Essential information about peoples' food intake and habits, activity, cultural influences, and the socioeconomic situation provide a fundamental base for nutritional assessment. Our main objective in the present study was to investigate the overall nutritional status of elderly people in rural Pakistan. We were also interested to compare nutritional status of these elderly with young from the same family in order to ascertain whether malnutrition runs in families within the same socioeconomic background.

Materials and methods

Study Site and Sample Selection

For the current study we used a sub-sample from our previous study conducted during 2008-09 in Peshawar, Pakistan (15). We selected a convenient sample of 50 families and from each family we selected one young and one elderly subject fulfilling the inclusion criteria. Clinically healthy subjects were included when they had no history of disease and were not regularly taking any drugs. Based on their BMI values (1), young and elderly subjects fell into one of four BMI categories i.e., obese (OB; BMI ≥ 30; N=12), overweight (OW; BMI=25-30; N=12), normal weight (NW; BMI = 18.5 – 24.9; N=14) and underweight (UW; <18.5; N=12). In the present study, in most cases young and elderly were close relatives like son and father or grandson and grandfather. Selection of one young and one elderly person from the same family was deliberately done in order to minimize the effects of possible confounding factors like genetic and socio-demographic variations.

Anthropometric Data

Detailed procedures for collection of data on anthropometric measurements, body composition and nutrient intake are reported elsewhere (15). Briefly, age was assessed from the official records of the subjects (the National Identity Card, NIC). Weight and height were measured and BMI (Body Mass Index) was calculated as: weight/height^2 (kg/m^2) (1). WC and HC (waist and hip circumferences) were measured in accordance to the standard procedures (16). Percent body fat (%BF) was assessed using Futrex-5000 according to the procedures recommended by the manufacturer (Futrex®, Hagerstown, MD) (15). Based on their WC and WHR values, subjects were grouped into one of three risk categories. For WC, the risk categories were defined as: low risk (LR, WC; <89 cm), moderate risk (MR, WC; 90 – 99 cm) and high risk (HR, WC; ≥100 cm). For WHR, the risk categories were defined as low risk (LR, WHR; < 0.89), moderate risk (MR, WHR; 0.90 – 0.94) and high risk (HR, WHR; ≥ 0.95) (17-19). Similarly, on the basis of their body fat, subjects were divided into any of the three categories i.e., low fat (LF, % BF; <10%), normal fat (NF, % BF; 10-25%) and high fat (HF, % BF; >25%) (14).

The dietary data were collected using 24-hr dietary recalls (24-hr DRs) through face-to-face interviews. These 24-hr DRs were repeated three times over the three alternative days of a week (15). From information of 24-hr DR, nutrient intakes were computed using an in-house nutrient calculator (using Microsoft Office Excel 2003, USA) based on the data of food composition tables for Pakistan (20).

Clinical Chemistry Analysis

Blood samples were collected by a trained medical technician; plasma was separated by centrifugation at 1200 g and stored in a -80°C freezer in the Department of Human Nutrition, Agriculture University Peshawar. These samples were shipped on dry ice to the Center for Medical Research (ZMF), Tübingen University, Germany, where they were stored at -80°C until further analysis. Albumin, ferritin, C-reactive protein (CRP), triglycerides and total protein concentrations were measured on a Modular Analytics SWA automated analyzer system according to the manufacturer's recommendations (Roche Diagnostics, Mannheim, Germany). All the clinical chemistry analyses were performed in the facilities of Department of Clinical Chemistry, University Medical Center Göttingen, Germany.

Statistical Analysis

All anthropometric measurements were made in duplicate and the means of paired values were used in the analyses. The data were statistically analyzed using JMP (Version 7.0. SAS, USA) and GraphPad (5.0). As the current study involved four BMI categories, mean values of nutrient intake in these categories were taken for one-way analysis of variance (ANOVA), and post-hoc comparisons with Dunnett's test taking the normal weight group as reference. BMI-adjusted partial correlation coefficients were calculated to establish associations between anthropometric measurements, clinical chemistry and nutrient intake.

The study was approved by the Board of Studies, Department of Human Nutrition, Agriculture University Peshawar. Written informed consent was obtained from all the participants before the start of the study.

Results

Age, anthropometric measurements, nutrient intake and selected plasma factors of young and the elderly subjects are shown in Table 1. Young men had higher BMI and WHR while elderly men had higher body weight, WC and % BF. However, the only statistically significant difference between young and elderly was in % BF (p=0.02). There were significant differences in nutrient intake between young and elderly ($p<0.05$, Table 1); the former had significantly higher intake of almost all nutrients.

Young and elderly subjects were stratified into four BMI groups. Table 2 and Table 3 show mean (±SD) age, anthropometrics, nutrient intake and selected plasma factors of the four BMI groups of young and elderly, respectively. For both age groups, there were no significant differences in mean age of the subjects in any of the four BMI categories (p, for all trends ≥0.05). Both in young and elderly, weight, WC, WHR and % BF of the three BMI categories differed significantly ($p<0.05$) compared to their respective NW BMI categories. Comparison of energy and protein intake between the three BMI categories (OB, OW, UW) of young vs. NW young were as follows: for energy, OB young had significantly higher intake (p= 0.007); OW young tended to have higher intake (p=0.295); UW young had significantly lower intake (p=0.001); for protein, OB and OW young tended to have higher intake (p=0.591 and 0.075, respectively), while UW young had significantly lower intake compared to NW young (p=0.001). In the elderly, however, only protein intake of people in the OB group did not differ significantly compared to NW (p=0.0566), while energy intake differed significantly between the three BMI vs. the NW BMI categories ($p<0.05$).

Young and elderly in the matched BMI categories were compared for their anthropometrics, nutrient intake and plasma chemistry and the results are shown in Figures 1 and 2 and Table 4. Great variations of significant differences in these parameters of BMI matched young and elderly were observed as summarized in Table 4.

Table 1 and Table 2, respectively, also show mean (±SD) values of selected plasma factors of young and elderly men in the four BMI categories. Within young, no significant differences were noted in the plasma chemistry between the three BMI vs. NW BMI (p, for all trends≥0.05), whereas in UW elderly both albumin and ferritin levels were significantly lower than the NW elderly (p=0.0005 and 0.0501, respectively).

For both young and elderly, the WCs and WHRs were divided into three groups. Figures 3A and 3B depict percent frequencies of young and elderly subjects with low, moderate and high risk based, respectively, on their

Table 1

Mean (SD) age, anthropometric measurements, nutrient intake and plasma biochemicals

	Young		Elderly		
	Mean	**Range**	**Mean**	**Range**	**p-value[1]**
Anthropometry					
Age (years)	24.2 (3.43)	18.0 - 29.2	67.3 (8.77)	50.1 – 85.5	-
Weight (Kg)	67.6 (14.02)	45.3 - 92.4	68.7 (14.57)	46.0 – 97.0	0.7329
BMI (Kg/m^2)	25.0 (5.37)	16.3 - 33.4	24.2 (5.47)	15.4 – 33.8	0.5056
WC	82.1 (11.20)	64.1-102.2	86.7 (12.39)	62.1- 113.2	0.0735
WHR	1.0 (0.11)	0.70 – 1.17	0.9 (0.12)	0.67 – 1.21	0.3676
%BF	17.7 (8.48)	5.5 – 33.1	21.3 (7.99)	9.0 – 32.6	0.0200
Nutrient intake					
Energy (Kcal)	2344 (498.8)	1262 - 3280	1778 (479.9)	659 -2487	<0.0001
Protein (g)	48.8 (11.39)	29.5 – 77.2	37.6 (12.19)	14.6 – 68.6	<0.0001
Fat (g)	111.5 (38.97)	53 – 222	61.5 (25.07)	14.5 -149.2	<0.0001
Fiber (g)	6.3 (2.46)	1.0 – 12.0	5.0 (1.95)	1.0 – 10.0	0.0155
Calcium (mg)	485.8 (155.89)	227 – 819	344.6 (102.54)	133.0 – 664	<0.0001
Phosphorus (mg)	753.5 (148.23)	490 – 1147	550.6 (179.39	215.0 – 1037.0	<0.0001
Iron (mg)	15.2 (4.38)	7.0 – 27.0	12.1 (5.42)	3.0 – 25.0	0.0021
Zinc (mg)	9.8 (4.97)	0.5 – 23.5	7.6 (3.95)	0.5 -18.5	0.0181
Vitamin A (RE.μg)	234.6 (70.88)	51.0 – 354	227.5 (83.13)	92.0 – 469.1	0.0688
Vitamin C (mg)	32.4 (7.78)	21.0 – 52.0	25.2 (6.40)	13.0 – 41.1	<0.0001
Thiamin (mg)	0.9 (0.26)	0.50 – 1.40	0.7 (0.15)	0.5 – 1.1	0.0221
Riboflavin (mg)	0.7 (0.32)	0.20 – 1.40	0.5 (0.28)	0.10 – 1.40	0.0761
Cholesterol (mg)	156.0 (78.42)	35.0 – 352.0	172.3 (109.21)	22.0 – 488.1	0.0811
Blood Chemistry					
Albumin (g/dL)	3.7 (0.48)	1.93 – 4.7	3.6 (0.64)	1.91 – 4.65	0.3537
Total protein (mg/dL)	5.9 (0.56)	3.1 – 7.3	5.7 (0.76)	3.11- 7.33	0.2131
Triglycerides (mg/dL)	117.7 (67.71)	26.0 – 344.0	109.1 (58.33)	26.0 – 296.1	0.6171
C-Reactive Protein (mg/L)	2.0 (2.38)	0.1 – 17.2	2.4 (1.41)	0.10 – 5.7	0.0376
Ferritin (mg/dL)	72.6 (52.86)	40.2 – 206.6	79.8 (43.68)	9.29 – 196.8	0.2962

1. Significant at p <0.05

Table 2

Mean (SD) of anthropometrics, nutrient intake and blood biochemicals in the four BMI categories of the young

	OB	OW	NW	UW	P-value[1] OB-NW	OW-NW	UW-NW
Age & Anthropometry							
Age (years)							
Weight (Kg)	81.6 (4.1)	76.6 (5.5)	60.7 (6.6)	52.3 (7.5)	0.0002	0.0005	0.0035
BMI (Kg/m²)	31.5 (0.8)	28.5 (2.0)	22.9 (2.6)	18.5 (2.0)	<.0001	<.0001	<.0001
WC (Cm)	96.2 (1.9)	87.1 (6.5)	77.2 (8.0)	70.9 (5.4)	<.0001	0.0040	0.0028
WHR	1.0 (0.02)	1.0 (0.1)	0.9 (0.1)	0.9 (0.1)	<.0017	0.0023	0.0027
% BF	29.6 (1.8)	21.7 (3.0)	14.2 (3.1)	7.8 (2.8)	0.0021	0.0201	<.0001
Nutrient Intake							
Energy (Kcal/day)	2847 (383.6)	2512 (364.3)	2305 (283.1)	1804 (326.1)	0.007	0.295	0.001
Protein (g)	52.9 (8.8)	48.8 (8.0)	56.6 (10.2)	37.1 (7.8)	0.591	0.075	0.001
Blood Chemistry							
Albumin (g/dL)	3.7 (0.4)	3.6 (0.6)	3.8 (0.5)	3.7 (0.6)	0.6040	0.3272	0.545
Total protein (mg/dL)	5.5 (0.5)	5.5 (0.8)	5.9 (0.8)	5.9 (0.9)	0.4712	0.4588	0.9951
Triglycerides (mg/dL)	112.0 (36.8)	117.8 (86.5)	117.8 (84.1)	122.3 (54.9)	0.3514	0.5326	0.8798
C-Reactive Protein (mg/L)	2.1 (0.4)	1.5 (0.5)	1.8 (0.8)	2.3 (0.4)	0.8886	0.9997	0.4731
Ferritin (mg/dL)	81.7 (43.5)	61.3 (45.3)	64.1 16.8)	60.6 (14.6)	0.5025	0.4008	0.3501

1. Significant at $p < 0.05$

Table 3

Mean (SD) of anthropometrics, nutrient intake and blood biochemicals in the four BMI categories of the elderly

	OB	OW	NW	UW	P-value OB-NW	OW-NW	UW-NW
Anthropometry							
Age (years)							
Weight (Kg)	88.1 (6.63)	72.1 (6.54)	62.0 (9.59)	53.6 (4.63)	<.0001	0.0025	0.0135
BMI (Kg/m²)	31.7 (1.28)	26.4 (1.59)	21.2 (2.22)	17.7 (0.78)	<.0001	<.0001	<.0001
WC (Cm)	100.2 (7.81)	92.2 (3.89)	83.4 (4.88)	71.5 (9.23)	<.0001	0.0056	0.0001
WHR	1.08 (0.08)	0.99 (0.06)	0.89 (0.04)	0.79 (0.72)	<.0001	0.0008	0.0027
% BF	31.1 (1.04)	24.7 (2.54)	19.6 (4.13)	10.2 (0.81)	<.0001	<.0001	<.0001
Nutrient Intake							
Energy (Kcal/day)	2202.2 (133.9)	1935.3 (235.3)	1655.2 (128.4)	1172.3 (393.7)	<.0001	0.0148	<.0001
Protein (g)	37.10 (5.96)	36.2 (7.63)	45.6 (11.91)	25.9 (8.66)	0.0566	0.0305	<.0001
Blood Chemistry							
Albumin (g/dL)	3.70 (0.34)	3.60 (0.45)	3.93 (0.36)	3.03 (0.91)	0.6040	0.3272	0.0005
Total protein (mg/dL)	5.53 (0.44)	5.52 (0.77)	5.90 (0.89)	5.96 (0.81)	0.4712	0.4588	0.9951
Triglycerides (mg/dL)	124.7 (47.7)	117.8 (86.5)	91.4 (34.6)	105.4 (56.7)	0.3514	0.5326	0.8798
C-Reactive Protein (mg/L)	3.39 (1.51)	2.23 (1.37)	2.27 (0.52)	1.63 (0.43)	0.0386	0.9997	0.4731
Ferritin (mg/dL)	99.8 (53.6)	79.8 (41.5)	77.1 (36.6)	59.2 (32.5)	0.5025	0.4008	0.0501

1. Significant at $p < 0.05$

Table 4

Summary of p-value statistics for comparison of anthropometrics, nutrient intake and plasma factors in the same BMI categories of young versus elderly

	OB young – OB elderly	OW young – OW elderly	NW young – NW elderly	UW young – UW elderly
Anthropometrics				
WC (cm)	0.074	0.0257	0.0168	0.7280
WHR	0.1927	0.2971	0.5625	0.0921
%BF	0.0501	0.0035	0.0018	0.0005
Nutrients				
Energy (Kcal)	0.0072	0.0067	<0.0001	0.0032
Protein (g)	0.0027	0.0012	0.1081	0.0281
Fat (g)	0.0022	0.0004	0.0660	0.0002
Fiber (g)	0.6799	0.0308	0.0067	0.0280
Calcium (mg)	0.0018	0.0211	0.0051	0.0781
Phosphorus (mg)	0.0041	0.0003	0.0431	0.0022
Iron (mg)	0.0319	0.0432	0.1595	0.0114
Zinc (mg)	0.0979	0.5046	0.3210	0.0219
Vitamin A (RE.μg)	0.3864	0.0367	0.0731	0.0833
Vitamin C (mg)	0.0559	0.0782	0.0021	0.0002
Thiamin (mg)	0.0004	0.1382	0.1299	0.2112
Riboflavin (mg)	0.0167	0.0051	0.8121	0.7233
Biochemicals				
Albumin (g/dL)	0.7068	0.0842	0.6290	0.0496
Total Protein (mg/dL)	0.7942	0.3266	0.7130	0.7431
Triglycerides (mg/dL)	0.2134	0.1660	0.2123	0.4555
C-Reactive Protein (mg/L)	0.0014	0.2122	0.0812	0.3104
Ferritin (mg/dL)	0.0855	0.3398	0.0432	0.5253

WC, Waist Circumference; WHR, Waist to Hip Ratio; % BF, % Body Fat. Significant at $p < 0.05$.

WC and WHR values. Similarly, the percent number of young and elderly subjects with low fat, normal fat and high fat are depicted in Figure 3C.

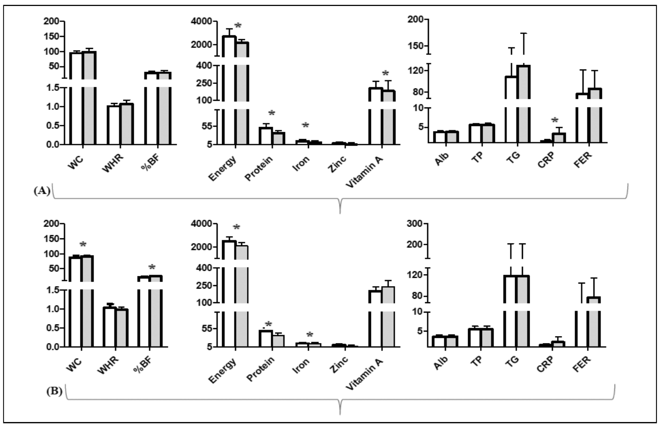

Figure 1. Percentages of young (white bar) and elderly (grey bar) subjects in each of three WC (A), WHR (B) and % BF (C) categories. HR, High Risk; LR, Low Risk; MR, Moderate Risk, HF, High Fat; LF, Low Fat; NF, Normal Fat. For WC, the risk categories were defined as: low risk (LR-WC), moderate risk (MR-WC) and high risk (HR-WC). For WHR, the risk categories were defined as low risk (LR-WHR), moderate risk (MR-WHR) and high risk (HR-, WHR) similarly, on the basis of body fat, subjects were divided into three categories i.e., low fat (LF, % BF), normal fat (NF, % BF) and high fat (HF, % BF).

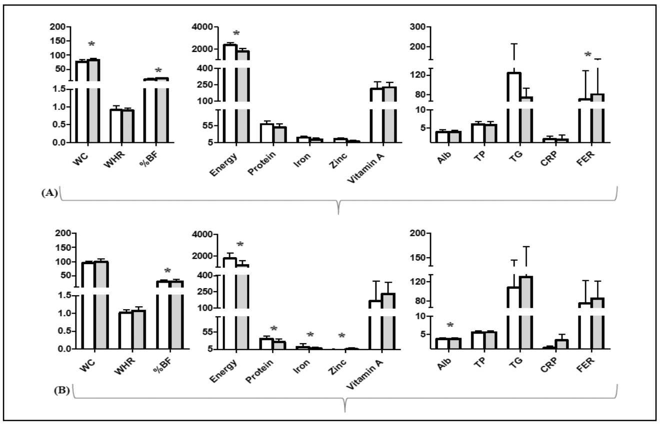

Figure 2. Comparison between young (white bar) and elderly (grey bar) for their anthropometrics, nutrient intake and plasma concentrations. (A) Obese young vs. Obese elderly; (B) Overweight young vs. Overweight elderly. The asterisk (*) shows significant differences at p<0.05.

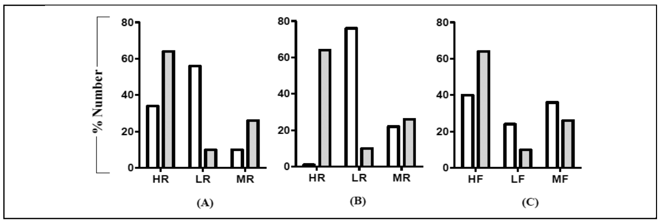

Figure 3. Comparison between young (white bar) and elderly (grey bar) for their anthropometrics, nutrient intake and plasma concentrations. (A) Normal weight young vs. Normal weight elderly; (B) Underweight young vs. Underweight elderly. The asterisk (*) shows significant differences at p<0.05.

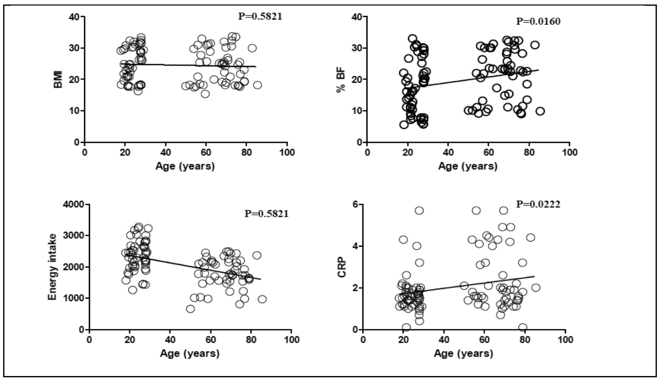

Figure 4. Correlation analyses of age with BMI, % BF, energy intake and CRP. Correlations significant at p<0.05.

Discussion

The effects of aging on nutritional status have been extensively investigated but almost exclusively in so-called "WEIRD" subjects (Western, educated, industrialized, rich, and democratic). It is not well established whether changes in nutritional status with aging found in these populations are representative of the rest of the elderly, who live in developing countries. The main objective of this study was to compare anthropometric measurements, intake of selected nutrients and plasma clinical chemistry of young and elderly rural Pakistani men. The exclusion of a female group in our study is due to difficulties to access this population mainly arising from traditional constraints. Most of the young participants (70%) were selected as close family members of the elderly subjects living in the same household. This selection criterion was adopted purposefully in an attempt to minimize the effects of genetic variations, socioeconomic differences and access to nutrients which may affect the nutritional and health status. A second objective was to compare these parameters within the four BMI categories of young and elderly subjects in order to investigate any possible differences in these parameters within different BMI categories. In the third objective, we wanted to see whether these age-associated changes in nutritional status of the elderly in a developing society are comparable to those seen in "WEIRD" populations. Finally we will be correlating these parameters with assessments of immune status (manuscript in preparation).

All the anthropometric measurements included in this study are related to their expected associations with food habits, health and well-being (21). Weight, height, WC, and WHR are useful indices for the assessment of nutritional health (5, 21-24). We already reported relatively high percentage not only of underweight, but also of overweight and obese elderly subjects (2, 15). There are several other reports (25, 26) that Asian adults have higher risks of developing certain diseases even at lower BMI and WC, which warrants studies to establish and report the prevalence of malnutrition in the elderly and to target interventions.

We note here that elderly and young individuals in the same family tend to have very similar trends of nutritional status independent of age. For example, 85% of the obese or overweight young belonged to families where their elderly counterparts were also either obese or overweight (data not shown). Similarly, 75% of the normal weight young belonged to families where their elderly relatives were also of normal weight. This coincidence might be due to genetic factors. Family and twin studies have shown that genetic factors account for 40–70% of the population variation in BMI (27, 28). But it might also be explicable on the grounds that with the same dietary practices and within the same socioeconomic background, family members are more likely to have more or less identical nutritional status (29). However, we need more data from a larger sample size to generalize these observations.

Taken as a whole, there were little differences in the anthropometrics except % BF, which differed significantly between young and elderly (Table 1). Young and elderly as a whole had significant differences in almost all nutrients studied (Table 1). Young and elderly were divided into four BMI groups for comparison. These BMI groups also showed large differences in anthropometrics, nutrient intake and clinical chemistry (Tables 2 and 3). Energy intake in OB young subjects was the highest followed by OW, NW, and UW (Table 2). However, statistically significant differences in the energy intake could only be shown between OB vs. NW, and UW vs. NW young subjects ($p=0.007$ and 0.001, respectively). Regarding protein, the OW and UW young subjects had significantly lower intake compared to the NW young ($p=0.075$ and 0.001, respectively). In the four BMI groups of the elderly (Table 3), the energy and protein intake of OB, OW and UW differed significantly from NW elderly (p, for all trends <0.05).

The mean values of plasma albumin, total protein (TP), triglycerides (TG), C-Reactive protein (high sensitivity; hsCRP) and ferritin of the four BMI categories of young subjects were not significantly different (p, for all trends ≥ 0.05), although CRP in young OB (2.1±0.4) and elderly OB (3.39±1.51) were higher compared to their respective NW categories (Table 2 and Table 3). Although an increasing CRP level associated with central obesity has been reported previously (30), results of the current study failed to show any such relationship. The serum CRP level in OB elderly tended to be higher than in NW elderly but this did not reach statistical significance. In the elderly, there were significant differences in serum albumin of UW ($p=0.0005$) and ferritin levels ($p=0.0501$) as compared to NW elderly. Serum albumin is the best-studied serum protein having prognostic value for subsequent mortality and morbidity in community-dwelling older persons and is extensively used for nutritional assessment (31, 32). A plasma level of <3.4 mg/dL is considered as an indicator of malnutrition (33). The mean albumin levels in our sample of young (mean (g/dL) ±SD: 3.7±0.48) and elderly (3.6±0.64); Table 1) are fractionally above this threshold. However, serum albumin level is of limited utility in detecting acute nutritional changes owing to its long half-life (18 days) (34). Instead, total protein (TP) has a relatively longer biological half-life and therefore it is a rather late indicator of protein malnutrition (35). The mean plasma protein levels both in young (5.9±0.56 g/dl) and the elderly (5.7±0.76 g/dl) were, however, below the normal standard mean value (7.5 g/dl) (37), which might imply a chronic protein deficiency in both young and the elderly. Some recent data show that elevated serum ferritin has been reported to be significantly associated with several CVD risk factors including BMI, waist circumference or waist-to-hip ratio (36). In our results (data not shown), ferritin was positively and significantly correlated with WC ($p=0.0311$; $r=1820$) and WHR ($p=0.0254$; $r=2037$), while there was a borderline significant correlation with % BF ($p=0.0503$; $r=1350$). Ferritin levels increase with BMI ($p=0.2718$; $r=0.0309$) and age ($p=0.0651$; $r=0.0957$) but non-significant. Our results are in agreement with some other data suggesting that serum ferritin concentration is associated with WHR and other indices of body fat distribution and obesity (37). In our current study, we failed to find any significant correlation between triglycerides and the anthropometric indices for central obesity although triglycerides have been reported to have a close positive relationship with WC and WHR (38). The only reason our subjects did not show any such correlation might be relatively small sample size. We need large studies to investigate such correlations in Pakistani subjects. Many epidemiological studies have demonstrated a univariate association between triglycerides and cardiovascular risk, particularly in relation to coronary heart disease (CHD) (39).

Comparing anthropometrics, nutrient intake and plasma clinical chemistry of young and elderly men in the same BMI category suggests greater variations (Figs 1 and 2). A summary of these differences is also shown in Table 4. WC and % BF differed significantly between young and elderly (p, for all trends <0.05) across all BMI matched pairs, while WHR did not differ significantly (p, for all trends ≥ 0.05). Similarly, young and elderly in the same BMI categories (Figs 2 and 3; Table 4) show that energy intake differed significantly (p, for all trends <0.05) across all BMI matched pairs of young and the elderly, while protein intake differed significantly (p, for all trends <0.05) across the BMI matched pairs of OB, OW and UW but did not differ significantly ($p=0.1081$) between NW young and NW elderly. Of particular note, significant differences were observed only for albumin (UW young vs. UW elderly; $p=0.0496$), CRP (OB young vs. OB elderly; $p=0.0014$) and ferritin (NW young vs. NW elderly; p=0.0432). These large variations in anthropometric measurements, nutrient intake and to some extent in plasma values across the matched BMI pairs of young and the elderly may suggest the effect of aging across the same BMI categories. People of different age but of the same BMI may present differences in their overall health, an effect of aging physiology. For example, energy and protein intake have been reported to generally decrease with age adjusted for BMI (40).

Risk assessment for obesity-related conditions (e.g., type-II diabetes, hypertension, CVD etc) by using WC and/or WHR are well established and documented (16-18). The results of the current study report a relatively large number of elderly placed in any of the high risk (HR) categories based on WC or WHR (HR-WC or HR-WHR) (Fig 3 A, B). Furthermore, we found that 24% of young obese and overweight were in the moderate risk (MR-WC) category; only 2% were in the HR-WC category, while 44% of young obese and overweight were in the HR-WHR category. In the elderly, 10% of obese and overweight were in HR-WC category. None of the normal weight young or elderly (BMI=18.5–24.9 kg/m2) had a high WC and hence were at low risk (either LR-WC or LR-WHR). These results are partially in agreement with previous data (12), which reported that only 1% of men with a normal BMI had a high WC and were in the overweight range (BMI=18.5-24.9 kg/m2), whereas 25% of men had a high WC.

With respect to body fat (Fig 3 C), 79% of the young obese and overweight had high body fat (HF-%BF of ≥25%), while 100% (24 of 24) of overweight and/or obese elderly had high body fat (HF-%BF of ≥25%). Also, 9 of 14 (64%) elderly with a normal BMI nonetheless had high body fat (HF-%BF of ≥25%), whereas all young subjects with normal BMI had healthy/normal body fat (10 – 20%). These results suggest that beyond the upper normal BMI threshold (i.e., 24.9 kg/m2) an increase in BMI may be an indication of increased WC, WHR and %BF. These results further suggest that the elderly have increased likelihood of central obesity (defined by high WC or WHR value) not only at higher than normal BMI (i.e., 24.9 kg/m2) but also even at normal BMI. These findings are in agreement with previous observations that although BMI is a reliable measure of fatness (41) better results can be obtained in conjunction with WC and WHR; thus these latter values are better for discrimination of obesity, particularly the central or abdominal variety (9). Here we see that central obesity and body fat increase with age.

Of our particular interest and as we expected (Fig 4), age was positively correlated with %BF (p=0.0160; r=0.2404) and CRP (p=0.0222; r=0.197) but negatively correlated with energy intake (p<0.0001; r=-0.4705). BMI had negative but no significant correlation with age (p=0.5821;r=-0.0559). These results are in agreement with previous studies on relationships between age and body fat (42), age and CRP (43), and age and energy intake (44). A decrease in BMI with advancing age has also been reported (44). There are changes in body fat with advancing age as several studies have reported age-related increases in body weight and fat mass and decreases in lean body mass (44, 45). A number of studies have quantified the gain in adiposity, with an approximate doubling of body fat between 20 and 50 years of age. The Fels Longitudinal Study (FLS) found that total body fat increases with age by 0.37 kg/year in men and by 0.41 kg/year in women. Thus, the percentage of body fat in the FLS was 23.6% in men at 40 years of age, reaching 29.3% at 60 years of age (46). Other studies have determined that fat increases at a rate ≥7.5% per decade in both genders (47), and that older subjects have a mean fat tissue 7 kg higher than young (48). An increase in body fat is usually associated with a progressive increase in total abdominal fat (and especially visceral fat), as well as a progressive loss of lower body subcutaneous fat. What is more, these changes can occur even without changes in body weight or waist circumference (49). We need further longitudinal studies to confirm these observations in elderly Pakistani men.

Our study has several strengths but also several limitations: The major strength was the use of validated tools for anthropometric measurements and nutrient intake through thorough interview sessions and careful evaluation. The major limitations included a relatively small sample of young and elderly representative of only a small locality and only one gender; thus the results can-only be generalized with cautions. . However, the results of this study may represent a vast majority of elderly of the low-middle socio-economic rural segment of the Pakistani population. Another limitation was the possibility that BMI cut-off points used in this study may understate health risk. The cut-off points are those recommended by the WHO 2000 (1). Although these cut-offs have been proven to be fairly robust for classifying obesity across populations, they are based primarily on the association between BMI and mortality in European and North American populations. Furthermore, as a small cross-sectional study, the present analysis is limited in its ability to elucidate causal relationships between risk factors and overweight. BMI can overestimate body fat in individuals who are very muscular and underestimate body fat in individuals who have lost muscle mass, such as many elderly (27). However, estimates from these potentially misclassified groups likely had little overall impact on the analysis. Although we have not carried out any special studies of the validity or reliability of data for this analysis, we made sure to check consistency and, where possible, to ensure completeness of data. Our experience with other parts of the datasets reported (2, 15) gives us some confidence that data quality is sufficient for this type of study and that our results provide useful additional evidence on the prevalence of and risk factors for underweight, overweight, and obesity. Despite the above limitations, the findings presented here may add substantially to our understanding of malnutrition in the elderly Pakistanis that has been under-represented in past studies.

In conclusion, our data show that young and elderly have differences in their anthropometrics and nutrient intake. Overall, elderly men seem to have nutrient deficiencies as compared to young. The nutritional status of the elderly in the present study is characterized by relatively lower body weight (a possible indication of loss of lean body mass) and higher % body fat. Their nutrient intake seems to be unbalanced in terms of higher energy intake and disproportionately lower intake of other important nutrients. These data suggest that elderly people in developing countries like Pakistan have almost the same dietary malpractices as observed in most of the WEIRD populations surveyed. However, the results of this present pilot small-scale cross-sectional study are difficult to compare with those of larger studies conducted across Europe, mainly due to methodological and study type differences. Nonetheless, in general the findings from the present study are broadly in agreement, for example, with the findings of the SENECA study (Survey in Europe on Nutrition and the Elderly: a Concerted Action) reviewed by de Groot et al., (50). That study was designed to assess regional or cross-cultural differences in nutrition, lifestyle, health, and performance of elderly Europeans in different countries. The survey concluded that nutritional deficiency is more common at older ages than at other periods in life and dietary intake of elderly people was reported to decline over time. Finally, we suggest that BMI, WC and WHR should be used in combination to define nutritional status.

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