Original Article

Chronic energy deficiency and relative abdominal overfatness coexist in free-living elderly individuals in Ho Chi Minh City, Vietnam

Tran Thi Thanh Tam[1,2] MD, MSc, Rainer Gross[3] PhD, Widjaja Lukito[1] MD, PhD and Johanna SP Rumawas[1,4] MD

[1]*SEAMEO-TROPMED Regional Center for Community Nutrition, University of Indonesia, Jakarta, Indonesia*
[2]*Department of Pediatrics, Faculty of Medicine, University of Medicine and Pharmacology, Ho Chi Minh City, Vietnam*
[3]*Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany*
[4]*Department of Nutrition, Faculty of Medicine, University of Indonesia, Jakarta, Indonesia*

As part of the Cross-Cultural Research on Nutrition of Older Subjects (CRONOS) project, the aim of this cross-sectional study was to observe the nutritional status and body composition of free-living elderly and middle-aged people in a low-income area of Ho Chi Minh City, Vietnam. Anthropometric data (weight; height; arm span; four skinfold thicknesses; left upper mid-arm, abdomen, hip and calf circumferences) were collected from 50 Vietnamese men and 50 Vietnamese women aged between 35 and 44 years and 50 men and 50 women aged between 60 and 74 years who lived in Village 2, District 4, Ho Chi Minh City. The prevalence of chronic energy deficiency (CED) in the elderly men (BMI = 19.9 ± 2.8 kg/m^2) was higher (52 *vs* 34%) than that in the middle-aged men (BMI = 19.2 ± 3.4 kg/m^2). Fat-free mass and calf circumference of the elderly were lower than those of the middle-aged ($P < 0.001$). However, the Vietnamese elderly had higher body fat content, higher abdomen-to-hip ratios and lower fat-free mass than their younger counterparts ($P < 0.05$). In particular, 36% of middle-aged women and 20% of elderly women were classified with 'relative abdominal overfatness'. Vietnamese middle-aged and older adults are shorter and thinner than their counterparts in American and European countries but overfatness increases with age, particularly in women. Urban elderly are vulnerable to both undernutrition and overnutrition, both of which merit consideration in the geriatric care system in Vietnam.

Key words: urban, anthropometry, elderly, undernutrition, obesity, abdominal fatness.

Introduction

Advancing adult age is associated with profound changes in body composition. The changes in body composition that are characteristic of senescence are analogous to those that occur with growth in the earlier years of life, but are in the opposite direction, representing catabolic rather than anabolic changes.[1] However, adipogenesis increases and this is indicated by an increase of body fat and fat redistribution with age. Body fat tends to slowly increase between the ages of 25 and 45 years, and in the mid-forties, both males and females continue to accumulate a greater fat mass until 70–75 years of age.[2] The percentage of fat increases by approximately 2% of body weight per decade after the age of 30.[3] This can result in a total increase in fat of between 10 and 15% during an adult life span. A redistribution of fat has also been demonstrated with advancing age. This is sometimes referred to as the centralization and the internalization of body fat whereby more total body fat is situated internally rather than subcutaneously.[4,5] While information on these changes is already available for many European and North American populations, there is still little information available from populations in Asia.

It is generally recognized that fat distribution, as ascertained from the ratio of waist-to-hip circumference, is an important prognostic indicator of the occurrence of hypertension,[6,7] coronary heart disease, stroke, diabetes, and gallbladder disease.[8,9] It has been suggested that abdominal obesity contributes to an increased flux of free-fatty acids, which may be responsible for several metabolic disorders.[10] Age and physical activity were proven to be independent determinants of relative fat mass. Information on body fat in Vietnamese elderly, which is presently limited, will be useful for the prevention of age-related diseases.

There are now several methods available for the assessment of body fat. They vary in accuracy and validity, ease of operation, and cost. Durnin[11] has argued that the value for body fat mass derived from skinfold measurements by using the equation of Durnin and Wormersley[4] provides adequately valid information for field studies of adults up to 60 years of age and for children down to 10 years of age. More data from beyond these two extremes of age are needed, but the method

Correspondence address: Dr Widjaja Lukito, SEAMEO-TROPMED Regional Center for Community Nutrition, University of Indonesia, PO Box 3852, Jakarta 10038, Indonesia.
Tel. 62 21 391 3933; Fax: 62 21 391 3933.
Email: stropmed@rad.net.id
Accepted 16 November 1998.

is reasonably acceptable for the great majority of purposes. Although more sophisticated methods requiring more elaborate and/or expensive techniques have been developed to assess body composition, the skinfold measurement technique, a more accessible and practical method, is useful and relatively reliable for community-based body composition measurements.[12–14]

There is some evidence, from Deprés *et al*. for example, which seems to show that waist circumference, waist-to-hip ratio, and sagittal diameter can be used to predict deep abdominal adipose tissue, thus avoiding invasive and expensive techniques (computerized axial tomography and nuclear magnetic resonance imaging).[15]

The aims of the present study were to determine relative and absolute body fat, fat-free mass, fat distribution expressed as abdomen-to-hip ratio, and abdominal circumference in the elderly population living in an underprivileged urban area of Ho Chi Minh City, Vietnam and to compare these with fat mass and its distribution in the middle-aged living in the same socioeconomic area.

Subjects and methods

Subjects

As part of the Cross-Cultural Research on Nutrition of Older Subjects (CRONOS) project,[16] this study had a cross-sectional design. According to the CRONOS protocol, 600 individuals should be chosen by selecting 50 men and 50 women from each of two age groups, 35–44 and 60–74 years, in each of the following: a rural area, a low-income urban community and a middle-income urban community.

In this study, only the subset from the low-income urban community participated. The study was carried out during January and February 1996 in Village 2 of District 4 of Ho Chi Minh City, a low-income squatter area of the city. The study population consisted of two age groups: the middle-aged group (35–44 years old) and the elderly group (60–74 years old). The subjects consisted of 50 male and 50 female elderly and 50 male and 50 female middle-aged individuals. The subjects were selected by systematic random sampling out of the community list for each age group.

Anthropometry

Anthropometric measurements were made in the morning in the non-fasting state in the field. In the collection of anthropometric data, standardized methodology was applied by a single investigator and an assistant.[17,18] Weight was measured to the nearest 0.1 kg with the subjects in indoor clothing and bare feet using a digital weighing scale (model 770; SECA, Hamburg, Germany). The standing height was measured to the nearest 0.1 cm using a microtoise (Stanley, Mabo, London) with the subjects wearing no shoes and standing straight on a horizontal surface with heels together, shoulders relaxed, arms at the sides and head in the Frankfurt horizontal plane. Armspan (posterior) was measured, with back against the wall, between the longest finger on each hand in the horizontal position at the level of extension of the arms. The reading was taken to the nearest 0.1 cm.

Skinfolds thickness were measured to the nearest 0.2 mm with a Holtain caliper (Crymych, UK). The triceps skinfolds were determined on the back of the left arm parallel with the axial line of the upper arm, over the triceps muscle, halfway between the acromial process and the olecranon. The biceps skinfolds were measured on the front of the arm directly above the centre of the antecubital fossa. Subscapular skinfolds were measured just posterior to the inferior angle of the left scapula. Supra-iliac skinfold thickness was taken with the person standing and on the midaxillary line immediately superior to the iliac crest. The skinfolds were measured in duplicate, both of which usually agree within 4 mm, and the average of the two measurements was used in further analysis. In case the measurements did not agree within 4 mm, a third measurement was also taken.

Four body circumferences were measured in duplicate with the subjects standing upright. Measurement of the left upper arm circumference was made midway between the inferior aspect of the acromion and the olecranon. Abdominal circumference was measured over the superior border of the iliac crest to the nearest 0.1 cm at mid-respiration. Hip circumference was assessed at the level of maximum protrusion of the buttocks to the nearest 0.1 cm. Calf circumference was taken at the largest site of the left calf to the nearest 0.1 cm.

Body mass index (BMI) was obtained by dividing weight (kg) by height squared (m^2). Body mass index using armspan instead of height (BMA)[19] was derived by dividing weight (kg) by armspan squared. The abdomen-to-hip ratio (AHR) was calculated by dividing abdominal circumference (cm) by hip circumference (cm). Mid-upper arm muscle area (MAMA) was calculated using the formula:

$$\text{MAMA (cm}^2\text{)} = [\text{MUAC} - (3.14 \times \text{triceps skinfold}/10)]^2/12.56.$$

Mid-arm fat area (MAFA) was assessed using the formula:

$$\text{MAFA (cm}^2\text{)} = \text{MUAC}^2/12.56 - \text{MAMA}$$

The body density was calculated using the Durnin and Wormersley equation from each age–gender specific value of c and m.[4] Percentage of body fat (BF) was calculated according to the equation suggested by Siri.[20] Body fat and fat-free mass were derived based on calculated percentage body fat and body weight. Basal metabolic rate was predicted based on the age–gender specific equation from actual weight (kg) and height (m) proposed by WHO.[21]

Statistical analysis

Statistical analyses were carried out using SPSS for Windows version 6.01 (SPSS Inc., Chicago, USA). Significance of differences in prevalence among groups was proved with the χ^2 test. Continuous variables were all checked for normal distribution using the Kolmogoro–Smirnov goodness of fit test. Natural log-transformation was performed for those variables not normally distributed. Two-independent sample Student's *t*-test was used to compare middle-aged and elderly groups. Analysis of covariance (ANCOVA) was used when there was intention to adjust for confounding factors. Stepwise multiple linear regression was used to find out the correlation between one continuous dependent and independent variables.

Ethical considerations

The international ethical guidelines for epidemiological studies suggested by the Council for International Organizations of Medical Sciences (CIOMS) were considered in this study.[22] Study design and protocol were approved by the

Committee of the SEAMEO-TROPMED Regional Center for Community Nutrition. The aims and overall objectives were explained thoroughly to participants, who all signed consent forms before taking part in the study. Participants were informed if health problems, such as hypertension or anemia, were identified during the study and they were sent to the nearest health service.

Results

The anthropometric and body composition characteristics of the subjects are summarized in Table 1. The middle-aged men were taller and heavier than the elderly men ($P < 0.01$), while middle-aged women were taller than their elderly counterparts ($P < 0.01$) but of comparable body weight. Abdomen and hip circumferences in both elderly men and women did not differ from those of their middle-aged counterparts. Middle-aged women had a higher BMI and BMA than did elderly men after adjusting for smoking status ($P < 0.05$). However, the elderly had a higher percentage of body weight as fat than did the middle-aged but statistical significance was only found in women ($P < 0.001$).

Calf circumference was significantly lower in the elderly men and women compared with their younger counterparts ($P < 0.001$). Fat-free mass in kg estimated from total body fat was significantly lower in the elderly group than in the middle-aged group ($P < 0.001$). Furthermore, a comparison of the two genders within each group demonstrated that males were heavier and taller but had a lower body fat mass than females. Both relative and absolute values for fat mass were lower in male subjects of both age groups compared with their female counterparts. Fat-free mass of male subjects was higher than that of their female counterparts.

Despite the higher percentage in fat mass in elderly women, their skinfolds thicknesses of two sites (triceps and subscapular) were lower than those of middle-aged women (Table 2). The significant elevation of abdomen-to-hip ratio in the elderly in comparison with the middle-aged group ($P < 0.05$) may have contributed to the discordance between elevation of fat mass percentage and decline in the skinfolds thickness, reflecting the central tendency of body fat redistribution with age.

Table 3 indicates the proportion of subjects classified into different groups of chronic energy deficiency (CED). As a

Table 1. Anthropometric and body composition characteristics of the study population by age–gender group

	Middle-aged		Elderly	
	Men (n = 50)	Women (n = 50)	Men (n = 50)	Women (n = 50)
Weight (kg)	52.9 (8.0)^{†a}	49.3 (7.5)	49.2 (9.8)*	46.8 (9.6)
Height (cm)	162.8 (4.9)†††	152.5 (5.1)**	159.8 (5.4)**	148.9 (5.7)†††
Armspan (cm)	166.9 (6.5)†††	154.3 (6.3)*	164.2 (7.2)*	151.4 (6.5)†††
BMI (kg/m^2 height)^b	19.9 (2.8)†	21.2 (3.3)	19.2 (3.4)*	21.1 (3.9)†
BMA (kg/m^2 armspan)^b	19.0 (2.9)††	20.7 (3.2)*	18.2 (3.3)*	20.5 (4.1)††
Abdomen circumference (cm)	73.9 (7.6)	72.0 (7.4)	74.8 (10)	74.7 (9.8)
Hip circumference (cm)	87.0 (5.3)†	89.2 (6.1)	85.4 (6.2)	89.8 (8.1)††
Abdominal–hip ratio	0.85 (0.05)†††	0.81 (0.05)*	0.87 (0.07)*	0.83 (0.06)†††
Mid-arm circumference (cm)	25.4 (2.5)	26.0 (3.3)	24.6 (4.4)	25.0 (3.7)
Calf circumference (cm)	32.0 (2.6)	32.0 (2.7)**	30.1 (3.0)***	29.6 (2.9)
Mid-arm muscle area (cm^2)	40.5 (7.2)†††	33.0 (5.8)	38.2 (1.8)	32.0 (7.4)†
Mid-arm fat area (cm^2)	11.5 (7.5)†††	21.6 (10.3)	11.3 (7.1)	18.6 (9.2)†††
Fat mass (kg)	10.8 (4.1)†††	16.4 (4.7)	11.5 (5.8)	17.0 (5.7)†††
Fat mass (%)	20.0 (4.9)†††	32.7 (4.7)***	22.2 (7.1)	35.5 (5.3)†††
Fat-free mass (kg)	42.0 (4.7)†††	32.8 (3.6)***	37.7 (4.5)***	29.8 (4.2)†††
Fat-free mass (%)	80.0 (4.9)†††	67.3 (5.3)**	77.8 (7.0)	64.5 (5.3)†††

[a]Mean (SD) by two-independent sample t-tests except for body mass index (BMI) and body mass index using armspan (BMA); [b]difference between middle-aged and elderly subjects was measured by ANOVA adjusting for smoking status. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, significant difference between middle-aged and elderly in the same sex group. $^†P < 0.05$, $^{††}P < 0.01$, $^{†††}P < 0.001$, significant difference between men and women in the same age group.

Table 2. Distribution of skinfolds thickness of the study population by age–egender group

	Middle-aged Median (P_{25}, P_{75})	Elderly Median (P_{25}, P_{75})	P*
Men			
Biceps skinfold thickness	6.4 (4.4, 11.0)	4.7 (3.8, 6.8)	NS
Triceps skinfold thickness	7.0 (5.0, 11.8)	8.2 (5.4, 12.7)	NS
Subscapular skinfold thickness	10.9 (9.2, 14.4)	11.6 (8.4, 17.3)	NS
Suprailiac skinfold thickness	11.5 (8.9, 19.4)	12.0 (7.2, 20.3)	NS
Women			
Biceps skinfold thickness	9.7 (6.4, 13.2)	9.4 (6.1, 13.2)	NS
Triceps skinfold thickness	17.2 (10.8, 24.4)	15.5 (11.1, 20.4)	<0.05
Subscapular skinfold thickness	20.3 (14.4, 26.1)	17.7 (11.4, 22.6)	<0.05
Suprailiac skinfolds thickness	22.2 (12.2, 26.5)	20.1 (13.4, 24.4)	NS

*Difference between middle-aged and elderly subjects was measured by ANOVA with log-transformed value adjusting for BMI.

whole, the prevalence of CED (BMI <18.5) in elderly subjects was significantly higher than in the middle-aged adults ($P < 0.05$). When stratified by sex, it was found that nutritional status of middle-aged and elderly women was not different as assessed by BMI. In particular, elderly men had a higher proportion of CED than did middle-aged men (52% in the elderly *vs* 34% in the middle-aged).

Figures 1 and 2 illustrate the distribution of BMI and BMA of middle-aged and elderly subjects (sexes combined). Armspan was 4.4 cm longer than height in elderly men, 4.2 cm longer in middle-aged men, 2.5 cm longer in elderly women and 1.9 cm longer in middle-aged women (data not shown). Therefore, when body mass index (BMI) was corrected for the shrinking in height due to ageing by calculating the BMA (kg/armspan in m^2), the distribution shifted to the left in the elderly population (Fig. 2a,b).

Table 3. Classification of chronic energy deficiency of the study population based on body mass index (BMI)

	BMI (kg/m^2)					
	<16	16–<17	17–<18.5	18.5–<25	≥25	*P**
Total population						
Middle-aged (%)	3	6	20	61	10	0.045
Elderly (%)	13	6	21	46	14	
Men						
Middle-aged (%)	2	6	26	60	6	0.046
Elderly (%)	20	8	24	40	8	
Women						
Middle-aged (%)	4	6	14	62	14	0.686
Elderly (%)	6	4	18	52	20	

*χ^2 test was used to test difference between middle-aged and elderly subjects.

There was a significant linear correlation between body fat percentage and BMI in both elderly and middle-aged men and women (Fig. 3a,b). However, this relation in the middle-aged was different from that in the elderly, indicating a relatively greater body fat percentage in older *vs* middle-aged people of comparable BMI. The results of a multiple linear regression analysis indicate that there is an increase in body fat percentage of approximately 1.1% per BMI unit and 1.2% per decade (Table 4).

Table 5 shows the results of a multiple linear regression analysis of abdomen-to-hip ratio *vs* some of its potential determinants. Two contributing factors were age and BMI in both men and women. In other words, with a comparable BMI, older people had a higher abdomen-to-hip ratio than did the middle-aged adults.

In general, women had a significantly higher proportion of relative abdominal overfatness than did men in both of the two age groups. Using a cut-off point of 0.95 for men and 0.85 for women, the cut-off having been derived from Caucasian populations to classify relative abdominal overfatness, 36% of middle-aged women and 20% of elderly women were classified with ‘relative abdominal overfatness’; this was the case for only 2% of middle-aged men and 14% of elderly men. However, the difference of the proportion was found to

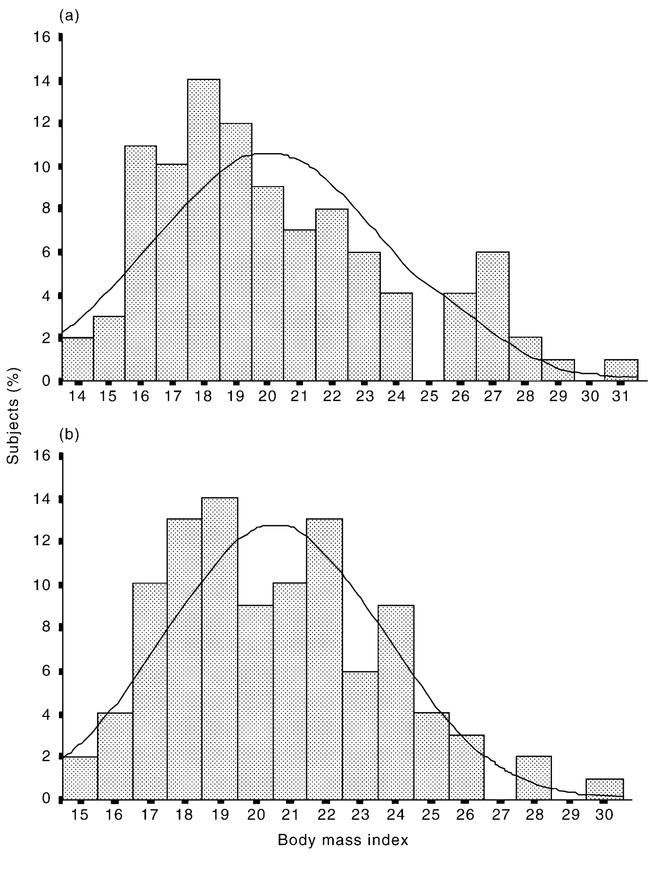

Figure 1. (a) Distribution of body mass index (BMI) of elderly subjects. Mean = 20.21; SD = 3.75; n = 100. (b) Distribution of BMI of middle-aged subjects. Mean = 20.62; SD = 3.12; n = 100.

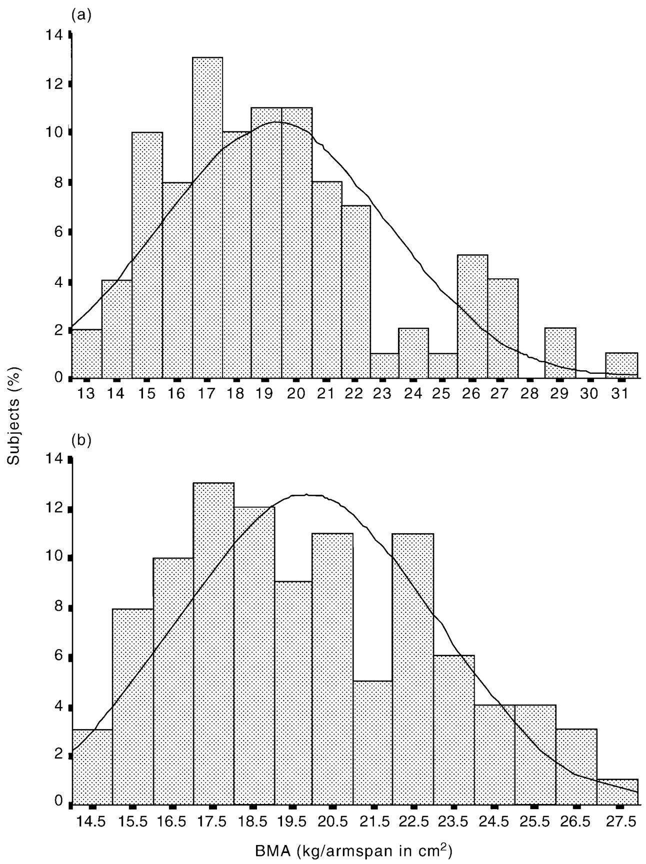

Figure 2. (a) Distribution of body mass index (BMA) of elderly subjects. Mean = 19.34; SD = 3.88; n = 100. (b) Distribution of BMA of middle-aged subjects. Mean = 19.88; SD = 3.17; n = 100.

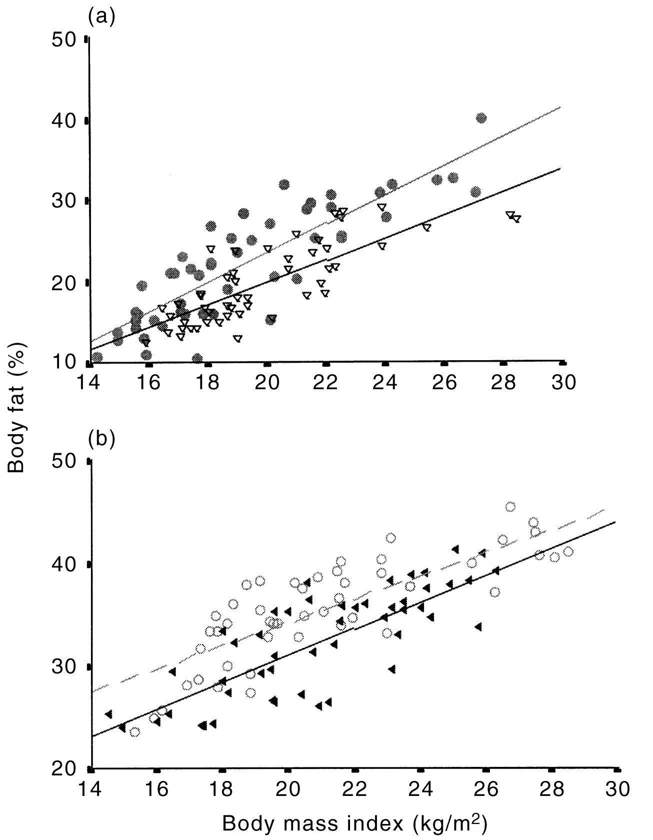

Figure 3 (a) Correlation between body mass index (BMI) and percentage body fat in (●) elderly (R^2 = 0.7359) and (▽) middle-aged men (R^2 = 0.6345). (b) Correlation between BMI and percentage body fat in (○) elderly (R^2 = 0.6832) and (▼) middle-aged women (R^2 = 0.6612) .

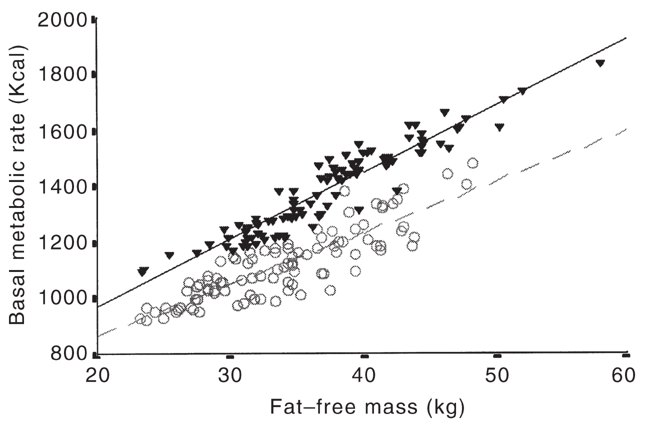

Figure 4. Correlation between fat-free mass and basal metabolic rate in (○) elderly (R^2 = 0.7413) and (▼) middle-aged subjects (R^2 = 0.8964).

be statistically significant between middle-aged and elderly men ($P < 0.05$; χ^2).

The estimated basal metabolic rate (BMR) from the formula suggested by WHO, Fig. 4, illustrates the correlation between BMR and fat-free mass (FFM).[21] Basal metabolic rate and FFM were found to be highly correlated in middle-aged adults (r = 0.95, $P < 0.001$) and in aged subjects (r = 0.86, $P < 0.001$). The strength of correlation in middle-aged was higher than that in elderly subjects. Even with the same fat-free mass the middle-aged always had a higher estimated BMR than did the elderly group.

Discussion

The present study provided information on body composition of older and middle-aged adults living in an underprivileged urban area of Ho Chi Minh City. Both of these Vietnamese groups were thinner than their American counterparts assessed by BMI, skinfolds thickness and mid-arm fat area. Compared with the data from the National Health and Nutrition Examination Survey (NHANES) I and NHANES II, the mean values of BMI of middle-aged and elderly men are only at the 5th percentile of the reference data.[23] The mean values of BMI of middle-aged women corresponded to the 25th percentile of the reference data, whereas those of the elderly women fell between the 10th and 25th percentile. The Euronut SENECA study of representative elderly persons, aged 75–81 years, in several European countries showed that BMI values ranged from 23.9 to 30.5 kg/m^2 and from 24.4 to 30.9 kg/m^2 for women and men, respectively.[24] The mean BMI values of this study (21.1 kg/m^2 for females and 19.2 kg/m^2 for males) were below the lowest mean BMI value of any European elderly subsample. However, the mean BMI values of this study were comparable with the elderly Chinese living in rural Tianjin.[25] Mean values of the skinfolds thickness and mid-arm fat area of elderly and middle-aged subjects always fell between the 10th and 25th percentile range of the reference data for corresponding age–gender group.[23]

Cross-sectional[26,27] and longitudinal[28] data have shown that advancing age is associated with body composition changes such as a decline in fat-free mass and an increase in fat mass. In our study, body fat percentage was different between the elderly and middle-aged groups when adjusted for BMI. Among 70-year-olds, average values of body fat are approximately 21% for men and 39% for women.[29] Although in our study the absolute fat mass did not show any difference between elderly and middle-aged, possibly due to the great reduction of food intake and ensuing undernutrition among the elderly group (data not shown), the body fat percentages

Table 4. Multiple linear regression analysis of body fat percentage versus body mass index and age

	Men (n = 100)		Women (n = 100)	
	Regression coefficient Mean ± SE	Partial R^2	Regression coefficient Mean ± SE	Partial R^2
Intercept	–17.75 ± 2.65		2.93 ± 2.22	
BMI (kg/m^2)	1.64 ± 0.10*	0.423	1.21 ± 0.02*	0.464
Age (years)	0.12 ± 0.02*	0.288	0.11 ± 0.02*	0.226
		R^2 = 0.711		R^2 = 0.690

Stepwise linear regression was used. R^2 explained variance of the model; SE, standard error; *$P < 0.001$.

Table 5. Multiple linear regression analysis of abdomen-to-hip ratio versus body mass index (BMI) and age

	Men (n = 100)		Women (n = 100)	
	Regression coefficient Mean ± SE	Partial R^2	Regression coefficient Mean ± SE	Partial R^2
Intercept	0.523 ± 0.031		0.610 ± 0.036	
BMI (kg/m^2)	0.0137 ± 0.0013*	0.341	0.0074 ± 0.0014*	0.186
Age (years)	0.00130 ± 0.0003*	0.213	0.0010 ± 0.0004*	0.079
		R^2 = 0.574		R^2 = 0.265

Stepwise linear regression was used. R^2 explained variance of the model; SE, standard error; *P < 0.001.

of the elderly men and women of this study were 22% and 36%, respectively, comparable with the results from the previous study.[29] Most evidence points to a relation between body fat and physical inactivity. Klesges *et al*. found a significant but low correlation (r = –0.26) between excessive body fat and physical inactivity.[30] They indicated that aerobic recreational physical activity, rather than work activity, was the better predictor of body fat.

The abdomen-to-hip ratio (AHR) is an important anthropometric measure of body fat distribution.[31] Abdomen-to-hip ratio increases with advancing age. An increase in AHR is associated with insulin resistance[32] and a more atherogenic plasma lipid pattern.[33] However, these AHR-related metabolic changes have not yet been verified in the aged individuals. Furthermore, an age-related increase in AHR may be at the cost of the reduction in the circumference at the hip.[1] Chumlea *et al*. claimed that trunk circumferences provide more information regarding stores of body fat and risk factors for cardiovascular disease in the healthy elderly than do skinfolds.[34]

Abdomen-to-hip ratio is also strongly influenced by gender and BMI.[35] This appears to indicate that, as age and BMI increase, the AHR also increases. The results of this study in aged subjects are in agreement with data in the literature for both men and women. However, the extent of a discrepancy between the two age groups would be expected to be larger, considering a survival effect. This seems especially relevant in men, given that a high AHR is associated with higher mortality due to cardiovascular disease, diabetes, stroke and cancer. The subjects in a cross-sectional study such as this one might be the ones who had lower AHR and a higher chance of survival. As a result, only longitudinal studies can provide detailed data to accurately investigate this difference.

Fat-free mass begins to decline gradually both in men and women primarily due to the wasting of muscle tissue, which begins in middle adulthood. Fat-free mass is significantly lower in elderly women than in younger women.[36] According to Forbes and Reina, FFM decreases 3 kg per decade, commencing from the middle-aged to elderly periods.[37] The losses found in the Forbes and Reina longitudinal study were higher than those in the present cross-sectional study which were 1.0 kg and 1.9 kg per decade in women and men, respectively. These losses were almost 1.5–2 times as great in men as in women because men were found to lose fat-free mass at the rate of 0.33 kg/year whereas women lose FFM at the rate of 0.22 kg/year.[38]

Between 40 and 80 years of age, men lose FFM at the rate of 5% each decade, whereas women lose about 2.5% FFM each decade.[39] At these rates, men and women lose approximately 20% and 10% of total FFM, respectively, between the ages of 40 and 80 years. Looking at Vietnamese people from this study, men lose 10% and women 9% of total FFM between the ages of 35 and 65 years.

With advancing age a decrease in resting and daily energy expenditure occurs, mainly because of a decline in physical activity and changes in body composition. Several studies have attributed the age-mediated decline in resting metabolic rate (RMR) to the loss of FFM.[40,41] However, it is clear that differences in FFM cannot fully account for the lower RMR in the aged, suggesting that ageing is associated with an alteration in tissue energy metabolism.[42] We also found in the current study that even when the middle-aged and elderly had the same FFM, the basal metabolic rate of the elderly was always lower than that of the middle-aged. There might be other factors causing a reduction of basal metabolic rate besides the decline in fat-free mass in the aged. One factor studied by Vaughan *et al*. is the blunted response to sympathetic nervous system activation that in turn can explain, at least partially, the decreased RMR found in aged subjects.[43]

The substitution of height by armspan as the denominator of BMI resulted in a decrease in the prevalence of overweight and an increase in the number of both middle-aged and elderly men being identified as part of the chronic energy deficiency group. Reeves *et al*. claimed that armspan is significantly higher than height in young Asian men, but not in young Asian women.[44] Consequently, the BMA could cause an overcorrection to the left of the BMI distribution. Given the ethnic differences in the relationship of height to armspan, the height to armspan ratio of young adults should be established for each geographical area of interest.

In conclusion, the data of the present study demonstrated that Vietnamese middle-aged and older adults are shorter and thinner than their counterparts in American and European countries. The elderly had higher body fat content, abdomen-to-hip ratio and lower fat-free mass than their middle-aged counterparts. Chronic energy deficiency and relative abdominal overfatness coexist in the elderly at a high prevalence, suggesting a need for public health attention. Cardiovascular disease is not only prevalent in developed countries but also threatens the life of elderly people in developing countries, where the prevalence of relative abdominal overfatness is now increasing. As a result, a sound public health policy in developing countries such as Vietnam should consider not only mother and child care but also geriatric preventive medicine.

Acknowledgements. This study was financially supported by the South-East Asian Ministers of Education Organization and the German

Federal Ministry of Economic Cooperation and Development through the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. The authors are grateful to Noel Solomons for his critical review of the manuscript.

References

1. Kuczmarski RJ. Need for body composition information in elderly subjects. Am J Clin Nutr 1989; 50: 1150–1157.
2. Young CM, Blondi J, Tensuan R, Fryer JII. Body composition of older women. J Am Diet Assoc 1963; 43: 344–348.
3. Walser M. Creatinine excretion as a measure of protein nutrition in adults of varying age. JPEN 1987; 11: S73–S78.
4. Durnin JVGA, Wormersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr 1974; 32: 77–97.
5. Baumgartner RN, Heymsfield SB, Roche AF, Bernardino M. Quantification of abdominal composition by computer tomography. Am J Clin Nutr 1989; 50: 221–226.
6. Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Björntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity and risks of cardiovascular diseases and death: 13-year follow up of participants in the study of men born in 1913. Clin Res 1984; 288: 1401–1404.
7. Side X, Mingtang S, Shuquan Z *et al*. Anthropometric and dietary survey of elderly Chinese. Br J Nutr 1991; 66: 355–362.
8. Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjöström L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow up of participants in the population study of women in Gothenburg Sweden. BMJ 1984; 289: 1257–1261.
9. Björntorp P. Classification of obese patients and complications related to the distribution of surplus fat. Am J Clin Nutr 1987; 45: 1120–1125.
10. Pouliot M-C, Deprés J-P, Lemeiux S *et al*. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 1994; 73: 460–468.
11. Durnin JVGA. Appropriate technology in body composition: a brief review. Asia Pac J Clin Nutr 1995; 4: 1–5.
12. Wong WW, Butte NF, Smith EO, Garza C, Klein PD. Body composition of lactating women determined by anthropometry and deuterium dilution. Br J Nutr 1989; 61: 25–33.
13. McNeill G, Fowler PA, Maughan RJ *et al*. Body fat in lean and overweight women estimated by six methods. Br J Nutr 1991; 65: 95–103.
14. Fuller NJ, Jebb SA, Laskey MA, Coward W, Elia M. Four component model for the assessment of body composition in humans: comparison with alternative methods, and evaluation of the density and hydration of fat-free mass. Clin Sci (Colch) 1992; 82: 687–693.
15. Deprés JP, Prud'homme D, Pouliot M-C, Tremblay A, Bouchard C. Estimation of deep abdominal adipose tissue accumulation from simple anthropometric measurements in men. Am J Clin Nutr 1991; 54: 471–477.
16. Gross R. Cross-cultural Research on Nutrition of Older Subjects. SEAMEO-TROPMED Regional Center for Community Nutrition. Jakarta 1994.
17. Chumlea WC, Roche AF, Mukherjee D. Nutritional assessment of the elderly through anthropometry. Columbus, OH: Ross Laboratories, 1984.
18. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual, abridged edn. Champaign, IL: Human Kinetics Books, 1988.
19. Rabe B, Thamrin MH, Gross R, Solomons NW, Schultink W. Body mass index of the elderly derived from height and from armspan. Asia Pac J Clin Nutr 1996; 5: 79–83.
20. Siri WE. Body composition from fluid spaces and density. In: Analysis of methods techniques for measuring body composition. Washington DC: National Research Council, National Academy of Sciences, 1961: 223–44.
21. World Health Organization. Energy and Protein Requirements. Report of a WHO Expert Committee. Technical Report Series 724: 178. Geneva: WHO, 1985.
22. Anonymous. Ethics and epidemiology. XXV CIOMS Conference. Wkly Epidemiol Rec 1991; 25: 17–19.
23. Gibson RS. Nutritional assessment: a laboratory manual. New York: Oxford University Press 1993.
24. de Groot LC, Sette S, Zajkas G, Carbayal A, Amorim JA. Nutritional status: anthropometry. Euronut SENECA Investigation. Eur J Clin Nutr 1991; 45 (Suppl. 3): 31–42.
25. Roche A. Anthropometry. In: Wahlqvist ML, Hsu-Hage BH-H, Kouris-Blazos A, Lukito W, eds. Food habits in later life: a cross-cultural approach (Auscript). Melbourne: Asia Pacific Journal of Clinical Nutrition and United Nations University Press, 1995.
26. Allen TH, Andersen EC, Longham WH. Total body potassium and gross body composition in relation to age. J Gerontol 1960; 15: 348–357.
27. Borkan GA, Norris AH. Fat redistribution and the changing body dimensions of the adult male. Hum Biol 1977; 49: 495–513.
28. Flynn MA, Nolph GB, Baker AS, Martin WM, Krause G. Total body potassium in aging humans: a longitudinal study. Am J Clin Nutr 1989; 50: 713–717.
29. Fulop T Jr Worum I, Csongor J, Foris G, Leovey A. Body composition in elderly people. Determination of body composition by multiisotopic methods and the elimination kinetics of these isotopes in healthy elderly subjects. Gerontology 1985; 31: 6–14.
30. Klesges RC, Erk LH, Isbell TR, Fulliton W, Hanson CL. Physical activity, body composition, and blood pressure: a multimethod approach. Med Sci Sports Exerc 1991; 23: 759–765.
31. Krotkiewski M, Björntorp P, Sjöström L, Smith U. Impact of obesity and metabolism in men and women: importance of regional adipose tissue distribution. J Clin Invest 1983; 72: 1150–1162.
32. Evans DJ, Hoffman RG, Kalkhoff RK, Kissebah AH. Relationship of body fat topography to insulin sensitivity and metabolic profiles in premenopausal women. Metabolism 1984; 33: 68–75.
33. Anderson AJ, Sobocinski KA, Freedman DS, Barboriak JJ, Rimm AA, Gruchow HW. Body fat distribution, plasma lipids, and lipoproteins. Atherosclerosis 1988; 8: 88–94.
34. Chumlea WC, Guo SS, Vellas B. Changes in body composition with aging and sarcopenia. J Nutr Health Aging 1997; 1: 137–138.
35. Jakicic JM, Donnelly JE, Jaward AF, Jacobsen DJ, Gunderson SC, Pascale R. Association between blood, lipid and different measures of body fat distribution: effects of BMI and age. Int J Obes Relat Metab Disord 1993; 17: 131–137.
36. Blanchard J, Conrad KA, Harrison GG. Comparison of methods for estimating body composition in young and elderly women. J Gerontol 1990; 45: B119–B124.
37. Forbes GB, Reina JC. Adult lean body mass declines with age: some longitudinal observations. Metabolism 1970; 19: 653–663.
38. Forbes GB, Halloran E. The adult decline in lean body mass. Hum Biol 1976; 48: 162–173.
39. Rudman D, Feller AG, Cohn L, Shetty KR, Rudman IW, Draper MW. Effects of human growth hormone on body composition in elderly men. Hormone Res 1991; 36 (Suppl. 1): 73–81.
40. Keys A, Taylor HL, Grande F. Basal metabolism and age of adult man. Metabolism 1973; 22: 579–587.
41. Tzankoff SP, Norris AH. Longitudinal changes in basal metabolism in man. J Appl Physiol 1978; 45: 536–539.
42. Fukagawa NK, Bandini LG, Young JB. Effect of age on body composition and resting metabolic rate. Am J Physiol 1990; 259: E233–E238.
43. Vaughan L, Zurlo F, Ravussin E. Aging and energy expenditure. Am J Clin Nutr 1991; 53: 821–825.
44. Reeves SL, Varakamin C, Henry CJ. The relationship between armspan measurement and height with special reference to gender and ethnicity. Eur J Clin Nutr 1996; 50: 398–400.