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Body mass index and fat patterning of adults in rural Sarawak

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ABSTRACT

Body fatness distribution is a useful epidemiological and clinical marker of health risk among European and other populations. Prevalence of obesity among adults is rising in many parts of Malaysia, and it is important to understand the extent to which fat patterning is robust across different age groups and between the sexes. This analysis examines fatness and fat distribution in rural Sarawakian adults aged 20 to 80 years to determine the extent to which fat patterning varies by sex and age. Principal component analysis of five skinfolds (biceps, triceps, subscapular, suprailiac and medial calf) shows upper body-lower body fat distribution as contributing most to within-group variation in the sum of five skinfolds for both males and females. When divided into younger and older age groups, clear differences were identified. For the males, while absolute fatness does not change with age, there is a change in fat patterning, with a trunk-extremity component disappearing, and a trunk-lower body pattern persisting. Females experience a decline in subcutaneous fatness across age groups, and while the most important component of fat distribution, trunk to lower body subcutaneous fatness, the same for younger and older women, the second component is different, with upper limb-lower body distribution in the younger age group being replaced with upper to lower trunk distribution. The similarities in fat patterning among males and females suggest that the use of fat patterning indices in this Malaysian population need not be sex-specific, but age group- and sex-dependent differences in the second principal component indicate that they should be used with caution, since the relationships between fat patterning and mortality are still poorly understood among Malaysian populations.

INTRODUCTION

Body fatness and fat patterning are important markers of risk of cardiovascular disease (Lapidus *et al,* 1984, Folsom *et al,* 1993, Freedman *et al,* 1995), non-insulin-dependent diabetes mellitus (Evans *et al,* 1984, Dowse *et al,* 1991, Colman *et al,* 1995), Hypertension (Blair *et al,* 1984, Gerber *et al,* 1995) and breast cancer (Seller *et al*, 1993), with centripetal patterning, in which deposits of subcutaneous fat are greater on the trunk than on the extremities, carrying higher risk (Mueller *et al,* 1984, Ducimetiere *et al,* 1986). In Malaysia, the increasing prevalence of overweight among adults even in rural areas has been identified as a potential health problem for the future (Ismail *et al*, 1995). Among Malaysian male executives, body mass index (BMI) has been shown to increase with age (Teo *et al*, 1988), while Strickland and Ulijaszek (1993) have shown that body mass index (BMI) and fat-free mass of adults above the age of 40 years in rural

Sarawak falls markedly with age in both sexes, with fat mass declining with age in women only. Since body fatness distribution is a useful epidemiological and clinical marker of health risk among European populations (Mueller *et al*, 1984), this analysis examines fatness and fat distribution in rural Sarawaki adults to determine the extent to which fat patterning varies by sex and age.

SUBJECTS AND METHODS

The population consists of Iban adults in the Kanowit district of Sarawak measured in a survey of nutritional status in 1990. Longhouse villages were selected randomly from official lists and represent both upriver and downriver locations relative to the Rejang River, and reflect both wealthier and poorer villages, according to their remoteness. The sampling frame was to measure a total of 1000 individuals of all ages in the selected villages, taking a total sample in each village. Data on a total of 498 adults, excluding pregnant women, was thus obtained, and forms the basis of this analysis. Measurements made included weight, height, and biceps, triceps, subscapular, suprailiac and medial calf skinfolds, collected according to methods described by Weiner and Lourie (1981). Identity cards and birth certificates were used to establish ages exactly or to the nearest year; for adults born before the Japanese invasion (1941 to 1945), ages may be accurate only to +5 years. The study population was probably biased as a consequence of migrant labour, and possibly differential mortality among males.

Descriptive statistics, analysis of variance, Scheffes multiple range tests and principal components analyses were carried out using the SPSS/PC+ programme. Principal component analysis is a form of factor analysis in which constructs such as body shape are derived from other, directly observable variables. In the case of fat patterning, subcutaneous fat distribution across different parts of the body can be reduced to ëcomponentsí of topography which are based on skinfold measurements. In nutrition research, principal components analysis can be used to see if nutritional status according to different measures (for example, *Z* scores of weight for height, height for age, serum albumin, transferrin, retinol binding protein) cluster in meaningful ways, in this example, with respect to growth and protein nutritional status. Similarly, measures of serum lipids, glucose tolerance, obesity and blood pressure could be subjected to principal components analysis in the study of Syndrome X, the metabolic syndrome in which these factors have been aetiologically linked (Walker and Alberti, 1993). With the present data-set, principal components analysis, following the procedure of Healy and Tanner (1981), was carried out on logarithmically transformed skinfold data. A regression of each log-transformed skinfold was made on the mean log skinfold for each individual and the resulting residual log skinfolds were subjected to principal components analysis to produce indices of body fat distribution. Failure to adjust for variation in the size of anthropometric variables can lead to erronous estimations of the relative variation due to different types of fat patterning (Bailey *et al*, 1982, Baumgartner *et al*, 1986), and this regression procedure removed the effect of individual differences in body fatness on fat patterning. Only those components producing and eigenvalue greater than 1.0 were accepted as meaningful (Mueller *et al*, 1986).

RESULTS

Table 1 gives mean values for BMI, while Figures 1 and 2 show geometric means for the five skinfold measurements, respectively, by age group and sex. There are significant differences in BMI between sexes, and between age groups. There is also significant interaction between sex and age, indicating that the age group differences of males and females do not run in parallel. Women have higher values than men for all six variables in earlier adulthood, but have similar skinfold values to males in the age group 65-80 years, but lower BMI. Two-way analysis of variance of skinfolds (Table 2) shows that there are strong sex and age-group differences in all skinfolds. As with BMI, there are significant interactions between age and sex for all five skinfolds, the least strong of which is with medial calf skinfold.

Table 1. Mean body mass index

Age group (years)	n	Males Mean	(SD)	n	Females Mean	(SD)
20-34.9	68	21.3	2.2	93	23.2	3.4
35-49.9	75	21.2	2.9	85	22.8	3.6
50-64.9	42	20.0	2.0	69	20.2	3.7
65-80	33	19.6	2.1	33	18.1	2.7

Two-way analysis of variance

	F	P
Sex	13.8	<0.001
Age	29.5	<0.001
Interaction	5.9	<0.001

One way analysis of variance of age group differences within-sex shows that females have lower values for BMI and all five skinfolds with increasing age (BMI: F=24.6; skinfolds: biceps: F= 17.6; triceps: F=22.8; subscapular: F=22.6; suprailiac: F=19.7; medial calf: F=22.5; all $p<0.001$), while the same is true only for BMI ($F=5.9$, $p<0.001$) and medial calf skinfold ($F=3.9$, $p<0.01$) in males. A posteriori Sheffe tests show that the most consistent differences between age groups in females lie between the age group 65-80 years and all other age groups for all variables, as well as between the age group 50-64.9 years and the other two younger age groups for BMI, subscapular and medial calf skinfolds. Significant differences between the 50-64.9 years age group and the youngest age group also exist for biceps, triceps and suprailiac skinfolds, while no significant differences exist between the age groups 20-34.9 years and 35-49.9 years. For males, Scheffe tests show differences between the oldest age group and the age groups 20-34.9 and 35-49.9 years for BMI, and between the youngest and oldest age groups for medial calf circumference.

Table 3 gives details of principal component analysis of the five skinfolds by sex. Of the two components emerging from the analysis for males, and the three components emerging for females, only the first two have eigenvalues of 1.0 or more. Thus only the first two components are accepted as meaningful. Furthermore, loadings of about 0.3 account for less than 10% of the variance, and are considered unimportant in any interpretation of fat patterning. Thus the loadings of 0.69 for the medial calf site and -0.78 for the subseapular site in males suggests a trunk-lower body first component to fat patterning. The second component, with loadings of -0.47 for the medial calf skinfold, and 0.88 for biceps skinfold suggests a pherphery upper-body lower-body pattern. These two components collectively explain 43.5% of the variance in the sum of skinfolds in these males. Females show the same patterns, with the first compenent having loadings of 0.71 (medial calf) and -0.76 (suprailiac), and the second component having loadings of -0.40 (medial calf) and 0.90 (biceps) respectively. These two components explain 42.2% of the total variance in the sum of skinfolds for females.

Table 2. Two way analysis of variance of male-female and age group differences in skinfolds (log-transformed data used)

Analysis of variance:	Skinfold:									
	Biceps		Triceps		Subscapular		Suprailiac		Medial Calf	
	F	p	F	p	F	p	F	p	F	P
Sex	173.7	*	414.9	*	121.0	*	89.4	*	295.8	*
Age	15.5	*	16.3	*	20.6	*	17.7	*	25.1	*
Interaction	9.4	*	10.6	*	9.0	*	7.7	*	5.9	*

Table 3. Fat distribution patterns using principal components analysis on five skinfolds.

	Males Principal components			Females Principal components		
	PC1	PC2	PC3	PC1	PC2	PC3
Skinfold						
Biceps	0.16	0.88	0.44	0.03	0.90	0.42
Triceps	-0.01	-0.01	-0.12	0.03	-0.02	-0.08
Subscapular	-0.78	-0.223	0.57	-0.05	-0.02	-0.11
Suprailiac	-0.02	-0.05	-0.16	-0.76	-0.25	0.61
Medial Calf	0.69	-0.47	0.54	0.71	-0.40	0.59
Eigen values	1.12	1.05	0.86	1.08	1.03	0.91
Proportion of variance explained	22.4	21.1	17.3	21.7	20.5	18.2

Age group differences in fat patterning are given in Table 4. For males, eigenvalues are greater than 1.0 for the first two components for the younger group of males, and for the first component only, for the older group. For the younger group, the first component shows strong upper-body lower body fat-patterning, with loadings of -0.76 (medial calf), 0.46 (triceps) and 0.53 (suprailiac). The second component reveals a trunk-upper body extremity component to fat patterning, with loadings of 0.75 (triceps) and -0.67 (suprailiac). For the older age group, the only component to fat patterning is of trunk-lower body, with loadings of 0.74 (medial calf) and -0.74 (subscapular). Thus, it would appear that although absolute fatness does not change with age in the males, there is a change in fat patterning, with the trunk-extremity component disappearing, and the trunk-lower body pattern persisting.

For the women, two principal components had eigenvalues greater than 1.0. For the younger women, both components show strong upper body-lower body fat patterning, with loadings of –0.77 (suprailiac) and 0.64 (medial calf) for the first component, and 0.85 (biceps) and -0.52 (medial calf) for the second component. For the older women, the first component is strongly due to trunk-lower body fat patterning with loadings of 0.58 (subscapular) and -0.82 (medial calf), while the second component reveals a change in fat patterning between the upper and lower trunk, with the subscapular having a loading of -0.64 and the suprailiac having a loading of 0.80. Thus it would seem that older women do not only have less body subcutaneous fat than younger women, but that it is distributed differently.

Table 4. Fat distribution patterns using principal components analysis on five skinfolds, by age group and sex

Males	20 – 49.9 years Principal components		50 – 80 years Principal components
	PC1	PC2	PC1
Skinfold			
Biceps	-0.02	0.01	0.06
Triceps	0.46	0.75	0.03
Subscapular	0.06	-0.01	-0.74
Suprailiac	0.53	-0.67	0.02
Medial Calf	-0.76	-0.02	0.74
Eigen values	1.08	1.01	1.10
Proportions of variance explained	21.6	20.3	22.2

Females	20 – 49.9 years Principal components		50 – 80 years Principal components	
	PC1	PC2	PC1	PC2
Skinfold				
Biceps	0.27	0.85	-0.01	0.01
Triceps	0.03	-0.03	-0.05	-0.03
Subscapular	-0.08	-0.02	0.58	-0.64
Suprailiac	-0.77	-0.14	0.40	0.80
Medial Calf	0.64	-0.52	-0.82	-0.07
Eigen values	1.08	1.03	1.17	1.06
Proportions of variance explained	21.7	20.5	23.3	21.2

DISCUSSION

Despite differences in mean BMI between the sexes, subcutaneous fat distribution is similar for both males and females. However, when disaggregated by age group, clear sex and age differences in fatness and fat patterning emerge. Women have more subcutaneous fat than men as younger adults, but become leaner relative to men across adult life, so that in the oldest age groups, both men and women have similar values for skinfold thicknesses. Younger males and females show similar patterns of upper-body lower body fat distribution, but males also show significant variation in trunk-periphery fat distribution. Older males and females have similar patterns of trunk-lower body fat distribution, but females also show significant variation in upper-to-lower trunk fat distribution. Thus although the similarities in fat patterning among males and females might suggest that the use of fat patterning indices in this Malaysian population need not be sex-specific, the significant but less dominant second component variation in fat patterning between younger and older adults, and between younger and older groups within each sex, indicate that any such index should be used with caution. The changing pattern with age, especially in males, might be due to differences in population structure early mortality due to diseases such as coronary heart disease known to associate with trunk-limb fatness ratios. If this were the case, then it is plausible that the same index could be used in the older age group predictively. However, in the absence of data, one can only speculate. More information is needed for this and other Malaysian populations about fat patterning and mortality in adults of all ages.'

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