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Correlation and prediction of trunk fat mass with four anthropometric indices in Chinese males

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To increase our understanding of the relationships of trunk fat mass (FM_{trunk}) and four anthropometric indices in Chinese males, 1090 males aged 20–40 years were randomly recruited from the city of Changsha, China. Waist circumference (WC) and hip circumference (HC) were measured using standardized equipment, and three other anthropometric indices of BMI, waist:hip ratio (WHR) and conicity index (CoI) were calculated using weight, height, HC and WC. FM_{trunk} (in kg) was measured using a Hologic QDR 4500 W dual-energy X-ray absorptiometry scanner. There was an increasing trend of FM_{trunk}, $\%FM_{trunk}$ (percentage of FM_{trunk}) and BMI, WC, WHR, CoI in successively older age groups (e.g. the mean FM_{trunk} values were 4·63 (SD 2·58), 5·39 (SD 2·74), 5·93 (SD 2·82), 6·57 (SD 2·94) in four 5-year age groups, respectively). FM_{trunk} and $\%FM_{trunk}$ were significantly correlated with four anthropometric indices with the Pearson's correlation coefficients ranging from 0·25 to 0·86. Principal component analysis was performed to form three principal components that interpreted over 99·5% of the total variation of four related anthropometric indices in all age groups, with over 65% of the total variation accounted by principal component 1. Multiple regression analyses showed that three principal components explained a greater variance (R^2 70·0–80·1%) in FM_{trunk} than did BMI or WC alone (R^2 57·8–74·1%). The present results suggest that there is an increasing trend of FM_{trunk} and four anthropometric indices in successively older age groups; that age has important effects on the relationships of FM_{trunk} and studied anthropometric indices; and that the accuracy of predicting FM_{trunk} using four anthropometric indices is higher than using BMI or WC alone.

Anthropometric index: Trunk fat mass: Percentage of trunk fat mass: Principal component analysis

The prevalence of obesity is increasing worldwide: there are about 250 million obese adults, with far larger numbers of overweight adults (James & Ralph, 1999). The preferential accumulation of adipose tissue in the central region, i.e. trunk fat mass (FM_{trunk}), is clearly associated with increased risk of human chronic diseases, such as diabetes and CVD (Van Pelt *et al.* 2002; Pi-Sunyer, 2004), although the potential mechanisms remain to be elucidated fully. In addition, there are ethnic and sex-specific distributions of body fat mass. Compared with Caucasians, the Asian population accumulates central fat mass at lower body weight (McKeigue *et al.* 1992). Observations have shown that the risks of excess central fat mass emerge stronger and the hazards of even modest weight gain seem more drastic in the Asian population (James & Ralph, 1999). Men have been shown to have higher risks of disease for a given weight than women, which may be attributed to the propensity of depositing fat mass centrally in men (Vague *et al.* 1985; Pi-Sunyer, 2004). Therefore, the measure of fat mass at trunk is of clinical significance in Chinese males to identify who is at risk of such diseases.

A number of techniques have been developed to allow an accurate estimation of body fat mass, such as dual-energy X-ray absorptiometry (DXA). However, it is difficult to apply these complex techniques widely for clinical measurement of total or regional fat mass in developing countries, including China, because the measurement approaches depending on such technologies incur relatively high cost. On the other hand, the anthropometric indices, with their simple and cheap characteristics, continue to play an important role in assessing overall and regional fat mass in clinical practice. Dozens of studies have used several anthropometric indices, such as

Abbreviations: CoI, conicity index; DXA, dual-energy X-ray absorptiometry; FM_{trunk}, trunk fat mass; $\%FM_{trunk}$, percentage of FM_{trunk}; HC, hip circumference; PC1, principal component 1; WC, waist circumference; WHR, waist:hip ratio.

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BMI, waist circumference (WC), waist:hip ratio (WHR) and conicity index (CoI), as predictors of central body fat mass (Taylor *et al.* 1998, 2000; Janssen *et al.* 2002; Brambilla *et al.* 2006), whereas the studies generally employed only one anthropometric index to predict fat mass, which may partially account for the current inconsistent results of the accuracy of the prediction, due to the potential confounders of adipose distribution.

To date, relatively few data on the correlations between anthropometric indices and truncal region fat mass measured by sophisticated methods, such as DXA, have been accumulated in the Chinese population. DXA is a safer and quicker method which typically has been used to assess bone mineral mass but also has been a valuable tool in assessing overall and regional body composition (Svendsen *et al.* 1993; Kohrt, 1995) than other technically complicated methods. However, to the best of our knowledge, there are no data on simultaneously employing the four anthropometric indices to assess trunk adipose tissue in either Chinese or Caucasians. Therefore, the current study was undertaken in Chinese males with three major aims: (1) to evaluate the effects of age on FM_{trunk} and anthropometric indices; (2) to investigate the correlations between FM_{trunk} and anthropometric indices; (3) to evaluate the ability of predicting FM_{trunk} using the four anthropometric indices (BMI, WC, WHR and CoI) and to develop four age-specific equations to predict FM_{trunk} by the four anthropometric indices.

Material and methods

Subjects

The project was approved by the Research Administration Departments of Hunan Normal University. The subjects were from a large population that was randomly recruited, through the use of fliers and posters advertising in the surrounding communities of Hunan Normal University (located in the central south area of China), for genetic studies searching for genes underlying peak bone mass variation in the Chinese population. After the subjects signed informed consent documents, a questionnaire was given to obtain the subject's individual data including age, medical history, family history, physical activity, alcohol use, dietary habits and smoking history. We adopted the exclusion criteria detailed by Deng *et al.* (2002) to screen and recruit 'healthy' subjects. A total of 1090 healthy Chinese males, aged 20–40 years, were finally included in the study.

Measurements

Weight and height were measured using standardized equipment. BMI (kg/m^2) was calculated as weight (kg) divided by height squared (m^2). WC and HC were measured using an anthropometric tape over light clothing, with measurement of WC and HC at the minimum circumference between the iliac crest and the rib cage, and at the maximum protuberance of the buttocks. WHR was calculated as WC divided by HC. CoI was calculated using the following formula: CoI = WC/[0·109 × $\sqrt{}$(weight/height)] (WC and height in m; weight in kg) (Valdez *et al.* 1993; Taylor *et al.* 2000). Fat mass, lean mass and bone mineral mass were measured by Hologic QDR 4500 W DXA scanner (Hologic Corp., Waltham, MA, USA). Body regions are distinguished using specific anatomic landmarks. The truncal region consists of the area bordered by a horizontal line below the chin, vertical borders lateral to the ribs and oblique lines passing through the femoral necks. The percentage of FM_{trunk} (%FM_{trunk}) was calculated as [FM_{trunk}/(FM_{trunk} + trunk lean mass + trunk bone mineral content)]. The normal and standard DXA quality control measures and equipment checks were conducted following the manufacturer's recommendations before each testing session. The CV of FM_{trunk}, obtained from thirty individuals repeatedly measured twice, of the DXA measurements was 0·99%.

Statistical analysis

Statistical analyses were performed with the SAS package (SAS Institute Inc., Cary, NC, USA). To investigate the effects of age, we divided the individuals into four 5-year age groups (20–24 years, 25–29 years, 30–34 years and 35–39 years). Pearson's correlation coefficients were used to investigate the linear correlation of FM_{trunk} and %FM_{trunk} with each anthropometric index. Because of the disturbance of the colinearity when simultaneously modelling four strongly correlated anthropometric indices (BMI, WC, WHR and CoI) in the multiple regression analysis, to avoid these confused effects, a principal component analysis was performed to form three principal components accounting for most of the variation of the four anthropometric indices, as well as eigenvalues of the matrix and eigenvectors. Subsequently, the three principal component values were calculated by eigenvalues of the matrix and eigenvectors (Green, 1978; Vapnik, 1998), and then they were used to estimate their regression coefficients and the proportion of the variance (R^2) of FM_{trunk} predicted by these principal components by multiple regression analysis. Regression analyses were also conducted to determine whether the three principal components explained a greater variance (R^2) of FM_{trunk} than did BMI or WC alone and also to investigate the correlation coefficients of the measured FM_{trunk} and the predicted FM_{trunk} by the three principal components and by BMI or WC alone. Finally, we developed four age-specific equations to predict FM_{trunk} by the measured values of four anthropometric indices. The equations were calculated as follows:

$$\begin{aligned}
\text{The predicted } FM_{trunk}\text{ (kg)} = {} & \text{intercept} + RC_{PC1} \\
& \times PC1\,(E_{PC1\,BMI} \times S_{BMI} \\
& + E_{PC1\,WC} \times S_{WC} + E_{PC1\,WHR} \\
& \times S_{WHR} + E_{PC1\,CoI} \times S_{CoI}) \\
& + RC_{PC2} \times PC2\,(E_{PC2\,BMI} \times S_{BMI} \\
& + E_{PC2\,WC} \times S_{WC} + E_{PC2\,WHR} \\
& \times S_{WHR} + E_{PC2\,CoI} \times S_{CoI}) \\
& + RC_{PC3} \times PC3\,(E_{PC3\,BMI} \times S_{BMI} \\
& + E_{PC3\,WC} \times S_{WC} + E_{PC3\,WHR} \\
& \times S_{WHR} + E_{PC3\,CoI} \times S_{CoI}),
\end{aligned}$$

where RC_{PCn} is the regression coefficient for the three principal components, respectively; $E_{PCn\,BMI}$, $E_{PCn\,WC}$, $E_{PCn\,WHR}$ and $E_{PCn\,CoI}$ are the corresponding eigenvectors of BMI, WC, WHR and CoI for the three principal components; S_{BMI}, S_{WC}, S_{WHR} and S_{CoI} are the corresponding standard values [(measured value − mean measured value)/standard deviation of measured value] for each anthropometric index.

Results

Age was significantly correlated with FM_{trunk}, $\%FM_{trunk}$ and the four studied anthropometric indices in the whole group, but was not significantly associated with them in each 5-year age group (data not shown). The subject characteristics for total and each of four groups are summarized in Table 1. There was an increasing trend of FM_{trunk}, $\%FM_{trunk}$, BMI, WC, WHR and CoI in successively older age groups (e.g. mean FM_{trunk} was 4·63 (SD 2·58), 5·39 (SD 2·74), 5·93 (SD 2·82) and 6·57 (SD 2·94) in the four 5-year age groups, respectively).

Correlations between FM_{trunk} and the four anthropometric indices were generally higher than those between $\%FM_{trunk}$ and the studied anthropometric indices in each age group (Table 2). The higher correlations resulted in more accurate predictions, and thus the following analyses focused on the prediction of FM_{trunk} with the four anthropometric indices. FM_{trunk} and $\%FM_{trunk}$ were significantly correlated with BMI, WC, WHR and CoI, with the correlation coefficients ranging from 0·25 to 0·86. In each age group, the correlation coefficients of BMI and WC with FM_{trunk} were significantly higher than those of WHR or CoI with FM_{trunk} (e.g. the correlation coefficients between FM_{trunk} and BMI, WC, CoI and WHR in the 20–24 age group were 0·84, 0·81, 0·48 and 0·26, respectively).

As shown in Table 3, the three principal components interpreted over 99·5% of the total variation of four relative anthropometric indices by principal component analysis, with over 65% of the total variation accounted for by PC1. Regression analyses (Table 4) showed that the three principal components explained a greater variance (R^2 70·0–80·1%) of FM_{trunk} than did BMI or WC alone (R^2 57·8–74·1%) (e.g. in the 20–24 age group, the proportions were 65·0, 70·9 and 75·6% by WC, BMI and the three principal components, respectively). Although the three principal components or BMI, WC, WHR and CoI were strongly correlated with FM_{trunk}, approximately more than 20% of the variance in FM_{trunk} remained unexplained by them. Figure 1 intuitively illuminates the simple correlation coefficients between the measured FM_{trunk} and the predicted FM_{trunk} by the three principal components, single BMI or WC in regression analyses. Obviously, the correlations of the measured FM_{trunk} and the predicted FM_{trunk} by three principal components were higher than by BMI or WC alone, indicating that the three principal components predicted a more precise FM_{trunk} than did BMI or WC alone. We also developed four age-specific simple equations to predict FM_{trunk} using measured values of the four anthropometric indices (Table 5), which were detailed in the statistical analysis. Then, to investigate the external validation of predicting FM_{trunk}, we determined the equations to predict FM_{trunk} in half of the randomly collected subjects and tested the prediction equations in the other half. The prediction equations in half of the randomly collected samples were very similar to those in the whole samples (data not shown), and then the predicted FM_{trunk} using these equations in the other half were highly correlated with the measured FM_{trunk} (r 0·71–0·89).

Discussion

The major observation of the present study is that, independent of age, the use of BMI, WC, WHR and CoI in combination is better than using them alone for the prediction of FM_{trunk} in Chinese males. The present study also confirms the finding that age has a significant influence on the truncal region fat mass and four anthropometric indices, all of which increase in ageing groups. The central adipose tissue was a widely used predictor of health risk. Thus, the results of the present study may imply the importance and a more accurate pattern of incorporating these four anthropometric indices into routine clinical practice.

Table 1. Basic statistical characteristics of the studied sample of Chinese males*
(Mean values and standard deviations)

	Age group (years)									
	20–24 (n 415)		25–29 (n 472)		30–34 (n 159)		35–39 (n 44)		Total (n 1090)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	23·7	1·05	26·9	1·44	32·0	1·41	37·3	1·60	27·2	4·17
Height (m)	1·70	0·05	1·69	0·05	1·68	0·05	1·68	0·06	1·69	0·05
Weight (kg)	61·3	8·29	62·8	8·50	63·5	8·13	64·8	8·36	62·6	8·58
BMI (kg/m^2)	21·2	2·57	21·9	2·71	22·4	2·63	23·0	2·64	21·8	2·73
WC (cm)	74·2	7·59	76·7	7·41	78·7	7·54	79·9	7·76	76·3	7·85
HC (cm)	90·7	6·77	92·1	5·93	93·1	7·47	93·3	5·52	91·8	6·56
WHR	0·82	0·06	0·83	0·07	0·85	0·07	0·86	0·06	0·83	0·07
CoI	1·14	0·07	1·16	0·07	1·18	0·07	1·18	0·07	1·15	0·07
FM_{trunk} (kg)	4·63	2·58	5·39	2·74	5·93	2·82	6·57	2·94	5·28	2·79
$\%FM_{trunk}$	15·72	6·28	17·69	6·65	19·12	7·03	20·58	7·21	17·37	6·78

CoI, conicity index; FM_{trunk}, trunk fat mass; $\%FM_{trunk}$, percentage of trunk fat mass; HC, hip circumference; WC, waist circumference; WHR, waist:hip ratio.
* For details of procedures, see p. 950.

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Table 2. Correlation coefficients of trunk fat mass (FM_{trunk}) and percentage of trunk fat mass ($\%FM_{trunk}$) with anthropometric indices

	Age group (years)			
	20–24	25–29	30–34	35–39
FM_{trunk} (kg)				
BMI	0·84	0·86	0·79	0·85
WC	0·81	0·79	0·76	0·84
WHR	0·26	0·41	0·31	0·74
CoI	0·48	0·40	0·42	0·62
$\%FM_{trunk}$				
BMI	0·76	0·78	0·70	0·72
WC	0·74	0·72	0·70	0·73
WHR	0·25	0·39	0·32	0·71
CoI	0·47	0·40	0·42	0·61

CoI, conicity index; WC, waist circumference; WHR, waist:hip ratio.

Central fat mass was demonstrated to be strongly related with many chronic diseases (Folsom *et al.* 1990; Rexrode *et al.* 1998; Van Pelt *et al.* 2002), and in routine clinical practice, the inexpensive and convenient anthropometric index was commonly used for assessing central adipose tissue, especially in developing countries. However, compared with Caucasians, few data on the relationships of anthropometric indices with fat mass in the truncal region have been reported in the Chinese population. The apparent differences in energy expenditure and body build among various ethnic groups may lead to ethnic-specific relationships (Deurenberg *et al.* 1998; Duncan *et al.* 2004). Additionally, the higher incidence of some diseases, such as CHD, in men compared to women, may partially result from the more central distribution of fat mass in men (Freedman *et al.* 1990; Larsson *et al.* 1992; Pi-Sunyer, 2004). Therefore, to increase our understanding of the ethnic-specific correlation and prediction of FM_{trunk} with four anthropometric indices, we conducted the present study in a large cohort of Chinese males with ages ranging from 20 to 40 years.

Consistent with previous studies (Shimokata *et al.* 1989; Lemieux *et al.* 1995; Zamboni *et al.* 1997), the present results showed a progressive trend toward increasing central fat mass deposition with ageing, which gives support to the earlier finding that age had an effect on upper-body fat mass in males (Horber *et al.* 1997). It may be partially credited to blunted growth hormone and testosterone secretion in old men (Corpas *et al.* 1993; Bjorntorp, 1996; Johannsson *et al.* 1997; Harman & Blackman, 2004). Johannsson *et al.* (1997) found that growth hormone treatment in adult men with abdominal obesity had favourable effects on abdominal fat mass and several obesity-related diseases. Declining physical activity with ageing may also enhance a more central shape (Mitchell *et al.* 2003; Parsons *et al.* 2005). Thus, to try to decrease the disturbance of age on the estimation of relationships between four anthropometric indices and FM_{trunk}, it was appropriate to divide our sample into four 5-year age groups, because age was significantly correlated with FM_{trunk} and four anthropometric indices in all samples, but was not associated with them in each divided age group.

We have confirmed that the four anthropometric indices were highly correlated with FM_{trunk} and $\%FM_{trunk}$, and BMI and WC were better predictors of FM_{trunk} than were WHR and CoI (Lean *et al.* 1995; Taylor *et al.* 2000; Snijder *et al.* 2004). However, more importantly, the present results indicated that the three principal components from four anthropometric indices assessed FM_{trunk} more accurately than did BMI, WC, WHR and CoI alone, explaining at least an additional 2·6% of the variation of FM_{trunk}. It was also supported by the simple correlation coefficients between the measured FM_{trunk} and the predicted FM_{trunk} by the three principal components, which were higher than those between the measured FM_{trunk} and the predicted FM_{trunk} by BMI or WC alone (Fig. 1). In past years, numerous studies have been striving for the accuracy of a single anthropometric index for estimating central fat mass, but the results have been largely inconsistent among the studies (Ross *et al.* 1994; Taylor *et al.* 1998, 2000; Kamel *et al.* 1999, 2000; Lindsay *et al.* 2001).

Table 3. Eigenvalues of the correlation matrix and eigenvectors in the principal component analysis for four anthropometric indices

	Eigenvalues of the matrix		Eigenvector			
Age group (years)	Eigenvalue	Proportion	BMI	WC	WHR	CoI
20–24						
PC1	2·602	0·651	0·478	0·603	0·374	0·518
PC2	0·813	0·203	−0·561	−0·212	0·773	0·206
PC3	0·570	0·143	0·507	−0·135	0·512	−0·680
25–29						
PC1	2·898	0·728	0·418	0·567	0·498	0·506
PC2	0·849	0·212	0·755	0·216	−0·410	−0·464
PC3	0·240	0·060	0·159	−0·294	0·763	−0·553
30–34						
PC1	2·796	0·699	0·408	0·577	0·480	0·519
PC2	0·862	0·215	0·773	0·192	−0·443	−0·411
PC3	0·326	0·082	0·219	−0·297	0·756	−0·541
35–39						
PC1	3·139	0·785	0·466	0·552	0·495	0·483
PC2	0·546	0·136	0·755	0·068	−0·173	−0·630
PC3	0·297	0·074	−0·108	−0·325	0·851	−0·398

CoI, conicity index; PC1, PC2, PC3, principal components derived from the four anthropometric indices by principal component analysis; WC, waist circumference; WHR, waist:hip ratio.

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Table 4. The R^{2*} and standard error of estimation (SEE) of the three principal components (PC), BMI or waist circumference (WC) and the regression coefficients of the PC

	Age group (years)			
	20–24	25–29	30–34	35–39
Variations				
R^2 (PC)	75·6	76·7	70·0	80·1
SEE (PC)	1·27	1·32	1·57	1·31
R^2 (BMI)	70·9	74·1	61·9	71·5
SEE (BMI)	1·40	1·40	1·75	1·52
R^2 (WC)	65·0	62·8	57·8	71·1
SEE (WC)	1·51	1·67	1·83	1·53
Regression coefficients				
PC1	1·219	1·150	1·149	1·431
PC2	−1·093	1·515	1·474	0·960
PC3	0·550	−0·105	−0·380	0·198
Intercept	4·60	5·41	5·91	6·57

* R^2 is the percentage of the variance of trunk fat mass explained by the three PC, BMI and WC.

WC is a commonly and widely used tool for central adipose tissue assessment (Taylor *et al.* 1998, 2000; Snijder *et al.* 2004). However, the use of WC as the predictor of central fat mass has been criticized (Ross *et al.* 1994; Kamel *et al.* 2000) for the relatively low correlation coefficients between WC and central fat mass. Adipose distribution may partially disturb the accuracy of assessment as anatomic adipose distribution in the central region has been demonstrated to be different among individuals with differential BMI (Ross *et al.* 1994; Han *et al.* 1997; Kamel *et al.* 2000). Thus there are limitations in only using one anthropometric index to evaluate regional fat mass. In Janssen *et al.* 2002, demonstrated that the combined use of WC and BMI substantially increased the variance explained in abdominal subcutaneous and visceral fat mass than did either variable alone. Their results support our belief that it may be more significant and accurate to evaluate fat mass in the truncal region using combined anthropometric indices. BMI, WC, WHR and CoI were all useful and accurate tools for assessing central adipose tissue (Taylor *et al.* 1998, 2000; Janssen *et al.* 2002; Brambilla *et al.* 2006). However, as those indices were highly related, they cannot simply be involved in multiple regression analysis to predict FM_{trunk}. A principal component analysis was adopted in the present study to attempt to extract useful information from these four related indices. To the best of our knowledge, the present study is the first effort to use four anthropometric indices simultaneously to predict FM_{trunk} in Chinese adult males with age varying from 20 to 40 years.

With the aim of predicting FM_{trunk} with a simple method, in the present study we developed four age-specific equations using the measured values of four anthropometric indices which have practical significance for routine clinical assessment in Chinese males. The validation of predicting FM_{trunk} is very high. The correlation coefficients between the measured FM_{trunk} and predicted FM_{trunk} by the three principal components using multiple regression analysis were high, ranging from 0·83 to 0·88 (Fig. 1). Although predictive equations have been developed and proposed for estimating central fat mass by combining anthropometric indices with DXA data in Caucasians (Jensen *et al.* 1995; Bertin *et al.* 2000), several studies have reported the limitations when the generalized formulas based on Caucasians were used to estimate the body composition of non-white populations (Vickery *et al.* 1988; Jakicic *et al.* 1998). Furthermore, the assessment of adipose tissue with measurement of anthropometric indices is much cheaper and technically easier than using DXA, computed tomography or magnetic resonance imaging. Therefore, it is of very important clinical implication to develop ethnic-specific equations for accurately assessing central fat mass using simple and costless anthropometric indices, especially in developing countries like China. This is the primary motive for performing the present study in the Chinese population.

However, the present study has some limitations. First, although DXA as a three-component model is becoming increasingly popular for the measurement of soft tissue composition as well as bone mineral mass, it cannot distinguish between visceral and subcutaneous adipose tissue and is less accurate compared with computed tomography or magnetic resonance imaging. But research has illustrated strong correlations between the fat mass at trunk measured by DXA and abdominal fat mass measured with computed tomography or

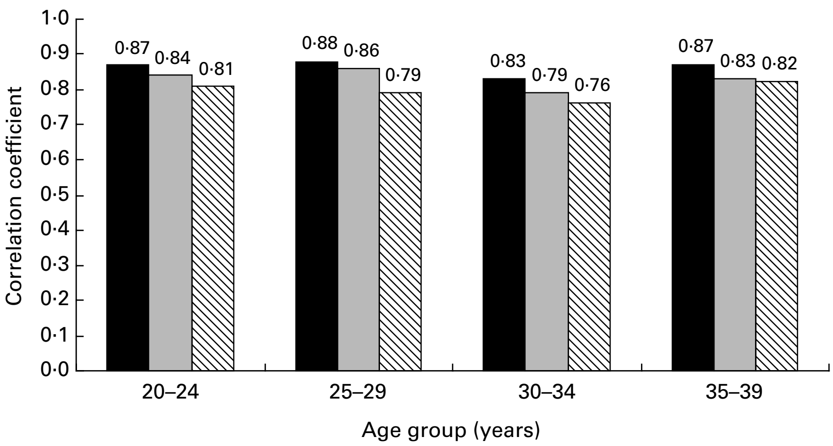

Fig. 1. Simple correlation coefficients, using regression analysis, between trunk fat mass (FM_{trunk}) and the predicted FM_{trunk} by the three principal components (■), BMI (▨) and waist circumference (▧). For details of procedures, see pp. 950–951.

Table 5. Predicted trunk fat mass (FM_{trunk})* calculated from the measured values of four anthropometric indices using principle component analysis

Age group (years)	Predicted equation
20–24	Predicted FM_{trunk} (kg) $= 0.5738 \times$ BMI $+ 0.1176 \times$ WC (cm) $- 1.7891 \times$ WHR $+ 0.4645 \times$ CoI $- 15.3484$
25–29	Predicted FM_{trunk} (kg) $= 0.5934 \times$ BMI $+ 0.1364 \times$ WC (cm) $- 1.8377 \times$ WHR $- 0.8922 \times$ CoI $- 15.4855$
30–34	Predicted FM_{trunk} (kg) $= 0.5802 \times$ BMI $+ 0.1403 \times$ WC (cm) $- 5.5438 \times$ WHR $+ 2.7996 \times$ CoI $- 16.7229$
35–39	Predicted FM_{trunk} (kg) $= 0.5190 \times$ BMI $+ 0.1018 \times$ WC (cm) $+ 13.2577 \times$ WHR $+ 0.1302 \times$ CoI $- 25.0608$

CoI, conicity index; WC, waist circumference; WHR, waist:hip ratio.
* For the equation for predicted FM_{trunk}, see p. 950.

magnetic resonance imaging (Treuth *et al.* 1995; Goran *et al.* 1998; Glickman *et al.* 2004). Second, the present results from a healthy population with normal body weight might be inappropriate for obese populations or other patients with chronic diseases and conditions. But, central fat mass is an undeniable necessity for accessing disease risk in non-obese populations as well. Goodpaster *et al.* (2005) demonstrated that apart from general fat mass, the abdominal adipose tissue was independently associated with the metabolic syndrome in men and women, particularly among those of normal body weight. Third, the subjects were aged between 20 and 40 years. Therefore, it may not be possible to generalize the results of the present study to older or younger Chinese males. Fourth, the small number of men in the 35–39 age group (only forty-four subjects) may easily result in randomized bias. Therefore, an expanded sample in this age group should be recruited in a further study to form more confident results.

In conclusion, the present study explored the complex relationships between four anthropometric indices and FM_{trunk} in a very large sample of Chinese males with ages varying from 20 to 40 years. The results obtained added to our understanding of the relationships of anthropometric indices and fat mass in the trunk region, as well as the effects of age on them.

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