Original Article

# Increased abdominal fat in young women of Indian origin

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People of Indian origin develop type 2 diabetes at a relatively young age and low body mass index compared to people of other racial groups, possibly because of preferential accumulation of abdominal fat. We examined the relationship between abdominal fat and body mass index (BMI) in healthy premenopausal women of different racial groups, and compared abdominal fat measurements at different ages. Women of Chinese, European, Indian or Polynesian origin (50 of each, mean age 31) had dual energy x-ray absorptiometry of the lumbar spine, with estimation of the percentage fat in the abdominal area. Polynesian women had a significantly greater mean BMI ($P$<0.001) than all other groups, and a higher abdominal fat than European and Chinese woman ($P$<0.001). Although the Indian women had a similar mean BMI to the European and Chinese women, they had a significantly greater abdominal fat ($P$<0.001). When examined by age tertile, the Indian women had significantly more abdominal fat than Chinese or European women at all ages ($P$<0.001), with marked differences evident even in the youngest group (mean age 23 years). Compared to other racial groups, women of Indian origin preferentially accumulate abdominal fat - a trait that is well established in young adulthood.

**Key Words: abdominal obesity, diabetes, body mass index, fat mass, premenopausal women, Chinese, European, Polynesian, Indian.**

## Introduction

Many studies have documented the high incidence of cardiovascular disease and diabetes affecting people originating from the Indian subcontinent, particularly when they are exposed to urban environments and western lifestyles.[1-5] The emergence of these disorders appears to be related to gain in body weight and the development of the metabolic syndrome. Features of the metabolic syndrome tend to develop earlier in life in Indians compared to Europeans, and at relatively low levels of body mass index.[4-9] Several studies have documented that the metabolic syndrome is more closely associated with the accumulation of central (abdominal) fat rather than generalised body fatness.[6,9-11] The preferential accumulation of fat in the central or abdominal area could thus be critical to the early development of the metabolic syndrome and type 2 diabetes in people of Indian ancestry. In this study we have compared abdominal fat in healthy young women from four racial groups, and examined the relationship with age, in order to determine if differences in abdominal fat accumulation are present early in life.

## Subjects and Methods

200 premenopausal women, 50 each of Indian, European, Chinese and Polynesian origin, were recruited by adverisement in local hospitals and tertiary educational institutes. The original purpose of the study for which they were recruited was to examine inter-racial differences in bone density.[12] The Chinese women were either New Zealand-born or migrants from the People's Republic of China, Hong Kong, Malaysia, Singapore or Taiwan. The Indian women were either New Zealand-born or migrants from India, Fiji, Sri Lanka or Uganda. All the European women were New Zealand-born. The Polynesian women were either New Zealand-born (Maori) or migrants from Tonga, Samoa, the Cook Islands or Niue Island. All the participants were premenopausal, with no systemic illness (including diabetes), and taking no medication known to affect body fat metabolism. Each subject had her height measured using a Harpenden stadiometer and her weight (wearing light indoor clothing) using an electronic balance. Body mass index (BMI: kg/m$^2$) was calculated from these measurements.

The abdominal fat percentage was obtained from antero-posterior scans of the lumbar spine, using dual energy x-ray absorptiometry (DEXA) scans (Lunar DPX-L, software version 1.3). DEXA was originally developed as a method for measuring bone mineral density (the ability to measure fat mass has been a useful by-product), and the region most easily and frequently assessed for this is the lumbar spine, an area that includes the waist.

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The Lunar system for DEXA automatically generates an "R-value", an estimate of the percentage fat in the scan field. The R-value is derived from the relative intensity of measured transmitted x-rays at the two energies through the soft tissue, and reflects the percentage of fat in a given region. No further analysis of the scan is necessary, as the calculation of the R-value is integral product of the software. Our subjects all had lumbar spine DEXA scans, and the percentage fat on this scan was taken to represent abdominal fat. In 67 normal women (not part of this study) having both lumbar spine and total body scans we have found that the abdominal fat percentage on the lumbar spine scan and the percentage fat in the trunk region of interest are closely correlated (r =0.87, $P$ <0.0001, data not shown). All scans were analysed by a single operator (MCE).

The research protocol was approved by the North Health Ethics Committee. Correlations were calculated by the Pearson method and a linear regression analysis was performed. Friedman's two-way analysis of variance was performed to test for differences in BMI and abdominal fat percentage by age tertiles and ethnic group.

**Results**

Details of the women in each racial group are summarised in Table 1. For the entire group, the abdominal fat percentage was significantly correlated with weight (r = 0.69, $P$<0.001) and BMI (r = 0.65, $P$<0.001). Polynesian women had a significantly greater mean BMI ($P$<0.001) than all the other groups, and a higher abdominal fat percentage than the European and Chinese woman ($P$<0.001). Although the Indian women had a similar mean BMI to the European and Chinese woman, they had a significantly greater abdominal fat percentage ($P$ <0.001, Fig. 1). Linear regression modelling showed that for a given BMI, Indian women tended to have higher abdominal fat percentage than other groups, with this relationship holding true even in lean individuals. For example the predicted abdominal fat percentage at a BMI of 20 (the lower limit of the healthy range) was significantly higher in Indian women (mean 16.2%, 95% CI 14.3-18.1) than the other three groups (European 9.0%, 95%CI 7.3-10.7, Chinese 11.6%, 95% CI 9.8-13.4, Polynesian 9.5%, 95%CI 6.7-12.3). There was a tendency in all the groups for the abdominal fat percentage to be greater in the older age groups ($P$<0.001, Table 2), but the between–race differences noted above were apparent in all age groups, and similar in magnitude across all three age tertiles. The difference was proportionately greatest in the youngest age group. For example, the mean age and the BMI were similar in the youngest tertile for Indian and European women (average age 23 years) but the Indian women had 50% more abdominal fat ($P$ <0.001, Fig. 2).

**Discussion**

In this study of healthy premenopausal women we observed two striking phenomena. First was that the relationship between BMI and abdominal fat was clearly different in the Indian women, compared to that in women from the other groups, and secondly that the phenotypic trait of having a relative increase in abdominal fat was already present in healthy young women in their early twenties.

In Chinese, European and Polynesian women, the relationship between BMI and abdominal fat was linear across a wide range of BMI values. The Polynesian women were on average more obese as judged by BMI, and their abdominal fat was increased proportionately. The Indian women had a similar mean BMI to that of the Chinese and European women, but their abdominal fat was disproportionately increased – in absolute terms it was slightly higher than that of the Polynesian women, who had a greater BMI by an average 5.1 kg/m$^2$.

This data is consistent with other studies employing clinical methods of assessing abdominal fat such as the waist-hip ratio.[8,9,13] There have been few studies using DEXA, computed tomography or magnetic resonance imaging to assess body fat in Indian subjects. Those that have been published have generally studied older subjects or men only, but they do consistently show a similar pattern to that which we describe. Increased abdominal adiposity in Indian men has been shown to be present even when total body fat content is similar to European men.[14,15] Total body fat has been shown to be under predicted by BMI in Indians living in Singapore[16] and Northern India,[17] and in several Asian ethnicities utilising anthropometry or bioimpedance-derived predictive formulae based on European populations.[18,19] Estimation of adiposity by DEXA avoids these biases.

When we analysed the relationship between BMI and abdominal fat according to age, we observed no age/race interaction. The difference in abdominal fat between the Indian women on the one hand, and Chinese or European women on the other was evident in the youngest age group, and the same differential (in absolute terms) was maintained across all the age groups. As abdominal fat (and BMI) tended to be greater with age in each racial group, the difference between the Indian women and the Chinese or Europeans was proportionately greater in the youngest age group. This observation suggests that the trait of abdominal fat accumulation is determined early in life, but how early cannot be deduced from our data. Clearly studies of even younger subjects would be of interest. One study of children, using anthropometric measures, found no difference between waist circumference or waist-hip ratio in Indian compared with European children, although such differences existed between their mothers.[20] The research group from Pune have shown that newborn Indian babies have smaller abdominal circumferences, relatively preserved subcutaneous fat and are hyperinsulinaemic compared to British newborns.[21,22] In eight-year-old Indian children the ratio of subscapular (central) to triceps (peripheral) skinfold thickness and biochemical markers of insulin resistance were found to be inversely related to birthweight.[23] This data has been interpreted as supporting intrauterine programming as the cause of the predisposition to abdominal obesity, but it remains possible that Indian people have a genetic predisposition to accumulate fat preferentially in the abdomen,[24] a possibility that our study would support.

**Table 1.** Characteristics of the 200 pre-menopausal women

| | European | Chinese | Indian | Polynesian |
|---|---|---|---|---|
| Age (years) | 32.1 ±8.5 | 32.6 ± 8.1 | 31.4 ± 8.1 | 30.8 ± 7.3<br>30.9 |
| % Smokers | 22 | 4 | 2 | 28 |
| Height (cm) | 165.4 ± 6.6 | 157.9 ± 5.5 | 157.4 ± 5.9 | 165.1 ± 5.3 |
| Weight (kg) | 60.1 ± 8.1 | 53.0 ± 5.7 | 56.2 ± 6.5 | 75.7 ± 14.4 |
| BMI (kg/m$^2$) | 22.2 ± 2.8<br>22.2 (20.4-22.9) | 21.4 ± 1.9<br>21.4 (19.6-22.5) | 22.7 ± 2.7<br>22.7 (20.4-24.7) | 27.8 ± 5.2†<br>26.8 (24.1-30.1)† |
| Abdominal fat (%) | 13.0 ± 7.0<br>13.3 (6.9-17.2) | 13.0 ± 5.7<br>11.6 (8.8-16.1) | 20.3 ± 6.2*<br>19.9 (16.1-24.2)* | 18.5 ± 8.2*<br>19.7 (11.8-23.9)* |

Data are expressed as mean ± standard deviation, and for BMI and abdominal fat also as median (with interquartile range); † greater than European, Chinese and Indian ($P < 0.001$); *greater than European and Chinese ($P < 0.001$) – ANOVA.

**Table 2.** Body mass index and abdominal fat grouped by age tertile for each racial group

| Race | Tertile | Number of subjects | Age (years) | | Body mass index (kg/m$^2$) | | Abdominal fat (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean (SD) | range | Median (IQR) | Mean (SD) | Median (IQR) | Mean (SD) |
| European | 1 | 18 | 23.1 (2.4) | 18-26 | 21.7 (20.1-22.6) | 21.7 (2.2) | 11.0 (5.6-14.5) | 10.8 (5.5) |
| | 2 | 14 | 31.3 (2.5) | 27-36 | 22.1 (20.2-22.4) | 22.0 (3.0) | 11.9 (4.9-14.6) | 10.4 (5.6) |
| | 3 | 18 | 41.7 (3.6) | 37-49 | 22.3 (20.6-24.1) | 23.0 (3.2) | 16.0 (9.3-22.3) | 17.3 (7.5) |
| Chinese | 1 | 15 | 22.6 (2.1) | 18-25 | 21.1 (20.1-24.1) | 21.6 (1.9) | 9.4 (7.7-12.7) | 10.2 (3.9) |
| | 2 | 14 | 31.4 (3.4) | 27-36 | 21.4 (19.6-22.3) | 20.7 (1.4) | 11.2 (9.1-17.8) | 11.6 (4.2) |
| | 3 | 21 | 40.5 (3.1) | 37-46 | 21.6 (19.3-22.5) | 21.4 (2.2) | 13.8 (11.3-19.5) | 15.9 (6.3) |
| Indian | 1 | 17 | 22.7 (2.5) | 18-25 | 21.2 (19.7-22.6) | 21.6 (2.8) | 16.7 (12.9-16.7) | 18.2 (6.4) |
| | 2 | 18 | 31.4 (3.1) | 27-36 | 21.5 (20.4-24.8) | 22.8 (2.7) | 19.4 (16.6-23.6) | 20.3 (5.3) |
| | 3 | 15 | 41.1 (4.4) | 37-51 | 23.9 (22.8-25.0) | 24.0 (2.3) | 22.0 (18.1-26.7) | 22.5 (6.5) |
| Polynesian | 1 | 17 | 22.5 (1.9) | 18-25 | 24.6 (22.5-27.7) | 25.4 (3.8) | 13.7 (9.0-20.4) | 15.5 (7.3) |
| | 2 | 22 | 32.2 (2.7) | 28-36 | 27.3 (24.5-29.0) | 28.4 (5.5) | 21.1 (9.9-24.2) | 19.9 (9.5) |
| | 3 | 11 | 40.6 (3.2) | 37-45 | 32.3 (26.0-36.3) | 30.1 (5.5) | 21.5 (16.4-27.3) | 20.2 (5.6) |

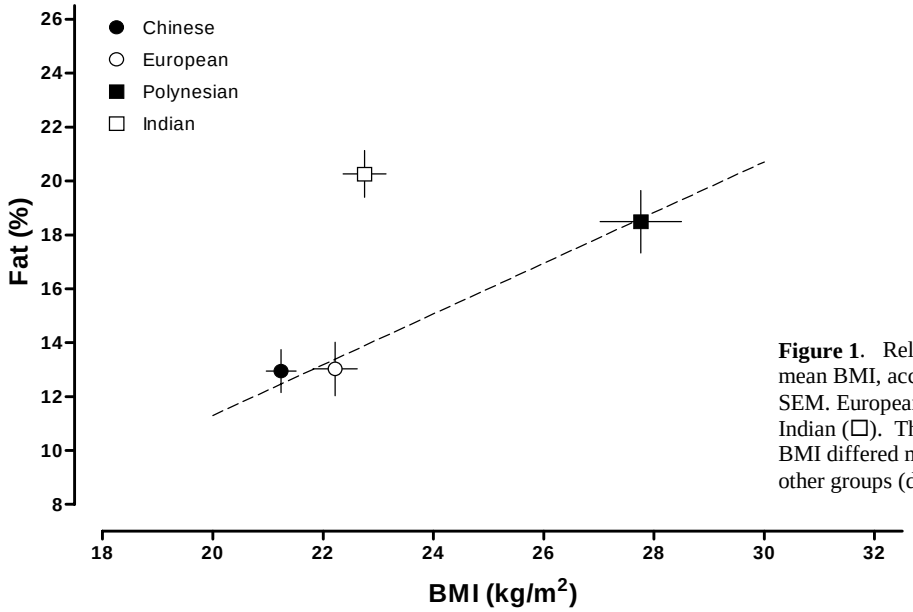


**Figure 1**. Relationship of mean abdominal % fat and mean BMI, according to racial group. Error bars indicate SEM. European (○), Chinese (●), Polynesian (■), and Indian (□). The relationship between abdominal fat and BMI differed markedly for Indian women compared to the other groups (dotted line).

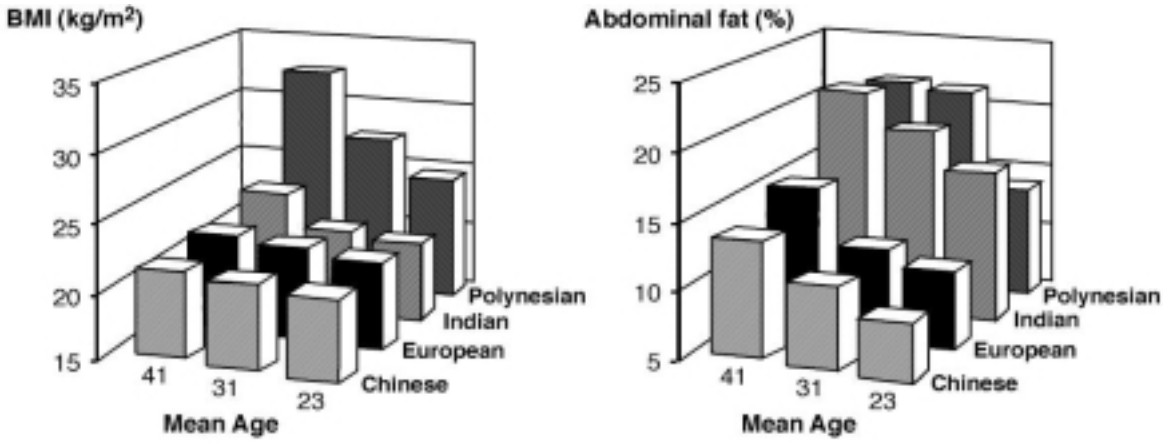


**Figure 2.** Comparison of median values of abdominal % fat and BMI according to racial group and age tertile. The mean age of each tertile is shown.

The main limitations of our study are its *post hoc* design, which meant that we did not have data collected on anthropometric variables other than BMI, and neither was there data on diet and exercise, nor biochemical findings in our subjects. In addition, the DEXA method does not distinguish between intra-abdominal and subcutaneous fat, which may not be equally diabetogenic.

In summary, using the readily accessible estimate of percentage fat on lumbar spine DXA scans, we have identified an apparent predisposition to the development of truncal adiposity in healthy premenopausal Indian women, that is established early in life. Abdominal fat is now acknowledged to have a pivotal role in the genesis of the metabolic syndrome and type 2 diabetes, disorders that are particularly prevalent in people of Indian origin. Future research needs to identify the genetic or early life environmental influences that permit this phenotype to develop.

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