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Tonkin, Andrew M., Balkau, Beverley, Tuomilehto, Jaakko, Chitson, Pierrot and Shaw,

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Manuscript title: Cut-points for waist circumference in Europids and South Asians.

Running title: Cut-points for waist circumference in Europids and South Asians.

Author names and affiliations: Adrian J Cameron¹,², Richard A Sicree¹, Paul Z Zimmet¹, KGMM Alberti³, Andrew M Tonkin², Beverley Balkau¹,⁴,⁵, Jaakko Tuomilehto⁶, Pierrot Chitson⁷, Jonathan E Shaw¹

¹ Baker IDI Heart and Diabetes Institute, Melbourne, Australia
² Monash University, Department of Epidemiology and Preventive Medicine, Melbourne, Australia
³ Department of Medicine, University of Newcastle, Newcastle upon Tyne, United Kingdom
⁴ INSERM, Unit 780, Villejuif Cedex, France
⁵ Université Paris-Sud 11, Orsay, France
⁶ Department of Public Health, University of Helsinki, Helsinki, Finland
⁷ Ministry of Health and Quality of Life, Mauritius

Correspondence to:
Adrian Cameron,
Baker IDI Heart and Diabetes Institute, 250 Kooyong Road, Caulfield, Australia, 3162.
Telephone: +61 3 9258 5041; Fax: +61 3 9258 5090
Email: Adrian.Cameron@bakeridi.edu.au

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Abstract

There is little strong evidence that currently recommended higher waist circumference cut-points for Europids compared with South Asians are associated with similar risk for type 2 diabetes. This study was designed to provide such evidence.

Longitudinal studies over five years were conducted among 5515 Europid and 2214 ethnically South Asian participants. Age-standardized diabetes incidence at different levels of waist circumference and incidence difference relative to a reference value were calculated. The Youden Index was used to determine waist circumference cut-points.

At currently recommended cut-points, estimated annual diabetes incidence for a 50 year old Europid was < 0.6% for both sexes, and for a 50 year old South Asian, 5.8% for men and 2.1% for women. Annual diabetes incidence of 1% was observed for a 50 year old at a waist circumference 35-40 cm greater in Europid compared to South Asian men and women. Incidence difference between recommended cut-points and a reference value (80 cm in men, 70 cm in women) was 0.3 and 4.4 percent per year for Europid and South Asian men, and 0.2 and 0.8 percent per year for Europid and South Asian women respectively.

Waist circumference cut-points chosen using the Youden Index were shown to be dependent on obesity levels in the population.

The much higher observed risk of diabetes in South Asians compared to Europids at the respective recommended waist circumference cut-points suggests that differences between them should be greater. Approaches that use the Youden Index to select waist circumference cut-points are inappropriate and should not be used for this purpose.
Introduction

The continuing rise in the proportion of adults who are overweight and obese observed in most developed countries over the past three decades is now also being seen in developing countries.(1) The increasing global burden of chronic non-communicable diseases has been described as setting the agenda for global public health, with pandemics of obesity and type 2 diabetes threatening progress toward achievement of the Millennium Development Goals.(2) Obesity is associated with an increased risk of many diseases including type 2 diabetes, cardiovascular diseases and several cancers as well as premature mortality,(3-5) and is a precursor to the development of the components of the metabolic syndrome.(6) Because obesity is modifiable and often occurs many years before the development of the associated negative health outcomes, it is an ideal target for chronic disease prevention.

Increasingly, abdominal obesity has been shown to be a stronger indicator of associated risk than overall body fatness as measured by the Body Mass Index (BMI).(1, 7-9) Waist circumference is easily determined and a commonly used and valid surrogate measure of abdominal adiposity.(10) Evidence-based cut-points for abdominal obesity are therefore important for both clinical and public health uses.

The cut-points of waist circumference for overweight and obesity recommended by the World Health Organization (WHO) (men 94/102 cm; women 80/88 cm)(1) were those statistically corresponding to a BMI of 25 and 30 kg/m², respectively in a small study involving a largely Europid population.(11) Specific cut-points for other ethnic groups have been published by some organizations,(12) but not the WHO. A large number of studies have attempted to define waist circumference cut-points related to ethnicity,(13-34) mostly using approaches based on Receiver Operating Characteristic (ROC) curves. Little evidence exists from longitudinal studies with incident outcomes such as type 2
diabetes and cardiovascular disease. Despite an abundance of reports from cross-sectional studies, there remains a need for evidence to inform waist circumference cut-points in different ethnic groups, (35, 36) and the methods used for selecting them.(37)

Using data from two national, longitudinal cohort studies, our primary aim was to determine whether differences in currently recommended waist circumference cut-points between Europids and South Asians are an adequate reflection of the differences in risk for incident type 2 diabetes related to obesity between the two populations. We compared the following using the two populations:

1. The incidence of diabetes at currently recommended waist circumference cut-points.
2. The waist circumference at which the age-adjusted annual incidence of diabetes is 1%. This method compares the two populations at a fixed level of absolute risk.
3. The waist circumference increment at which diabetes incidence increases by 50%, 100% and 200% above that observed for the 10th percentile of waist circumference. This method compares the two populations at fixed levels of relative risk.
4. The age and waist circumference profile of those who developed diabetes in the two populations.
5. The waist circumference cut-points determined using the Youden Index (the waist circumference at which sensitivity + specificity for incident diabetes is maximized) and whether this was affected by the prevalence of obesity in the population.
Methods and Procedures

Population-based surveys

The study methods and response rates for both the AusDiab and Mauritius surveys have been described in detail elsewhere.(38, 39)

The AusDiab study was a nation-wide population-based stratified cluster survey of 11247 Australian adults (45% men) aged \( \geq 25 \) years in 1999-2000. The response rate was 55% of those completing a household interview, estimated to be 37% of the eligible population. In 2004-2005, 59% (n=6400) of the 10788 eligible participants returned for a follow-up physical examination.

The Mauritius non-communicable disease survey began in 1987 and included all persons aged \( \geq 25 \) years living in 10 randomly selected population clusters and a purposely selected area of Chinatown in Port Louis. Response rate was 80% (n=5083). Of those surviving and eligible, 74% (n=3771) were followed up in 1992.

Survey procedures

Those individuals with diabetes at baseline, pregnant women and those without data on waist circumference or diabetes status at baseline or follow-up were excluded from all longitudinal analyses. Only those defined as having Europid ancestry in AusDiab, and South Asian ancestry in Mauritius were included. Ancestry was based on country of birth and language spoken at home in the AusDiab study, and self-reported ethnicity in Mauritius (Chinese, Creole or South Asian). After exclusions, the number available for longitudinal analyses in Mauritius from 1987 to 1992 was 2214; and in AusDiab from 2000 to 2005, 5515.
In both studies, and at both time points, a 75g oral glucose tolerance test (OGTT) was performed on all non-pregnant participants, except those taking insulin or oral anti-diabetic drugs. For the purpose of this report, diabetes was classified according to the WHO criteria.(40)

Biochemical measures and blood pressure for all surveys were obtained as previously described.(41, 42) In the AusDiab study, waist circumference was measured mid-way between the lower border of the ribs and the iliac crest on a horizontal plane. In Mauritius, waist circumference was measured as the minimum value of the horizontal plane between the xiphisternum and umbilicus.(42) In both surveys, two measurements to the nearest 0.5 cm were recorded. If the measurements varied by more than 2 cm, a third measurement was taken and the mean of the two closest measurements calculated. A study of mean waist circumference in a multi-ethnic population found the difference between measurements taken at the mid-point between the ribs and the iliac crest and the narrowest waist to be only 1.5 cm in men and 2.7 cm in women.(43) For this reason, 1.5 cm and 2.7 cm was added to the waist circumference of all South Asian men and women respectively for all analyses involving comparisons of Europid and South Asian populations.

The AusDiab survey protocols were approved by the Ethics Committee of the International Diabetes Institute and the Monash University Standing Committee on Ethics in Research involving Humans (SCERH). The Mauritius survey protocols were reviewed and approved by the Alfred Healthcare Group Ethics Committee (Melbourne, Australia) as well as the Ministry of Health, Mauritius. Informed consent was obtained from all participants.

**Statistical Analysis**

Statistical analysis used SPSS 15.0 (SPSS Inc., Chicago IL, USA). Means (±SD) or proportions of various physical and demographic characteristics were calculated and
compared using t-tests, Mann-Whitney U tests or chi-square tests as appropriate. Geometric means and geometric standard deviations were calculated for skewed variables (triglycerides, fasting and 2-hour post load plasma glucose). Gender- and population-specific logistic regression adjusted for age and age squared was used to estimate diabetes incidence for a 40, 50 and 60 year old, at 1 cm intervals of waist circumference. Improvement in the model after inclusion of a waist squared term was tested using a post-estimation likelihood ratio test. Model fit was assessed via Hosmer and Lemeshow goodness-of-fit statistics. A similar logistic regression including interaction terms of waist circumference and both sex and ethnicity was modelled in a dataset including participants from both surveys. The 10th percentile of waist circumference and the diabetes incidence for a 50 year old at this waist circumference were calculated for men and women in both populations. The waist circumference at which diabetes incidence was 50%, 100% and 200% greater than that seen at the 10th percentile of waist circumference was calculated in order to assess the strength of the relationship between waist circumference and diabetes in each population.

ROC curves for the prediction of diabetes were constructed and the waist circumference that maximised the sum of sensitivity and specificity (the Youden Index) calculated.(44) To assess the impact of the prevalence of obesity on the value of the Youden Index, ethnically and culturally similar populations with differing levels of obesity were required. Two approaches were used. Firstly, cut-points were calculated for prevalent diabetes (screen detected and diagnosed) in the 1987 and 1992 Mauritius surveys. The 1987 cohort included those who attended the 1987 survey only, and a randomly selected 50% of those who attended both the 1987 and 1992 surveys. Conversely, the 1992 cohort included those who attended the 1992 survey only, and the randomly selected 50% of those who attended both the 1987 and 1992 surveys not included in the 1987 cohort (i.e. no individual is included in both the 1987 and 1992 cohorts tested - they are
The 1987 and 1992 Mauritius surveys were chosen because of the sharp increase in mean waist circumference between 1987 and 1992. Secondly, cut-points were calculated from two Europid cohorts with “high” and “low” average waist circumference in the AusDiab study. This was done by random selection of individuals within each decile of waist circumference, with the proportion included in the “high” cohort increasing from 30% of the lowest decile to 75% of the highest decile (and vice versa for the “low” cohort).

Role of the funding source
The study sponsors had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Results
The baseline physical and demographic characteristics of those who attended both surveys in the AusDiab and Mauritius studies are shown in Table 1. At baseline, Europid subjects from AusDiab were on average older, and had higher BMI, waist circumference, fasting plasma glucose and systolic blood pressure levels and a higher percentage reported tertiary education (all p<0.001). Mean waist circumference was 19 cm greater in Europid than South Asian men (97 cm vs 79 cm) and 11 cm greater in Europid than South Asian women (84 cm vs 76 cm) (both p<0.001). Smoking was more common in men than women, and strikingly so among South Asians (56.8% in men vs. 1.4% in women) (p<0.001).

[Insert Table 1 here]

Relationship between waist circumference and diabetes
Five year diabetes incidence was 3.8% (n=210) among Europid AusDiab participants, and 9.4% (208) in South Asian participants in the Mauritius study. Models predicting
incident diabetes did not improve (at p<0.05) following the inclusion of a waist squared term for either the South Asian or Europid populations (or in a combined dataset), suggesting a log-linear relationship between waist circumference and diabetes incidence. In a combined dataset containing cases from both studies, interactions of waist circumference and sex and of waist circumference and ethnicity were not statistically significant (p>0.05). No evidence of lack of fit was observed with age and an age-squared term included in the model, with Hosmer and Lemeshow statistics not significant for either the Mauritius or Europid cohort in men or women (all p>0.3).

Relative to annual diabetes incidence at the 10th percentile of waist circumference (0.96% and 1.27% in South Asian women and men respectively, 0.25% and 0.35% in Europid women and men respectively), the increment in centimetres of waist circumference over which age-adjusted incidence increased by 50%, 100% and 200% was essentially the same for Europid and South Asian women (9 cm, 15 cm and 24 cm respectively). In men, diabetes incidence increased by 50%, 100% and 200% over 7 cm, 12 cm and 20 cm in Europids and 6 cm, 10 cm and 17 cm in South Asians. The similar relationship between diabetes incidence and waist circumference in these populations is also reflected in similar age- and sex-adjusted odds ratios of developing diabetes (1.052 (95%CI 1.041-1.064) per cm of waist circumference in Europids and 1.059 (1.044-1.074) per cm in South Asians; both sexes combined for each ethnicity).

**Difference in age-adjusted risk**

Five-year incidence of diabetes (for a 50 year old) was ~11 fold higher among South Asian men and ~ 6 fold higher for women at any level of waist circumference (Figures 1a and 1b), with a 1% annual incidence of diabetes occurring at a waist circumference 35-40 cm greater in Europids compared to South Asians for both men (103 cm vs. 65 cm) and women (99 cm vs. 64 cm). Similar results were observed when the relationship was modelled for a 40 or 60 year old respectively.
Risk at currently recommended cut-points

At the currently recommended waist circumference cut-points (94 cm and 90 cm in Europid and South Asian men respectively; 80 cm in both Europid and South Asian women), estimated annual diabetes incidence for a 50 year old was 0·6% and 0·4% in Europid men and women, respectively, and 5.8% and 2.1% in South Asian men and women, respectively. The magnitude of difference was similar when the relationship was modelled for a 40 or 60 year old respectively.

The difference in annual incidence at recommended Europid cut-points compared to a reference waist circumference of 70 cm in women and 80 cm in men was calculated. In Europid men at 50 years of age, the difference was 0.3% per year, while in South Asian men at 50 years of age, the difference was 4.4% per year. The corresponding figures for Europid and South Asian women at 50 years of age were 0.2% per year and 0.8% per year.

Waist circumference and age profile of those developing diabetes

The 210 Europid participants who developed diabetes over five years were on average older (mean age 54 and 57 years for women and men respectively) and with a larger waist circumference (mean 93 cm and 104 cm for women and men respectively) than their 207 South Asian counterparts (mean age 47 years and 44 years; mean waist 82 cm and 84 cm for women and men respectively).

Effect of obesity prevalence on the Youden Index

To determine whether cut-points based on maximizing the Youden Index are affected by the prevalence of obesity in the population, we calculated such cut-points among ethnically and culturally similar populations with differing levels of abdominal obesity. Figure 2 shows the mean waist circumference and cut-points calculated from the 1987 and 1992 Mauritius surveys, analysed cross-sectionally with the outcome of prevalent
diabetes. In both men and women, cut-points increased between 1987 and 1992 (Men: 1987, 80.5cm (sens. 0.64, spec. 0.33, AUC 0.70); 1992, 88.9cm (0.49, 0.28, 0.64). Women: 1987, 77.9cm (0.68, 0.35, 0.69); 1992, 82.5cm (0.78, 0.53, 0.69)), mirroring the increase in mean waist circumference over this period (77.5cm to 85.5cm in men and 76.5cm to 83.3cm in women).

Figure 3 shows the results of an analysis from the 1999/2000 AusDiab survey (analysed cross-sectionally) in which the cohort was divided into two groups – one with a higher average waist circumference than the other. “Optimal” cut-points calculated were greater in the sub-group selected to have higher average waist circumference (Men, 101.6cm (sens. 0.67, spec. 0.38, AUC 0.68); Women 89.9cm, (0.69, 0.38, 0.65) than among those with lower average waist circumference (Men, 96.2cm (0.74, 0.35, 0.74); Women, 85.7cm (0.67, 0.27, 0.69), again mirroring the difference in mean waist circumference between the two groups.

Discussion

These results demonstrate that in these populations, the difference between recommended waist circumference cut-points in Europid and South Asian populations (4 cm in men, no difference in women) does not lead to similar diabetes risk at the cut-points. High risk for diabetes in the South Asian population studied was observed at what have been traditionally regarded as normal waist circumference values (even for this ethnic group), suggesting that waist circumference cut-points in South Asians should be lower than currently recommended, for both men and women.

Our observations add to the accumulating evidence suggesting that people of South Asian ancestry develop risk factors for cardiovascular disease and type 2 diabetes at lower levels of waist circumference than Europids.(45)
Should the Youden Index/ROC curves be used to determine waist circumference cut-points?

Approaches based on ROC curve analyses have been used almost exclusively in studies aiming to choose waist circumference cut-points in different ethnic groups (13-25, 27-34), with few studies using other methods. Stevens et al. have explored other methods for the choice of cut-points in relation to the BMI.

Maximizing the Youden Index has been recommended to determine an “optimal” point on a ROC curve, minimising the impact of the prevalence of the outcome while obtaining the cut-point with the optimal (equally weighted) combination of sensitivity and specificity.

A serious and largely ignored limitation of the Youden Index for the selection of “optimal” waist cut-points is that such cut-points are linked to the prevalence of the risk factor (in this case, obesity) in the population. Indeed, to our knowledge Stevens et al. are the only authors in this field to have identified and noted the impact of the distribution of obesity on specificity and sensitivity. Although this property of the Youden Index may be intuitively obvious to some, the fact that it has largely gone unacknowledged (with ongoing use of the Youden Index for estimation of waist cut-points) leads us to believe that this is an important point to demonstrate, as we have done using both the Mauritius and AusDiab cohorts. The Youden Index is simply the most efficient way of dividing a specific population, rather than reflecting the nature of a biological association between a risk factor and a disease. The cut-point identified will be particular to the tested population and its risk factors levels, and is unlikely to be the most efficient cut-point in another population, even one of the same ethnicity.

Our analysis of these Europid and South Asian populations demonstrates that the mean waist circumference and Youden Index-derived cut-point are positively correlated for these groups. Similar results have been observed in immigrant populations in the United
States and the United Kingdom, where consistently higher Youden Index-derived waist circumference cut-points are observed than those from ancestrally similar but slimmer populations living in either their native countries or countries with lower levels of adiposity.\(^{(13, 26)}\) Furthermore, Youden Index-derived waist circumference cut-points in older populations have been shown to differ considerably from those obtained in younger, less obese populations.\(^{(17)}\) Intuitively, cut-points should not change with the prevalence of obesity in a population. Therefore, the changeable nature of Youden Index-derived cut-points means they are inappropriate for use beyond the specific population in which they were generated, and at that specific time.

**Challenges in the choice of waist circumference cut-points**

While there are obvious benefits in establishing waist circumference cut-points appropriate for different ethnic groups, the increasingly multi-cultural nature of many communities means that problems such as communicating the use of multiple cut-points within a single population and the calculation of cut-points for individuals of mixed ethnicity will become increasingly common.\(^{(37)}\) Indeed, the feasibility of ethnicity-specific cut-points in multi-ethnic societies such as the Unites States has been questioned.\(^{(37)}\) Furthermore, a method for recognising in cut-points the age-dependency of the relationship between obesity and cardiovascular disease risk factors (often absent in the elderly)\(^{(48)}\) has thus far not been developed.

The relation between waist circumference and diabetes risk is continuous.\(^{(5)}\) No natural cut-point exists, meaning that the choice of cut-point is essentially arbitrary and should account for both scientific and economic considerations. It is indeed possible that the best way to reflect ethnic differences in risk may be through the creation of country-specific guidelines, rather than ethnicity-specific global waist circumference cut-points.\(^{(49)}\) Both are likely to be required in practice, however, with country-specific guidelines also needing to be informed by accurate scientific evidence.
Consensus has not been reached in the obesity literature regarding the most appropriate method for selecting waist circumference cut-points. We have suggested here that the Youden Index is inappropriate, and have investigated other methods such as comparison of incidence rates and incidence differences relative to a reference value. The latter of these two methods has been suggested as being a more meaningful estimate because of the non-obesity related influences that can impact incidence rates.(37) In our analysis, however, as has been shown previously,(37) when the difference in incidence between the populations is great, choosing cut-points corresponding to existing Europid cut-points remains difficult. We have observed in Figures 1a and 1b that increases in waist circumference have a similar consequence in these two populations, but that the level of risk at any given reference level is much higher in the South Asian population studied. The fact that the difference in risk is so large makes the choice of a South Asian cut-point corresponding to that used in Europid populations difficult. Lower cut-points for South Asian populations than those currently in use appear justified. However, exactly how much lower they should be may depend on political, economic and other pragmatic reasons. Similar data utilising other outcomes and in other South Asian populations would also aid such decisions.

**Limitations of this work and prospects for future data**

The impact of different waist circumference measurement techniques in the AusDiab and Mauritius surveys should be considered. Based on the results of a study of mean waist circumference (in a multi-ethnic population), in which the difference between measurements taken at the mid-point between the ribs and the iliac crest and the narrowest waist was found to be 1.5 cm in men and 2.7 cm in women,(43) we have increased the waist measurement of all South Asian subjects accordingly. This should mean that the impact of measurement differences on the results presented was minimal. The particularly high incidence of diabetes in the South Asian population in Mauritius
may have affected the findings. The same study in a different South Asian population with a lower diabetes incidence and different exposure to diabetes risk factors may have resulted in less extreme differences than those observed here. Despite this, the extremely high incidence of diabetes at comparatively low levels of waist circumference in the South Asian population studied demonstrates that diabetes risk can increase at what have been traditionally thought to be very low levels of waist circumference. This message should in some way be reflected in the choice of cut-points for this population group. Furthermore, the South Asian participants in the Mauritian study who developed diabetes were considerably younger than those developing diabetes in the AusDiab study. Whether this is simply a reflection of the impact of obesity at a younger age in this population, or whether other factors are influencing this is unknown. The age standardisation of the South Asian and Europid population at age 50 may therefore have impacted the findings, although diabetes incidence for a 40 year old South Asian at currently recommended waist cut-points was still at least eight times higher than for a 50 year old Europid. Even if the South Asian population studied developed diabetes at a younger age, and this partly explained the high diabetes incidence at low levels of waist circumference, this does not change the conclusion that waist cut-points for the South Asian population should be lower than is currently the case. Finally, the response to the follow-up in these two studies means that neither sample should be considered to be representative of the population from which it was drawn. Response bias may exist, for example, through the differential loss to follow-up of those in relatively lower socioeconomic positions (known to be associated with overweight and obesity and with diabetes incidence) in one or both of the studies. Caution should therefore be exercised in generalising these results to the populations from which they were drawn.

Prospective studies such as those used here, are the ideal setting in which to determine cut-points for waist circumference. Few similar studies in South Asians and other non-
Europid populations exist. Therefore, similar cross-sectional studies in South Asians and other ethnic groups, and studies using outcomes other than incident diabetes may help inform the revision of ethnicity-specific waist cut-points. Two large, multinational studies that are as yet un-reported (the International Study of Prediction of Intra-Abdominal Adiposity and its Relationships With Cardiometabolic Risk [INSPIRE ME] and INSPIRE ME IAA [Intra-Abdominal Adiposity study]) are likely to add to the evidence base in this area.

**Conclusion**

The purpose of cut-points for waist circumference is to identify those individuals at increased risk for obesity-related negative health outcomes in order to allow implementation of prevention strategies. Obesity is a precursor to the components of the metabolic syndrome,(6) and is important before the development of co-morbidities, not simply as a correlate for existing disease. As a preventive strategy, the choice of cut-points for obesity is therefore particularly important. The large increases in the prevalence of obesity and diabetes seen in South Asians in Mauritius and among South Asian immigrants to the UK(50) is now being seen throughout Asia due to swift economic development.(2, 51)

A consensus of opinion suggests that waist circumference cut-points should differ according to ethnicity. The results presented here suggest that currently recommended cut-points for South Asians have been set too high. Since most studies on this topic have used the Youden Index, which we demonstrate is inappropriate for this purpose, this work adds significantly to the evidence on which to base appropriate ethnicity-appropriate waist circumference cut-points.
Funding Sources

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Disclosure

The authors have no conflicts of interest to declare.
References


### Table 1. Baseline characteristics of Europid participants in the AusDiab study (2000 to 2005); and South Asian participants from the Mauritius (1987 to 1992) longitudinal study

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<thead>
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<td></td>
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<td>Men</td>
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<tr>
<td>n</td>
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<tr>
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<td>131.8 (16.1)‡</td>
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<tr>
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<td>5.5 (1.1)‡</td>
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<tr>
<td>2hr Plasma glucose (mmol/L)²</td>
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<td>5.6 (1.3)‡</td>
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<tr>
<td>Serum Triglycerides (mmol/L)²</td>
<td>1.3 (1.7)†</td>
<td>1.4 (1.7)</td>
</tr>
<tr>
<td>Serum HDL cholesterol (mmol/L)</td>
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<td>1.3 (0.3)‡</td>
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<td>Higher education³</td>
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<td>Smokers</td>
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<td>12.7‡</td>
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<tr>
<td>Incident diabetes⁴</td>
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</tr>
</tbody>
</table>

Data are:
- ¹ Means (standard deviation) or percentages
- ² Geometric mean and standard deviation
- ³ Higher education defined as education beyond high school (University or Technical and Further Education college)
- ⁴ Diabetes diagnosed between baseline and follow-up, based on WHO criteria

†p<0.05, ‡p<0.001 for comparison between Europid and South Asian study participants.
Figure 1a. Estimated annual diabetes incidence for Europid and South Asian men at age 50 according to waist circumference, based on data from studies in Australia (2000-2005) and Mauritius (1987-1992) (Note – the distribution curve of waist circumference also plotted).¹

![Diabetes Incidence for Europid and South Asian Men](image)

¹Model used included age, age squared and waist circumference.

Figure 1b. Estimated annual diabetes incidence for Europid and South Asian women at age 50 according to waist circumference, based on data from studies in Australia (2000-2005) and Mauritius (1987-1992) (Note – the distribution curve of waist circumference also plotted).¹

![Diabetes Incidence for Europid and South Asian Women](image)

¹Model used included age, age squared and waist circumference.
Figure 2. Mean waist circumference and “optimal” waist circumference cut-points chosen on the basis of cross-sectional relationships with prevalent diabetes in Mauritius 1987 and 1992.

1 1987 cohort includes those who attended the 1987 survey only, and a randomly selected 50% of those who attended both the 1987 and 1992 surveys. Conversely, the 1992 cohort includes those who attended the 1992 survey only, and the randomly selected 50% of those who attended both the 1987 and 1992 surveys not included in the 1987 cohort (i.e. no individual is included in both the 1987 and 1992 cohorts tested – they are separate populations).
Figure 3. Mean waist circumference and “optimal” waist circumference cut-points chosen on the basis of relationships with incident diabetes among cohorts with high and low average waist circumference\textsuperscript{1} in the AusDiab study 1999-2000.

\textsuperscript{1} Two equally sized cohorts with “high” and “low” average waist circumference respectively were created by random selection of individuals within each decile of waist circumference. The proportion chosen for the “high” cohort increased from 30\% in the lowest waist decile to 75\% in the highest waist decile. Conversely, the proportion of those chosen for the “low” cohort ranged from 30\% in the highest waist decile to 75\% in the lowest waist decile.