Epidemiology and epigenetics of type 2 diabetes among African migrants in Europe
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Chapter 4

The contribution of body composition to ethnic differences in type 2 diabetes

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ABSTRACT

**Aims:** To compare type 2 diabetes (T2D) prevalence among three ethnic groups resident in the Netherlands: Ghanaians, African Surinamese and Dutch origin. Secondly, to determine the contribution of measures of body composition to ethnic differences in T2D.

**Methods:** Baseline data from Ghanaian (n=1873), African Surinamese (n=2189) and Dutch (n=2151) origin participants of the HELIUS study (aged 18–70 years) were analysed. T2D was defined according to the WHO criteria. Logistic regression tested ethnic differences in T2D and the contribution of body fat percentage and waist-to-hip ratio.

**Results:** Among men, T2D prevalence was higher in Ghanaians (14.9%) than in African Surinamese (10.4%) and Dutch (5.0%). Among women, T2D prevalence in Ghanaian (11.1%) was higher than in Dutch (2.3%), but similar to African Surinamese (11.5%). After adjusting for age, body fat percentage and waist-to-hip ratio, the odds ratios for having T2D were 1.55 (95%CI:1.12-2.15) for Ghanaian men compared with African Surinamese and 4.19 (95%CI:2.86-6.12) compared with Dutch. Among women these odds ratios were 0.94 (95%CI:0.70-1.26) and 4.78 (95%CI:2.82-8.11).

**Conclusions:** The higher prevalence of T2D among Ghanaian compared with African Surinamese men suggests a need to distinguish between African descent populations when assessing their T2D risk. The higher odds for T2D among Ghanaians cannot be attributed to differences in body composition. Further research on the contribution of lifestyle factors as well as genetic and epigenetic factors is needed to identify the reasons for the observed disparities.
BACKGROUND

Worldwide, the prevalence of type 2 diabetes (T2D) is high and rising. Many ethnic minority populations in Europe and North America have been disproportionately affected by T2D compared with the local host populations. Diabetes UK estimates the prevalence of T2D to be 17% for the African Caribbean community in the UK compared with 3% for the UK general population. Data from the Netherlands among 35-60 years-olds also show a higher prevalence of T2D in the African Surinamese group (14.2%) than in the Dutch origin group (5.5%).

Data among Africans who have a recent sub-Saharan African origin are limited. These data, however, seem to suggest differences in health between Africans with a recent origin in sub-Saharan Africa (henceforth: sub-Saharan Africans) and those who have an African ancestral origin but migrated to the Netherlands via Suriname (henceforth: African Surinamese). In Ghanaian residents in the Netherlands, a sub-Saharan African population, a greater burden of hypertension was found than among African Surinamese, with prevalence of 54% in men and 56% in women compared with 43% and 36% in African Surinamese men and women. These differences may be due to variations in migration histories, socio-economic circumstances, early life factors and genetic predispositions or epigenetic mechanisms.

The prevalence of T2D has not yet been assessed for Ghanaians in the Netherlands, but among Ghanaians resident in Australia a high prevalence was found already in 2001 with a large discrepancy between men (20.0%) and women (11.4%). If we can determine whether sub-Saharan Africans are more susceptible than African Surinamese for T2D, we may be able to account for this in assessing their T2D risk and ultimately develop ethnic specific guidelines or preventive strategies.

Adiposity is a well-known risk factor for T2D. Overweight and obesity (Body Mass Index (BMI) ≥ 25.0 kg/m²) have been estimated to account for about 65 to 80 per cent of new cases of T2D. While generalised obesity is usually defined using BMI, there are indications that there is a wide disparity in the relation between BMI and body fat between ethnic groups. Hence, body fat percentage is possibly a more accurate measure of generalised obesity than BMI. Furthermore, the size of the effect by which body fat increases the risk for T2D may differ by ethnicity. Numerous mechanisms for the ethnic-specific relation between adiposity and T2D have been postulated, but the mechanism underlying this phenomenon is not exactly known. Potential mechanisms leading to insulin resistance, a central issue in T2D, include exposure to glucocorticoids, alterations in sex hormones and body fat distribution.
In addition to body fat, body fat distribution is an important determinant of T2D. Central body fat, in particular visceral adipose tissue, is a major determinant of insulin resistance while peripheral subcutaneous adipose tissue deposition has been shown to be associated with less insulin resistance\textsuperscript{13,14}. Hence, a larger waist – more central fat – and smaller hip circumference – less peripheral subcutaneous adipose tissue – are associated with an increased risk of T2D\textsuperscript{15}. While it is postulated that body fat and body fat distribution differ between African and European populations\textsuperscript{16,17}, it is unclear how body fat and body fat distribution contribute to the risk of T2D in African origin populations as compared with European populations.

We hypothesised that sub-Saharan Africans are more susceptible to T2D than African Surinamese and that body fat percentage and body fat distribution are associated with ethnic differences in T2D. Hence, we assessed the prevalence of T2D among Ghanaians, a sub-Saharan African origin population in the Netherlands, and compared them with Surinamese of African origin and Dutch origin adults living in the Netherlands. Furthermore, we determined the contribution of body fat and body fat distribution to ethnic differences in T2D.

**METHODS**

The Medical Ethical Committee of the Amsterdam Academic Medical Center (AMC) approved the study protocols. Written informed consent was obtained from all participants involved in the study.

**Study population and study design**

The rationale, conceptual framework, design, and methodology of the HELIUS (HEalthy LIfe in an Urban Setting) study have been described in detail elsewhere\textsuperscript{18}. In brief, the HELIUS study is a multi-ethnic cohort study conducted in Amsterdam, the Netherlands. Subjects were randomly selected from the municipal registers, stratified by ethnicity. We were able to contact about 65% of those invited (54% among Dutch, 73% among African Surinamese, 69% among Ghanaians), either by response card or after a home visit by an ethnically-matched interviewer. Of those contacted, about 42% agreed to participate (57% among Dutch, 43% among African Surinamese, 50% among Ghanaians). After a positive response, participants received a confirmation letter of the appointment for the physical examination, including a digital or paper version of the questionnaire (depending on the preference of the subject). Participants who were unable to complete the questionnaire themselves were offered assistance from a trained ethnically-
matched interviewer. Baseline data collected between January 2011 and June 2014 were used including participants of Ghanaian (n=1873), African Surinamese (n=2189) and Dutch (n=2151) origin.

Ghanaians and African Surinamese are both of Western African descent. During the independence of Suriname in 1975, almost half of the Suriname population migrated to the Netherlands. Ghanaians migrated to the Netherlands in two waves. The first wave took place around 1973 due to the economic consequences of the 1970s oil crisis. The second migration wave was around 1981 generated by a combination of political and economic instabilities in Ghana. It is estimated that about 22,000 Ghanaians and at least 132,000 African Surinamese are currently resident in the Netherlands19,20.

Measurements

Information on demographics and education were collected using a questionnaire either self-administered or completed by interviewer. The definition of Ghanaian and African Surinamese origin (respectively) was being born in Ghana or Suriname with at least one parent being born in Ghana or Suriname (first generation); or being born in the Netherlands but both parents being born in Ghana or Suriname (second generation). Suriname’s population is made up of several ethnic groups including African Surinamese, South Asian Surinamese, Javanese, Amerindian, and Chinese. Hence, self-identification was also used to further distinguish Surinamese of African origin from Surinamese of other origins.

Self-reported T2D was a positive reply in the questionnaire to: “Has a doctor or other health worker ever diagnosed you with diabetes?”. Medication use was recorded during a physical examination, where participants were asked to bring their prescribed medication. Blood glucose and Hba1c concentrations were measured from fasting blood samples drawn during the physical examination. Whole blood was used to determine the concentration of Hba1c using the HPLC technology (TOSOH, Japan). Plasma samples were used to determine the concentration of glucose by spectrophotometry, using hexokinase as primary enzyme (Roche Diagnostics, Japan). Individuals were classified as having T2D according to the World Health Organization (WHO) diagnostic criteria (main analysis) and American Diabetes Association (ADA) diagnostic criteria. WHO criteria (2006) entail: fasting glucose ≥ 7.0 mmol/L, or current use of medication prescribed to treat diabetes, or self-reported diabetes21. ADA criteria (2011) are equal to WHO criteria but add individuals with a Hba1c of ≥ 6.5% (48 mmol/mol)22.

Body fat was determined using arm-leg bio-impedance measurements taken with a Bodystat 1500 analyser (Bodystat Ltd, Isle of Man, UK). Body fat is
the total mass of fat, assuming that the body consists of two compartments; fat mass and fat free mass. Body fat percentage was calculated by applying the formula by Kyle et al.\textsuperscript{23} on the generated Bodystat output. Body fat distribution was defined using the waist-to-hip ratio as a measurement of abdominal obesity. Waist circumference was measured at the level midway between the lower rib margin and the iliac crest. Hip circumference was measured at the widest point measured over the trochanter major.

**Data analysis**

Characteristics of the study population were expressed as numbers and percentages or means and standard deviations (SD). Prevalence of T2D was calculated by sex using both T2D criteria for the three ethnic groups, and standardised for age with a direct method. Subsequent analyses are only shown for WHO T2D criteria. For each ethnic group, T2D prevalence was calculated for those with low and high body fat based on generally used cut-offs for body fat percentage (> 25% men, > 35% women)\textsuperscript{24} and with and without abdominal obesity based on WHO cut-offs from 2008 (waist-to-hip ratio >0.90 men, >0.85 women)\textsuperscript{25}, for both men and women separately. Logistic regression models were fitted for each ethnic group by sex with adjustment for age to estimate the strength of the association between body fat percentage or waist-to-hip ratio and T2D. In addition, interaction by ethnicity was tested. Subsequently, logistic regression models were used to assess the contribution of body fat percentage and waist-to-hip ratio to the ethnic differences in T2D with adjustment for age. Multi-colinearity between body fat percentage and waist-to-hip ratio was studied by the tolerance statistic. If the tolerance was < 0.1, the stability of the regression model was considered to be disturbed by multi-colinearity. Body fat percentage was centered (around the mean). Waist-to-hip ratio was also centered and subsequently multiplied by 10 in the models to not compare 0 with 1, but to study steps of 0.1. An interaction term was included in the model when significant interaction (p<0.10) was found. Analyses were performed using SPSS 20.0 and R 3.1.0.

**RESULTS**

**Characteristics of the study population**

There was no significant difference in age for men between the three ethnic groups (Table 1). Among men, body fat percentage did not differ by ethnicity. Waist and hip circumferences were higher in Dutch than in Ghanaian and African Surinamese origin men, but waist-to-hip ratio was similar. Average
fasting glucose was similar among the three ethnic groups, while HbA1c was lower in Dutch than in Ghanaian and African Surinamese men.

Ghanaian women were younger than those of African Surinamese and Dutch origin (Table 1). Body fat percentage and waist-to-hip ratio were lower in Dutch and African Surinamese as compared with Ghanaian women. Waist- and hip circumference separately were lower in the Dutch than in Ghanaian and African Surinamese. Both fasting glucose and HbA1c levels were higher in African Surinamese and lower in Dutch compared with Ghanaian women.

**Type 2 diabetes prevalence**

ADA criteria yielded higher T2D prevalence than WHO criteria for all ethnic groups due to the inclusion of HbA1c in the definition (Figure 1). Regardless of which criteria were used, the highest prevalence of T2D was observed among Ghanaian men. The T2D prevalence in Ghanaian men was higher compared with African Surinamese men. Among women, T2D prevalence was similar between Ghanaian and African Surinamese. Ghanaian and African Surinamese, both men and women, had higher T2D prevalence compared with the Dutch. The discrepancy between African origin groups and Dutch was larger for ADA criteria than for WHO criteria, which is in line with higher HbA1c values in these groups.

**Figure 1.** Age adjusted percentage of type 2 diabetes per ethnic group for both men and women by WHO criteria and ADA criteria.

*WHO criteria: fasting glucose ≥ 7.0 mmol/L, or self-reported diabetes, or diabetes medication use.*

*ADA criteria: HbA1c ≥ 6.5% (48 mmol/mol), or fasting glucose ≥ 7.0 mmol/L, or self-reported diabetes, or diabetes medication use.*
### Table 1. Characteristics of study participants by ethnicity and sex.

<table>
<thead>
<tr>
<th></th>
<th><strong>MEN</strong></th>
<th></th>
<th><strong>WOMEN</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Ghanaian (n=758)</td>
<td>African Surinamese (n=804)</td>
<td>Dutch (n=987)</td>
<td>Ghanaian (n=1115)</td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Age, years</td>
<td>47.1 ± 11.4</td>
<td>47.6 ± 13.1</td>
<td>47.3 ± 13.8</td>
<td>43.9 ± 10.7</td>
</tr>
<tr>
<td>1st generation migrants</td>
<td>721 (95.1)</td>
<td>667 (83.0)</td>
<td>1058 (94.9)</td>
<td>1178 (85.1)</td>
</tr>
<tr>
<td>Length of stay (years)</td>
<td>20.9 ± 8.7</td>
<td>33.0 ± 10.3</td>
<td>19.9 ± 8.0</td>
<td>31.8 ± 10.0</td>
</tr>
<tr>
<td><strong>Education level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None or elementary</td>
<td>129 (17.2)</td>
<td>84 (8.1)</td>
<td>31 (3.1)</td>
<td>428 (39.3)</td>
</tr>
<tr>
<td>Lower secondary</td>
<td>342 (45.6)</td>
<td>318 (40.1)</td>
<td>140 (14.2)</td>
<td>367 (33.7)</td>
</tr>
<tr>
<td>Higher secondary</td>
<td>214 (28.5)</td>
<td>271 (34.1)</td>
<td>235 (23.8)</td>
<td>246 (22.6)</td>
</tr>
<tr>
<td>University</td>
<td>65 (8.7)</td>
<td>141 (17.8)</td>
<td>580 (58.8)</td>
<td>49 (4.5)</td>
</tr>
<tr>
<td><strong>Adiposity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>26.8 ± 3.7</td>
<td>26.4 ± 4.5 a</td>
<td>25.2 ± 3.6 c</td>
<td>29.5 ± 5.2</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>24.4 ± 5.9</td>
<td>24.4 ± 6.2</td>
<td>24.3 ± 6.0</td>
<td>37.9 ± 6.0</td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>92.2 ± 10.9</td>
<td>92.4 ± 12.5 b</td>
<td>94.0 ± 11.3 b</td>
<td>93.9 ± 12.8</td>
</tr>
<tr>
<td>Hip circumference, cm</td>
<td>97.9 ± 7.3</td>
<td>98.5 ± 8.3</td>
<td>99.8 ± 6.8 c</td>
<td>106.0 ± 10.2</td>
</tr>
<tr>
<td>Waist-to-Hip ratio</td>
<td>0.94 ± 0.07</td>
<td>0.93 ± 0.07</td>
<td>0.94 ± 0.07</td>
<td>0.88 ± 0.08</td>
</tr>
</tbody>
</table>
Table 1 - Continued

<table>
<thead>
<tr>
<th>Data are means ± SD or n (%)</th>
<th>MEN</th>
<th>WOMEN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ghanaian (n=758)</td>
<td>African Surinamese (n=804)</td>
</tr>
<tr>
<td><strong>Diabetic markers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes WHO&lt;sup&gt;d&lt;/sup&gt;</td>
<td>114 (15.1)</td>
<td>85 (10.6)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Diabetes ADA&lt;sup&gt;e&lt;/sup&gt;</td>
<td>139 (18.4)</td>
<td>108 (13.6)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fasting glucose, mmol/L</td>
<td>5.6 ± 1.3</td>
<td>5.6 ± 1.4</td>
</tr>
<tr>
<td>Impaired fasting glucose&lt;sup&gt;f&lt;/sup&gt;</td>
<td>215 (28.4)</td>
<td>216 (26.9)</td>
</tr>
<tr>
<td>Undiagnosed diabetes&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15 (2.0)</td>
<td>21 (2.6)</td>
</tr>
<tr>
<td>HbA1c, % (mmol/mol)</td>
<td>5.8 ± 0.93</td>
<td>5.9 ± 0.91</td>
</tr>
<tr>
<td></td>
<td>(40.3 ± 10.2)</td>
<td>(40.5 ± 9.9)</td>
</tr>
</tbody>
</table>

*Data are means ± SD or n (%).

<sup>a</sup>) *p < .05 compared with Ghanaian.

<sup>b</sup>) *p < .01 compared with Ghanaian.

<sup>c</sup>) *p < .001 compared with Ghanaian.

<sup>d</sup>) Crude diabetes prevalence according to WHO criteria: fasting glucose ≥ 7.0 mmol/L, or self-reported diabetes, or diabetes medication use.

<sup>e</sup>) Crude diabetes prevalence according to ADA criteria: HbA1c ≥ 6.5% (48 mmol/mol), or fasting glucose ≥ 7.0 mmol/L, or self-reported diabetes, or diabetes medication use.

<sup>f</sup>) Impaired fasting glucose defined as fasting glucose ≥ 5.6 and < 7.0 mmol/L.

<sup>g</sup>) Undiagnosed diabetes based on fasting glucose ≥ 7.0 and no self-reported diabetes or medication use.
Table 2. Age-adjusted odds ratio’s (95% CI) for association body fat percentage and waist-to-hip ratio with type 2 diabetes according to WHO criteria and corresponding p-values for interaction, by ethnicity and sex.

<table>
<thead>
<tr>
<th></th>
<th>Ghanaian</th>
<th>African Surinamese</th>
<th>p-value&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Dutch</th>
<th>p-value&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body fat percentage</td>
<td>1.04 (1.00-1.08)</td>
<td>1.09 (1.04-1.13)</td>
<td>0.108</td>
<td>1.08 (1.02-1.14)</td>
<td>0.170</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>2.31 (1.58-3.37)</td>
<td>4.22 (2.75-6.46)</td>
<td>0.022</td>
<td>2.19 (1.35-3.56)</td>
<td>0.504</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body fat percentage</td>
<td>1.03 (0.99-1.07)</td>
<td>1.09 (1.05-1.13)</td>
<td>0.053</td>
<td>1.18 (1.09-1.27)</td>
<td>0.003</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>3.40 (2.40-4.82)</td>
<td>3.18 (2.49-4.07)</td>
<td>0.714</td>
<td>2.50 (1.44-4.35)</td>
<td>0.377</td>
</tr>
</tbody>
</table>

<sup>a</sup> p-value for interaction, Ghanaian compared with African Surinamese.

<sup>b</sup> p-value for interaction, Ghanaian compared with Dutch.

Body fat percentage was used centered.

Waist-to-hip ratio was used centered and multiplied by 10.
Table 3. Odds Ratio’s (95% CI) for type 2 diabetes among Ghanaian compared with African Surinamese and compared with Dutch, by sex.

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ghanaian compared with African Surinamese</td>
<td>Ghanaian compared with African Surinamese</td>
</tr>
<tr>
<td>Adjusted for age</td>
<td>1.67 (1.22-2.28)</td>
<td>1.15 (0.88-1.52)</td>
</tr>
<tr>
<td>Adjusted for age + BF%</td>
<td>1.63 (1.18-2.24)</td>
<td>1.08 (0.82-1.44)</td>
</tr>
<tr>
<td>Adjusted for age + BF% + WHR</td>
<td>1.55 (1.12-2.15)</td>
<td>0.94 (0.70-1.26)</td>
</tr>
<tr>
<td>Adjusted for age + BF% + WHR + ethnicity * WHR</td>
<td>2.52 (1.47-4.32)</td>
<td>0.94 (0.70-1.26)</td>
</tr>
<tr>
<td>Adjusted for age + BF% + WHR + ethnicity * BF%</td>
<td>1.42 (0.83-2.43)</td>
<td>1.42 (0.83-2.43)</td>
</tr>
</tbody>
</table>

|                                | Ghanaian compared with Dutch            | Ghanaian compared with Dutch            |
|                                |                                         |                                         |
| Adjusted for age               | 4.18 (2.89-6.05)                       | 8.69 (5.35-14.12)                      |
| Adjusted for age + BF%         | 4.16 (2.85-6.06)                       | 6.27 (3.74-10.52)                      |
| Adjusted for age + BF% + WHR   | 4.19 (2.86-6.12)                       | 4.78 (2.82-8.11)                       |
| Adjusted for age + BF% + WHR + ethnicity * BF% | 11.79 (4.94-28.12) | 11.79 (4.94-28.12) |

BF% = body fat percentage, WHR = waist-to-hip ratio.

Body fat percentage was used centered and WHR was used centered and multiplied by 10.
Body fat, body fat distribution and type 2 diabetes

Figure 2 shows the T2D prevalence for those with low and high body fat percentage within each ethnic group for men (Figure 2A) and women (Figure 2B). T2D prevalence was higher in those with high body fat percentage as compared with low body fat percentage in all ethnic groups. The prevalence in Ghanaian men was particularly high, both in those with high and low body fat percentage, suggesting a weaker association between body fat percentage and T2D among Ghanaian than among African Surinamese and Dutch. The association of body fat percentage with T2D was confirmed by the logistic regression analyses (Table 2). Interaction terms revealed significant interaction between body fat percentage and ethnicity in the relationship with T2D for Ghanaian compared with African Surinamese (p-value 0.053) and Dutch women (p-value 0.003). The association between body fat percentage and T2D was less strong in Ghanaian, in both men and women, than in African Surinamese and Dutch.

Figure 2. Low compared with high body fat percentage (A and B), and low compared with high waist-to-hip ratio (C and D) specific prevalence of type 2 diabetes according to WHO criteria, by ethnicity and sex.
The prevalence of T2D was higher in those with high waist-to-hip ratio compared with low waist-to-hip ratio, in all ethnicities, in both men (Figure 2C) and women (Figure 2D). Nevertheless, Ghanaian men had a 6.9% T2D prevalence even in the low waist-to-hip ratio group. Waist-to-hip ratio and ethnicity showed significant interaction among Ghanaian men compared with African Surinamese (Table 2, p-value 0.022). Waist-to-hip ratio was most strongly associated with T2D in African Surinamese men.

Table 3 shows adjusted odds ratios and 95% confidence intervals of T2D for Ghanaian compared with African Surinamese and Dutch, in men and women. In the age-adjusted model, Ghanaian men were 1.67 more likely than African Surinamese men and 4.18 times more likely than Dutch men to have T2D. In accordance with the stratified analyses in Figure 2, adding body fat percentage and waist-to-hip ratio to the model did not substantially alter the ethnic differences in the odds of T2D in men. Ghanaian men continued to have a 1.55 times higher odds for T2D compared with African Surinamese and 4.19 compared with Dutch men. The model with the interaction term for waist-to-hip ratio included showed that for the same average waist-to-hip ratio, Ghanaian men had 2.52 higher odds for T2D compared with African Surinamese men.

Among women, Ghanaians had a 8.69 fold higher odds compared with Dutch, but a similar odds with African Surinamese. Including body fat percentage and waist-to-hip ratio in the model, decreased the difference in odds of Ghanaian women compared with Dutch, but still a 4.78 fold higher odds remained. With the same average body fat percentage, Ghanaian women were 11.79 times more likely than Dutch women to have T2D. The elevated odds ratio after inclusion of interaction terms shows that the association of body fat percentage with T2D is stronger in Dutch than in Ghanaian women. Results were similar using ADA diagnostic diabetes criteria (not shown).

**DISCUSSION**

**Key findings**

Our study found a higher prevalence of T2D among Ghanaians compared with African Surinamese in men. Among women, Ghanaian and African Surinamese had a similar T2D prevalence. Ghanaian and African Surinamese, both men and women, had higher odds for T2D in comparison with the Dutch origin participants. Ghanaian men had higher odds for T2D compared with African Surinamese men regardless of their body fat and body fat distribution. In women, accounting for body fat and body fat...
distribution reduced differences between Ghanaian and Dutch, but a higher odds for T2D in Ghanaian women remained.

**Discussion of the key findings**

Our findings emphasise the need to distinguish between different African descent populations, at least for men, when assessing T2D risk. The heterogeneity of African descent population has been a long standing scientific debate\(^\text{26}\). Our results suggest higher odds for T2D in men of Ghanaian origin, who have migrated directly to the Netherlands from sub-Saharan Africa, compared with those of African Surinamese origin, who are also of West-African descent but have migrated via Suriname.

The differences in T2D could be due, in part, to differences in lifestyle and environmental exposures between the countries of origin – Ghana and Suriname. However, the observed difference in T2D prevalence between Ghanaian and African Surinamese living in the Netherlands does not reflect differences in T2D prevalence between the countries of origin. The prevalence of T2D is 3.8% in Ghana compared with 11.1% in Suriname\(^\text{27}\). The explanations for these differences are unclear, but may be due to variations in self-selection of Ghanaian and African Surinamese migrant groups\(^\text{28}\).

Despite the fact that body fat and body fat distribution were shown to be strong independent risk factors for T2D, our results suggest that these measures of body composition do not explain the higher odds for T2D among Ghanaian men compared with African Surinamese men and the Dutch origin host population. This suggests that different mechanisms may be involved. This is supported by our observation of a high T2D prevalence among Ghanaian men, even in those with low body fat percentage and low waist-to-hip ratio, as well as body fat percentage being less associated with T2D in Ghanaians than in African Surinamese and Dutch. African Surinamese men on the other hand had very low odds for T2D with a low waist-to-hip ratio, and therefore show an even stronger association between waist-to-hip ratio and T2D.

A potential explanation for these observed differences in T2D between Ghanaian and African Surinamese could be the different migration history. African Surinamese migrated via the Suriname with some degree of genetic admixture, while Ghanaians are direct sub-Saharan African migrants.

A second possible mechanism for the higher T2D prevalence among Ghanaian compared with African Surinamese may be differential integration in the Dutch system. African Surinamese may be more integrated into the
Dutch society due to strong links between Suriname and the Netherlands. For example, African Surinamese and Dutch share the same language, while most Ghanaians speak English and a Ghanaian indigenous language (such as Twi) upon migration. Language, differences in culture and other socio-cultural determinations are intermediate variables in determining incidence and prognosis of disease. Due to the shared language with Dutch, African Surinamese are more likely to have access to preventive services than Ghanaians. Furthermore, a larger proportion of Ghanaians are first generation migrants than African Surinamese. First generation migrants are thought to be less well adapted to the Dutch system than their offspring. However, the higher prevalence and odds for T2D among Ghanaians compared with African Surinamese remained when migrant offspring were excluded from the analysis, as well as when length of stay in the Netherlands among the first generation was added to the model (data not shown).

Furthermore, differences in environmental and health-related behaviour factors between Ghanaian and African Surinamese in the Netherlands may play a role in the difference in T2D between Ghanaian and African Surinamese. Socio-economic status (SES) is lower in the Ghanaian group than African Surinamese. Lower SES in turn has been shown to be associated with higher HbA1c. However, inclusion of education as a proxy for SES in the model did not change the results (data not shown). Health-related behaviour factors such as physical activity and (quality of) dietary intake differ between both groups and may have a direct effect on T2D, not mediated via body fat and body fat distribution. Similarly, environmental factors during childhood can have effect on obesity and T2D in later life. According to the UNICEF country statistics, the prevalence of stunting (chronic undernutrition) is 8.8% in Suriname compared with 22.7% in Ghana.

A few studies have reported the prevalence of T2D among Ghanaians in Europe, the US or Australia. One small-scale study on T2D among Ghanaians in Sydney found similar prevalence rates; 20% in Ghanaian men and 11% in Ghanaian women. They used a lower threshold for fasting glucose which is likely the reason for higher prevalence rates compared with what we found. Several studies have shown a high burden of T2D among African descent populations from other African countries. Among African origin populations both in UK and the Netherlands, higher prevalence have been reported compared with the host populations. Also in the US, African Americans have more T2D compared with White Americans and the difference has increased over time. However, while in 2011 about 8.5% of adult African American population was diagnosed with T2D, the prevalence of 17.9% and 14.4% T2D we observed in this study of migrant Ghanaian men and women, is far higher.
The ethnic differential association between body composition measures and T2D has been reported previously. Weaker associations between body composition and T2D were observed among African Americans than among White Americans\(^ {38}\). Also the differences in body composition between men and women in relation to T2D is in line with previous findings. A more favourable fat distribution in Ghanaian women was related to less elevated fasting glucose compared with men\(^ {39}\). This suggests that in African origin populations other mechanisms causing T2D may play a role than in European origin populations.

In our study, the ADA T2D criteria yielded more T2D cases compared with WHO criteria due to inclusion of HbA1c in the definition. HbA1c levels tend to be higher in African origin than in European origin populations and differ by ethnicity in the relation with blood glucose\(^ {40-41}\). The reasons for this may include differences in red cell survival, extracellular-intracellular glucose balance, and non-glycemic genetic determinants of haemoglobin glycation\(^ {40}\). In the UK Preventive Diabetes Study, every 1% reduction in HbA1c was found to be associated with a 21% reduction in any end point related to T2D, in European British, Asian Indian and African Caribbean\(^ {42}\). These observations suggest the need to include HbA1c in identification of T2D cases in similar types of research in African descent populations.

**Limitations**

We did not have oral glucose tolerance test (OGTT) data for identification of undiagnosed T2D. OGTT is one of the two recommended tests for identification of undiagnosed T2D by the WHO, of which the OGTT is preferred over fasting glucose\(^ {21}\). ADA diagnostic criteria state OGTT as one of four possible biochemical tests, with a preference for the inclusion of HbA1c\(^ {22}\). Not including an OGTT may have led to underestimation of the prevalence of T2D. However, the prevalence of undiagnosed T2D was very low and hardly differed between ethnic groups. Therefore, observed ethnic differences are likely not affected. Furthermore, having used both fasting glucose and HbA1c for identification of undiagnosed cases, we have met both WHO and ADA diagnostic criteria and allowed for comparison between the two criteria.

We used bio-impedance for assessment of body fat percentage. There are several methods for measuring body fat percentage, such as dual energy X-ray, absorptiometry (DEXA) or computed tomography (CT). However, bio-impedance analysis has been shown to be a valid instrument in measuring body fat percentage and is highly correlated with DEXA\(^ {43}\). Furthermore, the same instrument was used in all the ethnic groups and therefore should not affect our study conclusions. Body fat percentage was calculated from the
Body Stat output using a non-ethnic specific formula\textsuperscript{23}. Comparison with an ethnic specific formula showed similar results (data not shown)\textsuperscript{44}. Therefore, the non-ethnic specific formula was used for better comparison between ethnic groups.

There is no general consensus on the cut-off values for body fat percentage. We therefore used in the analysis body fat percentage as a continuous variable. The cut-offs we used in Figure 2 are the ones generally used in literature\textsuperscript{24}. These cut-offs were used to facilitate comparison with other studies.

Moreover, bias could have resulted from a differential response rate by an ethnic group. However, the male and female study populations are largely representative of the original sample and therefore should not affect our study conclusions.

The cross-sectional nature of our study implies that causal associations cannot be established. The extrapolation of the results to Ghanaians in other European countries should be handled with caution due to heterogeneity between African descent populations and European countries.

We lack data on important variables that are known to influence T2D, such as childhood social circumstances and migration trauma\textsuperscript{45}. Future studies should take these factors into account. Also data of an equivalent population living in the origin regions of Africa is desirable for future studies. The odds of overweight and obesity among Ghanaian migrant men and women in Amsterdam were found to be 19 times and 11 times higher than their compatriots men and women living in rural Ghana\textsuperscript{46}. This type of data is essential for gaining insight in the mechanisms and causes of the increased T2D risk in Ghanaians\textsuperscript{47}.

Conclusions and implications

Our study shows a high burden of T2D among African descent populations living in the Netherlands compared with the Dutch host population, particularly among Ghanaian men. Replication in other cohorts and countries is needed to confirm the observed disparity between African descent populations as observed in men. Also, further research is needed to identify the reasons for the observed disparities of African descent compared with Dutch origin, especially given the (much) lower prevalence in the countries of origin. Such research will include the contribution of health-related behaviour factors (such as diet and physical activity) as well as genetic and epigenetic factors. Our findings demonstrate that the
prevalence of T2D is higher in Ghanaian men than in African Surinamese
men, which suggests a need to address the diversity within the African
descent populations in the Netherlands when assessing T2D risk. The ethnic
differences in the association of waist-to-hip ratio and body fat percentage
with T2D indicate that other mechanisms may be involved. Risk definition
on the basis of body fatness or similar measures would therefore miss many
Ghanaian men at risk of T2D. Current risk assessment does not suffice for
this group in particular. Longitudinal data are needed to study causality of
body fat on T2D.
REFERENCES


