Original Article

# Ethnicity and diabetes complications in Sudanese population: The need for further genetic population testing

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## ARTICLE INFO

## ABSTRACT

Background: The aim of the present study was to assess whether there is an association between ethnicity and the high prevalence of diabetes complications in Sudan.
Methods: This was cross-sectional hospital-based study with 316 individuals with diabetes conducted in Khartoum state, Sudan. A questionnaire was used to collect demographic information. In addition to measurements of blood pressure, lipid profile and HbA1c, weight and height measurement were also performed for calculation of body mass index.
Results: The study included individuals recruited from 62 tribes across Sudan. The effect of ethnicity on diabetic septic foot (DSF) was not statistically significant across different tribes (X-squared $= 2.6098$, df $= 4$, p-value $= 0.6251$). The effect of ethnicity on Albuminuria was also not statistically significant across different tribes recruited for this study (X-squared $= 4.3787$, df $= 4$, p-value $= 0.3572$). The Northern group carried a significantly higher unadjusted risk for development of retinopathy (OR $= 1.8471$, p-value $= 0.04603$). The Southern group was significantly different from the others regarding the effect of ethnicity on neuropathy, compared to the 'West' group (OR $= 0.1905$, p-value $= 0.0345$). The unadjusted effect for the Southern group was also significant (OR $= 0.2933$, p-value $= 0.0320$).
Conclusion: There was no role of ethnicity in term of DSF and albuminuria complications. However, retinopathy likely to be seen in tribes originally from north of Sudan, while neuropathy is more likely to be found in tribes originally from the south of Sudan. Further focus genetic population testing is needed.
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## 1. Introduction

Sudan is one of the largest countries in Africa. The prevalence of diabetes in the north of Sudan was estimated to be 19% [1]. The increase in incidence of diabetes in Sudan can be attributed to features of urbanization like an increase in the prevalence of obesity, lack of physical activity and increase in consumption of carbohydrate and sugar intake [2–4]. Awadalla et al. (2017) reported a high prevalence of diabetes complications in Sudanese individuals with type 2 diabetes [5]. Their study showed that hypertension was reported in 39.9%, myocardial infarction in 5.9%, while high cholesterol and triglyceride was noted in 59.9%, 32.5% respectively. Low high density lipoprotein cholesterol (HDL) was noted in 52.6%. In addition, complications like peripheral neuropathy, retinopathy, and diabetic foot were observed in 68.2%, 72.6% and 12.7% respectively. High prevalence of diabetes complications were also reported in other African countries [6–9]. For instance, diabetic retinopathy in Malawi was estimated to be 50.1%, while the prevalence of diabetic foot in Cameroon, Nigeria, and Tanzania were estimated to be 13%,9.5% and 15% respectively [6–8]. The prevalence of diabetic neuropathy in Egypt was estimated to be

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around 60% [9]. Eltom et al. (2017) showed that risk factor for type 2 diabetes in the north of Sudan (besides classic factors obesity and increasing age) is being of Egyptian descents (AOR 1.28, 95%CI 1.04–1.57) and mixed origin (AOR 1.24, 95%CI 1.04–1.48) [10]. Therefore, the present study aimed to assess whether there is an association between ethnicity and high prevalence of diabetes complications in Sudan.

## 2. Methods

This hospital-based cross-sectional study was conducted in Khartoum which is the capital of Sudan between September and December 2015, and enrolled 316 individuals with diabetes. We have used the WHO stepwise approach for collection of data in non-communicable diseases surveillance. We measured height and weight to calculate BMI. Blood tests for measurement of HbA1c, cholesterol, and triglycerides levels using Cobas c 111 analyzer. We used the Statistical Package for Social Sciences (SPSS) version 21.0 software program [for data management and analysis (SPSS, Inc., Chicago, IL, USA)]. Chi-squared test was used to test for significance between variables like retinopathy, neuropathy, albuminuria, blood pressure and a family history of diabetes mellitus, duration of diabetes, cholesterol, triglyceride, and HbA1c. Then we used logistic regression analysis to establish independent risk factors. *P*-value < 0.05 was considered statistically significant. The ethical clearance of this study was obtained from the Ethical Committee of the Faculty of Medicine − University of Medical Science and Technology, Khartoum, Sudan (IRB No. 00008867).

## 3. Results

### 3.1. Sociodemographic variables

This study included 62 tribes from different places in Sudan. These tribes were then categorized into five broad categories; according to their geographical locations (South, Central, West, North, and East) (Table 1).

### 3.2. Diabetic septic foot (DSF)

The prevalence of DSF was 17.7% (95% Confidence Interval CI: 17.63%–17.81%) (Table 2). Regarding logistic regression-related

calculation of odds ratio for the development of DSF about different ethnic groups, none of the ethnic groups was significantly different from the others, even after making the 'South' group as a reference (Table 3).

### 3.3. Albuminuria

The prevalence of albuminuria was 32.6% (95% Confidence Interval CI: 27.43%–37.76%). The proportion of patients who developed albuminuria were comparable among the different ethnic groups. Tribes from the West were observed to have the highest prevalence of Albuminuria (76.9%). However, this was not statistically significant from other tribes (X-squared = 4.3787, df = 4, p-value = 0.3572).The 'Central group' was second regarding the prevalence for albuminuria (namely 61.4%), followed by the South group (44.4%) and the North group (39.2%). The 'East group' was the least regarding albuminuria prevalence (33.3%) (Table 2). Regarding logistic regression-related calculation of odds ratio for the development of albuminuria about different ethnic groups, none of the ethnic groups was significantly different from the others, even after making the 'West' group as reference. (Table 3).

### 3.4. Retinopathy

The prevalence of retinopathy was 83.3% (95% Confidence Interval CI: 79.13%–87.43%). The proportion of patients who developed retinopathy were comparable among the different ethnic groups. Tribes from the South were observed to have the highest prevalence of Retinopathy (92.3%). However, this was not statistically significant from other tribes (X-squared = 5.8466, df = 4, p-value = 0.2109).The 'North and East groups' were second and third regarding the prevalence for retinopathy (namely 87.1% and 83.3% respectively), followed by the West group (77.3%) and the Central group (76.9%). (Table 2).Regarding adjusted logistic regression-related calculation of odds ratio for the development of retinopathy about different ethnic groups, none of the ethnic groups was significantly different from the others, even after making the 'West' group as reference. However, regarding the unadjusted analysis, the Northern group carried a significantly higher risk for development of retinopathy (OR = 1.8471, p-value = 0.04603) (Table 2).

### 3.5. Neuropathy

The prevalence of neuropathy was 73.3% (95% Confidence Interval CI: 68.45%–78.22%). The proportion of patients who developed neuropathy were comparable among the different ethnic groups. Tribes from the East and the West were observed to have the highest prevalence of neuropathy (83.3% and 81.8% respectively). However, this was not statistically significant from other tribes (X-squared = 6.3209, df = 4, p-value = 0.1764).The 'North group' was third regarding the prevalence for neuropathy (namely 73.6%), followed by the Central group (72.8%). The 'South group' was the least regarding neuropathy prevalence (54.5%)(Table 2).Regarding logistic regression-related calculation of odds ratio for the development of neuropathy about different ethnic groups, the Southern group was significantly different from the others, making the 'West' group as a reference (OR = 0.1905, p-value = 0.0345) (Table 2).

## 4. Discussion

Genetic structure of Sudanese populations showed exciting outcome. For instance, Babiker et al. (2012) showed that people living in North of Sudan and Nubian population are clustered together with those from Egypt. This was attributed to the link

**Table 1**
Number of tribes and ethnic groups (62) and individuals included in this study.

| Tribe | Count | Tribe | Count | Tribe | Count |
|---|---|---|---|---|---|
| Kwahla | 19 | mwaleed | 2 | Bsawri | 1 |
| Shwaiga | 30 | Nuba | 1 | Btahein | 3 |
| Musaba'at | 1 | arakia | 5 | Dar Hamid | 1 |
| Halfawi | 6 | four | 5 | Dewaihi | 1 |
| Mnaseer | 1 | mhas | 19 | Dherair | 1 |
| Gwamaa | 7 | Maghaba | 3 | Fadni | 1 |
| Gaal | 66 | Rezaigat | 1 | Fllata | 2 |
| Ahamda | 1 | kenaneia | 3 | Gaafra | 4 |
| Amwi | 1 | rufaeia | 9 | Halngy | 1 |
| Ashraf | 4 | bniamer | 5 | Hamr | 1 |
| Atmn(East) | 1 | biga | 1 | Hmari | 1 |
| Atrak | 1 | dnagla | 29 | Mesilati | 1 |
| Awamra | 2 | rukabeia | 4 | Hssaneia | 7 |
| Bedaireia | 11 | maslmeia | 3 | Hwara | 2 |
| BniHalba | 2 | Saida | 1 | Hwazma | 2 |
| Dubasi | 1 | fong | 1 | Lebian | 1 |
| Brgo | 1 | tabawi | 1 | Maslmeia | 1 |
| Brno | 1 | kbabeesh | 2 | Mesaireia | 6 |
| Brtaweiia | 1 | Maghaweer | 1 | Maghawiia | 1 |
| Osoleia | 1 | Sewahili | 1 | Zghawa | 7 |
| Rubatab | 6 | Shukreia | 4 | | |

**Table 2**
Tribes according to location in Sudan and prevalence of complications.

| Sector | Number of tribes included | Number of patients | Percentage | DSF (Percentage) | Albuminuria | Retinopathy | Neuropathy |
|---|---|---|---|---|---|---|---|
| Central | 29 | 92 | 29.4% | 17 (18.5%) | 35 (61.4%) | 70 (76.9%) | 67 (72.8%) |
| North | 10 | 174 | 55.6% | 31 (17.8%) | 49 (39.2%) | 149 (87.1%) | 128 (73.6%) |
| East | 5 | 12 | 3.8% | 1 (8.3%) | 3 (33.3%) | 10 (83.3%) | 10 (83.3%) |
| South | 4 | 13 | 4.2% | 4 (30.8%) | 4 (44.4%) | 12 (92.3%) | 6 (54.5%) |
| West | 12 | 23 | 7.3% | 3 (13%) | 10 (76.9%) | 17 (77.3%) | 18 (81.8%) |

**Table 3**
The different diabetes complications and associations with different tribes and ethnic groups.

| Diabetic septic foot | | | | | |
|---|---|---|---|---|---|
| Sector | Adjusted OR | 95% CI | P value | Unadjusted OR | P value |
| Central | 0.5100 | 0.1404 to 1.8530 | 0.3063 | 1.0753 | 0.8214 |
| North | 0.4878 | 0.1411 to 1.6858 | 0.2565 | 1.0145 | 0.9611 |
| West | 0.3375 | 0.0622 to 1.8311 | 0.2081 | 0.4116 | 0.3999 |
| East | 0.2045 | 0.0193 to 2.1686 | 0.1877 | 0.6792 | 0.544 |
| South | 1 | Reference | Reference | 2.145 | 0.2182 |
| **Albminuria** | | | | | |
| Sector | Adjusted OR | 95% CI | P value | Unadjusted OR | P value |
| Central | 0.7938 | 0.1463 to 2.5348 | 0.6246 | 1.4105 | 0.1843 |
| North | 0.5071 | 0.2088 to 1.2317 | 0.1337 | 0.6405 | 0.0648 |
| South | 0.6090 | 0.3412 to 1.7728 | 0.4955 | 0.9736 | 0.9647 |
| East | 0.4737 | 0.1038 to 2.1626 | 0.3348 | 0.7497 | 0.6635 |
| West | 1 | Reference | Reference | 1.6678 | 0.2435 |
| **Retinopathy** | | | | | |
| Sector | Adjusted OR | 95% CI | P value | Unadjusted OR | P value |
| Central | 0.9804 | 0.2946 to 2.8265 | 0.9721 | 0.5467 | 0.0555 |
| North | 1.9920 | 0.6072 to 5.6369 | 0.2166 | 1.8471 | 0.04603 |
| South | 3.5294 | 0.4849 to 72.2418 | 0.2763 | 2.4777 | 0.3885 |
| East | 1.4706 | 0.2601 to 11.6253 | 0.6773 | 1.0040 | 0.996 |
| West | 1 | Reference | Reference | 0.6603 | 0.4363 |
| **Neuropathy** | | | | | |
| Sector | Adjusted OR | 95% CI | P value | Unadjusted OR | P value |
| Central | 0.5956 | 0.1836 to 1.9319 | 0.3880 | 0.9641 | 0.896 |
| North | 0.6184 | 0.1988 to 1.9231 | 0.4063 | 1.0266 | 0.9184 |
| South | 0.1905 | 0.0410 to 0.8860 | 0.0345 | 0.2933 | 0.0320 |
| East | 1.1111 | 0.1721 to 7.1744 | 0.9118 | 1.8552 | 0.4313 |
| West | 1 | Reference | Reference | 1.6901 | 0.3556 |

created by the river Nile and ability of peoples to move and travel form South of Sudan to Egypt and vice versa(11). Importantly, individuals from southern Sudan clustered with those from the Karamoja population from Uganda [11].Interestingly, Eltom et al. (2017) showed that one of the risk factor for type 2 diabetes in north of Sudan is being of Egyptian descents and mixed origin [10].However, Dobon et al. (2015) showed that part of the Nubian population may have a genetic link related to Nilotes of South Sudan, but not to other Sudanese populations or other sub-Saharan populations. Dobon et al. agreed with Babiker et al. that population in north of Sudan are genetically linked with population in North Africa [12]. In this study the effect of ethnicity on diabetic septic foot (DSF) was not statistically significant across different tribes. Tribes from the West were observed to have the highest prevalence of Albuminuria (76.9%), however, this was not statistically significant across different tribes.The Northern tribes carried significantly higher unadjusted risk for development of retinopathy.The Southern tribes was significantly different from the others in terms of the effect of ethnicity on neuropathy. Therefore, it is possible to suggest that difference in genetic of Sudanese population in north and South of Sudan may in part influence the risk of diabetes complications. It worth mentioning, that there is scarcity in publications that explored the genetic of diabetes in Sudanese population. For instance, Magzoub et al. showed that there is an association between Asp 57-DQB alleles and type 1 diabetes in Sudanese individuals. They also found that there were no difference between alleles order in control and individuals with type 1 diabetes [12,13]. The only large genetic study in Sudanese population with type 2 diabetes was conducted by Ibrahim et al. [14]. Their study showed that in different ethnic population in Sudan there is an association between type 2 diabetes and single nucleotide polymorphism at TCF7L2, CAPN10 and HHEX. Therefore, it possible to suggest that further genetic studies are needed to explore whether there is an association between particular diabetes complications and genes profile. Future genetic studies in relation to diabetes may reveal an exciting genetic mapping due to the following (i) Sudan was land for one of the oldest civilisation in the world (Nubian civilization-Kingdom of Kush) (ii) Sudan is one of the largest country in Africa with more than 100 tribes living together (iii) History of Sudan showed significant interaction between tribes from South, West, North and East of Africa. In addition, Sudan is home for tribes that emigrated from Arabian peninsula for more than 1000 years.

One of the limitations of this study is fact that we have not done genetic studies. In addition, the cross-sectional design for the study may not allow applying the finding to all populations living in Sudan. However, this first study in Sudan to look at whether there is an association between diabetes complications and different ethnic groups and tribes living in Sudan. The finding of this study may also

be used in the design of future genetic analysis and the exploration of therapeutic benefit.

## 5. Conclusion

This study showed that there is no role of ethnicity in term of DSF and albuminuria complications. However, retinopathy likely to be seen in tribes originally from north of Sudan, while neuropathy is more likely to be found in tribes originally from the south of Sudan. Further genetic studies in the future are needed.

## Author contributions

(I) Conception and design:All authors.
(II) Administrative support:All authors.
(III) Provision of study materials or patients:All authors.
(IV) Collection and assembly of data:All authors.
(V) Data analysis and interpretation:HA,MHA,MO.
(VI) Manuscript writing: All authors.
(VII) Final approval of manuscript: All authors.

## Statement by authors

The manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes the manuscript represents honest work.

## Conflicts of interest

None.

## Conflicts of interest

"The authors declare that they have no competing interests."

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2018.10.017.

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