Metabolic control targets in Sudanese adults with type 1 diabetes: A population-based study

Ahmed O. Almobarak¹, Sufian K. Noor², Wadie M. Elmadhoun³, Sarra O. Bushara², Reham S. Salim⁴, Sittana A. Forawi⁴, Heitham Awadalla⁵, Einas S. Elwali⁴, Mohamed H. Ahmed⁶

Departments of ¹Pathology, Faculty of Medicine, ²Public and Tropical Health Program, Graduate College, University of Medical Sciences and Technology, ³Department of Community Medicine, Faculty of Medicine, University of Khartoum, Khartoum, Departments of ³Medicine and ¹Pathology, Faculty of Medicine, Nile Valley University, Atbara, Sudan, ⁴Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK

Abstract

Background: Type 1 diabetes is a challenging metabolic disorder for health authorities in Sudan. The objective of this study was to assess the level of glycemic control and to determine the prevalence of dyslipidemia and complications among individuals with type 1 diabetes in Sudan. Materials and Methods: Individuals with type 1 diabetes, who were having the disease for at least 1 year, were invited to participate in this study. Data were collected from two diabetes centers, in the Capital Khartoum and Atbara City, North of Sudan. Participants were interviewed using standardized pretested questionnaire to record medical history, sociodemographic data, and life style characteristics. Blood pressure, body mass index, and waist circumference were measured. Blood samples were taken for measurement of lipid profile and glycosylated hemoglobin. Results: A total of eighty individuals with type 1 diabetes volunteered to participate in this study, 37.5% of males and 62.5% of females. Majority of the patients were aged between 40 and 70 years old. There was poor glycemic control (glycosylated hemoglobin >7%), in 83.8%. Age and sex were significant factors associated with poor glycemic control in this cohort. High cholesterol, triglyceride, and low density lipoprotein were seen in 76.2%, 27.5%, and 48.8% of participants, respectively. Low high density lipoprotein was seen in 33.8%. Hypertension was determined in 21.3%. Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5% of patients, respectively. Conclusion: Sudanese adults with type 1 diabetes have poor glycemic control, high prevalence of dyslipidemia, and long-term complications.

Keywords: Dyslipidemia, Sudan, type 1 diabetes

Introduction

Sudan is part of the Middle East and North Africa (MENA) region, and this region has the highest prevalence of diabetes worldwide.¹ For instance, in a cross-sectional epidemiological study in MENA in 14 countries, the prevalence of diabetes was estimated to be around 25% of the total population.¹ This was attributed to the increased urbanization in Africa, low physical activity and excessive intake of carbohydrate. It is estimated that by the year 2030, diabetes will affect double the current number of patients.²⁻⁴ The estimated total global prevalence of diabetes is around 8.3% (382 million people) and the number is expected to increase beyond 10.1% (592 million) by the year 2035.⁵ Alarmingly, the global estimation of undiagnosed cases of diabetes is around 175 millions.⁶

Address for correspondence: Dr. Mohamed H. Ahmed, Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK. E-mail: elziber@yahoo.com

How to cite this article: Almobarak AO, Noor SK, Elmadhoun WM, Bushara SO, Salim RS, Forawi SA, et al. Metabolic control targets in Sudanese adults with type 1 diabetes: A population-based study. J Family Med Prim Care 2017;6:374-9.
Glycemic control constitutes a great challenge in the management of type 1 diabetes mellitus (T1DM). For instance, in China the median glycosylated hemoglobin (HbA1c) level was 8.5% (7.5%, 10.2%) and only one-fifth of participants had HbA1c levels <7%. The same result was also seen in Finland, as only one-fifth of participants had HbA1c levels <7% and less than half of them had low density lipoprotein cholesterol (LDL-c) levels within the target range. Despite intensive treatment for T1DM in the UK for 10 years, majority of people HbA1c remained above the target. In Morocco, only 22.2% of type 1 diabetes can achieve the target of HbA1c of <7%. Factors associated with poor diabetes control in type 1 are: (i) longer duration of diabetes (ii) lack of motivation (iii) psychological and emotional factors. The complexity of management of T1DM had lead many experts in the field of diabetes to suggest special management in addition to insulin therapy. For instance, structured education, multidisciplinary clinics, risk factors management, psychological and self-management support and dietary and life style changes.

There is no previous data concerning glycemic control among adults with T1DM in Sudan. Therefore, we conducted this study to evaluate the glycemic and metabolic control and to assess diabetes complications and associated risk factors among Sudanese adults with T1DM.

### Materials and Methods

#### Study design

This cross-sectional hospital based study that carried out at two diabetes centers.

#### Setting and population

Individuals who attended two diabetes centers in Khartoum (Gaber Abo-Elezz Center), Khartoum state and in Atbara city, River Nile state were included in this study. Inclusion criteria included adults over 18 years, being on diabetes type I, and on treatment for at least one year.

#### Data collection tools

A validated, pretested, interviewer-administered questionnaire was used to obtain demographic data, diabetes related enquiries, in addition to physical measurements including anthropometric measurements and biochemical tests were done through standard techniques.

#### Laboratory methods

Fasting levels of plasma glucose, cholesterol, triglycerides (TGs), high density lipoprotein (HDL), LDL, and HbA1c were measured using standardized laboratory techniques in a fully-automated chemistry analyzer.

#### Anthropometric measurements

Anthropometric measurements were taken using standardized and calibrated equipment, body mass index (BMI) was calculated using the formula; weight in kilogram divided by height per squared meter. BMI was classified according National Institute of Health of the USA as follows: BMI less 18.5 is under weight, between 18.5 and 24.9 is normal, between 25 and 29.9 is overweight, 30–34.9 is Class 1 obesity, from 35 to 39.9 is Class 2 obesity and BMI of 40 or more is Class 3 or morbid obesity.

#### Waist circumference

Waist circumference was measured by a tape at the level of the umbilicus. A waist circumference of 94 cm or more in males and 80 cm or more in females defines central obesity.

#### Ethical clearance

A written consent was obtained from all participants before enrollment. The following information was given during data collection, to insure that participants had the information need to make the informed consent. The participation was optional and without a penalty for refusal. A complete description of the aims of this study, potential benefits and risks, assurance of confidentiality, and any other additional information requested by participants were provided during data collection. A formal ethical approval was obtained from the ethical committees of the Faculty of Medicine of both UMST and NVU.

#### Statistical analysis

The collected data were analyzed by using Statistical Package for Social Sciences (SPSS) version 21 (IBM Statistics, Chicago, IL, USA). The frequencies, mean, and standard deviation were calculated. Pearson Chi-square test was used to compare between proportions. The level of significance was considered if the value of P < 0.05.

### Results

#### Sociodemographic variables

In this study, eighty individuals with type 1 diabetes were included. Their age range was 20–75 years. Males were 30 (37.5%) and females were 50 (62.5%). The majority were living in urban areas (72.5%) and 70% were married. Hypertension was found in 21%. The sociodemographic characteristics and duration of diabetes were displayed in Table 1. Optimal diabetes control was identified in 16.2% of participants only, whereas uncontrolled diabetes (HbA1c > 7%) was identified in 83.8% [Table 2]. High cholesterol, TG, and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 70% [Table 3].

#### Factors and complications associated with uncontrolled diabetes

Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively [Table 3]. Poor glycemic control was only significantly associated with age and sex in our cohort (P < 0.072, 0.039) [Table 4].
Table 1: Sociodemographic characteristics of Sudanese individuals with type 1 diabetes

| Characteristic       | Variable          | n (%)          |
|----------------------|-------------------|---------------|
| Sex                  | Male              | 30 (37.5)     |
|                      | Female            | 50 (62.5)     |
| Age group            | 20-30             | 25 (31.3)     |
|                      | 31-40             | 18 (22.5)     |
|                      | 41-50             | 19 (23.8)     |
|                      | 51-60             | 11 (13.8)     |
|                      | >70               | 7 (8.8)       |
| Marital status       | Married           | 56 (70.0)     |
|                      | Single            | 17 (21.3)     |
|                      | Divorced          | 3 (3.8)       |
|                      | Widow             | 4 (5.0)       |
| Educational level    | Illiterate        | 15 (18.8)     |
|                      | Basic             | 14 (17.5)     |
|                      | Secondary         | 35 (43.8)     |
|                      | College and above | 16 (20.0)     |
| Residence            | Urban             | 58 (72.5)     |
|                      | Rural areas       | 22 (27.5)     |
| Duration of DM at the time of study (years) | 0-5 | 14 (17.5) |
|                      | 6-11              | 21 (26.3)     |
|                      | 12-20             | 23 (28.8)     |
|                      | >20               | 22 (27.5)     |
| Hypertension         | Yes               | 17 (21.3)     |
|                      | No                | 63 (78.8)     |

Table 2: Complications among Sudanese individuals with type 1 Diabetes (n=80)

| Complication          | n (%)          |
|-----------------------|---------------|
| Peripheral neuropathy | Yes 40 (50.0) |
|                       | No 40 (50.0)  |
| Visual problem        | Yes 39 (48.8) |
|                       | No 41 (51.3)  |
| Diabetic foot         | Yes 15 (18.8) |
|                       | No 65 (81.3)  |
| Myocardial infarction | Yes 2 (2.5)   |
|                       | No 78 (97.5)  |

Table 3: Lipid profile and glycosylated hemoglobin level among Sudanese individuals with type 1 diabetes

| Variable            | Normal/abnormal | n (%)          |
|---------------------|-----------------|---------------|
| Cholesterol (mg/dl) | Normal/abnormal | n (%)          |
|                     | Normal>155      | 19 (23.8)     |
|                     | abnormal>155    | 61 (76.2)     |
| Triglycerides (mg/dl)| Normal>150      | 58 (72.5)     |
|                     | Abnormal>150    | 22 (27.5)     |
| LDL (mg/dl)         | Normal<100      | 41 (51.2)     |
|                     | Abnormal>100    | 39 (48.8)     |
| HDL (mg/dl)         | Normal>40       | 53 (66.2)     |
|                     | Abnormal<40     | 27 (33.8)     |
| HbA1c                | <7 good         | 13 (16.3)     |
|                     | >7 poor         | 67 (83.8)     |

Discussions

In this study, the poor glycemic control (HbA1c >7%) among Sudanese individuals with type 1 DM was found to be (83.8%). Age and sex were associated with poor glycemic control in this cohort. High cholesterol, TG, and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 33.8% and hypertension 21.3%. Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively. Elbagir et al. in 1995 have shown that the glycemic control in Sudan was adequate in only 12.5% of patients, and in this study, it is only adequate in 16.2%.[16] The high prevalence of inadequate diabetes control may be attributed, in part, to the high prevalence of diabetes; as recent estimation suggested this could be around 19% of the population.[17] Despite the fact that self-monitoring of blood glucose was significantly associated with better glycemic control in Sudanese, as assessed by HbA1c (P = 0.02) and blood glucose at clinic visits (P ≤ 0.0001), unfortunately, in more than 75% of individuals with type 1 diabetes in Sudan never self-monitored blood glucose.[18]

Glycemic control for type 1 DM is very difficult even for developed countries. This is also proved to be challenging in a large epidemiological study in which data were obtained from (324,501) individuals with type 1 DM from the following countries/regions: Western Australia, Austria, Denmark, England, Champagne-Ardenne (France), Germany, Epirus, Thessaly and Thessaloniki (Greece), Galway (Ireland), several Italian regions, Latvia, Rotterdam (The Netherlands), Otago (New Zealand), Norway, Northern Ireland, Scotland, Sweden, Volyn (Ukraine), USA and Wales from population or clinic-based registries. The proportions with HbA1c 58 mmol/mol (<7.5%) varied from 15.7% to 46.4% among 44,058 people aged <15 years, from 8.9% to 49.5% among 50,766 people aged 15–24 years and from 20.5% to 53.6% among 229,677 people aged ≥25 years and being male or female have no impact on glycemic control.[19] This study showed that about one-sixth of patients had glycemic control (HbA1c <7%). In China, Finland, and Morocco almost one-fifth can achieve glycemic control with HbA1c <7%.[6,7,9] Despite intensive treatment for T1DM in the UK for 10 years, majority of people HbA1c remained above the target.[8] Further research is needed to confirm whether availability and compliance with insulin therapy, disease awareness and education and poor health system are contributing factors in high prevalence of poor glycemic control in our study.

In this study, we have shown that high cholesterol, TG and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 33.8% and hypertension 21.3%. The Coronary Artery Calcification in Type 1 Diabetes study showed a higher HbA1c.
was associated with significantly worse levels of the lipids total cholesterol, LDL-c, TG, and non-HDL-c.\textsuperscript{[24,25]}

Type 1 diabetes is known as condition associated with disturbance in metabolism of TG, HDL, and LDL.\textsuperscript{[13]} The prevalence of dyslipidemia among 239 T1DM in Brazil was found to be 72.5%. High cholesterol in 56.7%, low HDL 21.7%, high LDL 44%, and high TG 11.8%,\textsuperscript{[24,25]} Hypercholesterolemia was found to be the most common dyslipidemia in T1DM in about 54.6%, whereas other study found that low HDL was also most common dyslipidemia.\textsuperscript{[20,23]}

We have shown in this study that peripheral neuropathy, retinopathy, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively. Elbagir et al. in 1995 have shown that the prevalence of diabetes complications in Sudan such as retinopathy was 43%, nephropathy 22%, cardiovascular disease 28%, peripheral vascular disease 10%, cerebrovascular accidents 5.5%, and neuropathy 37%.\textsuperscript{[24]} Despite the fact that in this study HbA1c was not significantly linked to any diabetic complication \textsuperscript{[Table 3]}, it is possible to say that the higher prevalence of uncontrolled diabetes is likely associated with these complications. Bos and Agyemang have shown in
their systemic review that diabetes in North Africa was associated with the high prevalence of chronic diabetes complications ranged from 8.1% to 41.5% for retinopathy, 21% to 22% for albuminuria, 6.7% to 46.3% for nephropathy, and 21.9% to 60% for neuropathy.[8] In systemic review about diabetes in MENA, it was shown that macro- and micro-vascular complications were observed in 9%–12% and 15%–54% of population with diabetes, respectively.[23] Another possible factor for high prevalence of diabetes complications that not researched in this study is late referral to specialist centers to deal with complications beside lack of modern equipment and well-trained health practitioners.[24] These are common challenges for the management of diabetes in Africa. Renzaho suggested several challenges for diabetes control in Africa, for example, poor documentation of risk factors, demographic transitions (rapid urbanization and aging), poorly regulated food and beverage industry and the urgent need to direct resources, policies, and implementation strategies hold the key to an effective response to diabetes in African countries.[25]

Limitation of this study is related to cross-sectional design of the study and hence we could not take account of the temporal relationship between potential risk factors and outcomes. Another limitation is relatively small sample and short duration of the study. Despite these factors, we believe that this study is novel and its findings reflect the trend of increasing prevalence of poor glycemic control and dyslipidemia in Sudanese individuals with Type 1 diabetes.

**Conclusion**

High prevalence of uncontrolled diabetes (83.8%) and dyslipidemia is noted in Sudanese adults with type 1 diabetes.

**Financial support and sponsorship**

Khartoum Health Insurance Corporation and Samasu Medical and Educational Service Company, Khartoum, Sudan.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Alsheikh-Ali AA, Omar ML, Raal FJ, Rashed W, Hamouli O, Kane A, et al. Cardiovascular risk factor burden in Africa and the Middle East: The Africa Middle East Cardiovascular Epidemiological (ACE) study. PLoS One 2014;9:e102830.
2. van Dieren S, Beulens JW, van der Schouw YT, Grobbee DE, Neel B. The global burden of diabetes and its complications: An emerging pandemic. Eur J Prev Rehabil 2010;17 Suppl 1:S3-8.
3. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev 2012;70:23-21.
4. Bos M, Agymang C. Prevalence and complications of diabetes mellitus in Northern Africa, a systematic review. BMC Public Health 2013;13:387.
5. Lam DW, LeRoith D. The worldwide diabetes epidemic. Curr Opin Endocrinol Diabetes Obes 2012;19:93-6.
6. Liu L, Yang D, Zhang Y, Lin S, Zheng X, Lin S, et al. Glycaemic control and its associated factors in Chinese adults with type diabetes mellitus. Diabetes Metab Res Rev 2015;31:803-10.
7. Kekäläinen P, Tirkkonen H, Laatikainen T. How are metabolic control targets of patients with Type 1 diabetes mellitus achieved in daily practice in the area with high diabetes prevalence? Diabetes Res Clin Pract 2016;115:9-16.
8. Anderson SG, Narayan RP, Amlesh J, Qureshi MZ, Heald AH. Type 1 diabetes in Cheshire: Cardiometabolic risk factor trends (2004-2009). Prim Care Diabetes 2012;6:123-6.
9. Chadli A, El Aziz S, El Ansari N, Ajdi F, Sebat M, Latrech H, et al. Management of diabetes in Morocco: Results of the International Diabetes Management Practices Study (IDMPS)-wave 5. Ther Adv Endocrinol Metab 2016;7:101-9.
10. Osan JK, Punch JD, Watson M, Chan YX, Barrie P, Fegan PG, et al. Associations of demographic and behavioural factors with glycemic control in young adults with type 1 diabetes mellitus. Intern Med J 2016;46:332-8.
11. Livingstone SJ, Looker HC, Hothersall EJ, Wild SH, Lindsay RS, Chalmers J, et al. Risk of cardiovascular disease and total mortality in adults with type 1 diabetes: Scottish registry linkage study. PLoS Med 2012;9:e1001321.
12. Ozcan S, Amiel SA, Rogers H, Choudhary P, Cox A, de Zoya N, et al. Poorer glycemic control in type 1 diabetes is associated with reduced self-management and poorer perceived health: A cross-sectional study. Diabetes Res Clin Pract 2014;106:35-41.
13. Christie D, Thompson R, Sawtell M, Allen E, Cairns J, Smith F, et al. Structured, intensive education maximising engagement, motivation and long-term change for children and young people with diabetes: A cluster randomised controlled trial with integral process and economic evaluation-the CASCADE study. Health Technol Assess 2014;18:1-202.
14. Noor SK, Bushara SO, Sulaiman AA, Elmadhour W, Ahmed MH. Undiagnosed diabetes mellitus in rural communities in Sudan: Prevalence and risk factors. East Mediterr Health J 2015;21:164-70.
15. Guy J, Ogden L, Wadwa RP, Hamman RF, Mayer-Davis EJ, Liese AD, et al. Lipid and lipoprotein profiles in youth with and without type 1 diabetes: The SEARCH for Diabetes in Youth case-control study. Diabetes Care 2009;32:416-20.
16. Elmadhour W, Noor SK, Ibrahim AA, Bushara SO, Ahmed MH. Prevalence of diabetes mellitus and its risk factors in urban communities of North Sudan: Population-based study. J Diabetes 2016;8:839-46.
17. Elbagir MN, Eltom MA, Rosling H, Berne C. Glycaemic control of insulin-dependent diabetes mellitus in Sudan: Influence of insulin shortage. Diabetes Res Clin Pract 1995;50:43-52.
18. Abdelgadir M, Elbagir M, Eltom MA, Rosling H, Berne C. The influence of glucose self-monitoring on glycemic control in patients with diabetes mellitus in Sudan. Diabetes Res Clin Pract 2006;74:90-4.
19. McHugh JA, Wild SH, Lamb MJ, Cooper MN, Jones TW, Davis EA, et al. Glycaemic control of type diabetes in clinical practice early in the 21st century: An international comparison. Diabet Med 2015;32:1036-50.
20. Maahs DM, Ogden LG, Dabelea D, Snell-Bergeon JK, Daniels SR, Hamman RF, et al. Association of glycemia with lipids in adults with type 1 diabetes: Modification by dyslipidaemia medication. Diabetologia 2010;53:2518-25.
21. Homma TK, Endo CM, Saruhashi T, Mori AP, Noronha RM, Monte O, et al. Dyslipidemia in young patients with type 1 diabetes mellitus. Arch Endocrinol Metab 2015;59:215-9.

22. Ladeia AM, Adan L, Couto-Silva AC, Hiltner A, Guimarães AC. Lipid profile correlates with glycemic control in young patients with type 1 diabetes mellitus. Prev Cardiol 2006;9:82-8.

23. Vieira Cunha Lima SC, Oliveira Lyra C, Galvão Bacurau Pinheiro L, Medeiros de Azevedo PR, Arrais RF, Campos Pedrosa LF. Association between dyslipidemia and anthropometric indicators in adolescents. Nutr Hosp 2011;26:304-10.

24. Elbagir MN, Eltom MA, Mahadi EO, Berne C. Pattern of long-term complications in Sudanese insulin-treated diabetic patients. Diabetes Res Clin Pract. 1995 30(1):59-67

25. Zabetian A, Keli HM, Echouffo-Tcheugui JB, Narayan KM, Ali MK. Diabetes in the Middle East and North Africa. Diabetes Res Clin Pract 2013;101:106-22.

26. Renzaho AM. The post-2015 development agenda for diabetes in sub-Saharan Africa: Challenges and future directions. Glob Health Action 2015;8:27600.