Case Series

Study of variation glycated haemoglobin in diabetic patients using PCA method. Case study: Moroccan eastern region

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ABSTRACT

In collaboration with the regional centre of diabetes and chronic diseases, we will present in this work, the variability of glycated haemoglobin of 200 diabetic patients, in the eastern region of Morocco. This work is the analysis of the values of glycated haemoglobin in the three quarters of the study in 2021, which are presented by variable quantitative values with the statistical method principal component analysis PCA. This study also includes an analysis of socio-demographic parameters, which are analysed by the multiple correspondence analysis MCA method. The proposed approach will be used to study the distribution of patients in a subset of equal qualities according to the duration of evolution and type of diabetes. This analysis allowed us to understand and know the distribution of the Eastern population. This allows us to begin a more in-depth analysis of our sample and the various complications of diabetes, particularly diabetic retinopathy, which remains a major public health problem in Morocco, in order to develop more appropriate strategies for the management of diabetic patients in the Eastern region of Morocco.

1. Introduction

1.1. Global context

Diabetes is a global threat to human and economic development and one of the most common chronic metabolic disorders. It continues to be an enormous public health problem in all over the world, both industrialised and developing. It is a metabolic disease caused by dysfunctional blood sugar regulation [1,2]. In Morocco, a country in full evolution and which presents an economic and demographic boom. Diabetes is a public health threat and a problem that physicians face in their practice [2]. Morocco has put in place a policy and an operational action plan to fight diabetes called: National Multisector Strategy for the Prevention and Control of Non-transmissible Diseases 2019–2029 [3,4].

Glycated haemoglobin is an epidemiological variable often used to assess glycaemic control in populations. In diabetic patients, variability in HBA1C is causally related to diabetic retinopathy and diabetic neuropathy [5]. However, few studies have been done on variability of glycated haemoglobin. Therefore, the aim of this study was to evaluate and describe the variation in glycaemic control in diabetic patients in the eastern region of Morocco, according to their sex, age, and antidiabetic treatment, using glycated haemoglobin as a variable factor. Many complications of diabetes can be prevented or delayed by preventive measures and diabetes management programmes, including identification of risk factors, early diagnosis of diabetes, monitoring of glycaemic control and education of patients and health professionals.

2. Materials, patients and methods

2.1. Study population

To answer these questions, we conducted a descriptive prospective and analytical epidemiological study, carried out in our ophthalmology diagnostic centre at the CHU Mohammed VI Oujda university hospital in collaboration with the Reference Centre for Diabetology and Chronic Diseases “RCD”.

Patients are referred to the specialised diabetes consultation by endocrinologists at the CHU, peripheral hospitals and private practices in the city.

This study concerns a sample of 200 diabetic patients who consulted...
the “RCD” during the period of January 2021–November 2021.

Inclusion criteria were: having type 1 diabetes (T1D) and type 2 diabetes (T2D), inaugural or not.

Exclusion criteria were gestational diabetes and irregular medical follow-up (patients registered in the centre but rarely coming for consultation).

All data were collected from patients after informing them and obtaining their consent. No personal information, including names and surnames, was divulged.

2.2. Doctors at the diabetes consultation centre and case sampling

Doctoral researchers belonging to the Laboratory of Oto-Neuro-Ophthalmology "LRONO."

In collaboration for an optimal charge of diabetic patients with:

- Diabetologists, endocrinologists and general practitioners with experience in insulin therapy, ophthalmologists and nephrologists as well as cardiologists participated in the elaboration of the patients’ files and their follow-up.

2.3. Data collection

All patients were interviewed and the following information was collected: age, sex, occupation, health insurance, type of diabetes, date of discovery of diabetes, treatment started, family history of diabetes, and treatment of diabetes, alcohol consumption, smoking, glycated haemoglobin, hypertension, body mass index, dyslipidaemia, nephropathy, heart disease, arterial disease, diabetic foot complications, neuropathy, and retinopathy.

This research study involving human subjects is registered in a publicly available database with ClinicalTrials.gov under NCT Number NCT05364723. (https://clinicaltrials.gov/ct2/show/NCT05364723).

2.4. Determination of HBA1C (Norms)

Glycation is directly correlated with hyperglycaemia. HbA1c is a reflection of the quality of glycaemic control over the 12-week period prior to testing. As suggested by an international panel of experts, HbA1c has a certain degree of glycaemic relevance in terms of unnecessary patient preparation (no fasting required) and sample stability, so HbA1c testing is less confounded by measurement errors. [6]

The determination of HBA1c is done by a 5 ml sample, from a venous blood sample of the patient; the determination of the hba1c level within our training is done by high-pressure liquid chromatography HPLC.

Standardisation of HBA1C measurement worldwide has allowed the standardisation of HBA1C values and the determination of therapeutic objectives. HBA1C is therefore considered the best biological variable for assessing the level of diabetic control of patients [7].

2.5. Main statistical analysis in this study

We stratified the analysis according to clinical demographic factors that may affect glucose metabolism. Not to mention the type of diabetes and the treatments of our patients being qualitative values were analysed by the method, multiple correspondence analysis ACM, besides the correlation test of PEARSON and the ANOVA test [8,9] the P value < 0.05 is considered statistically significant.

Since the results obtained during the monitoring of HBA1c along the 3 quarters of the study represent quantitative variables, it was proposed to study their distributions and variations in our sample with the following method: principal component analysis, PCA [10,11].

Principal Component Analysis, or PCA, allows the data to be reduced to two types of analysis. It is a statistical method for exploring data with multiples variables.

The analysis is done by standardised method or centred analysis. Allowing for correlation or covariance links, this model allows a good reduction and helps visualise the variables and observations.

The data were analysed using SPSS 20 statistical software.

This case series has been reported in line with the PROCESS Guide [12].

3. Results

3.1. Description of our sample

200 patients were collected; the average age of our patients was 59 years with a standard deviation of 13 years and extremes ranging from 15 to 89 years. The percentage of young patients under 40 years was 9%.

Female patients (70%) were twice as numerous as male patients (30%). The duration of diabetes in our sample varied from one diabetic patient to another, ranging from an inaugural diabetes to a duration of more than 45 years, with an average of 12 years.

Type 2 diabetics in our sample are largely predominant with more than 97.5%, against 2.5% of type 1 diabetic patients.

The average glycated haemoglobin in our study was 9%, with a maximum average value in a diabetic patient who was unbalanced throughout the 3 trimesters at 15% and a minimum average value in a diabetic patient who was well controlled at 6%. 18.5% of the patients had good glycaemic control over the three months with an HBA1c that remained below 7% (Figs. 1, 2 and 3).

33.3% of patients were on oral antidiabetic drugs (OADs) alone, while 31.4% were on OADs plus insulin. Patients on insulin alone represented 32.8% of our sample.

3.2. Results of statistical analyses by PCA and MCA methods

The aim of this work is to describe the variation of glycated haemoglobin as a variable quantitative factor according to the data reduction method via principal component analysis PCA, within our sample, we collect drained patients from different regions of eastern Morocco which will allow us to know the variation of hba1c and diabetic balance within the population of the eastern region of Morocco.

In parallel with our study, we started a more extended statistical analysis of demographic factors: gender, age, type of diabetes and duration of diabetes evolution; as factors influencing the variation of glycated haemoglobin along the 3 study quarters.

An analysis of variance (ANOVA or two-way analysis) of these

Fig. 1. Diagram describing the variation of first trimester glycated haemoglobin in our sample.
factors, consisting of crossing two variables at each time, was used to detect the relationship of dependence or independence of these two variables.

The ANOVA analysis showed a relationship of dependence and influence of the age of our population on the duration of the evolution of diabetes with an F decision at 3.3% and a significance level of 0.000 (<0.05).

Thus, according to the ANOVA method, we were able to determine a relationship of influence of the duration of the patients’ diabetes on the average glycated haemoglobin of these 3 study quarters, with an F decision of 4.2 and a significance of 0.000 (<0.05).

The Pearson correlation study crossing the age of our patients and the mean glycated haemoglobin, showed a weak relationship at 3% with a significance of 0.96 (>0.05).

Similarly, the study of the correlation between the duration of diabetes and the average glycated haemoglobin showed a weak relationship of 7% with a significance of 0.92 (>0.05).

The correlation between the age of the patients and the duration of the disease was strong at 26.4% and a significance of 0.00 (<0.05).

The analysis of the relationship between the distribution of patients’ sex, type and treatment of diabetes, duration of evolution and average glycated haemoglobin over the 3 months, of our sample is initiated by multiple correspondence analysis, aiming to reduce these variables and to detect the existing relationships between the variables.

The results showed that there is a strong relationship between the ages of the patients, the duration of evolution, the average glycated haemoglobin, and the treatment of diabetes; while the gender does not influence the type of diabetes and the correlation between the latter two and the average glycated haemoglobin is very weak (Figs. 4 and 5).

The final aim of this statistical analysis is to investigate the variation in glycated haemoglobin in this sample and to correlate this with the demographic and developmental factors of the patients. Using a bivariate analysis of dependence or independence by principal component analysis. The closer the correlation is to 1, the stronger it is and vice versa.

This analysis didn’t show any correlation and any impact of age and duration of diabetes on the variation of glycated haemoglobin over the study period (Table 1) (Fig. 6), which confirms the results obtained by the PEARSON analysis.

Finally, from this statistical analysis, we were able to establish a diagram showing the distribution of the variation of glycated haemoglobin according to age, sex, type of diabetes, treatment of the patients and the three values of glycated haemoglobin along the 9 months of the study, according to a simplified model (Fig. 7) obtained after the reduction of all these data according to the PCA method (see Fig. 8).

This diagram showed that the distribution and variation of glycated haemoglobin in the Eastern population was homogeneous with a few exceptional cases, and by reviewing the medical records of these exceptional cases, this variation could be attributed to their non-cooperation with therapy and to diet and other associated medical factors.

4. Discussion

Our study, conducted in the eastern region of Morocco, investigates variations in glycated haemoglobin in relation to socio-demographic characteristics, in a sample of 200 diabetic patients, and elaborates important information on the characteristics, and the level of control of
diabetes in the eastern population, in order to understand the distribution of diabetes in this population and hence subsequently improve the management of these diabetic patients and decrease the risk of diabetic complications.

Women dominated the population of our study; these results are parallel to a larger study conducted in the same region, where women represented 65% of the study population [1]. A similar study conducted at the Diabetology-endocrinology unit of the Centre Reference Health Centre of BAMAKO on 200 patients showed a female predominance of 73% [13]. On the other hand, a study carried out in Japan on 2511 patients found a male predominance with 52.7% [6,7]. A study carried out in Ethiopia on 148 patients showed a male predominance with 58.8% of cases [7]. This female predominance can be attributed to the menopause and the advanced age of diabetic patients as well as to the rhythm of life and diet in our region.

The average age of our sample was 59 years, and 91% of our patients were over 40 years of age, so type 2 diabetics are largely dominant in our sample.

These results are correlated with the results of different studies. The one conducted in the eastern region showed a percentage of 81% of patients over 50 years of age with a percentage of type 2 diabetic patients of 87.5% [1]. In the centre of Bamako, the percentage of patients over 40 years of age is 64% [13].

We found an average duration of diabetes of 12 years; whereas in the study carried out on a sample of more than 2000 patients in this region, more than 49.1% of patients have a duration of diabetes of more than 10 years [1].

In our study, only 18.5% of patients had good glycaemic control with an average HBA1c value of 9%. In the study by C. Lee et al., they noted an average HBA1c of 8%. W. Cheneke et al. found an average HbA1 rate of 7.6% [7].

The analysis of our statistical results remains limited due to the limited number of studies investigating the variability of glycated haemoglobin. Detailed statistical analyses were limited. Only A. DIAO in his small study in Bamako carried out a statistical correlation study on HBA1c and demographic factors. In this study, the authors did not find a statistically significant relationship between HBA1c and age. In our study, there was no statistically significant relationship between glycaemic control based on HbA1c and the duration of diabetes. A statistically significant relationship was found between blood glucose controls (based on HbA1c). In this study, patients’ sedentary lifestyle was additionally analysed, and a statistically significant relationship

Fig. 5. Distribution of our population according to their demographic characteristics showing a fairly even distribution of our sample.

Table 1
Table summarising the correlation between the different values of glycated haemoglobin and the factor duration and age of patients.

| Correlation matrix a | patient age | Duration of patient’s progress | first trimester glycated haemoglobin | 2nd trimester glycated haemoglobin | 3rd trimester glycated haemoglobin | average glycated haemoglobin |
|---------------------|-------------|-------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|-------------------------------|
| Correlation          |             |                               |                                     |                                   |                                   |                               |
| Age of patients      | 1000        | .264                          | .019                                | .010                              | -.027                             | .002                          |
| Duration of patient’s progress | .264        | 1000                          | .019                                | .010                              | -.027                             | .002                          |
| first trimester glycated haemoglobin | .019        | .037                          | 1000                                | .647                              | .535                              | .818                          |
| 2nd trimester glycated haemoglobin | .010        | .009                          | .647                                | 1000                              | .816                              | .937                          |
| 3rd trimester glycated haemoglobin | -.027       | .042                          | .535                                | .816                              | 1000                              | .888                          |
| average glycated haemoglobin | .002        | .032                          | .818                                | .937                              | .888                              | 1000                          |

Fig. 6. Diagram showing the correlation between the demographic factors of our sample and the mean glycated haemoglobin.
5. Conclusion

Our study focuses on the analysis of glycated haemoglobin and glycaemic control analysis of the Oriental population from a sample of 200 patients.

This study uses data reduction methods to facilitate, objectify and develop correlations and impact relationships between socio-demographic factors of our population and their glycaemic control (HBA1c).

This analysis allowed us to understand and know the distribution of the Eastern population. This allows us to begin a more in-depth analysis of our sample and the various complications of diabetes, particularly diabetic retinopathy, which remains a major public health problem in Morocco, in order to develop more appropriate strategies for the management of diabetic patients in the Eastern region of Morocco.

Ethical approval

This case series does not require a formal ethical committee approval. Data were anonymously registered in our database. Access to data was approved by the head of the department.

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Author contribution

Corresponding author and first author: Dr Oujidi Wissale: Consultation and management of patients, data collection, analysis and interpretation of data, writing of the article and submission of the article. Final approval of the version to be published,

Co-authors:Pr Sekhsoukh Rachid: Patients management, data collection, review of the article. Supervision; proof reading; final approval of the version to be published. Dr Harrar Youssef: Consultation and management of patients, data collection, revision of the article. Final approval of the version to be published. Dr Mohammed Amine Mehdi: Software; data analysis; curation and investigation, final approval of the version to be published.

Research registration number

1. Name of the registry: ClinicalTrials.gov.
2. Unique Identifying number or registration ID: NCT05364723.
1. Hyperlink to your specific registration (must be publicly accessible and will be checked): https://clinicaltrials.gov/ct2/show/NCT05364723.

Guarantor

Dr Oujidi Wissale.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

The method of consent of this study

Verbal and written.

Declaration of competing interest

No conflicts of Interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jamsu.2022.104459.

References

[1] J. Hammoudi, et al., Risk factors and diabetes related complications frequency in the population of the Northeastern Morocco, 08, Open J. Epidemiol. (2018) 164–185, 03.
[2] A. Farouqi, M.A. Harti, C. Nejjari, Prise en charge du diabète au Maroc : Résultats de l’International Diabetes Management Practices Study (IDMPS) - Vague 2, Med. des Mal. Metab. 4 (6) (2010) 704–711.
[3] WHO, World Health Organization. Country Profiles for Diabetes, 2016. Available at: http://www.who.int/diabetes/countryprofiles/mar_en.pdf, 2016, 2016.
[4] Ministère de la santé, “La stratégie nationale multisectorielle de prévention et de contrôle des Maladies Non Transmissibles(MNT) 2019- 2029,” vol. 44, 2019.
[5] WHO, Organisation mondiale de la santé. https://www.who.int/fr/news-room/fact-sheets/detail/diabetes.
[6] H. Sakura, Y. Tanaka, Y. Izumoto, Seasonal fluctuations of glycated hemoglobin levels in Japanese diabetic patients, Diabetes Res. Clin. Pract. 88 (1) (2010) 65–70.
[7] W. Cheneke, S. Suleman, Y. Yemane, G. Abebe, Assessment of glycemic control using glycated hemoglobin among diabetic patients in Jimma University specialized hospital, Ethiopia, BMC Res. Notes 9 (1) (2016) 1–10.
[8] J. Chiche, Développements récents en analyse des correspondances multiples, Monde des Util. Anal. Données 42 (2010) 110–117.
[9] Y.V.E.S.E. Scoufier, Y. Escoufier, UNE représentation des variables dans l’analyse des correspondances multiples, Rev. des Stat. appliquées 4 (1967) 5–15.
[10] P. Cazes, A. Chouakria, E. Diday, Y. Schektman, Estension de l’analyse en composantes principales à des données de type intervalle, Rev. Stat. appliquée 45 (3) (1997) 5–24.
[11] R. palm, L’Analyse en composantes principales:principes et applications, notes Stat. d Inform., 1998.
[12] I. J. of S.R.A. Agha, C. Sohrabi, G. Mathew, T. Franchi, A. Kerwan, O’Neill N pour le groupe PROCESS, Les Lignes Directrices PROCESS 2020 : updating Consensus Preferred Reporting Of CasE Series in Surgery (PROCESS) Guidelines, “No Title,” 84, 2020, pp. 231–235.
[13] A. Diao, Contrôle de l’équilibre glycemique par hemoglobine glyquee chez les diabetiques de type 2 suivis dans l’unité de diabetologie du centre de sante de reference de la commune i du district de bamako, 2020.
[14] Hemoglobine glyquee, PRÉCIS Biopathol. Anal. MÉDICALES SPÉCIALISÉES (2012) 1–4.