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Electrocardiographic Profile of a Group of Adolescents and Young Adults with Type 1 Diabetes at the Yaoundé Central Hospital

Mohamadou Adama[1,2], Liliane Kuate Mfeukeu[2,3], Fabrice Zobel Lekeumo Cheuyem[1], Mesmin Dehayem Yefo[2,3], Ahmadou Musa Jingi[4], Eugène Sobngwi[2,3]*

[1] *Department of Public Health, Faculty of Medicine and Biomedical Sciences of the University of Yaoundé 1, Yaoundé, Cameroon*

[2] *Department of Internal Medicine and Specialities, Faculty of Medicine and Biomedical Sciences of the University of Yaoundé 1, Yaoundé, Cameroon*

[3] *Yaoundé Central Hospital, Yaoundé, Cameroon*

[4] *Department of Clinical Sciences. Faculty of Health Sciences. The University of Bamenda*

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ABSTRACT

Objectives This study aimed to evaluate the electrocardiographic (ECG) profile of young Cameroonian subjects living with T1D. **Methodology** A descriptive and analytical cross-sectional study was conducted from December 2016 to May 2017. The study population included 89 patients with type 1 diabetes (T1D), recruited from the diabetes care unit of the Yaoundé Central Hospital and 89 gender-matched control subjects, and recruited from schools in the city of Yaoundé. Each participant underwent a full clinical evaluation (history, weight, height, and blood pressure) and a resting electrocardiogram. The outcome variables analysed were the existence of arrhythmias, conduction defects, ventricular hypertrophy, atrial enlargement, ischemic changes, and repolarisation defects. Data were analysed using Epi Info version 7 software. Continuous data are presented as mean ± standard deviation. ANOVA and Chi-squared tests were used to compare means and proportions, respectively. Electrical abnormalities were compared by calculating the Odds Ratio (OR). A p-value of <0.05 was considered statistically significant. **Results** Their mean age was 18.3 ±4.2 years for the cases (T1D), and 14.7 ± 2.2 years for the controls (p<0.001). Sex, weight, and systolic blood pressure (BP) were similar in both groups. In the DT group, the mean duration of diabetes was 4.7±3.5 years, the mean HbA1c was 8.7 ± 2.1%, and the mean daily insulin was 46.5 ± 17 UI. The Cases had significantly higher mean diastolic BP than controls (72.7±8.5 versus 64.1±7.4, p<0.001). The cases had significantly lower mean heart rate (74±11.9beats/min versus 80±13.6, p=0.002), longer P wave duration (104±10ms versus 84±10, p<0.00), longer QRS duration (86±10ms versus 71±20, p<0.001), shorter PR interval (149±20ms versus 156± 156±20, p=0.004). No pre-excitation, nor conduction defect was seen in the cases. The mean peripheral voltage criteria for ventricular hypertrophy (Cornell and Lewis indices) were similar between groups. The mean precordial (Sokolow index) criteria was significantly lower in the cases (22.1±5.6mm versus 24.7±7.2, p=0.009). Sinus arrhythmia (OR: 2.3, p=0.01), early repolarisation pattern (OR 16.4, p=0.001), left atrial enlargement (OR: 9.9, p=0.018), and Q waves in two concordant leads (OR: 4.3, p<0.001) were significantly more frequent in the cases. Moritz sign (predominantly negative biphasic P wave in V1) was significantly more frequent in controls (p=0.03). One case of Wolf-Parkinson-White pattern, one case of wandering pacemaker, were seen in the controls. The ECG changes in the cases were not associated with the dose of insulin, duration of diabetes, or HbA1c. **Conclusion** After approximately five years of T1D evolution, the ECG profile in adolescents and young adults shows significant changes compared to non-diabetics. These alterations notably include frequent sinus arrhythmia, left atrial enlargement, concordant Q waves, an early repolarisation pattern, and lower precordial voltage criteria (Sokolow index). They also had a significantly longer QRS and QTc duration, and a lower heart rate.

* *Corresponding author:* Mohamadou Adama. Email: bachiroudoc@yahoo.fr

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1. Introduction

Type 1 diabetes (T1D) is a heterogeneous, chronic metabolic disease. It is characterised by the destruction of pancreatic beta cells, leading to an absolute insulin deficiency. The majority of cases are attributable to an autoimmune process (Type 1a diabetes), while a small proportion results from idiopathic beta-cell destruction (Type 1b diabetes). T1D accounts for 5 to 10% of all diabetes cases worldwide [1]-[3]. T1D is one of the most common endocrine and metabolic disorders in children. The annual incidence of this condition is sharply rising, particularly among the very young, with a global growth rate of about 3% per year [3]-[5]. This trend is especially concerning in low- and middle-income countries where, despite an estimated incidence of 0.012% [6], underdiagnosis and unregistered deaths remain high. In Cameroon, a Sub-Saharan African country, the annual increase in T1D is estimated at 10.6% [1][6], signalling an emerging health crisis and a significant burden on the healthcare system [7]-[9].

Prolonged exposure to chronic hyperglycemia induces intense oxidative stress, which is the key pathophysiological mechanism underlying micro- and macrovascular complications [10]-[12]. This metabolic dysregulation is associated with long-term organ failure, specifically affecting microcirculation (eyes, kidneys, nerves) and the cardiovascular system (heart and blood vessels) [13]-[17]. Patients with T1D face a significantly increased risk of developing cardiovascular disease compared to their non-diabetic peers of the same age [6]. In fact, cardiovascular diseases are the leading cause of mortality in T1D [18]-[20]. Late diagnosis and management of cardiac involvement directly contribute to the rise in this mortality.

The major clinical challenge is to identify and stratify cardiovascular risk before the onset of manifest clinical symptoms. Studies have shown that the presence of major electrocardiographic (ECG) abnormalities is associated with an increased risk of cardiovascular disease in T1D patients [21]-[23]. This grants the surface electrocardiogram—a simple, non-invasive, and widely accessible test—a potential role in the early screening of at-risk patients. These ECG abnormalities may reflect subtle structural or electrophysiological changes, such as autonomic nervous system impairment or early signs of diabetic cardiomyopathy.

T1D constitutes a crucial public health issue in Cameroon, where cardiovascular complications are often diagnosed at an advanced stage. Given the increasing incidence of T1D and the strong association between ECG abnormalities and cardiovascular risk, generating local data is imperative. Consequently, our study aims to determine and characterise the electrocardiographic profile of adolescent Cameroonian patients with type 1 diabetes, to establish early markers of cardiovascular risk in this resource-limited setting.

2. Methodology

2.1. Study Type

We conducted a descriptive and analytical cross-sectional study from January to May 2017.

2.2. Study Site

Our study was conducted at the Changing Diabetes in Children (CDIC) clinic of the National Obesity Centre (NOC), the cardiology department of the YCH, and at the Collège d'Enseignement Technique, Industriel et Commercial (CETIC) of Ngoa-Ekellé. The CDIC clinic in Yaoundé is the largest of the 9 CDIC program clinics for type 1 diabetes patients, with approximately 150 adolescents living with the disease.

2.3. Population

***2.3.1 Inclusion Criteria*:** Eligible for this study were type 1 diabetes patients aged at least 8 years, regularly followed in the CDIC program, as well as non-diabetic subjects matched for gender who provided informed consent.

***2.3.2 Non-Inclusion Criteria*:** Participants with hypertension or other endocrine pathologies were excluded from the study.

***2.3.3 Exclusion Criteria*:** Participants who refused to give their consent were excluded.

***2.3.4 Sample Size*:** The sample size was calculated using the Lorenz formula: $N=r2Z2p(1-p)$. Based on Soliman et al. (2017), who found a proportion of 13% of major electrocardiographic abnormalities in type 1 diabetes patients [9], and for a significance threshold of 5% ($Z=1.96$) and a margin of error of 5% ($r=0.05$), the calculation was as follows: $N=0.0521.962\times0.13\times0.87\approx88.67$. Therefore, we recruited 89 type 1 diabetes patients and 89 control subjects.

2.4. Procedure

***2.4.1 Data Collection Process*:** After obtaining informed consent or the assent of the legal guardian, subjects were interviewed and examined. A physical examination was performed, followed by a blood glucose test for all participants and a 5 ml venous blood sample for glycated haemoglobin testing for type 1 diabetes subjects. A standard 12-lead ECG was performed for each participant. The ECG interpretation was performed by the principal investigator and validated by a cardiologist. All information was kept confidential in a database accessible only by our team.

2.4.2 Clinical Data Collection

2.4.2.1 Clinical and Demographic Data: Participants' weight was measured barefoot on a calibrated scale with a precision of 0.1 kg. Height was measured using a stadiometer with the subject standing upright. The Body Mass Index (BMI) was then calculated using the standard formula: BMI = weight (kg) / [height (m)]. Blood pressure was taken on the right arm after a five-minute rest, using a SPENGLER sphygmomanometer, and the average of two consecutive readings was recorded. Capillary blood glucose was measured on-site with an Accu-Chek glucometer. A diabetic patient was defined as a subject with a fasting blood glucose level $\geqslant$1.26 g/L (verified twice) or a blood glucose level $\geqslant$2 g/L accompanied by symptoms of diabetes. In contrast, a non-diabetic subject was defined as an individual with fasting blood glucose strictly less than 1.1 g/L.

2.4.2.2 Biological Data Collection: For each patient with T1D, a blood sample was collected in an EDTA tube to perform the glycated haemoglobin (HbA1c) test. This test was conducted at the NOC laboratory using high-performance liquid chromatography (HPLC), a technique based on ion-exchange chromatography to separate ionised compounds.

2.4.2.3 Electrocardiographic (ECG) Data Collection and Interpretation: A standard 12-lead resting ECG was performed. The device settings were configured to 1 mV=1 cm and a speed of 25 mm/second. The parameters recorded included rhythm, heart rate, P wave, PR interval, QRS axis, QRS complex, ST segment, T wave, and QT interval. The following established definitions were used for ECG interpretation: Tachycardia was defined as a heart rate greater than 100 beats/min, and Bradycardia as a rate less than 60 beats/min. Left Atrial Hypertrophy was diagnosed if the P-wave

duration was greater than 0.12 s, while Right Atrial Hypertrophy was defined by a P-wave amplitude greater than 0.25 mV in lead DII. An Atrioventricular Block was indicated by a PR interval duration exceeding 200 ms. Axial deviations included Left Axis Deviation if the QRS axis was greater than −30∘ and Right Axis Deviation if the axis was greater than 110∘. For ventricular hypertrophy, Left Ventricular Hypertrophy was identified if the Sokolow index exceeded 35 mm, and Right Ventricular Hypertrophy if the index exceeded 10.5 mm. Intraventricular conduction disorders included Complete Bundle Branch Block for a QRS duration greater than 120 ms and Incomplete Bundle Branch Block for a QRS duration between 100 and 120 ms. A Necrosis Q Wave was characterised by a Q wave greater than 25% of the R wave or a Q-wave duration greater than 0.04 s. ST-segment abnormalities included ST-segment Elevation greater than 2 mm in precordial leads or 1 mm in peripheral leads, and ST-segment Depression following the same thresholds. A Normal T Wave was defined as a non-inverted T wave in aVR and V1 with an amplitude less than 25% of the QRS complex. Finally, the QT Interval was considered Prolonged if the corrected QTc was greater than 0.44 s.

2.5. Statistical Analysis

Data were entered and analysed using Epi Info software version 7. Continuous data are presented as mean ± standard deviation, and discrete data as a percentage (frequency). The difference between means (diabetes versus non-diabetes) was compared using the ANOVA test, and the difference between proportions by the Chi² test. For all statistical analyses, we used a significance level of 5% with a 95% confidence interval. The comparison of electrical abnormalities between the two groups was performed by calculating the Odds Ratio (OR). A p-value of <0.05 was considered statistically significant.

2.6. Ethical Considerations

Ethical approval was obtained from the Institutional Ethics and Research Committee of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé I. Research authorisation was also granted by the administration of the Yaoundé Central Hospital (HCY) and the management of the CETIC of Ngoa-Ekellé. This study was conducted in compliance with the principles of the Declaration of Helsinki.

3. Results

3.1. General Characteristics of the Study Population

Our total population consisted of 178 participants, of whom 89 (50%) had type 1 diabetes and 89 (50%) were non-diabetic subjects. The average duration of diabetes in the patients was 4.7 ± 3.5 years, with extremes of 0 and 16 years.

3.2. Distribution of the Population by Sex and Age

The distribution of the population by sex was similar in both groups, with no significant difference (p=0.764), and a slight male predominance. The average age of the diabetic population was 18.3±4.2 years, with an extreme age range from 8 to 27 years. In comparison, the average age of the control group was 14.7±2.2 years, with a range of 11 to 20 years. The most represented age group among diabetic patients was 16 to 20 years old, while in the non-diabetic subjects, the most common age group was 11 to 15 years old. The complete distribution by age group and sex is illustrated in Table 1.

Table 1 - Anthropometric characteristics of participants

Variable		T1D, n (%)	Non T1D, n (%)
Age (year)			
	≤11	5(5.6)	0(0)
	11 - 15	17 (19.1)	57(64)
	16-20	39(43.8)	33(36)
	21-25	26(29.2)	0(0)
	≥25	2(2.5)	0(0)
Sex			
	Male	48(52.8)	46(50.6)
	Female	42(47.2)	44 (49.4)

3.3. Clinical Characteristics

Table 2 presents the clinical parameters of our study population. No statistically significant differences were observed between patients with type 1 diabetes and control subjects concerning systolic blood pressure, body mass index, and heart rate.

Table 2 - Anthropometric, hemodynamic and biological characteristics of participants

Variable	DT1	Non DT1	*p*-value
Height(meter)	1.6 ± 0.1	1.6 ±0.1	0.94
Weight(kilograms)	57.2 ± 12.1	55.6 ± 13.6	0.41
BMI	22.1 ± 2.8	21.6 ± 3.9	0.33
Systolic Blood Pressure (mmHg)	118 ± 8.8	116.7 ± 9,1	0.30
Diastolic Blood Pressure (mmHg)	72.7 ± 8.5	64.1 ± 7.4	**<0.001** *
Heart Rate (Beats per minute)	80.1 ± 9.6	80.4 ± 9.1	0.83
Last HbA1c ⩽ 3 months value (%)	8.7 ± 2.1	NA	NA
Insulin dose per day (IU/day)	46.5 ± 17	NA	NA

BMI (Body Mass Index), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR), HbA1c: Glycated haemoglobin

***3.3.1 Diabetic Retinopathy*:** This condition was found in one patient, representing 1.1% of the total. Diabetic retinopathy affects the eyes and can lead to vision loss. No Nephropathy or Arterial Disease: The text explicitly states that no cases of diabetic kidney disease (nephropathy) or arterial disease were noted in this group of patients. The data indicate that most patients in this group had poorly controlled diabetes.

3.3.2 High HbA1c: The average HbA1c (glycated haemoglobin) level was 8.7% with a standard deviation of 2.1%. An HbA1c level of 6.5% or higher is a common diagnostic criterion for diabetes, and a value this high suggests that blood sugar levels have been elevated over the past 2-3 months.

***3.3.3 Uncontrolled Diabetes*:** The text concludes that the majority of patients had uncontrolled diabetes, which is consistent with the high average HbA1c value [24]-[26].

3.4. Electrocardiographic Characteristics of Participants

Table 3 summarises the mean values of the electrocardiographic parameters in our study population. Compared to healthy subjects, the type 1 diabetic

patients showed prolonged P-wave, PR-interval, QRS-complex, and QTc durations, as well as left atrial enlargement. However, no atrioventricular block, pre-excitation syndrome, or bundle branch block was noted.

Table 3 - Mean values of ECG parameters

Variable	DT1	No DT1	*p*-value
Heart rate, (beats per minute)	74 ± 11.9	80 ± 13.6	0.002
P-wave Duration (ms)	104 ± 10	84 ± 10	<0.001
P-wave Amplitude, (ms)	1.3 ± 0.4	1.3 ± 0.4	0.33
PR Interval Duration (ms)	149 ± 20	156 ± 20	0.004
QRS Complex Duration (ms)	86 ± 10	71 ± 20	<0.001
QRS Complex Axis (◦)	51.5 ± 23	54.8 ± 22.4	0.331
QTc Duration (ms)	416 ± 30	409 ± 20	<0.001
T-wave Axis (◦)	35.3 ± 17.3	42.8 ± 14.3	0.002
QRS-T Angle (◦)	16.2 ± 25.3	11.4 ± 25.7	0.211

Table 4 summarises the mean values of voltage criteria for ventricular hypertrophy. Peripheral voltage criteria (Cornell index and Lewis index) were similar between the groups. The Sokolow index, however, was significantly lower in type 1 diabetic patients than in non-diabetic subjects.

Table 4 - Index for assessing left ventricular size

Variable	DT1	Non DT1	*p*-value
Sokolow Index (LVH) (mm)	22.1 ± 5.6	24.7 ± 7.2	0.009
Sokolow Index (RVH) (mm)	2.3 ± 1.9	4.0 ± 3.2	<0.001
Cornell Index (mm)	11.5 ± 5.9	12.9 ± 5.8	0.102
Cornell Product Index (LVH), (mm.s)	1.03 ± 0.6	0.9 ± 0.5	0.140
Perugia Index (mm)	11.5 ± 5.9	12.9 ± 5.8	0.102
Lewis Index (mm)	1.32 ± 5.9	0.28 ± 6.5	0.262
Gubner Index (mm)	6.8 ± 3.0	7.3 ± 3.5	0.271

3.5. Electrocardiographic Abnormalities

Table 5 presents the electrocardiographic abnormalities. Several abnormalities were significantly more frequent in type 1 diabetic patients: sinus arrhythmia, a PR interval duration > 0.20s, an early repolarisation pattern, and the presence of at least two Q waves in concordant leads. Furthermore, a P-wave duration > 0.12s, suggesting probable left atrial enlargement, was more frequent in diabetics (OR: 9.9). Conversely, Moritz's sign (biphasic P wave with negative predominance in V1) was significantly less frequent in this group. The Sokolow index ⩾35 mm, indicating probable left ventricular hypertrophy (LVH), was significantly more frequent in non-diabetic subjects.

Table 5 - Electrocardiographic abnormalities in diabetics and controls

Abnormalities	Diabetic, n (%)	Controls, n (%)	Odds Ratio (95% CI)	*p*-value
Non-Sinus Rhythm	1(1.1)	0(0.0)	NA	NA
Sinus Arrhythmia	50(56.2)	32(36.0)	2.3 (1.3- 4.2)	0.01
Sinus Tachycardia	1(1.1)	7(7.9)	0.13 (0.02 – 1.1)	0.064
Sinus Bradycardia	10(11.2)	3(3.4)	3.6 (0.96 – 13.7)	0.08
P-wave ≥0.12s	9(10.1)	1(1.1)	9.9 (1.2 – 79.9)	0.018
Moritz's Sign (V1)	26(29.2)	41(46.1)	0.5 (0.3 – 0.9)	0.03
P-wave >2.5 mm	1(1.1)	0(0.0)	NA	NA
PR Duration >0.20s	1(1.1)	0(0.0)	NA	NA
PR Duration <0.12s	3(3.4)	1(1.1)	3.1 (0.3 – 30.1)	0.621
Sokolow Index ≥35 mm (LVH)	3(3.4)	13(14.6)	0.2 (0.1 – 0.7)	0.016
Sokolow Index ≥ 10.5 mm (RVH)	0(0.0)	2(2.3)	NA	NA
Cornell Index ≥ 28/20 mm	2(2.3)	1(1.1)	2.0 (0.2 – 27.7)	0.560
Cornell Product > 2.44 mm.s	2(2.3)	0(0.0)	NA	0,497
Rapport R/S ratio in V1 >1	1(1.1)	5(5.6)	0.2 (0.02 – 1.7)	NA
Q wave ≥ 2 derivations	29(32.6)	9(10.1)	4.3 (1.9 – 9.8)	0.0004
Early Repolarization	13(15.7)	1(1.1)	16.4 (2.1 -127.9)	0.001
Negative T wave	84(94.4)	86(96.6)	0.6 (0.1 – 2.5)	0.720
Abnormal QRS-T Angle	23(25.8)	31(34.8)	0.7 (0.3 – 1.2)	0.254

Left atrial dilation was observed and was significantly 10 times more frequent in diabetic patients than in non-diabetic patients ($p<0.05$). Conversely, Moritz's sign, although sensitive and non-specific, was more represented in non-diabetic subjects. LVH (Left Ventricular Hypertrophy) according to the Cornell index, was 2 times more frequent in diabetics than in non-diabetics.

We observed that electrocardiographic abnormalities can appear on average after 5 years of disease progression. However, there is no correlation between these abnormalities and the insulin dose. An insulin dose >1 u/kg/day was not significantly associated with LVH after adjustment for a diabetes duration greater than 5 years (OR: 3.9; CI: 0.22-67.3; p=0.318). Furthermore, no correlation was found between the insulin dose and the P-wave duration.

Diabetes duration was associated with neither left atrial dilation nor LVH. However, it was 2.4 times more associated with an intraventricular conduction disorder. HbA1c was associated with neither left atrial dilation nor LVH. Finally, HbA1c was not significantly associated with an intraventricular conduction disorder (OR: 1.8; CI: 0.4-7.7; p=0.428).

4. Discussion

The identification of these predictive characteristics and risk markers is necessary to improve our ability to identify patients with Type 1 Diabetes who are at higher risk. Electrocardiography (ECG) is the most widely used non-invasive tool for cardiac investigation. The resting electrocardiogram (ECG) is the most accessible non-invasive test for screening and detecting cardiovascular diseases (CVD). In addition to its role in CVD assessment, ECG abnormalities have also been used to predict poor outcomes in different populations.

Understanding the determinants and risk factors for developing new ECG abnormalities in T1D could facilitate a better understanding of cardiovascular diseases in this high-risk population and identify those who should benefit from closer monitoring and aggressive management of risk factors.

There are no existing data on the electrocardiographic profile of diabetic patients in sub-Saharan Africa. We conducted a descriptive and analytical cross-sectional study in a group of young Cameroonians living with T1D compared to a non-diabetic control group. After 5 years of progression, the T1D group showed significant electrical abnormalities such as a prolonged P-wave duration, a shorter PR interval, and a prolongation of the QRS complex and QTc.

The interpretation of our results must consider limitations such as the cross-sectional nature of the study, which does not allow us to determine the time lag between the onset of ECG abnormalities and the diabetes diagnosis. Similarly, we did not correlate the ECG abnormalities with echocardiographic findings, which remains the non-invasive reference in our setting. Furthermore, we did not perform biological analyses such as a blood ionogram, as electrolyte disorders can cause electrical manifestations. Nevertheless, this study is the first to establish the electrocardiographic profile in T1D patients in Cameroon. Our sample was representative of the different ethnic groups. We used a control group to highlight the abnormalities specific to T1D.

We found a significantly lower average heart rate in the T1D group compared to the controls. Sinus tachycardia was more frequent in the controls (7.9% versus 1.1%). Coluzzi et al. found a higher average heart rate in T1D than in controls [27]. This finding is unexpected because cardiac autonomic neuropathy often presents as persistent tachycardia without heart rate variability [28]-[29]. For the same glycemic control and body habitus, Traon et al. found a 12.3% prevalence of cardiac diabetic autonomic neuropathy after 20 years of T1D progression in a group of patients aged around 43 years 错误!未找到引用源。[30]. This may explain the absence of cardiac autonomic neuropathy in our sample after only 5 years of T1D progression. The stress effect of the first contact (white coat effect) could explain the tachycardia in the control group. Sinus arrhythmia was more frequent in diabetic patients, which argues against cardiac diabetic autonomic neuropathy.

We found a significant prolongation of the P-wave duration in diabetic patients. Left atrial hypertrophy was more frequent in the T1D group, which could be an early sign of cardiac involvement. Moritz's sign (biphasic P wave with negative predominance in V1) was more frequent in the control group. This sign is sensitive but non-specific for echocardiographic left atrial dilation in adults (Jingi et al., in press). The morphological translation (remodelling) of this sign is not certain in the young T1D population. An electrical-echocardiographic concordance study is necessary to better understand the significance of these electrical abnormalities in this population.

We noted a significantly shorter PR duration in diabetic patients. However, there was no short PR syndrome or pre-excitation in the T1D group. We found one case of Wolf-Parkinson-White syndrome in the control group. We have no explanation for this finding. Coluzzi et al. did not find a significant difference in PR duration between diabetic and control subjects [27].

An analysis of the QRS complex showed significant abnormalities such as QRS prolongation and the presence of a concordant necrosis Q wave in diabetic patients. QRS prolongation and the presence of a concordant necrosis Q wave are major ECG changes that increase the risk of developing CVD by 30% in diabetic patients [[22][31]. These abnormalities could indicate involvement of the myocardial microcirculation in cases of poor diabetes control or long-standing diabetes. However, we did not find a significant association with glycemic control, diabetes duration, or insulin dose. This QRS prolongation has been reported by Coluzzi et al. [27]. The presence of a concordant necrosis Q wave suggests myocardial necrosis. An echocardiographic study analysing myocardial strain (longitudinal deformation) is needed to understand the significance of these necrosis Q waves.

The average Sokolow index was significantly higher in the control group. Conversely, the average Cornell index was higher in diabetic patients than in controls. The positivity of these indices suggests the presence of Left Ventricular Hypertrophy (LVH). Jingi et al. showed that the Cornell index was more effective (better sensitivity and specificity) than the Sokolow index in the diagnosis of LVH in adults [32]. The performance of these indices has not been evaluated in young subjects in our setting.

We found a significantly higher prevalence of the early repolarisation pattern in diabetic patients. This pattern is considered physiological in young black Africans. We have no explanation for this statistically significant difference between the two groups.

The average duration of the QTc interval was statistically significantly higher in diabetic patients than in controls. We did not find a pathological QTc (QTc>440 ms) in either group. However, diabetic patients have a six-fold increased risk of QTc prolongation 错误!未找到引用源。[33]. This is a major ECG change that is associated with acute phenomena such as diabetic ketoacidosis 错误!未找到引用源。[[34]-[35]]. In the long run, QTc prolongation is associated with a 30% increase in cardiovascular events [31]. Jingi et al. demonstrated that QTc prolongation is significantly associated with a morphological and functional abnormality of the left ventricle (Jingi et al., in press). We did not find a significant association between QTc

prolongation, glycemic control (HbA1c ⩾ 8%), diabetes duration (⩾ 5 years), patient age, and insulin dose (1 UI/kg/day). Similarly, Galli-Tsinopoulou et al. did not find an association between QTc prolongation and the duration or control of diabetes [33].

5. Conclusion

In conclusion, our study demonstrates that after approximately five years of progression of Type 1 Diabetes, the electrocardiographic profile of patients shows significant changes compared to non-diabetic subjects. Among the adolescents and young adults studied, we observed a higher frequency of sinus arrhythmia, left atrial dilation, the presence of concordant Q waves, and early repolarization patterns, alongside lower precordial voltage criteria for ventricular hypertrophy. Furthermore, diabetic patients exhibited significantly longer QRS and QTc intervals, as well as a lower heart rate. Notably, these electrical alterations were not associated with diabetes duration, insulin dosage, or HbA1c levels. Based on these findings, it is recommended that researchers conduct longitudinal studies coupled with echocardiography to more precisely determine the timeline of these abnormalities. From a clinical perspective, systematic screening for left atrial dilation and QTc or QRS prolongation should be implemented starting at the five-year mark of disease progression. Finally, it is imperative to reinforce patient education regarding therapeutic adherence to optimize glycemic control and prevent the cardiovascular complications that threaten their overall health.

A.1. Abbreviations

CAAF: Complete Arrhythmia with Atrial Fibrillation.
AVB: Atrioventricular Block
BBB: Bundle Branch Block
CETIC: Collège d'Enseignement Technique, Industriel et Commercial
CDIC: Changing Diabetes In Children Cameroon
T1D: Type 1 Diabetes
ECG: Electrocardiogram
VE: Ventricular Extrasystole
IDF: International Diabetes Federation
FMBS: Faculty of Medicine and Biomedical Sciences
HbA1c : Glycated Hemoglobin A1c
YCH : Yaoundé Central Hospital
HDL: High-Density Lipoprotein
LVH: Left Ventricular Hypertrophy
RVH: Right Ventricular Hypertrophy
BMI: Body Mass Index
CVD: Cardiovascular Diseases
MODY: Maturity Onset Diabetes of the Young
GDP: Gross Domestic Product
AIDS: Acquired Immunodeficiency Syndrome
HIV: Human Immunodeficiency Virus

A.2. Declaration

Author's contribution: Drafting of the protocol, data collection, analysis and interpretation: MA, KML, DYM, AMJ and SE: Drafting of original manuscript: MA, FZLC, AMJ, KML and SE; Critical revision of the manuscript: FZLC, KML, and SE; Conception, design, supervision of implementation, editing and final validation of the manuscript: MA, KML, and SE. All authors approved the final version of the article.

A.3. Ethical Approval Statement

The institutional Review Board (IRB) of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé 1 approved the protocol, and an ethical clearance was issued. Informed consent was obtained from participants before inclusion in the study. All methods were performed in accordance with the relevant guidelines of the Helsinki Declaration.

A.4. Availability of data and materials

All data generated or analysed during this study are included in this published article and supplementary materials.

A.5. Competing interests

All authors declare no conflict of interest

A.6. Declaration of interests

All authors declare no conflict of interest and approve the final article.

A.7. Acknowledgements

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