QT INTERVAL ANALYSIS IN PHYSICALLY ACTIVE DIABETIC PATIENTS

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Abstract: Cardiac Autonomic Neuropathy is a common complication of Diabetes. Prolonged QT interval can be associated with an increased risk of silent myocardial ischaemia and mortality. Physical activity is recommended to health promotion, prevention and treatment of DM. This work aimed to analyse QT interval at rest in diabetic patients with and without regular physical activity, trying to detect diabetic autonomic neuropathy (DAN) abnormalities. Two groups of type 2 diabetic patients were studied: sedentary subjects (n=4, 2M and 2F) and subjects engaged in cardiovascular rehabilitation program (n=7, 5M and 2F). ECG files were recorded at rest (5 minutes, 10-bit resolution, 240 samples/sec.), band-filtered and processed for RR, QT, QTc intervals measurements, QRS and T-wave duration as well. Results show that only RR and QTc intervals have strong differences between groups (p=0.0002 and p=0.021, respectively). Although it was not possible to detect DAN abnormalities, our data suggests ST segment plays a relevant role in the dynamics of QTc and RR intervals in diabetic patients.

Introduction

Diabetic Autonomic Neuropathy (DAN) has Diabetes Mellitus Type 2 (DM2) as its main cause and generally affects many organs with silent symptoms, many times not observed by patients or clinicians [1]. DAN manifests itself mainly by autonomic parasympathetic or sympathetic system fail with impaired cardiac frequency regulation. One of the main complications of DM2 is the cardiovascular autonomic neuropathy which results in increased patient mortality. Brazilian type 2 diabetic patients had a more than threefold excess mortality than the general population, largely because of an increased cardiovascular mortality risk [2]. Other high mortality risks include prolonged QT interval, DM complications and severe asymptomatic ischaemia [1].

Physical activity is recommended to health promotion and to quality of life improvement, as well as to prevention and treatment of DM [3]. Analysis of QT interval of regular physically active patients could be a simple and low cost method to record and detect possible cardiac events [4]. This study aims to analyse the QT interval at rest in diabetic patients engaged in regular physical activity in an attempt to detect autonomic neuropathy abnormalities in comparison to sedentary diabetic subjects.

Materials and Methods

Two groups of patients were studied, both comprised of type 2 diabetic individuals older than 50 years old. Group A (n=7, 5M and 2F) was composed by regularly physically active diabetic patients with cardiovascular disease, age 65.6±4.7 years, all participants of the Cardiac Rehabilitation Program of the Physical Education, Physiotherapy and Sports Centre, State University of Santa Catarina (UDESC). Group B (n=4, 2M and 2F) was composed by sedentary diabetic patients, age 66.3±5.4 years. These patients were from the University Hospital of the Federal University of Santa Catarina. Table 1 provides a summary of the groups main features.

Table 1: Groups summary. Values are displayed as Mean (SD) unless stated otherwise.

Profile		Group A (Rehabilitation)	Group B (Control)
Sex		5M / 2F	2M / 2F
Age (in years)		65.6 (4.7)	66.3 (5.4)
BMI		29.07 (4.1)	26.23 (1.5)
Glucose (mmol/L)		6.3 (9.3)	6.85 (3.5)
Diagnosed Diabetes (in years)		5.1 (3.9)	16 (10.4)
Rehabilitation Time (in years)		4.1 (1.9)	--
HbA1c (%)		10.9 (4)	6.9 (1.5)
Total Cholesterol (mg/dL)		221.8 (60.2)	203 (33.9)
Diet Restriction (subjects)	None	1	--
	Few	2	--
	Several	4	4

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After selection, patients had their ECG recording at rest (supine position). Group A subjects had their ECG recorded on an exercise resting day. A custom-made ECG-amplifier (designed at the Institute Biomedical Engineering, Federal University of Santa Catarina) was used for data recording. Data was collected at standard derivation II, 5-minute files, 10-bit resolution and at 240 Hz sampling rate.

Body Mass Index (BMI) was calculated for all subjects in both groups. Weight was measured in a digital scale, and height was measured with a height scale. Patients' clinical profile was established from survey and clinical exams (see Table 1 for summary).

We analyzed QT, QTc and RR intervals, QRS complex and T wave duration. All time intervals were automatically measured in custom-made software. All heart beats in each ECG data file were grouped in 10 clusters of averaged heart beats (to reduce noise) prior to intervals processing (see Figure 1).

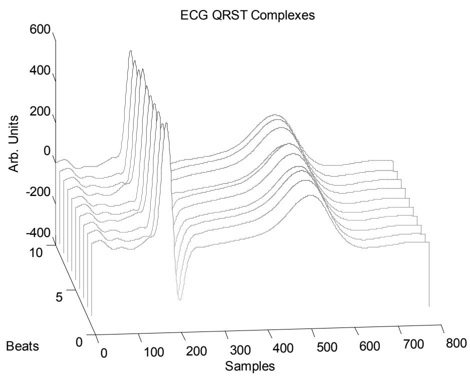

Figure 1: Heart beat clusters obtained from a subject from the rehabilitation group.

To enhance the algorithm performance on QRS processing, the signal was filtered in a Passband Butterworth Filter (4th order, 10-40 Hz) centered on the QRS frequencies. All subsequent QRS calculations were carried on this processed signal (see Figure 2). QRS duration was measured from Q wave onset to S wave offset.

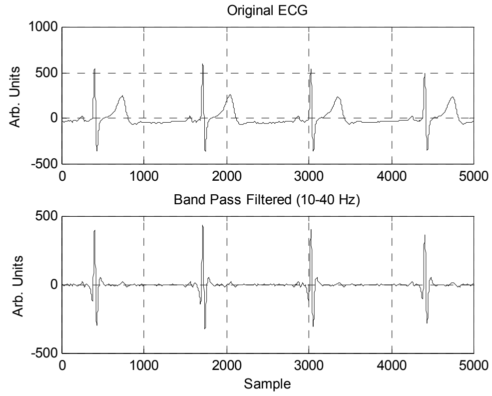

Figure 2: Original and band-filtered ECG signal from subject from the rehabilitation group.

QT interval was measured from Q wave onset to T-wave offset (marked at the intersection between the tangent and the isoelectric lines) and corrected to heart rate using Bazzett's formula. Results were considered statistically significant if $p<0.05$ using Mann-Whitney test.

Results

Our results (Table 2 and Figure 2) show non-significant differences between rehabilitation and control groups concerning QT interval (p= 0.42), QRS complex (p= 0.41) and T wave duration (p= 0.48).

Table 2: Data analysis summary. Values measured at rest, displayed as Mean (SE).

Time Intervals (ms)	Group A (Rehabilitation)	Group B (Control)	p
RR	952 (39)	724 (19)	< 0.01
QT	423 (10)	409 (15)	0.42
QTc	435 (10)	480 (15)	0.021
QRS	126 (5)	130 (1)	0.41
T-wave Duration	156 (8)	166(10)	0.48

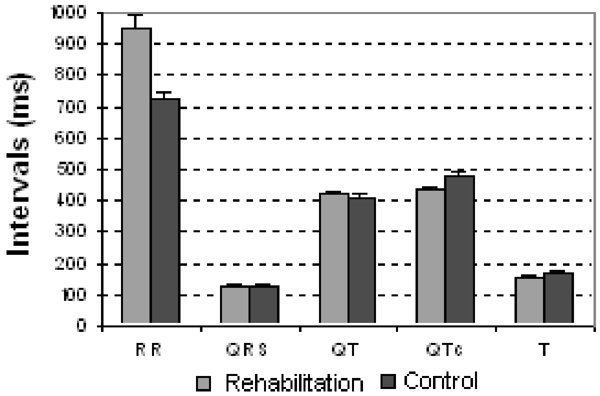

Figure 2: Time intervals (mean ± SE) measured at rest in Rehabilitation and Control groups.

On the other hand, patients under rehabilitation have showed a remarkably lower (p= 0.0002) heart rate at rest when compared to the control group (Figure 3).

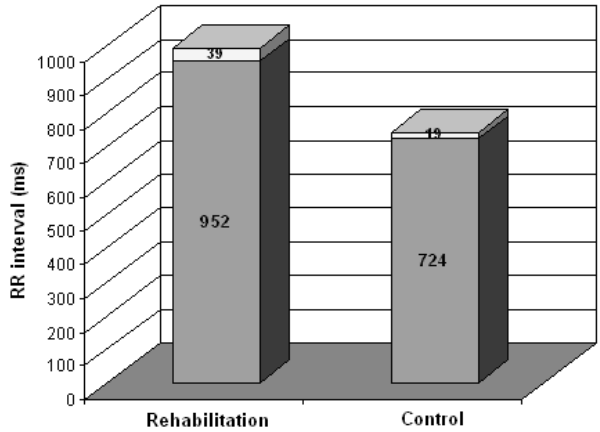

Figure 3: RR interval (mean ± SE) measured at rest in Rehabilitation and Control groups.

Although the QT interval was not able to discriminate between groups, the corrected QT interval (QTc) was significantly higher (p=0.021) in the control group (Figure 4).

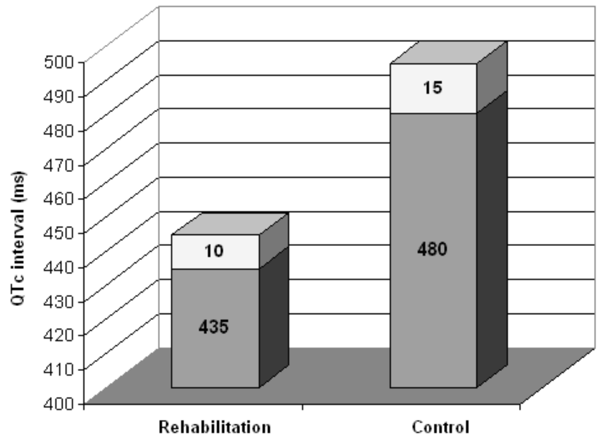

Figure 4: QTc interval (mean ± SE) measured at rest in Rehabilitation and Control groups.

Discussion

RR interval has showed a distinctively higher value 952±39 ms *versus* 724±19 ms in the rehabilitation group (p=0.0002) when compared to controls, respectively. In other words, this indicated that individuals from the rehabilitation group have lower instantaneous heart frequency at rest.

QT interval, QRS complex and T-wave duration analyses have not resulted in any significant differences between groups (QT interval, p=0.42; QRS complex duration, p=0.41 and T-wave length, p=0.48). Nevertheless, QTc interval has been significantly higher in the control group (p=0.021).

QT interval corresponds to the ventricular activation, including QRS complex (corresponding to ventricular depolarization), ST segment (early ventricular repolarisation) and T-wave itself (ventricular repolarisation). Our data suggests that the reason underneath the higher QTc interval in the control group is to be found in the ST segment. Further studies can help indicating whether it may be either lengthening of this segment or the shortening of the ST segment, at a lower rate than observed in RR interval.

QT interval is dependent on heart frequency, its correction being usually made by Bazzett's formula. In that case, QTc ≥ 440 ms would be considered as QT prolongation [4, 5]. Although the prevalence of QT lengthening is higher among diabetic subjects [4], it is considered a specific but not sufficient feature to indicate cardiovascular autonomic neuropathy [5].

It has been showed that aerobic training reduces QT and the correspondent QTc interval by decreasing the ventricular repolarisation overall time. This would lower the risks of malignant ventricular arrhythmias and sudden death among patients with regular aerobic training [6].

Our data agrees with the aforementioned study, suggesting that regular physical activity does contribute to maintain QTc interval within normal limits (QTc = 435±10 ms in the rehabilitation group; QTc = 480±15 ms in control group).

At the end of the study, all subjects in the rehabilitation group have reported a general increase in well-being and disposition, and lessening of inferior limbs paresthesias. On the other hand, subjects in the control (sedentary) group have reported tiredness, inferior limbs paresthesias and cramps.

Conclusions

Our work suggests that the analysis of ECG time intervals at rest (RR, QT, QTc, QRS and T-wave duration) alone is not enough to detect cardiovascular autonomic neuropathy. However, our data has corroborated the notion that regular physical activity may help on reducing QT and QTc intervals and, henceforth, lowering the risks of malignant arrhythmias and sudden death in type 2 diabetic patients [6].

We believe that there is enough circumstantial evidence to stress that ST segment should be carefully processed in any study aiming further comprehension of the QT interval behavior in physically active diabetic subjects. The distinctive differences in RR and QTc intervals between groups, not followed by similar behaviors from the QT extremes (QRS and T-wave duration), indicate that ST segment relevance in cardiac dynamics (specifically regarding to its influence on QT and QTc lengthening) may be underestimated.

Lastly, it should be emphasized the relevance of cardiac rehabilitation programs, not only helping on the study of QT dynamics in diabetic subjects but also for all the benefits reported by the patients under treatment.

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