



Early Evaluation of Type-2 Diabetics Mellitus Disease

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ABSTRACT: “Type-2 diabetes mellitus (DM)” is identified and prioritized health problem in India, which may reach out 80 million at 2030. Hence, early diagnosis of the disease is important. The aim was to investigate the usefulness of standard thermograms of both open mouth and backside of neck regions of an individual in the evaluation of disease, comparing to glycated hemoglobin (HbA1c, %) as a ‘standard’. Group-I: Type 2 DM (n=10, 58.7±7.5 years); and Group-II: Normal (n=10, 33.1±16.7 years). In each subject after overnight fasting condition, blood glucose was measured biochemically. Also, in each subject, standard infrared (IR) thermograms of open mouth and backside of the neck were taken using a thermal camera. The SST (skin surface temperature) of the above-mentioned ROI (region of interest) is measured using the software. Also statistical- as well as texture- features of the ROI’s were measured using MATLAB tool. Among all 20 subjects studied in normal and type 2 DM, there are significant and positive correlations between HbA1c (%) and average SST of both open mouth and backside neck per unit area of respective body region ($r=0.509$, $p<=0.052$ and 0.77 , $p<=0.013$ respectively); The FBG (fasting blood glucose) (mg/dl) was correlated statistically significant with average SST of backside neck per unit area of ROI ($r=0.748$, $p<=0.013$). Further PBBG (post breakfast blood glucose) (mg/dl) showed statistically significant correlations with average SST of both open mouth and backside of neck per unit area of ROI ($r=0.490$, $p<=0.052$, and $r=0.761$, $p<=0.013$ respectively). There were a statistically significant negative correlation between PBBG and entropy of backside neck, extracted from thermogram ($r=-0.447$, $p<=0.05$). This research paper shows that thermograms of the region mentioned above seem to be useful in the evaluation of disease.

Keywords: Diabetic mellitus, Infrared thermogram, Features of thermogram, Skin Surface, Thermal Image Acquisition.

I. INTRODUCTION

Diabetes Mellitus (DM) is a disorder in metabolism [1] of many causes characterized by chronic hyperglycemic by way of disturbances of carbohydrate, fat and protein metabolism evaluated from defects in either in insulin discharge and action [2]. In general it affects organs failure and damage of the organs in the human body [3]. The American Diabetes Association (ADA) and European Association for the study of Diabetes (EASD) have recommended that, if the measured HbA1c is greater than or equal to 6.5 % (7.7 mmol L⁻¹), then the individual is diagnosed as having DM.

The infrared (IR) thermography technique is used to evaluate various diseases. Moreover, it is non-invasive, noncontact, and non-irradiant [4]. In this research paper, the usefulness of IR thermograms of both open mouth and backside of neck of an individual was examined on the assessment of type II DM, when weigh against to the biochemical method as a ‘standard’.

II. BACKGROUND STUDY

A. Data Collection

This research work data is collected from T2D-Db resources [5], which provides closer and exact information on well-known molecular components

involved over the pathogenesis of type-II diabetes mellitus of human. The known type II DM for several years (more than one year) without any other complications [6] like neuropathy, nephropathy, retinopathy, foot damage and cardio-vascular disease were included in the attention. A total number of twenty subjects of both genders were studied, in which 10 (men:4 & women: 6) were known type-2 DM cases (Group-I: mean±SD age= 58.7±7.5 years) and the remaining 10 (men: 6 & women:4) were healthy normal volunteers (Group-II: mean ± SD age =33.1±16.7 years).

B. Biochemical Test and Anthropometric Measurements
In each subject, after overnight fasting blood glucose (FBG, mg/dl), post-prandial blood glucose (PBG, mg/dl) and glycated hemoglobin (HbA1c, %) were measured using standard biochemical methods. Further in each subject, body height (cm) and body weight (kg) were measured.

C. Thermal Image Acquisition Procedure

Each subject, after overnight fasting, was requested to sit in the temperature-controlled (28°C) room for 10 minutes before taking the thermogram. In each subject, standard IR thermogram of the following body regions, namely (i) open mouth –anterior to posterior view; and

(ii) back side of neck posterior to anterior view, were acquired in sitting position with thermal camera. Distance between the camera and the object was 0.9 meter. The obtained thermogram was in DICOM format. The resolution of each thermogram was 320 × 240 pixels. It had a thermal sensitivity of 0.95mk.

D. Skin Surface Temperature (SST) Measurement

Each thermogram was interpreted using FLIR Reporting software tool (v1.2). In this software, 'analyze' tool was selected and a 'rectangular box' was marked. It was carried in the following interest region (ROI) of the thermograms: (a) midpoint of open mouth; and (b) the Center part of backside of the neck. Now, in each ROI of the thermogram, the placed rectangular analyze box was positioned appropriately, and the following measurements would have done:

- Minimum SST (°C)
- Maximum SST (°C)
- Average SST (°C)
- Area of ROI (pixels)
- Average SST per unit area of ROI (°C/pixels)

E. Thermal image Processing

The thermogram was processed using MATLAB version 7.10.0 (R2010a). The obtained thermogram was loaded as an input image in MATLAB tool. A simple self-written coding was used to process thermogram. The algorithm for the same was given as follows:

- Step-1: Thermogram was given as an image input.
- Step-2: Gray scale image generated from input RGB image.
- Step-3: Crop region of interest manually and resize (ROI-1: open mouth and ROI-2: backside of neck).
- Step-4: Perform edge detection (Canny edge detection technique).
- Step-5: Apply adaptive filtering.
- Step-6: Perform statistical feature extraction (mean, kurtosis and skewness) and texture analysis (entropy and standard deviation).

F. Statistical Analysis

Data was evaluated using statistical package for social sciences (SPSS) software (version 10.0, SPSS Inc., Chicago, USA). The mean and standard deviation (SD) values of all the measured variables were compared between the groups studied using Student's t-test. Pearson correlation analysis was done among all the measured variables.

III. RESULTS AND DISCUSSION

A. Baseline Characteristics

Table 1 shows the mean ±SD values of different variables namely in Groups-I and II: (i) anthropometry, (ii) biochemical, (iii) SST of open mouth and back side of neck by corresponding thermograms; and (iv).features extracted from thermograms.

As like HbA1c, mean values of both FBG and PPBG were greater in type 2 DM patients (Group-I), when compared to healthy normal subjects (Group-II), and these were found to be statistically significant. In Group-I patients, average SST of open mouth per unit area of ROI was slightly higher, when compared to those value in Group-II subjects, but it was not statistically significant.

In Group-I patients, the calculated mean values of statistical features, namely mean, and skewness, extracted from thermograms of both open mouth, and back side neck were slightly higher than those corresponding values measured in Group-II subjects; but none of this difference was not statistically significant. Similarly, In Group-I patients, the calculated mean values of statistical feature, namely kurtosis and texture features, namely, entropy and standard deviation, extracted from thermograms of both open mouth, and back side neck were lesser than those corresponding values measured in Group-II subjects; but none of this difference was not statistically significant.

Table 1: Correlation between various variables studied in total subjects (n=20).

Biochemical variables	Skin surface temperature (SST) using thermogram		Extracted feature from thermogram
	Average SST of open mouth /area (°C/pixel)	Average SST of back side neck/area (°C/pixel)	Entropy backside neck
HbA1c (%)	0.509*	0.770**	—
FBG (mg/dl)	—	0.748**	—
PPBG (mg/dl)	0.490*	0.761**	-0.447*

*Correlation is significant at the 0.05 level (2- tailed)

**Correlation is significant at the 0.01 level (2-tailed).

B. Statistical Correlation Analysis

In all 20 subjects studied (both type 2 DM patients, and normal subjects), there were statistically significant and positive correlations between HbA1c (%) and average SST of both open mouth and back side neck per unit area of respective body region ($r=0.509$, $p<0.05$ and 0.770 , $p<0.01$ respectively). The FBG (mg/dl) was correlated statistically significant with average SST of back side neck per unit area of ROI ($r=0.748$, $p<0.01$). Further PPBG (mg/dl) showed statistically significant correlations with average SST of both open mouth and back side of neck per unit area of ROI ($r=0.490$, $p<0.05$, and $r=0.761$, $p<0.01$ respectively). There was a statistically significant negative correlation between PPBG and entropy of back side neck, extracted from thermogram ($r=-0.447$, $p<0.05$).

C. SST Measurement in Sample Thermograms

The image processing of digital thermograms of both ROI was done by using MATLAB software for both the groups and the processed images was observed that manually cropped ROI of the centre part of the open mouth region of a known type-2 DM patient had a comparatively higher temperature when compared to a normal subject. The canny edge detected image with a threshold; in type 2 DM case, the edge detected image was more complex than those observed in normal case. Also, in type 2 DM case, extracted texture features i.e., entropy and standard deviation showed a different pattern, when compared to those observed in a healthy normal subject [7].

HbA1c was correlated negatively ($p=0.01$) with SST of both eye- and nose- regions, measured from thermograms of corresponding regions in type-2 DM patients without cardiovascular disease [8]. Also, HbA1c correlated negatively ($p=0.01$) with SST of the carotid region by its thermogram in type2 DM patients [9]. In type 2 DM patients, mean SST of the regions in body, namely knee, tibia, forehead, and palm, which were measured by thermogram, were lesser significantly when compared to normal counterparts [10]. In this study, it was found that there was no statistical difference between mean SST of both open mouth and backside neck per unit area of the respective region within type 2 DM patients and healthy control patients.

IV. CONCLUSION

From this research paper, standard thermograms of both open mouth and backside neck of an individual were tested in the exhibit of type-II DM, when comparing to HbA1c as a 'standard'. In total subjects, both HbA1c and PBBG were positively correlated with the average SST of both open mouth and backside neck per unit area of their respective ROI. Here we have a significant statistical negative correlation between PBBG and the entropy of backside neck, extracted from thermogram. The results and discussions of this paper show that thermograms of the region mentioned above seem to be useful in the evaluation of disease.

V. FUTURE SCOPE

The next step of this research work is to compare the proposed model with existing medical process models. The proposed system can be experimented using the more number of real time data with performance measures.

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Conflict of Interest. There is no conflict of Interest in this work.

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