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Will Hyperglycemia Influence the Cardiorespiratory Endurance and Other Determinants Among Community-Dwelling Type 2 Dm Patients? A Cross-Sectional Study.

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Abstract

Objective - The objective of this study was to find out whether hyperglycemia influences cardiorespiratory endurance and other determinants among community-dwelling type 2 diabetes Meletus (DM) patients with poor control of blood glucose. **Methodology –** The study included 125 subjects with hyperglycemic status, due to type 2 DM who were recruited from Gujarat in two different clinical setups. They were screened for cardiorespiratory endurance, agility, quality of life (QOL), and blood glucose levels (HBA1C). **Results** -There was a significant correlation between the HbA1C values and the Vo2 Max, "T" Agility test and PER with values of p-value <0.001 (correlation 0.754), $p < 0.001$ (correlation 0.538) and $p < 0.001$ (correlation 0.427). However, there was no significant correlation between hyperglycemia and QOL. **Conclusion** - The high average blood glucose does influence the cardiorespiratory endurance, agility and perceived exertion rate, however, it doesn't influence the quality of life of DM patients with poor glycemic control.

Keywords - type 2 diabetes Meletus, hyperglycemic status, cardiorespiratory endurance, agility, quality of life.

1. Introduction

Hyperglycemia is the essential component of diabetes mellitus (DM) which is the initial blood marker to determine someone is diabetic. There are 2 predominant types of DM, type 1 and type 2. Out of these, we tend to deal with the type 2 diabetes, which is distinguished by the chronic hyperglycemia that is results when the pancreatic β-cell insulin secretion breaks to repay for the decline in insulin responsiveness [1] The worldwide incidence of diabetes in adults is around 8 percent more than 90 percent of whom have the type 2 diabetes, which is estimated to rise to more than ten percent by 2040. [2] It is suggested commonly that regular physical exercise is associated with less cardiorespiratory compromise among type 2 diabetes. However, it is known that there is no link between cardiorespiratory fitness and exercise. This is likely because the result of the self-reported exercise attitude variable does not actually and objectively represent the participant's behavior or chronic physical activity patterns. To avoid this issue the inherent limitations related to self-reported exercise should be overcome. [3] Hence any study relating the cardiorespiratory fitness with a variable should include standard outcome measures which can reflect the exercise status. Thus we tried to find the cardiorespiratory parameters that were affected by the hyperglycemia so that they can be used

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to measure the prognosis in phase 2 following our intervention.

Similar to findings in the normal subjects we found that in diabetic patients, weight status was correlated with cardiorespiratory fitness; It is already proved that obese samples with hyperglycemia were susceptible to poor cardiorespiratory fitness. The mean cardiorespiratory fitness among obese persons was in the relatively low category which was around 22.0 mL/kg/min. These results are expected given the link between obesity and diabetes, hence we didn't include obesity in this phase but included it in phase 2 as a standard outcome predicting cardiorespiratory endurance. The objective of this study was to find out whether hyperglycemia influences cardiorespiratory endurance and other determinants among community-dwelling type 2 DM patients with poor control of blood glucose.

2. Methods

This Cross-sectional study was performed with a consecutive sampling of 125 samples selected for the study after estimation using previous literature. [4]. The study included 125 subjects with hyperglycemic status, due to type 2 DM who were recruited from Gujarat in two different clinical setups. The word hyperglycemia was employed rather than DM because the study will not consider the DM subjects with good glycemic control measured through HBA1C. The operational definition for hyperglycemia for the current study is "a state at which the fasting blood glucose value is more than 140mm/hg and/or postprandial blood glucose value is more than 200 mm/hg or above and an HBA1C value of more than 7" we selected the sample if the subject had any one of this criteria.

The subjects were selected if they had hyperglycemia tested by an ISO certified laboratory within a duration of 10 days, both male and female, subjects of age between 30 to 60 years were selected for the study, subjects under insulin therapy, oral hypoglycemic agents were selected. Subjects were excluded if they presented with systemic hypertension, subjects who have undergone any thoracic and abdominal surgery, subjects with obstructive and restrictive lung diseases, subjects with peripheral vascular diseases, and subjects with any other conditions that may affect the relationship between the dependent and the independent variable and act as a confounding variable will be excluded.

All the subjects participating in the study were explained clearly about the study and signed an informed consent form. The study was presented to the institutional ethical committee of Madhav university and was cleared for any human ethical issues. (Ethical certificate – MU/IEC/20/07). The subjects were categorized into subjects treated with insulin therapy (IT), subjects treated with oral hypoglycemic agents (OHA), and subjects who did not receive any treatment for hyperglycemia. Out of this only, the subject treated with OHA and Insulin therapy were taken into study.

The recruited subjects were screened for cardiorespiratory endurance, agility, quality of life (QOL), blood glucose levels (HBA1C).

VO2 Max - VO2 max is an analysis of the maximum amount of oxygen that a person consumes during intense physical activity. Vo2 max is the best indicator of aerobic endurance, as well as cardiovascular fitness as it calculates how efficiently human cells use oxygen in generating energy. There are many methods of measuring VO2 max, however many methods require equipment like a treadmill or an exclusively calibrated exercise cycle. There are many difficulties in administering and are not feasible for all fitness levels. We employed a walking/jogging test.

The patient's maximum heart rate was calculated by subtracting the patient's age from 220. The VO2 Max was calculated using the simplest formula -

VO2 max = 15 x (Heart rate/Heart rate rest).

The units for VO2 max are milliliter per / body weight in kilograms / minute (mL/kg/min).

"T" Agility test - Subjects were requested to run straight for 9.14 m from the beginning line to the primary cone and contact the tip with their right hand, then shuffle for 4.57 M from the left to the subsequent cone and contact with their left hand, then, at that point, again shuffle for 9.14 M to the right to the third cone and contact with their right, shuffle 4.57 m back left to the center cone and contact with their left hand before at last returning to the beginning line. Time started upon subjects elapsing through the circumstance entryways and halted upon them going through on return. The test won't be

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counted if the subject crosses one step at a time while rearranging, neglects to contact the foundation of the cones, or neglects to look ahead all through the test. Take the best season of three fruitful preliminaries. [5]

The diabetic QOL scale – consisted of 9 questions that were about the fatigue and exercise predominantly and the patients were instructed to answer on 7 level ranking scale, which was evaluated based on the patient's answers, if they were high it indicated a poor quality of life and if t was less indicated a good quality of life.

HBA1C – this was calculated by the venous blood extracted by a professional and interpreted in the lab which was certified by ISO 9001- 2015.

Borg's modified perceived exertion scale - The scale is an extremely straightforward mathematical rundown. Subjects were approached to rate their effort on the scale during the exercises, thinking about sensations of actual pressure and weariness, ignoring any component, for example, leg agony or windedness yet zeroing in all on all sensations of effort. This number picked indicates the force of action permitting the member to accelerate or dial back developments/movement. The scale requires a couple of moments to finish and can be self or specialist-regulated on a solitary event or different occasions.

Statistical analysis

Correlation analysis was used to find the relation between the dependent variables (Agility, Quality of life, and perceived exertion) and the independent variables (Cardiorespiratory endurance and blood glucose levels). There was a correlation analysis performed between the Cardiorespiratory endurance and blood glucose levels as well. Spearman's correlation analysis was used for non-parametric samples and Pearson's correlation was used for parametric samples. The Significance level was fixed at o.05 at a confidence interval of 95%. SPSS version 23 was used for the statistical analysis.

3. Results

The results of the study comprised 125 samples selected to undergo the cross-sectional evaluation. A total of 5 outcomes were selected namely VO2 Max to evaluate cardiorespiratory endurance, HBA1C to assess the blood glucose control, "T" Agility test for testing the agility, diabetic QOL scale to test the quality of life, and Borg's modified perceived exertion scale to assess the amount of exertion experienced by the samples. The analysis of the data showed that there was a significant correlation between the HbA1C values and the Vo2 Max values with a p-value <0.001 and correlation value of 0.754.

The data are presented in table 4.2. The analysis of HBA1C and DM QOL shows that there was no significant correlation between them with a p-value of 0.770 and a correlation value of 0.026. The analysis of the HBA1C and "T" Agility test shows that there was no significant correlation between them with a p-value < 0.001 and a correlation value of 0.538.

The analysis of the HBA1C and PER test shows that there was a significant correlation between them with a p-value < 0.001 and a correlation value of 0.427. The data are presented in table 4.5. The analysis of the VO2 MAX and "T" Agility test shows that there was a significant correlation between them with a p-value < 0.001 and a correlation value of 0.304. The analysis of VO2 MAX and PER shows that there was a significant correlation between them with a p-value < 0.001 and a correlation value of 0.335. The analysis of VO2 MAX and DM QOL shows that there was no significant correlation between them with a p-value of 0.569 and a correlation value of -0.051. Figures 1 to 3 present the important findings as a scatter plot.

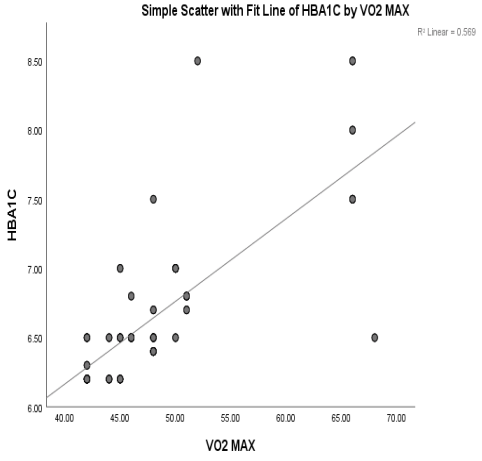

Figure 1 Scatter plot – HbA1C correlation with Vo2 Max

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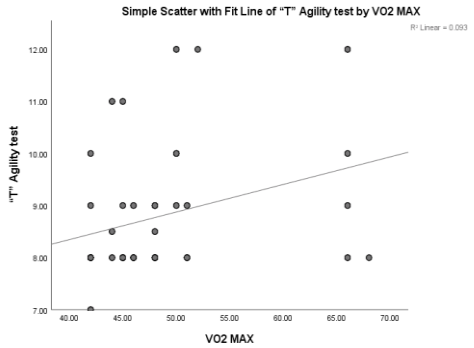

Figure 2 Scatter plot – "T" Agility test correlation with Vo2 Max

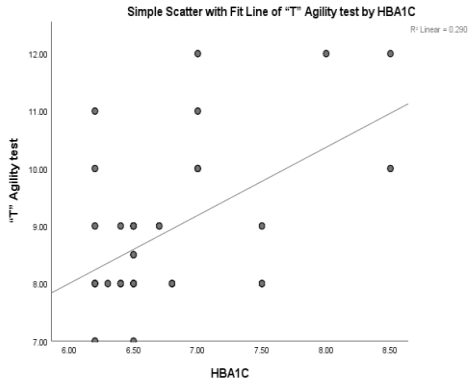

Figure 3 Scatter plot – "T" Agility correlation with HbA1C

4. Discussion

In Type-1 diabetics, there are no obvious constraints to the peak VO2 of the individual when compared to normal. However, studies reveal that they are linked to low cardiorespiratory fitness and impaired insulin sensitivity in those at risk for Type 2 diabetes. Research on the western population suggests an inverse relationship between cardiorespiratory fitness and the likelihood of developing diabetes. This indicates that diabetes has a significant impact on an individual's ability to exercise, lowering one's quality of life. Exercise is one of the preferred glycemic control strategies for people with Type 2 diabetes. Diabetes mellitus is a disorder of carbohydrate, lipid, and protein metabolism characterized by a decrease in tissue insulin sensitivity or a lack of insulin production. Increased non-enzymatic glycosylation of numerous bodily proteins such as hemoglobin, collagen, and albumin occurs as a result of persistent hyperglycemia. The Glycemic index is calculated by measuring the levels of glycated hemoglobin (Hb1Ac). Glycation occurs during the red blood cell's lifetime (90-120 days). HbA1c is the average blood glucose levels during the previous 3-4 months. A high Hb1Ac level suggests poor blood glucose control or a high Glycemic index. There is a wealth of material accessible in western literature, which brought into account western sedentary lifestyle habits. However, there is a scarcity of information on Indian Diabetics. [6](Sinclair et al, 2008)

The mean value of HbA1c in our study was 7.8 ± 0.74 %. It was observed that the subjects treated using OHA had higher GlycatedHemoglobin levels than the subjects treated with Insulin therapy. This suggests that the Diabetics' diabetes was poorly managed among the subjects who took OHA. The higher the level of GlycatedHemoglobin, the poorer the control of blood sugar i.e. higher is the level of circulating glucose, and as discussed earlier hyperglycemia leads to non-enzymatic glycation of intracellular and extracellular proteins forming advanced glycation end products (AGEs).

Maximal Oxygen Consumption (VO2max) - mean Resting pulse rate, Post-Exercise pulse rate & VO2max level in Type 2 Diabetics were 75.7 ± 6.12 beats/min, 149.04 ± 6.8 beats/min, 2.69 ± 0.308 L/Min. The difference in Resting pulse rate was nonsignificant, While, Post-Exercise pulse rate was significantly higher in subjects with higher HbA1C than in subjects who had less HbA1C. When Type-2 Diabetics were compared to controls, their VO2max was considerably lower. Schneider H. et al came to similar conclusions in 2008. This could be accounted for by an increased Glycolytic to Oxidative enzyme ratio, which is induced by increased Glycolytic enzyme activity combined with a decrease in the maximum speed of Oxidative enzymes. i.e citrate synthase & Cytochrome-c oxidase contributes to Insulin resistance in subjects with Type-2 Diabetes. Dysfunction in GLUT4 translocation owing to either signal transduction or intrinsic to the glucose transporter mechanism has been proposed as the primary cause of insulin resistance. Also, decrease in the enzymatic activity regulating storage and oxidation of glucose in skeletal muscle. Muscle fiber type and composition found in studies with diabetes such as changed skeletal muscle fiber type as

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well as increased fat content, capillary basement membrane width in the skeletal muscle may result in low work efficiency. The accumulation of Intramyocellular Triglycerides (IMCL). which correlates well within Vivo Insulin Resistance. In particular, the major issue generating IMTG (Intramyocellular Triglycerides) buildup and muscle insulin resistance in obese individuals, IRS, and type 2 diabetes is a failure in muscle fatty acid oxidation. Insulin sensitivity and VO2max are closely associated with a mitochondrial oxidative capability. It is also proposed that, even though the mitochondrial function is regular in type 2 diabetes, connected and disconnected respiration is slowed in type 2 diabetic individuals, resulting in decreased mitochondrial content. There is also an increased incidence of mitochondrial DNA abnormalities in skeletal muscle of Type-2 diabetic patients, with one deletion, in particular, 4,977 bp, being found to be considerably enhanced in Type-2 Diabetes Mellitus or impaired glucose tolerance muscle tissue. It is demonstrated that insulin-induced Mitochondrial ATP production is also compromised in Type-2 Diabetes. Peroxisome proliferator-activated receptor γ coactivator-1 (PGC-1)-responsive genes involved in oxidative phosphorylation are downregulated in human diabetes and their expression is high at sites where insulin-mediated glucose disposal is present. These sites are activated by PGC-1 and are found to be correlated with total-body aerobic capacity. Correlation between Glycatedhemoglobin and Maximal Oxygen Consumption (VO2max): The correlation between Glycatedhemoglobin and VO2max was studied as shown in the Tables and a statistically significant inverse correlation was found, with a correlation coefficient of -0.754 which was a much greater compared to the western population. This VO2max may decrease as the percentage of Glycatedhemoglobin increases i.e. more is the blood sugar level (uncontrolled diabetes) less may be the VO2max. these results were similar to previous studies which also reported a significant inverse correlation between glycated hemoglobin and VO2max. [7,8] Glucose transport stimulated by Insulin in skeletal muscle is down-regulated in the presence of hyperglycemia in patients with NIDDM. This increased glucose flux as a consequence of hyperglycemia may results in resistance to any further insulin-induced gain in GLUT4 (as occurred in nondiabetic subjects) at the plasma membrane level Reduced insulin-stimulated cellular glucose transport and type I muscle fiber percentage in skeletal muscle from morbidly obese control and morbidly obese NIDDM subjects hare related Factors leading to the development of the decreased glucose transport capacity mediated via insulin in skeletal muscle, are attributed to be included reduced blood flow and elevated free fatty acids. It was found that in the hexosamine biosynthetic pathway there was an increased outing in glucose which could be a contributing factor to the development of muscle insulin resistance in Type-2 diabetes. In middle-agediddleaged aged Type-2 Diabetics, despite fasting Hyperinsulinemia, have increased basal hepatic glucose output pairedlycemia induced insulin release and & increased resistance to Glucose disposal mediated by insulin actions. [9,10] Similar results were also observed by Meneilly GS. et al. in 1999 [11]. Thus poor glucose control (Hyperglycemia) may influence VO2max, i.e the Cardio-Respiratory fitness.

5. Conclusion

This study concludes that there was an inverse relationship between the maximum oxygen consumption and blood glucose levels among the type 2 DM patients. This was similar to the results from the western population. The high average blood glucose does influence the agility and perceived exertion rate, however, there was no significant influence of high glucose levels on the quality of life.

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