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Original Research Article

Study of heart rate recovery in diabetic women to predict the risk of cardiovascular disease

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ABSTRACT

Background: Diabetes mellitus is characterized by rise in the level of glucose concentration. Diabetes increases the risk of heart attack by four times in women and two times in men. An attenuated HRR immediately after exercise is considered an index to identify silent autonomic dysfunction. Individuals with low values for HRV and HRR present a higher risk of cardiovascular outcome.
Methods: 50 diabetic participants with a mean age of 54.52 and SD±8.63 years. All the participants were assessed for heart rate and blood pressure before the assessment and after the 3-minute YMCA step test. Post test heart rate was assessed immediately after 1, 2 and 3 minutes. Heart rate recovery was calculated by subtracting heart rate immediately after 3 minutes of test to heart rate after 1 minute.
Results: 50 diabetic women with the mean age of 38.96 and SD±9.36, the age ranged from 20 to 50. The resting heart rate mean was 98.08 and standard deviation was ±9.82. Mean and SD of heart rate immediately after 3 minutes was 142.66 and SD was ±8.05 and after 1 min was 130.86 and ±7.84 respectively. The heart rate recovery mean was 11.8 and SD was ±4.25.
Conclusions: Study concluded heart rate recovery is delayed in diabetic women and it is associated with increased risk of cardiovascular disease.

Keywords: Cardiovascular diseases, Diabetes, Diabetic women, HRR, Submaximal exercise test

INTRODUCTION

A metabolic condition known as diabetes mellitus is characterised by an increase in blood glucose levels. Type 2, which accounts for over 95% of identified cases, is the most prevalent. According to research, there will be 693 million people worldwide who have been diagnosed with diabetes by the year 2045.[1]

As insulin regulates blood sugar levels, diabetes is a chronic condition that develops when the pancreas does not create enough insulin or when the body cannot use the insulin that is produced. Diabetes causes hyperglycemia, an increase in blood sugar levels, which over time can harm numerous bodily systems, including the neurons and blood vessels.[2]

Most cases of diabetes are classified as type 1 (also known as insulin-dependent), which is defined by an inability to produce enough insulin and necessitates the daily dose of insulin. The signs and symptoms, which include polyuria, polydipsia, persistent hunger, loss of weight, abnormalities in vision, and weariness, might appear unexpectedly.[2] Type 2 diabetes, also known as non-insulin-dependent or adult-onset diabetes, is brought on by the body's ineffective use of insulin. Around 95% of diabetics have type 2, which is primarily brought on by being overweight and being inactive. The symptoms may

be identical to those of type 1 diabetes; however, they are frequently less obvious. As a result, the disease may only be discovered years after it first manifests, following complications. An increase in blood glucose levels above normal but below the threshold for a diabetes diagnosis is known as gestational diabetes. Throughout pregnancy, gestational diabetes can develop. During pregnancy and during delivery, the complication and risk could grow. These mothers and their offspring may be more susceptible to developing type 2 diabetes in the future. Typically, gestational diabetes is identified.[2]

Risk of stroke, loss of consciousness, intense thirst, vision problems, danger of heart disease, hypertension, exhaustion and lack of energy, excessive urine, damaged blood vessels, nerve damage, etc. are common symptoms that may appear because of diabetes. Many problems, including an increased risk of cardiovascular disease, renal, and ophthalmologic issues, can be brought on by diabetes.[3] The diabetes mellitus patients' most common cause of death is cardiovascular (CV) illness. As predictors of future coronary events that may result in death in this patient population, classic risk factors like hypertension, smoking, and cholesterol have been discovered. Non-traditional risk factors include microalbuminuria, left ventricular mass, and aberrant autonomic function.[4]

The increased incidence of sudden cardiac death (SCD) in people with diabetes mellitus (DM) is typically attributed in part to cardiac autonomic neuropathy (CAN). Anomalies in heart rate control and vascular dynamics CAN be brought on by injury to the autonomic nerve fibres that innervate the heart and blood vessels. The first indication of CAN is a decrease in heart rate variability.[1] Underdiagnosed in many cases, cardiovascular autonomic neuropathy is a type 2 diabetes consequence that increases the risk of significant cardiovascular events, silent myocardial ischemia, and subclinical left ventricular failure. Unrecognized subclinical type 2 diabetes may not be routinely screened, and clinical consequences (such as exercise intolerance, orthostatic hypotension, and resting tachycardia) usually only appear in more severe cases.[5] Epidemiology for diabetes includes the following pancreatic disorders-inflammation, neoplasia, cystic fibrosis, defects in insulin formation, destruction of beta cells, decreased insulin sensitivity, genetic defects, and autoimmunity. Environmental factors include the following sedentary lifestyle associated with type 2 diabetes mellitus. Patients with diabetes had higher resting heart rates and lower peak heart rates, heart rate reserve, chronotropic index, and heart rate recovery compared with those without diabetes. Diet-high saturated fats the diet is associated with a high risk of impaired GTT High fibre content in the diet reduces BSL, and insulin levels an increased intake of whole grain cereals, vegetables and fruits. Malnutrition (PEM) in infancy and childhood results in the failure of beta cell function. Alcohol-excessive intake of alcohol increases the risk of diabetes.

The prevalence of diabetes is 1598/100 000 among men and 1054/100 000 among women in India.[6]

Diabetes affects women and men almost at equal rates. However, the severity among women is more as compared with men with diabetes. Women with diabetes have a higher risk for heart disease. Diabetes increases the risk of heart attack by four times in women and two times in men. Lower survival rates and a poorer quality of life after a heart attack, a higher risk for blindness, higher risk for depression. Depression, which affects twice as many women as men, also raises the risk for diabetes in women. Complications developed in women with diabetes mellitus to include the following: higher risk of yeast and urinary tract infection, longer and heavier periods. Diabetes can make it harder to get pregnant, and high blood sugar can increase your risk for pre-eclampsia, delivery by caesarean section, stillbirth, or miscarriage.[7] The main effect of diabetes will be reduced heart rate recovery. Patients with diabetes had higher resting heart rates and lower peak heart rates, heart rate reserve, chronotropic index, and heart rate recovery compared with those without diabetes.[8]

Heart rate recovery is the difference between your heart rate pre- and post-workout and exercises. A heart rate recovery between 12 and 23 beats per minute is considered to be healthy. Attenuated heart rate recovery (HRR) after maximal exercise test is a predictor of mortality in healthy adults and those referred for diagnostic testing. Heart rate variability is a measure of sympathetic and parasympathetic influences on the heart, in the presence of autonomic dysfunction is reduced that is related to hyperglycemia. Heart rate variability reflects the overall balance between sympathetic and parasympathetic influences.[1]

Heart rate recovery (HRR) has emerged as a novel marker for mortality in predominantly nondiabetic populations and has been associated with the occurrence of CV events in other patient groups. An attenuated HRR immediately after exercise is considered an index of autonomic imbalance and may also identify clinically silent autonomic dysfunction. Autonomic dysfunction is a common complication in patients with T2DM that can be reversed with strict glycaemic control, it may be useful to identify those patients at risk as early as possible.[4] coronary artery disease is the foremost contributor to morbidity and mortality in type 2 diabetic patients, exercise stress testing referral is common, notwithstanding its indeterminate utility for routine investigation of asymptomatic patients. However, indications for an exercise test may extend to the derivation of additional prognostic or therapeutic information, including post-exercise heart-rate recovery. The poor prognosis associated with attenuated heart-rate recovery in exercise test referral populations and patients with type 2 diabetes may be attributed to reduced parasympathetic reactivation.[5]

Individuals with low values for HRV and HRR present a higher risk of some severe cardiovascular outcome, which seems to associate with a deficiency in response to physiological stress.[3] Thus, it seems important to evaluate these variables in populations with different clinical conditions and under stress. A study found that a slower decrease in heart rate after exercise increased the health problems like: heart disease, diabetes, chronic inflammation, heart attack, and Stroke.[9] Panzer et al reported that fasting plasma glucose is strongly associated with abnormal HRR, even in nondiabetic individuals. Similarly, data from Framingham heart study have shown reduced heart rate variability as well as sympathetic and parasympathetic imbalance in adults with diabetes and impaired fasting glucose. The predictive effect of low HRR on outcome might be associated with autonomic dysfunction.[10]

Physical fitness is characterized by the post-exercise heart rate (HR), considered to be an indicator of cardiorespiratory fitness. Individuals with high values of peak oxygen uptake (VO_2 max) are characterized by the ability to restore all pre-exercise reactions rapidly and a low HR during submaximal exercise. The importance of physical exercise as a non-pharmacological measure for the prevention of T2D has been increasingly acknowledged, and physical exercise may decrease the risk of T2D and its cardiovascular complications. Moderate aerobic physical training is related to numerous beneficial effects on glycaemic control and positive clinical outcomes in individuals with T2D, including a reduction in glycated haemoglobin (Hb1Ac), increased oxygen consumption (VO_2 peak), and an improvement in insulin sensitivity. However, in recent decades, studies revealed that high-intensity interval training (HIIT) has many benefits and might be a good time-efficient approach for exercise. However, HIIT might be performed in many different ways, with different combinations of effort and recovery, which might affect its acute and chronic responses.[3] The value of post-exercise HR obtained with the step test is considered to be an indicator of cardiorespiratory fitness.[8] One of the common step tests used is the three-minute step test (3MStepT) consisting of to step up and down on a platform for 3 minutes which is used to calculate the cardiovascular endurance in individuals. The YMCA 3-minute bench step test is based on how quickly your heart rate recovers following a short bout of exercise. The 3-minute YMCA step test is a good example of such a test. This test uses a 12-in (30.5 cm) bench, with a stepping rate of 24 steps/minute (estimated O_2 of 25.8 ml/kg/minute). After the step is completed, the subject immediately sits down, and HR is counted for 1 minute. Counting must start within 5 seconds at the end of the exercise.[11]

According to previous studies, regular exercise training may improve HRR in healthy individuals and patients with congestive heart failure or diabetes. Regular exercise also improves markers of glucose metabolism. We have previously described a strong, inverse association between cardiorespiratory fitness and 12-year mortality in a cohort of 1,263 men with documented type 2 diabetes.[10] The purpose of the current research was to evaluate whether slow HRR predicts cardiovascular disease (CVD) and all-cause mortality among diabetic women.

METHODS

The study was conducted among the diabetic women in Pravara Institute of Medical Sciences and Pravara Rural Hospital in Loni to find out the risk of developing cardiovascular disorders using the 3-minute YMCA step test.

The study received approval from Ethical Committee of Pravara Institute of Medical Sciences, Loni on 9th April,2022. Study period was from August 2022 to February 2023. The study conducted was an observational study.

For the study, sample size was 50. Participants were selected on the basis of inclusion and exclusion criteria. Study included patients with age group of 18-50 years of women and was diagnosed case since more than a year with type 1 or 2 diabetes. Samples with history of cardiovascular diseases or diagnosed case of hypertension or any other co morbidities were excluded. Participant was clearly explained about the study before the consent form was given. The written consent was taken regarding the study prior to the study. Also, confidentiality of information was explained and assured.

Each participant's baseline information was collected; heart rate was assessed prior to the exercise testing. Aim, objective and procedure of the study was briefed prior to the test. Exercise testing was performed following 3-minute YMCA step test. After stepping was completed heart rate recovery was noted post exercise.

The data was collected via Google sheet and was statistically analysed. The percentage of the result was obtained and conveyed through graphical presentation via graphs.

3-minute YMCA step test procedure

The metronome was set to 96 beats per minute. The patient was standing with face towards the step. Once the patient was ready to begin, stopwatch was start and the patient began stepping on and off the step to the metronome beat following a cadence up, up, down, down. Stepping was continued for 3 minutes and after 3 minutes the patient sat immediately. Heart rate was calculated post stepping immediately after 1 minute and reassessed after 3 minutes.

RESULTS

The present study conducted on "the study of heart rate recovery in diabetic women to predict the risk of

cardiovascular diseases" including 50 diabetic women with the mean age of 38.96 and SD ±9.36, the age ranged from 20 to 50. The mean and standard deviation values of heart rate at rest, immediate heart rate at the end of 3 minutes, after 1 minute and heart rate recovery was calculated using google sheets. The present study has taken place at Dr. APJ Abdul Kalam College of Physiotherapy including staff and members of Pravara Rural Medical Hospital and Pravara Institute of Medical Sciences. In this the average heart rate at rest was 97.48 of all the participants. Heart rate was calculated pre and post exercise testing.

Post exercise testing the heart rate was calculated immediately after the exercise test, 1 minute, 2 minutes and 3 minutes later.

Heart rate recovery of the patients were calculated by subtracting heart rate immediately after 3 minutes post-test and after 1 minute. The mean of resting heart rate was 98.08 and standard deviation was ±9.82. Mean and SD of heart rate immediately after 3 min was 142.66 and ±8.05 and after 1 minute was 130.86 and ±7.84 respectively. The heart rate recovery mean was 11.8 and SD was ±4.25.

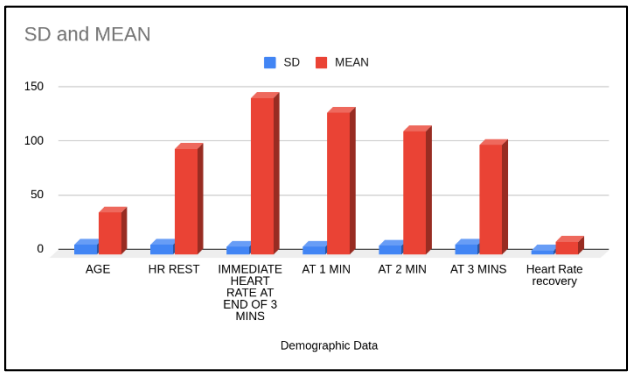

Figure 1: Demographic details of participants.

Age mean was 38.96 and SD±9.36, mean resting heart rate was 98.08 and SD ±9.82, mean and SD of heart rate immediately after 3 minutes was 142.66 and ±8.05, heart rate mean and SD± at 1 minute, 2 minutes, 3 minutes. Heart rate recovery mean was 11.8 and SD±4.25.

DISCUSSION

The present study was conducted at Dr. APJ Abdul Kalam College of Physiotherapy at Pravara Rural Hospital on 50 diabetic female staff workers aged 20-50. The result i.e., the mean of heart rate recovery was 11.8 and standard deviation was ±4.25.

Result of the study shows that heart rate recovery is delayed/reduced in female patients with diabetes predicting the risk of cardiovascular diseases. The present study demonstrates that HRR is associated with an increased risk of all-cause mortality in asymptomatic patients with T2DM. Additionally, an HRR was also associated with an increased risk for CV events in this population of T2DM patients. Thus, in addition to serving as an important prognostic marker of mortality, the attenuation of HRR may also identify individuals with T2DM at high risk for cardiovascular-related events and highlight those patients who are candidates for therapy directed at attenuated HRR. The potential mechanisms linking abnormal HRR and CV events are unclear.[9]

Attenuated HRR is considered to reflect abnormal control of autonomic function, suggesting reduced parasympathetic activity, increased sympathetic activity, or both after peak exercise. Low vagal tone and high sympathetic states have both been linked to excess mortality, particularly from sudden death, which is believed to be mediated through fatal arrhythmias. However, unlike the majority of markers for CV events in T2DM that focus on atherosclerotic disease and endothelial dysfunction as the basis of pathophysiology, attenuated HRR would seemingly identify those at risk for sudden death, although this relationship has not been rigorously evaluated. In this context, it is interesting to note that fasting plasma glucose, ratio of triglycerides to high-density lipoproteins, diabetes, endothelial dysfunction, and recently myocardial perfusion has all been associated with an attenuated HRR. Thus, it seems that factors associated with the progression of T2DM could provide a pathophysiologic rationale for the association of attenuated HRR with CV events in our study.[9]

As diabetic autonomic neuropathy is one of the least recognized and understood complications of diabetes mellitus (DM) due to its association with a variety of adverse sequela including fatal and nonfatal cardiovascular events and overall mortality. CAN is the most clinically important form of diabetic autonomic neuropathy. Early detection of subclinical autonomic dysfunction in diabetic patients is therefore of vital importance for risk stratification and subsequent management for prevention of serious adverse consequences.[1]

It is well recognized that the autonomic nervous system is essential in the maintenance of glycaemic homeostasis, in which parasympathetic fibers stimulate the β cells to release insulin in response to elevated glucose levels, and sympathetic activation inhibits insulin secretion. Dysfunction of the autonomic nervous system that is signified by attenuated HRR would then result in declined insulin secretion but raised glucose levels, leading subsequently to the development of diabetes mellitus and disorders such as CVD through multiple mechanisms including glucose toxicity, inflammation, and endothelial dysfunction. A recent cross-sectional study by Kuo et al noted that chronic inflammation and insulin resistance were inversely related to HRR, while both factors are believed to be hallmarks of CVD. Finally, since HRR may reflect parasympathetic nervous

system function, and given that increased parasympathetic tone has antiarrhythmic effects, it is conceivable that attenuated HRR would predict death because of the possibly increased risk of cardiac arrhythmias.[9] The exercise heart rate variables have potential clinical utility, not only with risk stratification, but also with directing us toward potentially improving survival interventions in patients with diabetes. Weight, gain, deconditioning, diabetes, and autonomic impairment are likely inextricably intertwined. Patients with diabetes had significantly higher BMI and lower FAC compared with those without diabetes.[2]

Although submaximal exercise testing is not as precise as maximal exercise testing, it provides a general reflection of an individual's physical fitness at a lower cost, potentially reduced risk for adverse events, and requires less time and effort on the part of the subject. Some of the assumptions inherent in submaximal tests are more easily met (e.g., steady state HR can be verified), whereas others (e.g., estimated HR max) introduce errors into the prediction of O_2 max. Despite this, when an individual is given repeated submaximal exercise tests over the course of an Ex-Rx, the HR response to a fixed work rate decrease. This indicates the individual's CRF has improved, independent of the accuracy of the O_2 max prediction. Despite differences in test accuracy and methodology, virtually all evaluations can establish a baseline and be used to track relative progress during exercise training.[12]

During exercise, there is an increase in heart rate due to increased sympathetic and reduced vagal (parasympathetic) activity. However, when the exercise bout is stopped, the rapid decrease in heart rate is predominantly accomplished by vagal reactivation, making HRR a marker of parasympathetic control of the heart. Therefore, a delay in HRR after exercise is an indicator of impaired autonomic nervous system functioning, specifically reduced parasympathetic activity.[13]

Results from the current study suggests that both slowed HRR and possibly very rapid HRR at 1 and 2 minutes should be considered when assessing risk of mortality and CV events in future studies. The usefulness of HRR may go beyond prognostic information, as recent work has focused on HRR as a modifiable risk factor. It has been demonstrated that exercise training can improve autonomic dysfunction and, thereby, HRR in this population.[9]

One limitation of our study is the small sample size, which may affect the generalizability of our results to larger populations. The study was conducted in a single geographic location which may limit the applicability of our findings to other populations. Another limitation is that our study only included healthy participants i.e. non hypertensive patients, which may limit the generalizability of our results to individuals with chronic diseases. Our study was limited to a single measurement of the outcome variable, which may not capture changes over time. The potential for measurement error in some of our variables, such as dietary intake or physical activity levels.

CONCLUSION

The present study concluded that heart rate recovery is delayed in diabetic women and it is associated with increased risk of cardiovascular disease. Hence delayed heart rate recovery can be taken as prognostic marker of mortality in diabetic women.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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