Evaluating Exercise Capacity and Heart Rate Recovery in Diabetic Type II Patients

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ABSTRACT

Introduction: Type 2 diabetes is a chronic disease with an increase in microvascular risks such as retinopathy and neuropathy. According to cardiac neuropathy in diabetic patients and the high prevalence of diabetes, the current study is designed to evaluate heart rate recovery and exercise capacity in diabetic versus healthy individuals. . **Methods**: This clinical study was performed on 228 patients. The age, sex, weight, BMI, educational level, duration of disease, history of other medical disease and smoking, TG, LDL, CHOL, HDL, FBS, SBP, and DBP were listed in the checklist and were evaluated later. The SPSS software was used to analyze data statistically using t-test, Mann-Whitney, and Chi-Square tests. P>0.05 was considered significant. **Results**: Mean Heart Rate Recovery, in the first mean, was 16.35 ± 10.56 in the study group and was 25.9 ± 13 in the control group (P=0.001). The mean heart rate during rest in the study group was 84.39 ± 13.5 and in the control group was 81.44 ± 14.27 beat/min (P=0.110). The mean Heart Rate Reserve in the study group was 48.43 ± 18.87 and in the control group was 57.8 ± 24.17 (P=0.001). Negative Chronotropic Incompetence was seen in 10 patients and 19 healthy individuals (P=0.048). **Conclusion**: According to our results and previous studies, heart rate recovery in diabetic patients is significantly less than in healthy individuals. The risk of cardiovascular disease in these patients is higher versus healthy individuals, and according to this fact, they need periodic visits.

Keywords: Exercise Test, Diabetes Mellitus, Heart Rate, Recovery of Function

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INTRODUCTION

Diabetes mellitus represents a group of syn¬dromes, typified by hyperglycemia, resulting from impairment of insulin secretion, defects in insulin action, or both (1). Type 2 diabetes is also called type 2 diabetes mellitus and adult-onset diabetes. That's because it used to start almost always in middle- and late-adulthood. However, more and more children and teens are developing this condition (2). The International Diabetic Federation reported that 366 million people were affected by diabetes in 2011 and estimated that by 2030 this number would rise up to 552 million (3). Due to its high prevalence and secondary effects, diabetes is one of the most lethal diseases and responsible for almost three million deaths per year worldwide, as reported by the World Health Organization (4). Patients with diabetes also have a higher risk of myocardial infarction and cardiovascular complications as well. Cardiac damages are one of the important and irreversible difficulties which have been caused by diabetes (5).

An exercise stress test (EST) is a cardinal assessment tool used to determine the ability of the heart to reply to stress. Heart rate recovery (HRR) and exercise capacity are two important indicators that could be calculated with EST and metabolic equivalents (6-8). HRR is defined as returning of the heart rate after the exercise stress test that is quantitated by the specific formula. Abnormal HRR descriptions have differed in similar trials from ≤12 to ≤18 beats per minute at one minute (9-11). The autonomic nervous system, which disturbs in chronic diabetes, regulates HRR after the exercise stress test (10-12). Abnormal HRR is associated with an increase in mortality and is a prognostic factor in patients with cardiovascular disease (6). Exercise capacity is the maximum of physical activity which a person can tolerate. A precise evaluation of exercise capacity requires that maximal exertion is adequately sustained to have a regular influence on the circulation (13). Exercise performance

reveals a synchronized response of cardiovascular, pulmonary, and neural function accompanied by exercising muscles activity (13). Patients with heart failure have a decreased exercise capacity because they cannot carry oxygen to skeletal muscle and other organs. Their damaged exercise capacity is intensely related to prognosis (14). The relationship between diabetic complications, exercise capacity, and heart rate recovery in diabetic patients has not been well delineated. The present study aims to evaluate this relationship.

MATERIAL AND METHODS

The current case-control study was conducted in 2021. In this study, 229 individuals entered, and finally, 228 individuals were analyzed. Informed consent was obtained from the participants (diabetic patients group and non-diabetic control group) for the EST and HRR detection in the scientific record. All the participants performed the exercise capacity test, and the information including name, age, gender, height, weight, body mass index (BMI (, education level, duration of diabetes, history of other medical illnesses, smoking, triglyceride (TG), high-density lipoprotein (HDL (, low-density lipoprotein (LDL (, systolic blood pressure (SPB (, diastole blood pressure (DPB (, fasting blood sugar (FBS (were recorded in the checklist for each participant. The demographic characteristics and individual risk factors were analyzed as well.

Inclusion and exclusion criteria

Diabetic patients, who accepted the informed consent, participated in the study as a diabetic patients' group and were referred to Shariati hospital of Isfahan for the exercise stress test. While the non-diabetic patients administrated to the Shariati hospital of Isfahan for the exercise stress test were considered as a parallel control group. Age and gender were considered when dividing the patients into two groups of study. The patients who have the unwillingness to participate in our research project, unable to perform the exercise stress test, patients with limited exercise stress test performance like acute myocardial infarction in the past two days, chronic renal failure, complete heart block, acute pulmonary thromboembolism, uncontrolled hypertension, acute myocarditis, severe aortic stenosis, decompensated heart failure, and pregnancy were excluded from the study.

Statistical analysis

Data were analyzed statistically using the statistical package for social science software (SPSS version 18) by multiple t-tests, Cochran's, Mann-Whitney, and chi-square tests. P-value <0.05 was considered significant.

RESULTS

Of 229 individuals, 51 males (44.3%) and 64 females (55.7%) were in the study group, while 61 males (53.5%) and 53 females (46.5%) participated in the control group. No significant difference was observed between the two groups (P=0.166).

The average age in the study group was 56.87 ± 7.84 years old, and their age range was between 41 to 79 years old. While the mean age was 54.81 ± 10.64 years old in the control group, and their age range was between 25 to 76 years old. No significant difference was observed between the two groups (P=0.096).

The mean BMI in the study group was 27.99 ± 3.69 kg/m2, and their BMI ranges were between 16.3 to 40.4 kg/m2. The mean BMI was 25.66 ± 2.32 kg/m2 in the control group, and their BMI ranges were between 19.81 to 32.03 kg/m2. A significant difference was observed between the two groups (P=0.001).

There were 63 individuals (54.8%) housewives, 31 individuals (27%) retired, 18 individuals (15.7%) self-employment, 3 individuals (2.6%) employee in the study group. The control group included in 53 individuals (46.5%) housewife, 22 individuals (19.3%) retired, 32 individuals (28.1%) self-employment, 4 individuals (3.5%) employees and 3 individuals (2.6%) worker. 14 individuals (12.3%) of the study group and 27 individuals of the control group were smokers. A significant difference was observed between the two groups (P=0.023). All of the Smoker patients in the study group were male. However, in the control group, one of them was female. Smoking in the control group of men was significantly more than in the study group (P=0.043). After controlling gender variables, smoking in the control group was seen more than in the study group. A significant difference was observed between the two groups (P=0.032).

The results of the participants' underlying disease are shown in Table 1. Also, the data obtained from the study of the exercise stress tests in the two groups are presented in Table 2.

Table 3 and Table 4 show the comparison of the duke treadmill scores (DTS) and functional classes of case and control groups (P=0.976).

Table 1. Underlying disease

Groups	Case group	Control group	P-Value
History of chronic kidney disease	(15.7%)18	0	0.001
History of hypertension	(67%)77	(38.6)44	0.001
Family history of diabetes	(72.3%)81	(10.6%)12	0.001
Family history of heart disease	(60.7%)68	(50.9%)57	0.139
History of hypertriglyceridemia	(93%)107	(28.3%)32	0.001

Distribution of Cholesterol, TG, FBS, HbA1c, LDL, HDL

The mean of cholesterol has been 157.01 ± 33.51 mg/dl in the study group and 187.65 ± 44.92 mg/dl in the control group. A significant difference was observed between the two groups (P=0.001). The mean of TG has been 155.16 ± 87.4 mg/dl in the study group and 125.26 ± 50.31 mg/dl in the control group. A significant difference was observed between the two groups (P=0.002). The mean of FBS has been 149.52 ± 38.36 mg/dl in the study group and 91.21 ± 8.13 mg/dl in the control group. A significant difference was observed between the two groups (P=0.001). The mean of HbA1c has been 7.53 ± 1.48 mmol/mol in the study group, and only one patient had done it in the control group, which was 5.4 mmol/mol. No significant difference was observed between the two groups (P=0.156). The mean of LDL has been 89.09 ± 25.07 mg/dl in the study group and 117.74 ± 38.27 mg/dl in the control group. A significant difference was observed between the two groups (P=0.001). The mean of HDL has been 41.89 ± 7.9 mg/dl in the study group and 43.10 ± 6.38 mg/dl in the control group. No significant difference was observed between the two groups (P=0.204).

DISCUSSION

This study was investigated to evaluate EST and HRR in diabetic type II patients performed at Shariati hospital of Isfahan.

Table 2. Exercise Stress Test Findings

	Case group	Control group	P-value
The average of resting heart rate	13.5 ± 84.39	14.27 ± 81.44	0.110
The average of resting systolic blood pressure	13.29 ± 128	13.99 ± 124.33	0.043
The average of resting diastolic blood pressure	7.12 ± 81.08	7.63 ± 79.2	0.055
The average of heart rate in the End of stage 1	16.68 ± 119.48	18.52 ± 116.77	0.245
The average of heart rate in the End of stage 2	18.06 ± 134.01	19.64 ± 132.81	0.606
The average of heart rate in the End of stage 3	17.68 ± 145.51	17.23 ± 145.9	0.882
The average of heart rate in the End of stage 4	10.64 ± 150.83	16.5 ± 152.64	0.741
The average of heart rate in the End of stage 1 recovery	19.02 ± 131.5	20.23 ± 125.37	0.019
The average of heart rate in the End of stage 2 recovery	17.13 ± 111.92	19.12 ± 108.07	0.112
The average of heart rate in the End of stage 3 recovery	16.01 ± 105.04	17.82 ± 102.45	0.251
The average of heart rate in the End of stage 4 recovery	15.49 ± 101.42	15.31 ± 98.11	0.242
The average of heart rate in the End of stage 5 recovery	13.53 ± 96.84	15.15 ± 94.36	0.545
The average of maximum heart rate	16.01 ± 148.19	151.21±17.84	0.179
The average of maximum systolic blood pressure	17.09 ± 161	19.42 ± 157.56	0.158
The average of maximum diastolic blood pressure	8.18 ± 93.73	8.72 ± 92.10	0.145
The average of first minute heart rate recovery	10.56 ± 16.35	13 ± 25.90	0.001
The average of second minute heart rate recovery	12.08 ± 35.77	11.63 ± 43.28	0.001
The average of third minute heart rate recovery	12.48 ± 42.64	12.01 ± 48.7	0.001
The average of fourth minute heart rate recovery	12.19 ± 46	9.9 ± 51.08	0.010
The average of fifth minute heart rate recovery	13.98 ± 48.15	8.54 ± 53.04	0.147
The average heart rate recovery	18.8 ± 48.43	24.17 ± 57.8	0.001
Negative Chronotropic Incompetence	(8.8%)10	(17.8%)19	0.048
The average of METS	1.71 ± 9.24	1.95 ± 9.89	0.009

We found that the end of the first-minute heart rate in the study group is significantly lower than the control group. In Karjalainen's study (15), which was published in 2012, the patients with coronary heart disease were divided into two groups: diabetes patients (50 individuals) and non-diabetes patients (55 individuals), and they were evaluated in heart rate recovery. It has been reported that the HRR was significantly lower in the diabetic group at the first minute than in the non-diabetic group (p=0.005). In a cohort study conducted by Cheng et al. (16), 2333 men who have diabetes were evaluated, and it was reported that HRR was significantly reduced in diabetic patients who continued until the fifth minute. The results of Karjalainen's study and Cheng's study are consistent with our study.

In a study conducted by Shafiei et al. (17) in 2011 that was carried out on 216 patients with metabolic syndrome and 254 patients without metabolic syndrome, the first-minute heart rate in unaffected individuals was more than patients with metabolic syndrome (P=0.007). But, the first-minute heart rate was normal in both groups (higher than 18 beats per minute). Exercise capacity level in patients with metabolic syndrome was less than the control group (P=0.022). In addition, it has been reported that there were 20 individuals with diabetes among patients with metabolic syndrome. In a published study conducted by Checko et al. (18) in 2008, the HRR of 890 diabetic patients was evaluated. The HRR was 23 in the first minute, 37 in the second minute, and 42 in the third minute. In our study, the HRR in the case group was 16 at the first minute, 35 in the second minute, and 42 in the third minute. The results of Checko's study are consistent with the present study. In a study by Panagiotis et al. (19) that was investigated on 206 diabetes patients, it was reported that 60 patients had impaired HRR. The diabetic patients with impaired HRR were at higher risk of cardiovascular disease. In this study, it was also reported that there is a significant relationship between HRR and chronotropic variables. In the published study conducted by Turker et al. (20) in 2013 that was carried out on the 35 patients with type 1 diabetes, the HRR was significantly lower in diabetic patients compared to the control group. The results of Turker's study are in agreement with the present study.

CONCLUSION

In conclusion, our findings showed that the heart rate recovery in diabetes patients is significantly lower than in the non-diabetic group. So that the risk of cardiovascular disease and diabetes-related complications are higher in diabetic patients compared to the non-diabetic people that require periodic monitoring of diabetic patients. It is suggested that the prospective studies be followed up in the future in the larger population and the complications such as cardiovascular disease be evaluated

Table 3. Duke Treadmill Score

	Case group	Control group
Low risk	(82.5%)94	(82.5%)94
Medium risk	(17.5%)20	(16.7%)19
High risk	0	(0.9%)1
P=0.976		

Table 4. Functional class

	Case group	Control group
Functional class I	(94.7%)107	(96.3%)94
Functional class II	(4.4%)5	(2.8%)20
Functional class III	(0.9%)1	(0.9%)1
P=0.976		

as well.

ETHICAL CONSIDERATION

This study was registered at Research Committee of Islamic Azad University, Najafabad branch of Medical Sciences, Isfahan, Iran. A written informed consent was taken from patients for participating in this study. All the personal information remained anonymous.

CONFLICT OF INTRESETS

There are no conflicts of interest in terms of the present manuscript.

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