Indian Heart Journal xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Original Article

Moderate intensity exercise improves heart rate variability in obese adults with type 2 diabetes

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ARTICLE INFO

Article history:
Received 31 December 2016
Accepted 3 October 2017
Available online xxx

Keywords:
Heart rate variability
Type 2 diabetes
Obesity
Aerobic exercise

ABSTRACT

Aim: The aim of this study was to determine the effect of moderate aerobic exercise on heart rate variability (HRV) in obese adults with type 2 diabetes.
Methods: 41obese adults with type 2 diabetes participated in this study. Anthropometric and metabolic parame¬ters were measured, and resting electrocardiogram (ECG) for the HRV analysis at spontaneous respiration was recorded for 5 min in supine position before and after six months of supervised aerobic training given thrice-a-week.
Results: The mean age, body mass index (BMI), and duration of diabetes of the study population were 44.1 ± 4.5 years, 30.94 ± 1.36 kg/m2, and 16.3 ± 2.7 years, respectively. In time domain variables, standard deviation of all RR intervals (SDNN), the square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD) and percentage of consecutive RR intervals that differ by more than 50 ms (pNN50) were significantly increased after exercise. In frequency domain variables, high frequency (HF) (ms2) and HF (nu) were significantly increased while low frequency (LF) (ms2) and LF/HF ratio were significantly decreased after exercise. But LF (nu) was unaffected after exercise.
Conclusion: This study suggests that thrice-a-week moderate intensity aerobic exercise for six months improves cardiac rhythm regulation as measured by HRV in obese adults with type 2 diabetes

1. Introduction

Several populations based studies show that regular physical activity is an important component of a healthy lifestyle and lack of activity is a predictor of cardiovascular mortality.[1,21,2] Physical inactivity is closely related to cardiovascular disease and a widening variety of other chronic diseases, including type 2 diabetes, obesity and hypertension.[3] Many studies have suggested beneficial effects of regular exercise in preventing sudden cardiac death in healthy individuals and in patients with cardiovascular diseases.[4,5]

It is commonly perceived that a regular heart beat with sinus arrhythmia is a sign of healthy heart. Thus, the rhythm of a healthy heart is characterized by significant beat to beat variability.[6] This heart rate variability (HRV) has been recognized as a powerful tool in the investigation of autonomic modulation of heart. Patients with type 2 diabetes exhibit altered autonomic modulation of heart as assessed by HRV.[7] Decreased HRV among patients with diabetes has been found to be predictive of cardiovascular morbidity and mortality.[8,9] Obesity, a key risk factor for the development of type 2 diabetes, is associated with dysregulation of autonomic nervous function.[10] It has been proposed that autonomic dysregulation is an important mediator in the development of obesity-associated diseases and insulin resistance although the nature of the link between adiposity and insulin sensitivity is still unclear.[11,12]

Exercise therapy has been shown to improve autonomic nervous system modulation of HRV in healthy individuals.[13–15] Therefore, exercise training may improve cardiac autonomic regulation in a variety of clinical populations including obese adults with type 2 diabetes. Thus, the main aim of this study was to determine the effect of thrice-a-week, six months, moderate aerobic exercise on cardiac autonomic function as measured by HRV in obese adults with type 2 diabetes.

2. Materials and methods

2.1. Subjects

Forty-one obese male adults with type 2 diabetes volunteered to participate in a supervised thrice-a-week aerobic training of

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https://doi.org/10.1016/j.ihj.2017.10.003

moderate intensity for six months. The exclusion criteria were overt cardiovascular disease, diabetic complications (e.g. nephropathy, retinopathy), chronic heart failure, hypertension, arrhythmias, known neuropathy of any other etiology, comorbid conditions (e.g. cancer, immunodeficiency, autoimmune diseases) and current smoking. The subjects with Ewing Score ≥3 and vibration perception threshold ≥6 V were also excluded from the study. The ethical clearance was obtained from the Ethics Committee of the College. Informed consent was obtained from all participants before commencement.

2.2. Clinical examination

In the personal interview with the subjects, detailed history was obtained with special reference to age, duration, symptoms of neuropathy, diabetes related complications and medication. All the participants were subjected to clinical examination.

Each participant underwent the measurement of his weight and height recorded while wearing light indoor clothes but no shoes. Body mass index (BMI) was calculated as weight in kilograms/height in meters squared as a measure of overall adiposity whereas waist circumference (midway between the lower rib margin and the top of the iliac crest) was considered a measure of central or abdominal adiposity.[16] Blood pressure was measured using standard protocol. In addition, they underwent a detailed neurological examination. Non-invasive Ewing battery tests: Valsalva maneuver, Heart rate response to standing, Heart rate response to deep breathing, Blood pressure response to standing, Blood pressure response to sustained handgrip were also performed for cardiac stress before undergoing an exercise program. Ewing scores were assigned as follows: 0 for a normal test, 0.5 for a borderline, and 1 for an abnormal value.[17] Peripheral somatic neuropathy was assessed by a biothesiometer (Genesis Medical System, India), measuring vibration perception threshold at toe, first metatarsal, third metatarsal, fifth metatarsal, instep, and heel surfaces of each foot.[18]

On the days before testing, all the participants were medication free and stable in terms of cardiopulmonary function. Possible diurnal variation was minimized by carrying out all tests in the same sequence between 09:00 and 11:00 A.M.

2.3. Training program

The participants were enrolled in a six-month program of aerobic exercise. Under the supervision by trained personnel, they performed thrice-a-week sessions of physical activity. In order to produce the desired metabolic effects, each exercise session lasted 50 min; 10 min of warm-up, 30 min of activity (brisk walking, light running), and 10 min of cool-down. Considering the linear relationship between heart rate and%VO_2 reserve, exercise intensity was set between 50% to 70% of maximum heart rate, which was calculated by the following formula: [(220 − age − resting heart rate) × % of maximum heart rate + resting heart rate].[19]

2.4. HRV measurement

The ECG signals for HRV were recorded using ECG machine (Maestros Magic R Series, India) after a supine rest of 15 min. The resting ECG at spontaneous respiration was recorded for five min in supine position at chart speed 100 mm/s. From ECG, R-R intervals were measured manually with a ruler. Then these R-R intervals were saved as ASCII file. This format was readable by software 'HRV analysis software 2.1'. This HRV analysis software which calculates the time domain results, frequency domain results, and nonlinear results was developed by Department of Applied Physics, University of Eastern Finland, Kuopio, Finland.

The time domain analysis of HRV consisted of the standard deviation of all RR intervals (SDNN); the square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD); and pNN50, which is the proportion of the total RR intervals that have differences of RR intervals greater than 50 milliseconds.[20]

The frequency-domain analysis of HRV consisted of power of high frequency (HF), (0.15–0.40 Hz); low frequency (LF), (0.04–0.15 Hz); and very low frequency (VLF), (below 0.04 Hz) power ranges.[20]

It has been speculated that analysis of HRV based on the methods of nonlinear dynamics might elicit valuable information for the physiological interpretation of HRV. One nonlinear method is Poincare plot. The Poincare plot is a scatterplot of the current R-R interval plotted against the preceding R-R interval. Using the method described by Brennan,[21] these plots were used to extract indexes, such as length (SD2) and width (SD1) of the long and short axes of Poincare plot images.

2.5. Biochemical measurements

Venous blood was drawn in the morning after an overnight fast immediately before (baseline) and at the end of the training program (after six months). Plasma glucose was measured by standard laboratory procedures (BS-380; Diagnova Enzokit, RFCL, India). Total cholesterol and triglycerides concentration were determined with fully enzymatic analyzer (BS-380; Diagnova Enzokit, RFCL, India). Similarly, serum HDL-cholesterol level was estimated by phosphotungstate precipitation method and serum LDL-cholesterol was calculated by the Friedewald equation. HbA_{1c} was measured by ion exchange affinity chromatography (Kamineni life sciences, Hyderabad, India).

2.6. Statistical analysis

Different anthropometric, cardiorespiratory and biochemical variables were compared before and after exercise using paired samples *t*-test and data are presented as mean ± standard deviation. However, non-parametric Wilcoxon signed-rank test was applied for comparisons of the HRV variables and the results are presented as median (interquartile range). The Pearson correlation coefficient was used to assess correlation between the HRV measures and the obesity indices (BMI and waist circumference) as well as between the obesity indices and the biochemical characteristics. A p value of <0.05 was considered statistically significant. Data were analyzed with statistical software IBM SPSS Statistics 21.

3. Results

3.1. Subject characteristics

The clinical characteristics of participants are shown in Table 1. All these variables were significantly decreased after exercise.

Table 2 shows biochemical characteristics of participants. All these variables were significantly decreased after exercise, except high-density lipoproteins which was significantly increased after exercise.

3.2. Heart rate variability measures

In the time domain variables, SDNN, RMSSD and pNN50 were significantly increased after exercise. The variables analyzed in frequency domain measures included power of LF and HF in ms^2