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Original Research Article

ASSESSMENT OF CARDIAC AUTONOMIC FUNCTION AND EXERCISE CAPACITY IN ADULTS: A CROSS-SECTIONAL STUDY

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Abstract

Background: Cardiovascular disease (CVD) is a major cause of sudden death worldwide, with a high prevalence in developing countries. Dysregulation of the autonomic nervous system (ANS) contributes to adverse cardiovascular effects, including heart rate recovery (HRR) and heart rate variability (HRV), which are key non-invasive predictors of cardiovascular health. This study assessed cardiac autonomic function, including resting heart rate (RHR), chronotropic competence, metabolic equivalent (MET) values, and exercise duration, among adults. **Materials and Methods:** This cross-sectional study included 178 participants aged 20–70 years, recruited from the Department of Cardiology, Chennai Medical College and Hospital Research Centre, Trichy, between December 2015 and 2016. Participants underwent a treadmill exercise test following the Bruce protocol, and the RHR, HRR, exercise duration, and MET values were recorded. **Result:** Mean RHR was 82.56 bpm. Peak exercise heart rate averaged 153.69 bpm, which decreased to 124.68 bpm at 1 minute and 108.41 bpm at 3 minutes' post-exercise. HRR was 29.98 bpm after 1 minute and 50.63 bpm after 3 min. The average exercise duration was 7.99 minutes, with a MET value of 9.49, and the chronotropic competence averaged 147.56 bpm. **Conclusion:** Cardiac autonomic function assessment revealed significant differences in RHR, HRR, and exercise performance, emphasizing the role of physiological and fitness factors in cardiovascular health.

INTRODUCTION

Cardiovascular disease (CVD) is the most common cause of sudden death worldwide. Compared to developed countries, the incidence of CVD is almost double in developing countries such as India. Younger generations are disproportionately affected in these regions, with nearly 52% of CVD-related deaths occurring before the age of 70, and rural areas are equally impacted. A survey conducted in 45 rural villages found that 32% of all deaths were due to CVD.[1]

The autonomic nervous system (ANS) plays a crucial role in regulating and integrating the functions of internal organs.[2] Dysregulation of ANS activity can lead to adverse cardiovascular effects.[3] Key parameters reflecting ANS interactions include resting heart rate (HR), peak exercise HR, heart rate recovery (HRR), and heart rate variability (HRV).[4] HRR, defined as the reduction in HR within the first minute after cessation of exercise, reflects parasympathetic reactivation and serves as a strong predictor of cardiovascular health and sudden death risk. Chronotropic incompetence, the inability of the heart to appropriately increase its rate during physical activity, is another significant marker of impaired autonomic function.[5] HRV and HRR are non-invasive markers commonly used to evaluate ANS activity. Additionally, the metabolic equivalent of task (MET), a unit that quantifies the energy cost of physical activities, is widely used in exercise physiology to assess cardiovascular fitness and exercise intensity.[5]

Heart rate recovery was calculated by reduction in heart rate from peak exercise to one minute after cessation of exercise ($HRR=HR_{Peak} - HR_{1mt}$). HRR of <18 beats per minute in the first minute after exercise and 22 beats per minute in the second minute after exercise was considered to be abnormal. The peak exercise capacity during the exercise stress test was estimated from treadmill time and expressed in metabolic equivalents (METs). One MET equal to 3.5 ml of O2 uptake per kg body weight /minute. The normal MET value in male is 9.8 and in female the

MET value is 7.4. The abnormal MET value was considered as less than 7.9 in male & 6 in female. Decreasing MET value predicts cardiovascular mortality.[5]

The exercise stress test is a non-invasive method for assessing autonomic function and evaluating the relationship between the ANS and adverse cardiovascular effects.[5] Resting HR is primarily determined by vagal tone, while an increase in HR above 100 beats per minute during exercise is mediated by sympathetic activation.[6] The initial increase in HR during exercise results from parasympathetic withdrawal and sympathetic stimulation, whereas the decrease in HR after exercise is caused by parasympathetic reactivation. HRR, the heart's ability to decelerate following exercise, serves as a marker of chronotropic competence.[7] Normal HRR values range between 18 and 22 beats per minute, and impaired HRR is associated with a higher CVD mortality risk in healthy adults.[5]

Furthermore, HRR is directly linked to cardiovascular fitness indices such as resting HR, blood pressure, cardiac output, maximal oxygen uptake, and endurance capacity.[8] By integrating these measures, HRR and other ANS-related markers provide valuable insights into cardiovascular health and risk assessment.

Aim

This study aimed to assess cardiac autonomic function, including resting heart rate, chronotropic competence, metabolic equivalent (MET) values, and exercise duration, in adults.

MATERIALS AND METHODS

This cross-sectional study included 178 patients of both sexes aged > 18 years in the Department of Cardiology at the Chennai Medical College and Hospital Research Centre, Trichy, between December 2015 and 2016. This study was approved by the Institutional Ethics Committee before initiation, and informed consent was obtained from all patients.

Inclusion criteria

Healthy patients aged 20-70 years of age were included in this study.

Exclusion criteria

Patients with a history of alcohol consumption, smoking, hypertension, diabetes mellitus, pregnant and lactating mothers, and psychiatric disorders were excluded.

Methods

All patients were instructed to avoid heavy meals and caffeinated drinks for at least 3 hours before the test. After collecting demographic details about the patients, a brief instruction on the test procedure was provided by the guidelines outlined in the American College of Sports Medicine's Guidelines for Exercise Testing and Prescription.[9]

Before Exercise

The patients rested in the supine position with their eyes closed for 5 minutes, after which their resting heart rates were recorded. Heart rate was measured by counting the radial pulse for one minute, and values ≥ 100 beats/min were considered abnormal. The maximum predicted heart rate was calculated as 220 minus ages. The resting blood pressure was measured three times using a mercury sphygmomanometer, and the average of the readings was recorded according to the standard and modified Bruce protocols.[7]

During Exercise

A treadmill exercise test was performed according to the Bruce protocol in the WISPER MILL 594 XL. Individuals were encouraged to perform the exercise until they experienced limiting symptoms, even if 85% of the maximum predicted heart rate was achieved. Heart rate, exercise duration, and metabolic equivalent levels were recorded during the peak exercise. The exercise was terminated when the patients experienced chest pain, syncope, dyspnoea, fatigue, changes in ECG, failure to increase systolic blood pressure by more than 10 mmHg, or a fall of blood pressure below the resting level.[10]

After Exercise

After cessation of the exercise, the patients were asked to lie on a couch. Heart rate was recorded within one minute and three minutes of post-exercise. Resting heart rate, heart rate recovery at 1 and 3 min, exercise capacity, and duration of exercise were calculated. The patients were monitored for 6-8 minutes until the heart rate and symptoms returned to the pre-exercise level because ECG changes that did not occur during the exercise might have occurred during the recovery period.[11] Data are presented as mean and standard deviation.

RESULTS

This study included 178 patients, with an average age of the patients is 46.39 years, and a standard deviation of 10.01 years, indicating that most patients fell within the age range of approximately 36 to 56 years. The average height is 163.23 cm, with a standard deviation of 9.25 cm, suggesting that the majority of patients have heights between 154 and 172 cm. Similarly, the average weight is 71.48 kg, with a standard deviation of 9.90 kg, indicating most patients weigh between about 62 and 81 kg [Table 1]. The resting heart rate measurements, with a mean value of 82.56 bpm and a standard deviation (SD) of 17.12, reflected the average resting heart rate of the patients [Table 1].

The mean heart rate of the patients at peak exercise (153.69 ± 20.59) was higher than that at 3 minutes (108.41 ± 19.24) post-exercise [Table 2].

The mean HRR after 3 minutes (29.98 ± 13.14) of exercise was higher than that after 1 min (50.63 ± 14.65) post-exercise [Table 3].

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The mean duration of exercise was 7.99 minutes, with a standard deviation of 2.25 minutes, indicating the average time spent exercising with variability in exercise duration among adults. The mean MET value was 9.49, with a standard deviation of 4.36. The mean chronotropic competence score was 147.56, with a standard deviation of 8.51 beats per minute (bpm) [Table 4]. The failure to achieve an 85% age-predicted HR during exercise is chronotropic incompetence.

Table 1: Patient demographic details.

	Mean ± SD
Age (Years)	46.39 ± 10.01
Height (cm)	163.23 ± 9.25
Weight (Kg)	71.48 ± 9.90
Resting Heart Rate	82.56 ± 17.12

Table 2: Heart rate measurements with exercise duration.

Heart Rate (HR)	Mean ± SD
Peak exercise	153.69 ± 20.59
1 minute after exercise	124.68 ± 22.51
3 minutes after exercise	108.41 ± 19.24

Table 3: Heart rate recovery measurements.

Heart Rate Recovery (HRR)	Mean ± SD
HRR after 1 minute	29.98 ± 13.14
HRR after 3 minutes	50.63 ± 14.65

Table 4: Measurement of exercise performance indicators

Indicators of exercise performance	Mean ± SD
Duration of exercise (minutes)	7.99 ± 2.25
MET	9.49 ± 4.36
Chronotropic competence	147.56 ± 8.51

DISCUSSION

Resting HR reflects the balance between the sympathetic and parasympathetic influences of the SA node. A higher HR indicates reduced parasympathetic influence or sympathetic overactivity.[1] In our study, resting HR was normal irrespective of age and sex. Conversely, Ogluwarde et al. stated that increased resting HR is a predictor of cardiovascular disease mortality in subjects with and without diagnosed cardiovascular disease.[1] The absence of differences in resting heart rate confirms the comparability of study participants and the minimal influence of confounding factors.

Peak heart rate refers to the maximal heart rate achieved at the termination of the graded maximal exercise test.[14] The maximal Heart rate achieved at a given age is commonly assessed by the formula "220 – age". Zavorsky et al. found that the maximum heart rate achieved in physically active subjects is slightly lower than that of their inactive counterparts.[12] The heart rate recovery after exercise is due to rapid central vagal reactivation. In a study by Nishime et al. patients with an abnormal HRR had an 8% mortality at 5.2 years and patients with a normal HRR had a mortality of 2% at 5.2 years.[13] Both increased resting HR and delayed HRR have been proven as a powerful predictor of all-cause mortality and cardiovascular mortality in many previous studies. This may be a reflection of the autonomic tone**.** Lauer et al. studied the HR response to exercise stress testing in healthy subjects and suggested that chronotropic incompetence predicts cardiovascular mortality.[5]

Framingham risk score proposed that there is a decrease in mortality risk by 17% for every 1 MET increase.[6] In a study conducted by Bourque et al. they found that more than 10 METs achieved during exercise stress test was associated with a lower prevalence of ischemia.[9]

CONCLUSION

Our findings revealed that peak exercise heart rate, HRR, and exercise capacity are significant predictors of cardiovascular health, with higher RHR and lower exercise capacity. This study underscores the critical role of fitness level in improving autonomic function and overall cardiovascular health. Future research should consider hormonal influences and fitness status to better understand these differences and refine strategies for early detection and management of cardiovascular risks. Regular exercise and lifestyle modifications should be promoted as preventive measures to enhance autonomic function and reduce CVD mortality.

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