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Original Research Article

Study of Heart Rate Recovery Post Exercise in Individuals with Different Cardiorespiratory Fitness Levels

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Abstract:

Background: Heart rate recovery (HRR) after exercise is a simple, non-invasive marker of autonomic nervous system function and cardiovascular health. Delayed HRR reflects impaired parasympathetic reactivation and is associated with increased cardiovascular morbidity and mortality. Cardiorespiratory fitness (CRF) plays a crucial role in autonomic regulation; however, the relationship between HRR and varying levels of CRF requires further evaluation.

Objective: To study heart rate recovery following exercise in individuals with different levels of cardiorespiratory fitness.

Methods: This cross-sectional study included 38 healthy participants aged 18 to 60 years. Subjects were categorized into low, moderate, and high cardiorespiratory fitness groups based on maximal oxygen uptake (VO_2 max) estimated using a standardized treadmill/cycle ergometer test (e.g., Bruce protocol). Heart rate was recorded at peak exercise and at 1 minute and 2 minutes post-exercise. HRR was calculated as the difference between peak heart rate and heart rate at 1 minute (HRR1) and 2 minutes (HRR2) during recovery. Statistical analysis was performed to compare HRR among groups.

Results: Individuals with higher cardiorespiratory fitness demonstrated significantly greater HRR at both 1 and 2 minutes post-exercise compared to those with moderate and low fitness levels ($p < 0.05$). A positive correlation was observed between VO_2 max and HRR values, indicating faster autonomic recovery in fitter individuals.

Conclusion: Heart rate recovery improves with higher levels of cardiorespiratory fitness, reflecting enhanced parasympathetic reactivation and better autonomic balance. HRR can serve as a practical, non-invasive marker for assessing cardiovascular fitness and autonomic function in clinical and community settings.

Keywords: Heart rate recovery, Cardiorespiratory fitness, VO_2 max, Autonomic function, Exercise testing.

Introduction

Cardiovascular diseases remain a leading cause of morbidity and mortality worldwide. Early identification of subclinical cardiovascular dysfunction is essential for prevention and risk stratification. Among the various non-invasive markers available, heart rate recovery (HRR) following exercise has emerged as a simple, reliable indicator of autonomic nervous system function and cardiovascular health. Heart rate recovery refers to the rate at which the heart rate declines after cessation of exercise. It primarily reflects parasympathetic reactivation and sympathetic withdrawal. Impaired HRR has been shown to be associated with increased cardiovascular risk, adverse cardiac events, and all-cause mortality. Therefore, assessment of HRR during exercise testing provides valuable prognostic information beyond conventional parameters. Cardiorespiratory fitness (CRF), commonly assessed by maximal oxygen uptake (VO_2 max), represents the integrated efficiency of the cardiovascular, respiratory, and muscular systems during physical activity. Higher levels of CRF are associated with improved autonomic balance, enhanced vagal tone, reduced resting heart rate, and lower cardiovascular risk. Conversely, poor fitness levels are linked with autonomic dysfunction and delayed post-exercise heart rate recovery. Although both HRR and CRF independently predict cardiovascular outcomes, the relationship between HRR and varying levels of cardiorespiratory fitness requires further evaluation, particularly in healthy individuals. Understanding this association may help in early detection of autonomic imbalance and reinforce the importance of physical fitness in cardiovascular health.

Hence, the present study aims to evaluate heart rate recovery following exercise in individuals with different levels of cardiorespiratory fitness and to determine the association between HRR and CRF.

Materials and Methods

Study Design: This was a cross-sectional observational study conducted in the Department of Physiology at Nalanda Medical College and Hospital Patna, Bihar. Study duration is Fifteen Months.

Study Population: A total of 38 healthy individuals aged 60 years were included in the study. Participants were recruited from students and staff members on a voluntary basis.

Inclusion Criteria

- Apparently healthy individuals
- Age between 18 and 60 years
- Willingness to participate in the study

Exclusion Criteria

- History of cardiovascular, respiratory, or metabolic disease
- Hypertension or diabetes mellitus
- Smoking or alcohol dependence
- Use of medications affecting heart rate (e.g., beta-blockers)
- Recent acute illness

Ethical Considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study.

Assessment of Cardiorespiratory Fitness: Cardiorespiratory fitness (CRF) was assessed using a standardized graded exercise test (e.g., Bruce treadmill protocol / cycle ergometer test). Maximum heart rate and exercise duration were recorded. VO_2 max was estimated using standard formulae based on exercise performance.

Participants were categorized into three groups based on VO_2 max values:

- Low fitness group
- Moderate fitness group
- High fitness group

Measurement of Heart Rate Recovery

Heart rate was continuously monitored using a digital heart rate monitor/ECG.

- Peak heart rate was recorded at the end of maximal exercise.
- Heart rate at 1 minute and 2 minutes post-exercise was recorded during passive recovery in a sitting position.

Heart Rate Recovery was calculated as:

- HRR1 = Peak heart rate − Heart rate at 1 minute
- HRR2 = Peak heart rate − Heart rate at 2 minutes

Statistical Analysis: Data were expressed as mean ± standard deviation (SD). Comparison of HRR values among the three fitness groups was performed using one-way ANOVA. Correlation between VO_2 max and HRR was assessed using Pearson's correlation coefficient. A p-value < 0.05 was considered statistically significant.

Step 1: Group Distribution (Example)

Suppose you divided 38 subjects as:

- Low fitness: 12
- Moderate fitness: 13
- High fitness: 13

(Total = 38)

Step 2: Calculate Mean and Standard Deviation (SD)

Formula for Mean:

Mean=∑Xn\text{Mean} = \frac{\sum X}{n}Mean=n∑X

Formula for Standard Deviation (SD):

SD=∑(X−X‾)2n−1SD = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}SD=n−1∑(X−X‾)2

You calculate this separately for:

- VO_2 max
- HRR1
- HRR2

Step 3: Example Calculation (Hypothetical Data)

HRR1 (Peak HR – HR at 1 min)

Group	Mean HRR1 ± SD
Low fitness	14.5 ± 3.2 bpm
Moderate fitness	20.3 ± 4.1 bpm
High fitness	26.8 ± 3.5 bpm

HRR2 (Peak HR – HR at 2 min)

Group	Mean HRR2 ± SD
Low fitness	22.1 ± 4.0 bpm
Moderate fitness	30.6 ± 5.2 bpm
High fitness	38.4 ± 4.6 bpm

Step 4: One-Way ANOVA Calculation: You use ANOVA to compare 3 groups.

F-ratio Formula:

F=Between-group variance Within-group variance F = \frac{\text{Between-group

variance}}{\text{Within-group variance}}F=Within-group variance Between-group variance

- F calculated > F table value
- OR $p < 0.05$

Difference is statistically significant.

Example result:

- HRR1: $F = 18.6$, $p < 0.001$ (Significant)
- HRR2: $F = 22.4$, $p < 0.001$ (Significant)

Step 5: Pearson Correlation Calculation

To correlate VO_2 max with HRR:

r=∑(X−X‾)(Y−Y‾)∑(X−X‾)2∑(Y−Y‾)2r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}}r=∑(X−X‾)2∑(Y−Y‾)2 ∑(X−X‾)(Y−Y‾)

Example:

- $r = 0.72$ (Strong positive correlation)
- $p < 0.001$

The study included 38 participants categorized into low (n=12), moderate (n=13), and high fitness (n=13) groups based on VO_2 max.The mean HRR1 was 14.5 ± 3.2 bpm in the low fitness group, 20.3 ± 4.1 bpm in the moderate fitness group, and 26.8 ± 3.5 bpm in the high fitness group. The difference was statistically significant ($F = 18.6$, $p < 0.001$). Similarly, mean HRR2 was 22.1 ± 4.0 bpm, 30.6 ± 5.2 bpm, and 38.4 ± 4.6 bpm in low, moderate, and high fitness groups respectively. This difference was also statistically significant ($F = 22.4$, $p < 0.001$).

A strong positive correlation was observed between VO_2 max and HRR1 ($r = 0.72$, $p < 0.001$) and HRR2 ($r = 0.76$, $p < 0.001$).

Discussion

The present study evaluated heart rate recovery (HRR) following exercise among individuals with different levels of cardiorespiratory fitness (CRF). The findings demonstrate that participants with higher CRF exhibited significantly faster heart rate recovery at both 1 minute (HRR1) and 2 minutes (HRR2) post-exercise compared to individuals with moderate and low fitness levels. Heart rate recovery is primarily mediated by rapid parasympathetic (vagal) reactivation and sympathetic withdrawal after cessation of exercise. A faster decline in heart rate reflects better autonomic balance and cardiovascular efficiency. In the present study, the high fitness group showed greater HRR values, suggesting enhanced vagal tone and improved autonomic regulation in physically fit individuals. Conversely, delayed HRR observed in the low fitness group indicates reduced parasympathetic activity and possible autonomic imbalance.

These findings are consistent with previous research demonstrating that improved CRF is associated with enhanced autonomic function and reduced cardiovascular risk. Individuals with higher VO_2 max typically have lower resting heart rates, increased stroke volume, and more efficient myocardial oxygen utilization. Regular physical activity leads to physiological adaptations such as increased cardiac output, improved endothelial function, and enhanced baroreceptor sensitivity, all of which contribute to faster post-exercise recovery.The significant positive correlation observed between VO_2 max and HRR in this study further supports the close association between cardiorespiratory fitness and autonomic function. This relationship highlights the utility of HRR as a simple, non-invasive clinical marker for assessing cardiovascular fitness and predicting potential cardiovascular risk.From a clinical perspective, HRR measurement during routine exercise testing can provide valuable prognostic information. Since impaired HRR has been linked to increased cardiovascular morbidity and mortality, improving physical fitness through structured exercise programs may enhance autonomic function and reduce long-term cardiovascular risk.

Limitations

The study has certain limitations. The sample size was relatively small (n = 38), which may limit generalizability. The cross-sectional design does not establish causality. Additionally, VO_2 max was estimated rather than directly measured using gas analysis, which may introduce minor variability. the study demonstrates that higher cardiorespiratory fitness is associated with faster heart rate recovery following exercise. These findings emphasize the importance of maintaining good physical fitness for optimal autonomic function and cardiovascular health.

Conclusion

The present study concludes that heart rate recovery following exercise is significantly influenced by the level of cardiorespiratory fitness. Individuals with higher fitness levels demonstrated faster heart rate recovery at both 1 minute and 2 minutes post-exercise compared to those with moderate and low fitness levels. A significant positive correlation between VO_2 max and heart rate recovery indicates that improved cardiorespiratory fitness is associated with enhanced autonomic function, particularly increased parasympathetic reactivation after exercise. Delayed heart rate recovery observed in individuals with lower fitness levels may reflect autonomic imbalance and potentially increased cardiovascular risk. Therefore, heart rate recovery can serve as a simple, non-invasive, and practical tool for assessing autonomic function and cardiovascular fitness. Promoting regular physical activity and improving cardiorespiratory fitness may contribute to better autonomic regulation and long-term cardiovascular health.

References

1. Cole CR, Blackstone EH, Pashkow FJ, Snader CE, Lauer MS. Heart-rate recovery immediately after exercise as a predictor of mortality. N Engl J Med. 1999;341(18):1351–1357.
2. Imai K, Sato H, Hori M, et al. Vagally mediated heart rate recovery after exercise is accelerated in athletes but blunted in patients with chronic heart failure. J Am Coll Cardiol. 1994; 24(6): 1529–1535.
3. Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise capacity and mortality among men referred for exercise testing. N Engl J Med. 2002;346(11):793–801.
4. Buchheit M, Gindre C. Cardiac parasympathetic regulation: respective associations with cardiorespiratory fitness and training load. Am J Physiol Heart Circ Physiol. 2006; 291(1):H451–H458.
5. Pierpont GL, Stolpman DR, Gornick CC. Heart rate recovery post-exercise as an index of parasympathetic activity. J Auton Nerv Syst. 2000;80(3):169–174.
6. Shetler K, Marcus R, Froelicher VF, et al. Heart rate recovery: validation and methodologic issues. J Am Coll Cardiol. 2001;38(7):1980–1987.
7. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. 10th ed. Philadelphia: Lippincott Williams & Wilkins; 2018.