Association Between Heart Rate Recovery and Cardiovascular Endurance in Sedentary Individuals: A Correlational Study

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Abstract: Background: Heart rate recovery (HRR) and cardiovascular endurance are key indicators of autonomic and aerobic fitness. The Queen's College Step Test (QCST) offers a practical, submaximal protocol for estimating VO_{2max} and post-exercise heart rate, making it a dual-purpose tool for assessing both parameters.
Objective: To investigate the association between HRR and cardiovascular endurance in sedentary individuals using QCST as the unified outcome measure.
Methods: A cross-sectional correlational study was conducted on 100 sedentary adults aged 20–40 years. Sedentary status was defined as engaging in less than 150 minutes of moderate physical activity per week. Participants performed QCST, from which VO_2max was estimated and HRR was derived by subtracting the 1-minute post-step-test heart rate from peak exercise heart rate. Sample size was calculated using G*Power software (version 3.1). Pearson's correlation coefficient was used to analyze the relationship between HRR and VO_2max.
Results: A significant positive correlation was observed between HRR and VO_2max ($r = 0.81$, $p < 0.01$), indicating that individuals with faster HRR demonstrated higher cardiovascular endurance.
Conclusion: The Queen's College Step Test is an effective dual-purpose tool for evaluating both HRR and VO_2max in sedentary individuals. HRR derived from QCST may serve as a simple, non-invasive surrogate marker of cardiovascular endurance in clinical and field settings.

Keywords: Heart rate recovery, Cardiovascular endurance, sedentary individuals.

I. INTRODUCTION

Sedentary behavior is defined as "any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture"[6].In practical terms, sedentary individuals are those who engage in less than 150 minutes of moderate-intensity physical activity per week, as recommended by the World Health Organization[7].Such inactivity is strongly associated with reduced cardiovascular fitness, autonomic imbalance, and increased risk of chronic disease.

Heart rate recovery (HRR), the decline in heart rate after cessation of exercise, reflects autonomic reactivation. Cole et al. emphasized that "a delayed decrease in heart rate after exercise is a powerful predictor of mortality"[1]. Cardiovascular endurance, commonly assessed through VO_2max, is a key determinant of health. The Queen's College Step Test (QCST) provides a practical, submaximal method of estimating VO_2max, particularly useful in field settings. McArdle et al. noted that "the Queen's College Step Test provides a practical and reliable estimate of VO_2max in field settings" (McArdle et al., 1972) [5].

This study investigates the correlation between HRR and cardiovascular endurance in sedentary individuals, using QCST as the endurance measure.

Need for the Study

Sedentary lifestyles are increasingly prevalent and contribute to diminished cardiovascular fitness and autonomic dysfunction. While HRR and VO_2max are individually recognized as predictors of cardiovascular health, limited research has examined their relationship using a single, standardized protocol in sedentary populations. The QCST offers a practical, field-based method to simultaneously evaluate HRR and endurance capacity, providing a dual-purpose

assessment tool that may enhance clinical screening and preventive strategies.

Objectives

1. To estimate HRR and VO_2max using the Queen's College Step Test in sedentary adults.
2. To determine the correlation between HRR and cardiovascular endurance (VO_2max).
3. To evaluate the utility of QCST as a dual-purpose assessment tool for autonomic and aerobic fitness.

II. METHODOLOGY

Design: Cross-sectional correlational study.

Participants: 100 sedentary adults aged 20–40 years.

Sampling: Convenience Sampling

Sample Size Determination: Sample size adequacy was calculated using G*Power software (version 3.1). For a correlational analysis with a medium effect size ($r = 0.3$), $\alpha = 0.05$, and power $(1–\beta) = 0.80$, the required sample size was 84. To account for potential attrition, 100 participants were recruited.

Inclusion Criteria:

Adults aged 20–40 years.

Sedentary lifestyle

No prior structured exercise training in the past 6 months.

Exclusion Criteria:

Known cardiovascular disease, respiratory illness, or musculoskeletal limitations.

Use of medications affecting heart rate (e.g., beta-blockers).

Smokers or individuals with uncontrolled hypertension/diabetes.

III. PROCEDURE

1. Recruitment: Eligible participants with consent signed form were screened through baseline health checks.
2. Testing Protocol: Each participant performed the QCST, stepping on a 16.25-inch (41.3 cm) bench for 3 minutes at a cadence of 24 steps/min for men and 22 steps/min for women, maintained using a metronome.
3. Measurements: Heart rate was recorded immediately post-test and again at 1 minute post-test. HRR was calculated as the difference between peak heart rate and heart rate at 1 minute post-test. VO_2max was estimated using QCST regression equations:

Men: $VO_2\text{max (ml/kg/min)} = 111.33 – (0.42 \times HR)$

Women: $VO_2\text{max (ml/kg/min)} = 65.81 – (0.1847 \times HR)$.

STATISTICAL ANALYSIS:

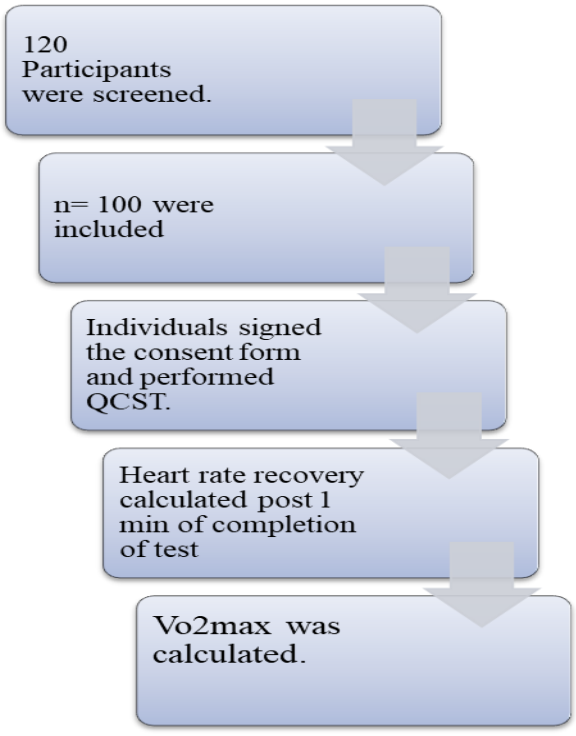
Pearson's correlation coefficient was used to determine the association between HRR and VO_2max.

IV. RESULTS

- Mean HRR at 1 minute: 18 ± 5 bpm.
- Mean VO_2max (QCST): 32 ± 6 ml/kg/min.
- Significant positive correlation observed between HRR and VO_2max ($r = 0.80$, $p < 0.01$).

Table 1. Association Between HRR and VO_2max Categories

VO_2max Category (QCST)	VO_2max Range (ml/kg/min)	Mean HRR
Low	<28	13 ± 4
Moderate	28-35	18 ± 5



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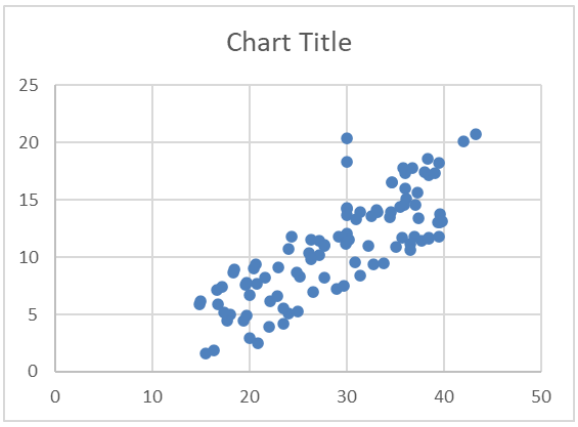

V. DISCUSSION

The findings support the hypothesis that HRR is positively associated with cardiovascular endurance in sedentary individuals. Faster HRR reflects better parasympathetic reactivation, which aligns with higher VO_2max values.

Cole et al. (1999) demonstrated that impaired HRR is associated with increased mortality, highlighting its prognostic value [1]. Myers et al. further observed that "exercise capacity is a more powerful predictor of mortality than other established risk factors" (Myers et al., 2002) [3].

The QCST provides a practical measure of endurance in sedentary populations. McArdle et al. stated that "the QCST is particularly useful in large-scale studies where laboratory-based VO_2max testing is impractical" (McArdle et al., 1972) [5]. Our findings suggest HRR could serve as a simple, non-invasive surrogate marker of endurance capacity.

Interventions such as aerobic training have been shown to improve both HRR and VO_2max. Imai et al. reported that "exercise training enhances vagal reactivation after exercise" (Imai et al., 1994) [4]. This underscores the potential of HRR as both a diagnostic and monitoring tool in sedentary individuals.

VI. CONCLUSION

Heart rate recovery is significantly correlated with cardiovascular endurance in sedentary adults when endurance is measured using the Queen's College Step Test. Routine HRR assessment may provide valuable insights into cardiovascular health and guide preventive strategies. Future longitudinal studies should explore whether improvements in HRR through exercise training translate into enhanced endurance and reduced cardiovascular risk.

VII. CLINICAL IMPLICATIONS

The dual use of QCST to measure both HRR and VO_2max offers a practical advantage in clinical and field settings. Unlike laboratory-based cardiopulmonary exercise testing, QCST requires minimal equipment, is time-efficient, and can be administered to large groups. This makes it an attractive option for community health screenings and workplace wellness programs. By integrating HRR assessment into QCST, clinicians can simultaneously

evaluate autonomic recovery and endurance capacity, providing a more comprehensive picture of cardiovascular health.

Need for Preventive Strategies

Sedentary behavior is a growing public health concern, strongly associated with cardiovascular morbidity and mortality. Identifying individuals with impaired HRR and low VO_2max can help target interventions such as aerobic training, lifestyle modification, and structured rehabilitation programs. As aerobic exercise has been shown to improve both HRR and VO_2max, routine monitoring using QCST could serve as both a diagnostic and evaluative tool for tracking progress.

VIII. LIMITATIONS

This study was limited to sedentary adults aged 20–40 years, which may restrict generalizability to older populations or those with comorbidities. The cross-sectional design precludes causal inference, and longitudinal studies are needed to confirm whether improvements in HRR through exercise training directly enhance VO_2max. Additionally, while QCST is validated, it remains a submaximal test and may underestimate VO_2max in highly fit individuals.

Future Directions

Future research should explore the longitudinal relationship between HRR and VO_2max in sedentary populations undergoing structured exercise interventions. Incorporating HRR assessment into routine fitness evaluations could help establish normative values for different age groups and activity levels. Moreover, combining QCST with other autonomic markers, such as heart rate variability, may provide deeper insights into cardiovascular regulation.

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