

## THE RELATIONSHIP BETWEEN HEART RATE RECOVERY AND MAXIMAL OXYGEN CONSUMPTION ACROSS DIFFERENT GRADED EXERCISE TESTING PROTOCOLS

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### Introduction

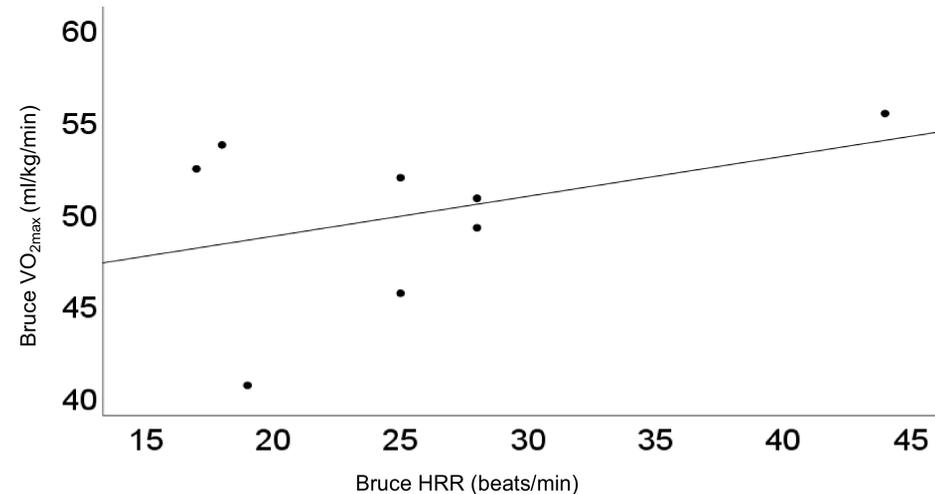
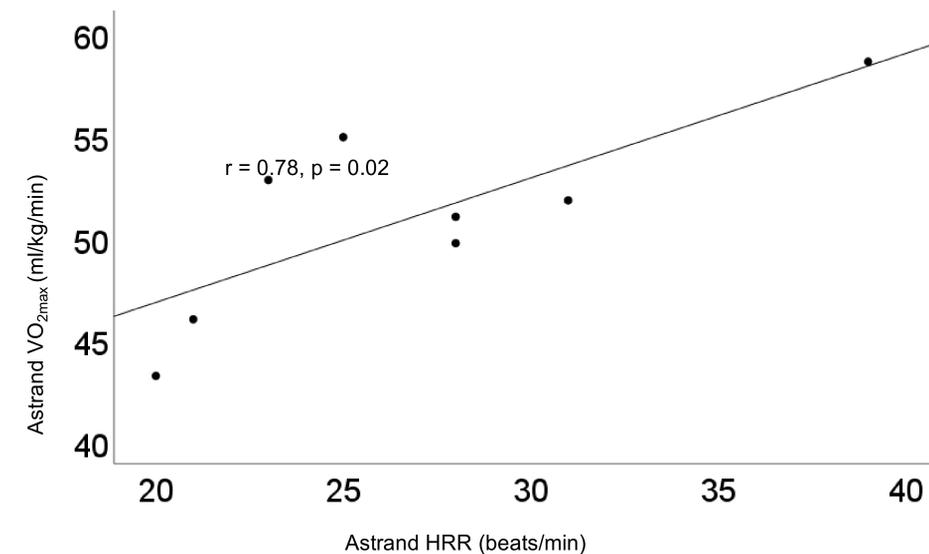
- Heart rate recovery (HRR) is a non-invasive marker of cardiac autonomic control and is used as an indicator of aerobic fitness.
- There is limited information that exists to determine the relationship between HRR and maximal oxygen consumption ( $VO_{2max}$ ) across various graded exercise test (GXT) protocols.
- The purpose of this study was to determine the relationship between HRR and  $VO_{2max}$  following two different maximal GXT protocols.

### Methods

- Nine adult male participants were recruited for this study (age =  $22.6 \pm 5.4$  years, height =  $163.8 \pm 6.4$  cm, weight =  $83.8 \pm 10.8$  kg)
- Participants completed two randomized GXT protocols 72 hours to 1 week apart.
- The Astrand method maintained a constant speed and increased grade every three minutes until exhaustion.
- The Bruce protocol increased speed and grade every three minutes until exhaustion.
- In both protocols,  $VO_{2max}$  was measured using direct oxygen consumption analysis via a metabolic cart.
- Heart rate was continuously monitored throughout each GXT and during a 3-minute active recovery period.
- The heart rate during the first minute of the active recovery period was subtracted from the maximal heart rate and recorded as HRR.

### Results

- The mean  $\pm$  SD  $VO_{2max}$  values for the Astrand protocol were  $51.0 \pm 4.9$   $ml \cdot kg^{-1} \cdot min^{-1}$  and for the Bruce protocol  $49.9 \pm 4.8$   $ml \cdot kg^{-1} \cdot min^{-1}$ .
- HRR =  $26.9 \pm 6.2$   $beats \cdot min^{-1}$  following Astrand and  $25.5 \pm 8.7$   $beats \cdot min^{-1}$  following Bruce protocol.



### Conclusions

- The mean  $\pm$  SD  $VO_{2max}$  values for the Astrand protocol were  $51.0 \pm 4.9$   $ml \cdot kg^{-1} \cdot min^{-1}$  and for the Bruce protocol  $49.9 \pm 4.8$   $ml \cdot kg^{-1} \cdot min^{-1}$ .
- Following the Astrand and Bruce protocols, HRR1 was  $26.9 \pm 6.2$   $beats \cdot min^{-1}$  and  $25.5 \pm 8.7$   $beats \cdot min^{-1}$ .
- The correlation between HRR and  $VO_{2max}$  were significant for the Astrand protocol ( $r = 0.78$ ,  $p = 0.02$ ).
- The correlation between HRR and  $VO_{2max}$  were not significant for the Bruce protocol ( $r = 0.39$ ,  $p = 0.34$ ).
- This shows that HRR is significantly correlated with  $VO_{2max}$  following the Astrand protocol, but not the Bruce protocol.
- This suggests that the extent to which HRR reflects aerobic fitness may vary depending on the testing protocol used.

### Practical Applications

- Practitioners can use HRR as a simple, non-invasive tool to assess aerobic fitness when using graded exercise protocols similar to the Astrand method.

### References

1. Kang, J., Chaloupka, E. C., Mastrangelo, M. A., Biren, G. B., & Robertson, R. J. (2001). Physiological comparisons among three maximal treadmill exercise protocols in trained and untrained individuals. *European Journal of Applied Physiology*, 84(4), 291–295. <https://doi.org/10.1007/s004210000366>
2. Miao, G., Yan, Q., Zhu, H., & Li, F. (2024). Study on heart rate recovery index to predict maximum oxygen uptake in healthy adults aged 30 to 60 years old. *Frontiers in Physiology*, 15, 1437962. <https://doi.org/10.3389/fphys.2024.1437962>
3. Mongin, D., Chabert, C., Courvoisier, D. S., García-Romero, J., & Alvero-Cruz, J. R. (2021). Heart rate recovery to assess fitness: comparison of different calculation methods in a large cross-sectional study. *Research in Sports Medicine*, 31(2), 157–170. <https://doi.org/10.1080/15438627.2021.1954513>
4. Reis, V. M., Van den Tillaar, R., & Marques, M. C. (2011). Higher precision of heart rate compared with  $VO_2$  to predict exercise intensity in endurance-trained runners. *Journal of Sports Science and Medicine*, 10(1), 164–168. <https://pmc.ncbi.nlm.nih.gov/articles/PMC3737894/>
5. Vanhoy, R. A. (2012). A comparison of two different treadmill protocols in measuring maximal oxygen consumption in highly trained distance runners (Master's thesis, University of North Carolina at Chapel Hill). <https://doi.org/10.17615/6gww-eh51>