# Validity of Maximal Heart Rate During an Intermittent Cycle Test: A Pilot Study

EXERCISE SCIENCE
SACRED HEART UNIVERSITY

Ella Frisbie *[Mentor: Dr. Alicja Stannard]*
College of Health Professions
Department of Physical Therapy and Human Movement Science

## ABSTRACT

The purpose of this study is to validate a cycle ergometer field test to elicit maximal heart rate (HRmax) that can be completed in a fitness setting by the general population. Seventeen participants (F=14, M=3), aged 20 to 21yrs partook in the study. Each subject completed the incremental text to volitional fatigue and a cycle field test in a random order with an average 6.88 ± 1.80 days between the tests. During both test the subjects pedaled at 60 repetitions per minute (rpm) wearing the Polar H10 tracking heart rate (HR). Expired gases were measured by the Parvo metabolic cart. $VO_2$max criteria were evaluated during incremental test. During the gold standard incremental test subjects started at 50 watts and every two minutes watts were increased by 25 watts; subjects continued this for as long as they could while pedaling at 60. Criteria for meeting the $VO_2$ max requirements were: 90% of predicted HRmax, RER>1.15, and VO2 plateau of 150ml $O_2$ during last two stages of the test. $VO_2$max criteria were met by 76.5% of the participants. During the intermittent cycle protocol, Rating of Perceived Exertion (RPE) 6-20 scale was used to determine effort. The experimental field test started with a 3-minute warm up (RPE: 8-9), then a three-minute intense period (RPE: 13-14), then a 2-minute easy period (RPE: 8-9). The previous two phases were repeated for a three-minute intense period (RPE: 13-14), then a 2-minute easy period (RPE: 8-9).The final phase was 2 minutes of all out effort (RPE:>17) Descriptive statistics were assessed for all variables. On average there was a 2.3 ± 10.5 higher heart rate in the incremental test. Differences between HRmax were compared using paired t-test. There was no significant differences between HRmax values between the tests suggesting the intermittent cycle test can be a valid method to assess HRmax.

## INTRODUCTION

Maximal heart rate (HR max) is commonly used in fitness settings to indicate intensity and provide exercise prescription. HR max is most commonly determined by various generic non-exercise formulas such 220-age. However, the validity of the prediction equations has been examined and reported that the equation should not be used to predict and individuals HR max.[1,2] HR max can be determined by an incremental cycle ergometer, but this test is performed in a laboratory setting which is inaccessible for most people. Additionally, HR max is used in prediction equations for submaximal test to estimate an individual's maximal uptake ($VO_{2\ max}$) for cardiorespiratory fitness.[3] However, to our knowledge no study has verified a test that can be completed on a cycle ergometer to elicit a HR max in an environment that is similar to a typical fitness setting.

### Purpose:

The purpose of this study was to validate the intermittent cycle ergometer to measure HR max that can be completed in a fitness setting by the general population.

### Hypothesis:

It was hypothesized that the maximal cycle ergometer field test that would elicit a HR max when compared to the gold standard incremental cycle ergometer test commonly used in the laboratory setting.

## PARTICIPANTS

- Seventeen subjects volunteered for this study (M=3, F=12)

Table 1. Participants Characteristics (N=18)

| | Age (yrs) | Weight (kg) | Height (cm) | BMI (kg/m$^2$) |
|---|---|---|---|---|
| Mean ± SD | 20.6 ± .5 | 65.0 ±13.7 | 166. ± 8.7 | 23.2 ± 2.9 |

Image 1. Monark Bike


## METHODS

- Participants (N=17) completed Physical Activity Readiness Questionnaire (PAR-Q+) and had no history of metabolic, cardiovascular, endocrine, thermoregulatory disorders, asthma or musculoskeletal problems.
- Subjects completed two tests in a random order.
- Before each session:
  - Age, sex, height, weight, resting HR, resting blood pressure and activity level were recorded.
  - The Rating of Perceived Exertion – Borg scale (RPE) of 6-20 was explained to each subject.
  - Polar H10 heart rate monitor was used to record heart rate.
- **Incremental Test Protocol:** (gold standard)
  - Subjects consistently pedaled at 60 rpm while the resistance increased every two minutes based on a 25-watt increase starting at 50 watts for as long as they could maintain 60 rpm.
  - HR, Watts, RPM, KP and RPE were recorded 15 seconds before each phase ended, and at the end of the test along with how long the subjects lasted, with the highest HR being recorded as the HR peak.
- **Field Test Protocol:**
  - Subjects pedaled at 60 rpm and adjusted their own resistance to stay in the target RPE zone.
  - The test started with a 3-minute warm up (RPE: 8-9), followed by a three-minute intense period (RPE: 13-14), and a 2-minute easy period (RPE: 8-9). The previous two phases were repeated for a three-minute intense period (RPE: 13-14), then a 2-minute easy period (RPE: 8-9).
  - In the final phase subjects were instructed to bike with maximal effort and a RPE of >17 as an extended Wingate test. The highest HR recorded in the last 2 minutes was considered the HR peak.
- Parvo metabolic cart (Sandy, UT) was used to collect expired gasses during both tests.
- VO2 max criteria for incremental test.
  - RER $\geq$ 1.15
  - 90% of predicted heart rate max using 220-age formula
  - $VO_2$ plateau <150ml of $O_2$
- Descriptive statistics were assessed for all variables. Differences between HRmax were compared using paired t-test.

## RESULTS

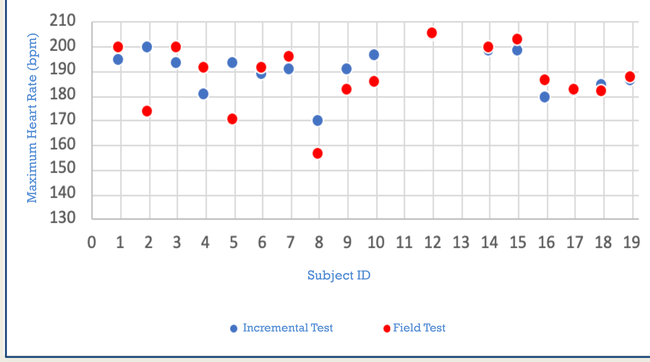
- There was no significant differences between HRmax values between the tests (p=0.38) suggesting the intermittent cycle test can be a valid method to assess HRmax.
- Seventeen subjects completed both tests with an average maximum heart rate 2.29 ± 10.5 beats higher in the incremental test.
- 76.5% of the subject's test met VO2max criteria during the incremental test.
- 13 subjects that met the $VO_2$ max criteria and averaged 3.1 ± 11.0 beats higher on the incremental test, while the subjects that did not meet the $VO_2$ max criteria averaged .25 ± 9.2 beats higher on the field test.
- On subjects first test they averaged a max heart rate of 188.8 ± 9.7 and on subjects second test they averaged 187.4 ± 12.3.
- Subject lasted on average 11:15 ± 2:21 for the incremental test

Table 2. Peak Heart Rate Obtained During Incremental and Intermittent Cycle Field Test

| | **HR max (bpm)** |
|---|---|
| Incremental (Mean ± SD) | 189.5 ± 8.9 |
| Field (Mean ± SD) | 187.2 ± 12.8 |
| Difference (Field – INC) (Mean ± SD) | -2.29 ± 10.5 |

## RESULTS

Figure 1. Maximum Heart Rate Reached During Incremental and Field Test for Each Participant




## DISCUSSION

- It appears the intermittent field test is a valid assessment to elicit a maximal heart rate.
- The field (intermittent) cycle test can be used in an applied setting such as a gym to more accurately determine target heart rate zone for a workout.
- This makes determining a heart rate max, much more accessible as an expensive lab test is no longer needed to get an accurate HR max.
- This is a pilot study, and more participants are needed.

## TAKE HOME MESSAGE

The intermittent cycle test can be used in an applied setting such as a gym to more accurately determine target heart rate zones for a workout, based on this pilot data.

Scan this for more information

## REFERENCES

1. ROY S, MCCRORY J. Validation of Maximal Heart Rate Prediction Equations Based on Sex and Physical Activity Status. Int J Exerc Sci. 2015;8(4):318-330.
2. Arena R, Myers J, Kaminsky LA. Revisiting age-predicted maximal heart rate: Can it be used as a valid measure of effort? Am Heart J. 2016;173:49-56. doi:10.1016/j.ahj.2015.12.006
3. Beltz NM, Gibson AL, Janot JM, Kravitz L, Mermier CM, Dalleck LC. Graded Exercise Testing Protocols for the Determination of VO2max: Historical Perspectives, Progress, and Future Considerations. J Sports Med. 2016;2016. doi: 10.1155/2016/3968393
4. Hostrup M, Kalsen A, Onslev J, et al. Mechanisms underlying enhancements in muscle force and power output during maximal cycle ergometer exercise induced by chronic ß2-adrenergic stimulation in men. JAppl Physiol. 2015;119(5):475-486. doi:10.1152/japplphysiol.00319.2015
5. Huebner M, Zhen Zhang, McGrath P, Thereau I, Pianosi P. Modeling trajectories of perceived leg exertion during maximal cycle ergometer exercise in children and adolescents. BMC Med Res Methodol. 2014;14(1):1-15. doi:10.1186/1471-2288-14-4
6. - Zagatto AM, Miyagi WE, Sakugawa RL, Kaminagakura EI, Papoti M. Aerobic Endurance Measurement by Respiratory Exchange Ratio during a Cycle Ergometer Graded Exercise Test. J Exerc Physiol Online. 2012;15(5):49-56.
7. Boer P-H. Sprint Interval Training Vs. High Intensity Interval Training in Untrained University Students. South Afr J Res Sport Phys Educ Recreat. 2019;41 (3):17-30.
8. Wang J, Ou J, Yiu, Hou Z, Benardot D, Cao W. Effect of sodium bicarbonate ingestion during 6 weeks of HIIT on anaerobic performance of college students. J Int Soc Sports Nutr. 2019;16(1):N.PAG-N.PAG.
9. Buusko K. Influence of Two High-Intensity Intermittent Training Programmes on Anaerobic Capacity in Humans. Biol Sport. 2011;28(1):23-30.
10. Goodman J, Thomas S, Burr JF. Physical activity series: cardiovascular risks of physical activity in apparently healthy individuals: risk evaluation for exercise clearance and prescription. Can Fam Physician Med Fam Can. 2013;59(1):46.