ASTRAND-RYHMING (A-R) CYCLE ERGOMETER TEST

This test estimates VO₂max using a single-stage, six-minute submaximal cycling protocol. It is a single-stage test and relatively simple to perform. Because it is easier to administer than the YMCA bike test, this test may be a more appropriate choice for trainers who are new to cycle-ergometer testing. Consider, however, that inexperienced riders might find riding at a moderate-to-hard intensity for six minutes fatiguing.

**Equipment:**
- Cycle ergometer
- HR monitor with chest strap
- Metronome (optional)
- Stopwatch
- Sphygmomanometer
- RPE chart

**Pre-test procedure:**
- Estimate 85% of MHR [based on 208 – (0.7 x Age)] and record the value on the testing form. If an HR strap and monitor are unavailable, calculate a 10-second count for this value. For safety reasons, it is up to the tester to ensure that the client does not exceed this HR limit.
- Measure and record the client’s weight and convert that value to kg by dividing the weight by 2.2.
- Measure and record a seated, resting BP.
- Discuss RPE and remind the client that he or she will be asked for perceived exertion levels throughout the test.
- Adjust the seat height and record the seat position for future tests to ensure consistency between tests:
  - Position the pedal at the bottom of a revolution so that the crank arm is orientated vertically. Have the client place the heel of the foot on the pedal. The knee should be almost straight (5 to 10 degrees of flexion) in this position, with the ankle held in neutral (i.e., the toes should not be pointed in either direction). Test results may be inaccurately low if the seat is set too low.
  - The seat and pedal position should be comfortable for the client.
- If a cadence meter is available on the bike, instruct the client to ride at 50 rpm. If it is unavailable, use a metronome set to 100 bpm to coincide with each pedal stroke.
- Allow for a two- to three-minute warm-up period at a low intensity (2- or 3-out-of-10 effort) to allow the client to practice and familiarize him- or herself with the cadence. There should be no tension on the cycle during the warm-up.
- Inform the client that the test will be six minutes in length, during which time he or she will attempt to maintain an HRss between 120 and 170 bpm to ensure test validity (ACSM, 2014). The test can be stopped if the client exceeds 85% of age-predicted MHR or cannot maintain the cadence. The client can stop the test at any time and for any reason, but especially if he or she experiences chest pain, shortness of breath, dizziness, or nausea.

**Test protocol and administration:**
- Recommend a two- to three-minute warm-up to achieve an HRss slightly above 120 bpm to determine an appropriate test intensity.
- The workload should be determined by the client’s gender and physical condition. The following workloads are used throughout the entire six minutes.
- Male, unconditioned: 300 to 600 kilogram-meters per minute (kgm/min) (50 to 100 watts)
- Male, conditioned: 600 to 900 kgm/min (100 to 150 watts)
- Female, unconditioned: 300 to 450 kgm/min (50 to 75 watts)
- Female, conditioned: 450 to 600 kgm/min (75 to 100 watts)
- After the first and second minutes, measure HR and adjust intensity accordingly:
  - Increase the exercise intensity/cycle resistance if the HR is below 120 bpm.
  - Decrease exercise intensity/cycle resistance if the HR is near 170 bpm.
- Instruct the client to maintain a steady pace throughout the test. Record RPE and HR at each minute to ensure the client is staying within the recommended target heart-rate range (THRR). Blood pressure should be assessed and recorded at the four-minute mark. Record the client’s HR at minute 5 and minute 6. These values will be averaged and used for determining VO₂max.
- Once the test is completed, the client should cool down at a reduced workload for three to five minutes, until HR and breathing rate return to normal. The trainer should continue to observe the client, as negative symptoms can arise immediately post-exercise.
• Using the Astrand-Ryhming nomogram, draw a line from the averaged pulse rate through the \( \dot{V}O_2 \max \) and to the workload used for the test, either male or female. The place where the line intersects the \( \dot{V}O_2 \max \) is used to determine the client’s maximum oxygen uptake.

• \( \dot{V}O_2 \max \) value must then be age-adjusted using the correction factors listed in the table below. To calculate the estimated \( \dot{V}O_2 \max \), the age correction factor is multiplied by the \( \dot{V}O_2 \max \) value from the nomogram.

• Record the value on the testing form.

• Convert to mL/kg/min and use Table 8–12 of the ACE Personal Trainer Manual (5th Edition) to rank the client’s maximum oxygen uptake.

### \( \dot{V}O_2 \max \) Correction Factors

<table>
<thead>
<tr>
<th>Age</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1.10</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
</tr>
<tr>
<td>35</td>
<td>0.87</td>
</tr>
<tr>
<td>40</td>
<td>0.83</td>
</tr>
<tr>
<td>45</td>
<td>0.78</td>
</tr>
<tr>
<td>50</td>
<td>0.75</td>
</tr>
<tr>
<td>55</td>
<td>0.71</td>
</tr>
<tr>
<td>60</td>
<td>0.68</td>
</tr>
<tr>
<td>65</td>
<td>0.65</td>
</tr>
</tbody>
</table>

### Sample \( \dot{V}O_2 \max \) Calculation

Determine \( \dot{V}O_2 \max \) for a 45-year-old female, weighing 115 pounds (52.3 kg), who completed the Astrand-Ryhming cycle ergometer test at 450 kgm/min (75 watts).

Her exercise HR was 142 bpm at the fifth minute and 146 bpm at the sixth minute. The average HR is 144 bpm.

According the nomogram, her \( \dot{V}O_2 \max \) is 2.6.

After multiplying by the age-correction factor, her adjusted \( \dot{V}O_2 \max \) is 2.028 L/min (2.6 x 0.78 = 2.028). To classify her effort, convert L/min to mL/min: 2.028 L/min x 1000 = 2,028 mL/min. Now divide 2,028 mL/min by her bodyweight of 52.3 kg to yield her \( \dot{V}O_2 \max \) in mL/kg/min: 2.028 L/min / 52.3 kg = 38.8 mL/kg/min, which ranks her in the 80th percentile for women of her age.

### Modified Astrand-Ryhming nomogram

[Diagram showing nomogram]
