



Work Tests to Evaluate Cardiorespiratory Fitness

Dr. Mahrukh (PT)

DPT,MSAPT (Dow University of Health Sciences)

Mahrukh.siddiqui@juw.edu.pk



Objectives

- Cardio respiratory fitness
- Testing procedures
- FIELD Tests for estimating CRF
- Graded exercise tests: measurements
- VO₂ max
- Graded exercise tests: protocols

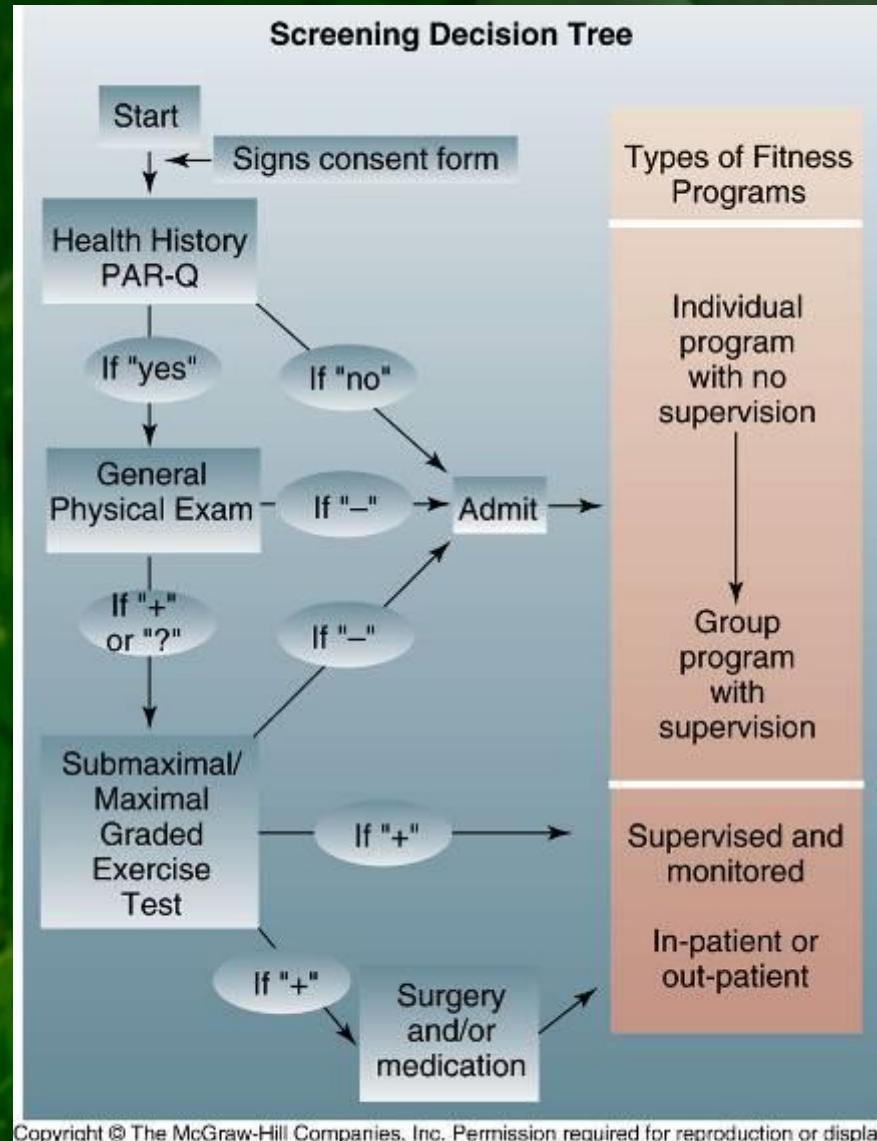


Testing Procedures

- Sign consent form
- Screening
 - PAR-Q and PAR_{med}-X
 - Classify individuals as low, moderate, or high risk
- Resting and exercise measures
 - HR and BP
 - Cholesterol
 - ECG
 - GXT or field test



Decision Tree in the Evaluation of Cardiorespiratory Fitness





Field Tests for Estimating Cardiorespiratory Fitness

- Use natural activities
 - Walking, running, or stepping
- Can test large numbers of people at low cost
- Physiological responses may be difficult to measure
- Motivation plays an important role in test results



Maximal Run Tests

- Measure how far a person can run in a set time or how fast they can run a set distance
 - Cooper's 12-minute run and 1.5 mile run
 - For adults
 - AAPHERD's 1-mile run/walk and PACER test
 - For children
- $\text{VO}_{2\text{max}}$ estimates based on the linear relationship between running speed and oxygen cost of running
 - Duration of 10–20 minutes
 - Running at speed demanding 90–95% $\text{VO}_{2\text{max}}$
 - Minimize contribution of anaerobic energy sources

$$\text{VO}_2 = 0.2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \text{ per m} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$$



Categories of $\text{VO}_{2\text{max}}$ Values

TABLE 15.1 Men's and Women's Aerobics Fitness Classifications

Men's

Category	AGE (YEARS)					
	13-19	20-29	30-39	40-49	50-59	60+
1. Very Poor	<35.0*	<33.0	<31.5	<30.2	<26.1	<20.5
2. Poor	35.0-38.3	33.0-36.4	31.5-35.4	30.2-33.5	26.1-30.9	20.5-26.0
3. Fair	38.4-45.1	36.5-42.4	35.5-40.9	33.6-38.9	31.0-35.7	26.1-32.2
4. Good	45.2-50.9	42.5-46.4	41.0-44.9	39.0-43.7	35.8-40.9	32.3-36.4
5. Excellent	51.0-55.9	46.5-52.4	45.0-49.4	43.8-48.0	41.0-45.3	36.5-44.2
6. Superior	>56.0	>52.5	>49.5	>48.1	>45.4	>44.3

Women's

Category	AGE (YEARS)					
	13-19	20-29	30-39	40-49	50-59	60+
1. Very Poor	<25.0*	<23.6	<22.8	<21.0	<20.2	<17.5
2. Poor	25.0-30.9	23.6-28.9	22.8-26.9	21.0-24.4	20.2-22.7	17.5-20.1
3. Fair	31.0-34.9	29.0-32.9	27.0-31.4	24.5-28.9	22.8-26.9	20.2-24.4
4. Good	35.0-38.9	33.0-36.9	31.5-35.6	29.0-32.8	27.0-31.4	24.5-30.2
5. Excellent	39.0-41.9	37.0-40.9	35.7-40.0	32.9-36.9	31.5-35.7	30.3-31.4
6. Superior	>42.0	>41.0	>40.1	>37.0	>35.8	>31.5

*Values for oxygen uptake in $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$

Data from Kenneth H. Cooper, 1977, *The Aerobics Way*. New York: Bantam Books, Inc.



Walk Tests

- One-mile walk test requires simple measurements
- $\text{VO}_{2\text{max}}$ is based on:
 - Age (years), weight (pounds), sex (0 for female, 1 for male), time (min), and HR (beats/min)

$$\text{VO}_2 (\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 132.853 - 0.0769 (\text{wt}) - 0.3877 (\text{age}) + 6.315 (\text{sex}) - 3.2649 (\text{time}) - 0.1565 (\text{HR})$$

- As fitness improves, HR and/or time will be lower
 - Results in higher estimated $\text{VO}_{2\text{max}}$



Canadian Home Fitness Test

- Uses 8-inch steps to evaluate cardiorespiratory fitness
- Measure HR after 3 minutes of stepping
 - Stop if it exceeds maximum allowable HR based on age
 - Continue for another 3 minutes if it is below maximum allowable HR
 - Fitness level is based on post-exercise HR



Fitness Evaluation from the Canadian Home Fitness Test

TABLE 15.2 Physical fitness Evaluation Chart for the Canadian Home Fitness Test

Age (yr)	TEN-SECOND PULSE RATE	
	After First Three Minutes of Exercise	After Second Three Minutes of Exercise
15–19	If 30 or more, stop. You have an undesirable personal fitness level.	If 27 or more, you have a minimum personal fitness level. If 26 or less, you have the recommended personal fitness level.
20–29	If 29 or more, stop. You have an undesirable personal fitness level.	If 26 or more, you have a minimum personal fitness level. If 25 or less, you have the recommended personal fitness level.
30–39	If 28 or more, stop. You have an undesirable personal fitness level.	If 25 or more, you have a minimum personal fitness level. If 24 or less, you have the recommended personal fitness level.
40–49	If 26 or more, stop. You have an undesirable personal fitness level.	If 24 or more, you have a minimum personal fitness level. If 23 or less, you have the recommended personal fitness level.
50–59	If 25 or more, stop. You have an undesirable personal fitness level.	If 23 or more, you have a minimum personal fitness level. If 22 or less, you have the recommended personal fitness level.
60–69	If 24 or more, stop. You have an undesirable personal fitness level.	If 23 or more, you have a minimum personal fitness level. If 22 or less, you have the recommended personal fitness level.

From R. J. Shephard, et al, "Development of the Canadian Home fitness Test," originally published in *Canadian Medical Association Journal*, 114:675–79, 1976. Copyright © 1976 Canadian Medical Association, Ottawa, Canada. Reprinted by permission.



Graded Exercise Tests: Measurements

- Heart rate
 - By palpation, stethoscope, ECG, or monitor
- Blood pressure
 - By auscultation
- ECG
 - Can diagnose arrhythmias or ischemia
 - ST segment depression
- Rating of perceived exertion (RPE)
 - Subjective measure of fatigue
- Termination criteria
 - From ACSM's *Guidelines for Exercise Testing and Prescription*



Three Types of ST Segment Depression

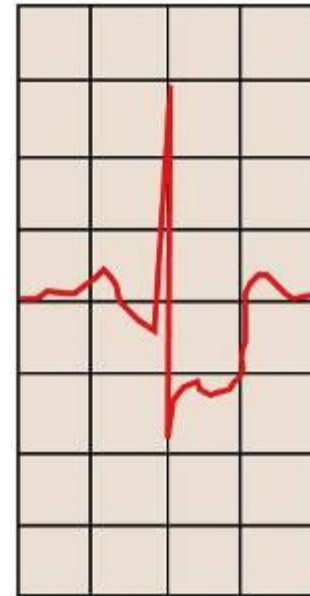
Upsloping
ST segment
depression



Horizontal
ST segment
depression



Downsloping
ST segment
depression



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Original and Revised RPE Scales

TABLE 15.3 Rating of Perceived Exertion Scales

Original Rating Scale	Revised Rating Scale
6	0 Nothing at all
7 Very, very light	0.5 Very, very light (just noticeable)
8	1 Very light
9 Very light	2 Light (weak)
10	3 Moderate
11 Fairly light	4 Somewhat hard
12	5 Heavy (strong)
13 Somewhat hard	6
14	7 Very heavy
15 Hard	8
16	9
17 Very hard	10 Very, very heavy (almost max)
18	• Maximal
19 Very, very hard	
20	

From G. A. U. Borg, "Psychological Bases of Physical Exertion" in *Medicine and Science in Sports and Exercise*, 14:377-81, 1982.
Copyright ©1982 American College of Sports Medicine,
Indianapolis, IN. Reprinted by permission.



GXT Termination Criteria

- Onset of angina or angina-like symptoms
- Drop in systolic blood pressure of >10 mm Hg from baseline blood pressure despite an increase in workload
- Excessive rise in blood pressure: systolic pressure >250 mm HG or diastolic pressure >115 mm HG
- Shortness of breath, wheezing, leg cramps, or claudication
- Signs of poor perfusion: light-headedness, confusion, ataxia, pallor, cyanosis, or cold and clammy skin
- Failure of heart rate to increase with increased exercise intensity
- Noticeable change in heart rhythm
- Subject requests to stop
- Physical or verbal manifestations of severe fatigue
- Failure of the testing equipment



VO₂ Max

- The gold standard measure of cardiorespiratory fitness
- Estimation from last work rate
 - Use equations to calculate estimated VO_{2max}
- Estimation from submaximal heart rate
 - Extrapolate measured submaximal HR to age-predicted maximal HR to estimate VO_{2max}
 - Careful measurement of HR is required



Estimation of VO_2 Max From Last Work Rate

- Used in many fitness and clinical settings
- Subject should achieve steady-state in each stage
 - Duration and rate of progression depends on fitness level
- Running:

$$\text{VO}_2 = 0.2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \text{ per m} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$$

- Walking:

$$\text{VO}_2 = 0.1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \text{ per m} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$$

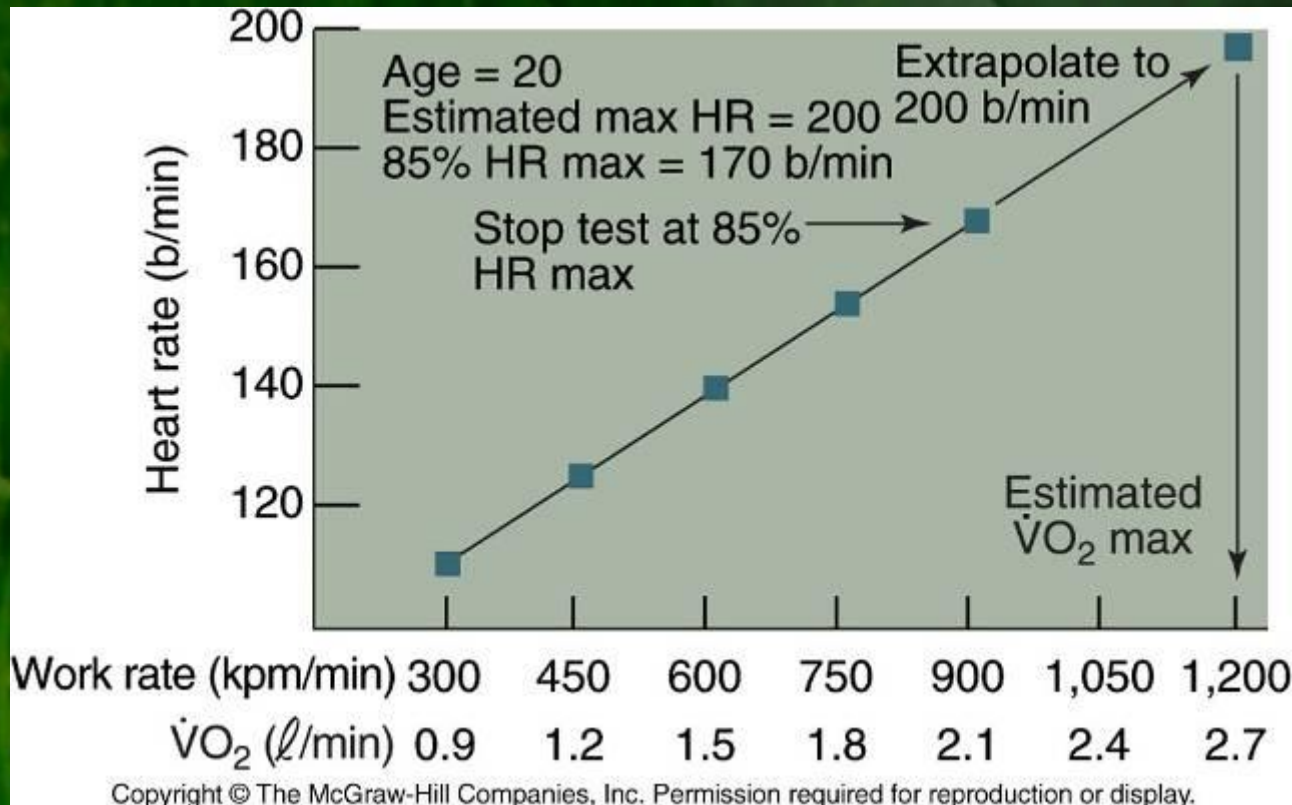


Estimation of VO_2 Max From Submaximal HR Response

- The test is stopped when the subject reaches 85% of maximal HR
- A line is drawn through the HR points measured during the test and is extrapolated to the age-adjusted estimate of maximal HR
- Another line is dropped down from that point to the x-axis, and the $\text{VO}_{2\text{max}}$ is identified



Estimation of $\dot{V}O_2$ max From Submaximal Cycle Ergometer Test





Graded Exercise Test: Protocols

- Consideration of the population tested
 - Submaximal vs. maximal test
 - Starting work rate
 - Rate of change of work rate
 - Mode of exercise
 - Treadmill
 - Cycle ergometer
 - Step test
- Subjects must follow instructions carefully
- Environmental conditions must be controlled
 - Temperature and humidity



Treadmill GXT Protocols

TABLE 15.5 Treadmill Protocols

**A—NATIONAL EXERCISE AND HEART DISEASE
PROTOCOL FOR POORLY FIT SUBJECTS (69)**

Stage*	METs	Speed (mph)	% Grade
1	2.5	2	0
2	3.5	2	3.5
3	4.5	2	7.0
4	5.5	2	10.5
5	6.5	2	14.0
6	7.5	2	17.5
7	8.5	3	12.5
8	9.5	3	15.0
9	10.5	3	17.5

*Stage lasts three minutes.

**B—STANDARD BALKE PROTOCOL FOR
NORMAL, SEDENTARY SUBJECTS (11)**

Stage*	METs	Speed (mph)	% Grade
1	4.3	3	2.5
2	5.4	3	5.0
3	6.4	3	7.5
4	7.4	3	10.0
5	8.5	3	12.5
6	9.5	3	15.0
7	10.5	3	17.5
8	11.6	3	20.0
9	12.6	3	22.5

*Stage lasts two minutes.

**C—BRUCE PROTOCOL FOR YOUNG,
ACTIVE SUBJECTS (18)**

Stage*	METs	Speed (mph)	% Grade
1	5	1.7	10
2	7	2.5	12
3	9.5	3.4	14
4	13	4.2	16
5	16	5.0	18

*Stage lasts three minutes.

**D—ÅSTRAND AND RODAHL PROTOCOL
FOR VERY FIT SUBJECTS (7)**

Stage*	METs	Speed (mph)	% Grade
1	12.9/18	7/10	2.5
2	14.1/19.8	7/10	5.0
3	15.3/21.5	7/10	7.5
4	16.5/23.2	7/10	10.0
5	17.7/24.9	7/10	12.5

*Stage lasts two minutes; vigorous warm-up precedes test.



Treadmill

- Use natural activities
 - Walking and running
- Can accommodate a wide range of subjects
 - Least fit to most fit
- Involve increasing speed and/or grade
- Estimating $\text{VO}_{2\text{max}}$
 - Usually based on extrapolating submaximal HR
 - Could also be a single-stage test

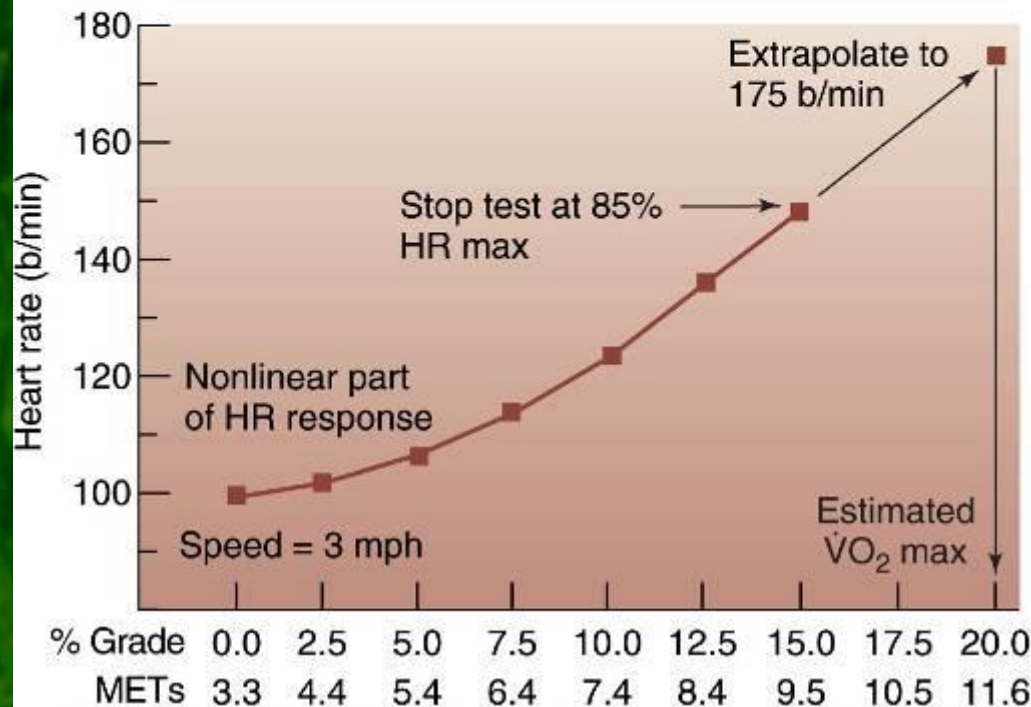


Estimation of $\dot{V}O_2$ Max From Submaximal Treadmill Test

Subject: male, age = 45 years
Estimated HR max = 175 b/min
85% HR max = 149 b/min

Data:

% grade	HR (b/min)
0	100
2.5	102
5.0	108
7.5	110
10.0	123
12.5	136
15.0	149



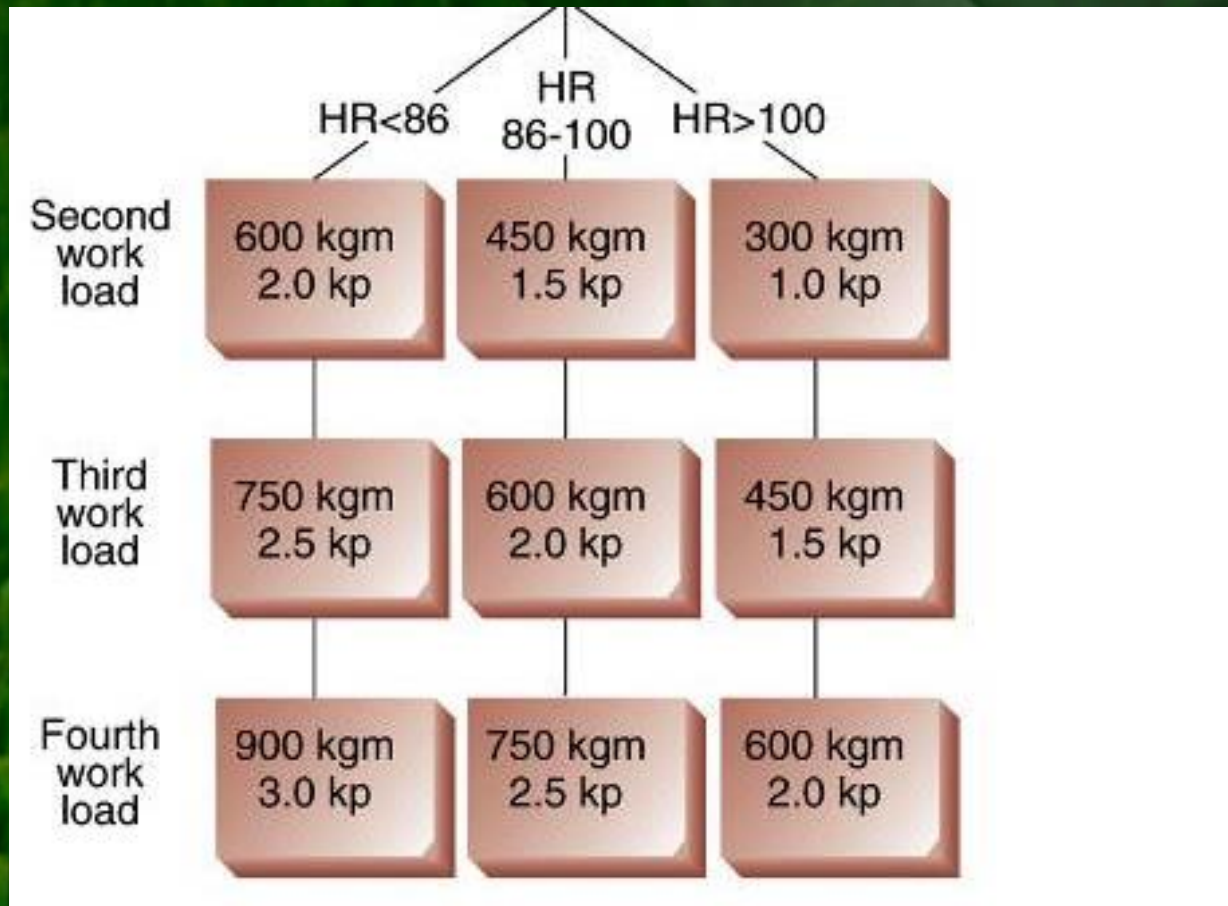


Cycle Ergometer

- Body weight is supported
 - Can accommodate subjects with orthopedic limitations
- Work rate depends on resistance and pedal rate
 - Generally, pedal rate is maintained, and resistance is increased
- Estimating $\text{VO}_{2\text{max}}$
 - Based on extrapolating submaximal HR during incremental test
 - YMCA protocol
 - From a single stage, 6-minute test
 - Åstrand and Ryhming nomogram



YMCA Protocol



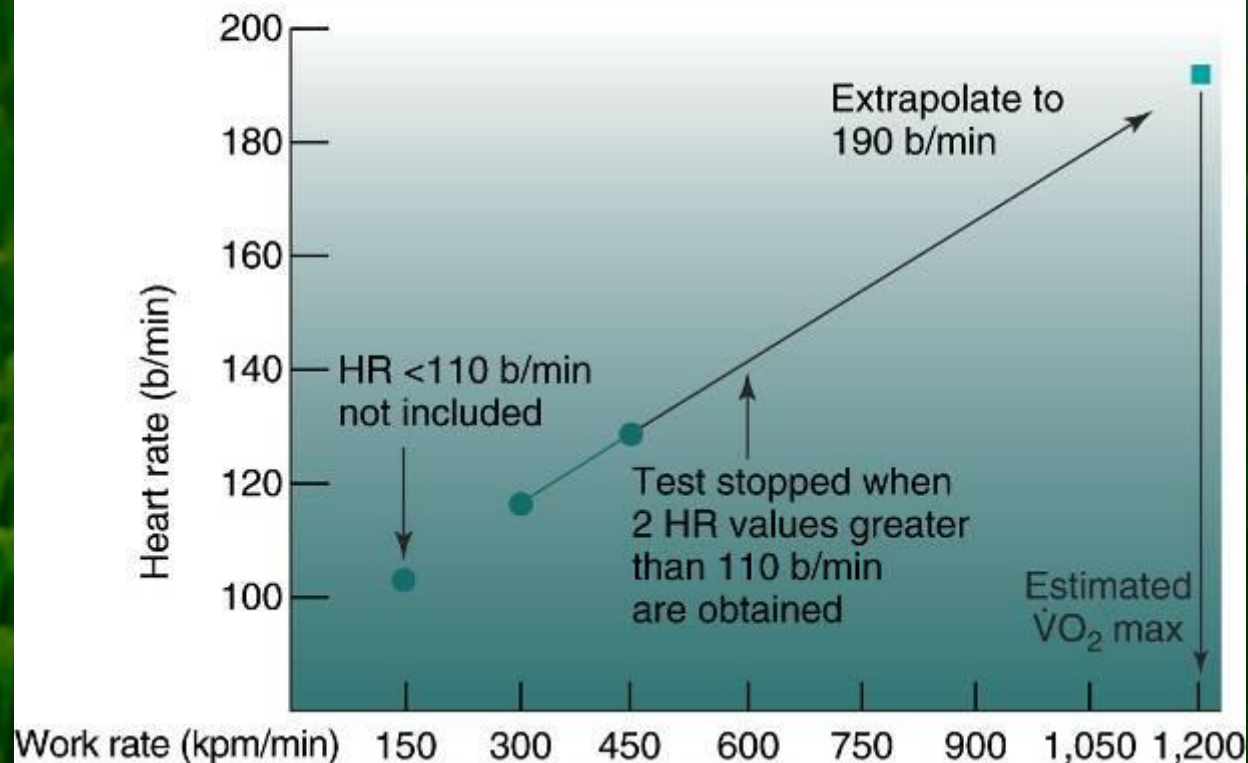


Example of the YMCA Protocol Used to Estimate VO_2 max

Subject: female, age = 30 years
Estimated HR max = 190 b/min
85% HR max = 162 b/min
Body weight = 60 kg

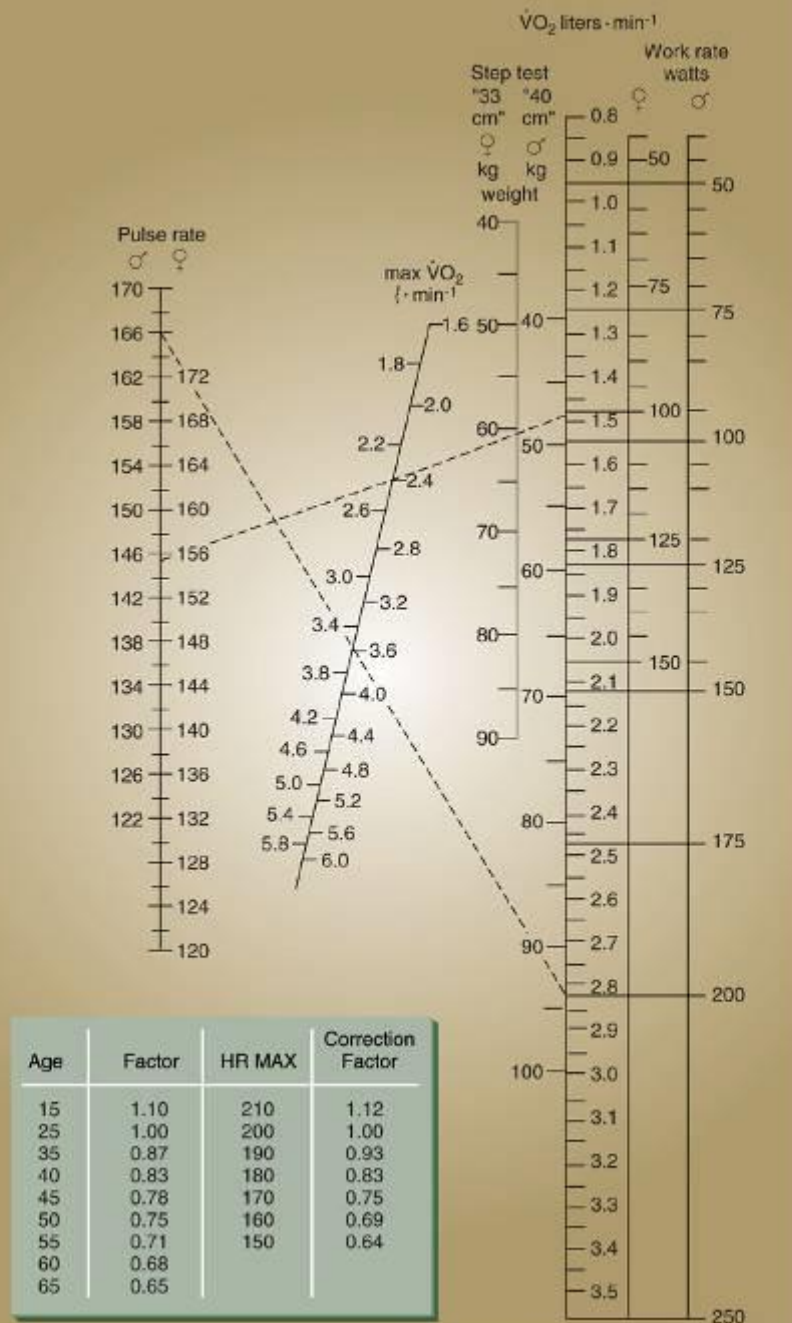
Data:

Work rate (kpm/min)	Heart rate (b/min)
150	103
300	115
450	128





Nomogram for Estimation of $\dot{V}O_2$ max from Submaximal HR





Step Test

- Simple, inexpensive equipment
- Protocols differ in:
 - Step height
 - Step rate
- Estimating $\text{VO}_{2\text{max}}$
 - Based on extrapolating submaximal HR
 - Can also use Åstrand and Ryhming nomogram

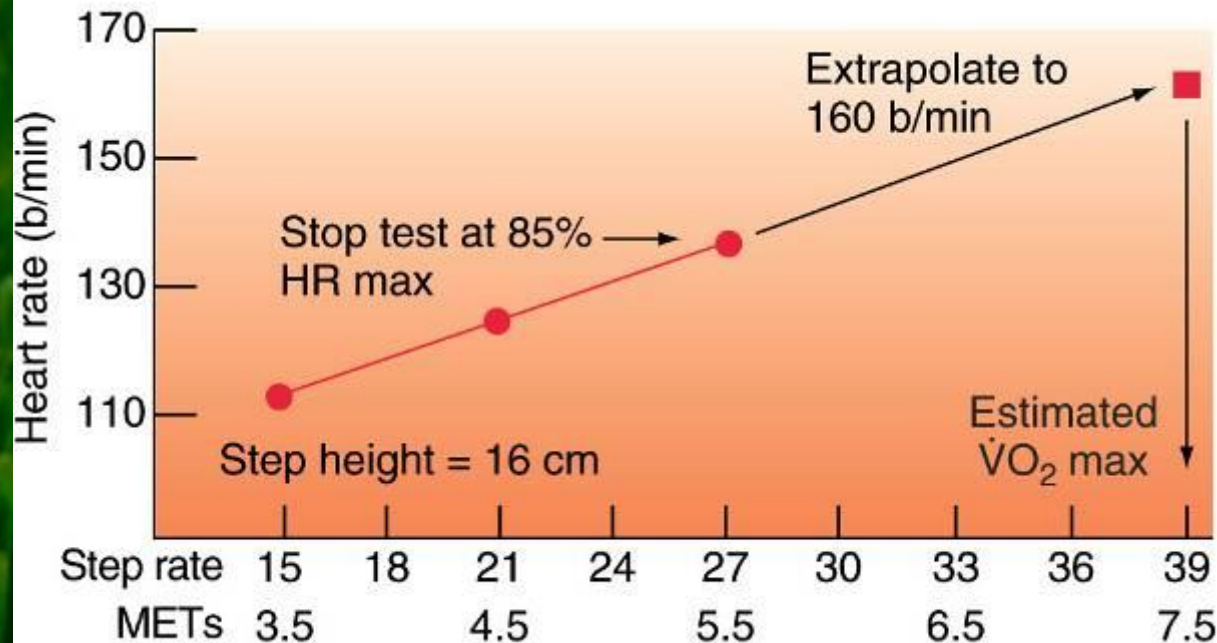


Predicting $\dot{V}O_2$ Max From Submaximal Step Test

Subject: female, age = 60 years
Estimated HR max = 160 b/min
85% HR max = 136 b/min

Data:

Step rate (lifts/min)	Heart rate (b/min)
15	112
21	124
27	136



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Thank you



Reference

Theory and Application to Fitness and Performance, 6th edition
Scott K. Powers & Edward T. Howley