



Exercise Testing The Simple Approach

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ACSM/ES



Steps to a Complete Exercise Test

- Pre-exercise evaluation
 - Equipment preparation
 - Patient preparation
 - Performing the exercise test
 - Post-exercise review
-



Pre-Exercise Evaluation

Medical History

Purpose of Cardiopulmonary Stress Test

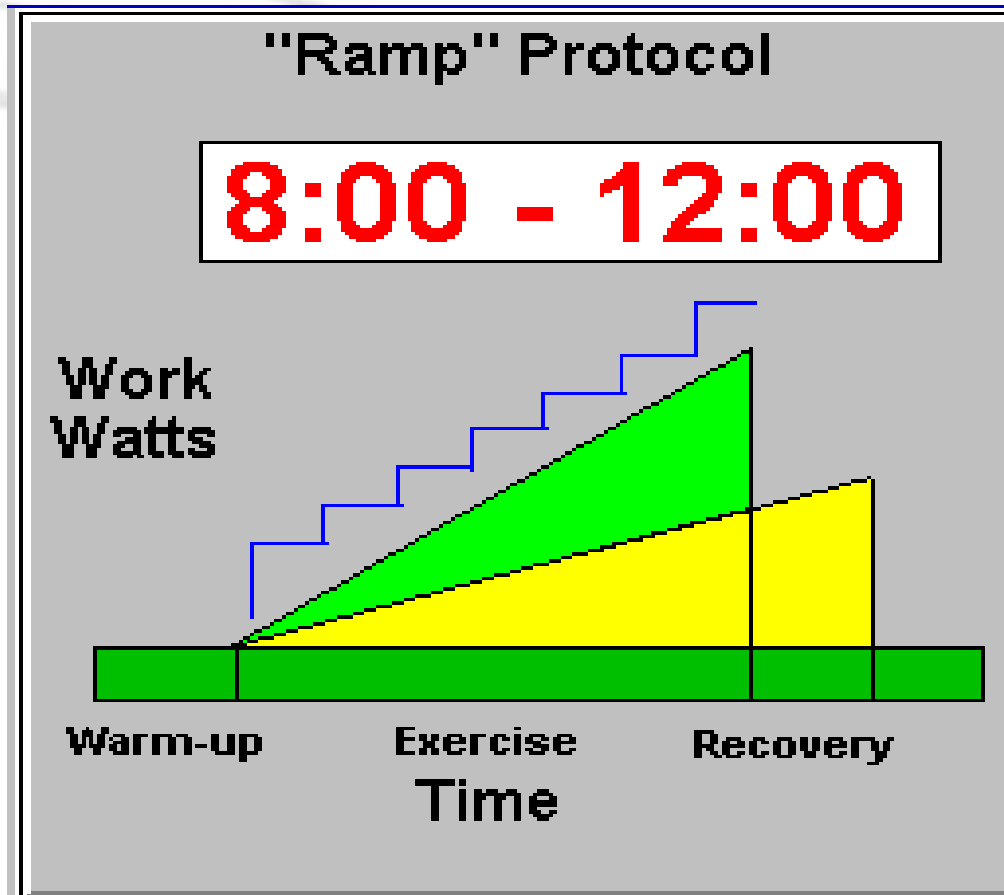
Medications

Hemodynamic status

Mode of Testing



Ideal Testing Duration





Protocol Selection

Metabolic Study --- , - Maxexercise mixing

VO₂ Help

Test Protocol

- CPX-1 [10 Watt Ramp]
- CPX-2 [15 Watt Ramp]
- CPX-2 [20 Watt Ramp]
- CPX-4 [25 Watt Ramp]
- ECG Treadmill Study
- Steady-State (ABG)
- Dilution Mask (REST)
- Canopy Study
- Elevated O₂ Exercise
- Ventilator Study

F1 Start Test

F4 Enhanced Spirometry

F2 **F8 Reports** **F10** **Esc**

- 1 Tabular Edit
- 2 Steady State
- 3 Summary Exercise
- 4 Anaerobic Threshold
- 5 Comments/Interpretation
- 6 Plot View
- 7 ECG Evaluation

Arrow Up/Down to select Protocol.



Predicted Values

$$(\text{Pred VO}_2 \text{ L/min} - 0.5 \text{ L/min}) \times 10$$

Reference Values —Bicycle, Bob - CPX Evaluation

Help

Work (max)	171	Watts	1045	KPM
VO2 (max)	2.472	L/min		
VO2/kg (max)	30	ml/kg		
HR (max)	163	BPM		
VE (max)	119	L/min		
VO2 (base)	0.231	L/min		
REE (base)	1458	Kcal/24 hr		

F5 Esc

F5 Print.

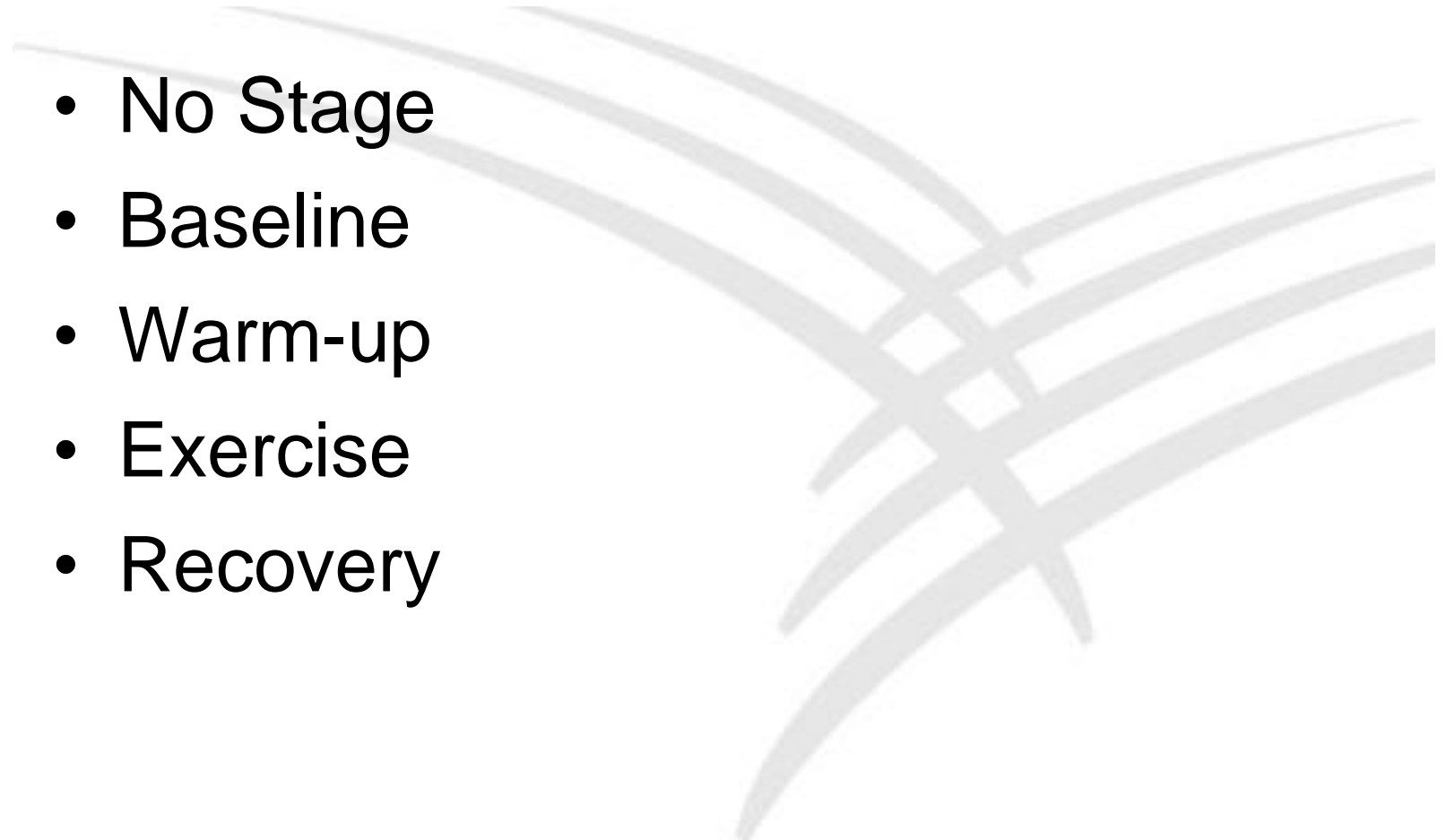


Equipment Preparation

- Proper warm-up for Vmax Metabolic Cart
 - Ergometer Calibration
 - Oximeter Calibration
 - Electrodes for ECG system
 - Blood Pressure Monitor
 - Emergency Equipment
-



Progression of the Exercise Test

- No Stage
 - Baseline
 - Warm-up
 - Exercise
 - Recovery
- 
-



No Stage

- Physiological data not saved
 - Patient Comfort
 - Data present
 - Roles identified
-



Baseline

- Physiological data saved
- Make sure parameters make sense

Respiratory Quotient

VO₂

Respiratory Rate

Heart Rate



Respiratory Quotient

- A reflection of substrate utilization
 - $V\text{CO}_2/V\text{O}_2$
 - RQ Range: 0.7 to 1.0 (at rest)
 - **0.70: Fat**
 - **1.00: Carbohydrate**
 - At rest generally 0.80 to 0.85
-



Baseline

Physiological data saved

Make sure parameters make sense

Respiratory Quotient

VO₂

Respiratory Rate

Heart Rate



Oxygen Consumption

Modified Haldane Equation

$$VO_2 \text{ (L/min)} = VE * (F_I O_2 - F_E O_2)$$



Oxygen Consumption

Absolute

L/min

Relative

ml/kg/min

Metabolic Equivalents

1 MET = 3.5 ml/kg/min



Baseline

Respiratory Quotient	(0.80-0.85)
VO ₂ ml/kg/min	(approx 3.5)
Respiratory Rate	(< 20)
Heart Rate	(<100)



Warm Up

Generally short in duration

Used to acclimatize the patient to the mode of testing

Can be loaded or unloaded activity

Exercise

Monitor Patient's response to exercise

HR

VO₂

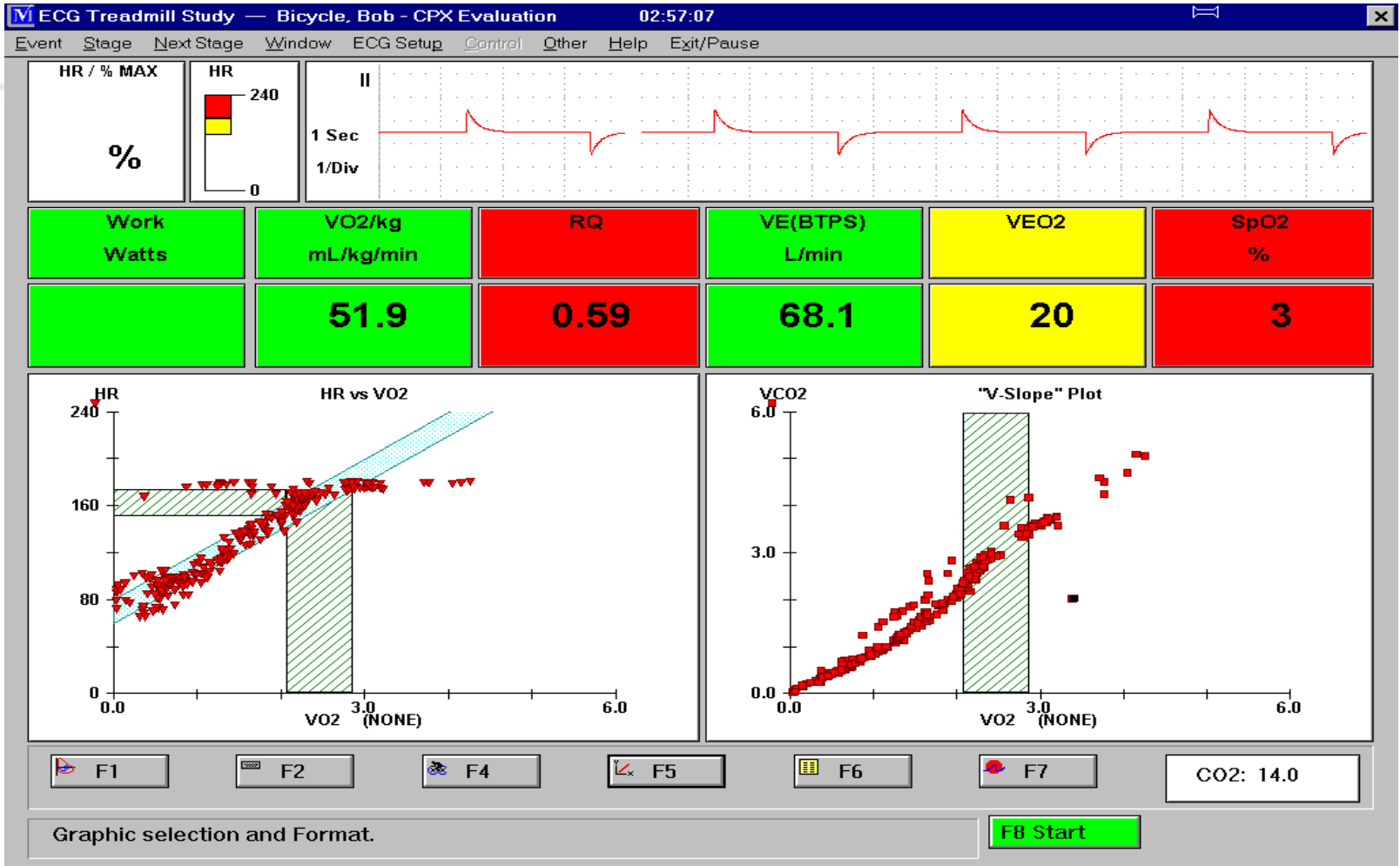
RQ

Understand Termination Criteria



Criteria of a Maximal Exercise Test

- Failure of HR to increase further with increasing workload
 - A plateau in oxygen uptake or failure to rise with increased workload
 - A RQ greater than 1.15
 - RPE of more than 17 (6-20 scale)
-





Absolute Indications for Terminating an Exercise Test

- Drop in Systolic Blood Pressure of > 10 mm Hg from baseline
 - ST or QRS changes such as excessive ST depression (>2 mm horizontal or downsloping)
 - Arrhythmias such as multifocal PVC's, SVT, or heart block
 - Fatigue, shortness of breath, wheezing, leg cramps, or claudication
 - Increasing chest pain
 - Hypertensive response (SBP >250 mm Hg or DBP > 115 mm HG)
-



Recovery

- Duration varies
 - Evaluate ECG activity....ectopy??
 - Ensure that metabolic parameters stabilize near pre-exercise values
-



Post-Exercise Review

Metabolic Study — Bicycle, Bob - CPX Evaluation

Help

Test Protocol

- CPX-1 (10 Watt Ramp)
- CPX-2 (15 Watt Ramp)
- CPX-2 (20 Watt Ramp)
- CPX-4 (25 Watt Ramp)
- ECG Treadmill Study**
- Steady-State (ABG)
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- Canopy Study
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F1 Start Test

F4 Enhanced Spirometry

1 Tabular Edit

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F2 F8 Reports F10 Esc

Arrow Up/Down to select Protocol.



Summary Graphic Edit

Exercise Summary Graphic Edit — Bicycle, Bob - CPX Evaluation

Graph: V02 vs TIME
Text: Exercise Profile

1 Baseline // 2 AT | 3 Peak \\\

The graph displays V02 (L/min) on the y-axis (0.0 to 6.0) against Time (min) on the x-axis (0 to 20). The profile shows a baseline at approximately 0.36 L/min, an AT point at 1.736 L/min at 09:09, and a peak at 4.275 L/min at 13:22. Shaded regions indicate these phases: Baseline (0-09:09), AT (09:09-13:22), and Peak (13:22-18:00).

	Time Sec HH:MM	Work Watts	V02/kg mL/kg/min	V02 L/min	VC02 L/min	RQ	VE(BTPS) L/min	Vt Liters	HR BPM	SpO2 %
Base	00:02:04	0	5.5	0.361	0.311	0.86	13.7	0.648	76	96
AT	00:09:09	163	26.3	1.736	1.762	1.02	41.9	2.491	138	95
Peak	00:13:22	273	64.9	4.275	5.065	1.18	136.0	4.280	181	78
Max	**:-8:**	278	0.0	0.000	0.000		136.0		181	0

AT Width (Sec): 20
Peak Width (Sec): ...

F1 F2 F3 Esc

Arrow Right/Left to select Region. Enter.



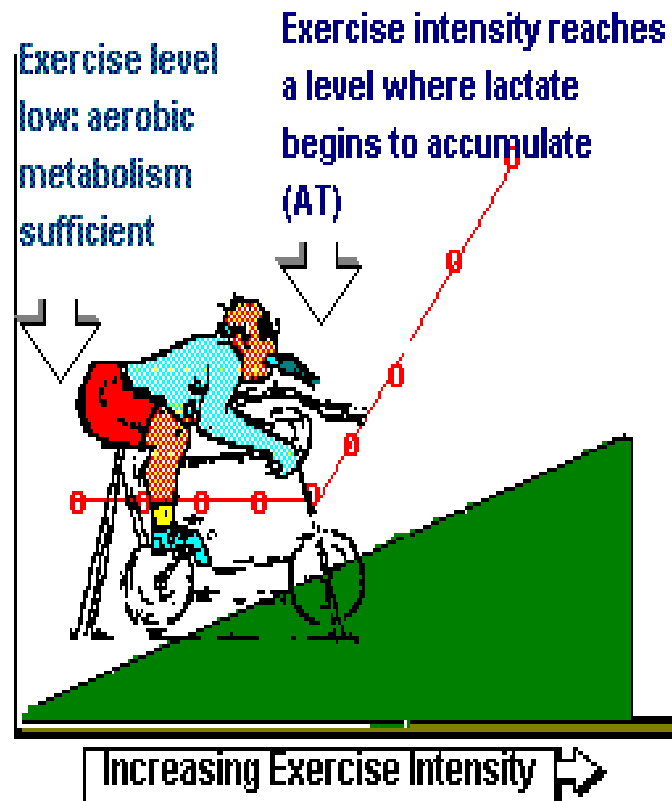
Anaerobic Threshold

Anaerobic Threshold (AT)

The highest exercise level or level of oxygen consumption ($\dot{V}O_2$) that can be sustained without developing metabolic acidosis.

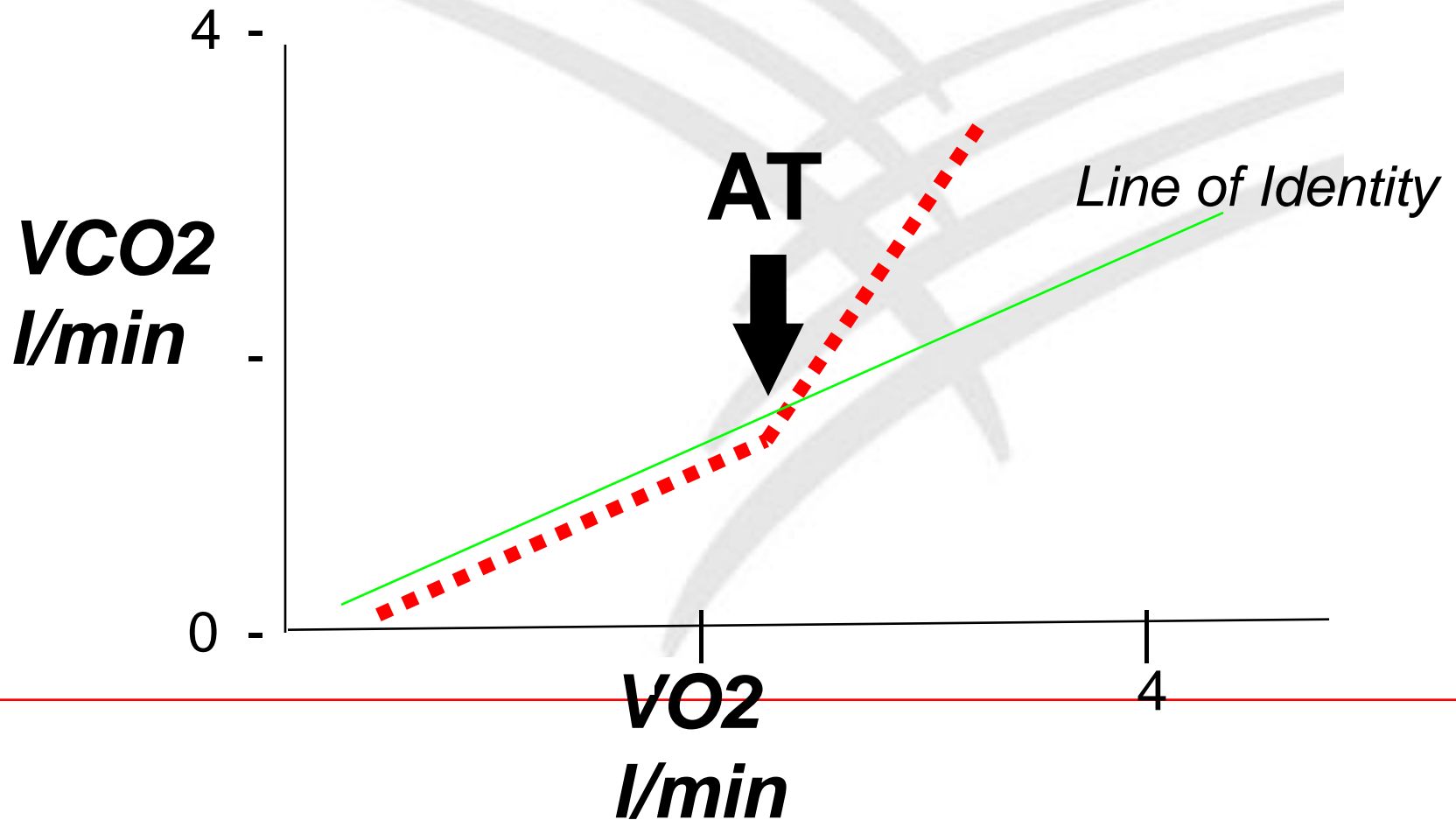
If one exercises at a low intensity, all of the demands of that exercise may be met through aerobic metabolism (with O_2). As the intensity increases, there is a point at which all the demands cannot be met aerobically, and anaerobic metabolism (without O_2) starts to contribute. The by-product of anaerobic metabolism is lactic acid. Initially, the body may "clear" (utilize) this lactate. The point at which it accumulates and begins to rise is the AT.

$O-O$ = Lactic Acid





V-Slope Method of AT





Anaerobic Threshold Graphic Edit — Bicycle, Bob - CPX Evaluation

Graph
 V-Slope(VCO2 vs V02)
 AT (Dual Criteria)

Text
 "V-Slope" Display
 OBLA Display

10 Second Average

Manual AT Point selected

Slope 1 1.05

Slope 2 1.74

	% Peak	% Ref
V02	55	70

1 Lower **2 AT** **3 Upper**

	Time Sec HH:MM	Work Watts	V02/kg mL/kg/min	V02 L/min	VCO2 L/min	RQ	VE(BTPS) L/min	HR BPM	VE02	VEC02
AT	00:09:09	163	26.3	1.736	1.762	1.02	41.9	138	24	24

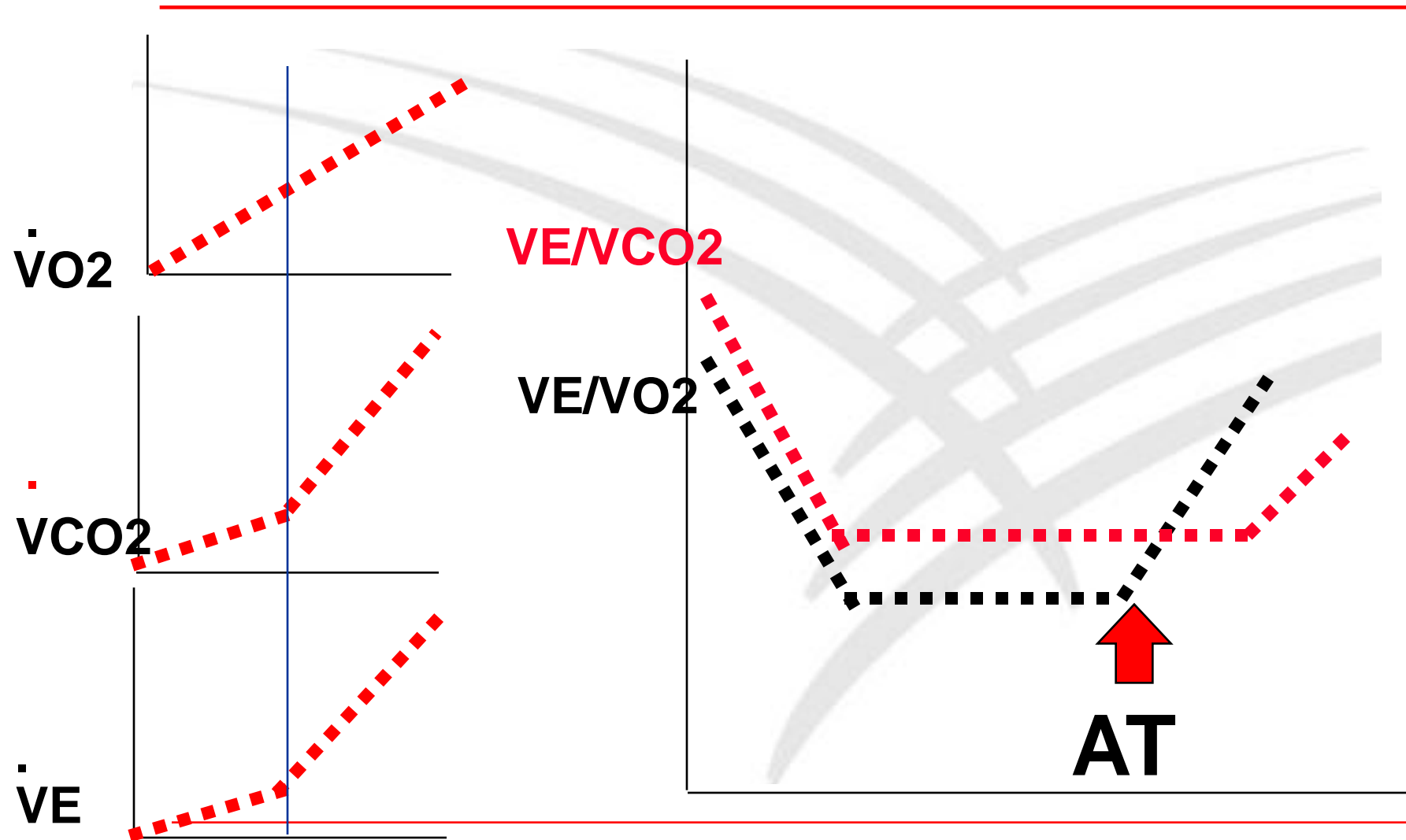
AT Width (Sec) 20

F1 F2 F3 Grid Print Copy Paste Esc

Arrow Up/Down to select Graph. Enter to Format.



Dual Criteria AT Method





Anaerobic Threshold Graphic Edit — Bicycle, Bob - CPX Evaluation

2 AT

Graph: AT (Dual Criteria), AT (PetO2/PetCO2)

Text: "V-Slope" Display, OBLA Display

10 Second Average

Manual AT Point selected

Slope 1 1.05

Slope 2 1.74

	% Peak	% Ref
V02	55	70

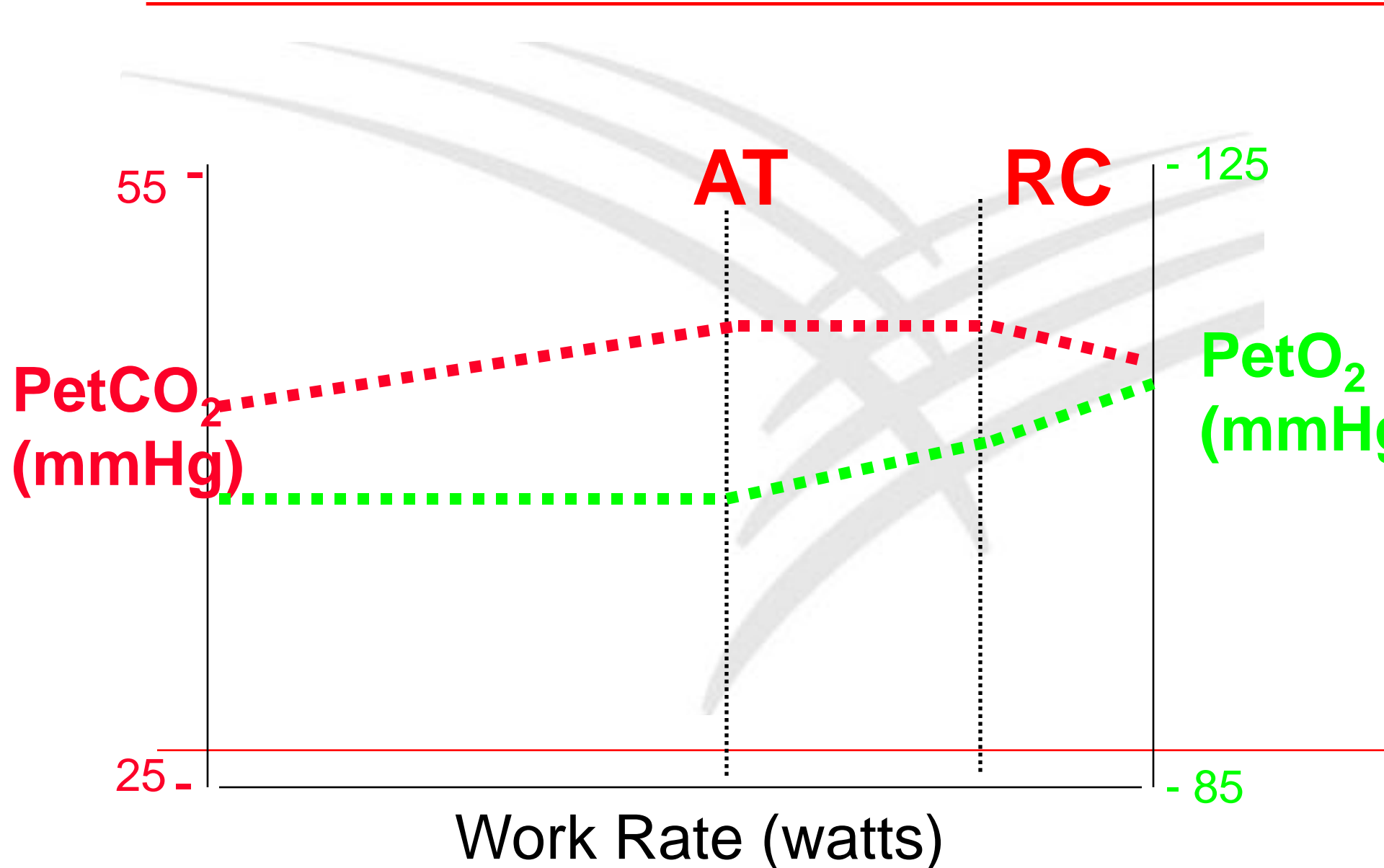
	Time Sec HH:MM	Work Watts	V02/kg mL/kg/min	V02 L/min	VC02 L/min	RQ	VE(BTPS) L/min	HR BPM	VE02	VEC02
AT	00:09:09	163	26.3	1.736	1.762	1.02	41.9	138	24	24

AT Width (Sec) 20

Arrow Up/Down to select Graph. Enter to Format.



PetO₂ and PetCO₂ : AT





Anaerobic Threshold Graphic Edit — Bicycle, Bob - CPX Evaluation

Graph
 AT (PetO2/PetCO2)
 RC Plot

Text
 "V-Slope" Display
 OBLA Display

10 Second Average

Manual AT Point selected

Slope 1 1.05

Slope 2 1.74

	% Peak	% Ref
VO2	55	70

2 AT

	Time Sec HH:MM	Work Watts	VO2/kg mL/kg/min	VO2 L/min	VC02 L/min	RQ	VE(BTPS) L/min	HR BPM	VE02	VEC02
AT	00:09:09	163	26.3	1.736	1.762	1.02	41.9	138	24	24

AT Width (Sec) 20

Arrow Up/Down to select Graph. Enter to Format.



Post-Exercise Review

- Breathing Reserve:

$$[(MVV - V_{e_{max}}) / MVV] * 100$$

Normal: 20-40%

Lower: Pulmonary Limitation



Post-Exercise Review

- Slope

VO_2/WR : Cardiovascular disease

HR/VO_2 : Cardiovascular disease


VE/VO_2 : Pulmonary Disease

VE/CO_2 : Pulmonary Disease







Post-Exercise Review

Slope Values —Bicycle, Bob - CPX Evaluation

 Help

	Ref	Observed
VO ₂ /Work	10.3	<input type="text" value="9.5"/>
HR/VO ₂	3.8	<input type="text" value="3.0"/>
VE/VO ₂	27.5	<input type="text" value="18.6"/>
VE/VC0 ₂	25.1	<input type="text" value="21.2"/>

 F3  F5  F8  Esc

Enter Work VO₂ Slope (0-50).



Interpreting the Results

	Normal	Pulmonary	Cardiac	Obesity	Malingering	Decon.
VO₂ (R)	200-300 ml	elevated	elevated	elevated	normal	normal
VO₂ (M)	>80% Pred	decreased	decreased	decreased	decreased	decreased
HR (R)	65 - 80	elevated	elevated	elevated	normal	elevated
HR (M)	>80% Pred	decreased	normal	normal	decreased	normal
VE (R)	6 – 8 l/m	elevated	elevated	elevated	normal	normal
VE (M)	>70% Pred	>70% Pred	normal	normal	decreased	decreased



Interpreting the Results

	Normal	Pulmonary	Cardiac	Obesity	Malingering	Decon.
RQ	> 1.1	elevated	decreased	normal	normal	normal
SpO2	< 4% drop	decreased	normal	normal	normal	normal
BR	20 - 30 %	< 20 %	elevated	decreased	elevated	decreased
HRR	< 10 bpm	elevated	low	decreased	elevated	decreased
VE/VO2	25 - 35	elevated	normal	increased	normal	normal
VE/CO2	25 - 35	elevated	normal	increased	normal	normal



Interpreting the Results

	Normal	Pulmonary	Cardiac	Obesity	Maligner	Decon.
VD/Vt	<.3 and falls	elevated	normal	normal	normal	normal
O2 Pulse	5 @ rest increases	normal little change	decreased	decreased	normal	normal

Exercise Testing: The Simple Approach



- Safe
- Effective
- Reasonable
- Prudent