Cardiopulmonary Exercise Testing (CPET) & Evaluating Functional Capacity

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History

- CPET for a Clinical Trial in CFS
- Research and Publication
- Disability Evaluation
- Pacific Fatigue Laboratory
  - Research and clinical laboratory focused on measuring function in patients with fatigue-related disorders

What Should be Measured?

- What is work?
- Work Capacity
  - The ability to sustain work for a 40 hour work week
- Physical Demands vs Physiological Function
- Effort

Medico-legal Assessments/ Validity and Reliability

- Functional Capacity Evaluations (FCE)
  - Provide little scientific evidence for predicting future work performance.
  - Problems with extrapolating data from short term testing to an 8 hour work day.
  - Fails to assess the impact of the test itself, APTA.
  - Objective physiological measures such as HR and BP and pulmonary analysis are usually not taken.
  - Does not take diagnosis into account

Medico-legal Assessments/ Validity and Reliability

- Cardiopulmonary Exercise Testing
  - Measures aerobic capacity
  - Measures work output
  - Measures ability to sustain work
  - Measures exercise/work limitation and determines which system limits function
  - Objectively measures impairment/disability

CPET: What is it?

- Measuring the cardiovascular, pulmonary and metabolic responses at rest and during exercise.
- Key measures:
  - Peak Oxygen Consumption (VO_2)
  - Anaerobic Threshold (AT)
  - Heart Rate (HR)
  - Blood Pressure (BP)
  - Ventilation (VE)

Uses for Cardiopulmonary Exercise Testing (CPET)

- Diagnostic Tool to Evaluate Cardiac, Vascular, Pulmonary and Metabolic Disorders
- Disability Evaluation
- Clinical Trial Outcome Measure
- Fitness Assessment & Exercise Prescription

What is a good FCE? Cardiopulmonary Exercise Testing (CPET): The Gold Standard

- American College of Cardiology/American Heart Association (ACC/AHA)
- American Thoracic Society/American College of Chest Physicians (ATS/ACCP)
- Social Security Administration (SSA)
- American Physical Therapy Association (APTA)
- American Medical Association (AMA)
- American College of Sports Medicine (ACSM)

ACC/AHA 2002 Guideline Update for Exercise Testing

- *"Direct measures of VO2 are reliable and reproducible and provide the most accurate assessment of functional capacity."* Page 31.

American Thoracic Society/
American College of Chest Physicians

ATS/ACCP Statement on Cardiopulmonary Exercise Testing

- *"CPET complements other clinical and diagnostic modalities, and by directly quantitating work capacity improves the diagnostic accuracy of impairment/disability evaluation."*

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Social Security Administration

"When the results of tests with measurement of oxygen uptake are available, every reasonable effort should be made to obtain them.

"How does an ETT with measurement of maximal or peak oxygen uptake (VO2) differ from other ETTs?

While ETTs without measurement of VO2 provide only an estimate of aerobic capacity, measured maximal or peak oxygen uptake provides an accurate measurement of aerobic capacity, which is often expressed in METs (metabolic equivalents)."

http://www.socialsecurity.gov/disability/professionals/bluebook/4.00-Cardiovascular-Adult.htm

References

- Wasserman, K., Hansen, J., Sue, D., Whipp, B., & Casaburi, R. (1994). *Principles of Exercise Testing and Interpretation, 2nd Edition.* Williams and Wilkins.
- Cocchiarella L and Anderson BJ (2001). *Guides to the Evaluation of Permanent Impairment*, 5th Ed. Chicago: American Medical Association.
- American College of Sports Medicine. (2010). *ACSM's Guidelines for Exercise Testing and Prescription 8th Edition.* Philadelphia, PA: Lippincott, Williams and Wilkins.
- http://www.socialsecurity.gov/disability/professionals/bluebook/4.00-Cardiovascular-Adult.htm

Evaluating Disabling Fatigue Based on CPET

- Respiratory Impairment - AMA
  - Peak VO_2
- Circulatory Failure/NYHA
  - Peak VO_2
  - VO_2 at the Anaerobic Threshold
- Functional Aerobic Impairment
  - Percent predicted VO_2

AMA Disability Classification

Class 1 0% No Impairment of the Whole Person	Class 2 10-25% Mild Impairment of the Whole Person	Class 3 30-45% Moderate Impairment of the Whole Person	Class 4 50-100% Severe Impairment of the Whole Person
FVC ≥ 80% of predicted, *and* FEV_1 ≥ 80% of predicted, *and* FEV_1/FVC ≥ 70% *and* **OR** > 25 ml/(kg•min)	FVC between 60% and 79% of predicted, *or* FEV_1 between 60% and 79% of predicted, *or* FEV_1/FVC between 60% and 69%. **OR** Between 20 and 25 ml/(kg•min)	FVC between 51% and 59% of predicted, *or* FEV_1 between 41% and 59% of predicted, *or* FEV_1/FVC between 41% and 59%. **OR** Between 15 and 20 ml/(kg•min)	FVC ≤ 50% of predicted, *and* FEV_1 ≤ 40% of predicted, *and* FEV_1/FVC ≤ 40%. **OR** < 15 ml/(kg•min)

AMA's Guidelines for the Evaluation of Permanent Impairment, 5th Ed.

Circulatory Failure/NYHA

Severity of Impairment	Functional Class	VO_2 Max ml/kg/min	VO_2 AT ml/kg/min
None to Mild	A	>20	>14
Mild to Moderate	B	16-20	11-14
Moderate to Severe	C	10-16	8-11
Severe	D	<10	<8

Modified from: Weber and Janicki, Cardiopulmonary Exercise Testing, W.B. Saunders, Philadelphia, 1986

Subclassifying CFS Using Impairment Ratings

American Medical Association Guidelines

Severity of Impairment	Peak VO_2 (ml/kg/mi)	# of patients	Group VO_2 (ml/kg/min)	Predicted VO_2 (ml/kg/min)
None to Mild	>25	33	29.5 ± 0.9	38.6 ± 1.2
Mild to Mod	20-25	72	22.1 ± 0.2	35.3 ± 0.8
Mod to Severe	15-20	**77**	17.2 ± 0.2	34.2 ± 0.6
Severe	<15	**21**	12.1 ± 0.5	33.0 ± 0.6

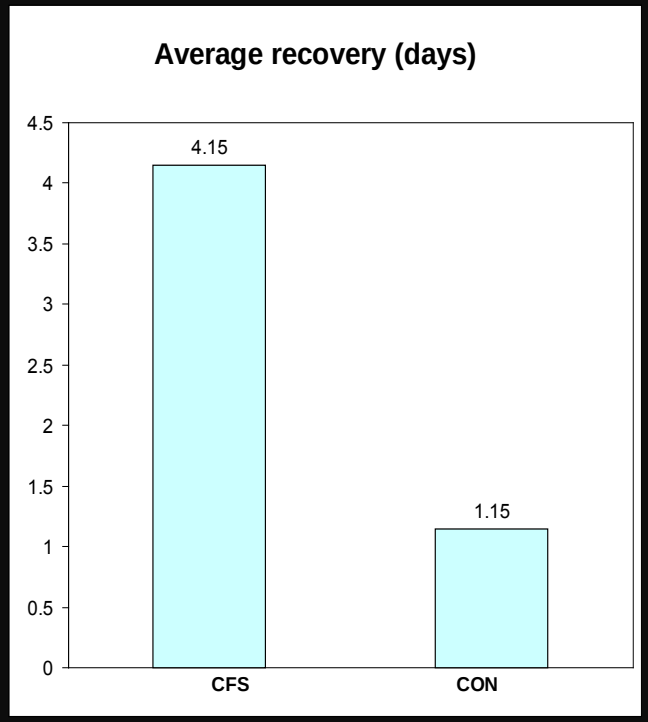
VanNess et al, 2003

Post Exertional Malaise (PEM)

- Canadian Case Definition for CFS
- PEM & Cardiopulmonary Exercise Testing

Maximal exercise “induces” a controlled and defined post-exertional state

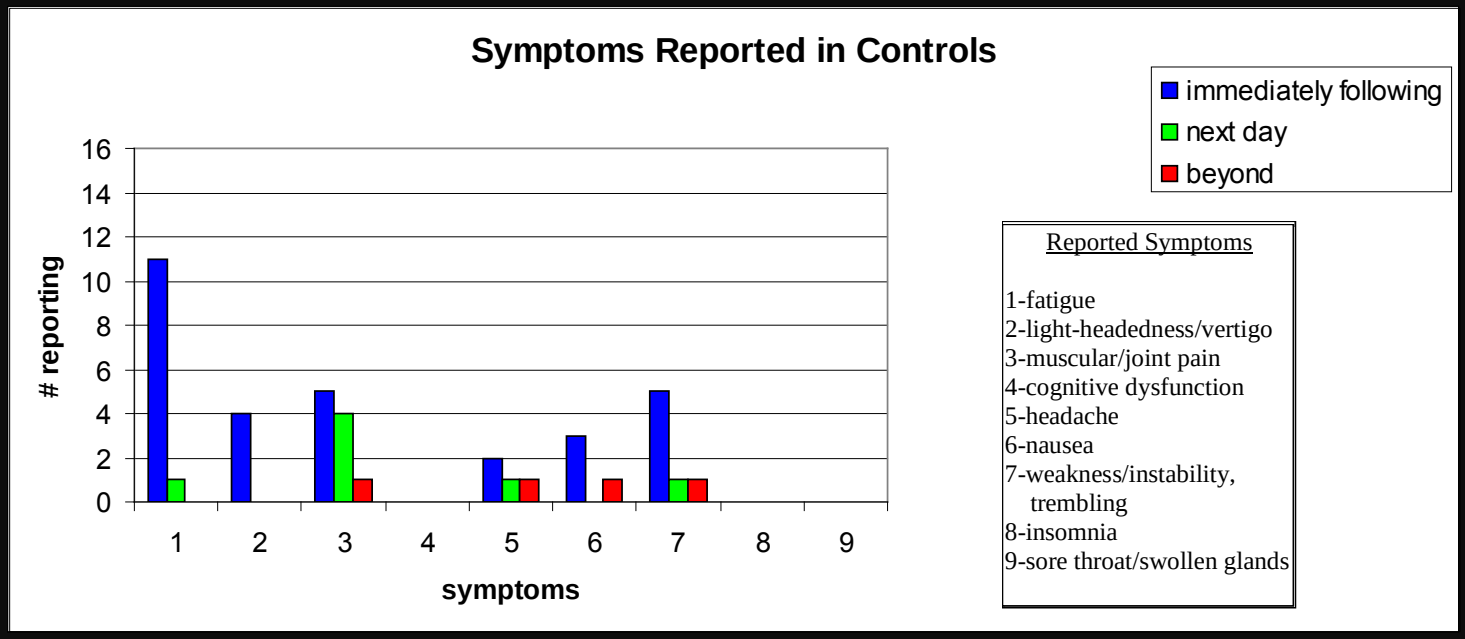
Days to Recovery



- Within 24 hours, *85% of CON indicated full recovery in contrast to 0% of CFS patients*.
- The remaining 15% of CON recovered within 48 hours.
- Only one CFS patient recovered within 48 hours.

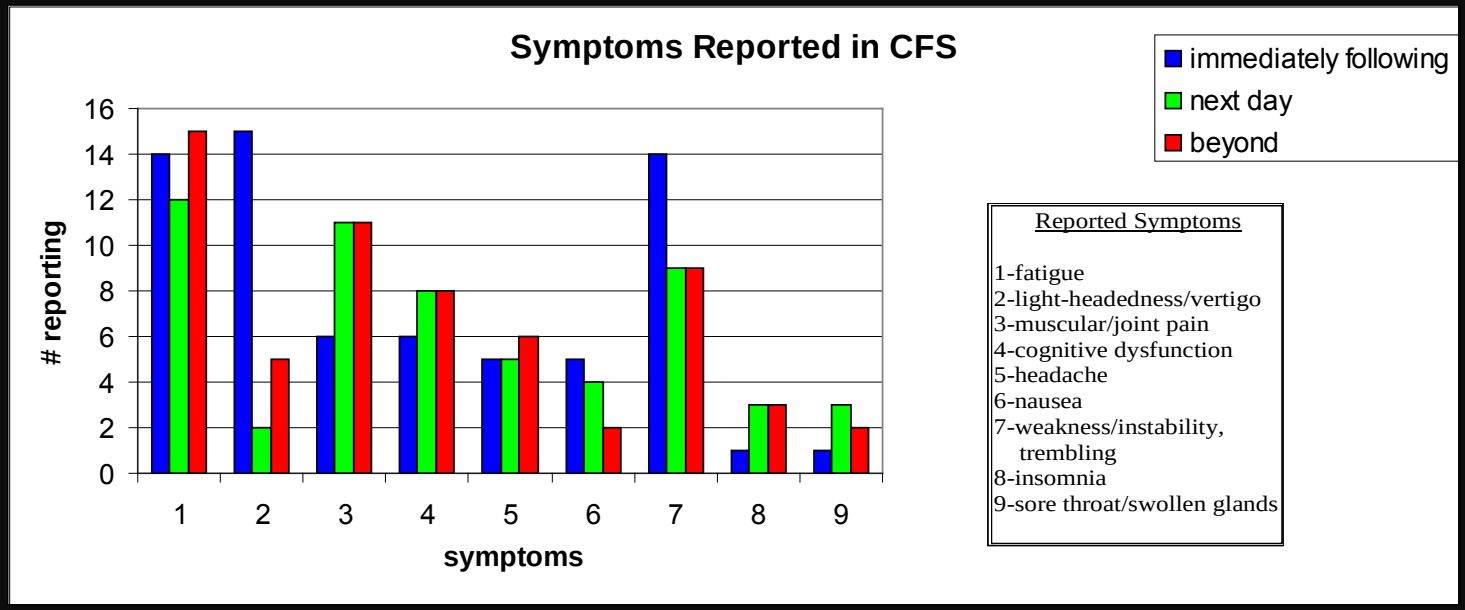
Stevens et al, 2007

Control Symptoms



Stevens et al, 2007

CFS Symptoms



Stevens et al, 2007

Test-Retest Strategy

Test 1

Test 2

Pre-testing

"Post-Exertional State"

Test, Retest: *"Stevens' Protocol"*

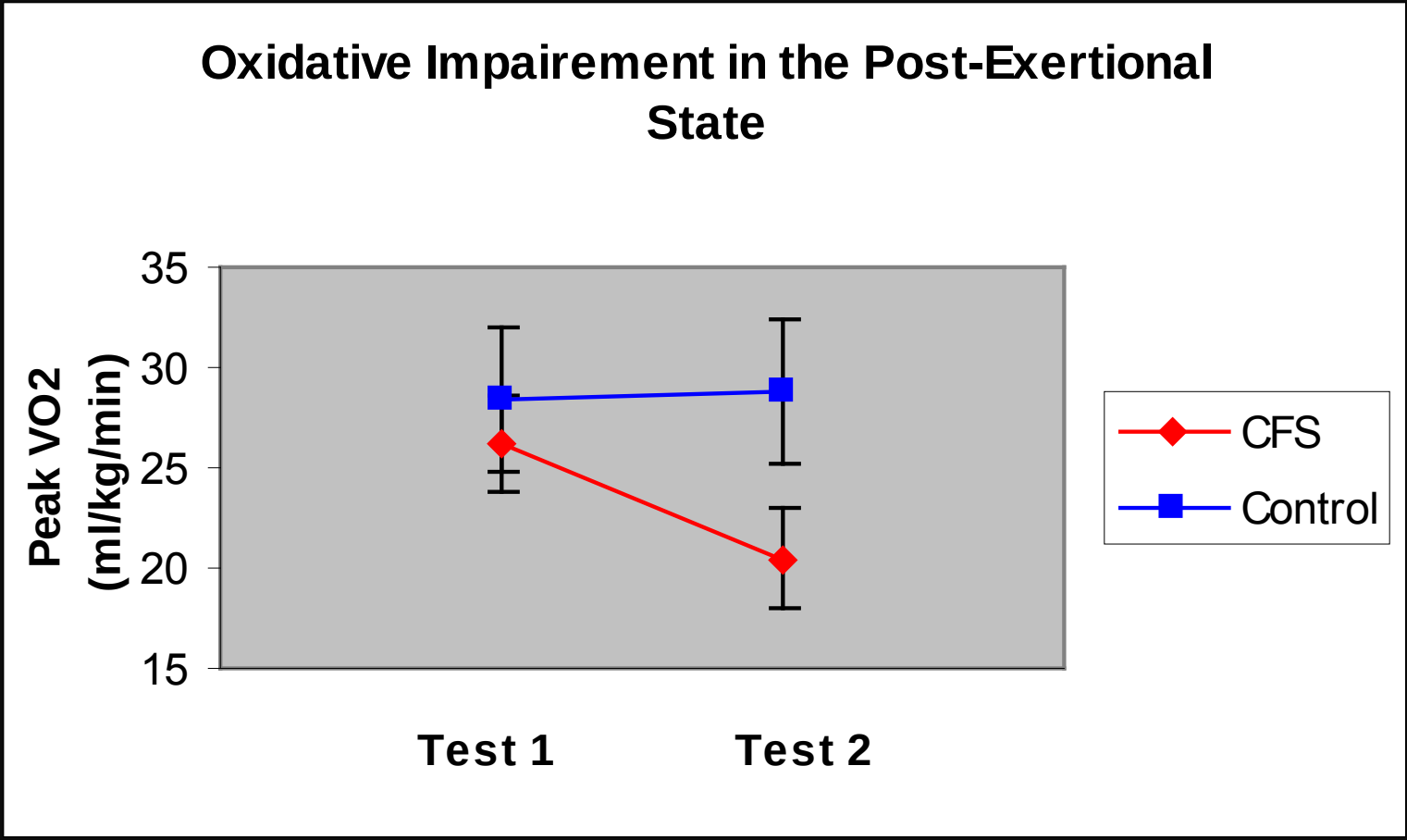
- New way to look at fatigue through the prism of post exertional maliase.
- It is the best technique to capture the delayed effects of physical stress.
- *"One test is not enough"*. Severe impairment is the exception

Test, Re-test

	CONTROL		CFS	
	Test 1	Test 2 (v)	Test 1	Test 2 (v)
Peak VO2	28.4	28.9 (2%)	26.2	20.5 (↓22%)
VO2 at AT	17.5	18.0 (3%)	15.0	11.0 (↓27%)
Peak RQ	1.19	1.21 (2%)	1.15	1.09 (5%)
HR%	94.8	97.6 (3%)	87.0	87.8 (1%)

VanNess et al, 2007

Metabolic Dysfunction



Justification

- Single test describes physical function in a rested state and creates the stressor necessary to induce PEM.
- The second test measures the patient in the PEM state.
- Allows for the determination of ***metabolic dysfunction***.

Top Rebuttal Questions

- Effort
- Deconditioning
- Obesity

The Florence Nightingale Effect

- Florence's behavior in those years of illness prejudiced severely her reputation and achievements
- Influenced by the failure to diagnose an organic illness, biographers suggest that she lied about her health for her own ends
- It is a sad irony that the founder of modern nursing should be remembered as history's most famous invalid and possibly its most successful malingerer

Assessment of Maximal Effort

2 of the below criteria must be met for the test to meet criteria for maximal effort.

Maximal Test Criteria	**Test 1**	**Test 2**	**Criteria Met Yes/No**
RQ ≥ 1.1	1.33	1.22	**Yes**
RPE ≥ 17	20	19	**Yes**
Plateau in VO2	Yes	Yes	**Yes**
HR ≥ 90% of pred	Yes	Yes	**Yes**
Tester Determination	Yes	Yes	**Yes**

Deconditioning

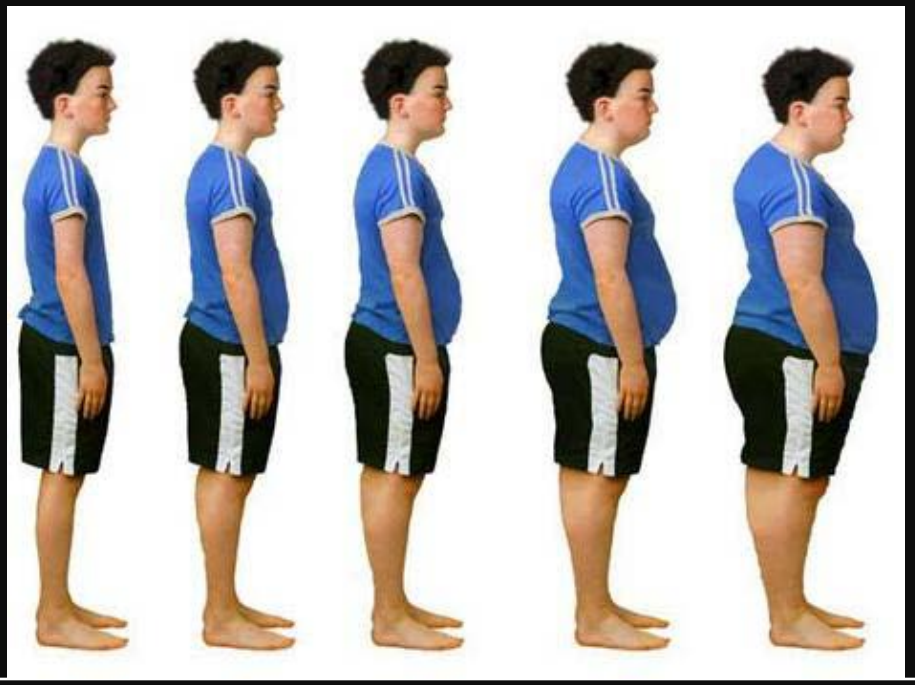
- Reproducibility of two day testing

Reproducibility of CPET in Other Fatiguing Illnesses

- Other pathologies: Reproducible CPET results
  - Pulmonary Hypertension
  - End Stage Renal Disease
  - Cystic Fibrosis
  - Heart failure
  - Lung diseases
- Even in patients with severe functional limitations exercise testing is reproducible.
- ***Failure to reproduce documents metabolic dysfunction***

Obestiy in US

- 67% Americans are obese yet are able to work a 40 hour week.



Conclusions

- CPET is the Gold Standard for measuring functional capacity.
- A single test is often inadequate to describe fluctuations in function due to fatigue or pain.
- Test-retest reductions provide objective evidence of metabolic dysfunction.
- CPET objectively documents the fluctuations experienced by patients.

FCE References

1. PM King, N Tuckwell, TE Barrett . A critical review of fuctional capacity evaluations. Physical Therapy, 1998 - physther.net.

2. Guidelines: Occupational Health Physical Therapy: Evaluating Functional Capacity (BOD G11-01-07-11) Alexandria, VA: American Physical Therapy Association, 2001.

3. American Thoracic Society/American College of Chest Physicians. ATS/ACCP statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med 2003;167:211–277.

4. SSR 99-2p: Policy Interpretation Ruling Titles II and XVI: Evaluating Cases Involving Chronic Fatigue Syndrome (CFS).

5. ACC/AHA Guidelines for Exercise Testing. JACC (1997) 30;1: 260-311.

Overtraining Syndrome

Sustained reductions in performance often accompanied by other biochemical, physiological and psychological changes

“The specific disease doctrine is the grand refuge of weak, uncultured, unstable minds, such as now rule in the medical profession. There are no specific diseases; there are specific disease conditions.”
Florence Nightingale, 1860