The Challenge of Keeping the Science in the Exercise: A Cardiac Rehab Perspective

Jeff Soukup, PhD, CEP

Disclosures

- No Disclosures

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Objectives

- To share my perspective on why I believe we need to keep the science of exercise physiology in cardiac rehab
- To review some of the research that suggests there is opportunity to be more scientific with our approach to exercise
- To review current statements by the ACSM, AHA, AACVPR and others that suggest that exercise testing needs to be part of the exercise prescriptive process
- To discuss shortcomings of the 6MWT and RHR +20 Ex Rx process

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My Opinions & Perspective

- I have heard…
  - there is a suggestion that cardiac rehab should be moving toward little or no monitoring of its nduring exercise in the out-patient setting

Little or no monitoring…my thoughts

<u>PRO</u>

1. fosters independence
2. improves productivity
3. decreases costs
4. Improved patient comfort

<u>CON</u>

1. eliminates knowledge of cardiac rate and rhythm
2. requires other method for assessing cardiac frequency, regularity
3. creates more cautious approach toward exercise
4. DECREASES PROFESSIONALISM

My Opinions & Perspective

- I have heard…
  - that exercise intensity should be based on your ability to talk while exercising

- Physiologic considerations of the talk test…
  - the disruption in the ability to talk while exercising occurs at or near the ventilatory anaerobic threshold (VAT) as non-metabolic CO_2 is produced from H^+ excess when conversion of pyruvic acid to lactic acid occurs
  - stimulates an increase in the ventilatory requirement to the point that the amount of air required for talking competes with the amount of air required for pulmonary ventilation and both are compromised
  - VAT occurs between 40-60% of VO_2 Reserve in the normal and non-CHF cardiac population
  - This training intensity is sufficient to provide for improvements in cardiorespiratory endurance

VARIATIONS IN EXERCISE INTENSITY DO NOT ALTER CHANGES IN PEAK OXYGEN UPTAKE OR THE OXYGEN UPTAKE EFFICIENCY SLOPE DURING MODERATE CONTINUOUS TRAINING IN OUT-PATIENT CARDIAC REHABILITATION

[1]Colleen Daubert, [1]Jeffrey Soukup, [2]Amanda Kosmata, and [3]Beth Ann Scott. [1]Intensive Cardiac Rehabilitation Department, New Hanover Regional Medical Center, Wilmington, NC, [2]Cardiac Rehabilitation Department, Alleghany Health Network, Pittsburgh, PA. [3]Cardiopulmonary Services, Appalachian Regional Heathcare System, Boone NC,

Table 3. Comparison of Pre and Post Program CPET Measures

	Pre-Program		Post-Program	
	MIE (n=36)	VIE (n=54)	MIE (n=36)	VIE (n=54)
Test Duration (min)	9.9 ± 1.1	9.6 ± 1.9	11.2 ± 3.4*	11.8 ± 2.7*
Peak HR ($beats \cdot min^{-1}$)	143.0 ± 21.7	136.6 ± 17.7	142.6 ± 27.0	143.4 ± 22.0*
Percent of Max HR (%)	93.6 ± 13.0	87.4 ± 10.6†	93.3 ± 16.1	91.9 ± 13.1*
Peak RER	1.15 ± 0.16	1.17 ± 0.13	1.17 ± 0.12	1.17 ± 0.10
Peak VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	23.5 ± 5.6	22.8 ± 4.6	26.0 ± 8.25*	26.3 ± 6.7*
VO_2 at VAT ($mL \cdot kg^{-1} \cdot min^{-1}$)	14.5 ± 3.5	14.4 ± 2.8	16.0 ± 4.9*	16.0 ± 4.0*
OUES ($ml \cdot min^{-1}/\log VE \cdot min^{-1}$)	2114.9 ± 606.3	2048.4 ± 492.8	2295.8 ± 740.4*	2263.4 ± 601.7*

VO2 Reserve for MIE = ~51.4%
VO2 Reserve for VIE = ~71.9%

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But Moderate Continuous Training May not be Optimal

- …here comes High Intensity Interval Training (HIIT)

- HIIT may provide greater improvement than MCT in:
  - Cardiorespiratory endurance
  - Preservation of coronary artery lumen diameter
  - Anti-inflammatory responses
  - LV geometry and performance

- Has been shown to be safe in high-risk populations such as those with HF

- And has made ACSM’s GETP 10 Exercise Training Considerations for Outpatient CR

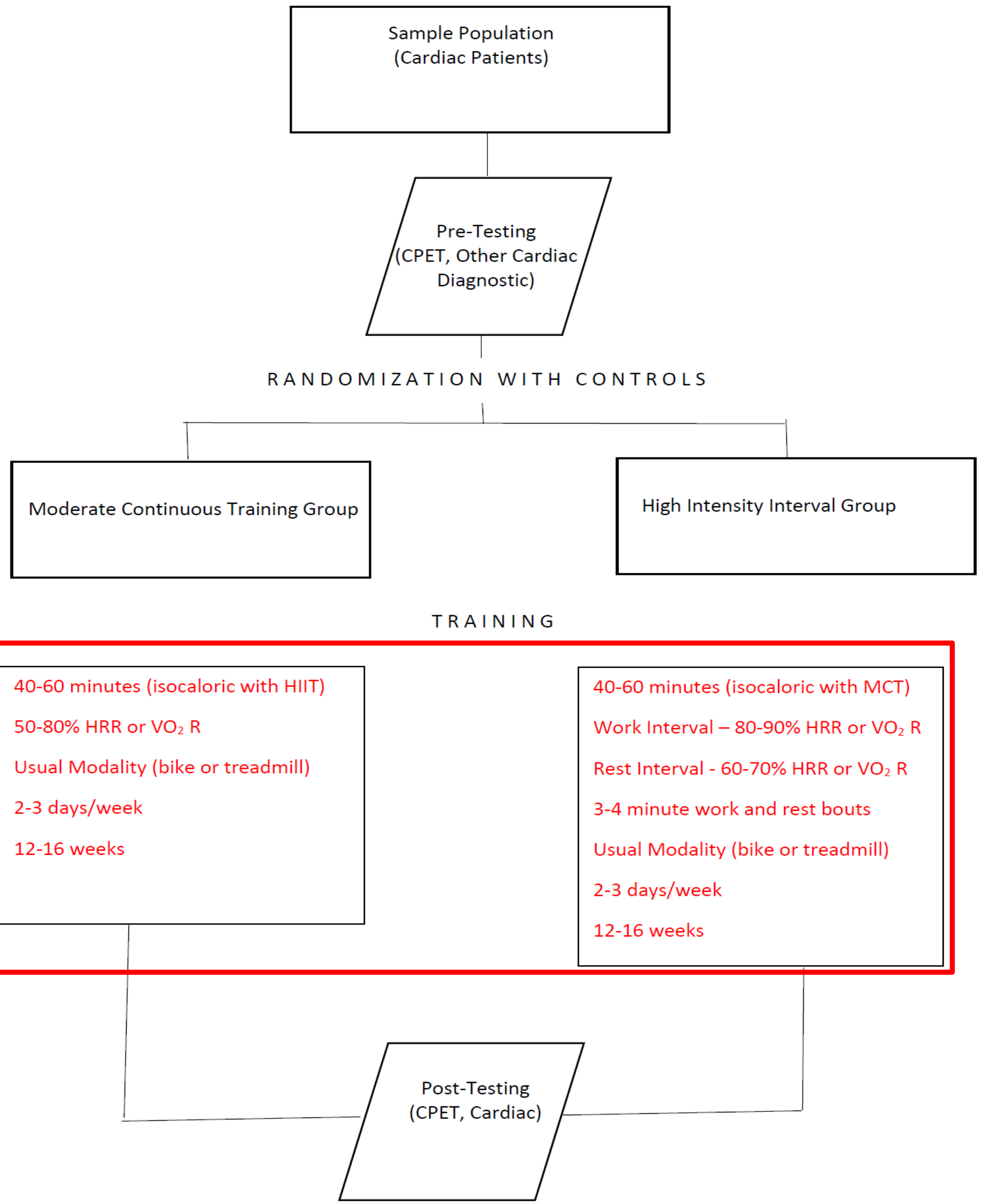

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Table 3 • Cardiorespiratory Responses to Exercise at Baseline and Followup

Parameter	Higher-Intensity Interval Training (n = 15), Mean ± SD		Moderate-Intensity Continuous Training (n = 13), Mean ± SD		*P* Values for Between-Group Comparisons
	Baseline	Followup	Baseline	Followup	
Exercise duration, min	13.3 ± 1.6	15.1 ± 1.7[a]	13.5 ± 2.8	15.3 ± 1.9[a]	.900
Peak heart rate, bpm	145 ± 17	151 ± 17	138 ± 24	135 ± 26	.101
Peak systolic blood pressure, mmHg	162 ± 17	169 ± 16	179 ± 29	164 ± 32	.096
Peak diastolic blood pressure, mmHg	79 ± 9	75 ± 13	78 ± 13	78 ± 12	.315
Peak oxygen uptake					
$mL \cdot kg^{-1} \cdot min^{-1}$	22.4 ± 4.2	26.0 ± 5.9[a]	21.8 ± 4.0	23.5 ± 4.6[a]	.050
$L \cdot min^{-1}$	2025 ± 544	2309 ± 598[a]	1982 ± 574	2119 ± 624[a]	.043
Peak oxygen pulse ($mL \cdot beat^{-1}$)	14.2 ± 3.5	15.8 ± 3.5[a]	14.6 ± 3.2	16.2 ± 4.2[a]	.967
Peak respiratory exchange ratio	1.20 ± 0.10	1.23 ± 0.10	1.23 ± 0.08	1.22 ± 0.10	.262
Ventilatory efficiency slope (V_E-CO_2)	28.7 ± 3.6	28.6 ± 3.2	29.3 ± 4.6	29.3 ± 5.2	.912
Change in heart rate from peak exercise to minute 1 of recovery, bpm	−25 ± 10	−25 ± 9	−28 ± 16	−29 ± 16	.577
Perceived exertion at peak exercise	16 ± 2	16 ± 2	17 ± 1	16 ± 2	.483

Abbreviation: bpm, beats per minute. [a]$P \leq .05$, within-group change from baseline to followup.

MCT = 60-80% HRR, HIIT = W:80-90% HRR & R:60-70% HRR

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Keteyian et al. JCRP 2014;34, 98-105.

High-intensity interval training may reduce in-stent restenosis following percutaneous coronary intervention with stent implantation: A randomized controlled trial evaluating the relationship to endothelial function and inflammation

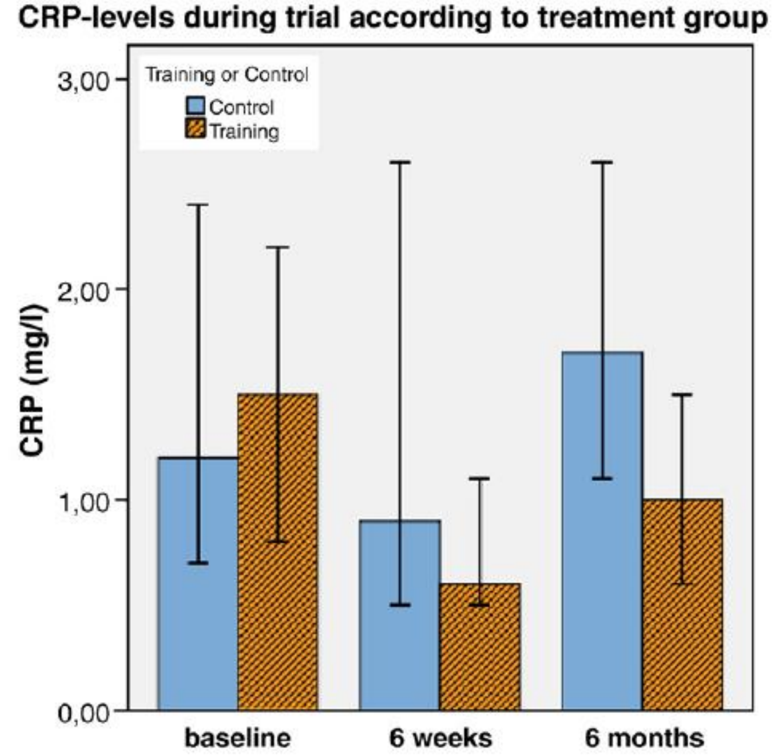
Peter S. Munk, MD,[a,b] Eva M. Staal, MD, PHD,[a,b] Noreen Butt, MD,[a] Kjetil Isaksen, MD,[a] and Alf I. Larsen, MD, PHD[a,b] *Stavanger and Bergen, Norway*

Table III. Angiographic results at 6 months

	Control	Training	*P*-value
Minimal luminal diameter (mm)	2.05 (0.55)	2.24 (0.9)	.15
Net lumen gain (mm) per patient	1.05 (0.81)	1.3 (0.73)	.03
Late luminal loss (mm) per patient	0.39 (0.38)	0.10 (0.52)	.01

P values refer to changes between control and training group.

Figure 3



Levels of CRP during trial period according to treatment group. Median CRP levels with range according to treatment group. *P* = .03 for trend.

HIIT = W:90-95% peak HR, R:60-70% peak HR

Am Heart J. 2009;158:734-741

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Cardiovascular Research (2013) **99**, 55–64
doi:10.1093/cvr/cvt080

Aerobic interval training attenuates remodelling and mitochondrial dysfunction in the post-infarction failing rat heart

Jasenka Kraljevic[1], Jasna Marinovic[1], Danijel Pravdic[2], Petra Zubin[1], Zeljko Dujic[1], Ulrik Wisloff[3], and Marko Ljubkovic[1]*

Table 1 Cardiac morphological and functional parameters after surgery and exercise training

Four-week post-surgery	Sham		MI-operated
FS (%)	53.1 ± 5.5		28.3 ± 5.7*
LVDd (mm)	5.82 ± 0.26		7.92 ± 0.59*
LVDs (mm)	2.73 ± 0.39		5.81 ± 0.91*
AWTd (mm)	1.76 ± 0.05		1.4 ± 0.39
AWTs (mm)	2.78 ± 0.13		2.00 ± 0.48*
PWTd (mm)	1.70 ± 0.18		1.59 ± 0.19
PWTs (mm)	2.88 ± 0.23		2.47 ± 0.35*
W_B (g)	257.4 ± 11.5		259.9 ± 13.1
Number of animals	16		31[a]
12-week post-surgery	Sham	MI-Sedentary	MI-Trained
FS (%)	58.3 ± 8.9	21.7 ± 5.5*,†	30.4 ± 8.5#
LVDd (mm)	5.86 ± 0.31	9.10 ± 0.98*	7.84 ± 1.09*
LVDs (mm)	2.46 ± 0.65	7.16 ± 1.17*	5.50 ± 1.30#
AWTd (mm)	1.52 ± 0.19	1.22 ± 0.61	1.49 ± 0.33
AWTs (mm)	2.78 ± 0.31	1.76 ± 0.83	2.36 ± 0.74
PWTd (mm)	1.78 ± 0.16	1.48 ± 0.40	1.81 ± 0.20
PWTs (mm)	2.84 ± 0.40	2.34 ± 0.50	2.63 ± 0.48

Superior Cardiovascular Effect of Aerobic Interval Training Versus Moderate Continuous Training in Heart Failure Patients

A Randomized Study

Ulrik Wisløff, PhD; Asbjørn Støylen, MD, PhD; Jan P. Loennechen, MD, PhD; Morten Bruvold, MSc; Øivind Rognmo, MSc; Per Magnus Haram, MD, PhD; Arnt Erik Tjønna, MSc; Jan Helgerud, PhD; Stig A. Slørdahl, MD, PhD; Sang Jun Lee, PhD; Vibeke Videm, MD, PhD; Anja Bye, MSc; Godfrey L. Smith, PhD; Sonia M. Najjar, PhD; Øyvind Ellingsen, MD, PhD; Terje Skjærpe, MD, PhD

TABLE 2. Aerobic Capacity and Exercise Data

	Control		MCT		AIT	
	Baseline	Follow-Up	Baseline	Follow-Up	Baseline	Follow-Up
Peak treadmill test						
$\dot{V}O_{2peak}$, mL · kg^{-1} · min^{-1}	13.2±1.9	13.4±2.0	13.0±1.1	14.9±0.9*	13.0±1.6	19.0±2.1*†
Peak heart rate, bpm	129±23	127±21	132±18	130±21	129±19	127±22
$[La^-]_b$ at $\dot{V}O_{2peak}$, mmol/L	6.3±1.6	6.3±1.2	6.8±1.2	6.4±1.0	6.2±0.8	6.0±0.6
RER at $\dot{V}O_{2peak}$	1.10±0.04	1.11±0.04	1.10±0.04	1.09±0.05	1.08±0.05	1.11±0.04
Anaerobic threshold						
% Of peak oxygen uptake	64±6	65±4	61±3	68±4*‡	63±5	61±3
mL · kg^{-1} · min^{-1}	8.5±1.6	8.7±3.9	8.0±0.7	10.1±0.9*§	8.2±0.8	11.6±1.0*†
Work economy						
mL · kg^{-1} · min^{-1}	8.5±1.6	9.1±2.8	8.0±0.7	7.6±0.8§	8.2±0.8	7.0±0.6*†
Heart rate, bpm	84±9	88±8	82±6	81±9	84±9	76±5*†
$[La^-]_b$, mmol/L	2.81±0.4	3.0±0.8	2.9±0.3	2.5±0.4	2.7±0.3	1.6±0.4*†

MCT = 70% peak HR, HIIT = W:90-95% peak HR, R:50-60% peak HR

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(*Circulation*. 2007;115:3086-3094.)

TABLE 3. LV Volumes and Resting Hemodynamics

	Control		MCT		AIT	
	Baseline	Follow-Up	Baseline	Follow-Up	Baseline	Follow-Up
LVDD, mm	67.2±8.1	67.8±12.5	69.1±8.6	68.2±6.5	66.7±6.8	59.0±6.8*†
LVSD, mm	56.2±9.2	56.7±13.7	56.6±8.8	53.9±7.4	53.9±6.7	46.1±8.2*†
LVEDV, mL	250.5±64.4	242.1±62.3	245.5±53.1	230.3±41.0	248.1±79.6	202.9±72.0*†
LVESV, mL	187.8±53.0	186.6±58.6	172.9±48.7	160.6±34.3	177.4±72.1	133.9±57.8*†
HR at rest, bpm	60±11	59±11	55±10	54±12	65±14	61±13
SV, mL	53.4±15.3	55.0±13.7	63.5±12.7	63.1±15.7	57.1±14.3	67.0±19.9*
CO, L/min	3.1±0.6	3.2±0.5	3.5±0.9	3.4±1.1	3.5±0.5	3.9±0.6*
EF, %	26.2±8.0	26.6±9.7	32.8±4.8	33.5±5.7	28.0±7.3	38.0±9.8*†

Data are mean±SD. LVDD indicates LV diastolic diameter; LVSD, LV systolic diameter; LVEDV, LV end-diastolic volume; LVESV, LV end-systolic diameter; HR, heart rate; SV, stroke volume; CO, cardiac output; and EF, ejection fraction.

*Different from baseline, $P<0.01$; †different from controls and moderately trained, $P<0.02$.

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(*Circulation*. 2007;115:3086-3094.)

ACSM GETP 10 exerpt:

- High-intensity interval training (HIIT) involves alternating 3–4 min periods of exercise at 80%–90% HRR with exercise at 60%–70% HRR. Such training for approximately 40 min, three times per week has been shown to yield a greater improvement in $\dot{V}O_{2peak}$ in patients with stable coronary heart disease (73) and HF (130). HIIT has also been shown to result in greater long-term improvements in $\dot{V}O_{2peak}$ in patients after CABG (83) compared to standard continuous, moderate intensity exercise. It appears that HIIT may be both a safe and very effective method of enhancing peak aerobic fitness in those with CVD (127).

ACSM GETP 10, 2017, page 236.

My Opinions & Perspective

- I have seen…
  - that the perpetuation of prescribing intensity at RHR + 20 bpm curtails the inclusion of progressive overload

- This is the intensity prescription for in-patient CR

FITT RECOMMENDATIONS FOR INPATIENT CARDIAC REHABILITATION[a] (5)

	Aerobic	Flexibility
Frequency	2–4 sessions · d^{-1} for the first 3 d of the hospital stay	Minimally once per day but as often as tolerated
Intensity	Seated or standing HR_{rest} +20 beats · min^{-1} for patients with an MI and +30 beats · min^{-1} for patients recovering from heart surgery Upper limit ≤120 beats · min^{-1} that corresponds to an RPE ≤13 on a scale of 6–20 (23)	Very mild stretch discomfort

ACSM's GETP 10, page 230

- Assumes that all individuals are working within a similar and acceptable intensity range

Comparison of Heart Rate & Oxygen Uptake during Steady State Treadmill Walking at +20 bpm

	Week 1		Week 6		Week 12	
	Low	High	Low	High	Low	High
RHR (bpm)	76.9 ± 4.0	74.7 ± 3.2	73.3 ± 3.6	73.0 ± 2.9	72.0 ± 4.3	73.6 ± 3.5
Exercise HR (bpm)	97.4 ± 3.4	97.5 ± 2.7	93.5 ± 3.4	93.2 ± 2.7	92.8 ± 4.0	95.6 ± 3.2
HR Change (bpm)	20.5 ± 2.4	22.8 ± 1.9	20.2 ± 0.7	20.2 ± 0.6	20.8 ± 1.1	22.0 ± 0.9
Exercise VO_2 (ml/kg/min)	13.2 ± 0.8	12.5 ± 0.6	13.3 ± 0.8	12.7 ± 0.6	13.0 ± 1.2	13.5 ± 0.9
VO_2 Reserve (%)	62.2 ± 5.6	42.3 ± 4.5*	62.7 ± 5.3	43.1 ± 4.2*	51.3 ± 5.3†	38.2 ± 4.2*

Values reported in Mean ± standard deviation. RHR, resting heart rate; HR, heart rate; VO_2, oxygen uptake. *p<0.05 low vs. high. †P<0.05 week 12 vs. week 6 and week 1.

Low = peak VO2 < 7 METs
High = peak VO2 > 7 METs

- Training at this level is unlikely to produce increases in SV such that HR responses will be decreased and workloads then be increased to allow patients to do more work within the same HR range

Comparison of Heart Rate & Oxygen Uptake during Steady State Treadmill Walking at +20 bpm

	Week 1		Week 6		Week 12	
	Low	High	Low	High	Low	High
RHR (bpm)	76.9 ± 4.0	74.7 ± 3.2	73.3 ± 3.6	73.0 ± 2.9	72.0 ± 4.3	73.6 ± 3.5
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Values reported in Mean ± standard deviation. RHR, resting heart rate; HR, heart rate; VO_2, oxygen uptake. *p<0.05 low vs. high. †P<0.05 week 12 vs. week 6 and week 1.

Low = peak VO2 < 7 METs
High = peak VO2 > 7 METs

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Inter-subject Variability is High

Exercise Prescription Using Resting Heart Rate Plus 20 or Perceived Exertion in Cardiac Rehabilitation

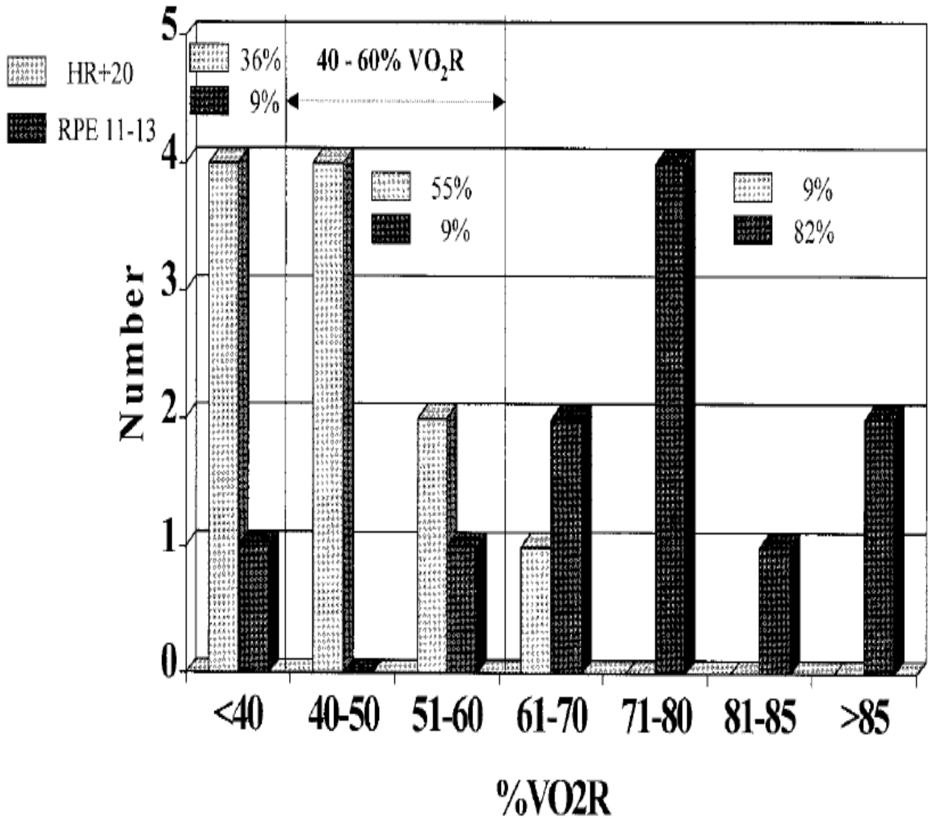

Figure 2. Histogram representing frequency of patients exercising at less than 40% peak oxygen uptake reserve (VO_2R), between 40 and 60% VO_2R, and more than 60% VO_2R. The light bars represent frequency in an evaluation of resting heart rate increased by 20 beats per minute (RHR+20), whereas the dark bars represent a range of 11 to 13 on Borg's Scale for Rating of Perceived Exertion (RPE 11-13).

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Journal of Cardiopulmonary Rehabilitation 2004;24:178-186

So…

- Even with beta blockade, many patients can achieve ~90% of APMHR

Table 3. Comparison of Pre and Post Program CPET Measures

	Pre-Program		Post-Program	
	MIE (n=36)	VIE (n=54)	MIE (n=36)	VIE (n=54)
Test Duration (min)	9.9 ± 1.1	9.6 ± 1.9	11.2 ± 3.4*	11.8 ± 2.7*
Peak HR (beats·min^{-1})	143.0 ± 21.7	136.6 ± 17.7	142.6 ± 27.0	143.4 ± 22.0*
Percent of Max HR (%)	93.6 ± 13.0	87.4 ± 10.6†	93.3 ± 16.1	91.9 ± 13.1*
Peak RER	1.15 ± 0.16	1.17 ± 0.13	1.17 ± 0.12	1.17 ± 0.10
Peak VO_2 (mL·kg^{-1}·min^{-1})	23.5 ± 5.6	22.8 ± 4.6	26.0 ± 8.25*	26.3 ± 6.7*
VO_2 at VAT (mL·kg^{-1}·min^{-1})	14.5 ± 3.5	14.4 ± 2.8	16.0 ± 4.9*	16.0 ± 4.0*
OUES (ml·min^{-1}/log VE·min^{-1})	2114.9 ± 606.3	2048.4 ± 492.8	2295.8 ± 740.4*	2263.4 ± 601.7*

*There may be a wide range and thus some outliers

- Knowing that:
  - higher intensities may be more beneficial to our patients
  - +20-30 may not be the best method for prescribing intensity in many of our patients
  - Some younger patients desire a return toward a vigorous lifestyle
  - Being too conservative may curtail referrals

- We need to be able to confidently prescribe exercise at higher intensities. This is best accomplished with exercise testing

- Our profession is called to do exercise testing for exercise prescriptive purposes by many of the governing agencies
- American Heart Association
  - "Exercise testing remains a remarkably durable and versatile tool that provides valuable diagnostic and prognostic information regarding patients with cardiovascular disease"

  and

  - "the addition of ventilatory gas exchange measurements during exercise testing provides a wide array of unique and clinically useful incremental information that heretofore has been poorly understood and underutilized by the practicing clinician."

AHA Scientific Statement

Clinician's Guide to Cardiopulmonary Exercise Testing in Adults

A Scientific Statement From the American Heart Association

Gary J. Balady, MD, FAHA, Chair; Ross Arena, PhD, FAHA; Kathy Sietsema, MD; Jonathan Myers, PhD, FAHA; Lola Coke, RN, PhD; Gerald F. Fletcher, MD, FAHA; Daniel Forman, MD; Barry Franklin, PhD, FAHA; Marco Guazzi, MD, PhD; Martha Gulati, MD; Steven J. Keteyian, PhD; Carl J. Lavie, MD; Richard Macko, MD; Donna Mancini, MD; Richard V. Milani, MD, FAHA; on behalf of the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee of the Council on Clinical Cardiology; Council on Epidemiology and Prevention; Council on Peripheral Vascular Disease; and Interdisciplinary Council on Quality of Care and Outcomes Research

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- American College of Sports Medicine
  - "…exercise testing at baseline is essential for the development of an exercise prescription in patients who have suffered from MI with or without revascularization, as well as those patients who have undergone coronary revascularization alone."

(Gibbons, R et al. *ACC/AHA 2002 Guideline Update for Exercise Testing: Summary Article. A Report of the American College of Cardiology/American Heart Association task Force on Practice Guidelines.* Am. J.Cardiol. 2002;40(8)1531-1540)

(Pescatello, L. (Senior Editor) *ACSM's Guidelines for Exercise Testing and Prescription* (9th edition) Lippincott, Williams & Wilkins, page 241, 2013)

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- European Association of Cardiovascular Prevention
  - Cardiopulmonary exercise testing is a methodology that has profoundly changed the approach to patient's functional evaluation, linking performance and physiologic parameters to the underlying metabolic substratum and providing highly reproducible exercise capacity descriptors"

Mezzani et al. *European Society of Cardiology, Standards for the use of cardiopulmonary exercise testing for the functional evaluation of cardiac patients: a report from the Exercise Physiology section of the European Association for Cardiovascular Prevention and Rehabilitation*, European Journal of Cardiology Prevention and Rehabilitation, 16;249-267, 2009.

- American Association of Cardiovascular & Pulmonary Rehabilitation
  - To establish a safe and effective program of comprehensive cardiovascular risk reduction and rehabilitation, each patient should undergo a careful medical evaluation and exercise test before participating in an outpatient Cardiopulmonary Rehabilitation program."
  - "The 6-minute walk test can be used as a surrogate test to assess exercise capacity when standard treadmill or cycle testing is not available."
    - **I do <u>not</u> agree with this entirely**

AACVPR Guidelines Cardiac Rehabilitation & Secondary Prevention (5th edition), page 58.

In Certain Populations…

- The distance walked correlates strongly with peak oxygen uptake

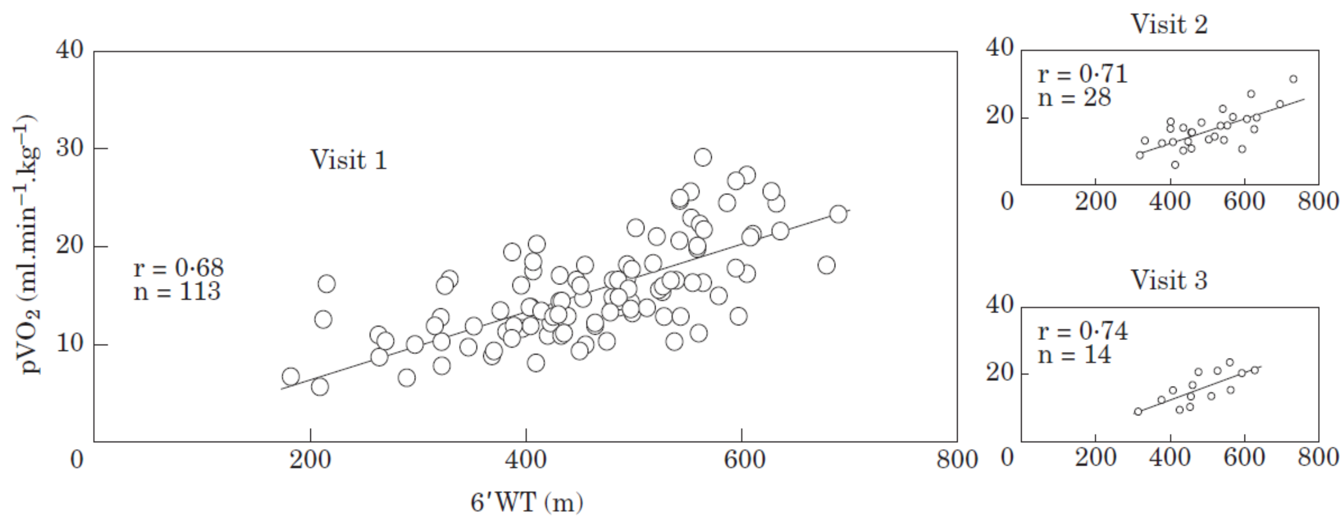

Figure 2 **Relationship between the ambulated distance (6'WT) and peak oxygen uptake (pVO_2) at the initial visit (visit 1) as well as the first (visit 2, after 263 ± 144 days) and second (visit 3, after 263 ± 144 days) follow-up visit.**

European Heart Journal (2000) **21**, 540–549
doi:10.1053/euhj.1999.1861, available online at http://www.idealibrary.com on IDEAL®

Is the 6-minute walk test a reliable substitute for peak oxygen uptake in patients with dilated cardiomyopathy?

C. Zugck, C. Krüger, S. Dürr, S. H. Gerber, A. Haunstetter, K. Hornig, W. Kübler and M. Haass

Department of Cardiology, University of Heidelberg, Germany

Significant correlation between 6MWD & Peak VO2

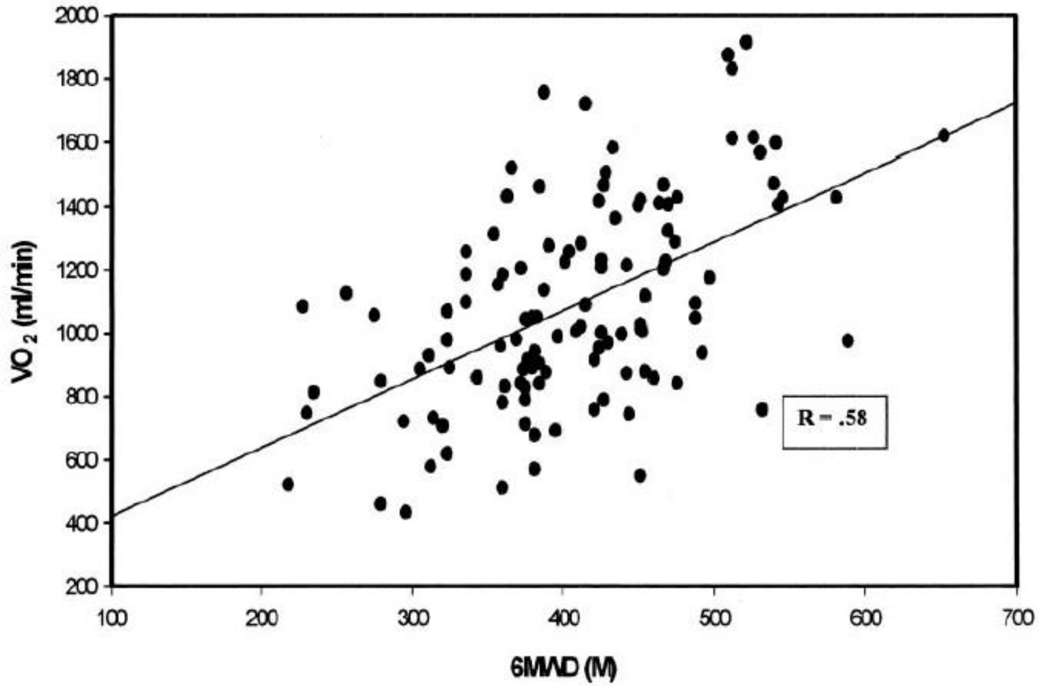

FIGURE 1. Plot of 6MWD by $\dot{V}O_2$.

Ross *et al. BMC Pulmonary Medicine* 2010, **10**:31
http://www.biomedcentral.com/1471-2466/10/31

BMC Pulmonary Medicine

RESEARCH ARTICLE Open Access

The six minute walk test accurately estimates mean peak oxygen uptake

Robert M Ross*[1], Jayasimha N Murthy[2], Istvan D Wollak[3] and Andrew S Jackson[4]

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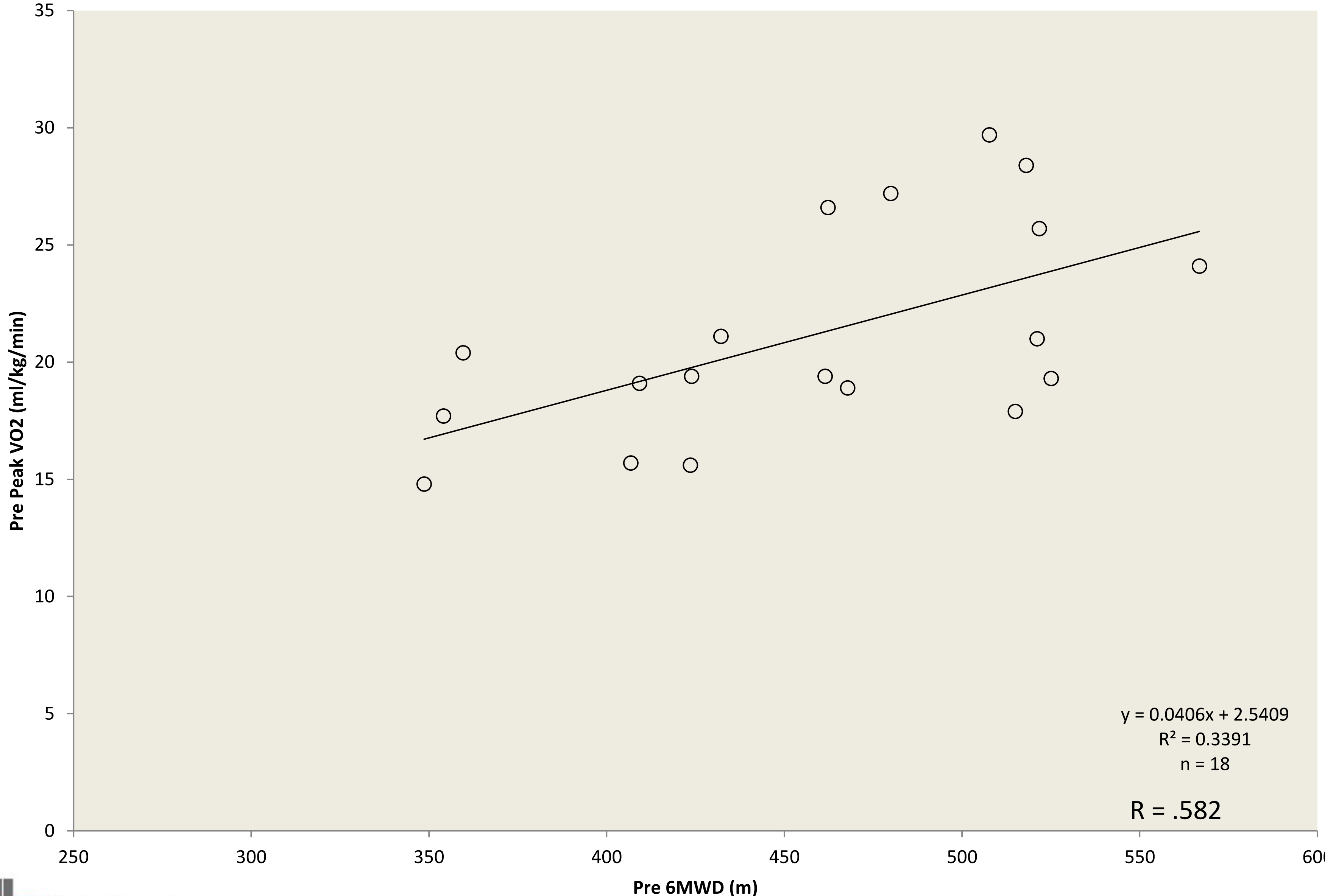
Table 1: Sample and linear regression characteristics for all subjects contrasted by study.

Study	Sample Characteristics				Linear Regression Statistics				
	Disease	n	peak VO2 Mean ± SD	6 MWT Mean ± SD	Slope	Intercept	R	SEE	(SEE/Mean) × 100
Cahalin 1996 (3)	CHF	45	12.4 ± 4.5	310 ± 103	0.028	3.583	0.65	3.44	27.7
Cahalin 1995 (2)	ESLD	60	9.6 ± 3.8	294 ± 139	0.019	4.042	0.69	2.81	29.2
Lucas 1999 (6)	CHF	307	14.2 ± 4.9	391 ± 105	0.027	3.666	0.59	3.99	28.1
Miyamoto 2000 (7)	PH	27	13.9 ± 4.4	377 ± 115	0.026	4.213	0.68	3.25	23.4
Opasich 2001 (8)	CHF	269	14.5 ± 4.9	378 ± 95	0.027	4.498	0.59	3.42	23.6
Roul 1998 (9)	CHF	114	16.8 ± 4.5	437 ± 108	0.009	12.910	0.21	4.43	26.4
Starobin 2006 (10)	COPD	49	14.0 ± 4.4	436 ± 89	0.027	2.184	0.55	3.69	26.4
Zugck 2000 (11)	DC	112	15.6 ± 5.2	463 ± 107	0.033	0.113	0.69	3.78	24.2
Faggiano 1997 (4)	CHF	26	15.1 ± 3.9	419 ± 121	0.019	7.260	0.58	3.25	20.8
Lipkin 1986 (5)	CHF	26	14.0 ± 4.1	452 ± 147	0.019	5.271	0.70	2.95	21.0
Baylor	CPD	48	13.1 ± 3.4	354 ± 131	0.017	6.921	0.68	2.50	19.1
All Data	All	1,083	14.3 ± 4.8	393 ± 115	0.025	4.682	0.59	3.82	26.7

ESLD - End Stage Lung Disease; DC - Dilated Cardiomyopathy; CHF - Congestive Heart Failure; PH -Pulmonary Hypertension; COPD - Chronic Obstructive Pulmonary Disease; CPD - Various Cardiopulmonary Disorders. Peak VO2 - peak oxygen uptake (ml/kg/min.); 6 MWD- distance walked (meters) during the 6-minute walk test.

Relation of 6MWT Distance and Peak VO2



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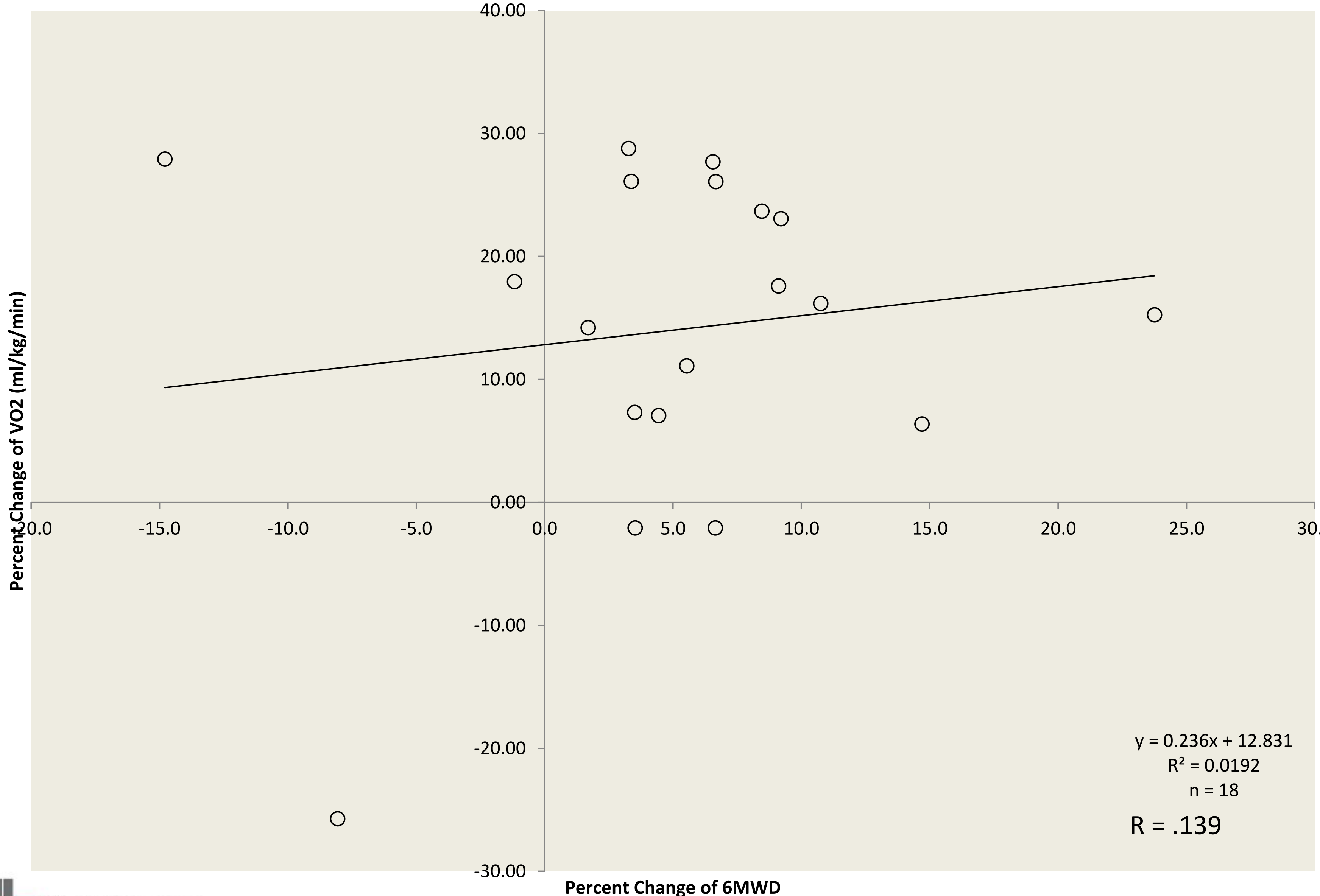
Relation of Percent Changes of 6MWD and Peak VO2



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The Six Minute Walk Test

- It is a valuable assessment of functional capacity and good index for therapeutic efficacy when:
  - the sample population is very low functioning (eg. oxygen uptake less than ~15 mL/kg/min)
  - the sample population being compared is homogenous
    - pulmonary
    - HF
    - Aortic Stenosis
    - Cardiomyopthy
  - the testing protocol is standardized (ATS guidelines)
    - walking course – 20-34 m
    - encouragement – same for all
    - assistance – can't walk alongside patient

Challenge: Put the science back in

- Make every effort to secure a pre-program exercise test, CPET preferred

- Prescribe by ACSM, AACVPR guidelines and always include progressive overload even if you do not get test results
  - Consider RHR progressions over time with demonstrated hemodynamic stability
  - Consider HR Reserve method

- Treat the patient not the monitor – if patient is stable and feeling good, desires to do more and has demonstrated stability, then do more

- Consider including HIIT whenever possible – less boredom, better results

- Questions?

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