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## Heart Rhythm Congress 2016 Chronotropic incompetence in heart failure patients

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Case report : an Amsterdam taxi driver with recurrent syncope



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## History

- 1994: recurrent syncope with sudden complete LOC



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Concl:- precolaps bij herstel  
- + cyclen → aanv. voor p. baanfibritter

R/R by maled.

R/Capote

Youwens Hole ECG; brede met stijlvolle en  
frequente multiforme VESSEN



onregelmatige ritme

in thuis verblijf paarsen zijn begon  
met open braken en lediglijke faecal.

Sinus arrhythmie message check!

Pt rechtkant weg!!

→ EMH



## DDD/rate drop response

Indication for cardiac pacing in patients with undocumented reflex syncope

Recommendations	Class <sup>a</sup>	Level <sup>b</sup>	Ref. <sup>c</sup>
<p><b>I) Carotid sinus syncope.</b></p> <p>Pacing is indicated in patients with dominant cardioinhibitory carotid sinus syndrome and recurrent unpredictable syncope.</p>	I	B	35–40

reflex.

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- 1995 remains having pre-syncopal attacks
- 2003: recurrent near syncope with restriction to drive
- 2003: device ERI change to Philos DR (accelerometer)
- 2003: restriction to drive

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- 2004: device change to Cylos DR (CLS)
- 2005: no syncope resuming work as a taxi driver



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- 2004: acute anterior myocardial infarction: CABG (St. Elsewhere)
- one months later: syncope (CLS function “off” ??!!???)
- 2005-2008: NYHA II-III
- poor LV function (LVEF = 0.28) → ICD



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19-AUG-1944 (63 yr)  
Male  
0cm 0kg  
Room:  
Loc:21

Vent. rate  
PR interval  
QRS duration  
QT/QTc  
P-R-T axes

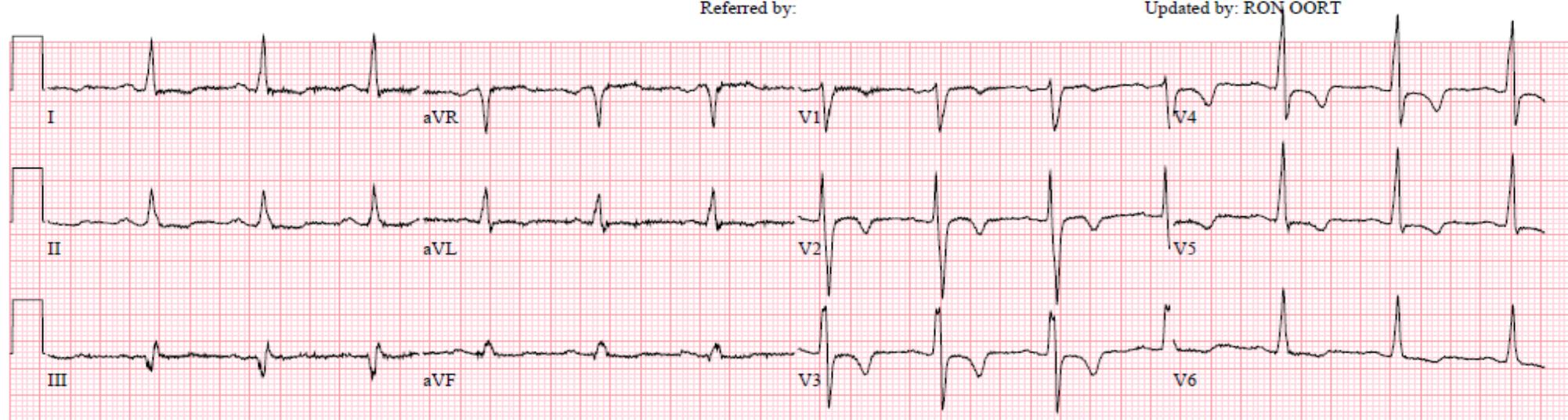
79 BPM  
168 ms  
120 ms  
384/440 ms  
31 23 188

Normal sinus rhythm  
Incomplete left bundle branch block  
ST & T wave abnormality, consider inferior ischemia  
ST & T wave abnormality, consider anterolateral ischemia  
Abnormal ECG

Technician:  
Test ind:

Referred by:

Updated by: RON OORT



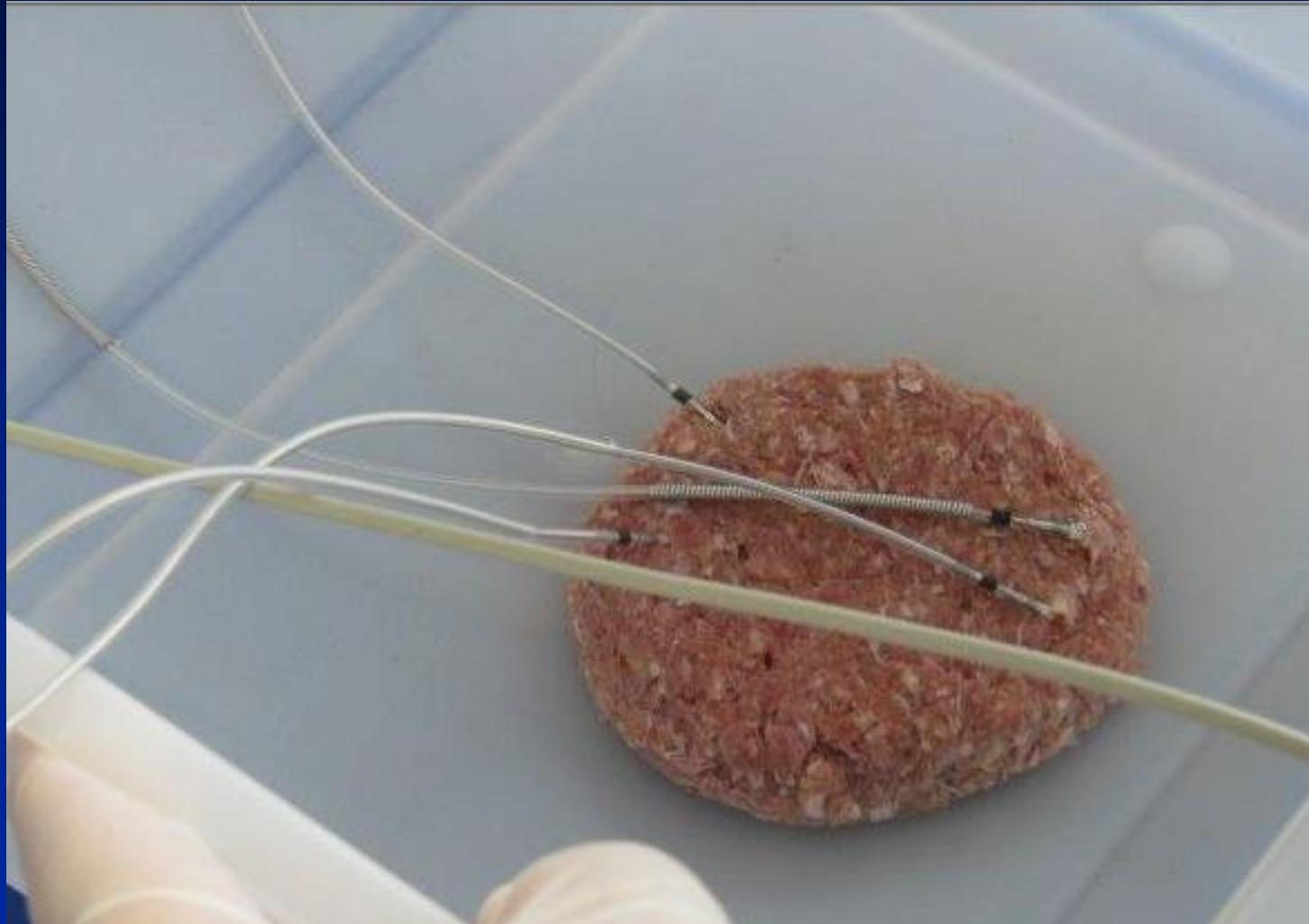
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## Closed Loop Stimulation & ICD?



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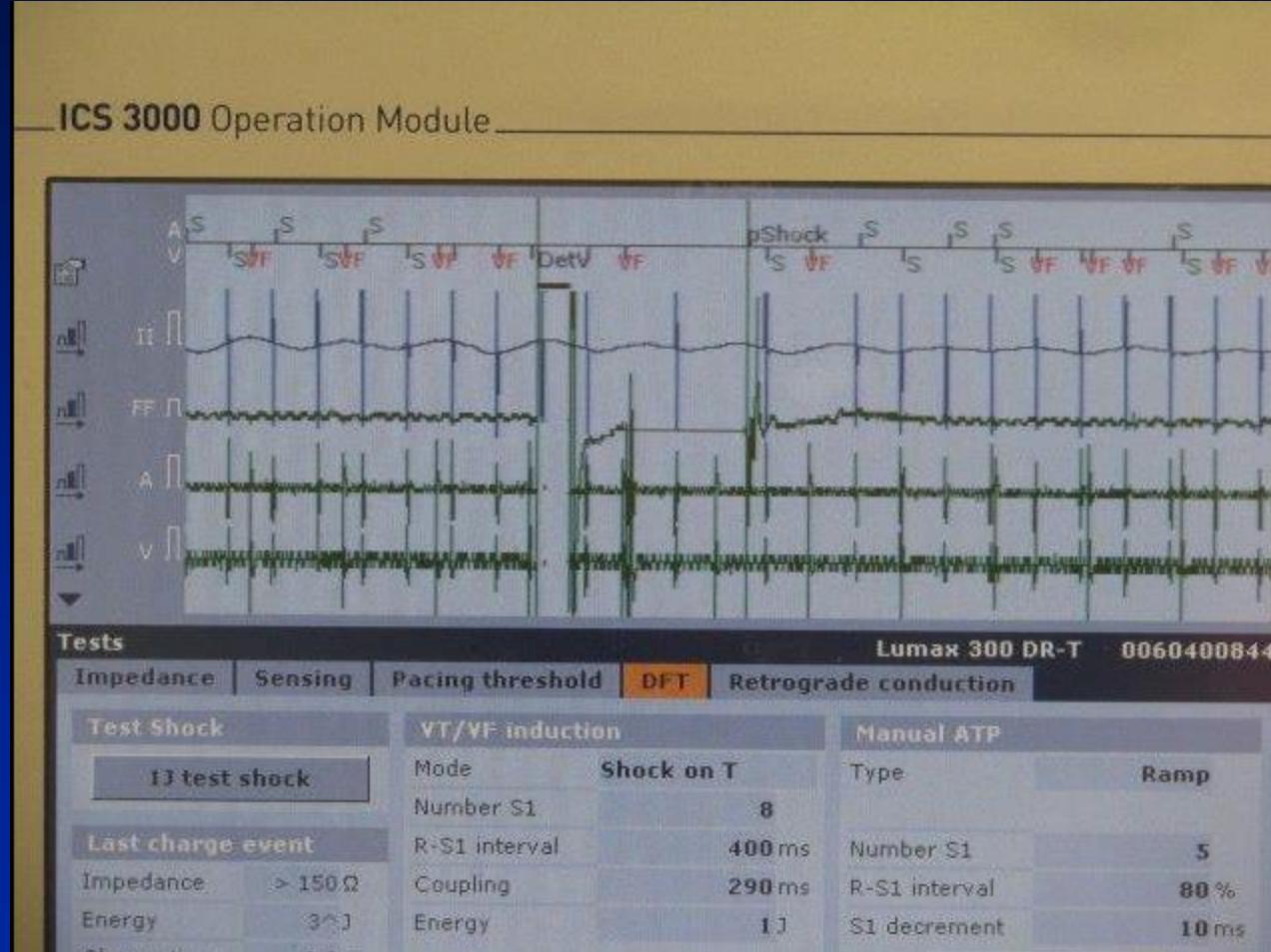
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2008

- 1-chamber ICD (left side) and PG (right side)
- VF zone 230 bpm, monitor zone 160 bpm
- ICD “off” during threshold measurements
- No professional taxi driver
- Still non-professional driving



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**3) Non-LBBB with QRS duration >150 ms.**  
CRT should be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.<sup>d</sup>

**IIa**

**B**

**48–64**

Indications for cardiac resynchronization therapy in patients in sinus rhythm

Recommendations	Class <sup>a</sup>	Level <sup>b</sup>	Ref. <sup>c</sup>
I) LBBB with ORS			

functional class II, III and ambulatory IV despite adequate medical treatment.<sup>d</sup>

5) CRT in patients with chronic HF with QRS duration <120 ms is not recommended.

	<b>III</b>	<b>B</b>	65, 66
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19-AUG-1944 (64 yr)

Male

180cm 104kg

Room:

Loc:30

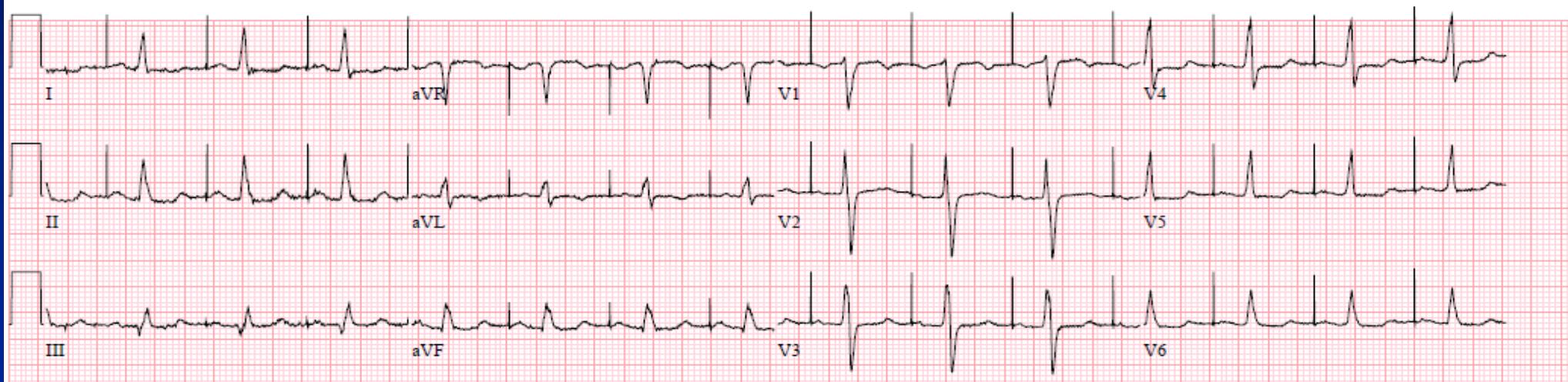
Vent. rate 87 BPM  
PR interval 170 ms  
QRS duration 116 ms  
QT/QTc 398/478 ms  
P-R-T axes 45 42 84

Electronic atrial pacemaker  
Nonspecific ST and T wave abnormality  
Prolonged QT  
Abnormal ECG

Technician: wj  
Test ind:

Referred by:

Updated by: RON OORT



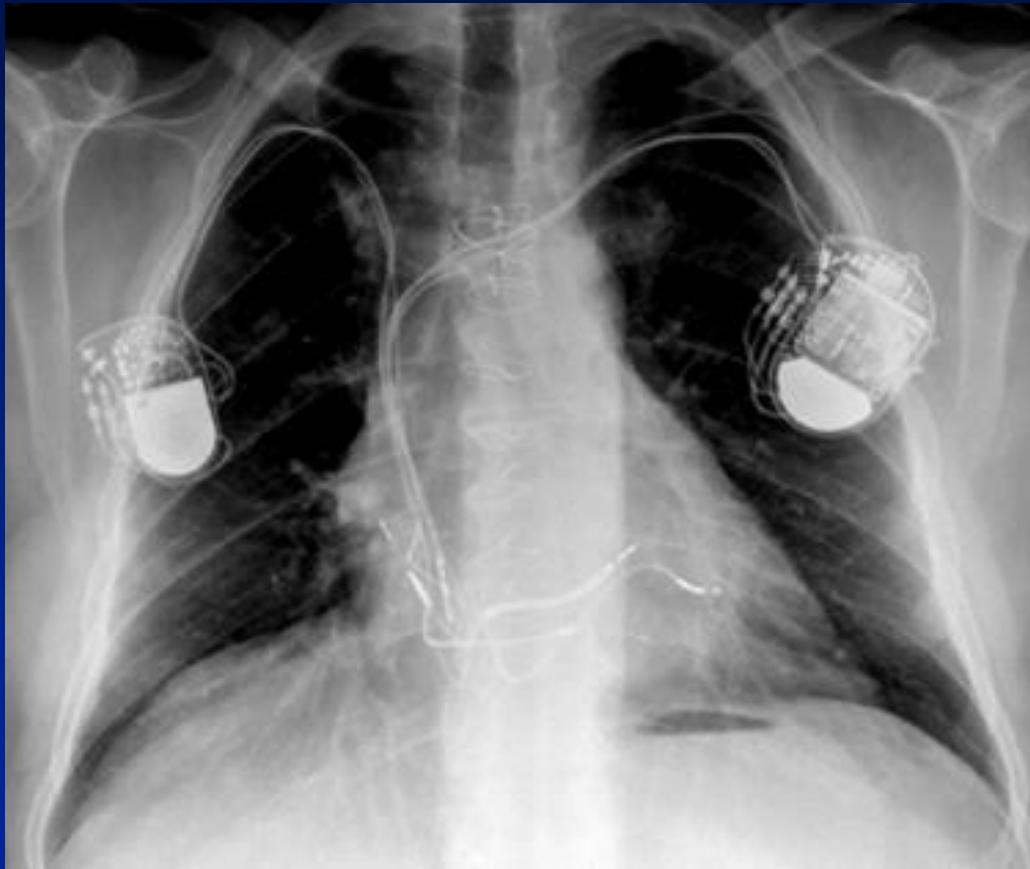
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MF Koster

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- Upgrade to CRT-D. CLS-pacemaker remains in situ.
- Suboptimal LV position.
- RV output 0.1V@0.10ms, mandatory for CLS function.
- Lower rate CRT-D 30 bpm. Triggered mode.

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- 2015 implantation Iperia DR.
- Explantation pulse generator
- NYHA I-II still recreational driving

## Chronotropic incompetence (CI)

Is the inability of the heart to increase its rate  
commensurate with increased activity or demand



## Maximal aerobic exercise ( $\text{VO}_2$ peak increase)

- 2,2 fold by increase in heart rate
- 1,5 fold by increase in arterial-venous oxygen difference
- 0,3 fold by increase in stroke volume

Total approximal 4 fold increase in  $\text{VO}_2$  peak



## Prevalence of CI in heart failure patients

CI in 25% - 70% of patients

(depending on definition and patients characteristics e.g. age, disease severity and medication)



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## NIH Public Access Author Manuscript

*JACC Heart Fail.* Author manuscript; available in PMC 2015 January 02.

NIH-PA Author Manuscript

## Chronotropy: The Cinderella of Heart Failure Pathophysiology and Management

Peter H. Brubaker, PhD and Dalane W. Kitzman, MD

Department of Health and Exercise Science, Wake Forest University, and the Sections on Cardiology and Geriatrics, Department of Internal Medicine, Wake Forest School of Medicine, Winston-Salem, North Carolina



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Brubaker et al JACC Heart Failure 2013;3:267-69

## Definition(s) of CI

Prediction of maximal HR;  $220 \text{ bpm} - \text{age}$

However:

- studies in middle aged men with
- high incidence of CAD
- high incidence of  $\beta$  blokker use



## Definition(s) of CI

Prediction of maximal HR;  $220 \text{ bpm} - \text{age}$

Consequently:

- high intersubject variability
- standard deviation of  $\pm 11 \text{ bpm}$
- high standard deviation in CAD ( $\pm 40 \text{ bpm}$ )



## Definition(s) of CI

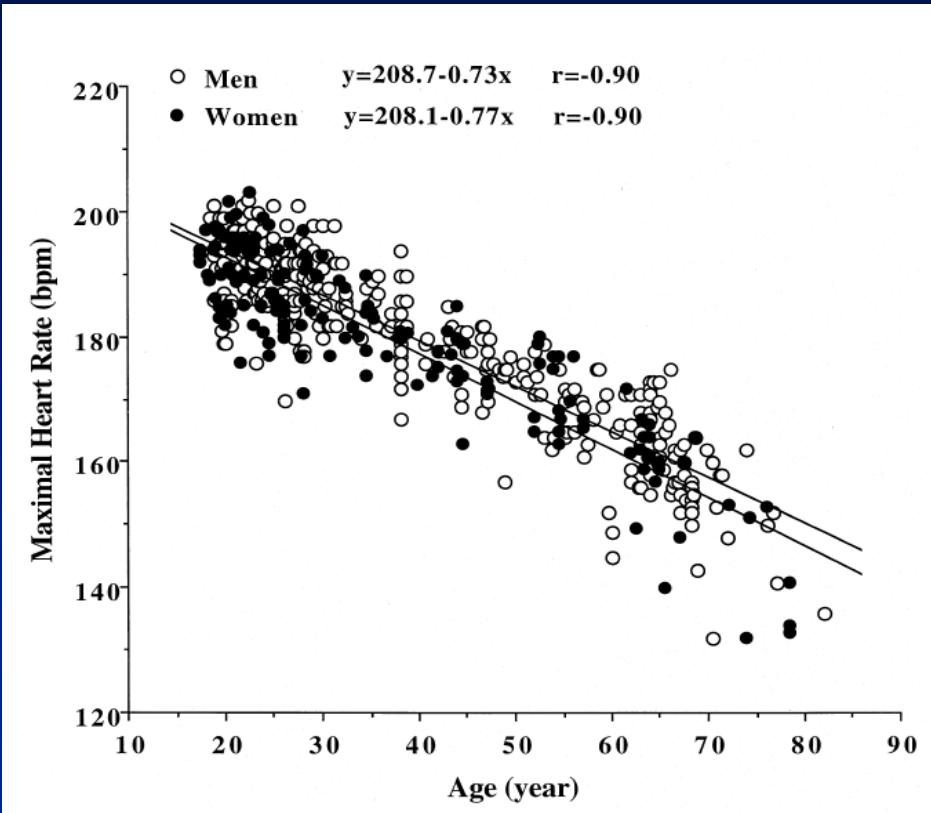
Tanaka et al studied

- older aged men and women
- no CAD
- no medication

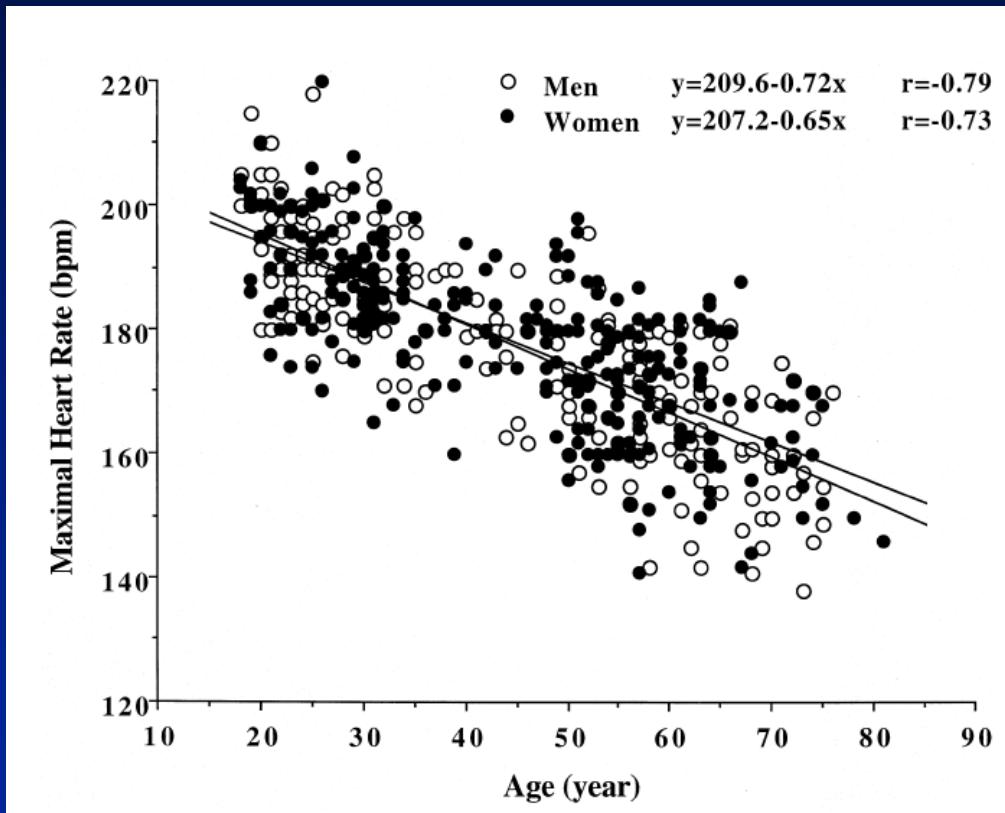


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## Retrospective analysis



## Prospective analysis

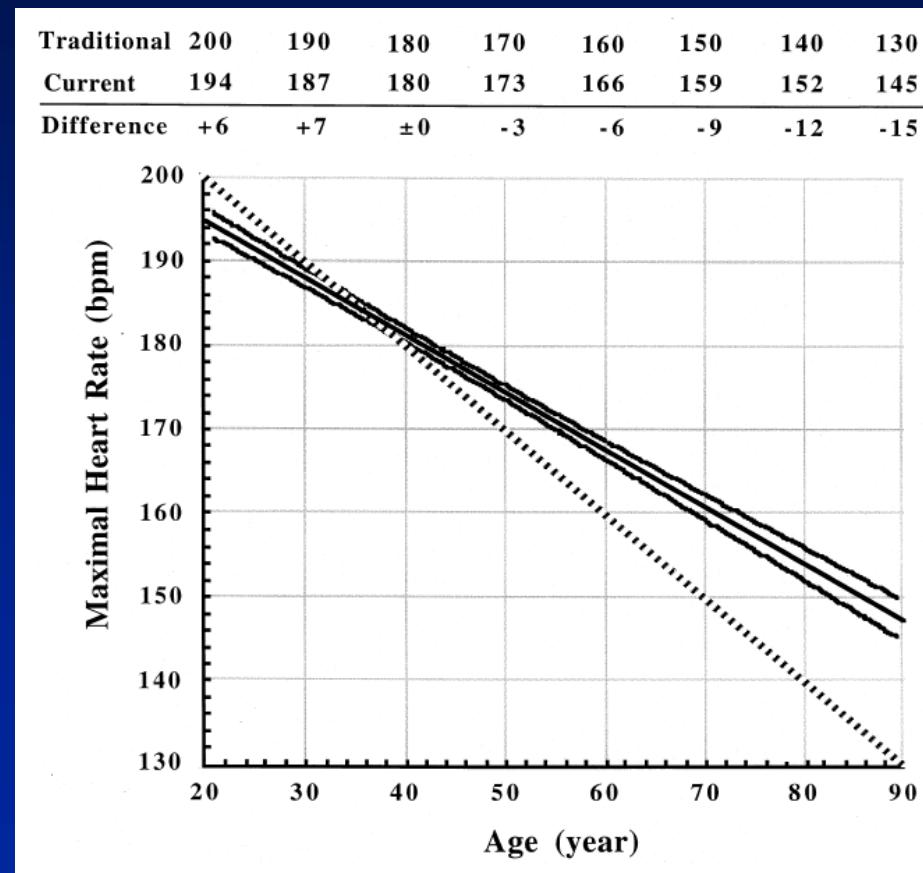


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Tanaka J Am Coll Cardiol 2001;37:153-6

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$HR_{MAX}$  IS  $208 - 0,7 \times AGE$  (SOLID LINE)



## Definition(s) of CI

Brawner et al studied

- patients with CAD
- with or without  $\beta$  blokker therapy
- age limit 80 years



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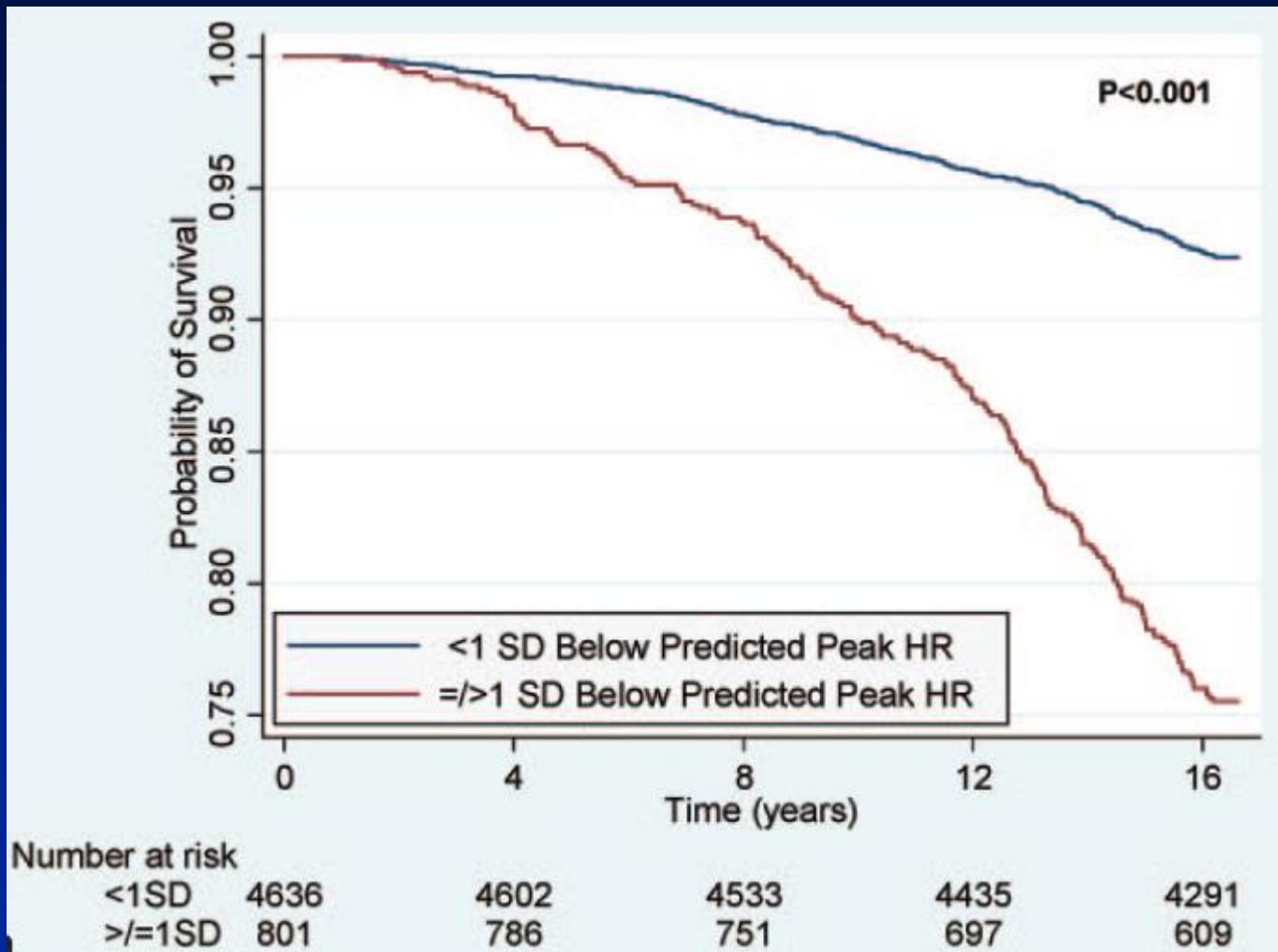
**Table III.** Measured  $\text{HR}_{\text{max}}$ , predicted  $\text{HR}_{\text{max}}$ , and mean prediction error, using a frequently reported prediction equation ( $220 - \text{age}$ ) and our BB-specific equation, among a cross-validation group on BB therapy ( $n = 94$ )

Prediction equation	$\text{HR}_{\text{max}}$ (per min)		Prediction error (per min)	P value	Correlation coefficient ( $r$ )
	Measured	Predicted			
$220 - \text{age}$	$121 \pm 21$	$161 \pm 10$	$40 \pm 19$	<.0001	0.38
New equation $164 - 0.72 \times \text{age}$	$121 \pm 21$	$121 \pm 7$	$-0.4 \pm 19$	.96	0.38

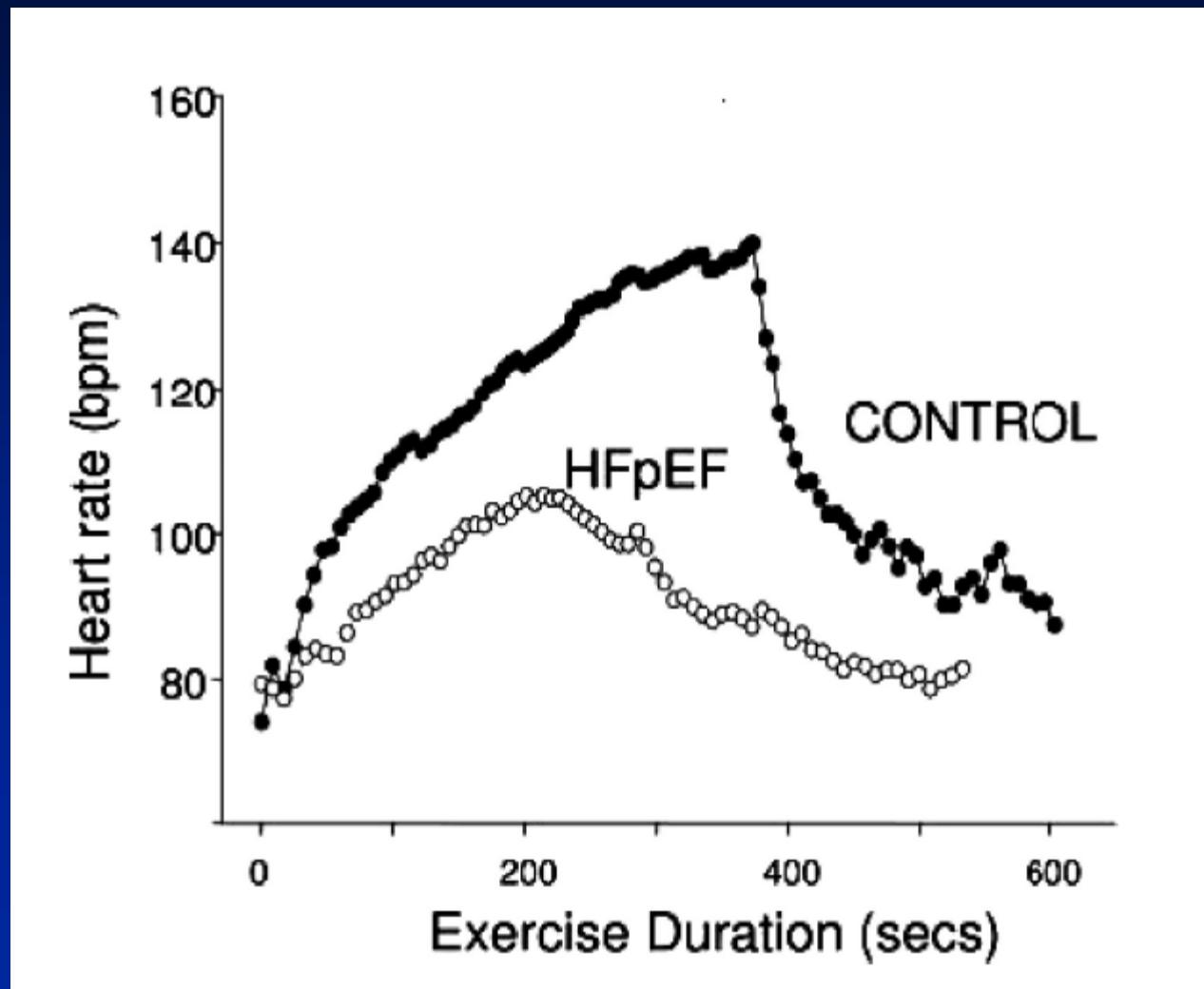


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n = 5437



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- 1538 patients referred for pacemaker implantation
- CI: heart rate reserve < 80% of metabolic reserve
- Randomized to two types of RR systems  
(accelerometer XL and XL and minute ventilation)



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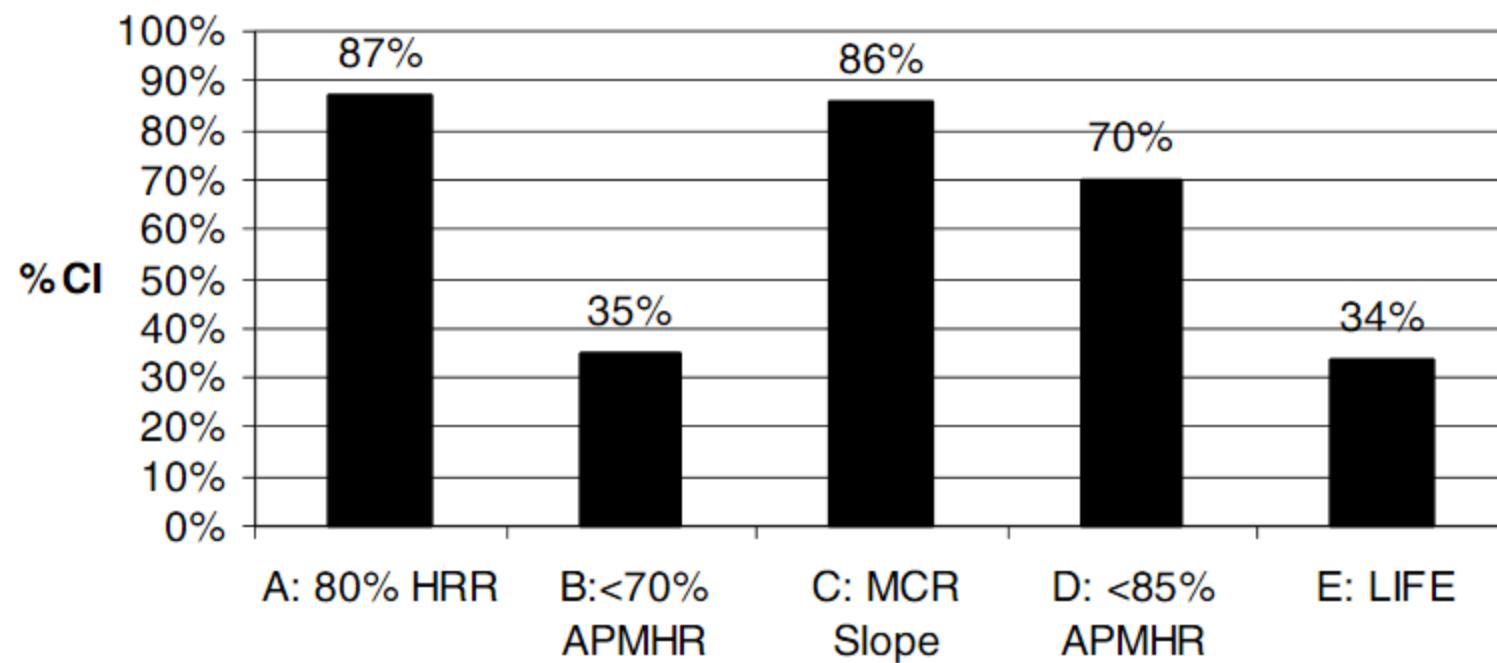
%Metabolic reserve (MR) used  
=  $[(\text{MET stage} - \text{MET rest}) / (\text{MET peak} - \text{MET rest})] \times 100$

%Heart rate reserve (HRR) used  
=  $[(\text{HR stage} - \text{HRrest}) / (220 - \text{age in years} - \text{HRrest})] \times 100,$



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## CR Definitions



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Changes in CR among all Patients, CC Patients, and Qualifying CI Patients Who Were Randomized to Receive Adaptive Rate Therapy Driven by Either BS or XL

CR Based on Three Stages of CAEP and RPE $\geq 16$				
	Visit	XL Mean $\pm$ Std(N) XL (95% CI)	BS Mean $\pm$ Std(N) (95% CI)	P-Value (Between Group)
MCR Slope	1-month-ALL	0.54 $\pm$ 0.24 (267) (0.51, 0.57)	0.56 $\pm$ 0.23 (280) (0.53, 0.59)	0.180
	1-month-CC	0.65 $\pm$ 0.20 (174) (0.62, 0.68)	0.64 $\pm$ 0.20 (188) (0.61, 0.67)	0.402
	1-month-CI	0.34 $\pm$ 0.15 (93) (0.31, 0.37)	0.38 $\pm$ 0.17 (92) (0.35, 0.42)	0.025
	6-month-CI	0.47 $\pm$ 0.19 (78) (0.43, 0.52)	0.59 $\pm$ 0.24 (61) (0.53, 0.65)	<0.001
Paired 1- and 6-month data	1-month-CI	0.32 $\pm$ 0.15 (39) (0.27, 0.37)	0.39 $\pm$ 0.15 (34) (0.33, 0.44)	0.036
	6-month-CI	0.47 $\pm$ 0.19 (39) (0.40, 0.53)	0.59 $\pm$ 0.25 (34) (0.50, 0.68)	0.011
	Change: 6 month–1 month	0.15 $\pm$ 0.22 (39) (0.08, 0.22)	0.20 $\pm$ 0.21 (34) (0.13, 0.28)	

CI patients with 1- and 6-month paired data are also shown.

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Differences in QOL (SF-36) at 1 Month between CI and CC Patients

**QOL—Among Patients with Slope Based on Three Stages of CAEP + Resting and Peak Borg  $\geq 16$**

QOL	Visit	CC Mean $\pm$ Std(N) Min, Max	CI Mean $\pm$ Std(N) Min, Max	P-Value
Physical component	1-month	43.99 $\pm$ 9.33 (352)	40.11 $\pm$ 8.95 (181)	<0.0001
Mental component	1-month	50.38 $\pm$ 9.41 (352)	48.25 $\pm$ 10.77 (181)	0.019

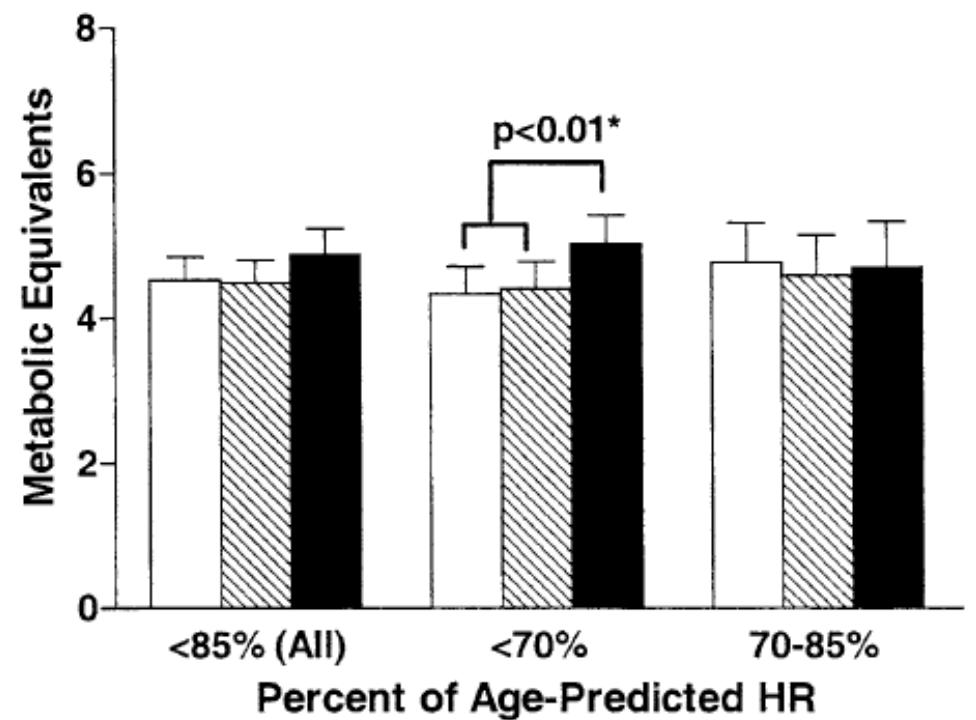
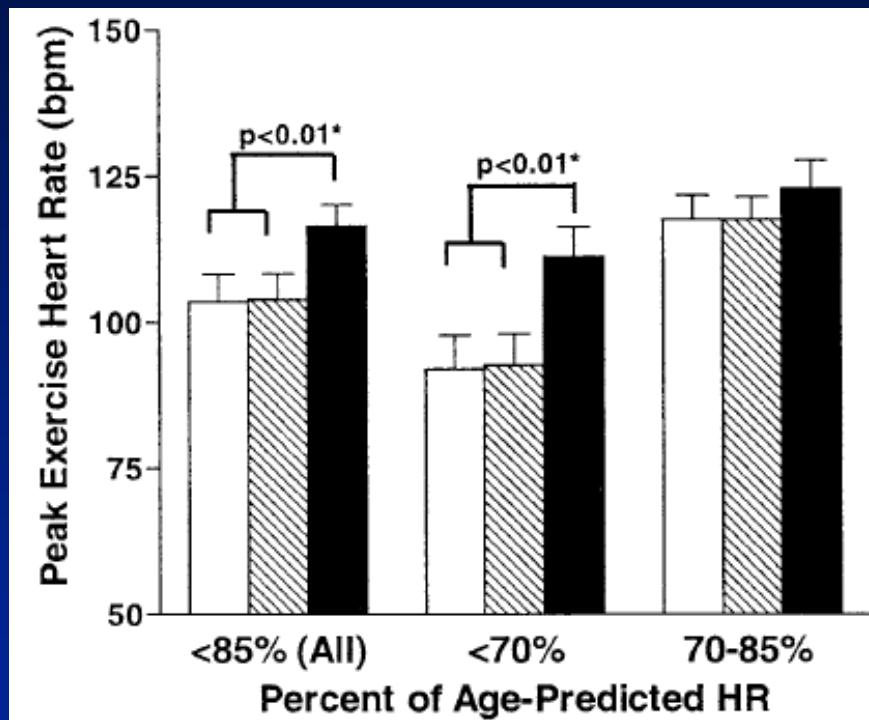


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- 20 patients with heart failure referred for CRT
- All had CI (< 85% APHR and < 80% HRR)
- Randomized to DDD or DDDR

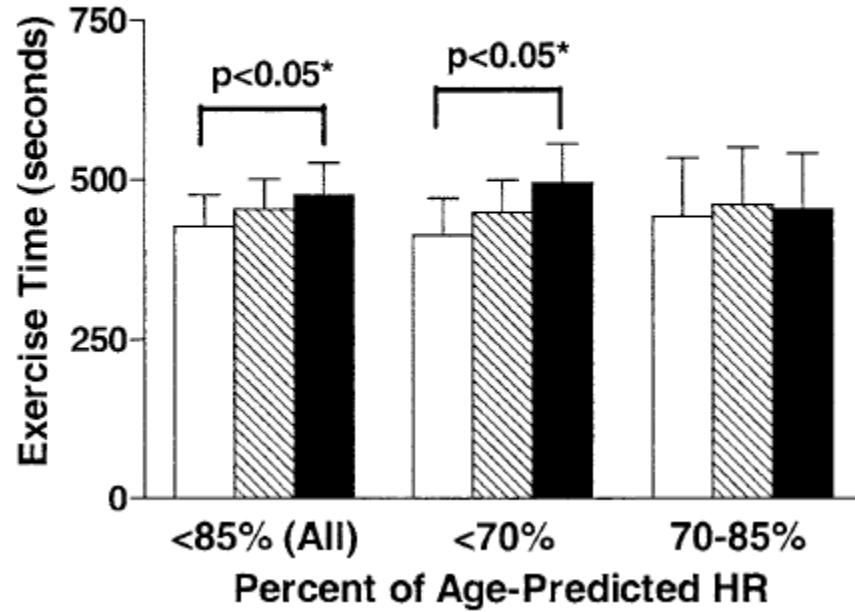


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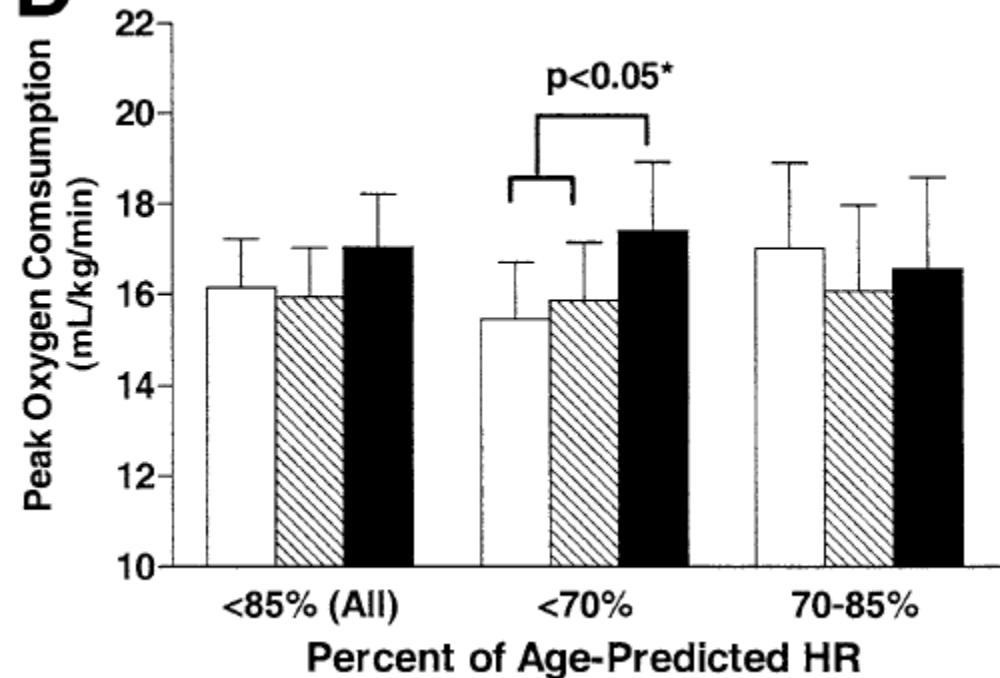


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B



D



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DDDR

DDD

Tse et al J Am Coll Cardiol 2005;46:2292-97

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Conclusion:

1. CI is present in at least 1/3 of patients with heart failure
2. CI is associated with impaired exercise tolerance, quality of life and prognosis



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Conclusion:

3. RR pacing should be considered for the “bad guys” with respect to CI
4. RR pacing in these patients improves dynamic exercise and quality of life
5. All “sensors” are not the same



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## QUESTION 1

In a normal individual  $\text{Vo}_2\text{max}$  can increase during exercise

1. Two fold
2. Four fold
3. Six fold
4. Twelve fold
5. Three fold



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## QUESTION 2

Compared to patients with heart failure and reduced ejection fraction the prevalence of CI in patients with hert failure and preserved ejection fraction is:

1. About the same
2. More prevalent
3. Less prevalent
4. Has not been studied so far
5. Is dependent on the functional (NYHA) class



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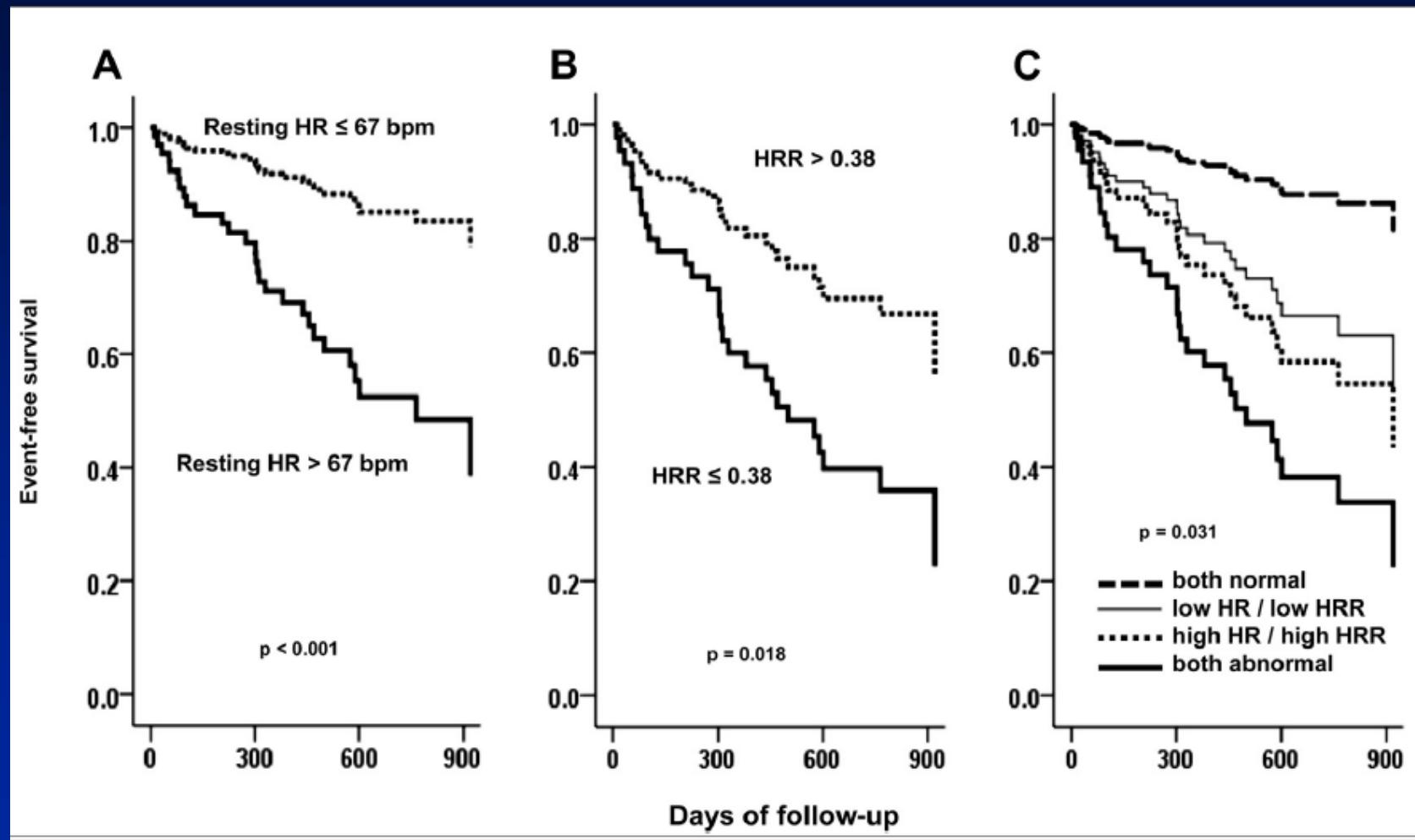
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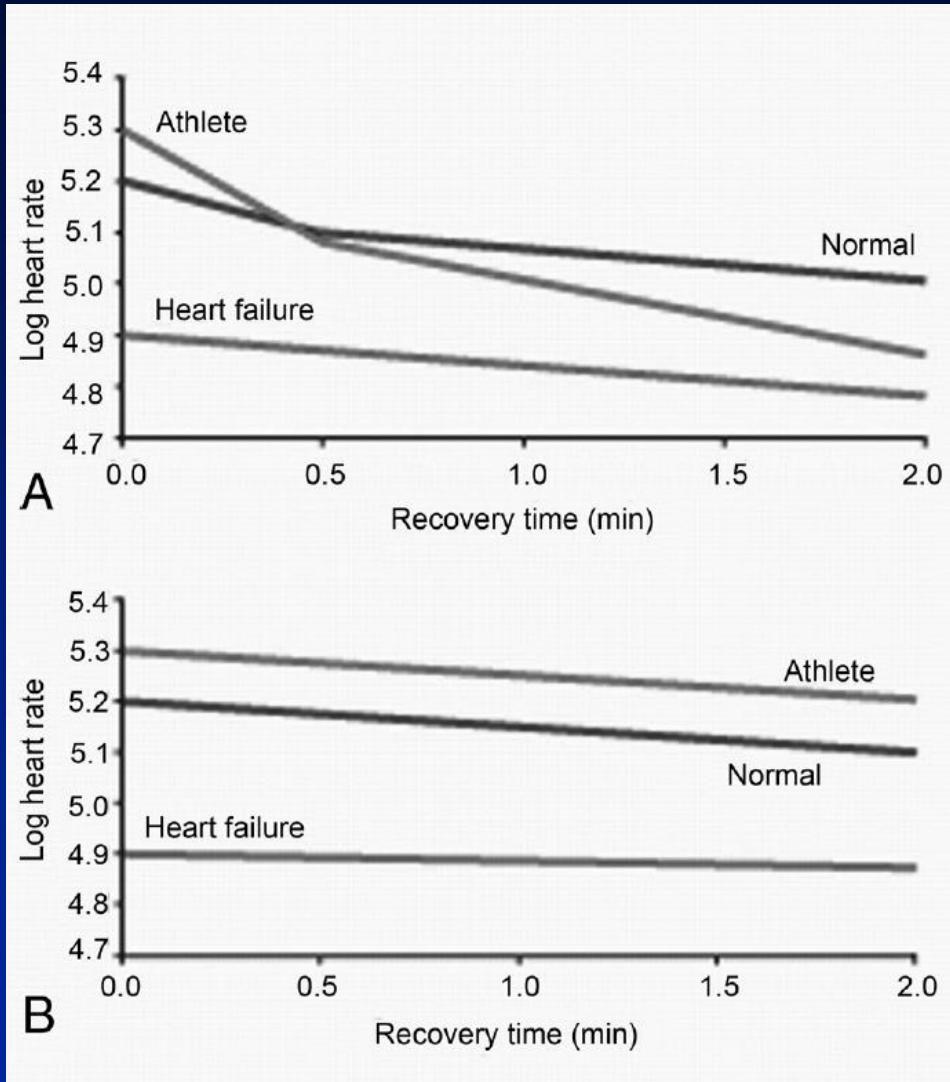
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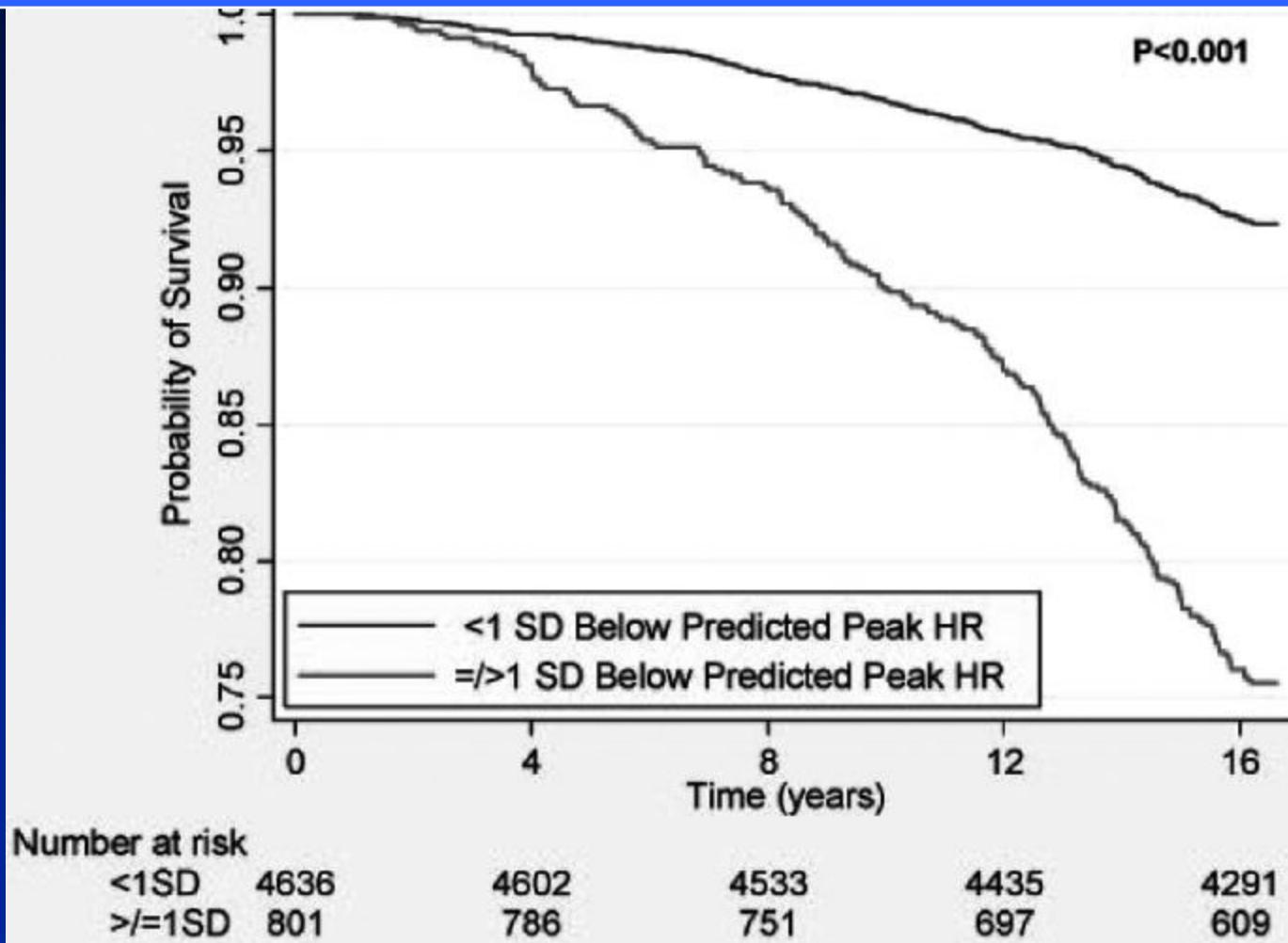
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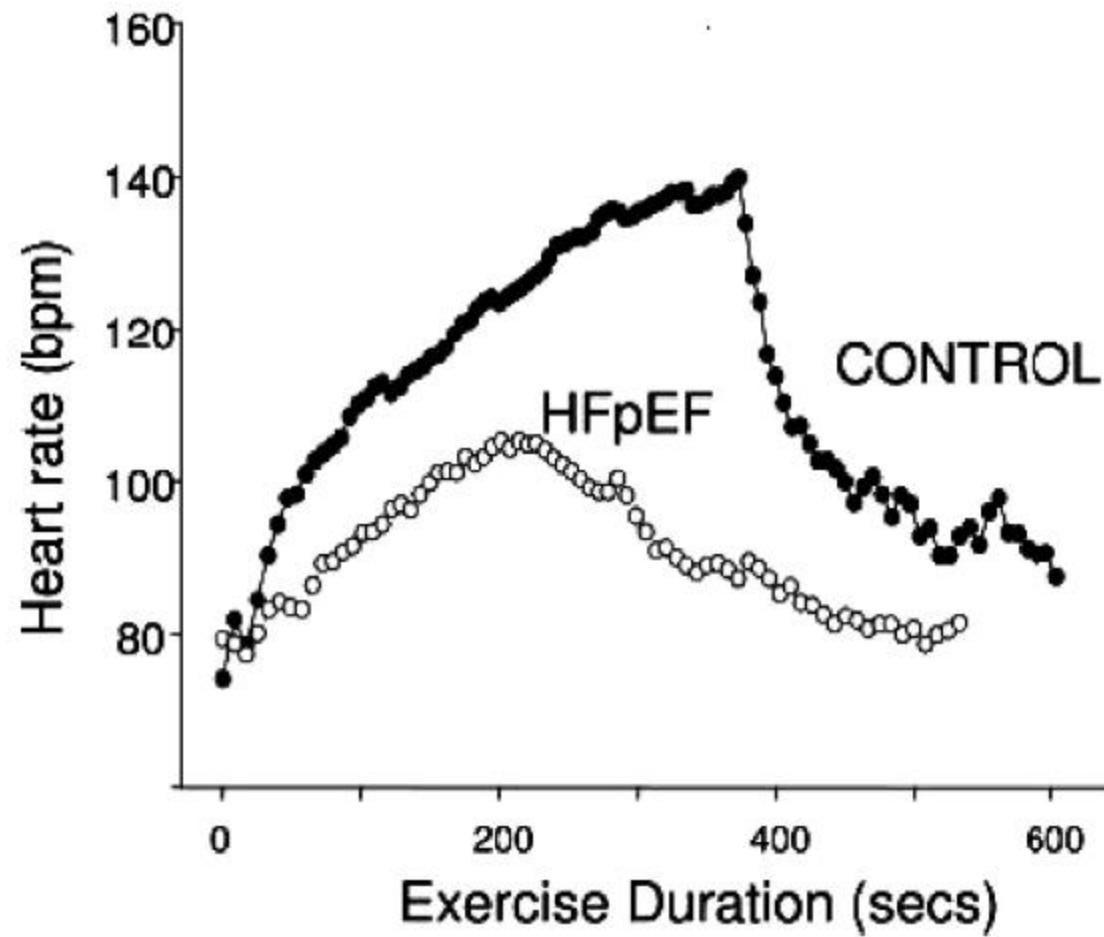




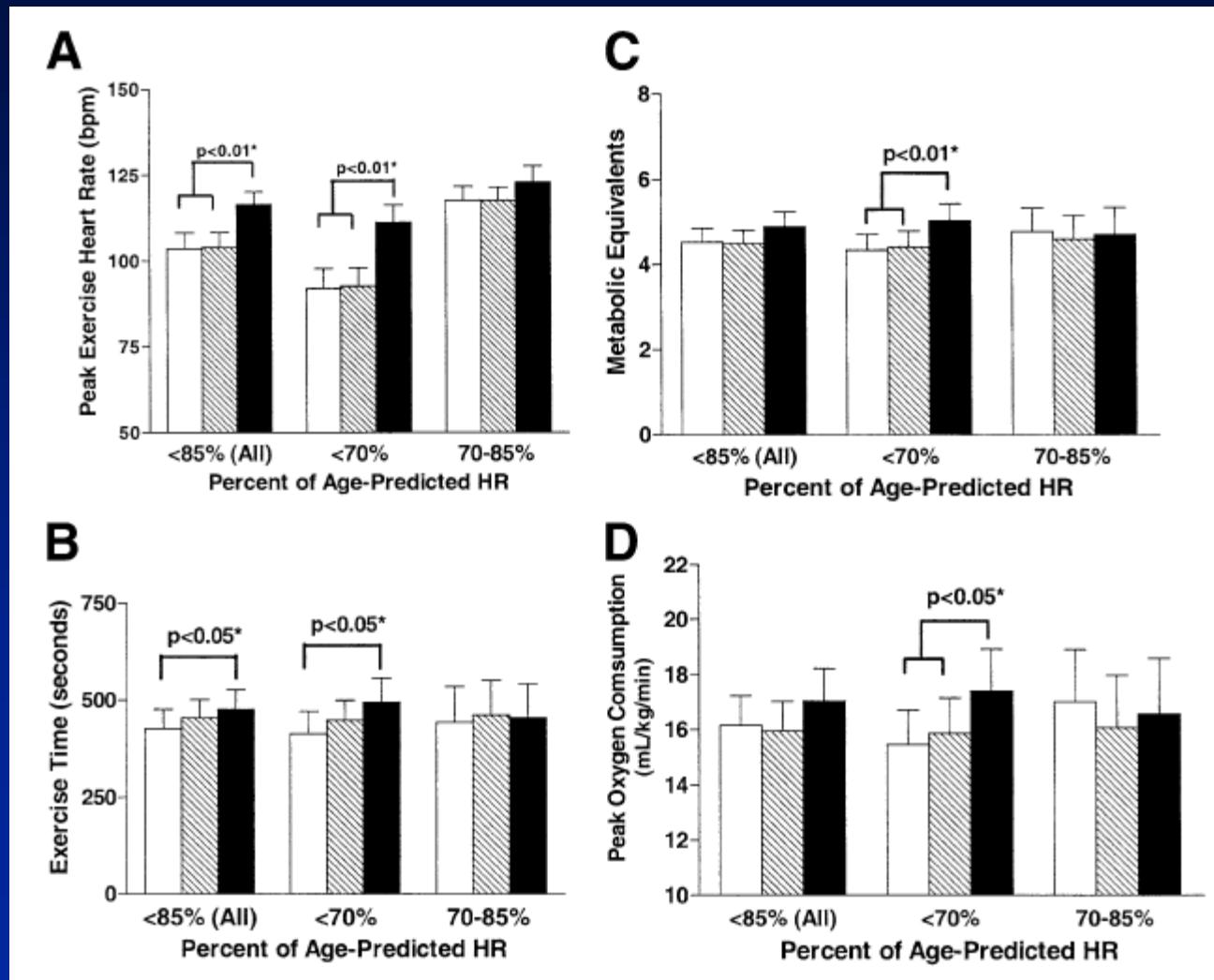
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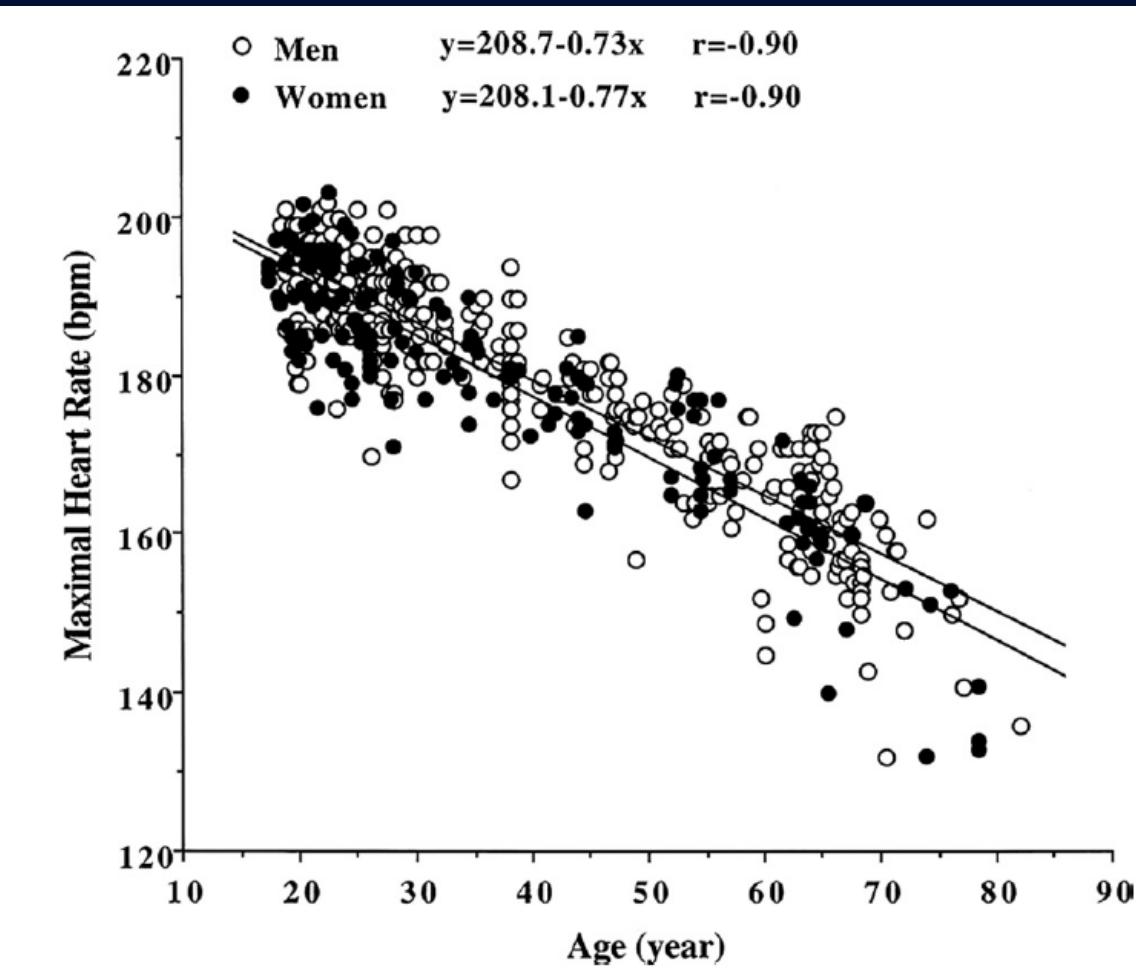


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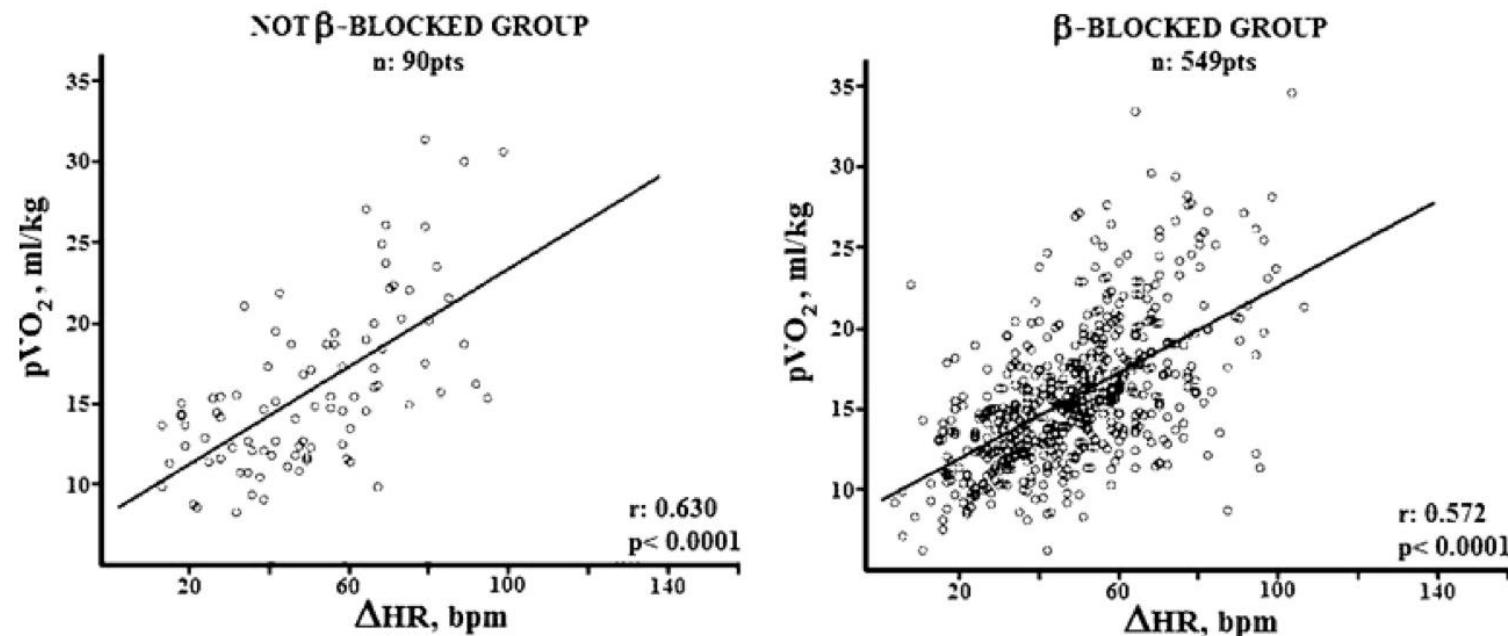
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**Figure 2.** Relationship between age and maximal heart rate in >5000 asymptomatic women, with 95% confidence limits. From these data, a new prediction equation was proposed: Peak heart rate=206–0.88×age. Reproduced from Tanaka et al.<sup>21</sup>





**Figure 3.** There is a significant relationship between change in heart rate (HR) during exercise and  $\dot{V}O_{2\text{peak}}$  in patients (pts) with heart failure with reduced ejection fraction, but there is no significant difference in this relationship between those patients taking  $\beta$ -blockers and those not taking them. Reproduced from Magri et al.<sup>40</sup>

