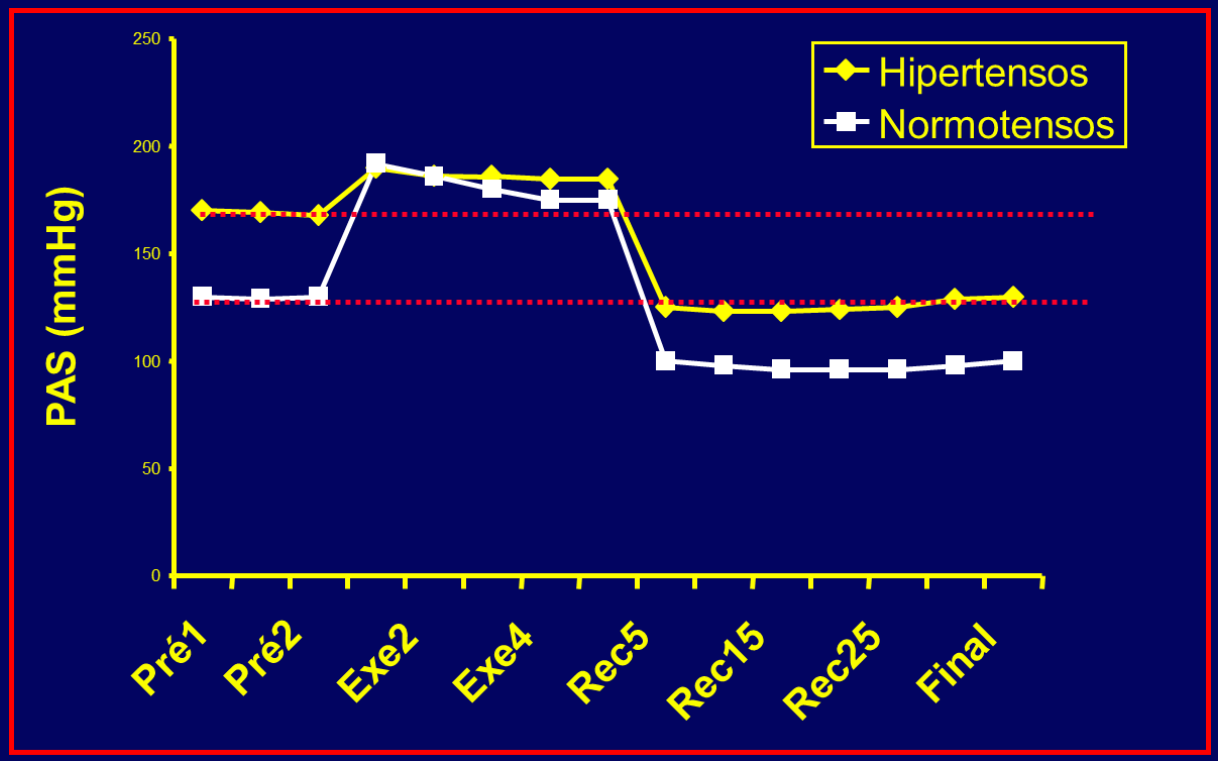
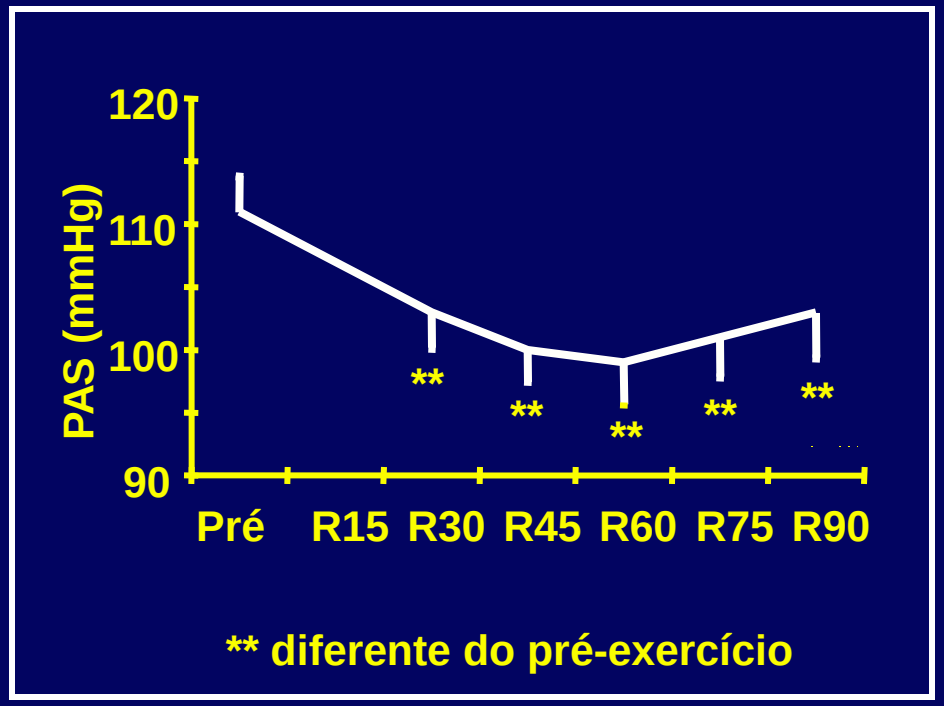
HIPOTENSÃO PÓS-EXERCÍCIO:

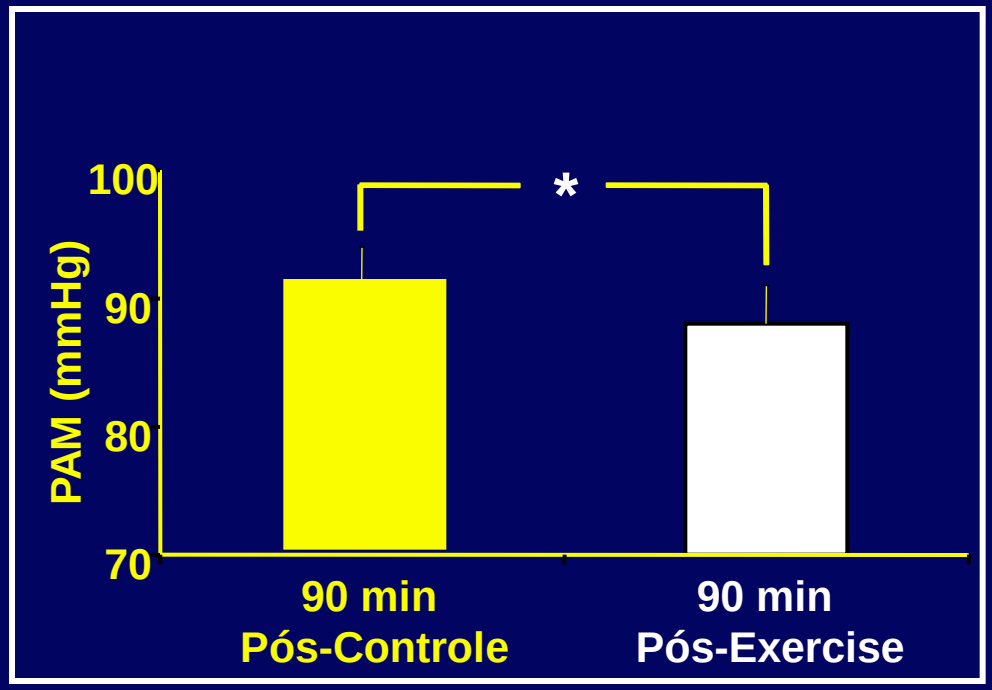


Profa. Dra. Cláudia L. M. Forjaz
cforjaz@usp.br
Escola de Educação Física e Esporte USP

HIPOTENSÃO PÓS-EXERCÍCIO



(FORJAZ et al. Arq. Bras. Cardiol. 70:99-104, 1998)



(FORJAZ et al. J. Appl. Physiol. 87:.824-9, 1999)

Definição:

"Queda significante da pressão arterial após uma única sessão de exercício, atingindo valores inferiores aos observados pré-exercício ou àqueles observados em um dia controle, sem a execução de exercícios";.

HIPOTENSÃO PÓS-EXERCÍCIO

AERÓBIO

- **1960 – 1a. Descrição – Krauls**
- **1980 – relato pessoal - Fitzgerald**

- **1980 a 1990 - Vários estudos**
- **1990 - Revisão - Kenney & Seals**
  Existência – importância
  mecanismos

- **1990 a 2000 - Vários estudos**
- **2004 – posicionamento – ACSM**
  Relevância clínica – grau B
  Mecanismo - ???

RESISTIDO

- **1990 – primeiros estudos**

HIPOTENSÃO PÓS-EXERCÍCIO
IMPORTÂNCIA CLÍNICA

- **Observada - homens e mulheres**
  jovens e idosos
  hipertensos e normotensos

(Forjaz et al. Rev SOCESP 10:16-24,2000)

HIPOTENSÃO PÓS-EXERCÍCIO
MAGNITUDE

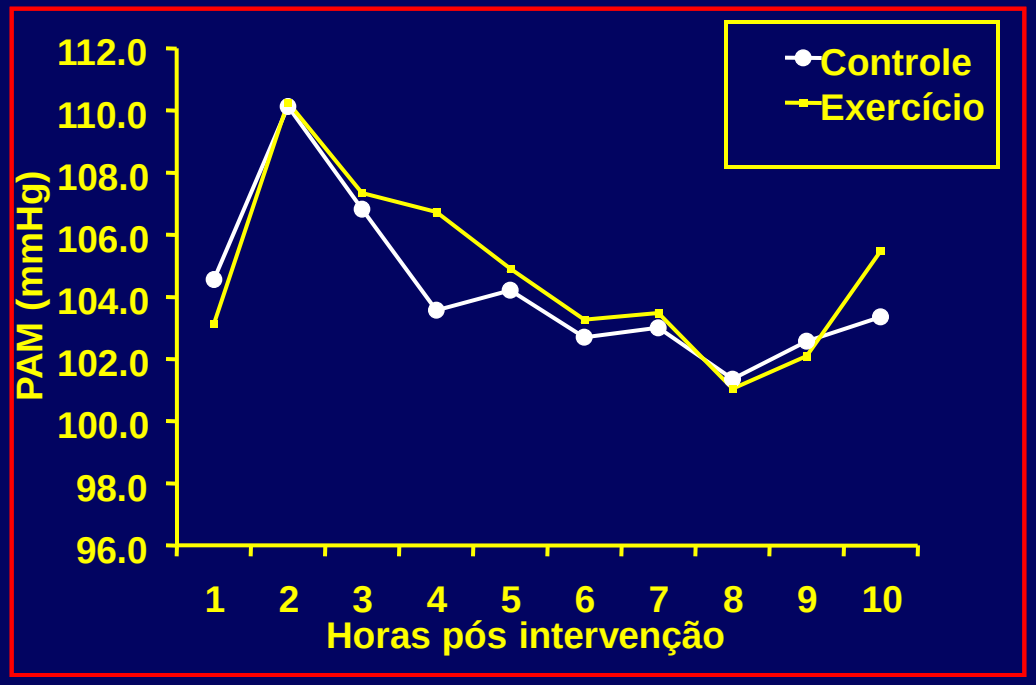
Grande Variabilidade:

NT – desde a ausência de queda até queda de 30 mmHg
média – 5 a 10 mmHg

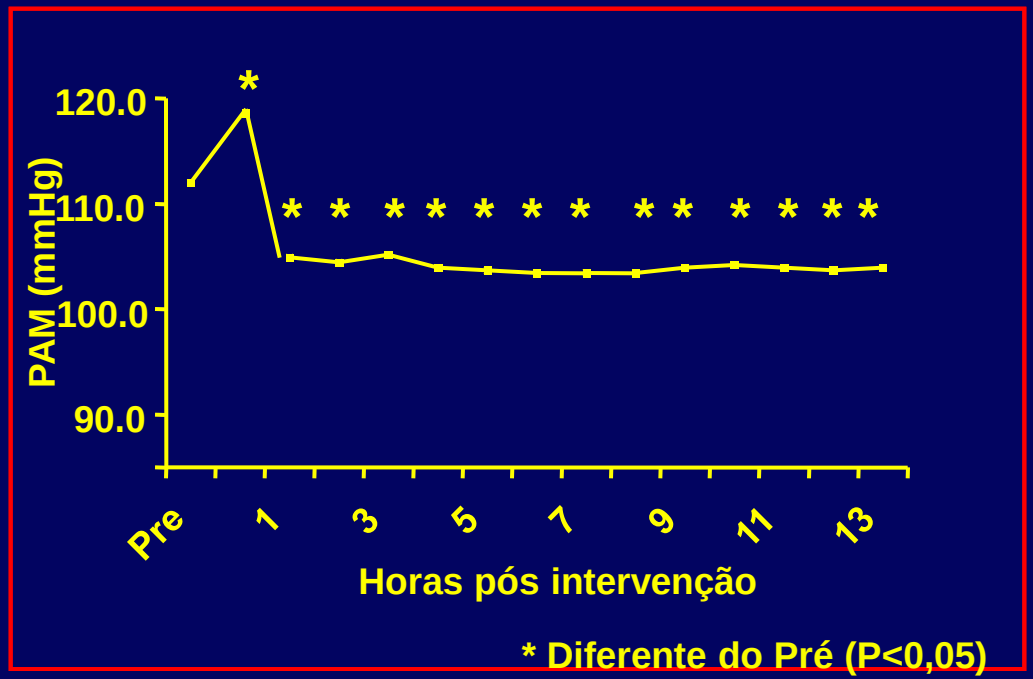
HT – desde a ausência de queda até queda de 40 mmHg
média – 20 mmHg

HIPOTENSÃO PÓS-EXERCÍCIO
DURAÇÃO

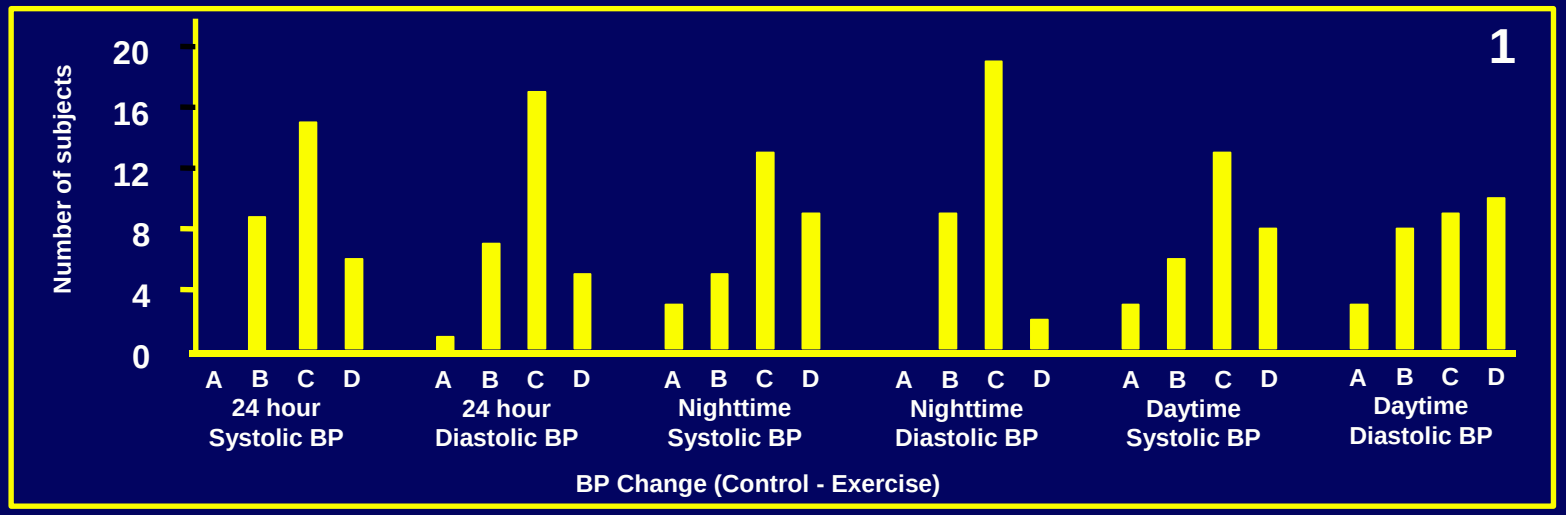
Grande Variabilidade:

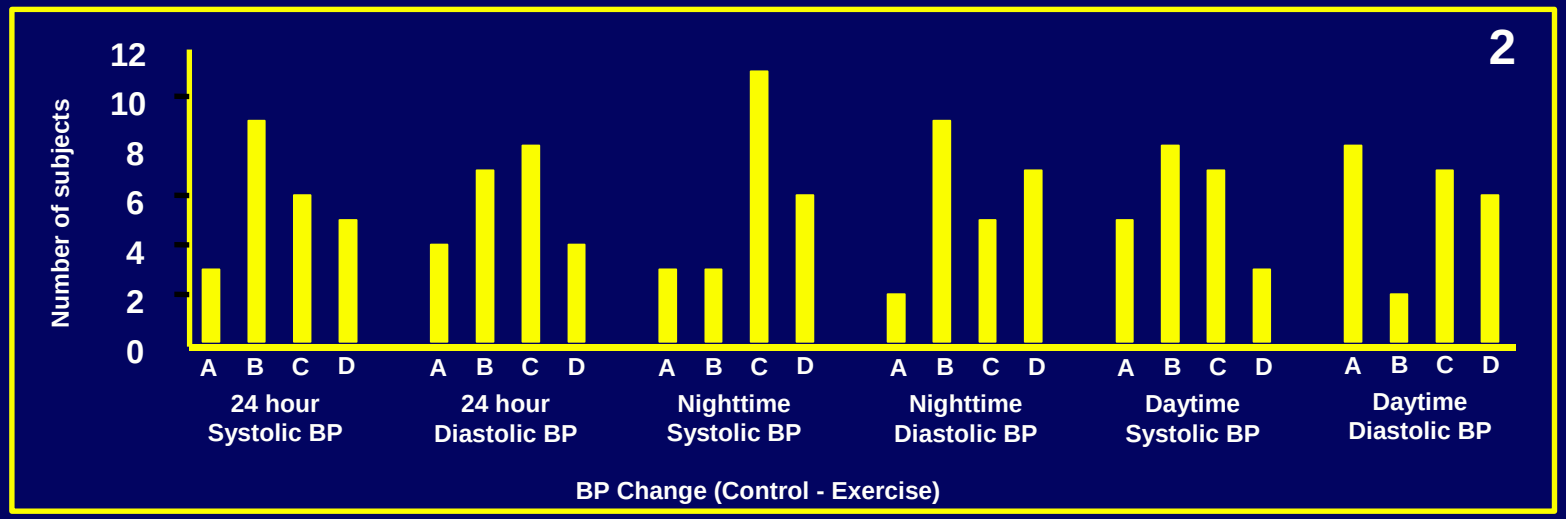


(FORJAZ et al. Blood Pressure Monitoring 5:255-62, 2000.)



(Pescatello et al. Circulation 83:1557-1561,1991)





A=>-5, B=-1 a –5, C=0 a 4, D=>4 mmHg

Respostas individuais variáveis

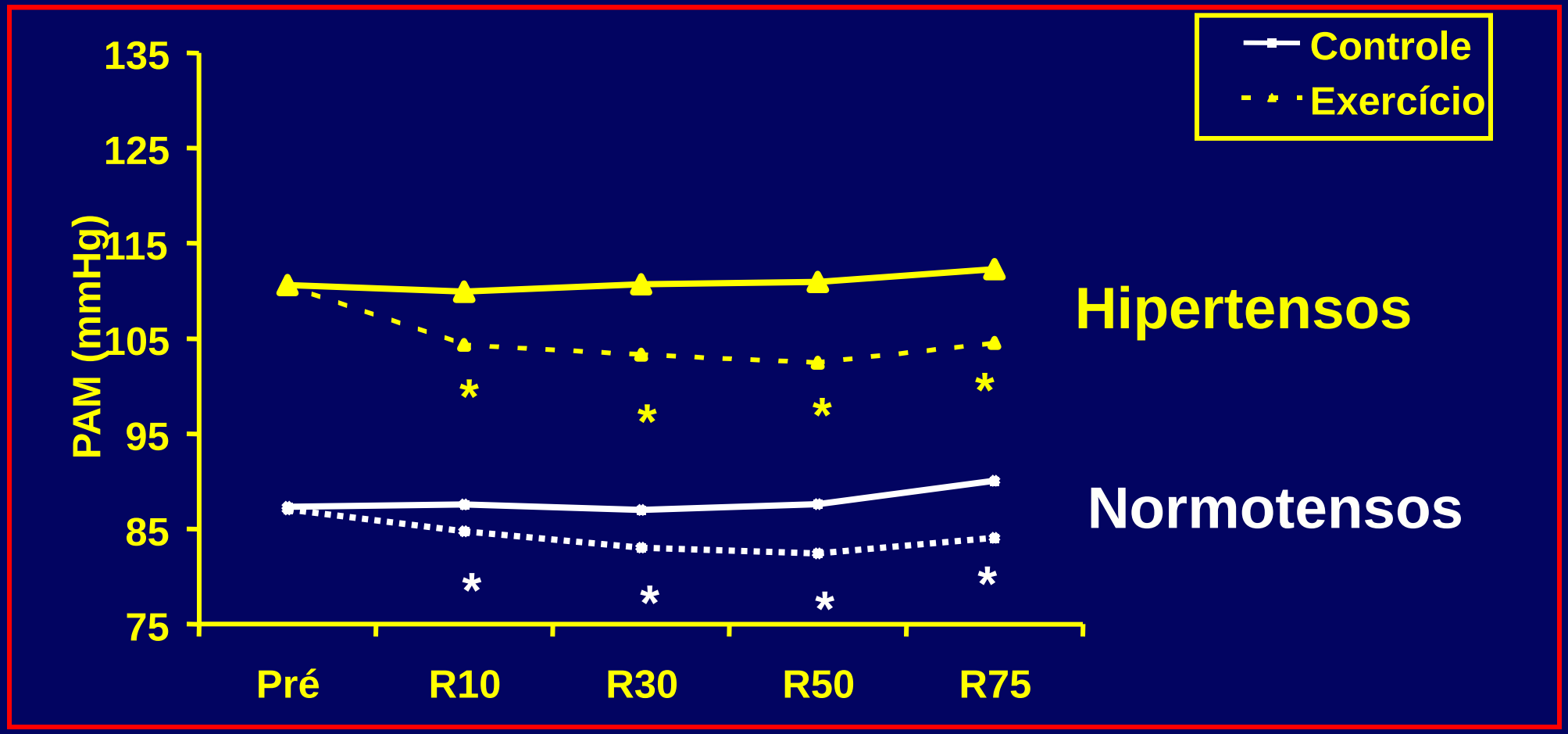
FATORES DE INFLUÊNCIA

População
Exercício

Massa
Intensidade
Duração
GET

POPULAÇÃO

HIPOTENSÃO PÓS-EXERCÍCIO
INDIVÍDUOS JOVENS



* Diferente do Pré e do Controle (P<0,05)

Santaella, SBH2002



PA Clínica
Característica da População

Variáveis	Δreal PAS		Δreal PAD	
	R	P	r	P
Cardiovasculares				
PAS de repouso	-0,184	0,010		
PAS pré-exercício	-0,239	0,001		

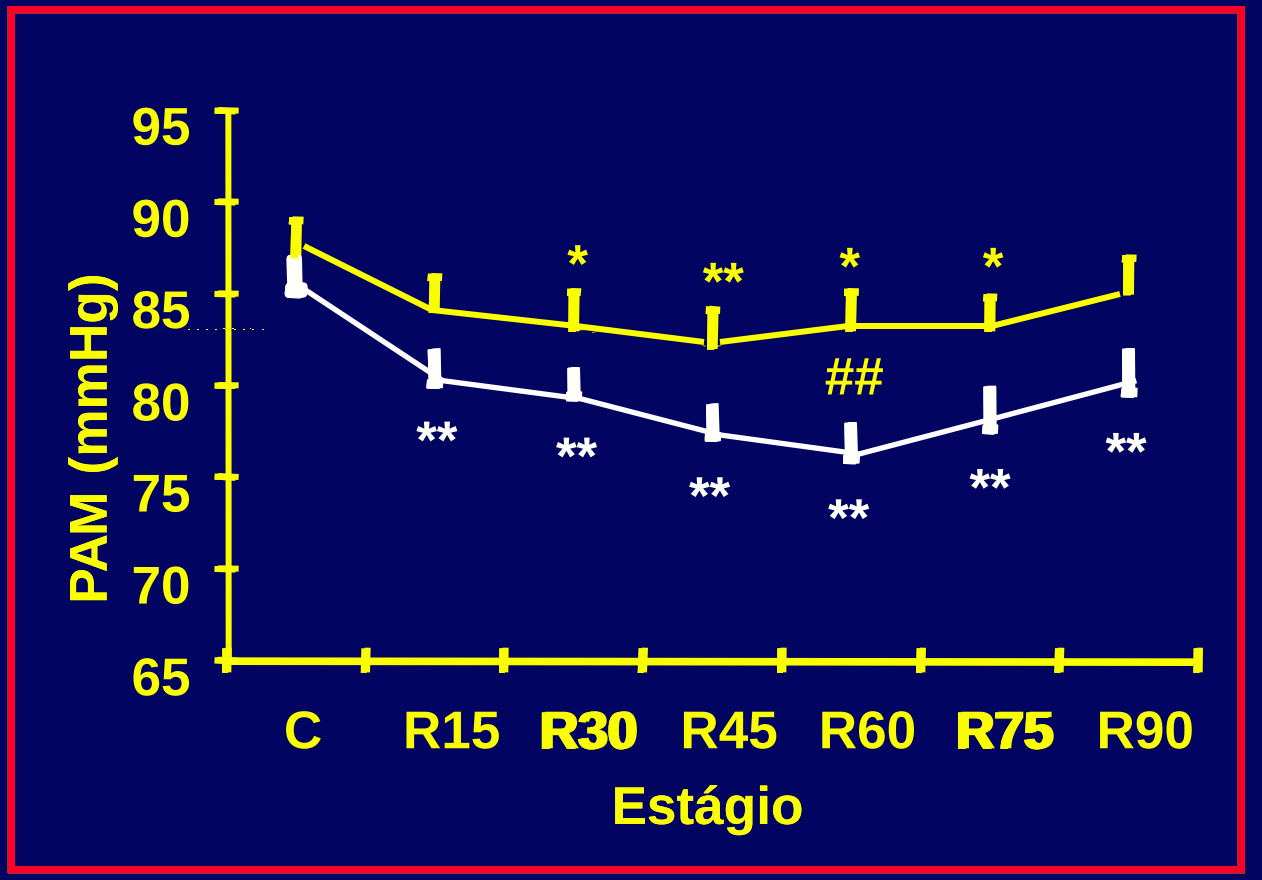
PAS = > PAS pré > redução

Forjaz, 2007

Fatores de Influência nos Normotensos

DURAÇÃO

HIPOTENSÃO PÓS-EXERCÍCIO
DURAÇÃO DO EXERCÍCIO

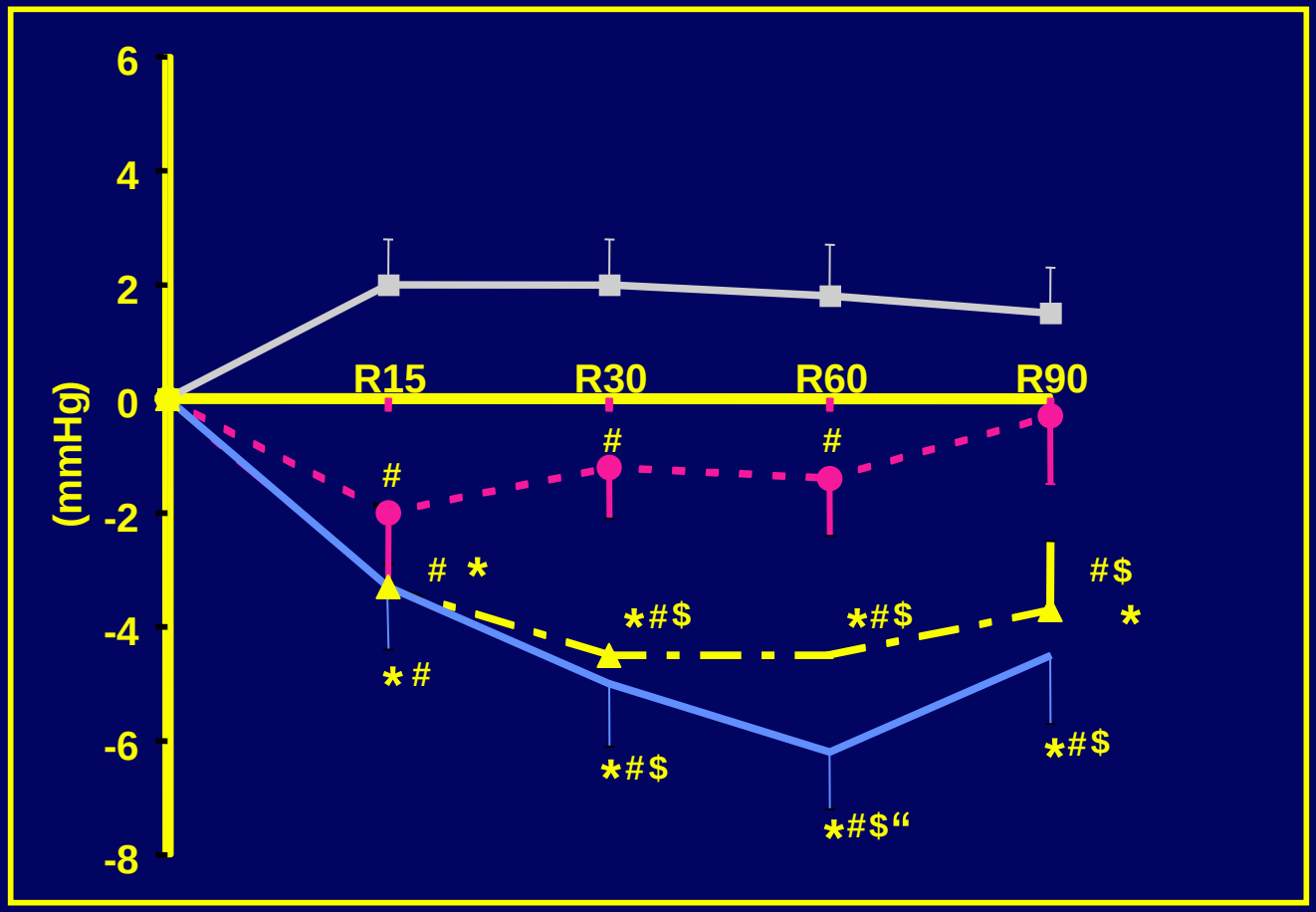


— 45 min. — 25 min.

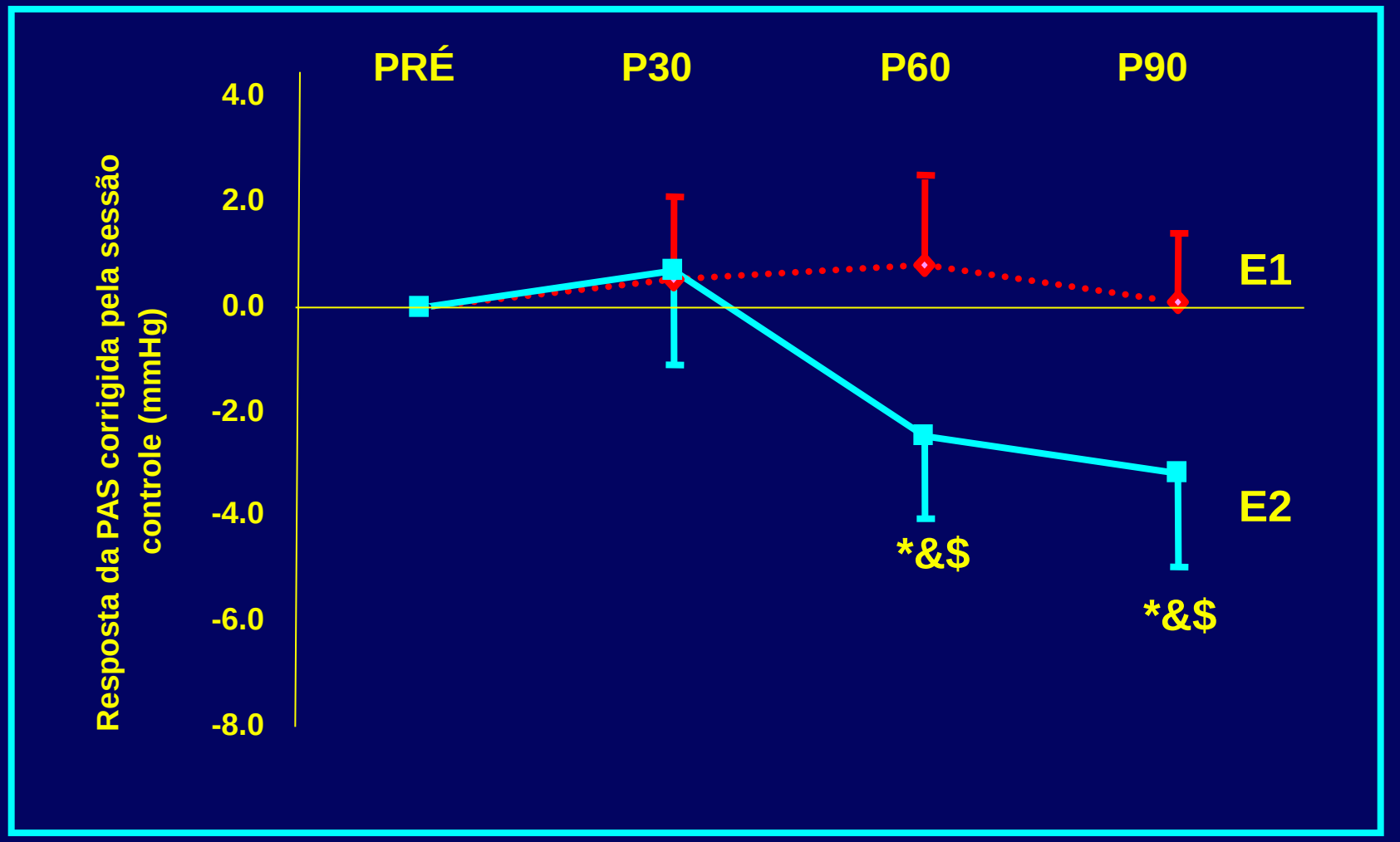
(FORJAZ et al. Arq. Bras. Cardiol. 70:99-104, 1998)

INTENSIDADE

Hipotensão Pós-Exercício - Intensidade



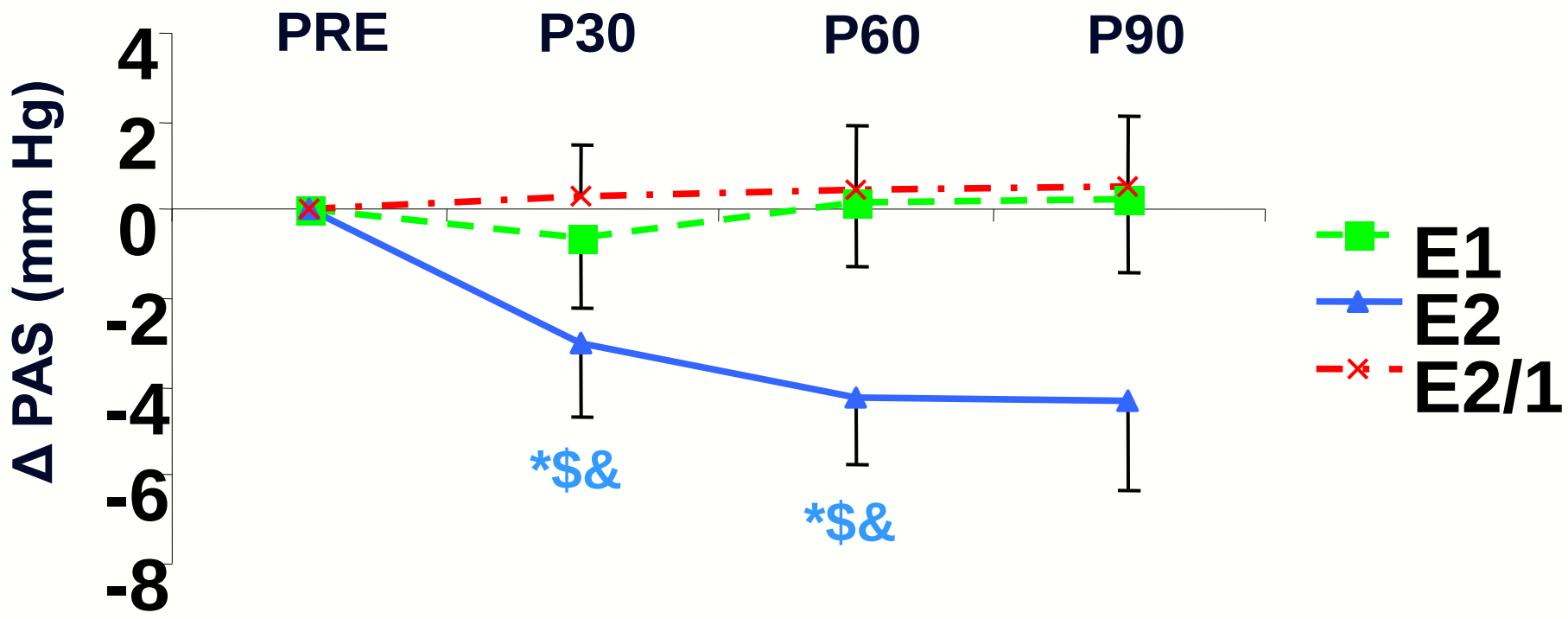
MASSA MUSCULAR



* Diferente do PRÉ; & Diferente da sessão E1; $ Diferente da sessão E2/1.

Araujo, dissertação 2007

GASTO ENERGÉTICO TOTAL



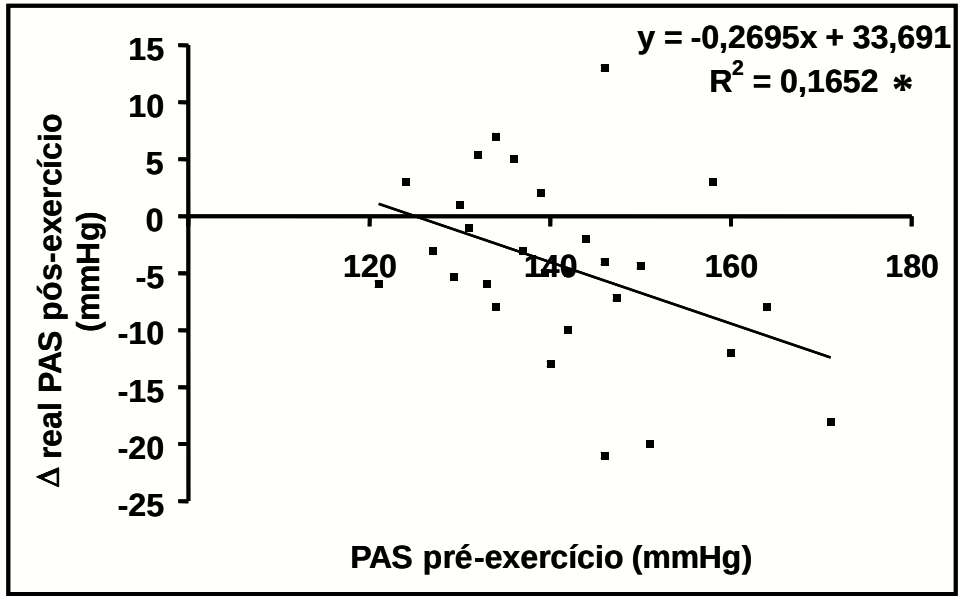
Sessões	Potência (watts)	GET (kcal)	Intensidade relativa (% do VO_2pico)
E1	26 ± 3	175 ± 10 *$&	57 ± 3 &@
E2	67 ± 5 $&	259 ± 21 $&	56 ± 2 &@
E2/1	26 ± 3	157 ± 12	36 ± 2

Cardoso Jr, dissertação, 2005

Fatores de Influência nos Hipertensos



PA Clínica
Característica da População



PAS = > PAS pré > redução

PAD = < PAD rep > redução

> $\%VO_2pred$ > redução

Forjaz, 2007



PA 24 horas
Característica da População

Hipertensos –	< Idade	> queda
	< IMC	> queda
	> VO_2max	> queda
	> PA ambulatorial	> queda
	> Carga PA	> queda

Maior queda – Hipertenso
mais jovem, mais magro, com maior aptidão aeróbia e COM MAIOR PA



Características do Exercício
Pouco estudado

Duração

SHR -	> duração	> efeito
Homem-	Intervalado	> queda com + estímulo

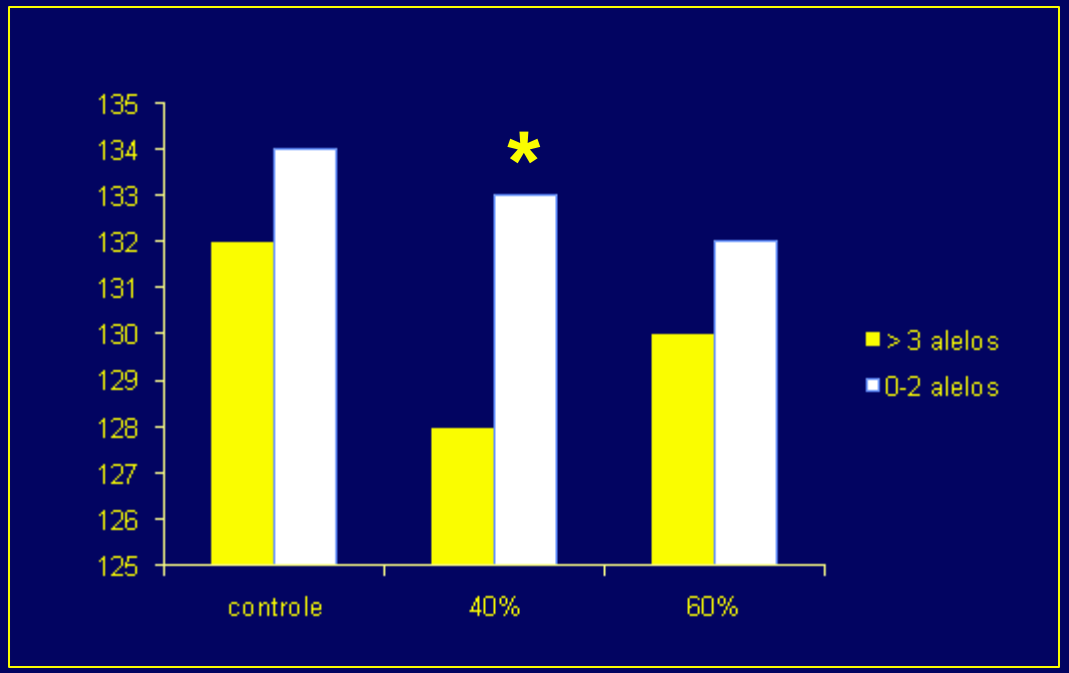


Características do Exercício Intensidade

Amostra total

	Controle	40%	60%
PAS (mmHg)	133±2	131±2 *	131 ±2 *
PAD (mmHg)	83±1	81±1 *	ns

Hipertensos com polimorfismos gene RAAS



Blanchard et al. EJAP, 2006

FATORES DE INFLUÊNCIA

Normotensos

> PA inicial

> Duração
> Intensidade
> Massa muscular
Gasto energético mínimo

Hipertensos

> PA inicial
< Idade, IMC
> Aptidão aeróbia

> Duração
< Intensidade

HIPOTENSÃO PÓS-EXERCÍCIO
MECANISMOS

HEMODINÂMICO SISTÊMICO
Débito Cardíaco – FC e VS
Resistência Vascular Periférica

NEURAIS
ANS Coração
ANS Muscular

LOCAIS
NO
Metabólitos

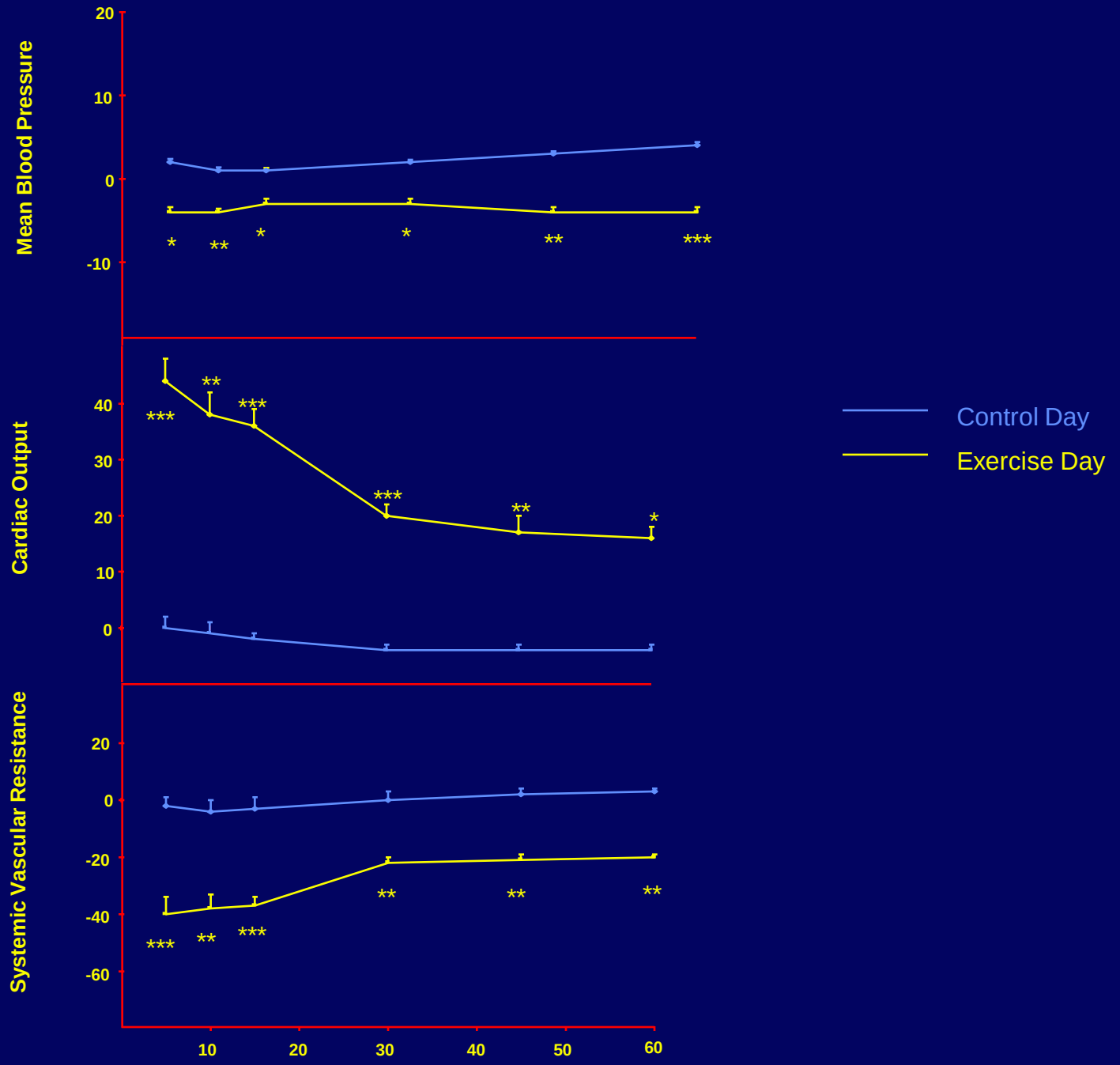
HUMORAIS
Opióides

Medida do DC – técnica reinalação de CO_2



Fórmula de Fick indireto

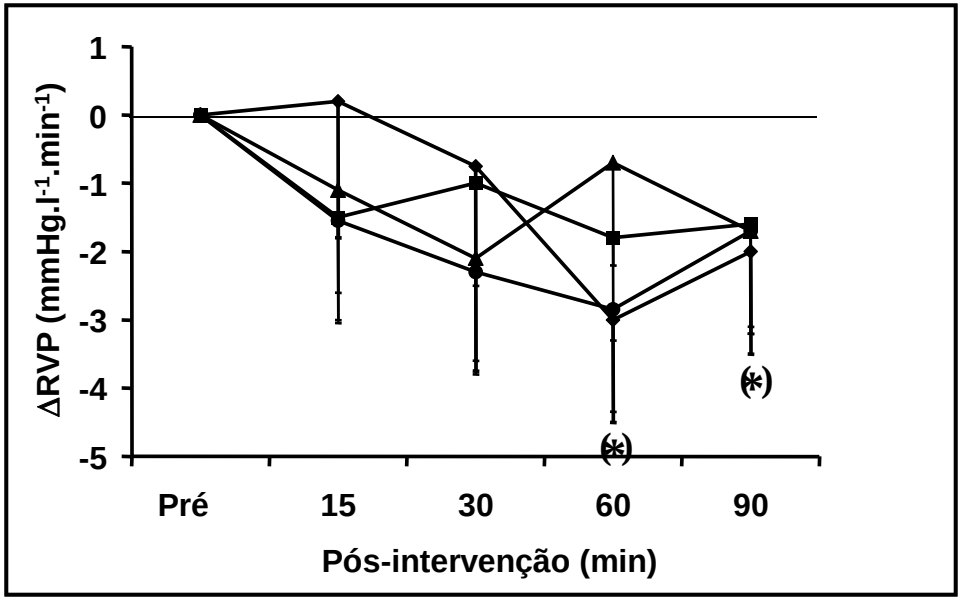
$$\text{Débito cardíaco} = \frac{VCO_2}{Dif_{(v\text{-}a)}Co_2}$$

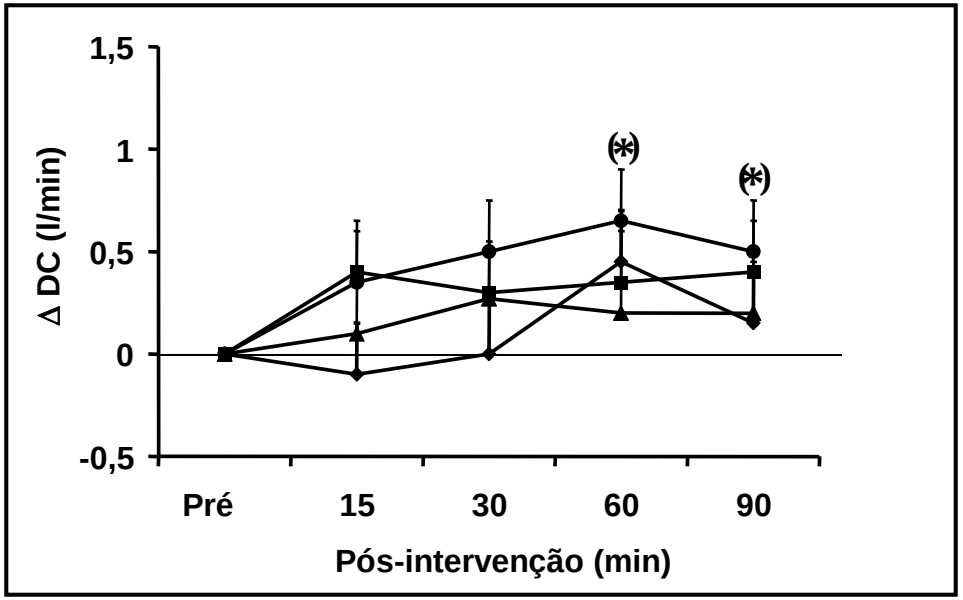


Adaptado de Coats et al. - J. Physiol. 1989, 413:289-298.

MECANISMO HEMODINÂMICO
Jovens Normotensos







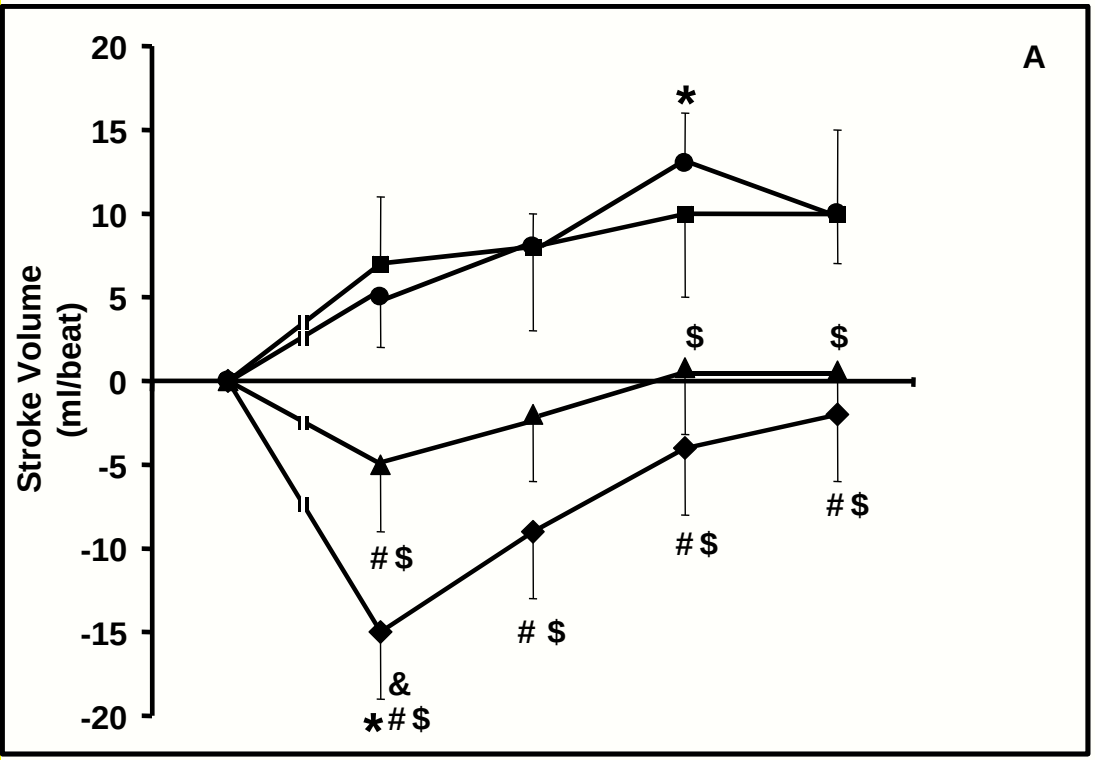
▮ controle ● 30% ▲ 50% ♦ 75%

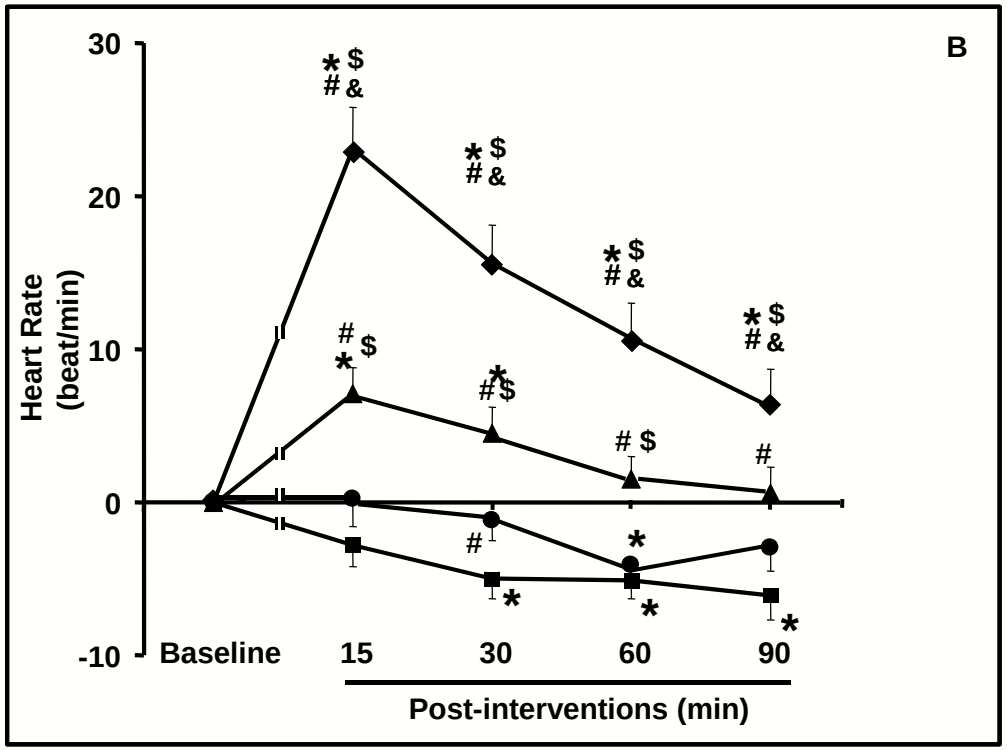
50% ↓ DC e 50% ↓ RVP

Forjaz et al., 2004

Redução do Débito Cardíaco

Mecanismo Hemodinâmico
Jovens Normotensos



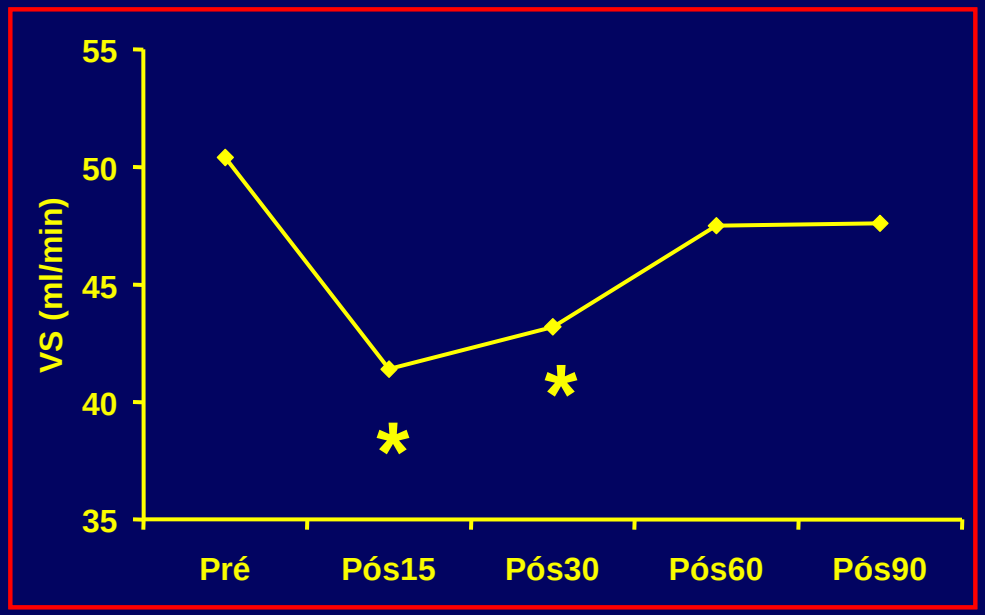


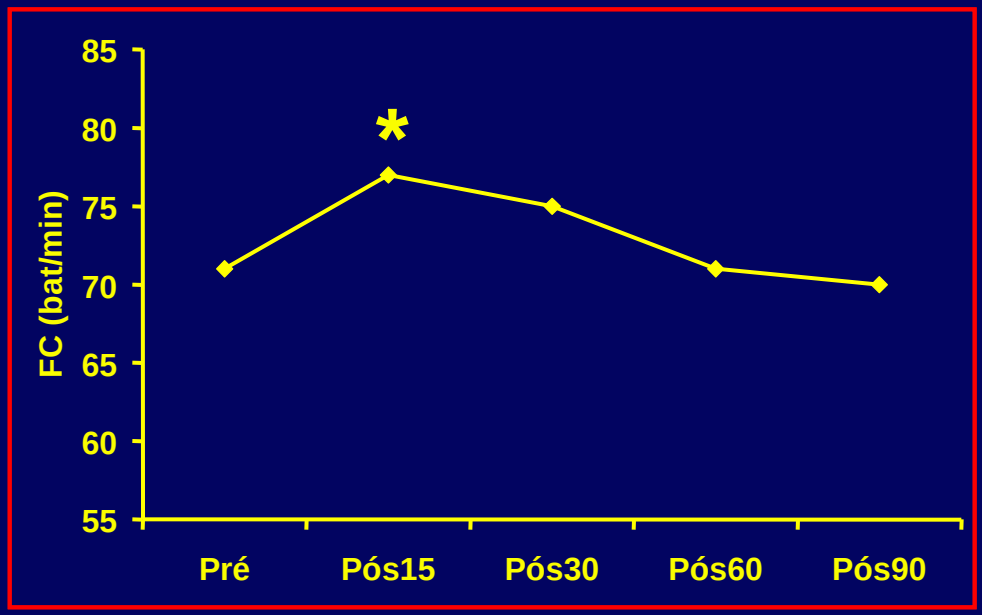
■ Control ● 30%VO_2peak ▲ 50%VO_2peak ◆ 75%VO_2peak

Forjaz et al. J.Sports Med. Phys. Fitness, 44:54-62, 2004

HIPOTENSÃO PÓS-EXERCÍCIO
MECANISMO HEMODINÂMICO

Diminuição de Débito





* Diferente do Pré (P<0,05)

↓ VDF

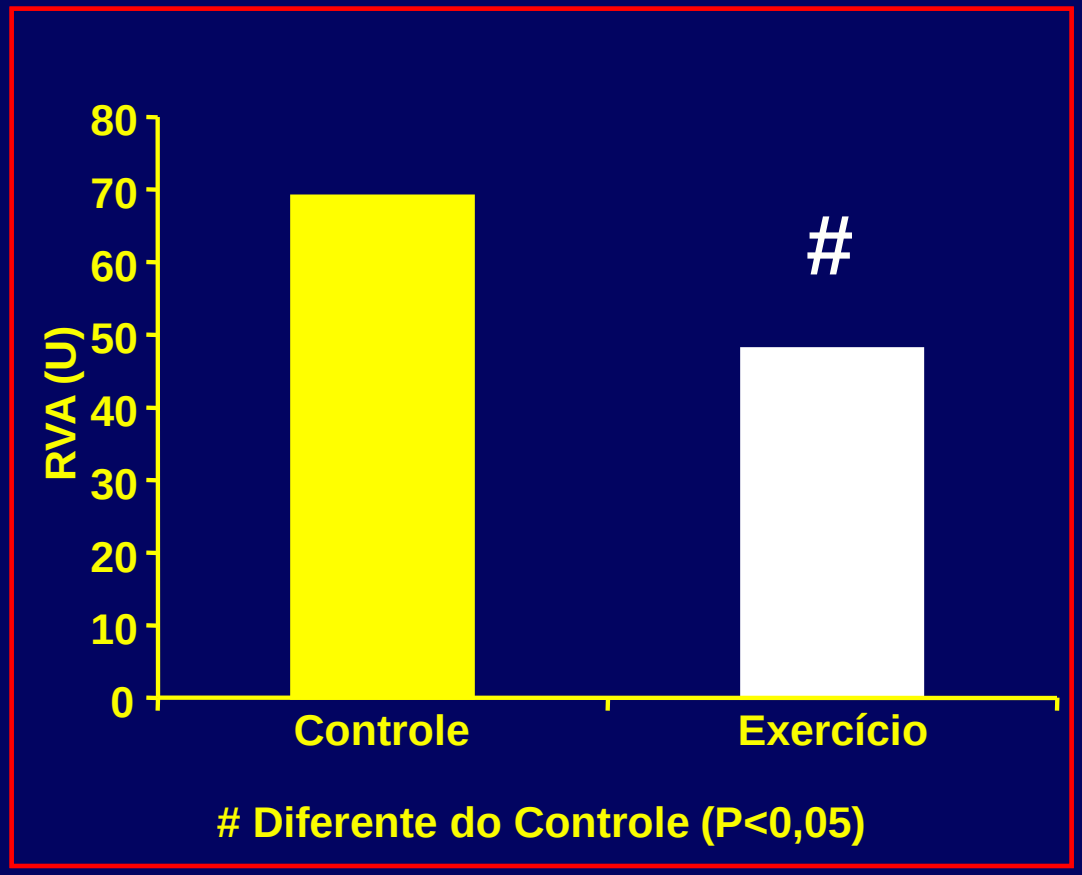
(Adaptado de Rondon et al. JACC 39:676-682, 2002)

Redução da Resistência Vascular Periférica

Medida do Fluxo Sanguíneo
Pletismografia de Oclusão Venosa a Ar



MECANISMO HEMODINÂMICO MUSCULAR



(Forjaz et al. JAP 87:.824-9, 1999)
(Forjaz et al. JAP no prelo)

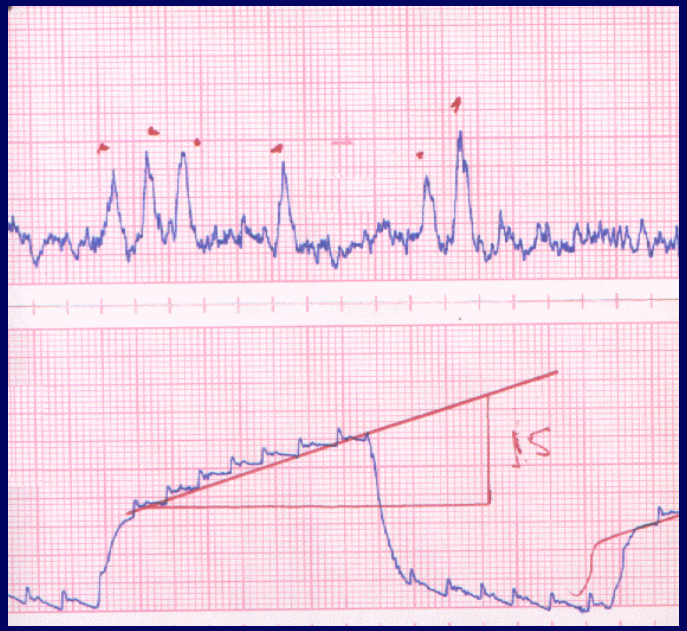
MECANISMOS NEURAIS

Medida da Atividade Nervosa Simpática Periférica
Microneurografia



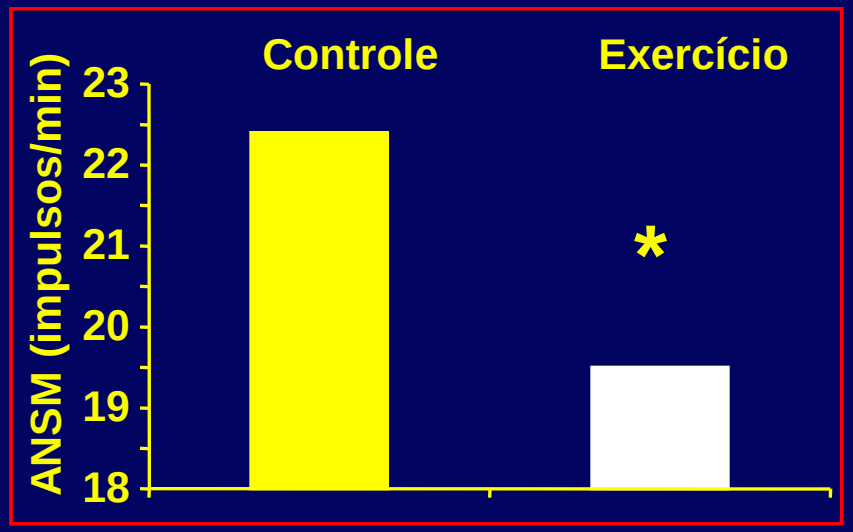
HIPOTENSÃO PÓS-EXERCÍCIO - MECANISMO NEURAL

CONTROLE
Basal



EXERCÍCIO
Basal



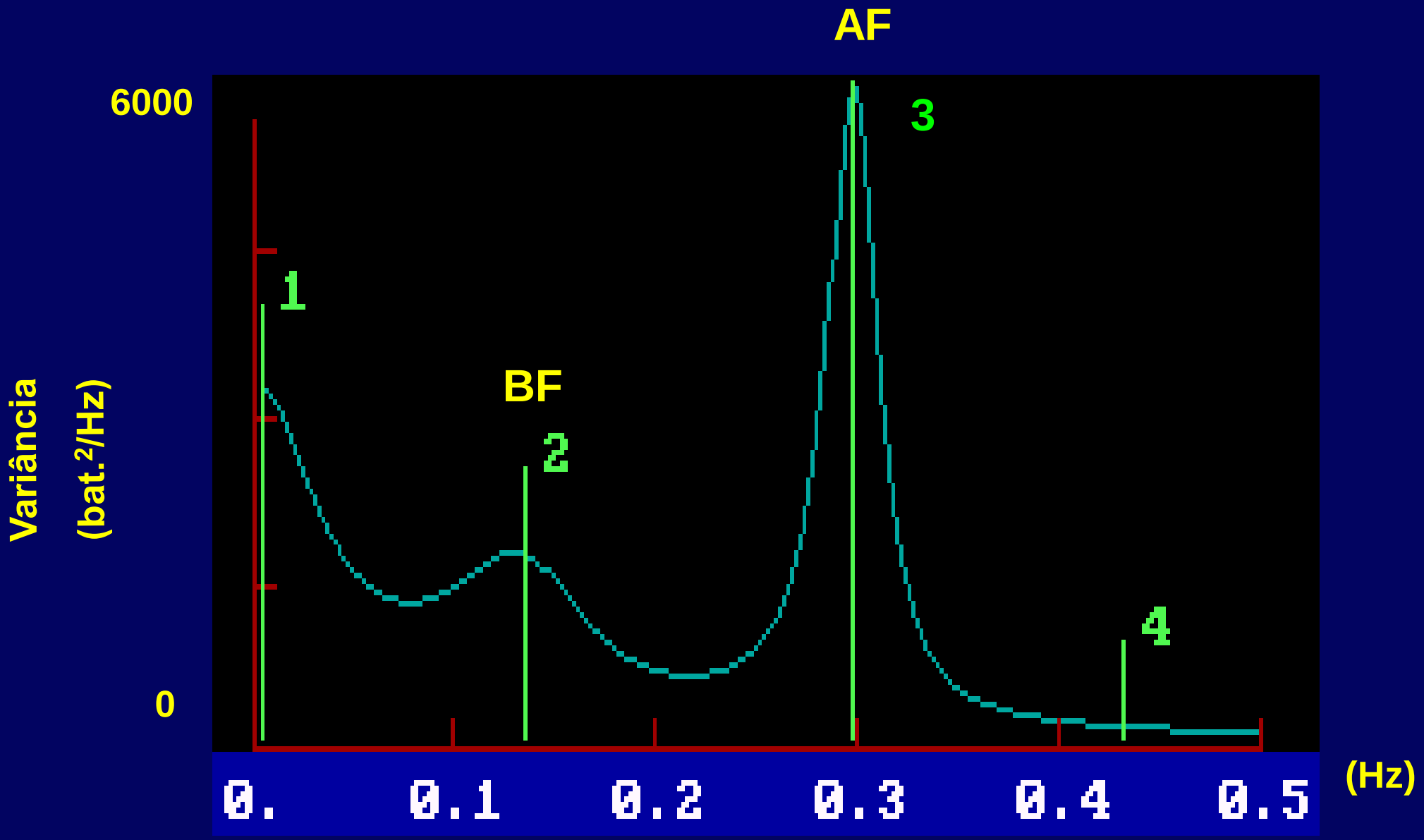


*** Diferente do Controle (P<0,05)**

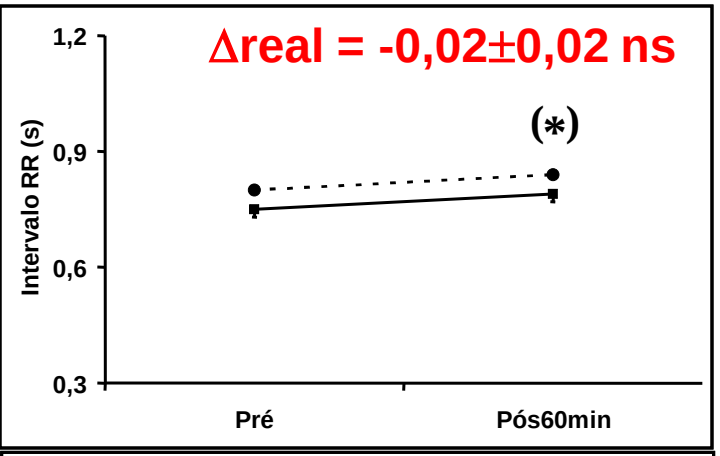
(Forjaz et al. JAP 87:.824-9, 1999)

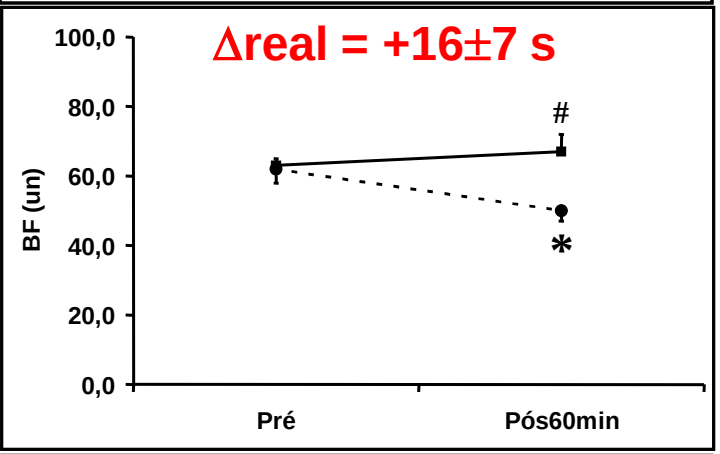
Medida da Atividade Nervosa Simpática para o Coração
Análise Espectral da Variabilidade da FC

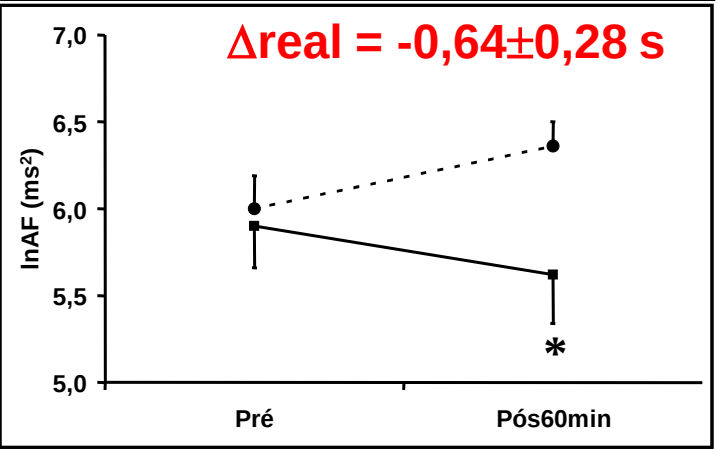


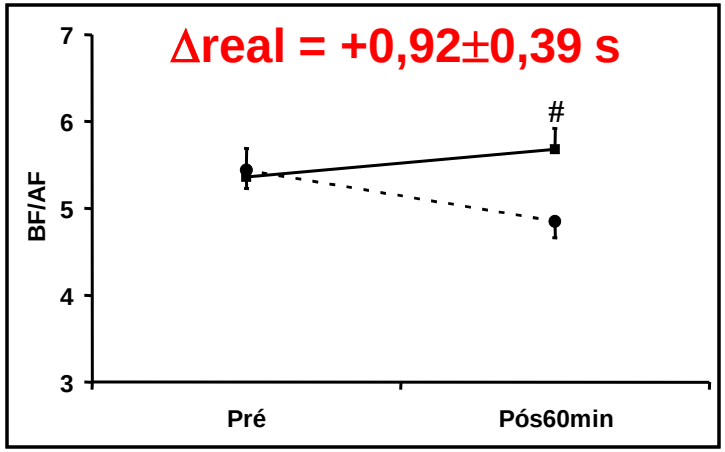

AF
6000
3
1
BF
2
4
0
Variância
(bat.²/Hz)
0.
0.1
0.2
0.3
0.4
0.5
(Hz)

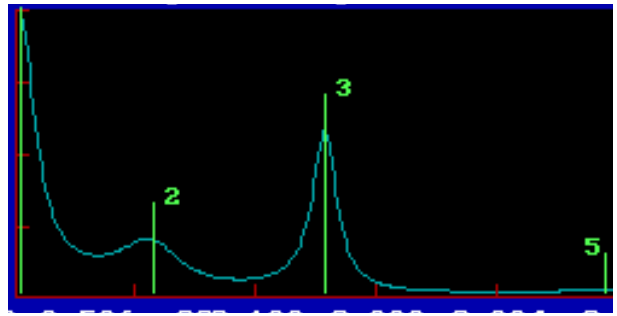
MODULAÇÃO AUTONÔMICA CARDÍACA

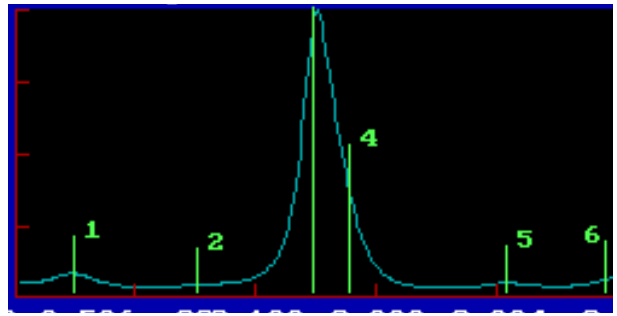












● Controle

■ Exercício

HIPOTENSÃO PÓS-EXERCÍCIO AERÓBICO:

- Fenômeno bem demonstrado – Diferentes populações
- Magnitude e duração – Importância clínica
- Influenciada – Características da população e do exercício
- Mecanismos – Diferentes entre indivíduos
  - Ação vasodilatadora
  - Redução retorno venoso

Profa. Dra. Cláudia L. M. Forjaz
cforjaz@usp.br
Escola de Educação Física e Esporte USP

HIPOTENSÃO PÓS-EXERCÍCIO RESISTIDO

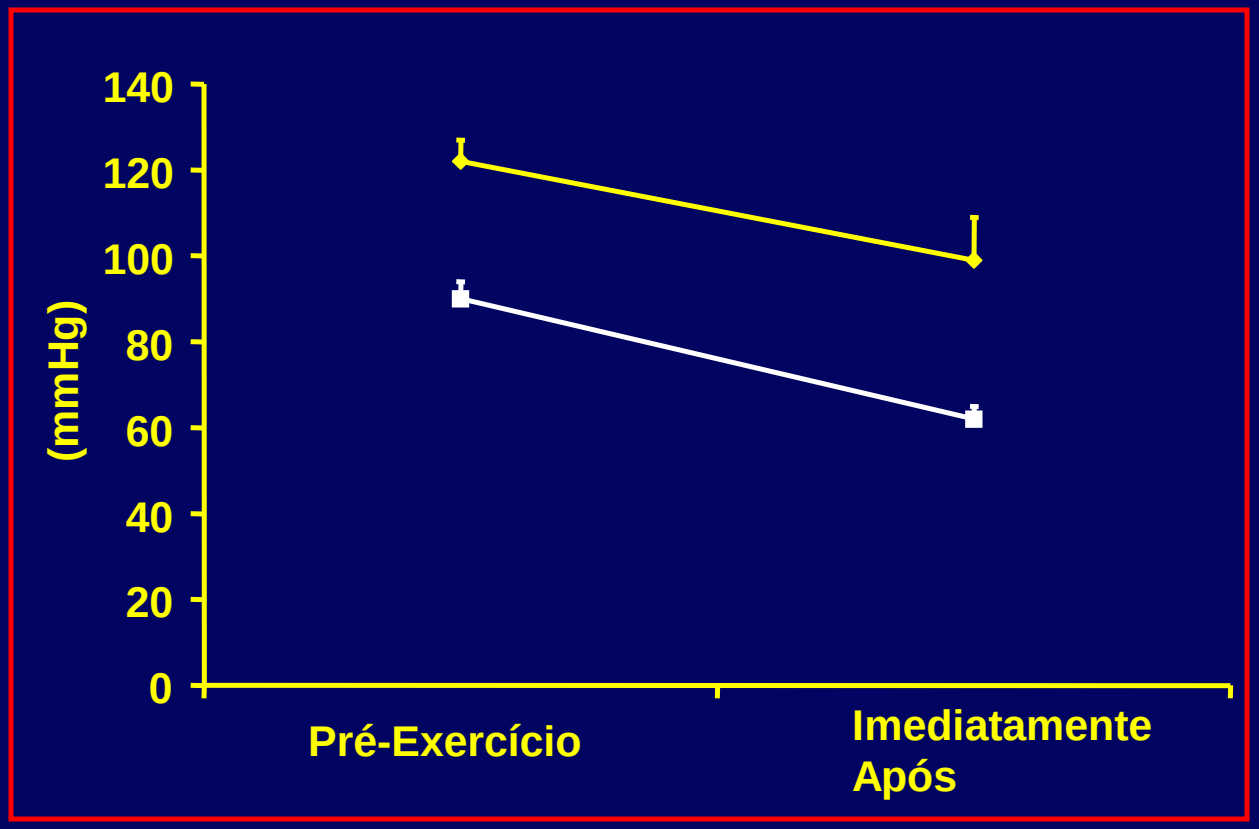




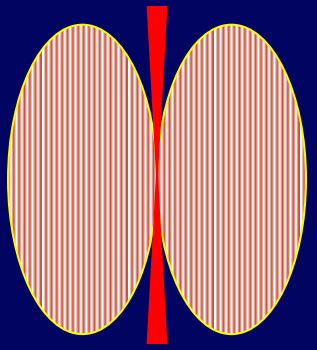




Imediatamente Após



Saudáveis
4 exercícios
70%1RM
Até exaustão
Auscultatório



Hill et al J. Applied Sports Sci Res 1989; 3:44-47

EXERCÍCIO RESISTIDO E PA PÓS-EXERCÍCIO

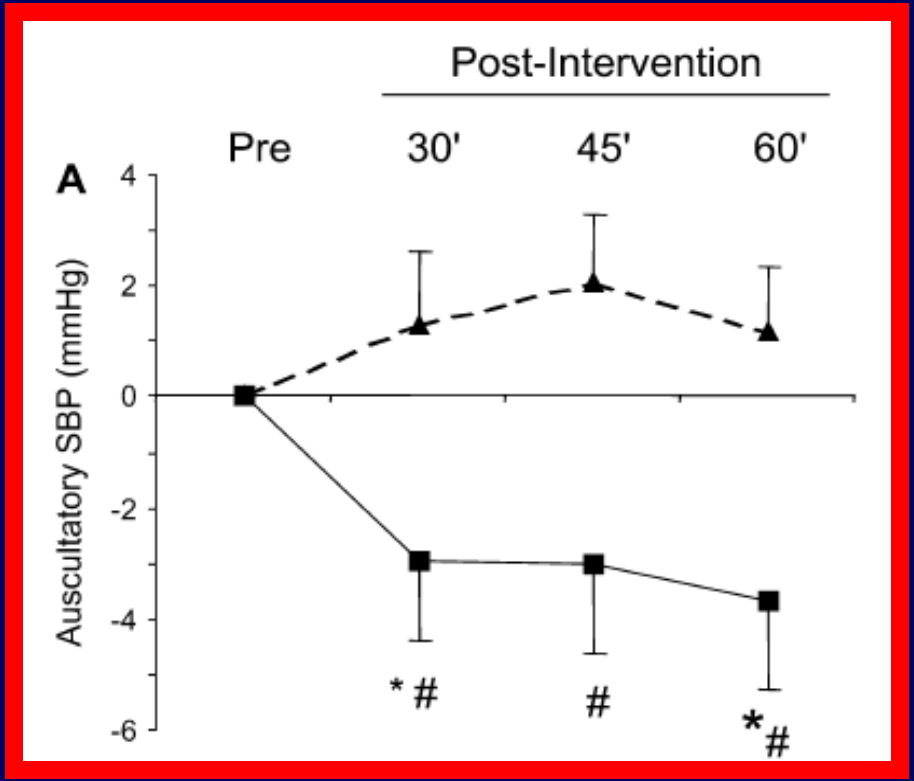
PAS

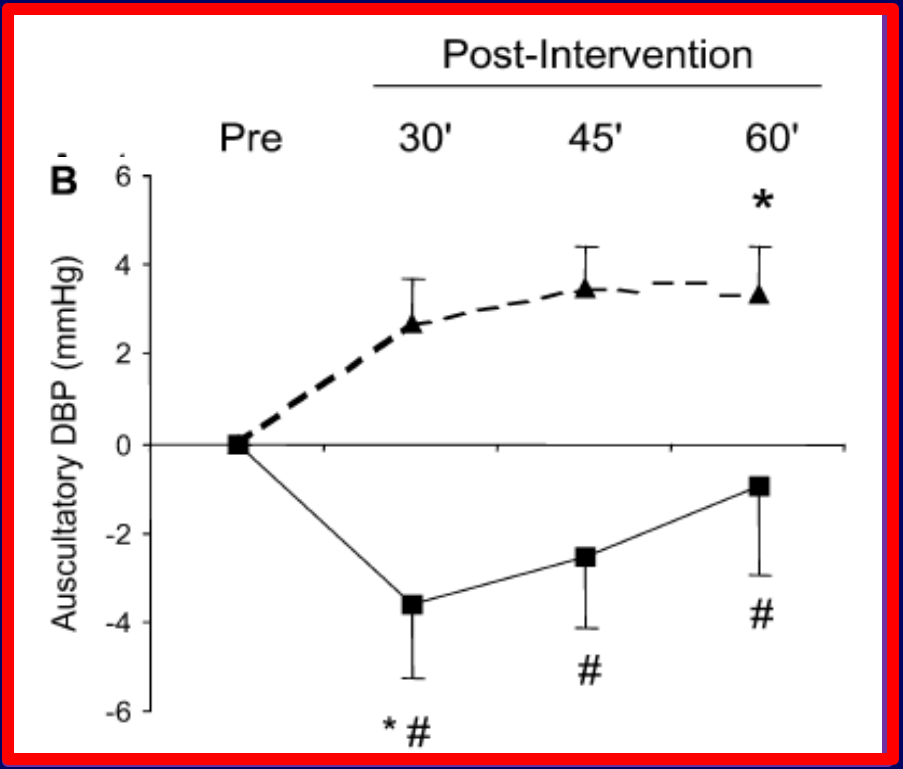
- ↑ (Brown et al., 1994; Focht e Koltyn, 1999; Koltyn et al., 1995; O´Connor et al., 1993; Raglin et al., 1993)
- → (Focht e Koltyn, 1999; O´Connor et al., 1993)
- ↓ (Fisher, 2001; Hardy e Tucker, 1998; MacDonald, 1999)

PAD

- → (Focht e Koltyn, 1999; Koltyn et al., 1995; O´Connor et al., 1993; Raglin et al., 1993)
- ↓ (Focht e Koltyn, 1999; Brown et al., 1994)

POST-RESISTANCE EXERCISE HYPOTENSION IN YOUNG SUBJECTS



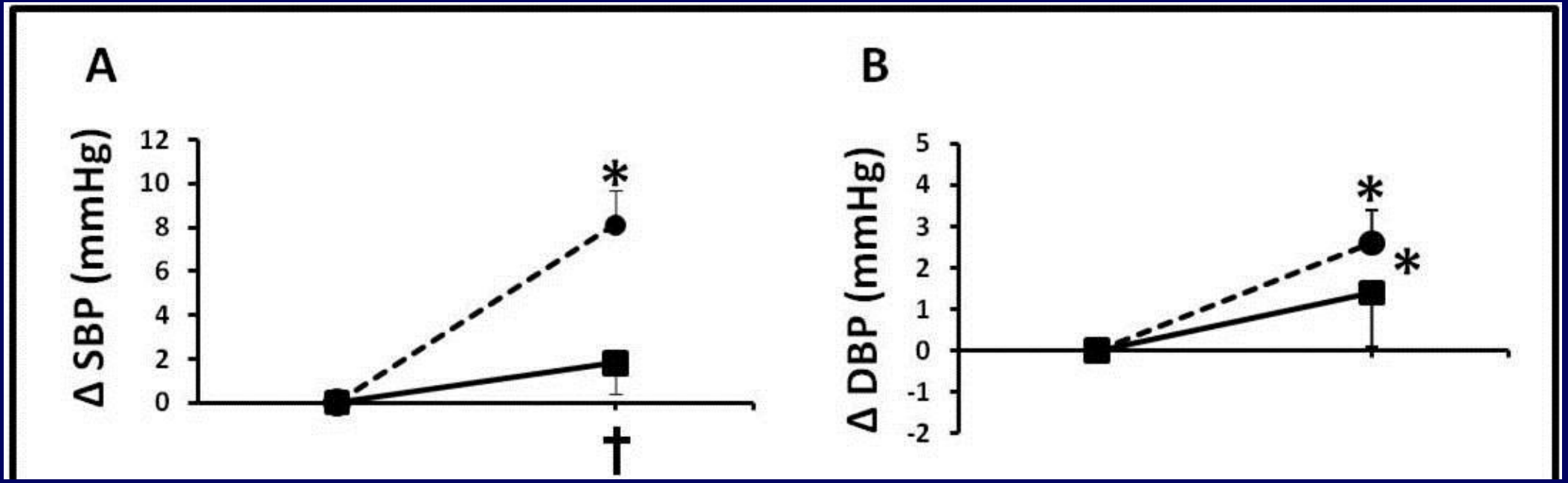


50% of 1RM
Moderate fatigue

∗ = Significantly different from pre-intervention, P<0.05.
= Significantly different from the control session, P<0.05.

Queiroz et al., J Strength Cond Res, 23(2):571-8, 2009.

POST-RESISTANCE EXERCISE HYPOTENSION IN OLD TRAINED SUBJECTS

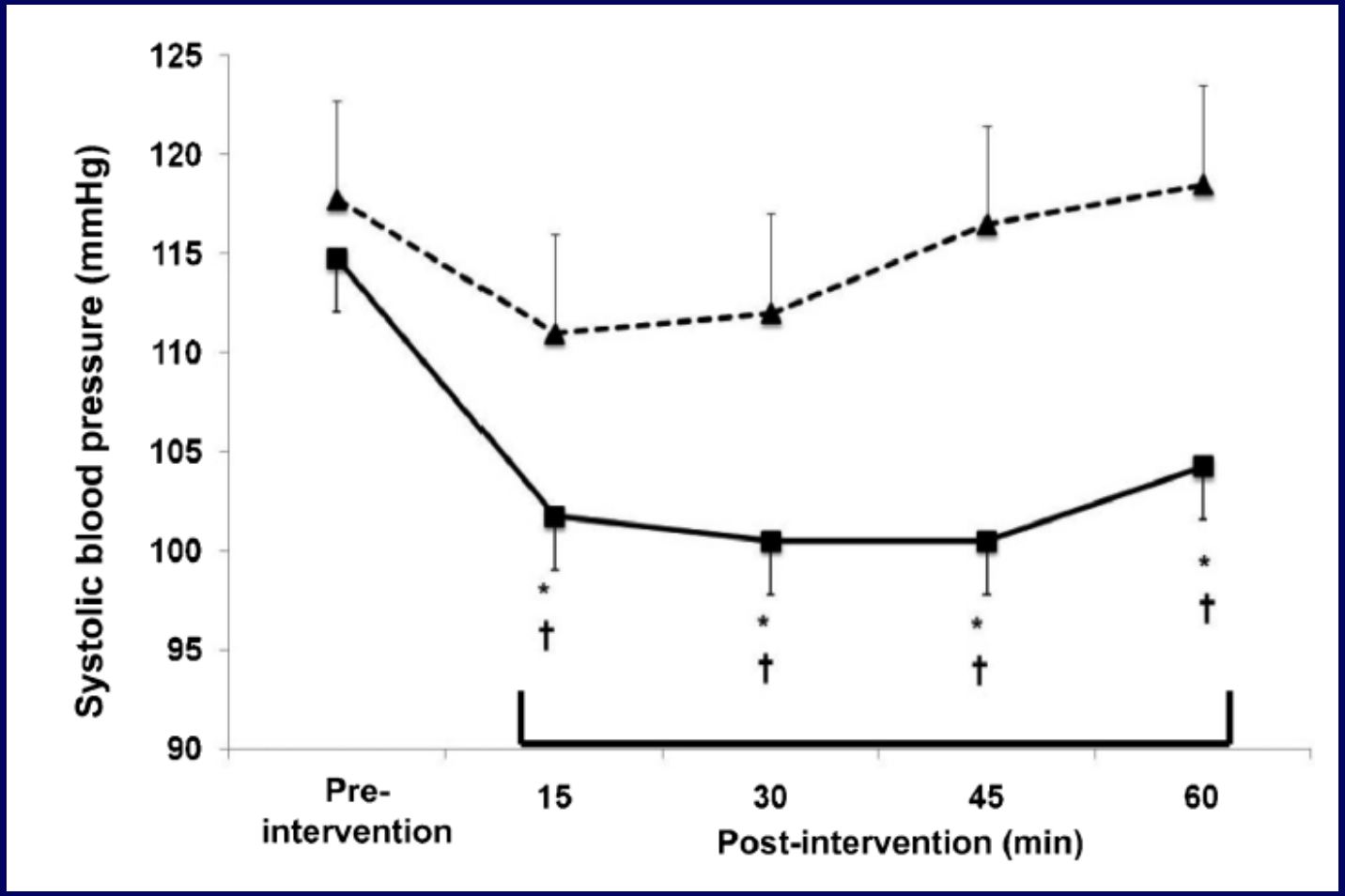


* = Significantly different from pre-intervention; # = Significantly different from the control session, P<0.05.

High intensity
8 RM
3 sets

Queiroz et al. SJMSS, submetido

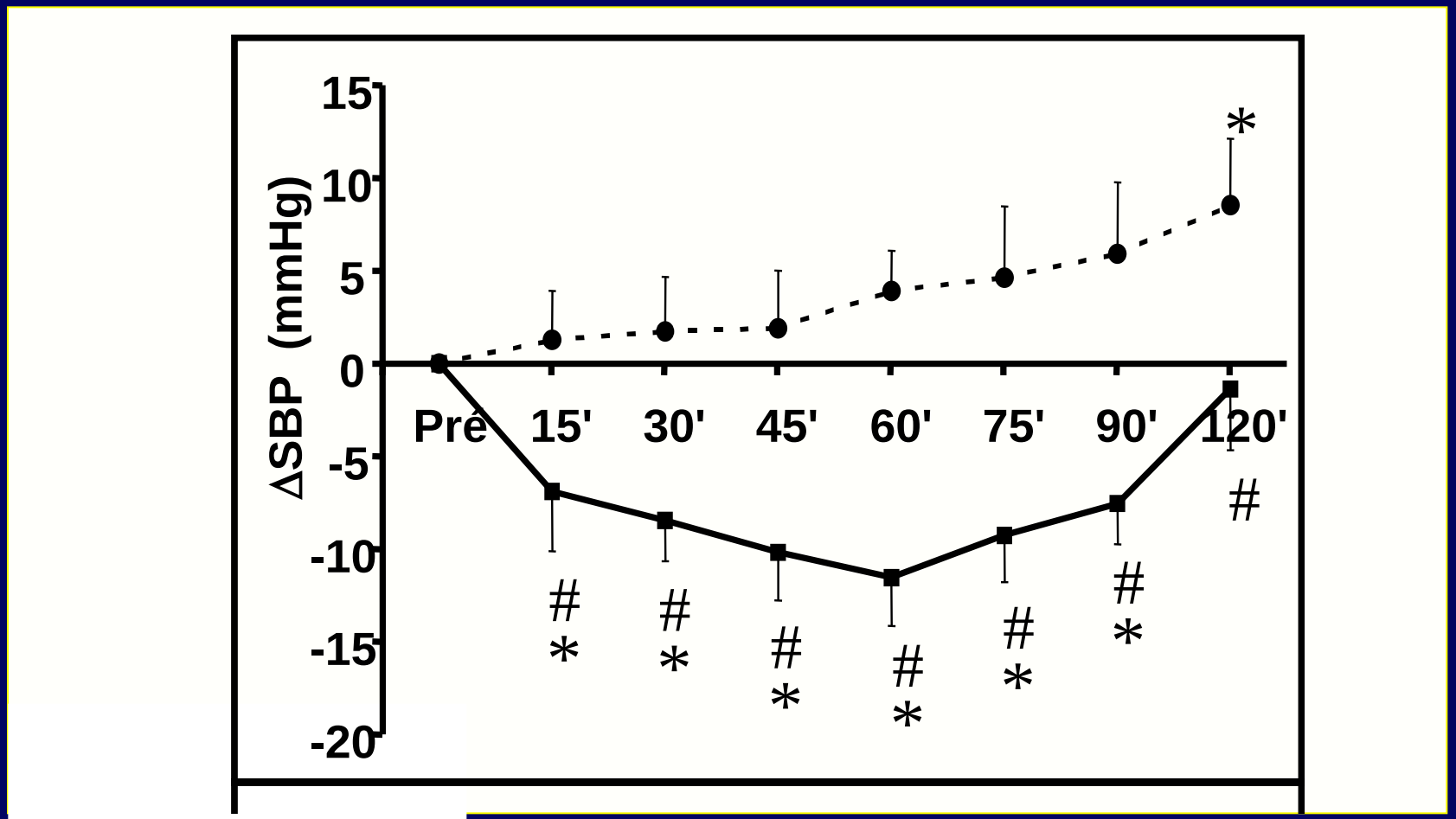
POST-RESISTANCE EXERCISE HYPOTENSION IN CLAUDICANT PATIENTS



6 exercises
3 sets
12, 10 and 8 rep
11 to 13 Borg

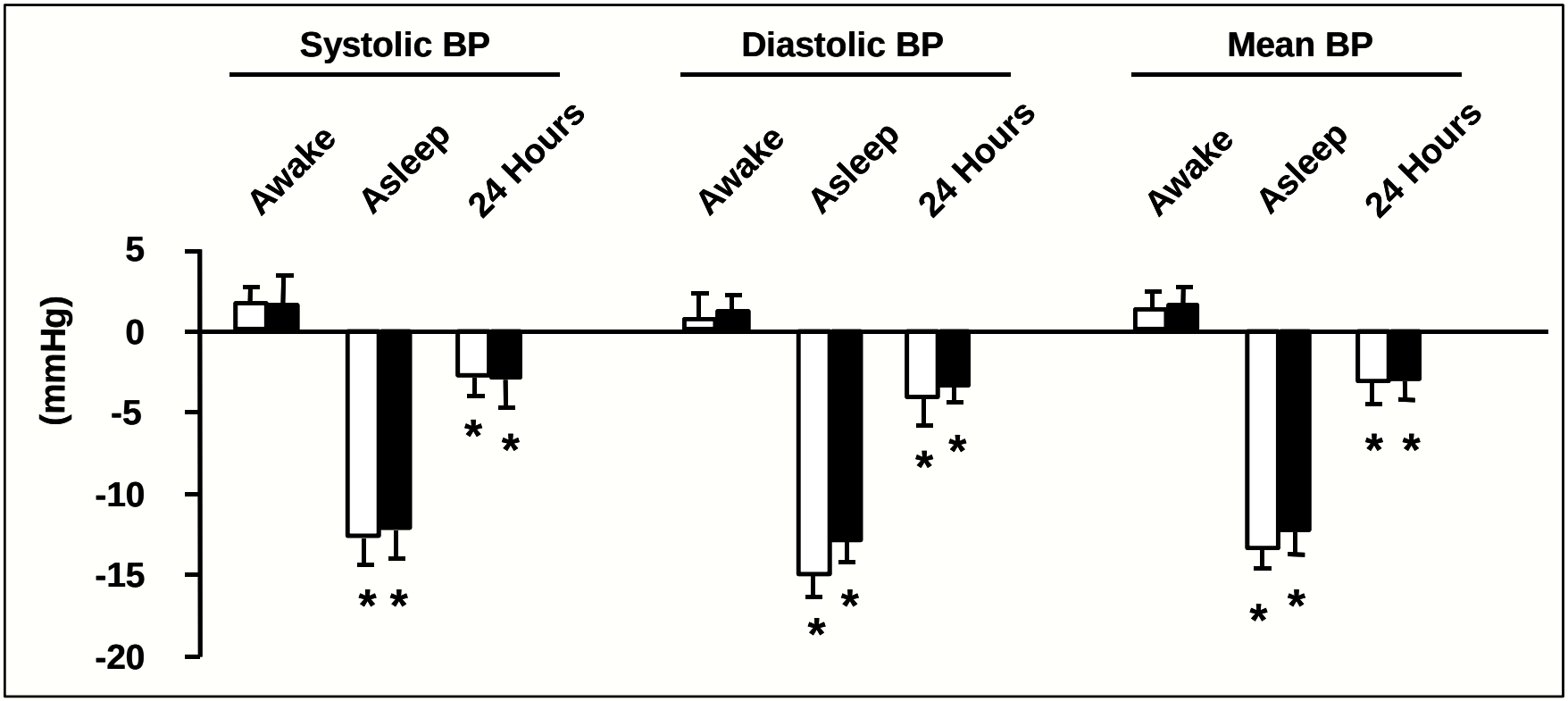
Cucato et al. Clinics, 2011 (in press)

POST-RESISTANCE EXERCISE HYPOTENSION IN HYPERTENSIVE WOMEN



Melo et al., ABPM 2006

POST-RESISTANCE EXERCISE 24 HOUR BP IN NORMOTENSIVE YOUNG SUBJECTS

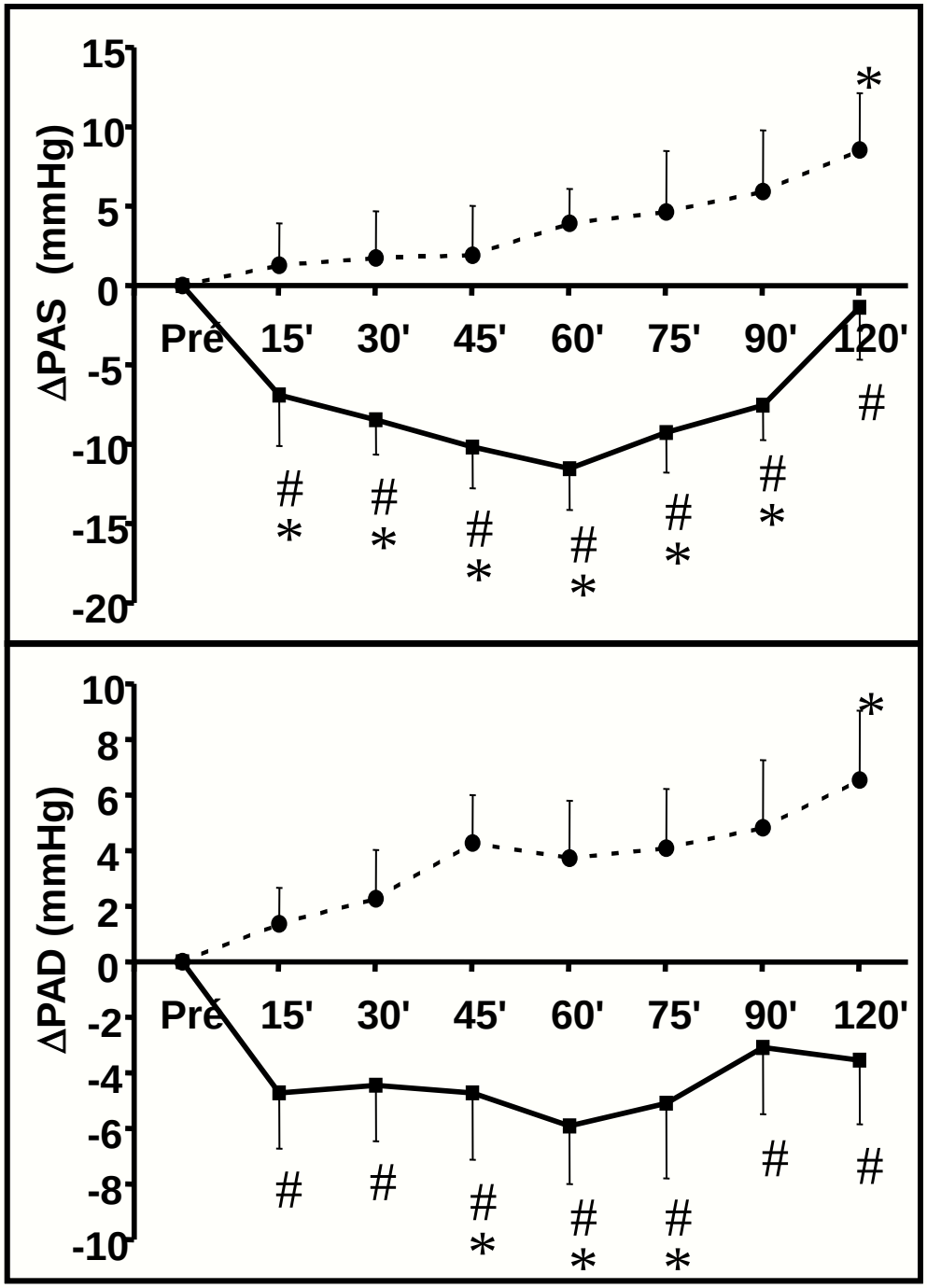


Queiroz et al., J Strength Cond Res, 23(2):571-8, 2009.

ABPM ELDERLY

	Control	Exercise
24-Hours		
Systolic BP, mmHg	120 ± 3	119 ± 2
Diastolic BP, mmHg	73 ± 2	73 ± 2
Mean BP, mmHg	90 ± 2	88 ± 1
HR, bpm	77 ± 1	77 ± 2
HPP, mmHg/bpm	9307 ± 298	9236 ± 334
Total Awake		
Systolic BP, mmHg	126 ± 3	125 ± 2
Diastolic BP, mmHg	79 ± 2	78 ± 2
Mean BP, mmHg	95 ± 2	93 ± 1
HR, bpm	81 ± 1	82 ± 2
HPP, mmHg/bpm	10259 ± 267	10261 ± 372
Asleep		
Systolic BP, mmHg	108 ± 2	109 ± 2
Diastolic BP, mmHg	63 ± 2	65 ± 2
Mean BP, mmHg	80 ± 2	80 ± 2
HR, bpm	68 ± 2	68 ± 2
HPP, mmHg/bpm	7374± 284	7459 ± 256

Queiroz et al. SJMSS, submetido



HIPERTENSAS

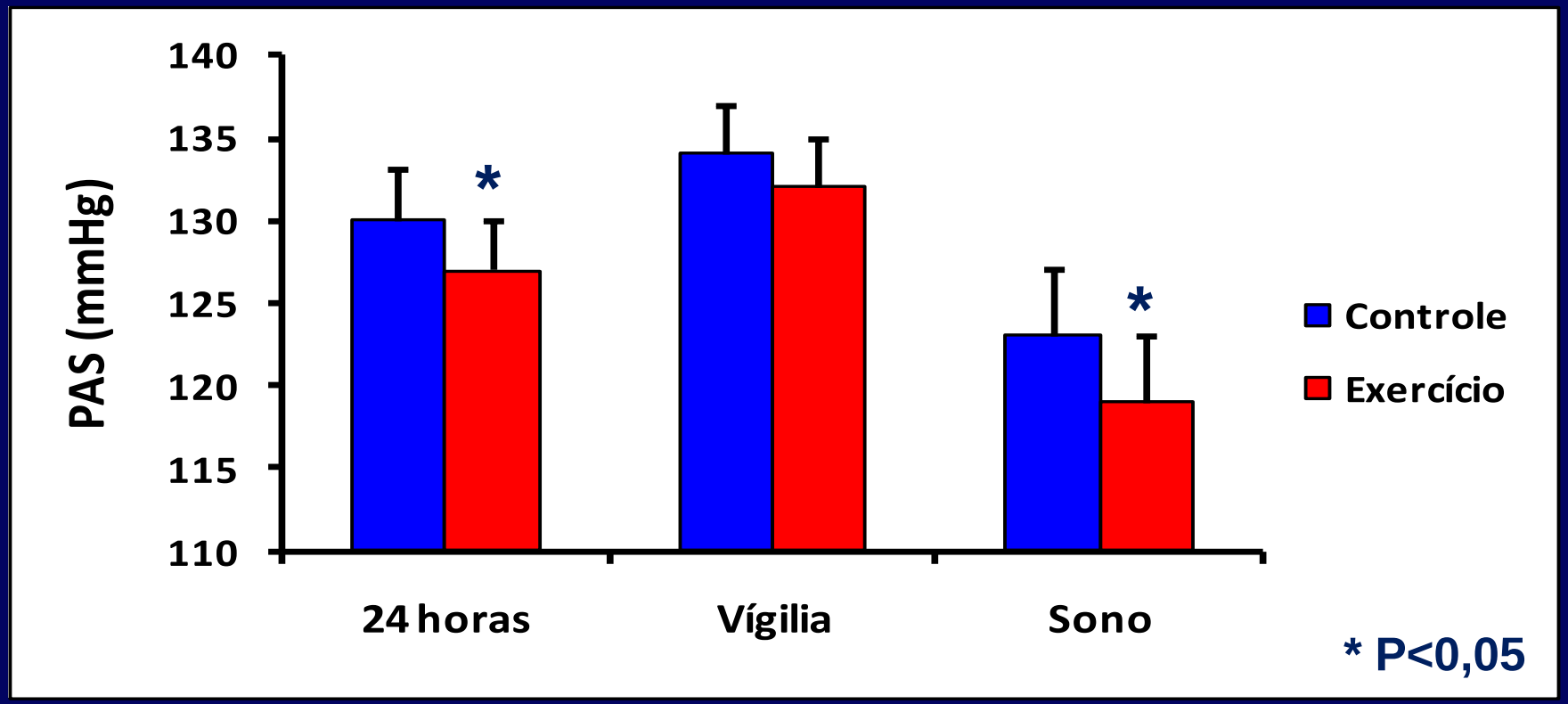
N	11
Idade (anos)	46±1
IMC (kg/m^2)	26,9±0,5
PAS repouso (mmHg)	134±6
PAD repouso (mmHg)	89±3
FC repouso (bat/min)	80±2

● Controle

■ Exercício

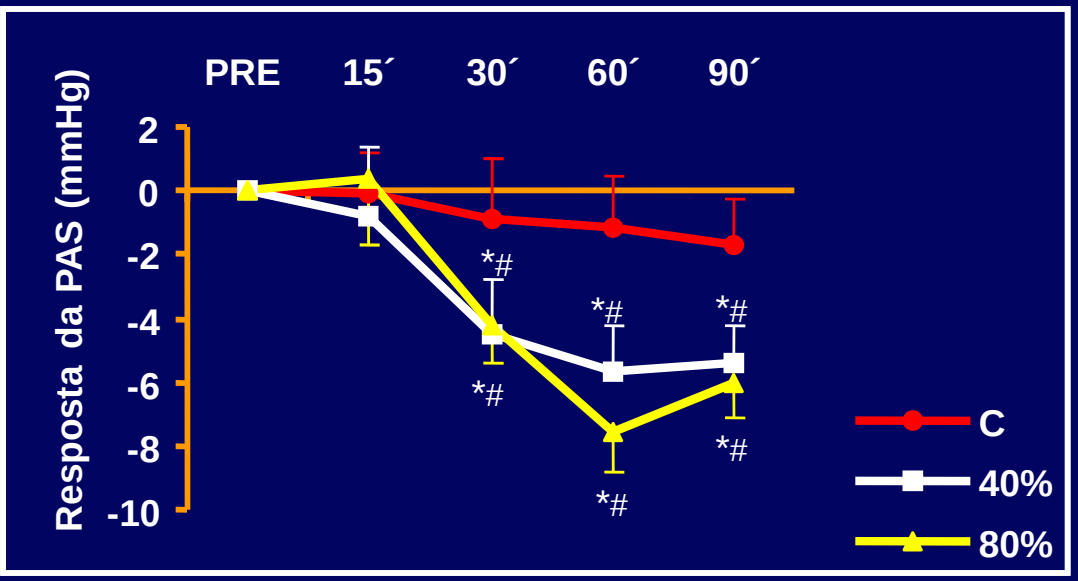
Melo et al., 2006

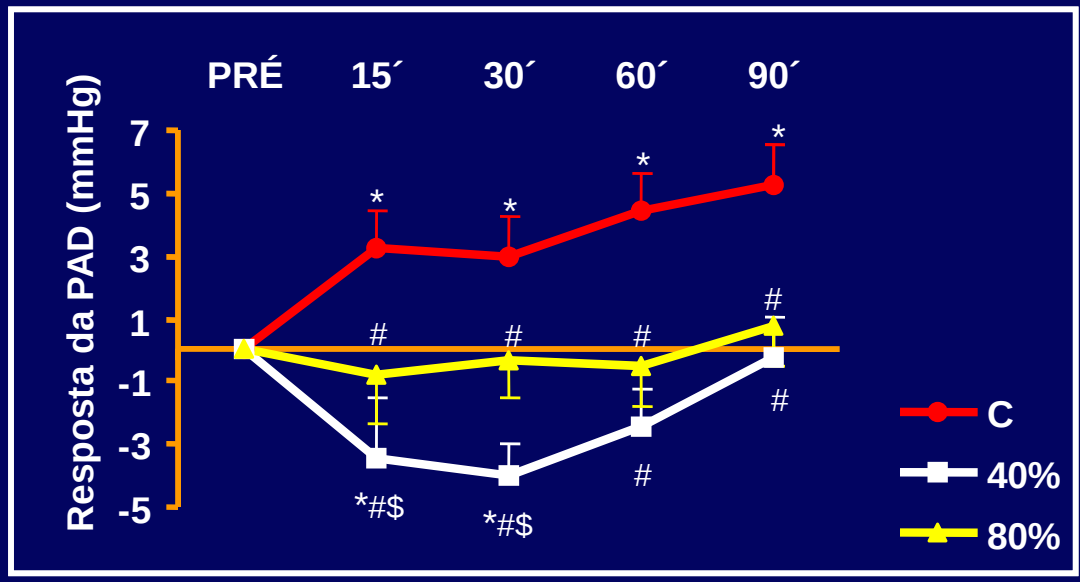
BLACK SUBJECTS



Forjaz et al. SBH, 2011

HIPOTENSÃO PÓS-EXERCÍCIO RESISTIDO DE DIFERENTES INTENSIDADES



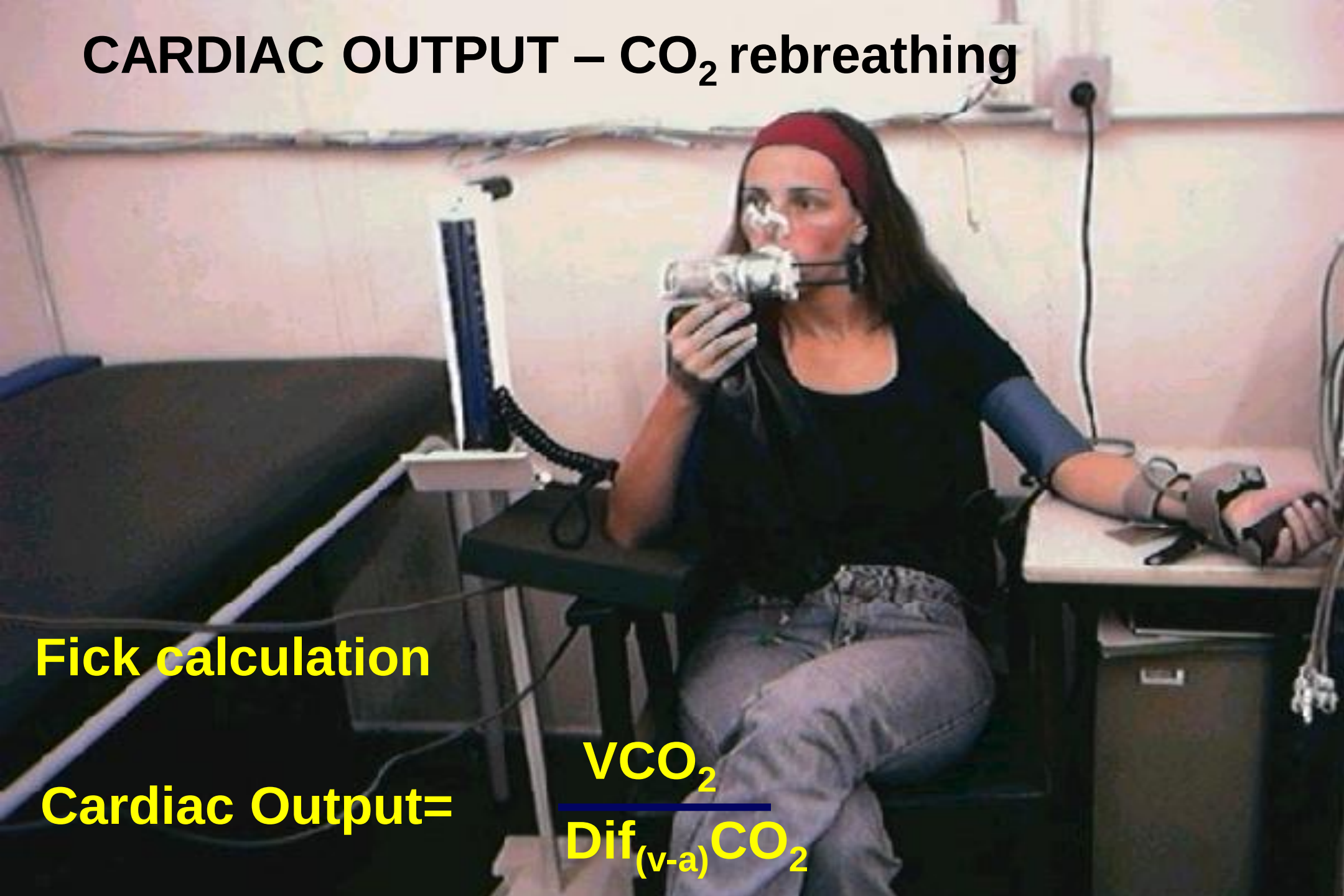


N	17
Idade (anos)	23±1
Feminino/Masculino	9/8
IMC (kg/m^2)	22,7±0,6
PAS repouso (mmHg)	111±3
PAD repouso (mmHg)	65±2
FC repouso (bat/min)	71±2

* ≠ PRE, # ≠ sessão C, $ ≠ sessão F/H

Rezk et al. EJAP, 2006

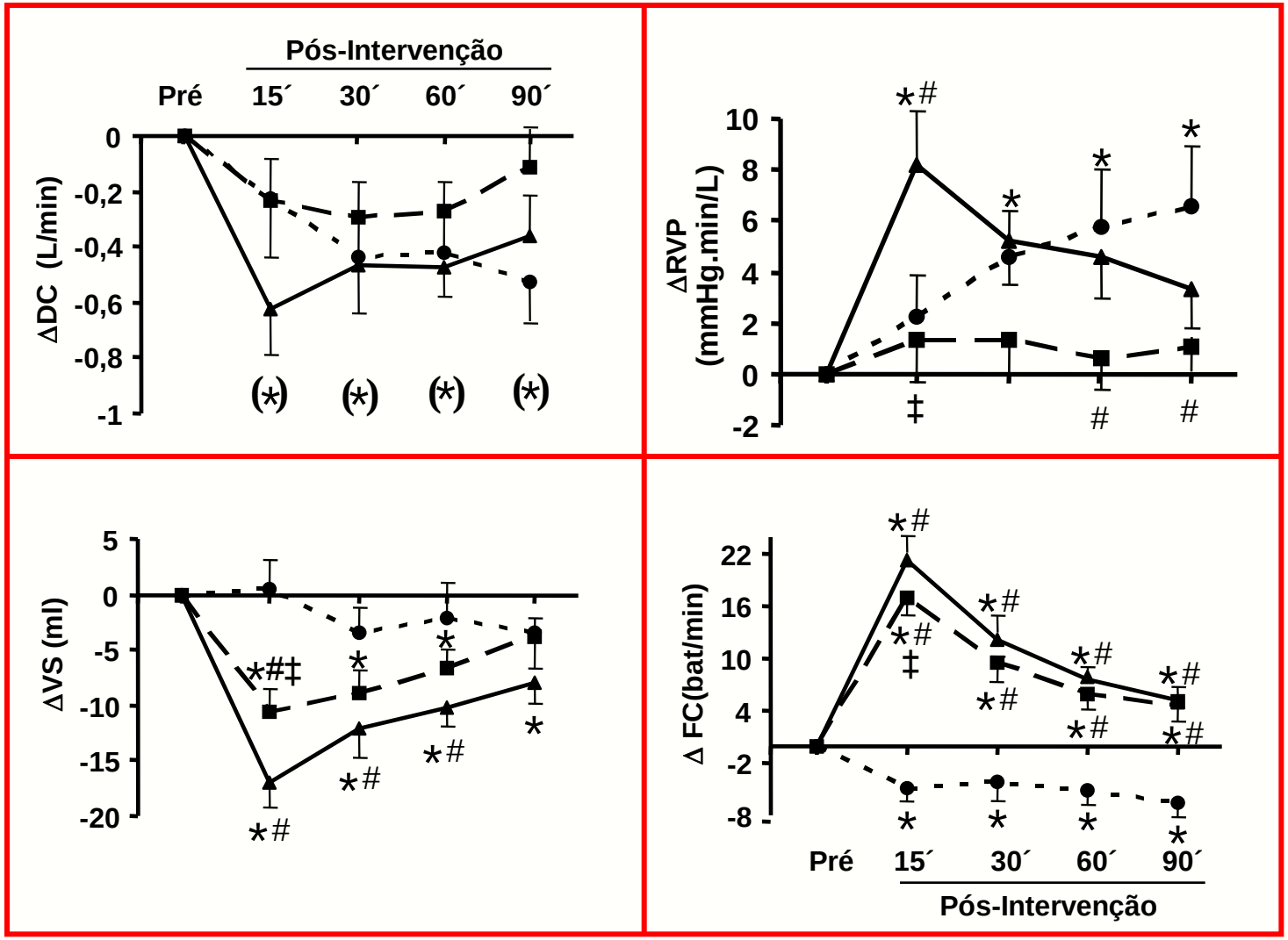
CARDIAC OUTPUT – CO_2 rebreathing



Fick calculation

$$\text{Cardiac Output} = \frac{VCO_2}{Dif_{(v\text{-}a)}CO_2}$$

MECANISMO HEMODINÂMICO



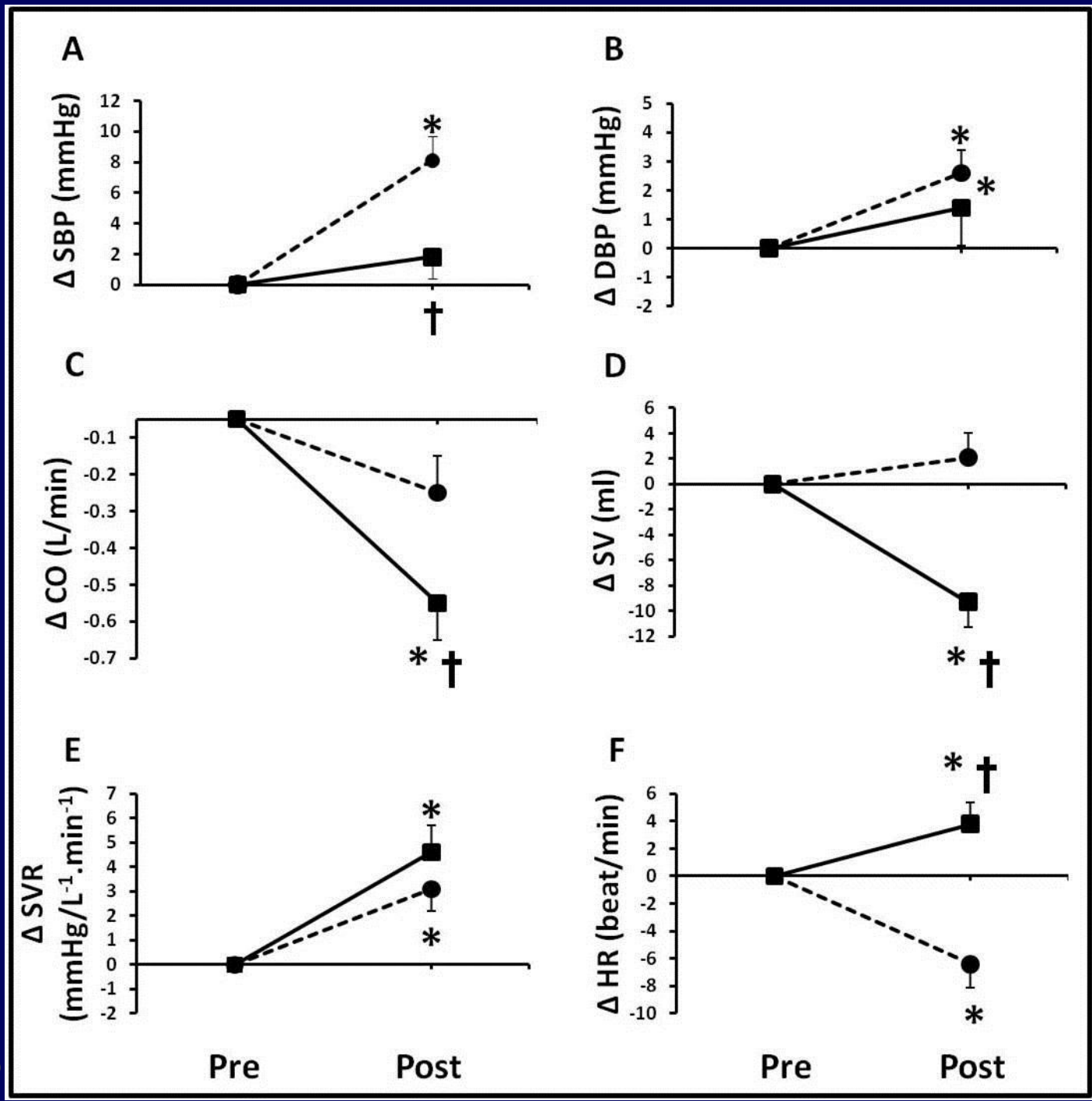
● Controle

■ 40%1RM

▲ 80%1RM

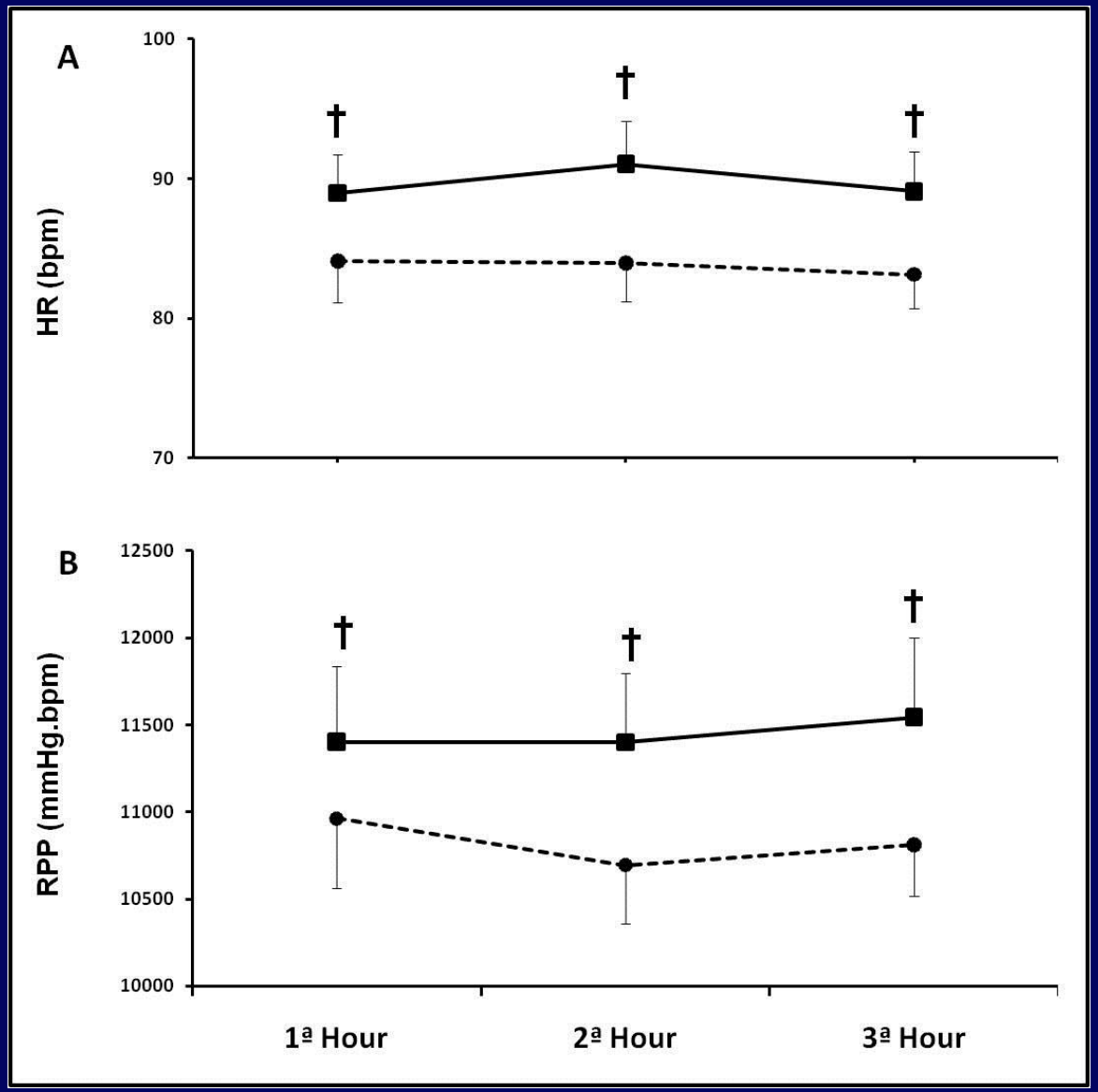
Rezk et al. EJAP, 2006

HEMODYNAMICS in ELDERLY



Queiroz et al. SJMSS, submetido

ABPM ELDERLY



Queiroz et al. SJMSS, submetido

AUTONOMIC MODULATION

	Pós-Intervenção		
	20-30’	40-50’	65-75’
RR Interval(s)			
Control	+0.043±0.025	+0.039±0.023	+0.035±0.028
Exercise 40%	-0.125±0.024 *#	-0.095±0.029 *#	-0.076±0.023 *#
Exercise 80%	-0.100±0.023 *#	-0.060±0.024 *#	-0.035±0.029 #
LF_{RR} un			
Control	+3.0±4.6	+1.1±7.0	+2.2±5.4
Exercise 40%	+23.0±3.5 *#	+17.1±3.3 *#	+14.4±4.0 *#
Exercise 80%	+23.2±3.1 *#	+15.4±3.1 *#	+15.6±5.5 *#
$lnHF_{RR}$ un			
Control	-0.11±0.10	-0.16±0.21	-0.14±0.12
Exercise 40%	-1.12±0.22 *#	-0.77±0.17 *#	-0.84±0.26 *#
Exercise 80%	-1.27±0.24 *#	-0.80±0.15 *#	-0.94±0.29 *#
lnLF/HF			
Control	+0.15±0.18	+0.16±0.32	+0.16±0.21
Exercise 40%	+1.45±0.24 *#	+1.02±0.20 *#	+1.05±0.30 *#
Exercise 80%	+1.59±0.25 *#	+1.02±0.19 *#	+1.13±0.37 *#

*** Different from pre, # different from control (P<0.05)**

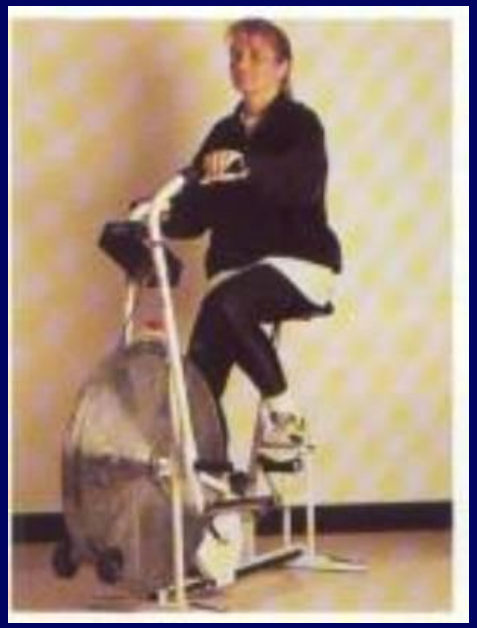
Rezk et al., 2006

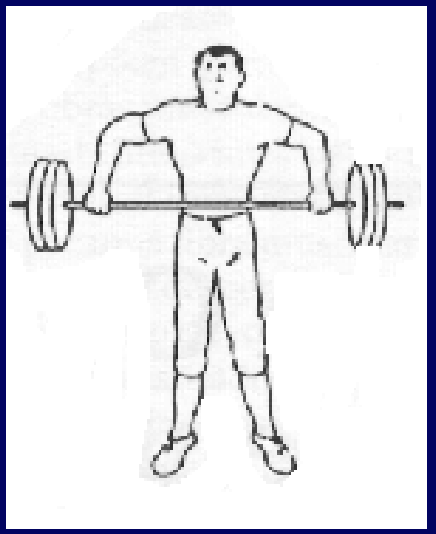
	Control	Exercise
$Variance_{R-R}$, ms^2	+972.8 ± 206.0 *	-79.7 ± 185.7 †
LF_{R-R}, ms^2	+90.3 ± 57.7	+45.9 ± 56.5
HF_{R-R}, ms^2	+69.4 ± 29.6 *	-29.3 ± 17.4 †
LF_{R-R}, nu	-8.7 ± 5.2	+15.5 ± 5.8 * †
ln HF_{R-R}, nu	+0.26 ± 0.13	-0.40 ± 0.28
ln LF/HF	-0.40 ± 0.21	+0.71 ± 0.34 * †
Systolic BP variance, $mmHg^2$	+7.7 ± 6.6	+1.1 ± 7.0
LF systolic BP, $mmHg^2$	+0.7 ± 3.2	+6.1 ± 3.4
Diastolic BP variance, $mmHg^2$	+1.7 ± 5.0	-2.7 ± 4.5
LF diastolic BP, $mmHg^2$	+0.1 ± 1.8	+2.3 ± 1.2
SBS, ms/mmHg	+2.3 ± 0.8 *	-1.0 ± 0.6 †
SBS (-R-R/-SBP), ms/mmHg	+1.4 ± 0.6	-1.5 ± 0.7 †
SBS (+R-R/+SBP) ms/mmHg	+2.8 ± 1.0	-2.6 ± 1.9

AUTONOMIC IN ELDERLY

*** Pre**
† C

AERÓBIO + RESISTIDO

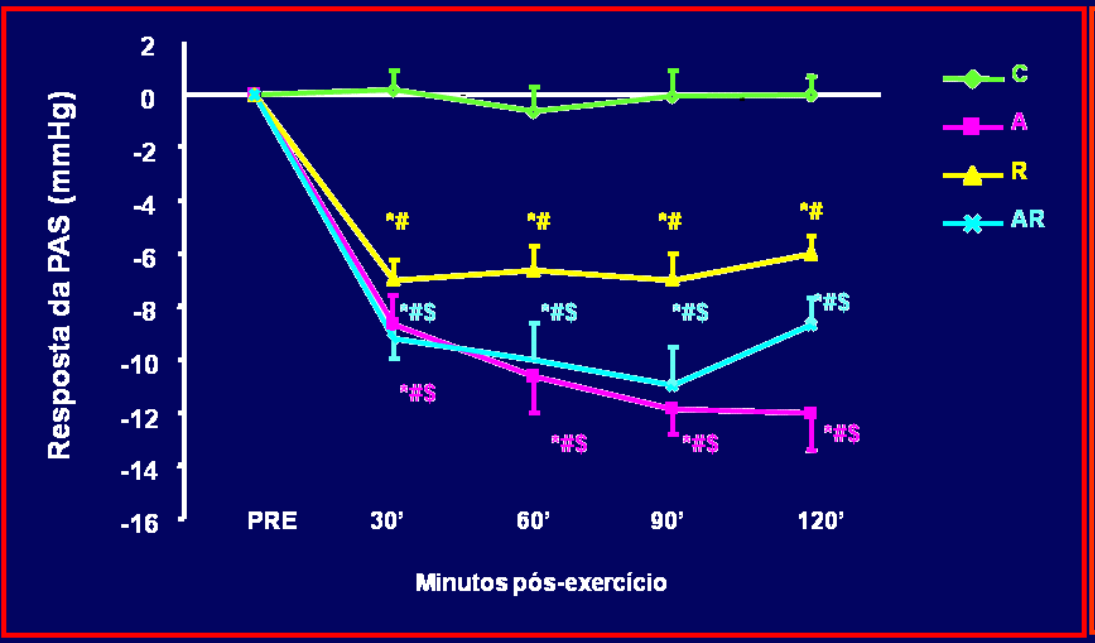


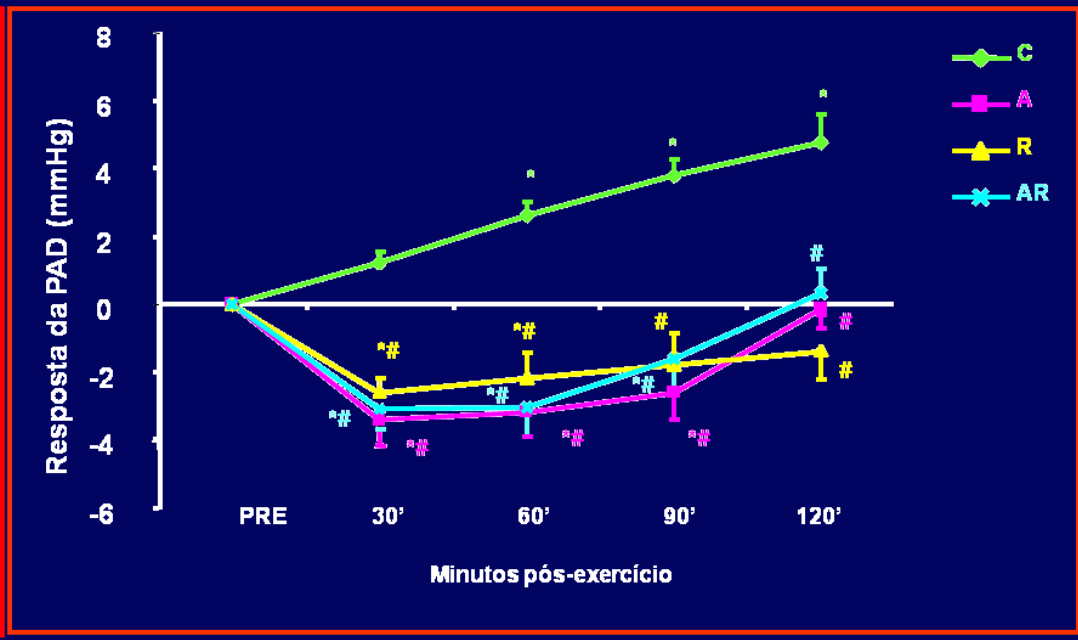


- Efeitos Hipotensores demonstrados
- Normalmente se associam em aulas de condicionamento físico
- Hipotensão mais evidente?

Teixeira L. Andamento

AERÓBIO + RESISTIDO

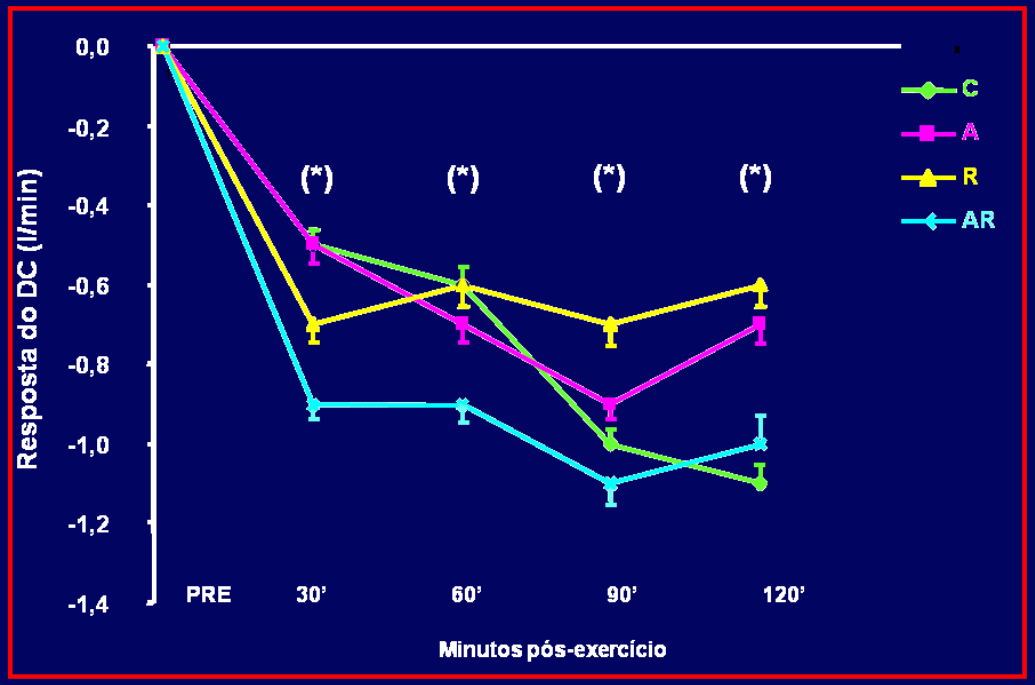


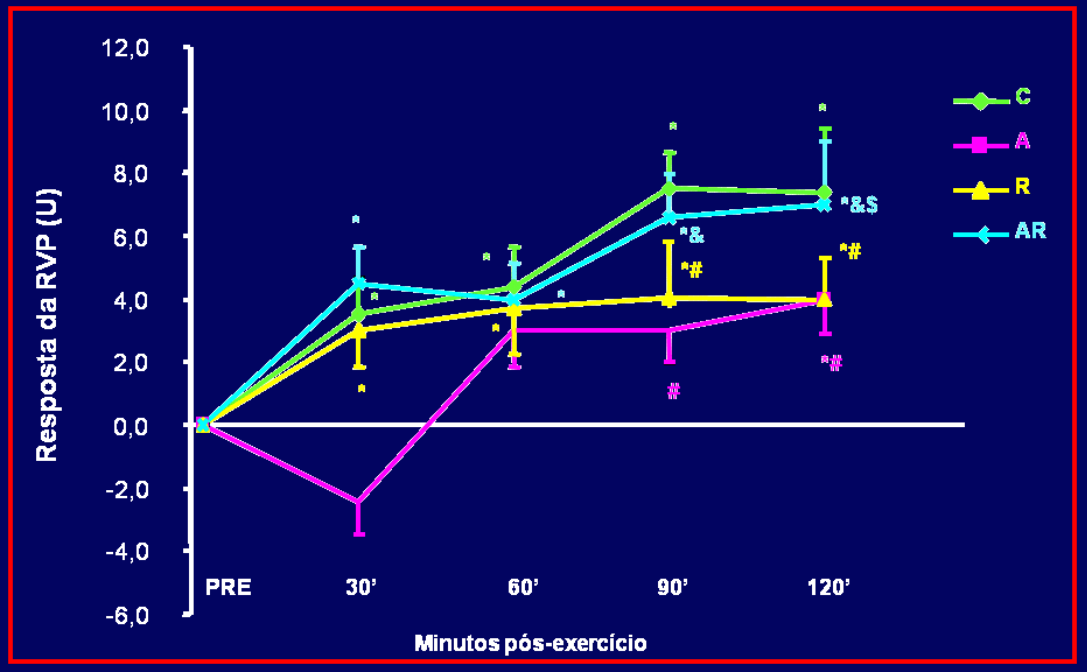


*** Diferente do Pré; # diferente do C; $ diferente do R; & diferente do A (P<0,05)**

Teixeira, dissertação, 2007

AERÓBIO + RESISTIDO

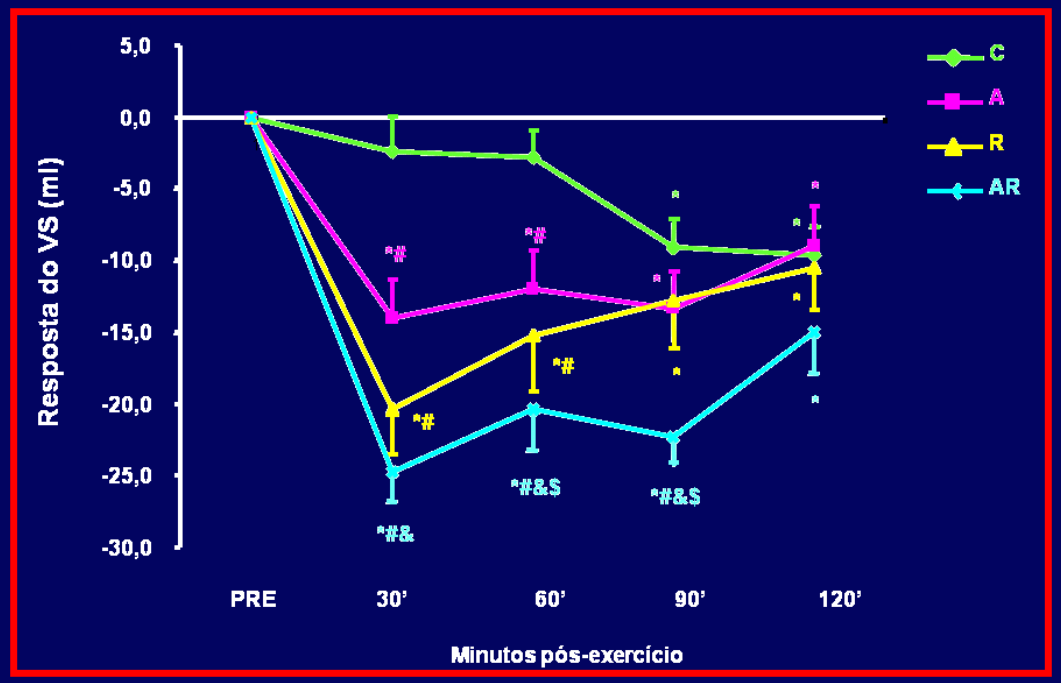


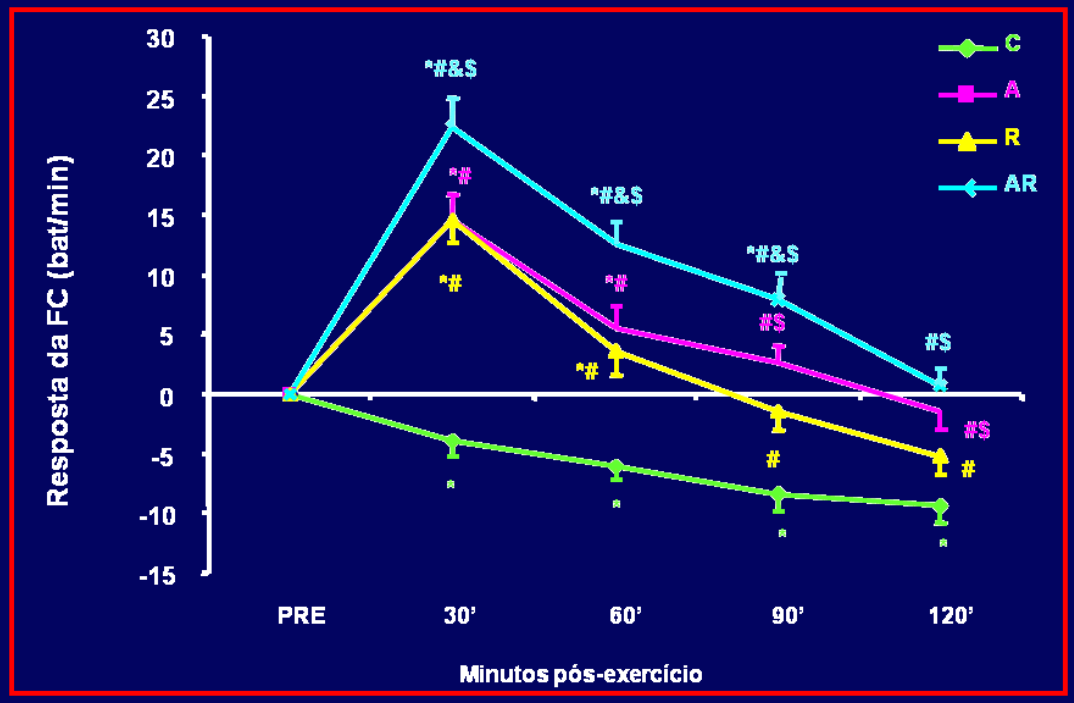


*** Diferente do Pré; # diferente do C; $ diferente do R; & diferente do A (P<0,05)**

Teixeira, dissertação, 2007

AERÓBIO + RESISTIDO



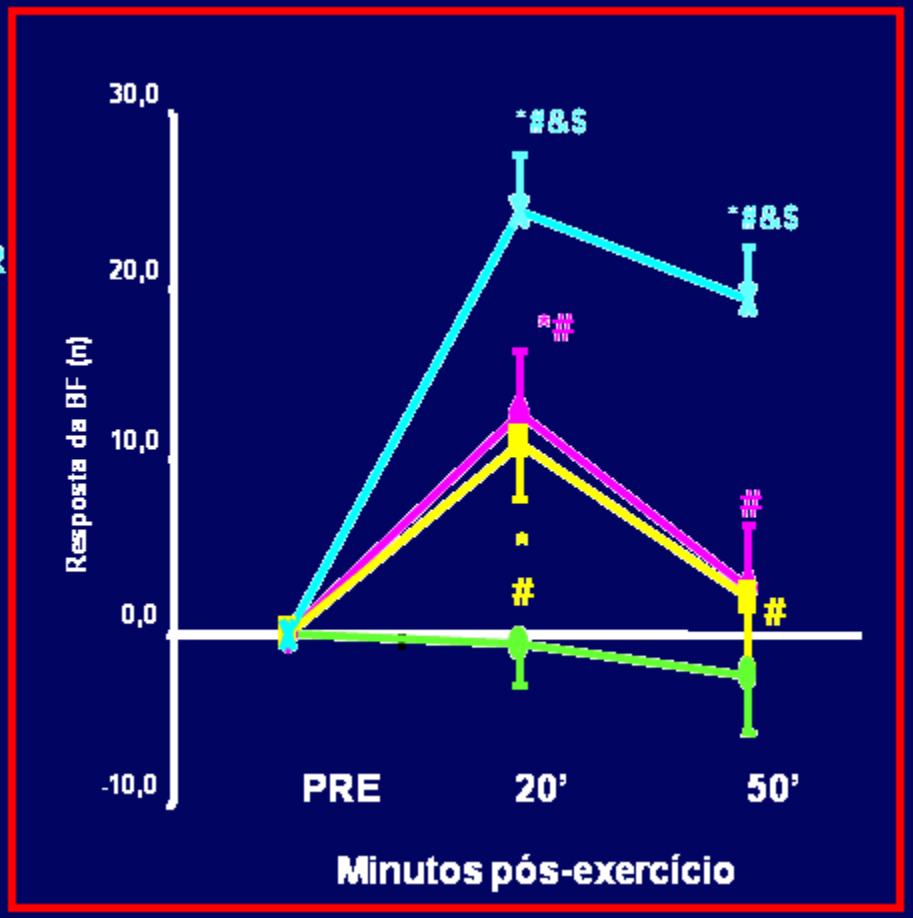


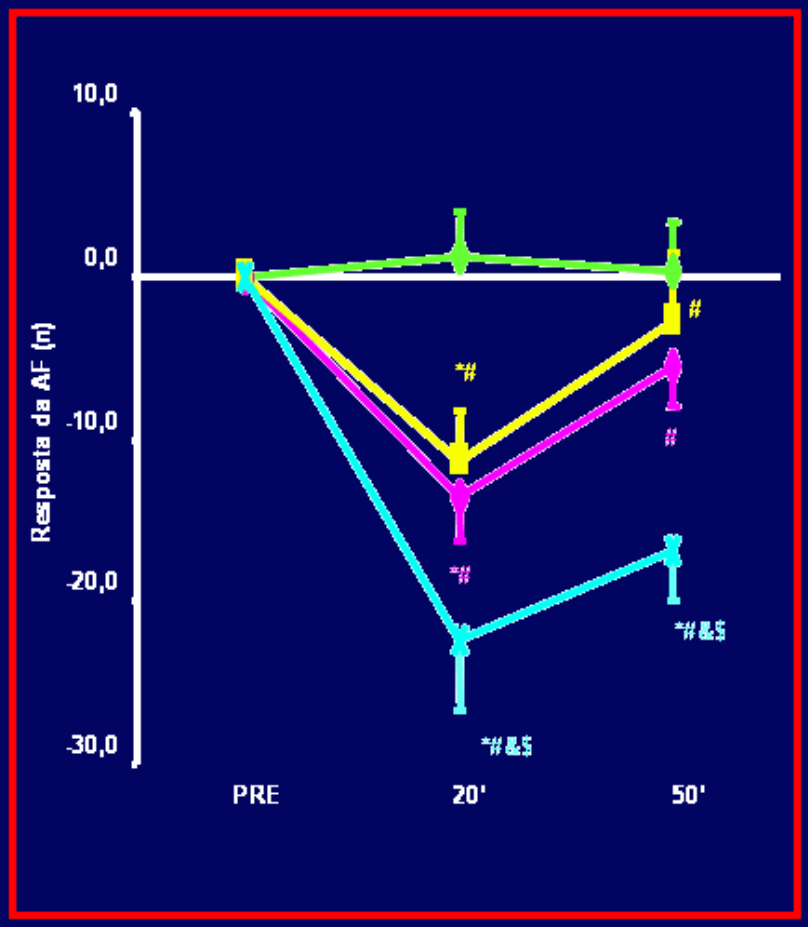
*** Diferente do Pré; # diferente do C; $ diferente do R; & diferente do A (P<0,05)**

Teixeira, dissertação, 2007

AERÓBIO + RESISTIDO

C
A
R
AR





*** Diferente do Pré; # diferente do C; $ diferente do R; & diferente do A (P<0,05)**

Teixeira, dissertação, 2007

AERÓBIO + RESISTIDO

Apenas 1 estudo

↓ da PA **pelo exercício aeróbio por ↓ DC sem ↑ RVP**

↑ da FC **maior com associação por ↑ ANS e ↓ ANP**