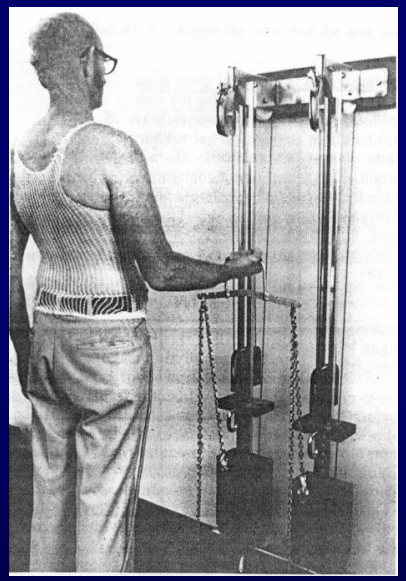
FUNÇÕES DO SISTEMA CARDIOVASCULAR DURANTE O EXERCÍCIO

RESPOSTAS CARDIOVASCULARES

- FC
- VS
- DC
- RVP
- PAS
- PAM
- PAD
- DP

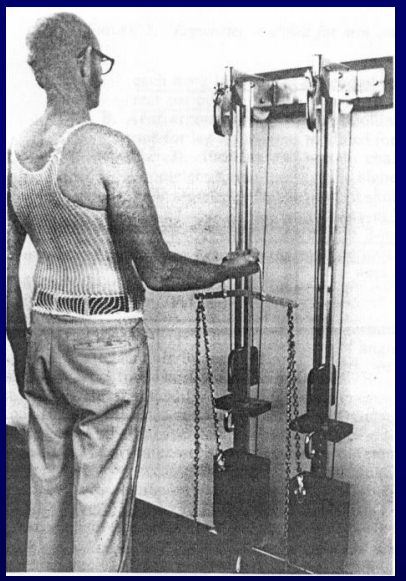
TIPO DE EXERCÍCIO

Dinâmico ou Isotônico



Contração muscular
e movimento articular

Estático ou Isométrico



Contração muscular
sem movimento articular

EXERCÍCIOS DINÂMICOS OU ISOTÔNICOS

Resposta Cardiovasculares – Intensidade
Duração
Massa Muscular

DURAÇÃO

- **Curta Duração:** 3’ a 10’.

- **Média Duração:** 10’ a 30’.

- **Longa Duração:** acima de 30’.

INTENSIDADE

- Intensidade ABSOLUTA:

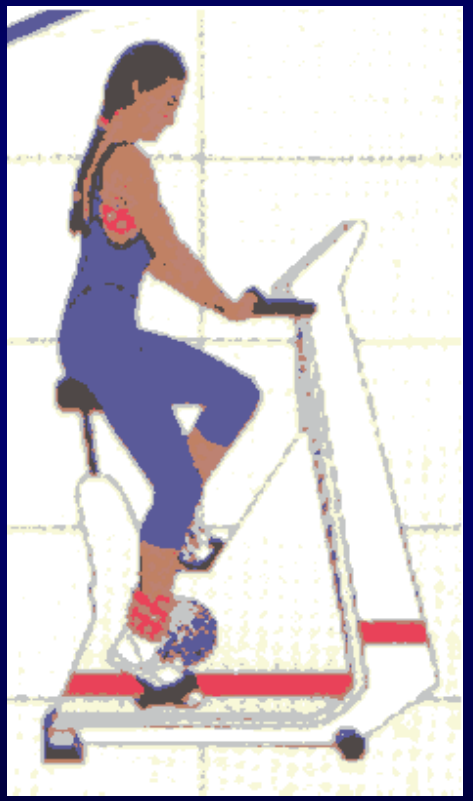
Carga de exercício – Watts, Kp, velocidade, inclinação, VO2

- Intensidade RELATIVA

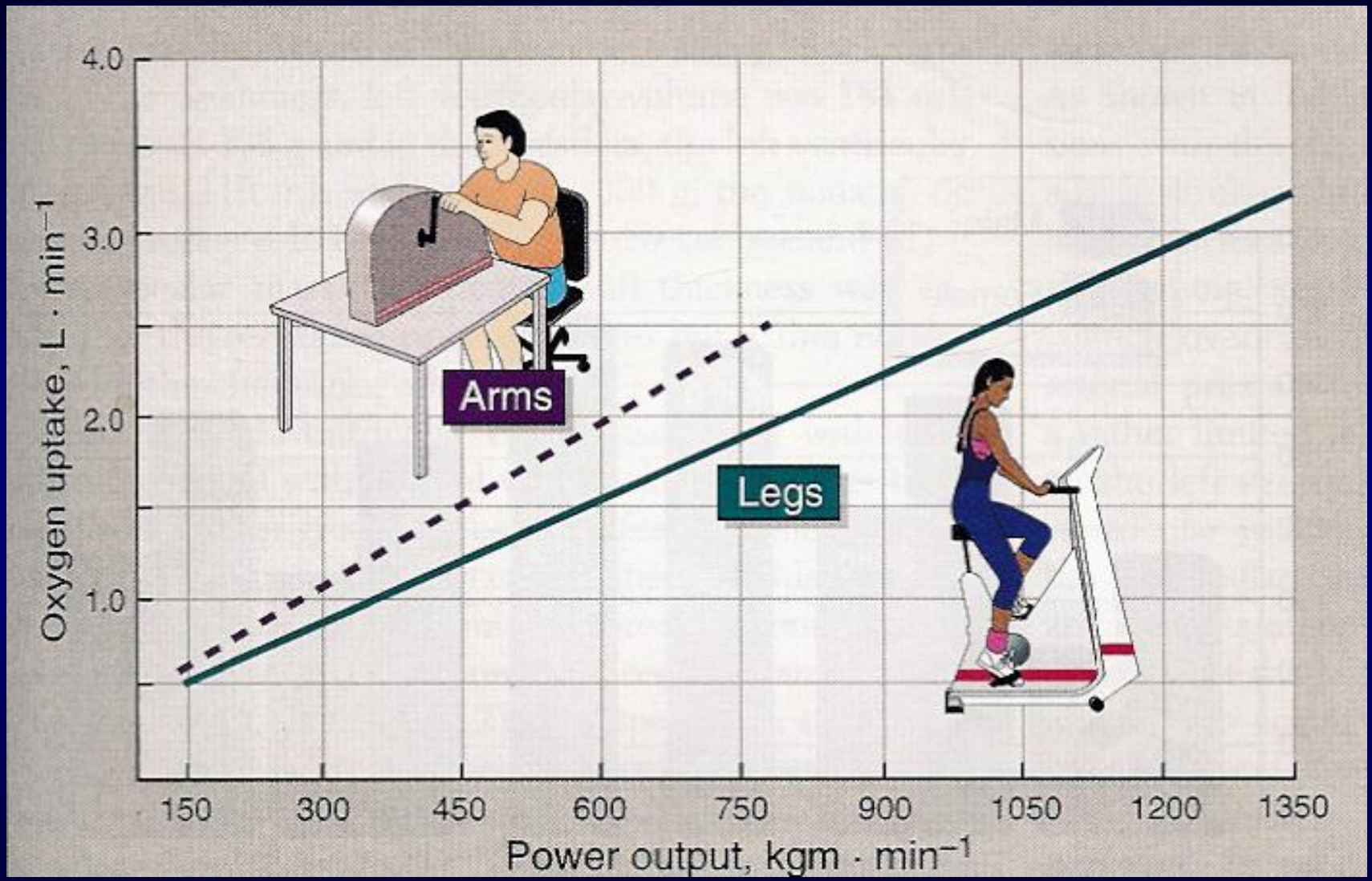
Percentual de função máxima - %VO_2 max, % FC máx

MASSA MUSCULAR

Pequena



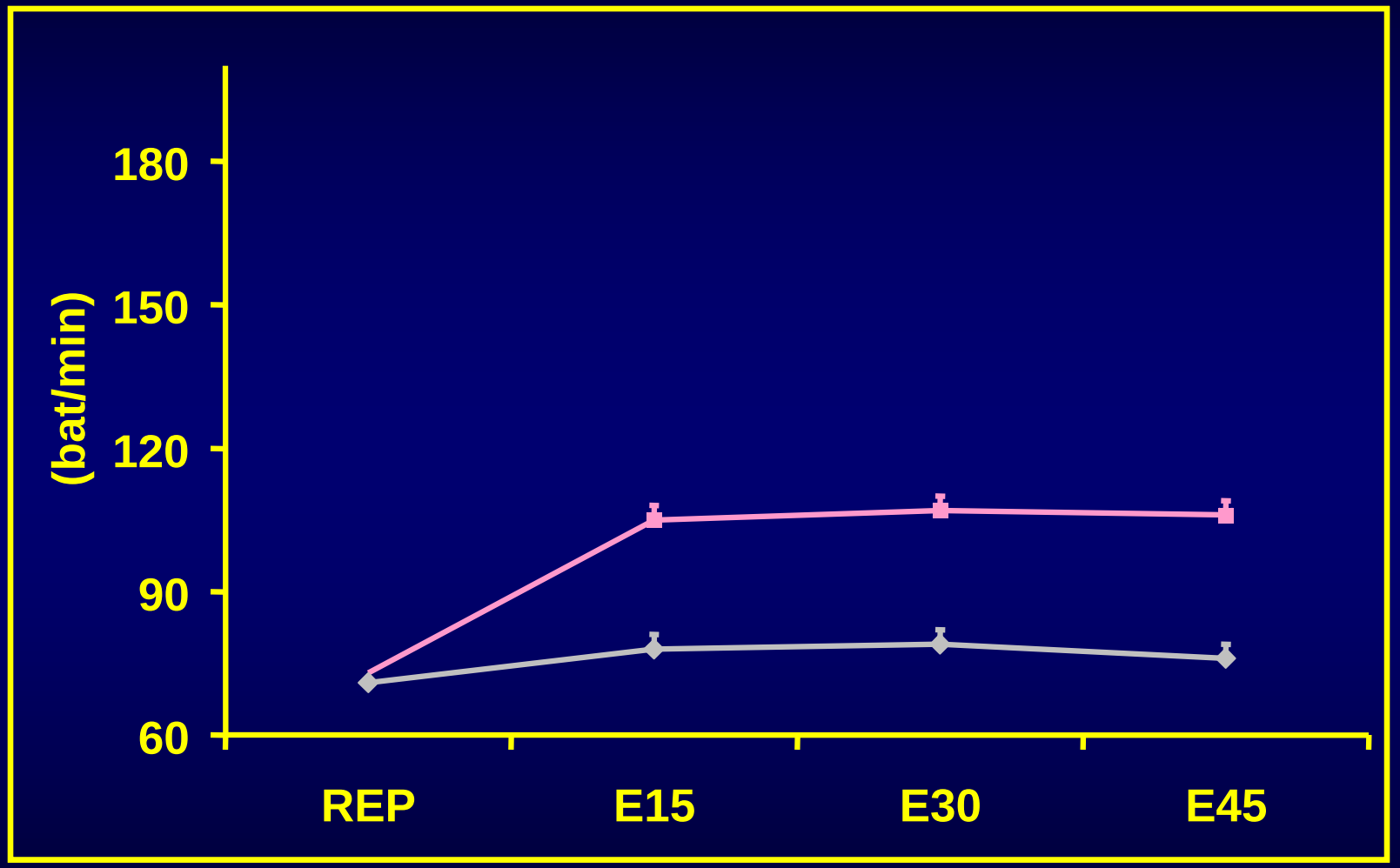
Grande

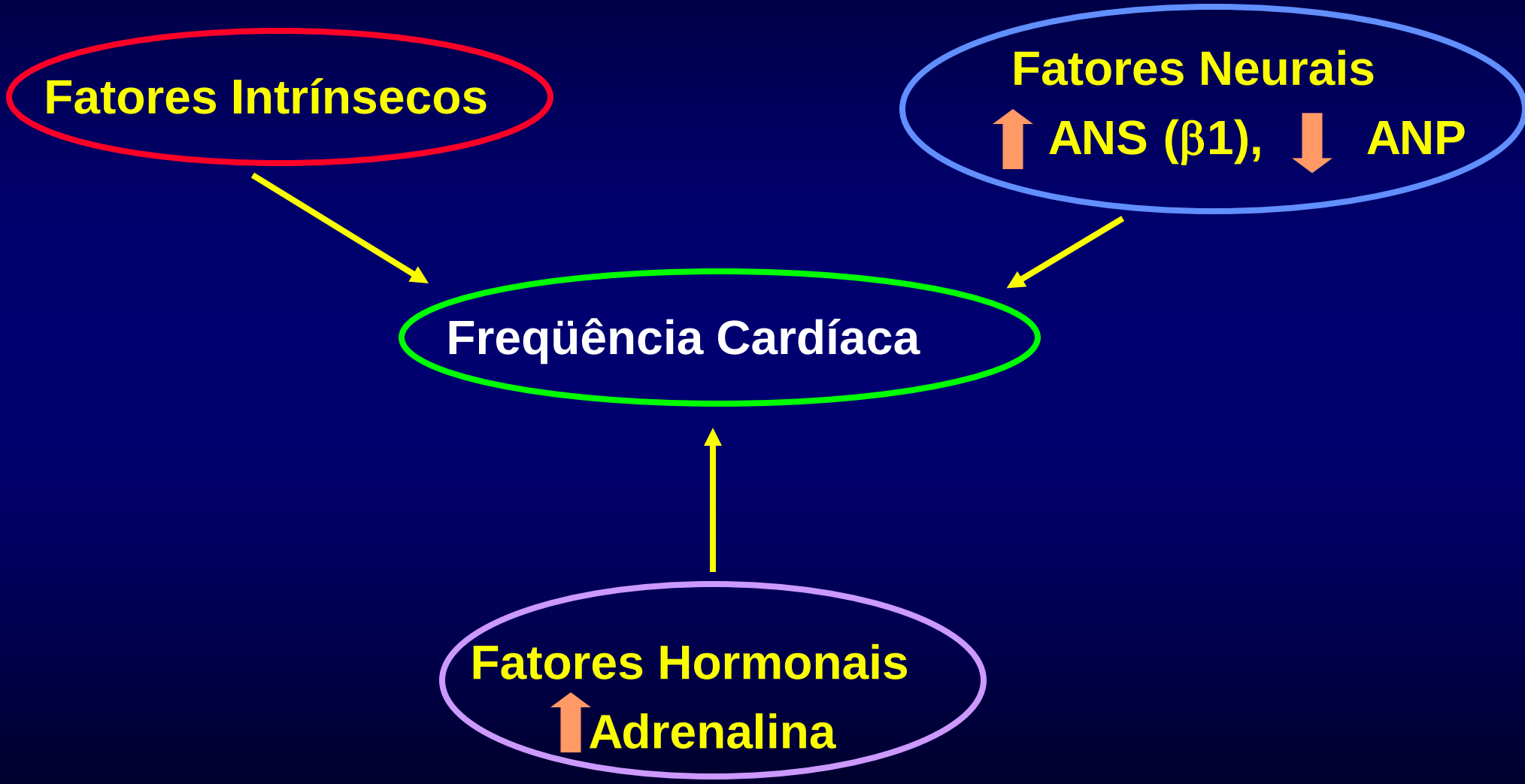

4.0
3.0
2.0
1.0
Oxygen uptake, L · min⁻¹
Arms
Legs
150
300
450
600
750
900
1050
1200
1350
Power output, kgm · min⁻¹

EFEITOS AGUDOS DURANTE O EXERCÍCIO

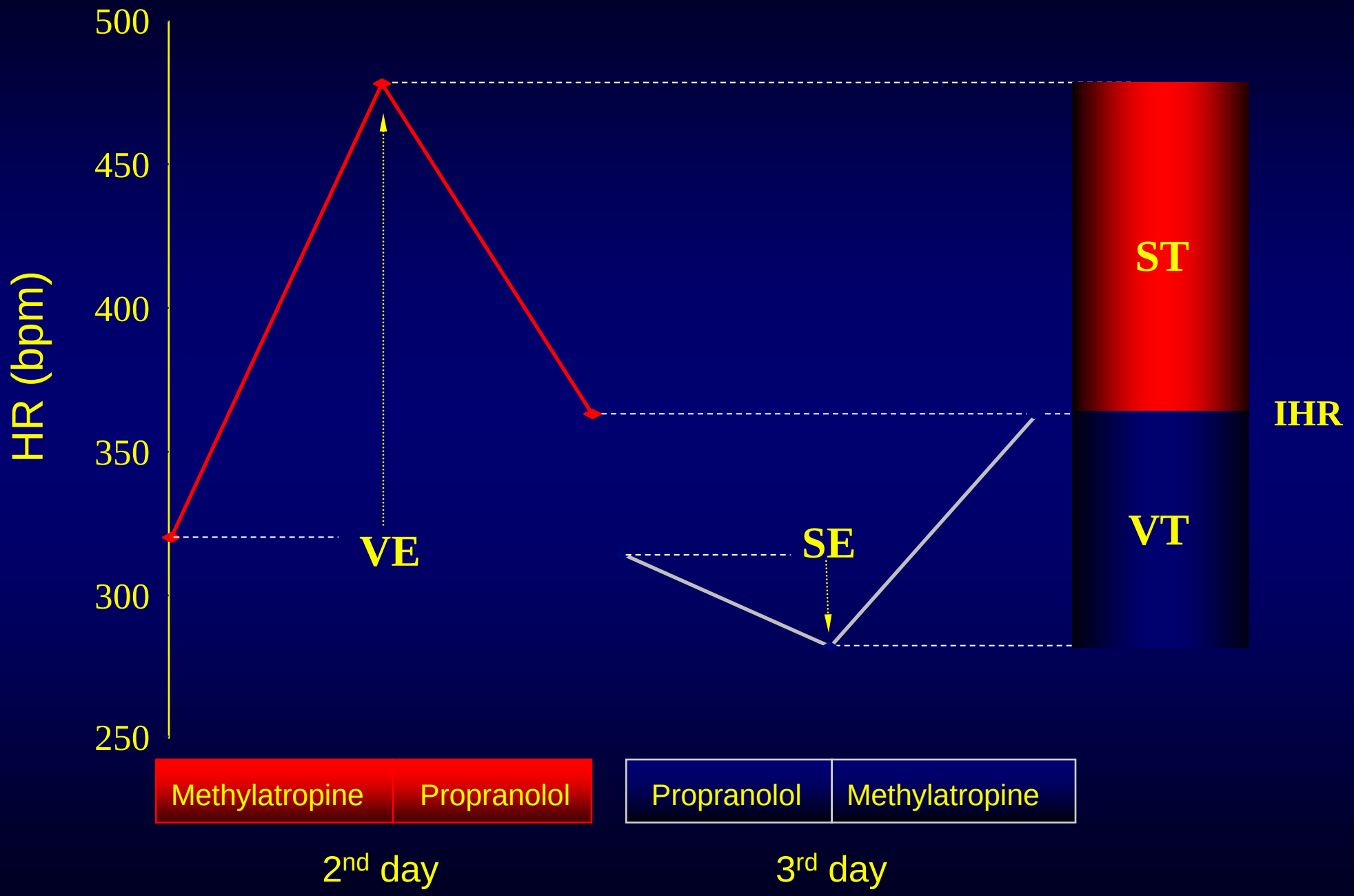
FREQUÊNCIA CARDÍACA

FC

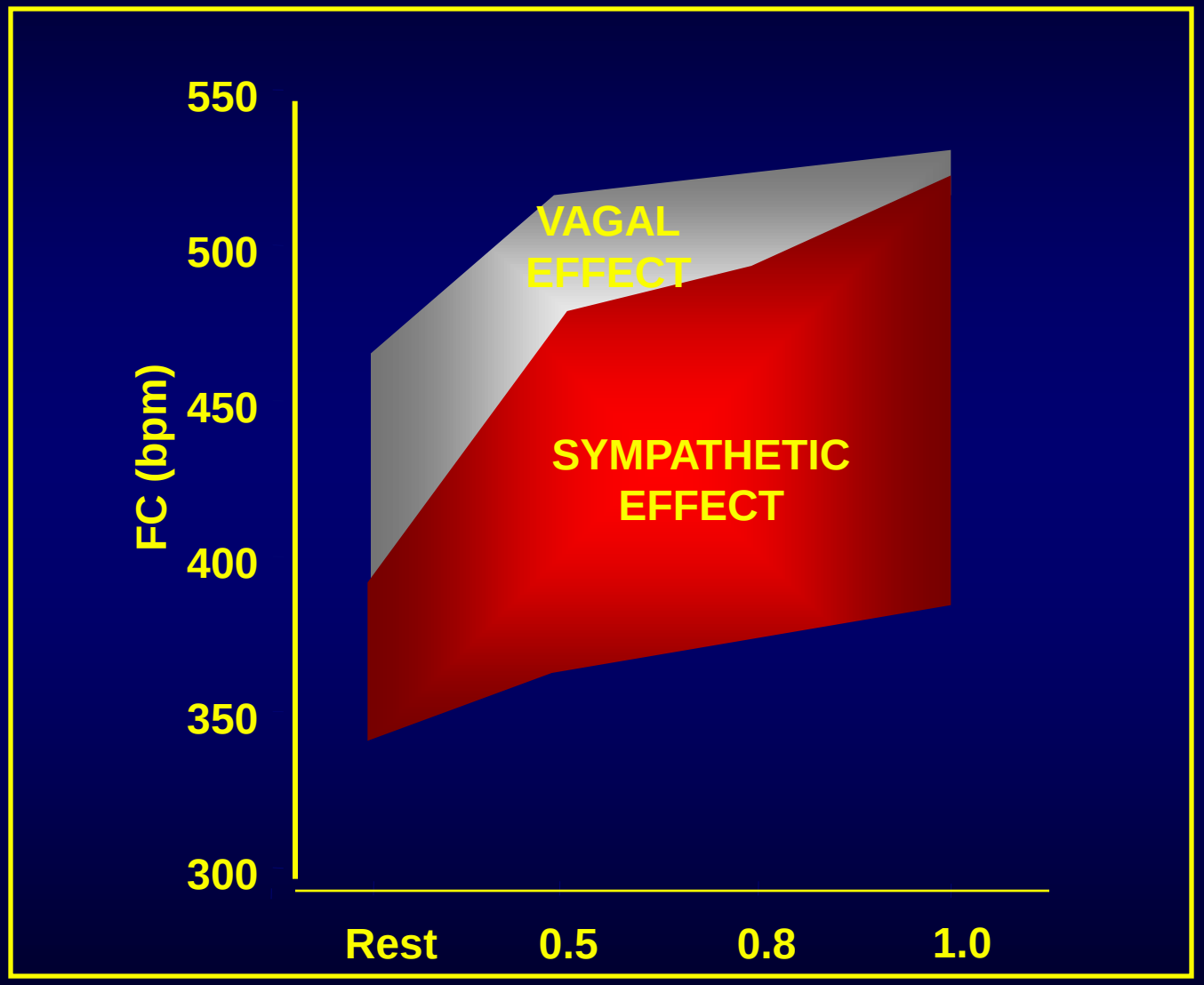



Fatores Intrínsecos
Fatores Neurais
↑ ANS (β1), ↓ ANP
Freqüência Cardíaca
Fatores Hormonais
↑ Adrenalina

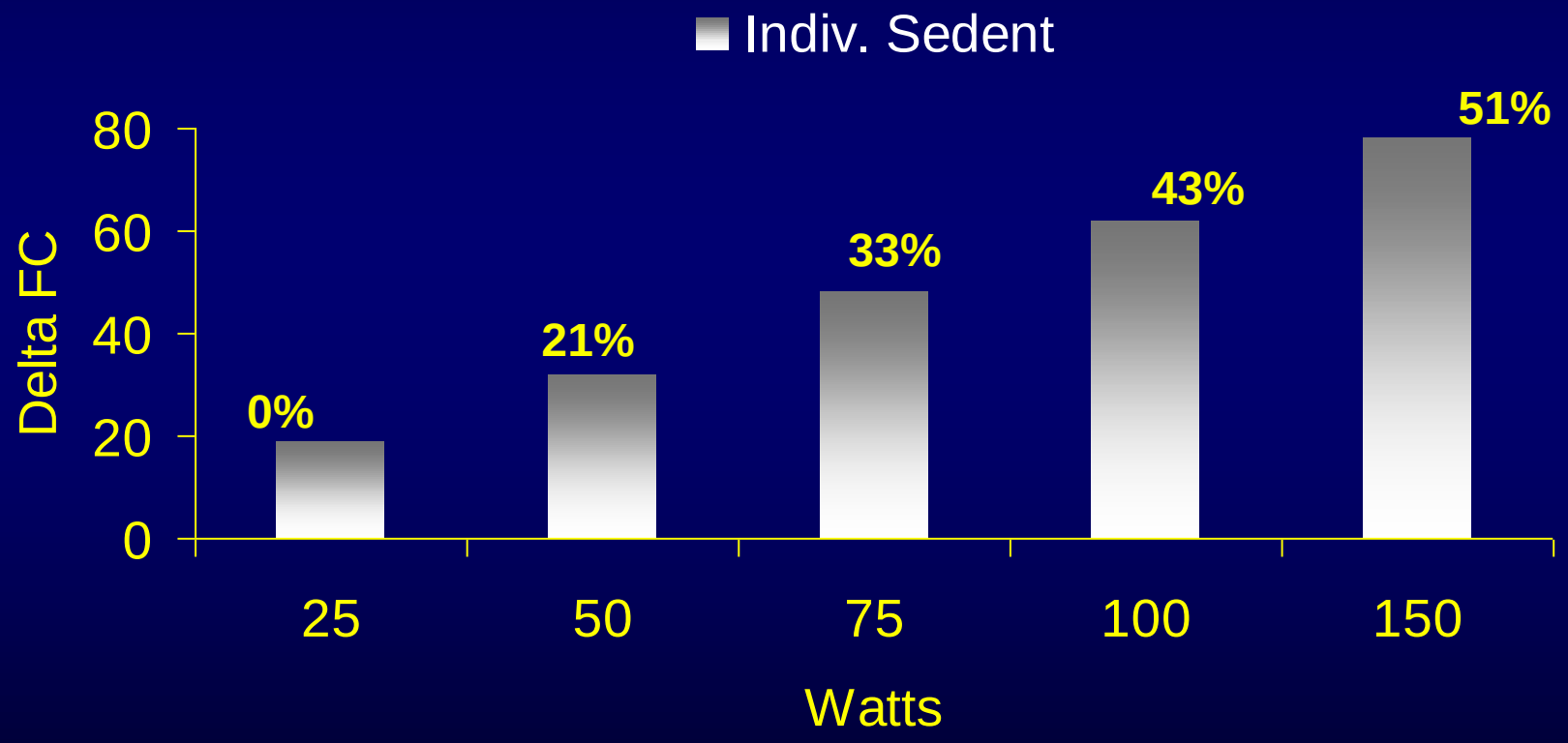
EFEITO E TONUS VAGAL E SIMPÁTICO E FREQUÊNCIA INSTRÍNSECA



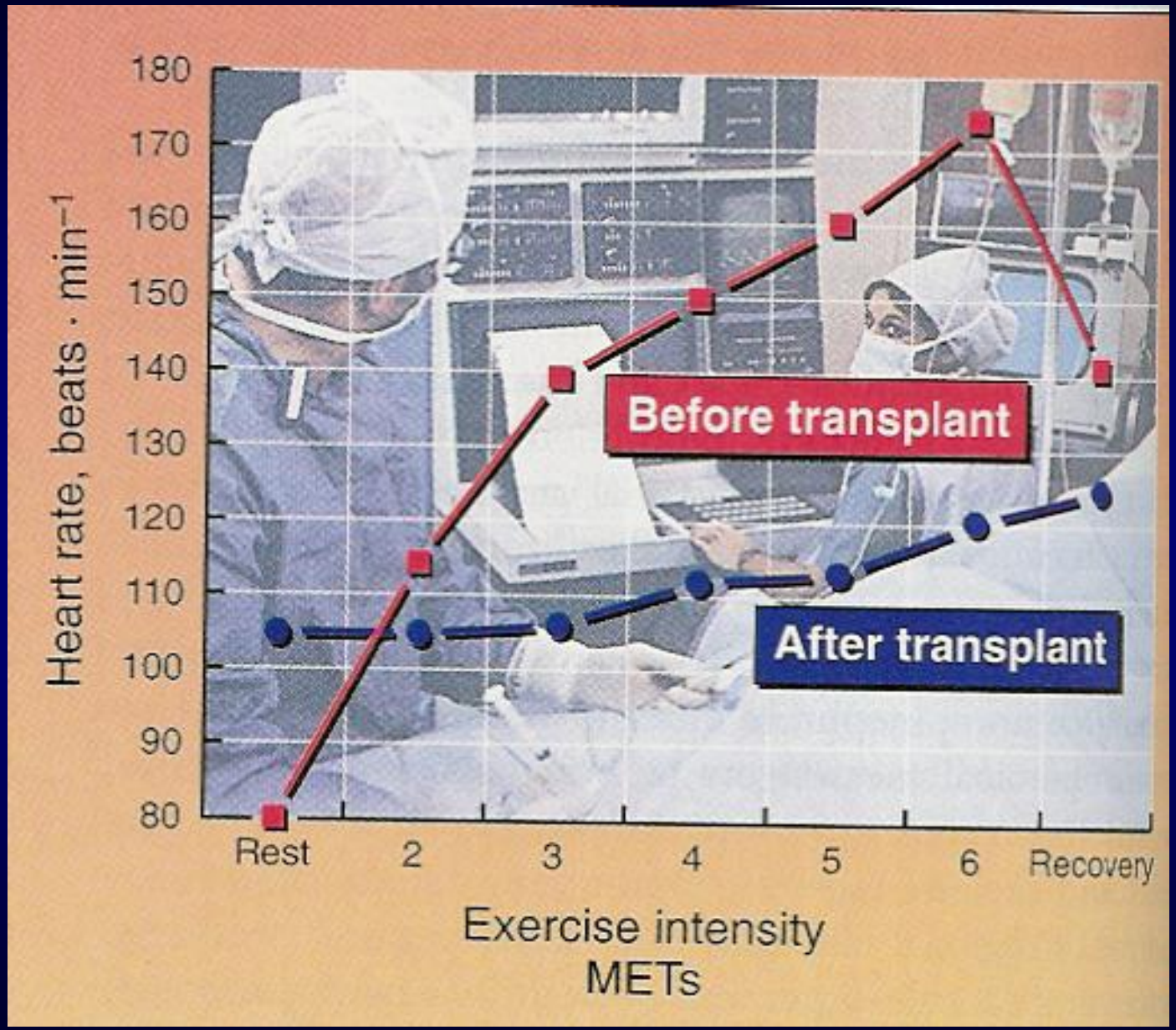
CONTROLE NEURAL DA FREQUÊNCIA CARDÍACA DURANTE O EXERCÍCIO



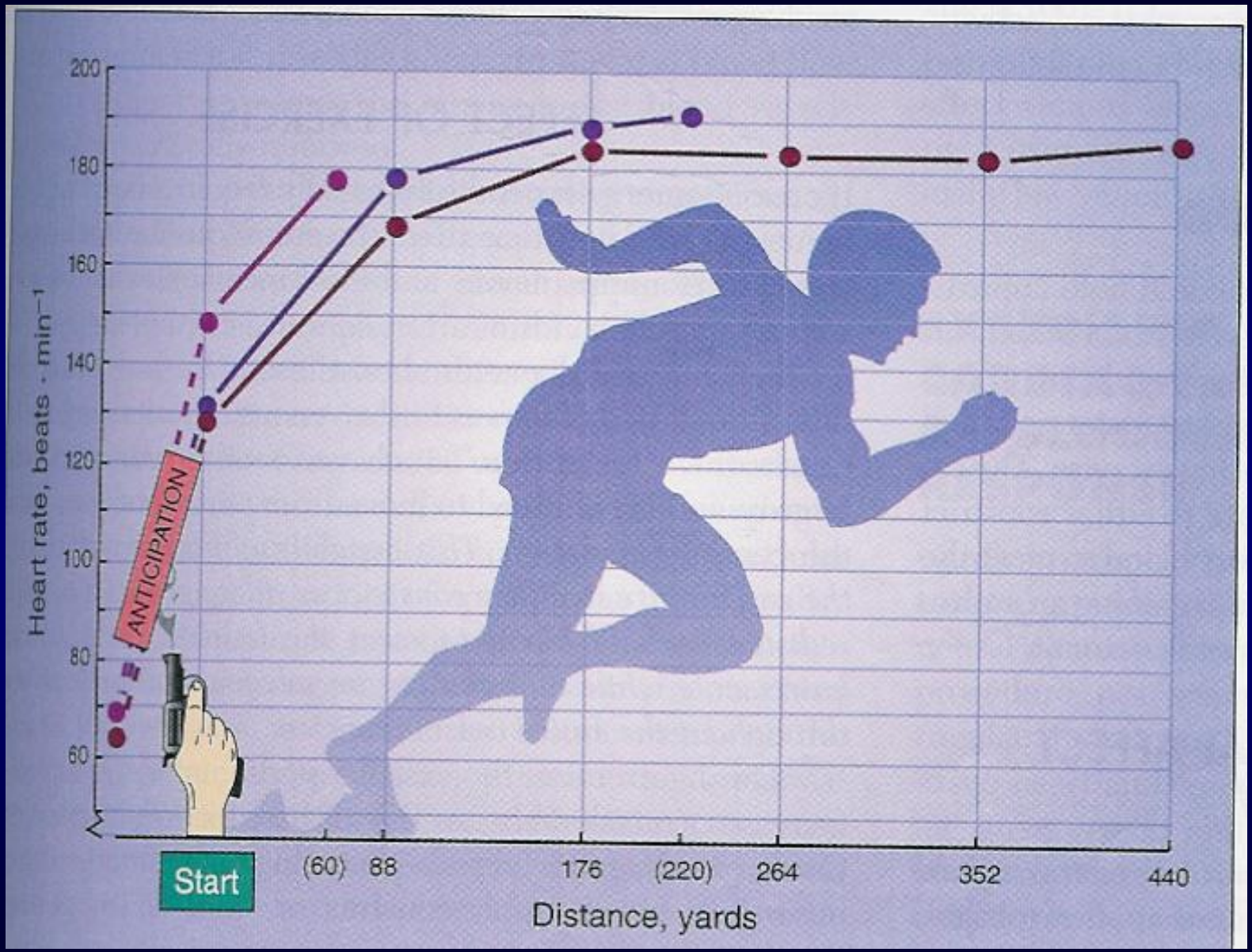
Percentual de ativação do SNAS na resposta da FC durante exercício progressivo.



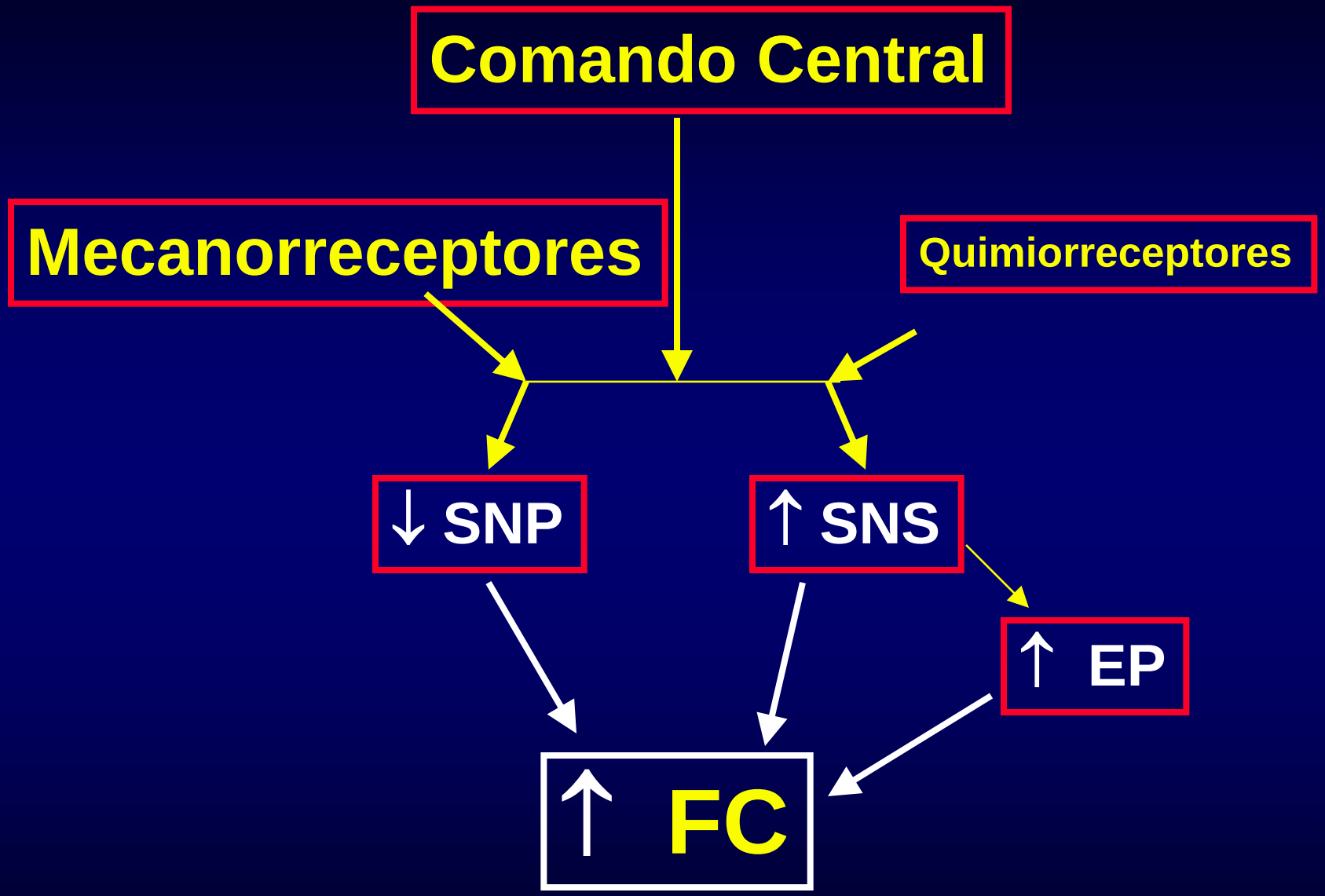
Adaptado de Gallo et al., 1989.


Heart rate, beats · min⁻¹
180
170
160
150
140
130
120
110
100
90
80
Rest
2
3
4
5
6
Recovery
Exercise intensity
METs
Before transplant
After transplant

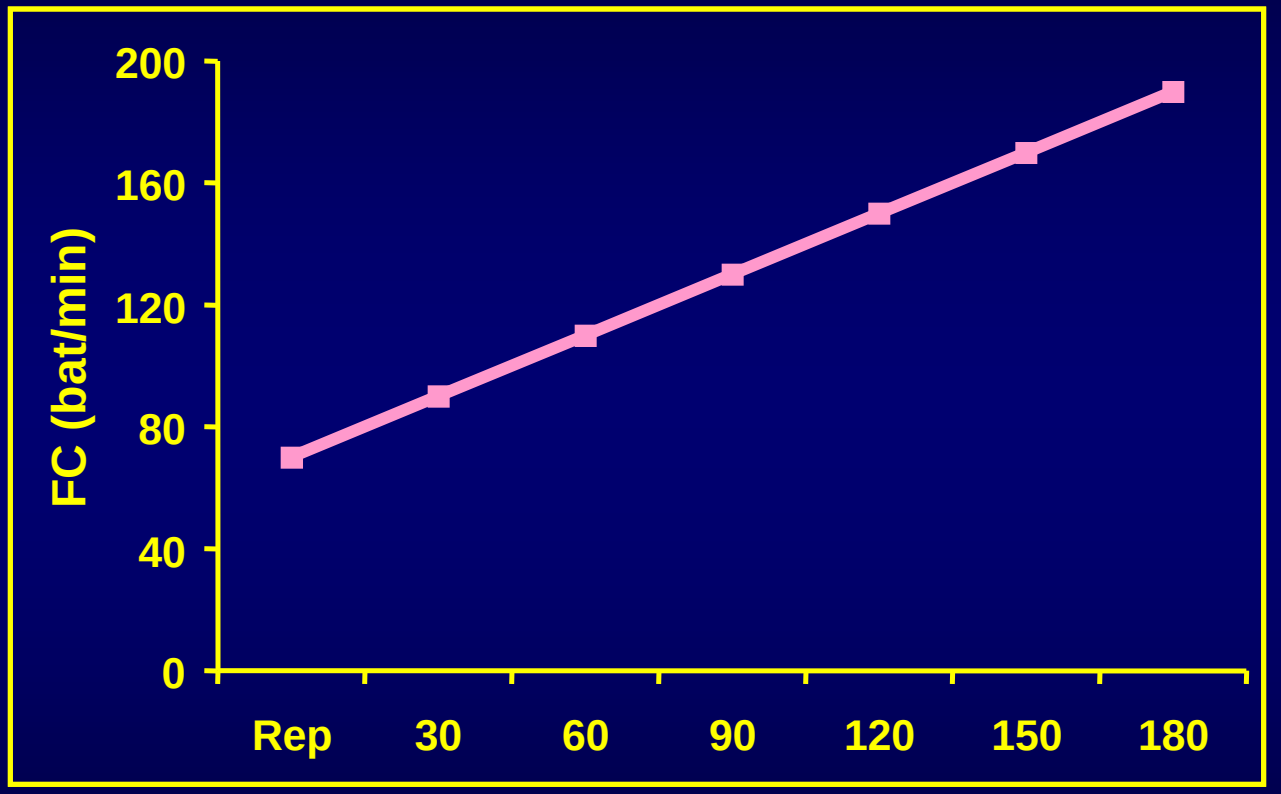
McArdle


200
180
160
140
120
100
80
60
Heart rate, beats · min⁻¹
ANTICIPATION
Start
(60)
88
176
(220)
264
352
440
Distance, yards

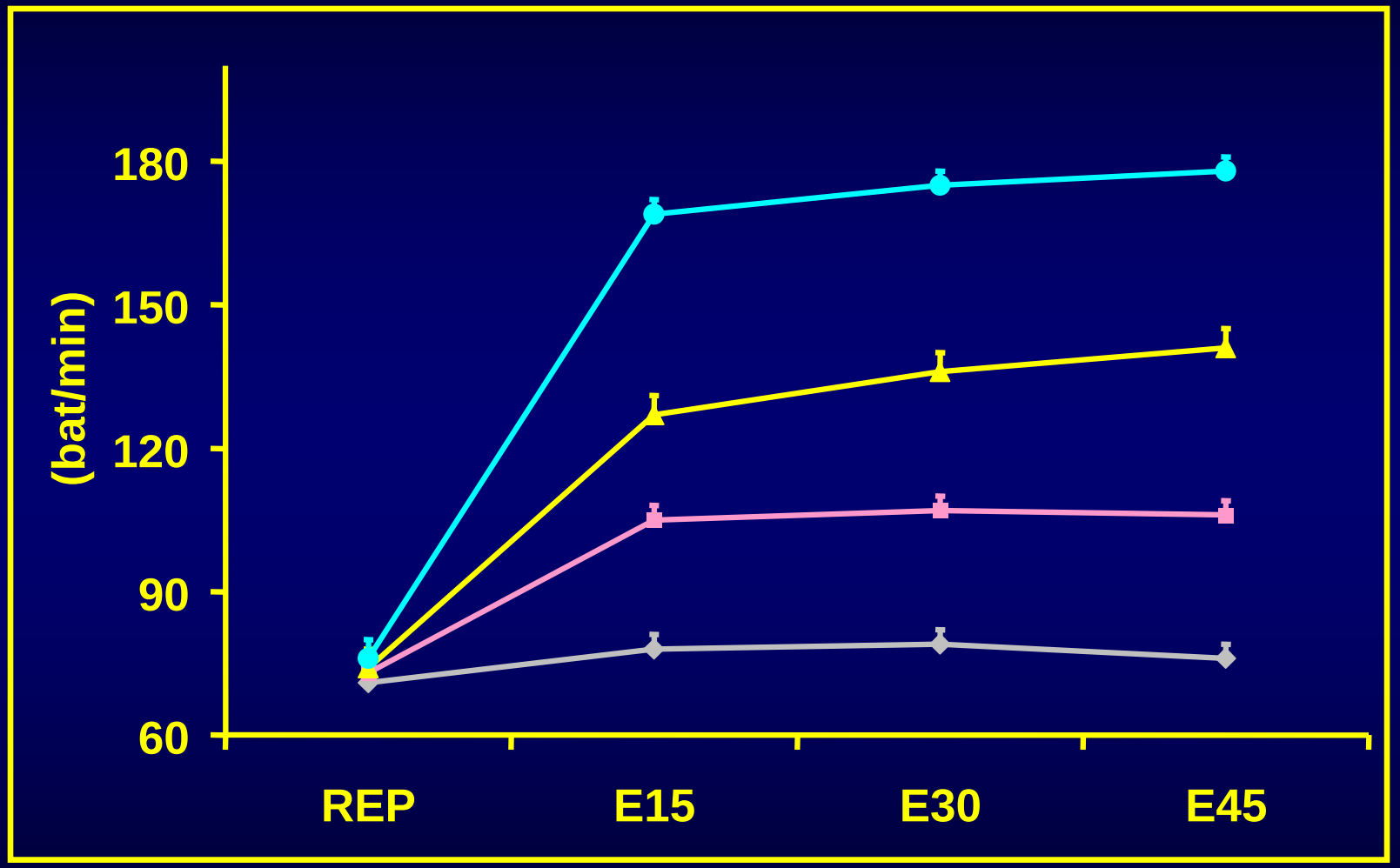
McArdle


Comando Central
Mecanorreceptores
Quimiorreceptores
↓ SNP
↑ SNS
↑ EP
↑ FC

FC – Teste Ergométrico

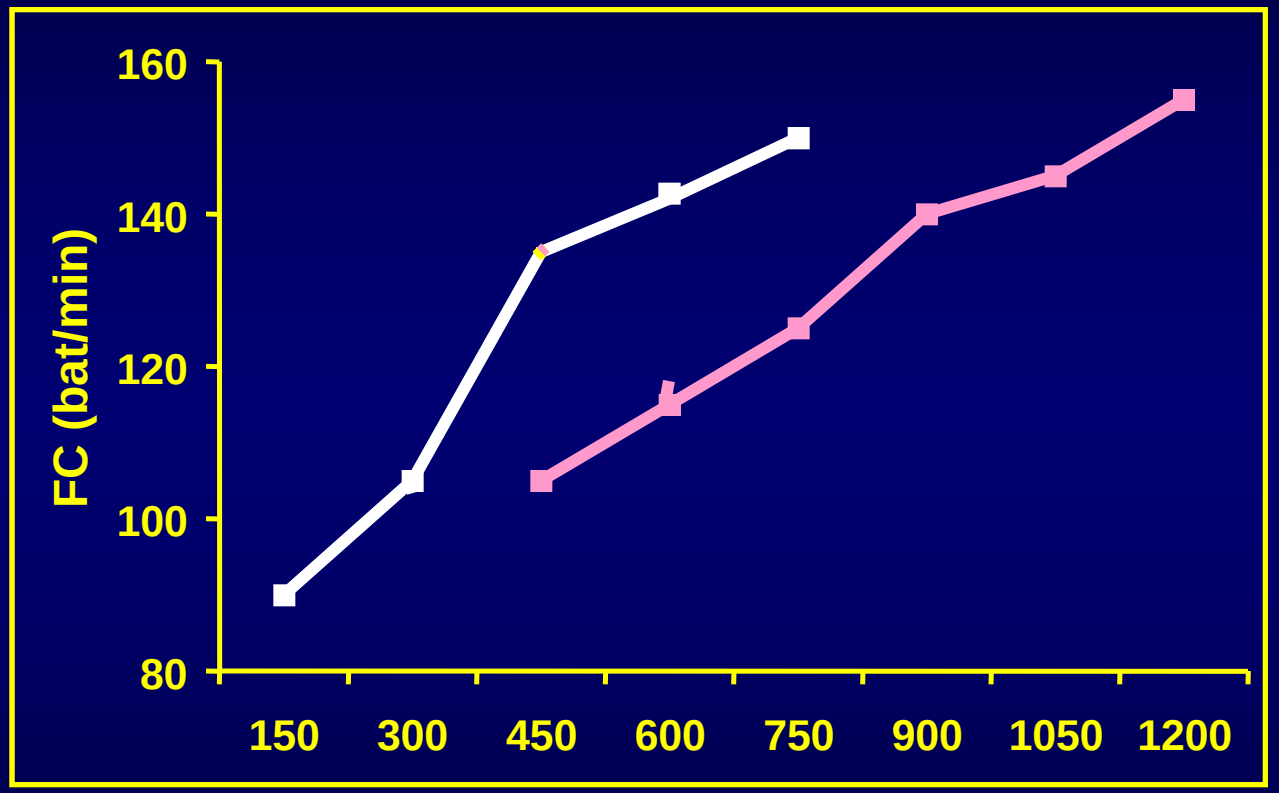


FC



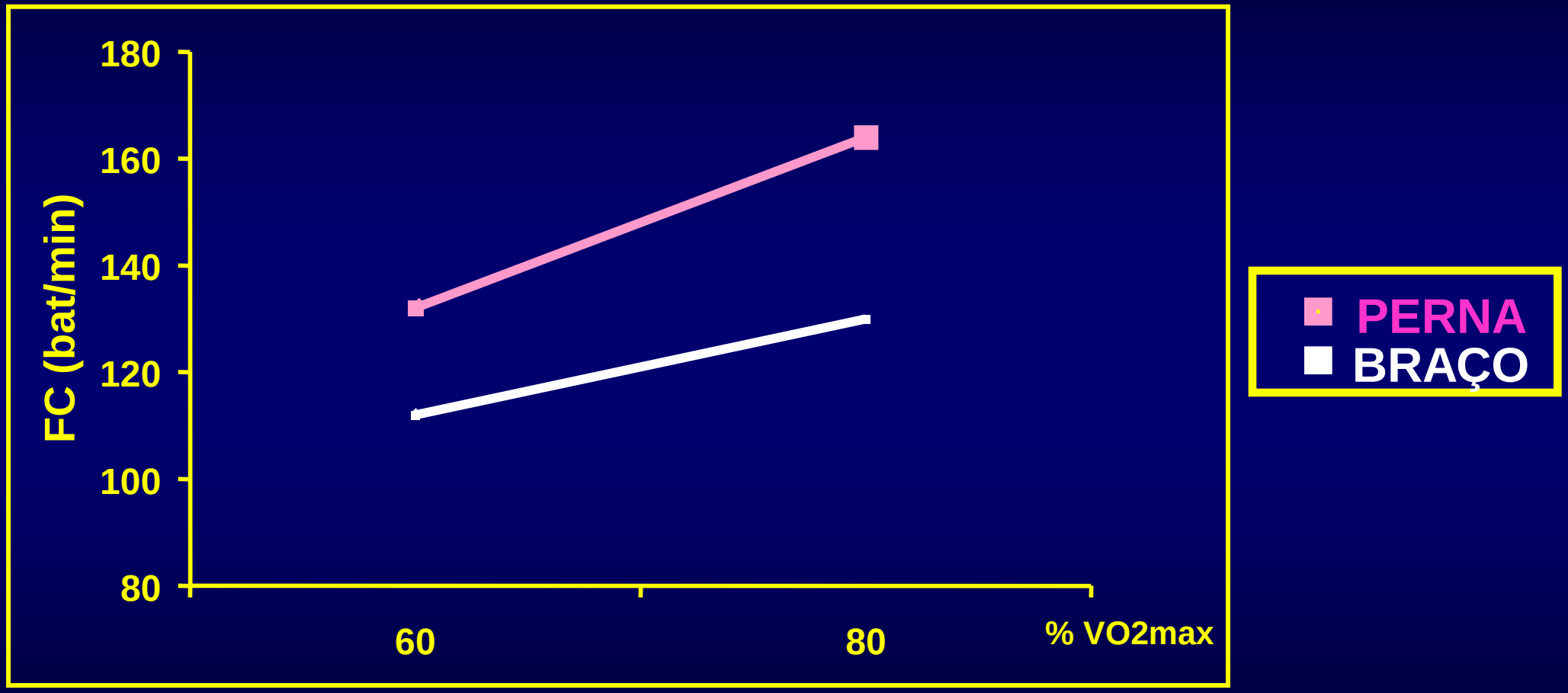
Controle 30%VO_2pico 50% VO_2pico 70%VO_2pico

FC – Massa Muscular



Adaptado de DeBusk et al. Circulation 58: 368-75, 2000

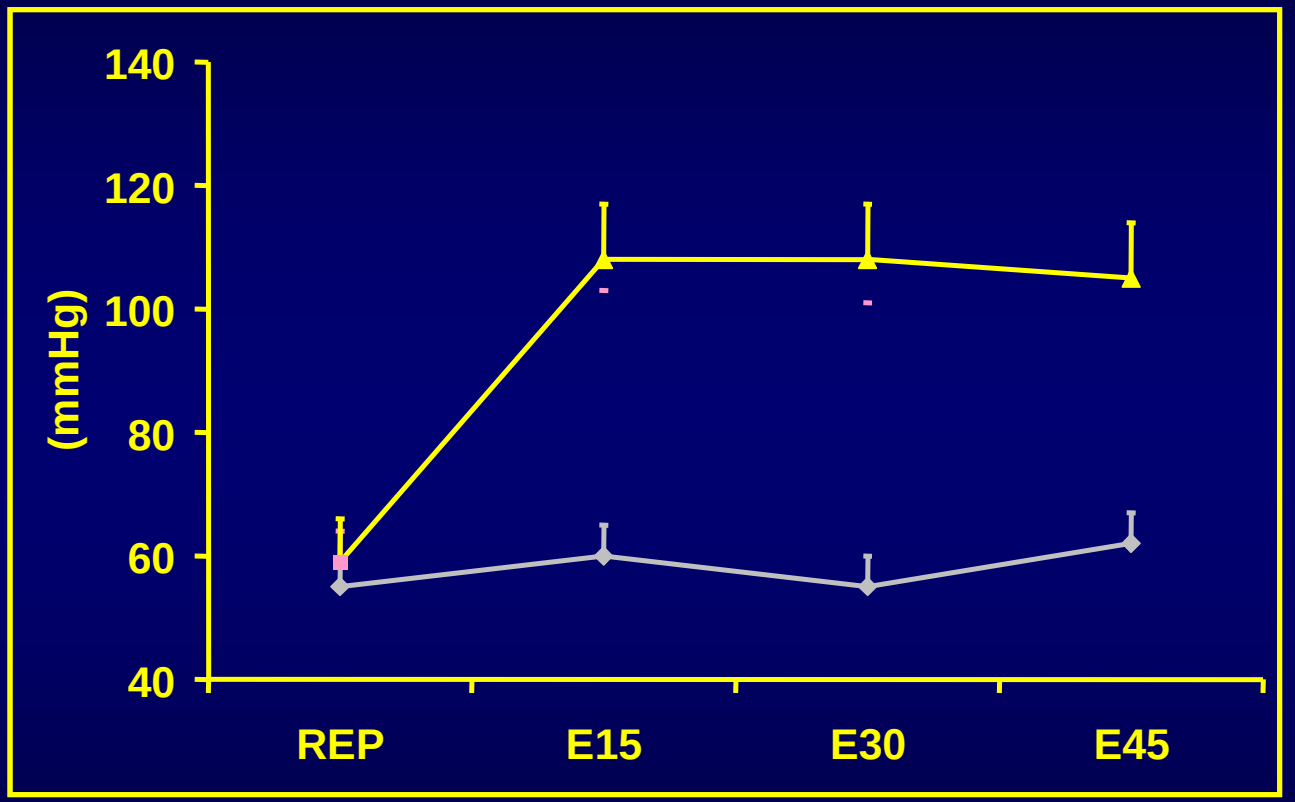
FC – Massa Muscular

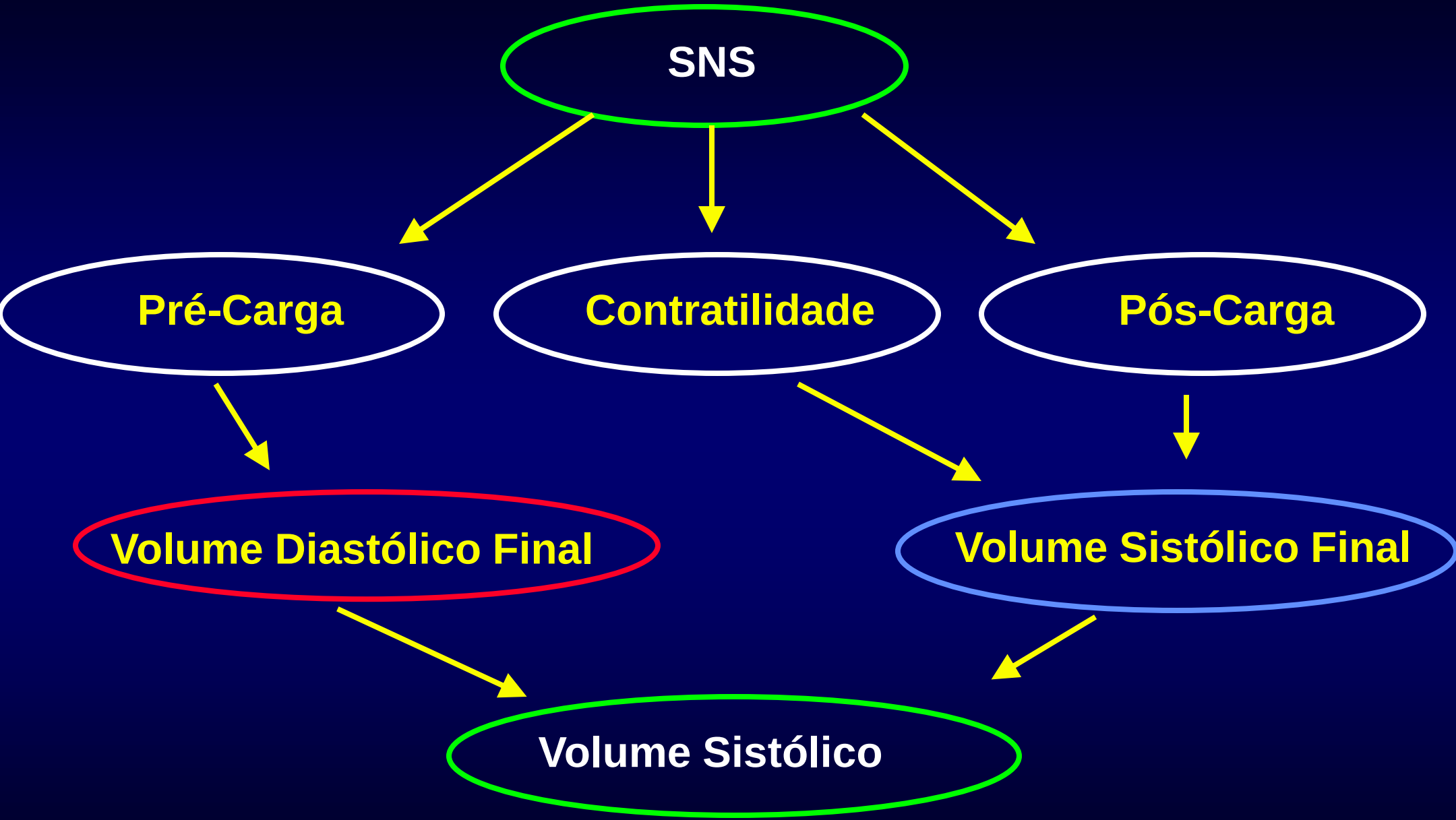


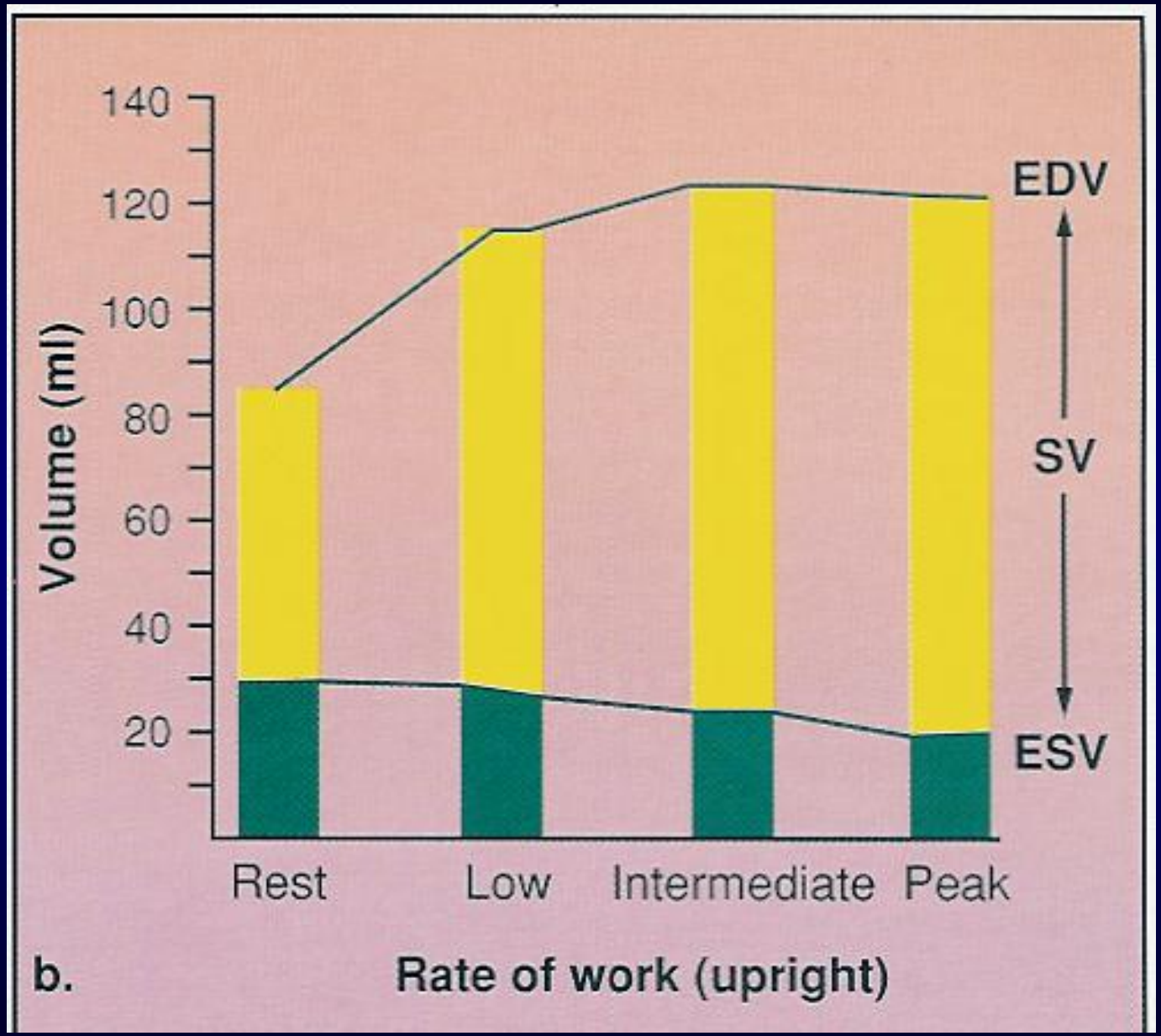
Adaptado de Bezucha et al. J. Appl. Physiol. 53:1589-93, 1982.

VOLUME SISTÓLICO

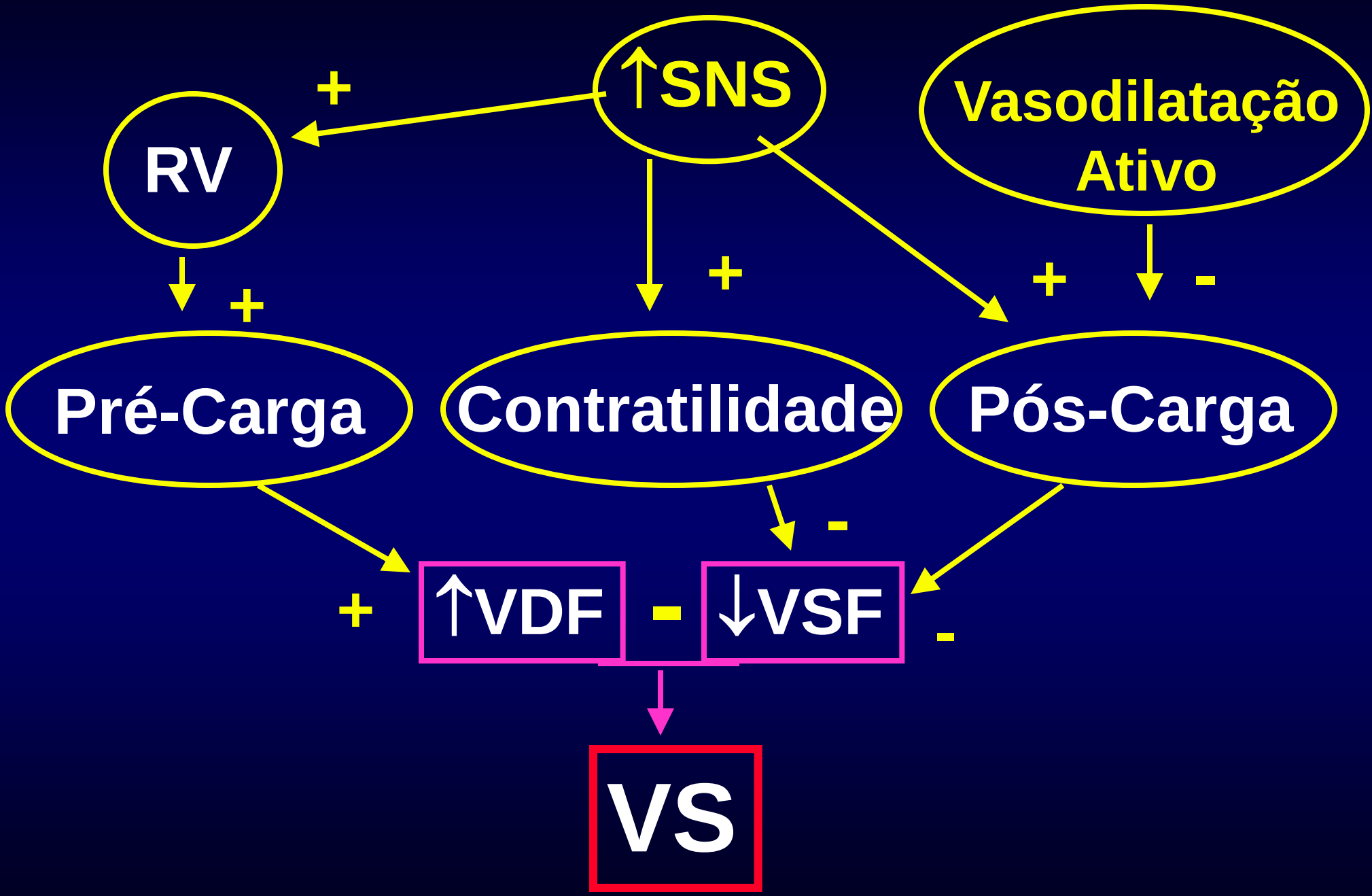
VS



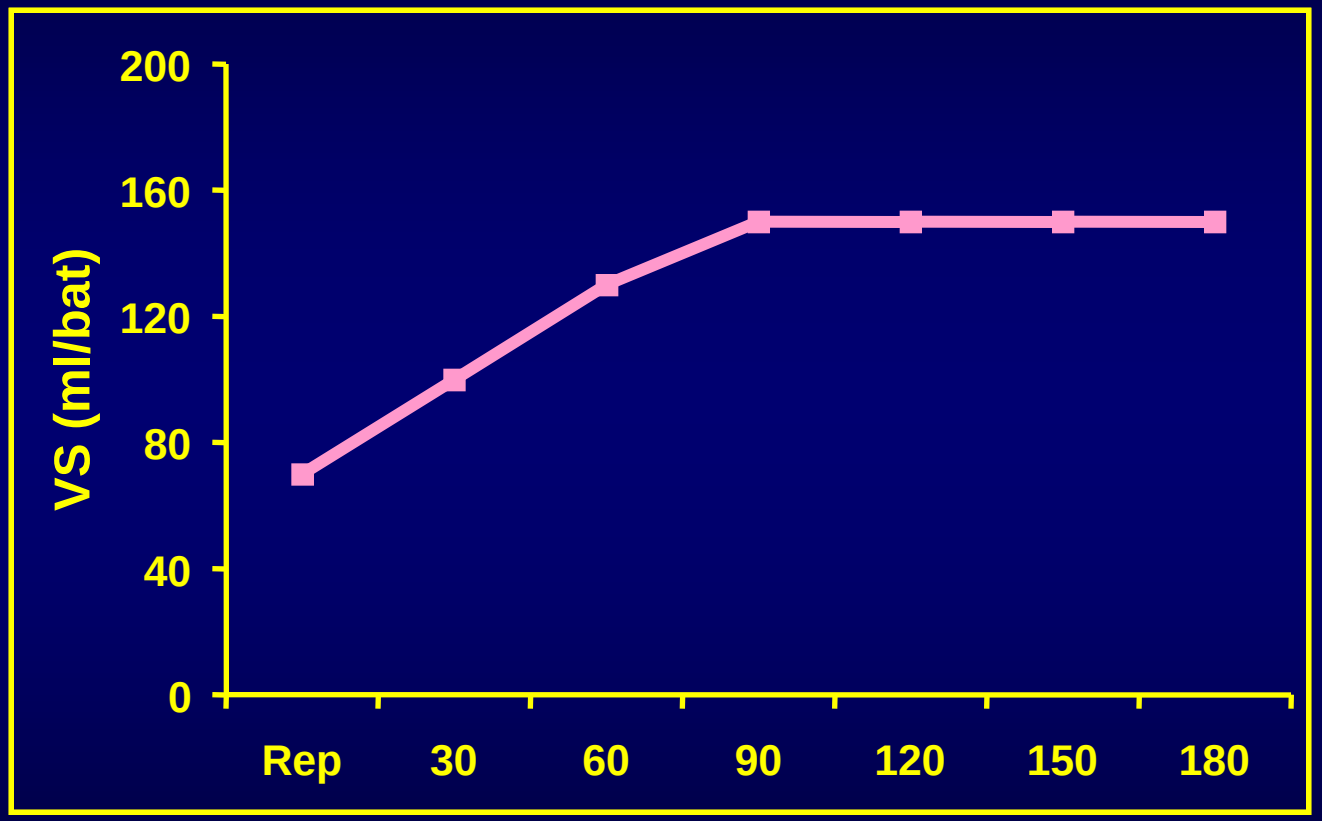

SNS
Pré-Carga
Contratilidade
Pós-Carga
Volume Diastólico Final
Volume Sistólico Final
Volume Sistólico


140
120
100
80
60
40
20
Volume (ml)
EDV
SV
ESV
Rest
Low
Intermediate
Peak
b.
Rate of work (upright)

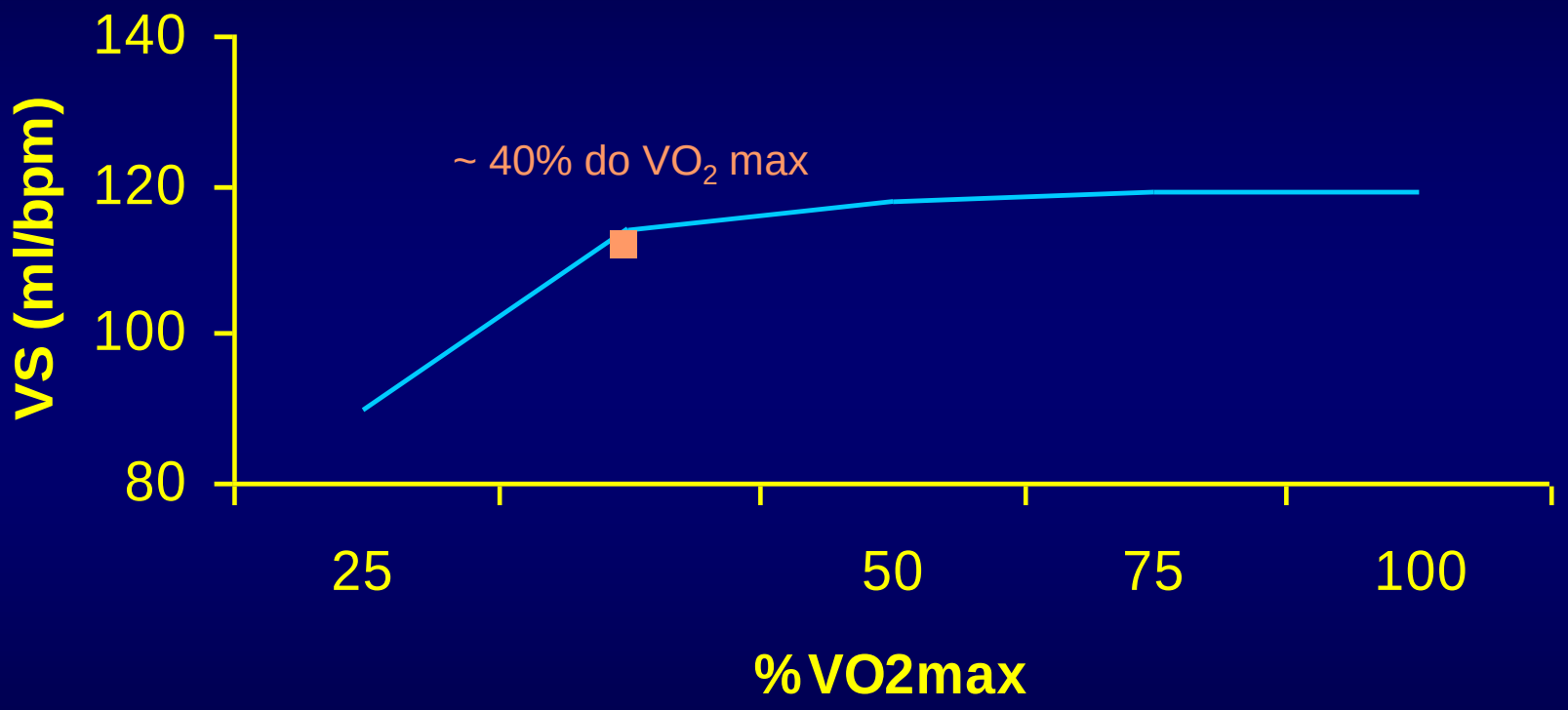
Wilmore


↑SNS
RV
+
Vasodilatação Ativo
+
+
+
-
Pré-Carga
Contratilidade
Pós-Carga
-
+
↑VDF
-
↓VSF
-
VS

VS – Teste Ergométrico

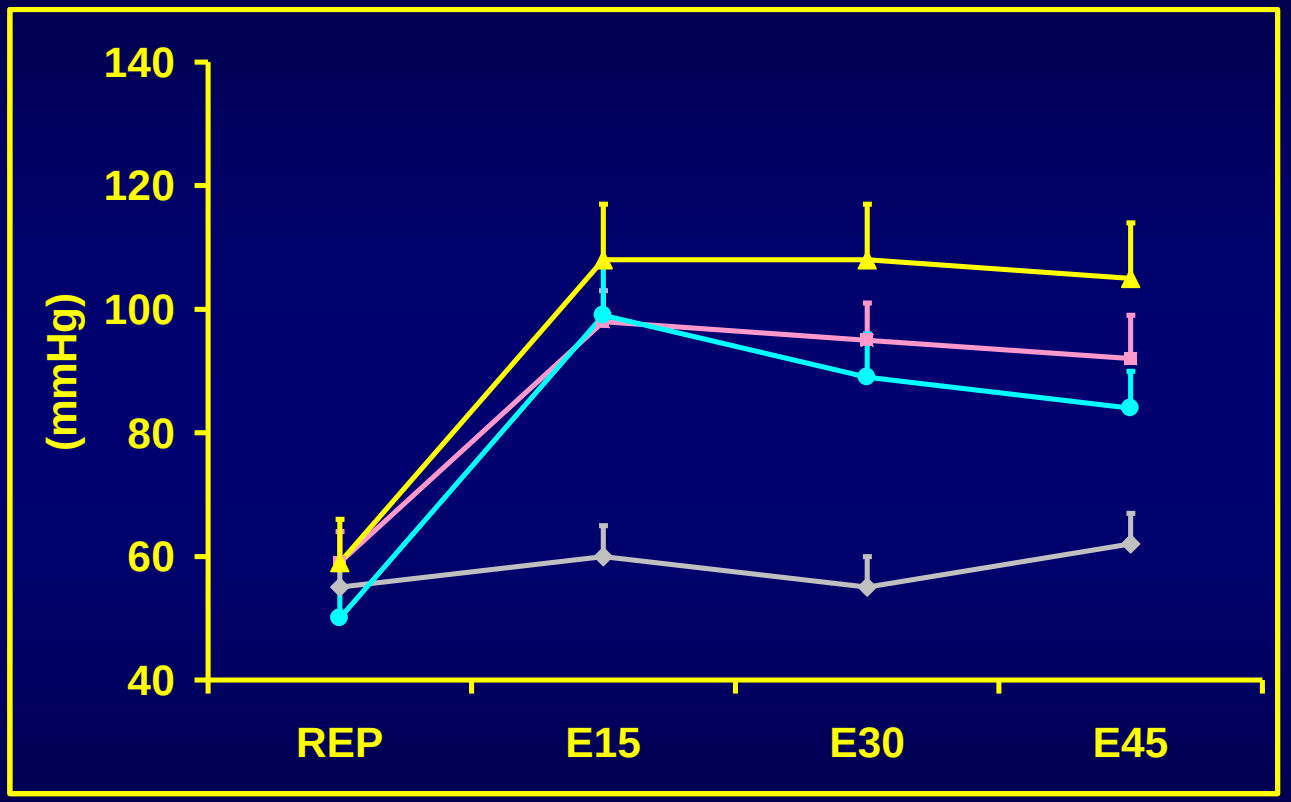


Estabilização do Vol. Sistólico



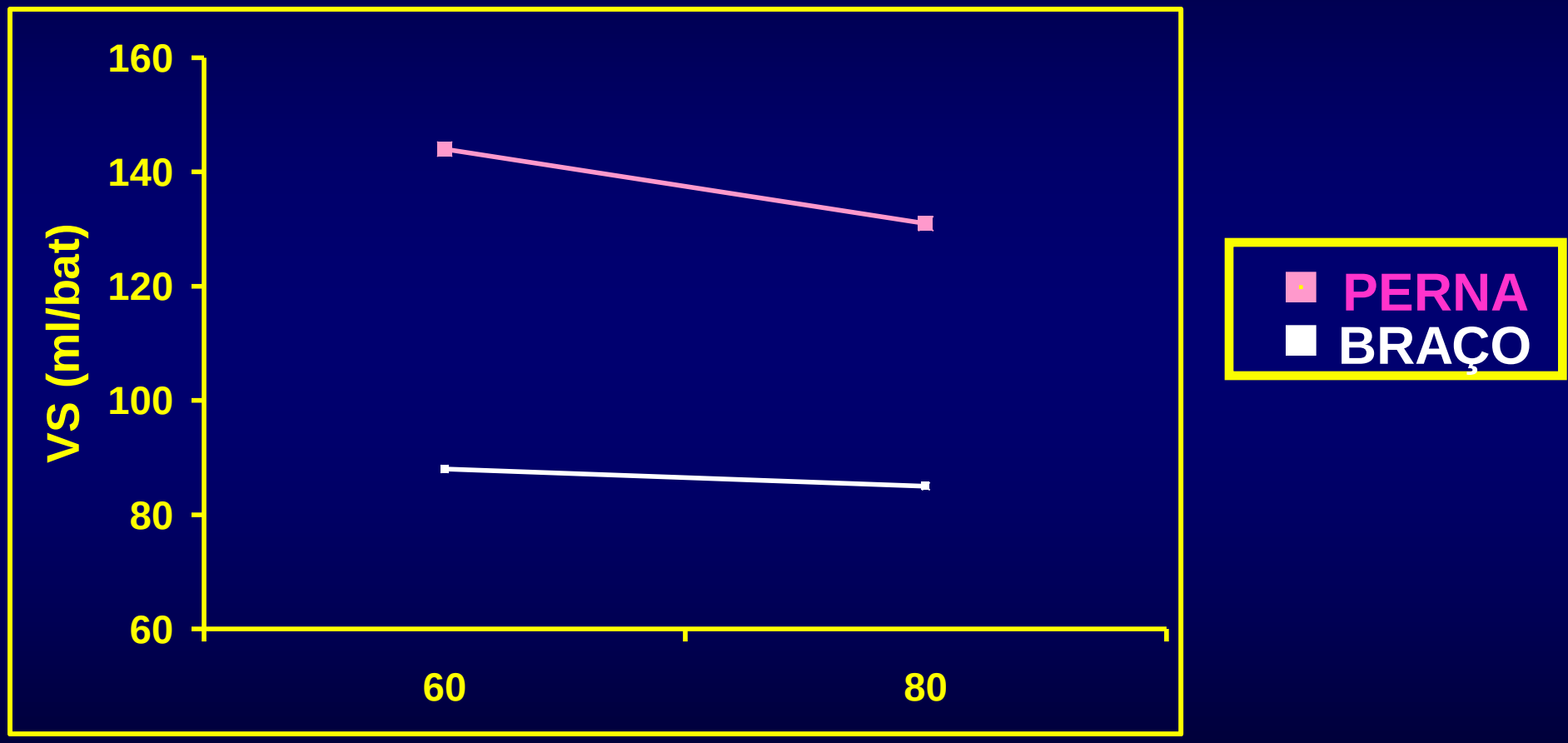
Adaptado de Powers & Howley.

VS



Controle 30%VO_2pico 50% VO_2pico 70%VO_2pico

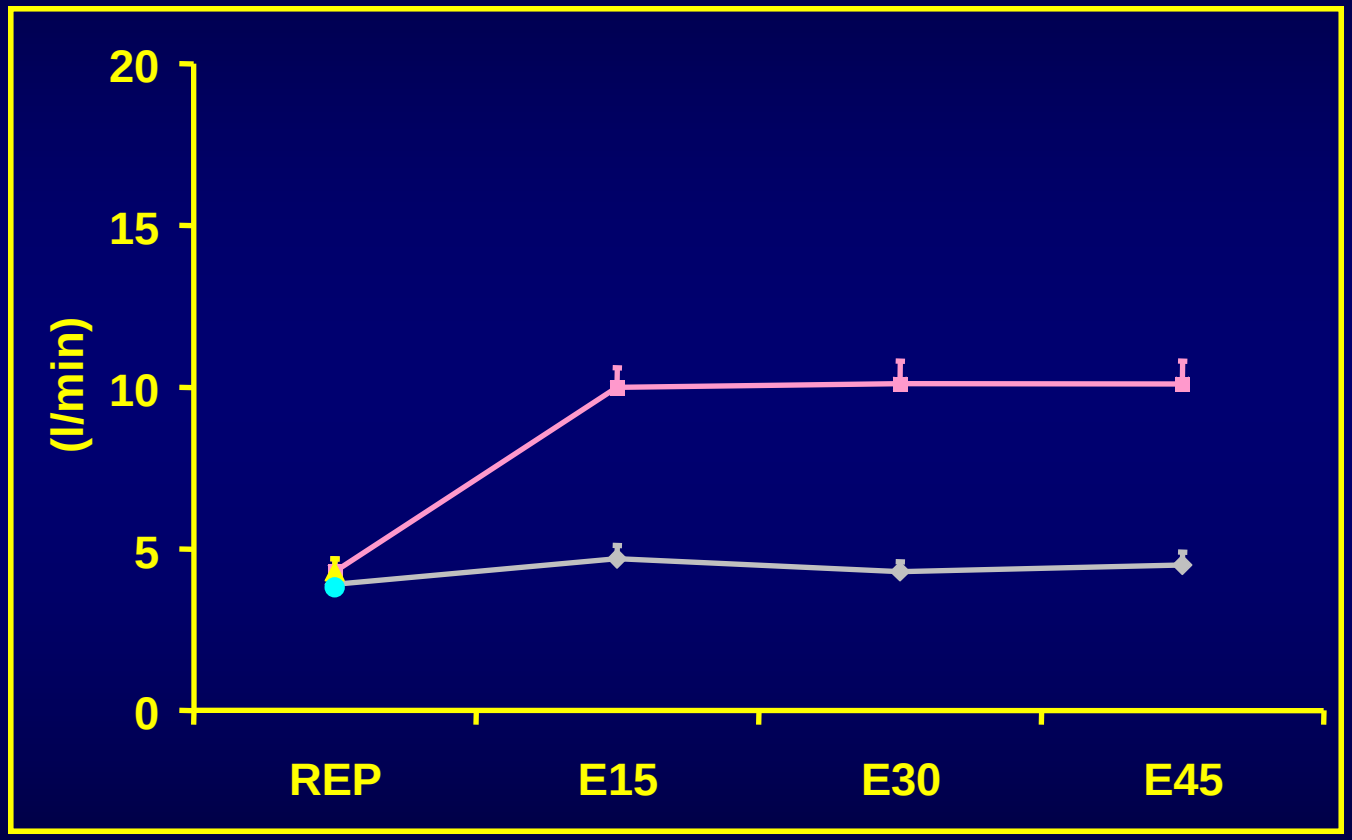
VS – Massa Muscular

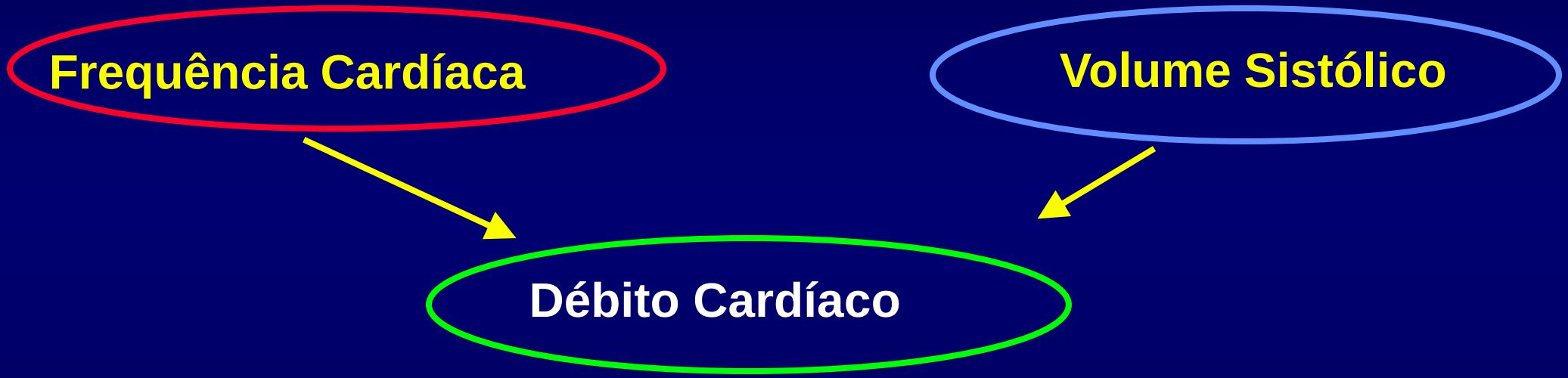


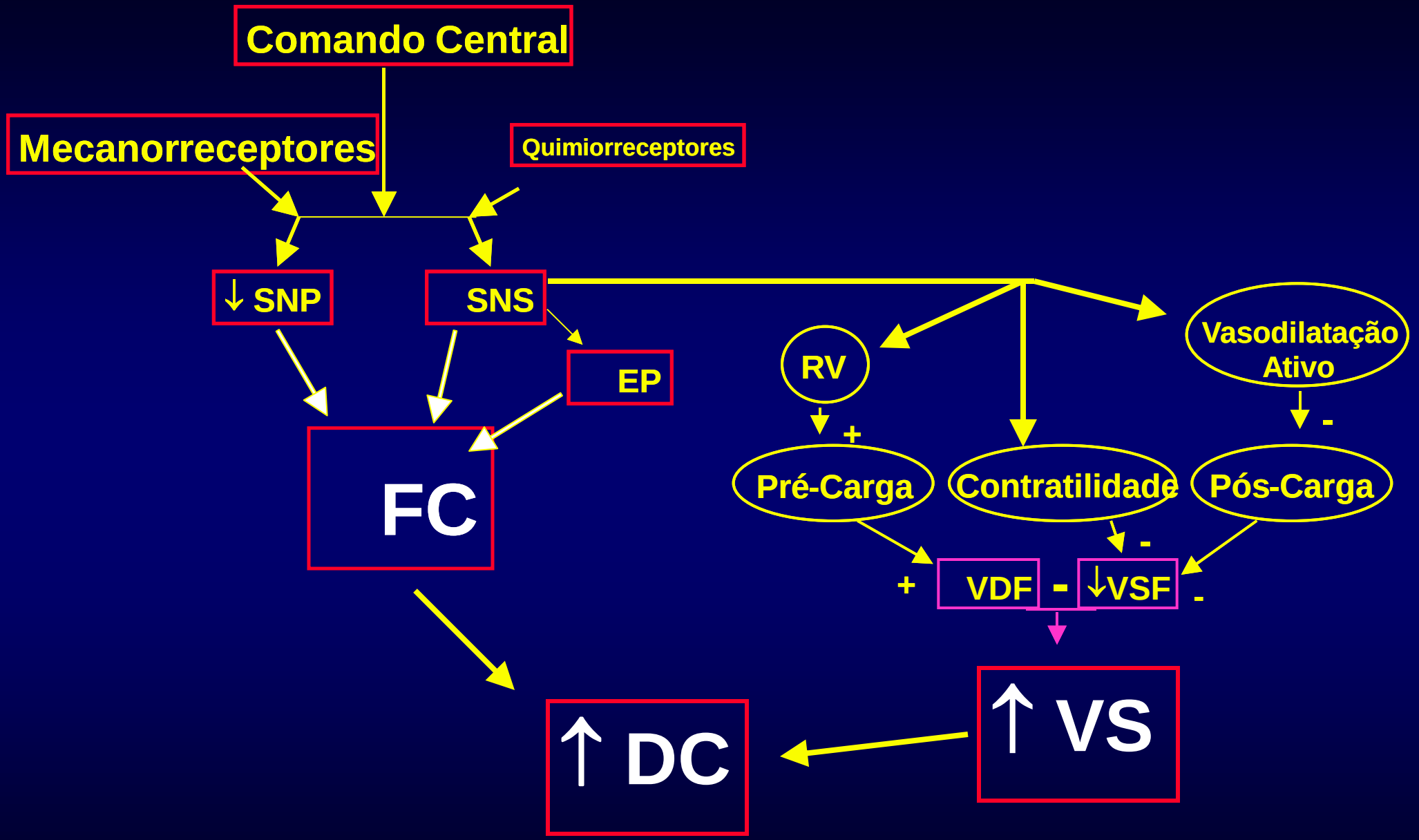
Adaptado de Bezucha et al. J. Appl. Physiol. 53:1589-93, 1982.

DÉBITO CARDÍACO

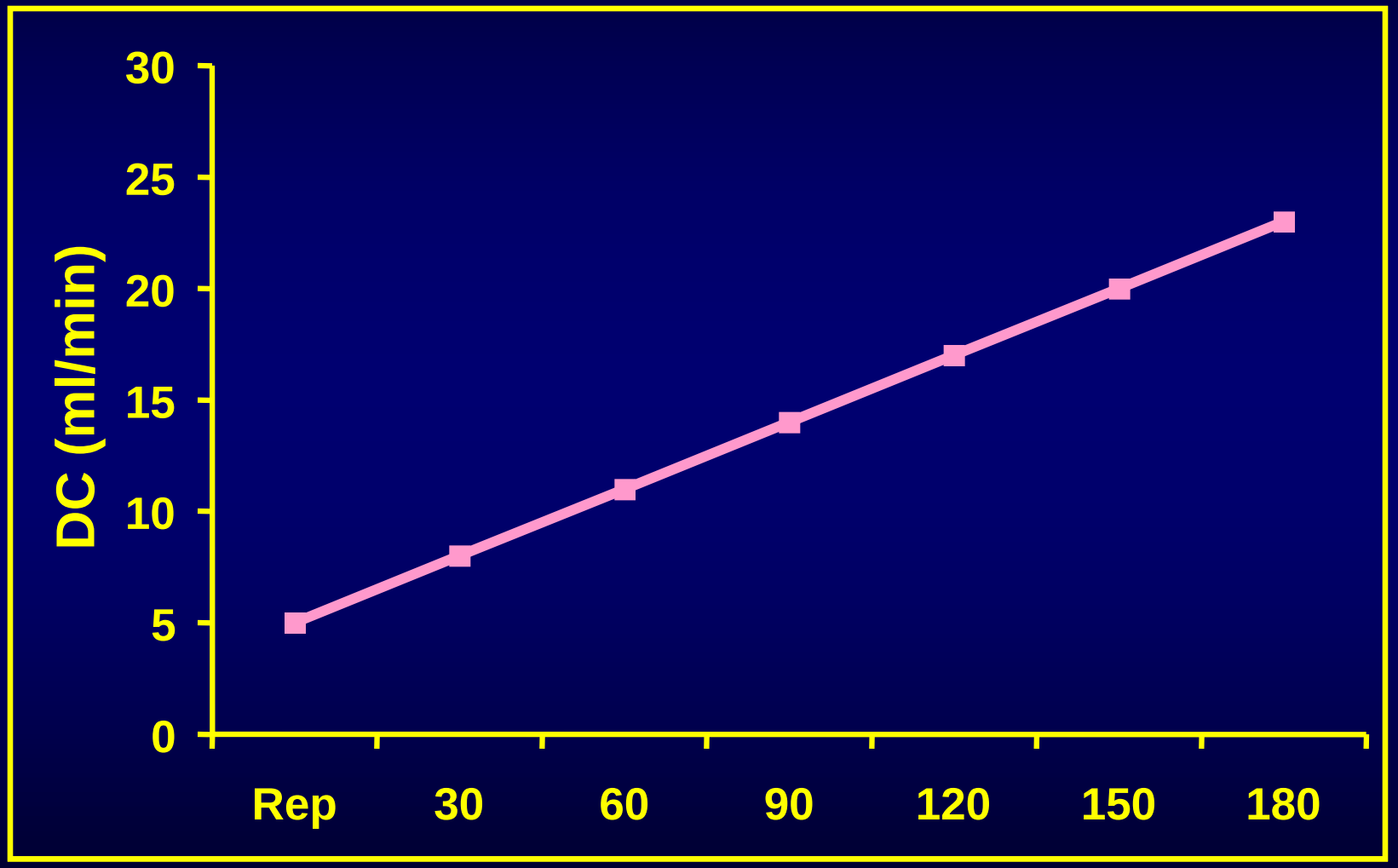
DC



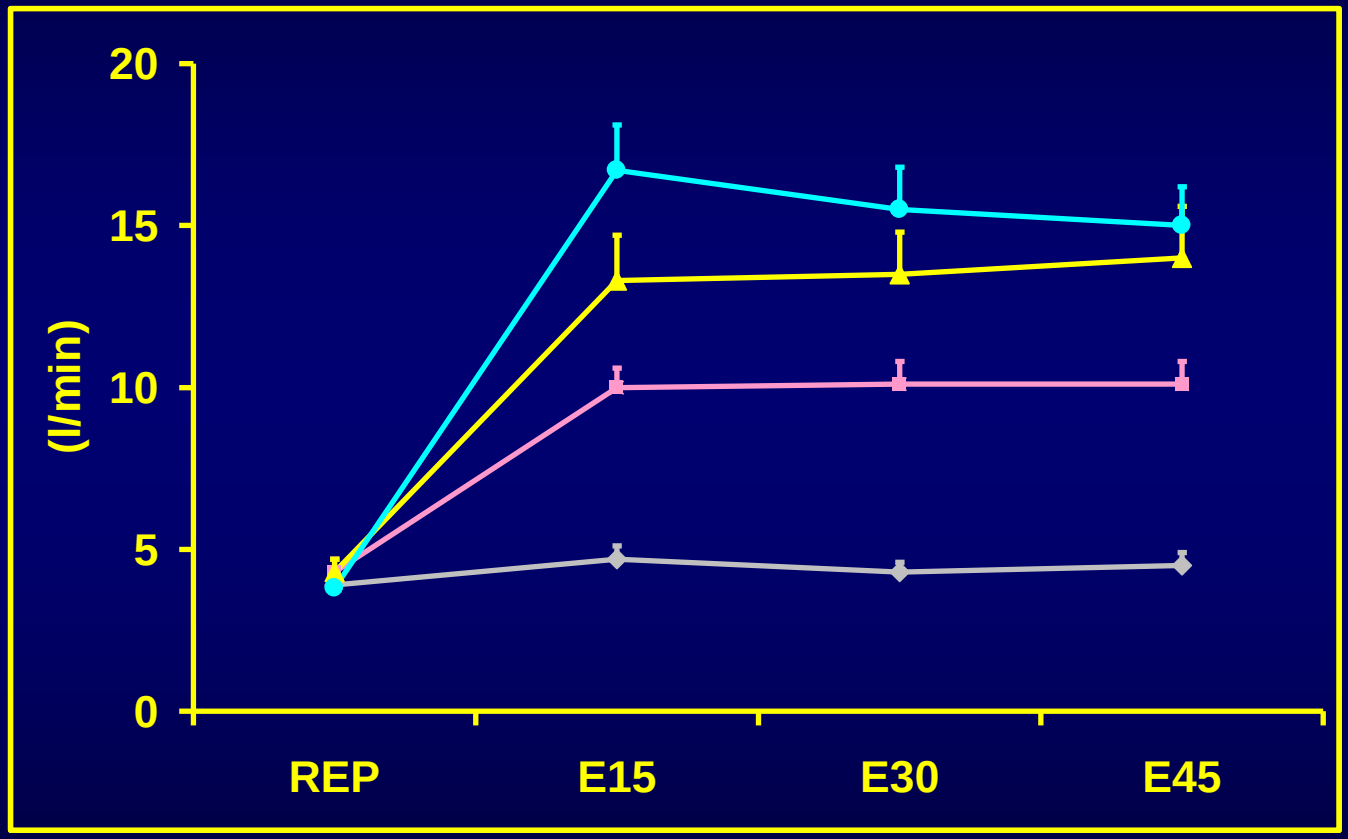

Frequência Cardíaca
Volume Sistólico
Débito Cardíaco


Comando Central
Mecanorreceptores
Quimiorreceptores
↓ SNP
SNS
EP
FC
RV
+
Pré-Carga
Contratilidade
-
Vasodilatação
Ativo
-
Pós-Carga
+
VDF
-
↓VSF
-
↑ VS
↑ DC

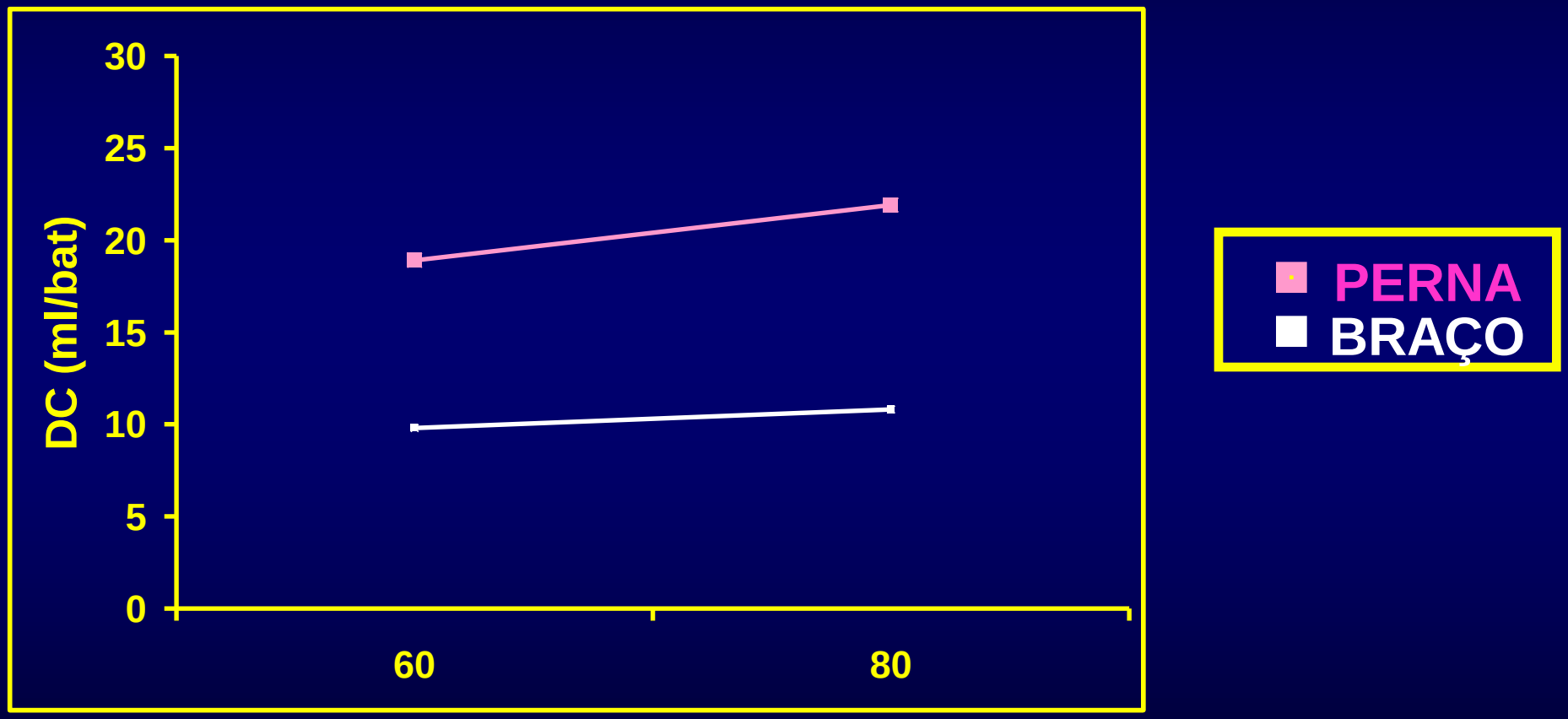
DC – Teste Ergométrico



DC


20
15
10
5
0
(l/min)
REP
E15
E30
E45
Controle
30%VO2pico
50% VO2pico
70%VO2pico

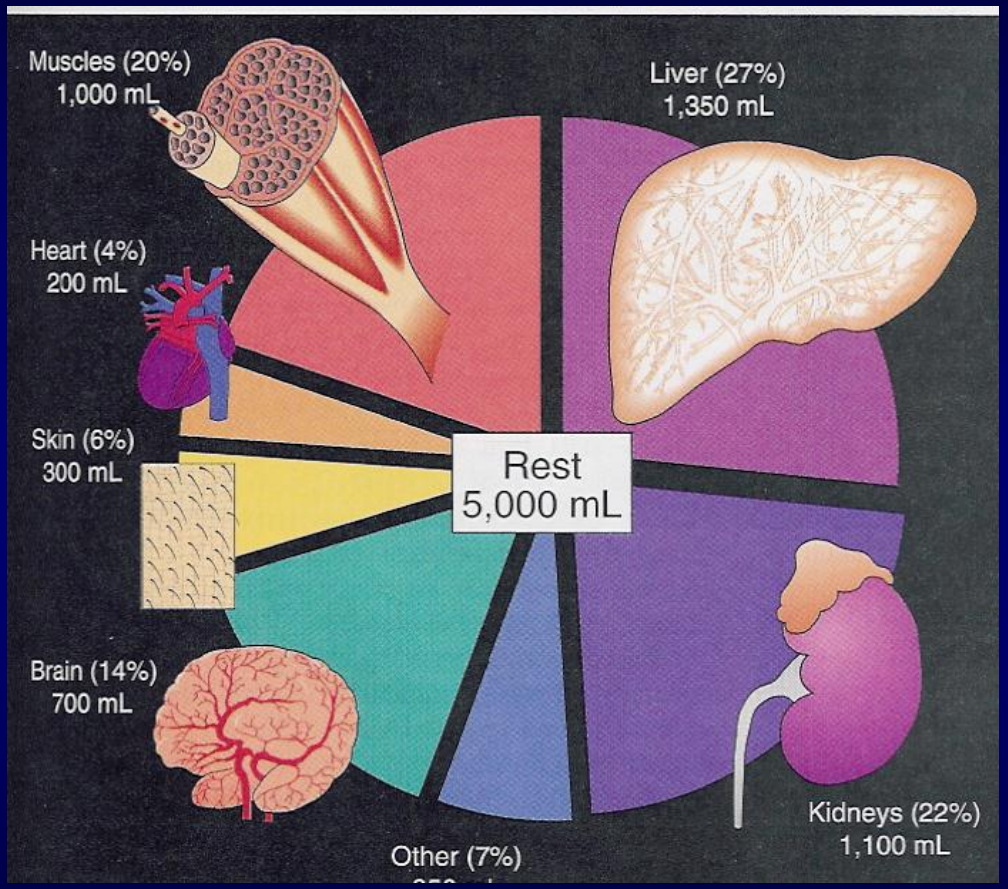
DC – Massa Muscular

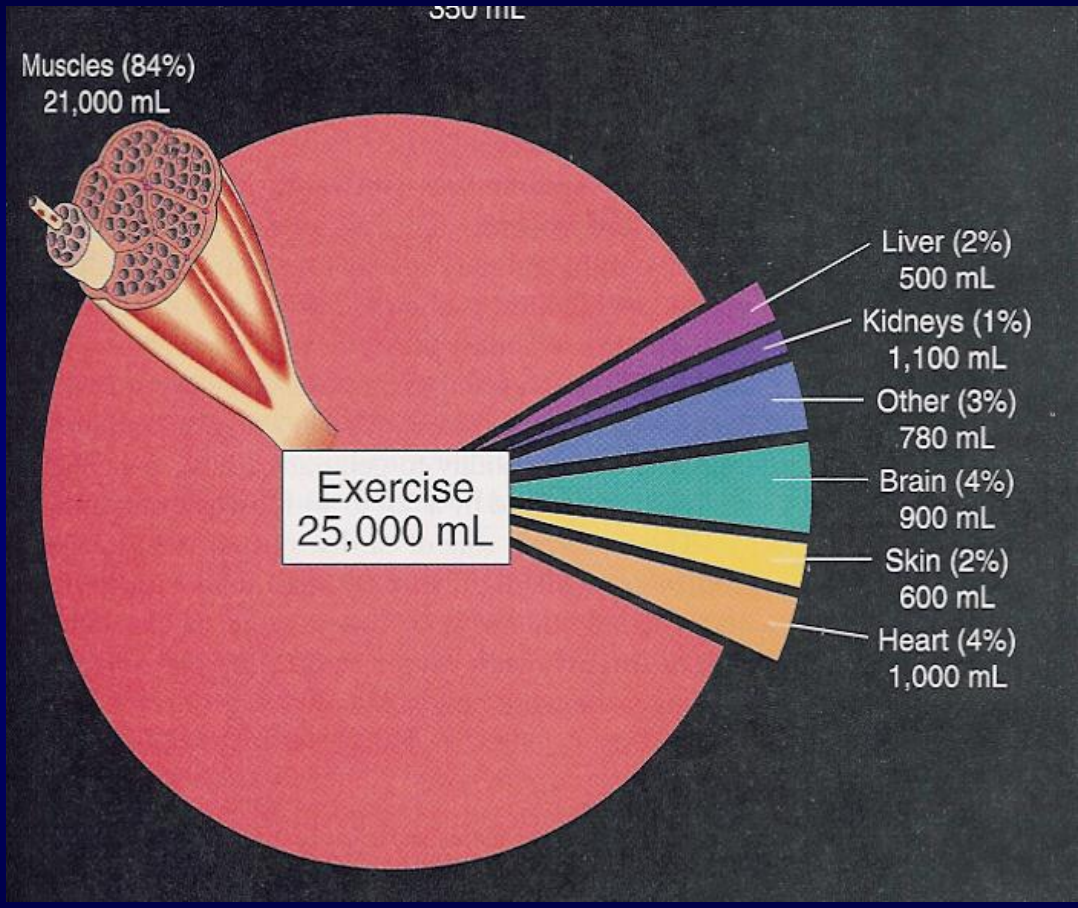


Adaptado de Bezucha et al. J. Appl. Physiol. 53:1589-93, 1982.

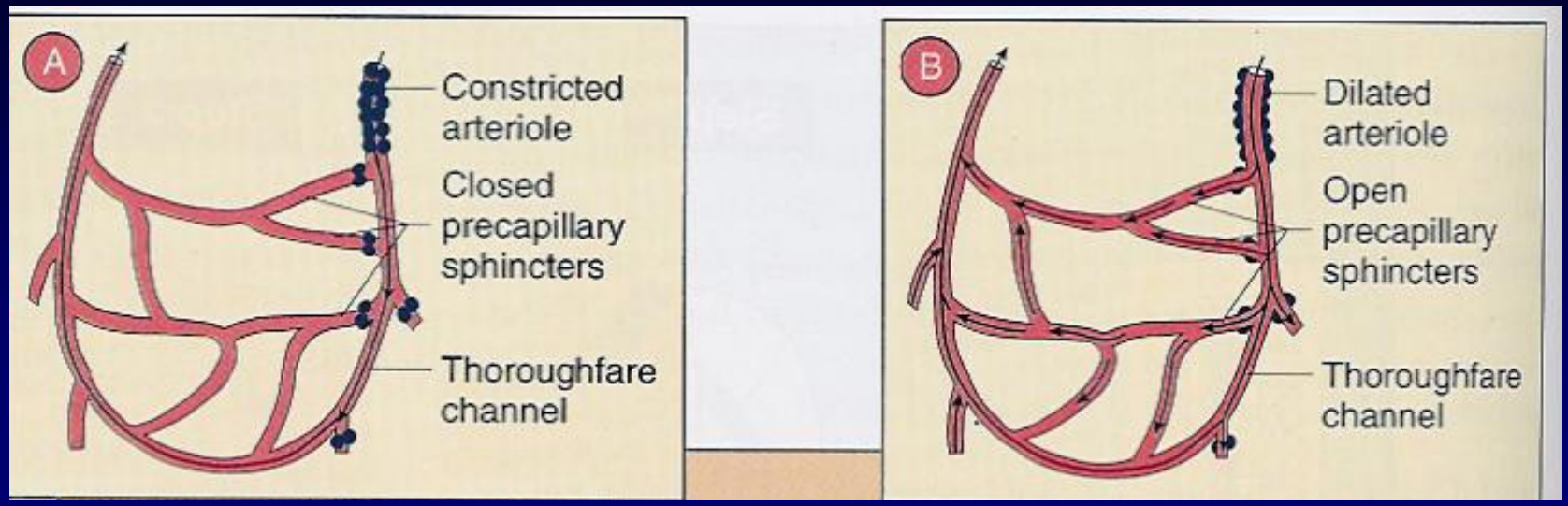
DISTRIBUIÇÃO DO DÉBITO CARDÍACO
E
RESISTÊNCIA VASCULAR PERIFÉRICA

REDISTRIBUIÇÃO DE FLUXO



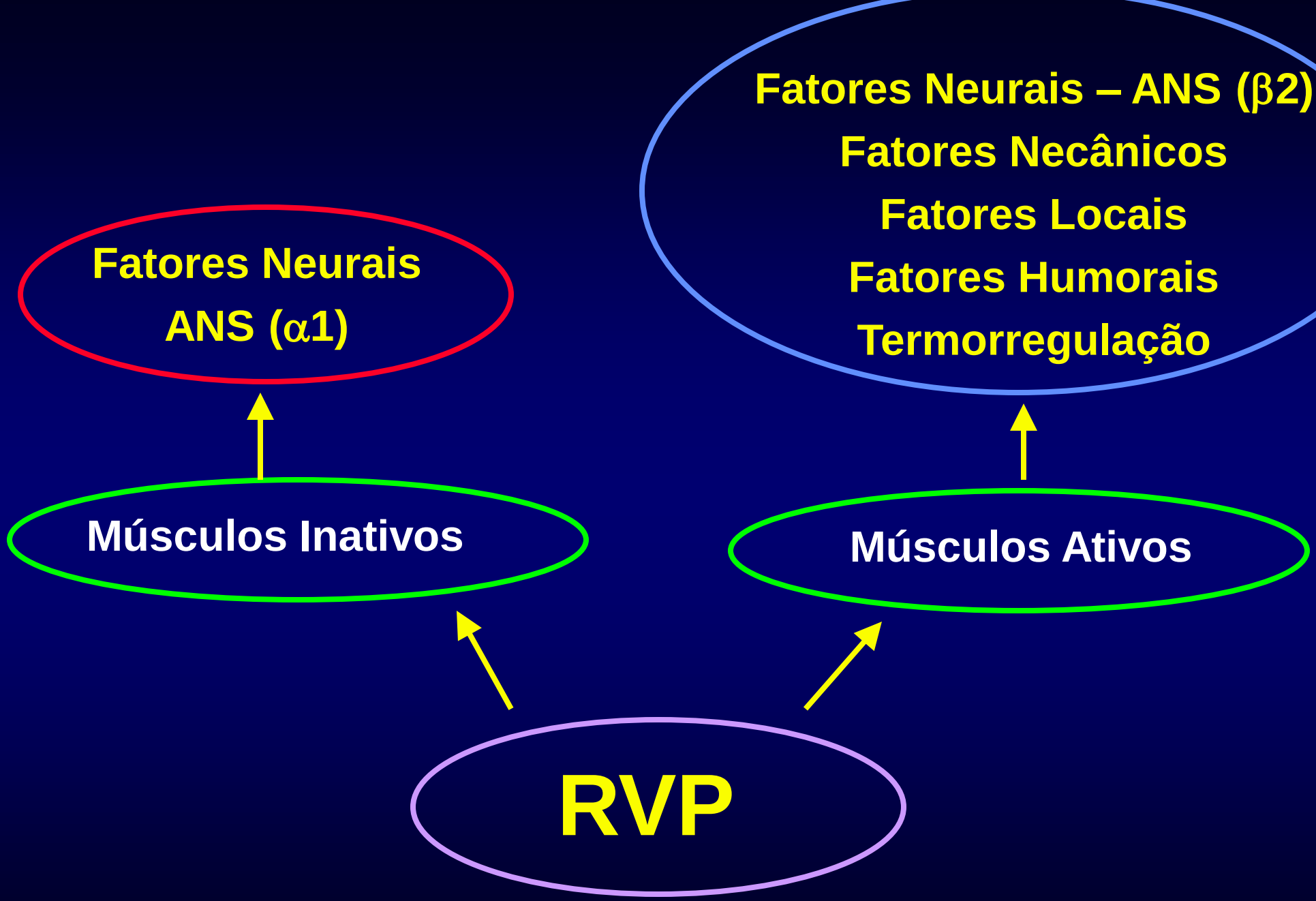


McArdle

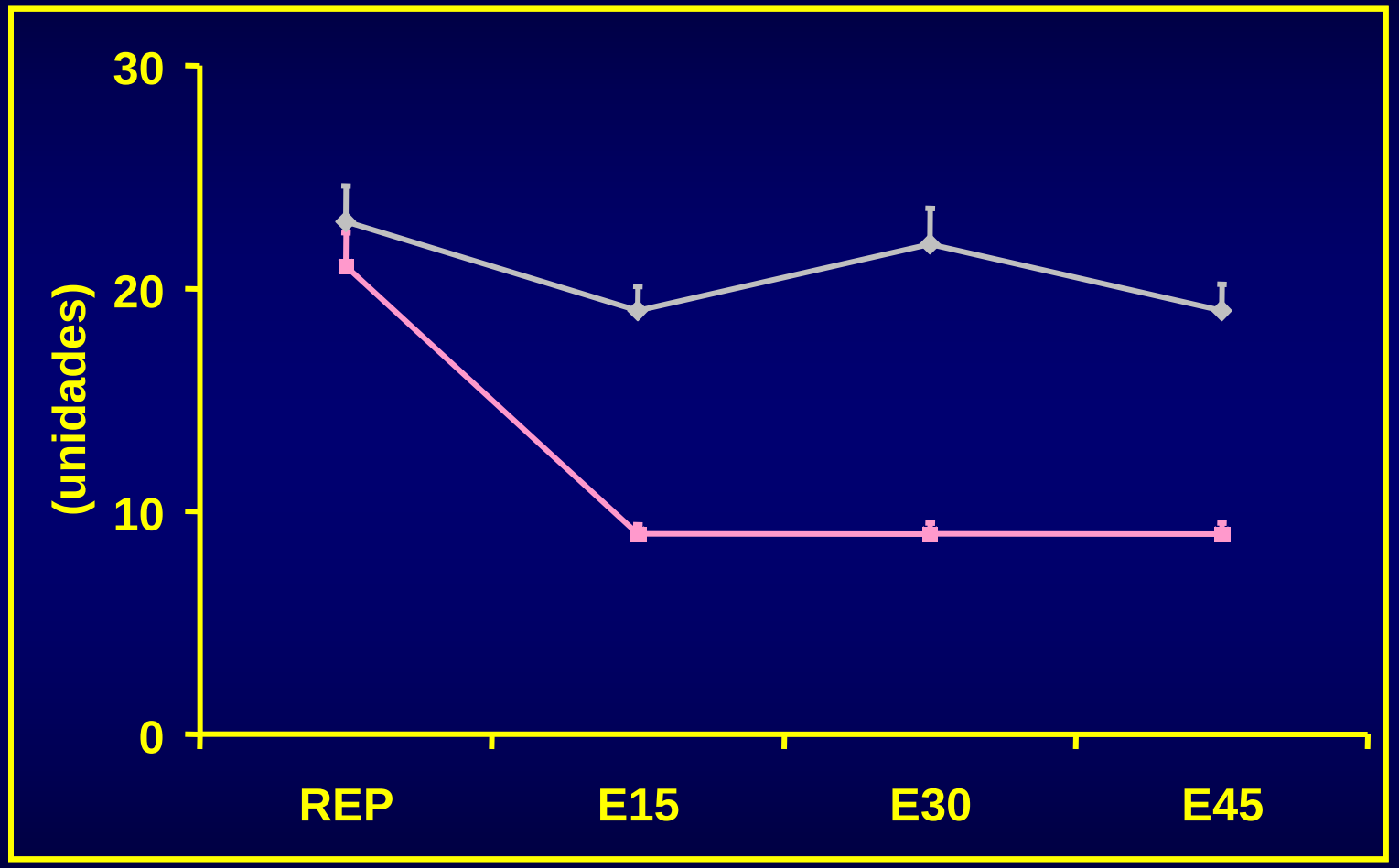


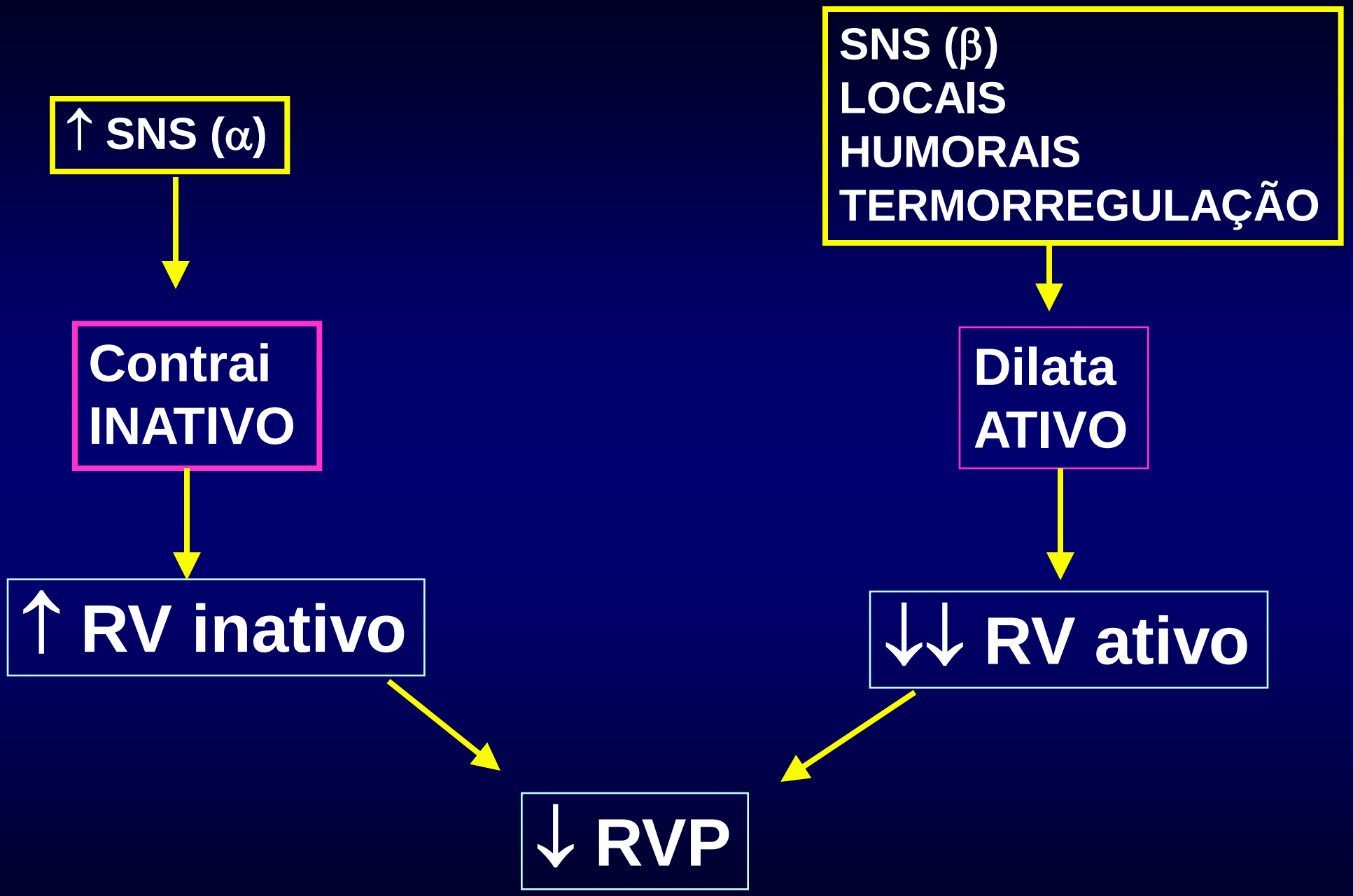
- **Fatores Mecânicos**
- **Fatores Químicos**
- **Fatores Neurais**

McArdle


Fatores Neurais – ANS (β2)
Fatores Necânicos
Fatores Locais
Fatores Humorais
Termorregulação
Fatores Neurais
ANS (α1)
Músculos Inativos
Músculos Ativos
RVP

RVP




↑ SNS (α)
SNS (β)
LOCAIS
HUMORAIS
TERMORREGULAÇÃO
Contrai
INATIVO
Dilata
ATIVO
↑ RV inativo
↓↓ RV ativo
↓ RVP

FLUXO SANGUÍNEO NO EXERCÍCIO

Mecânicos – Contração – esvazia veias para zona central
(Imediato) aumenta pressão de perfusão
- quando veia reespande
gera pressão negativa
- compressão de vasos
relaxamento miogênico
- aumento de fluxo – aumenta NO

Locais - Ions (K+ - dor)
Metabólitos (Adenosina)
Gases (CO_2)
Relaxantes do endotélio (NO)

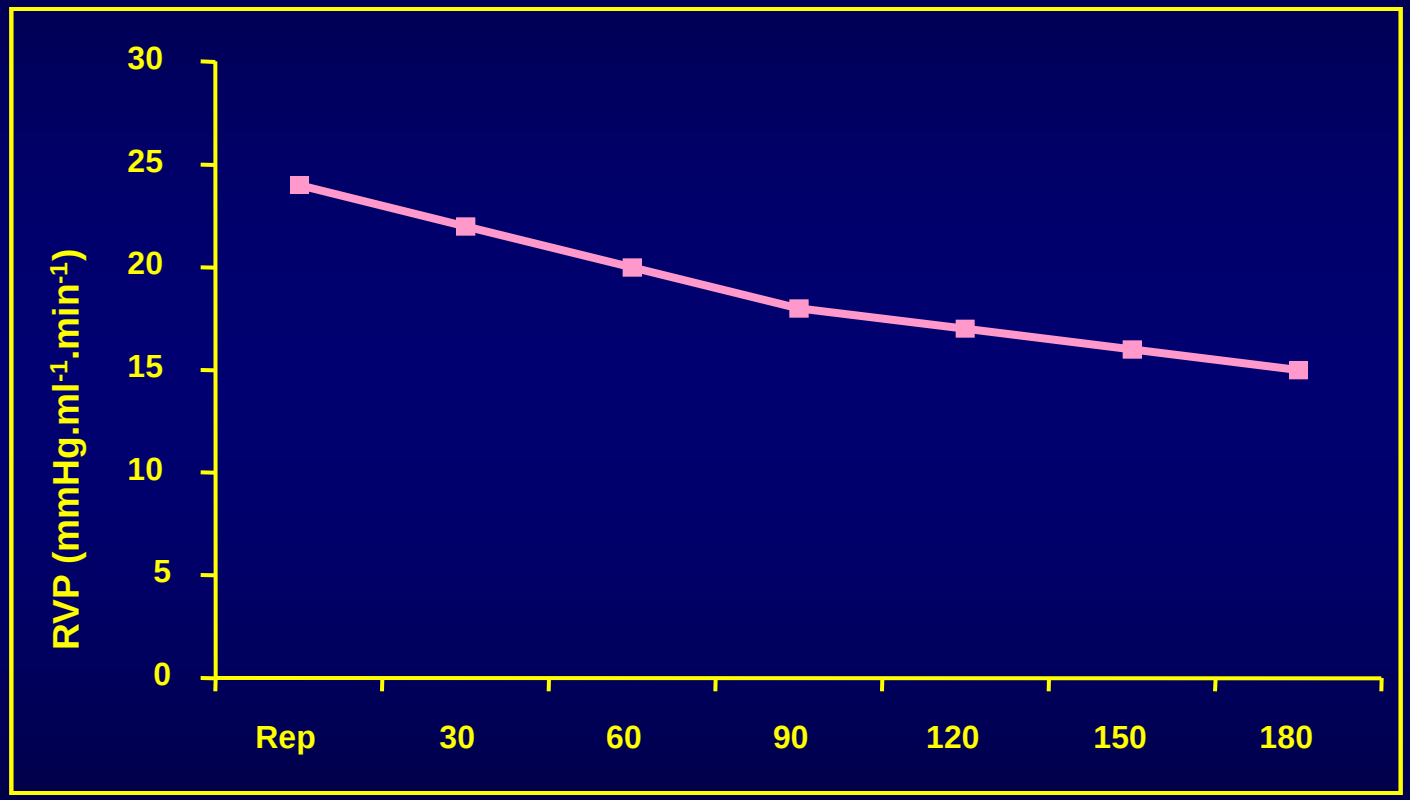
FLUXO SANGUÍNEO NO EXERCÍCIO

Circulantes – PaO2 - improvável
NO preso à hemoglobina junto ao O2

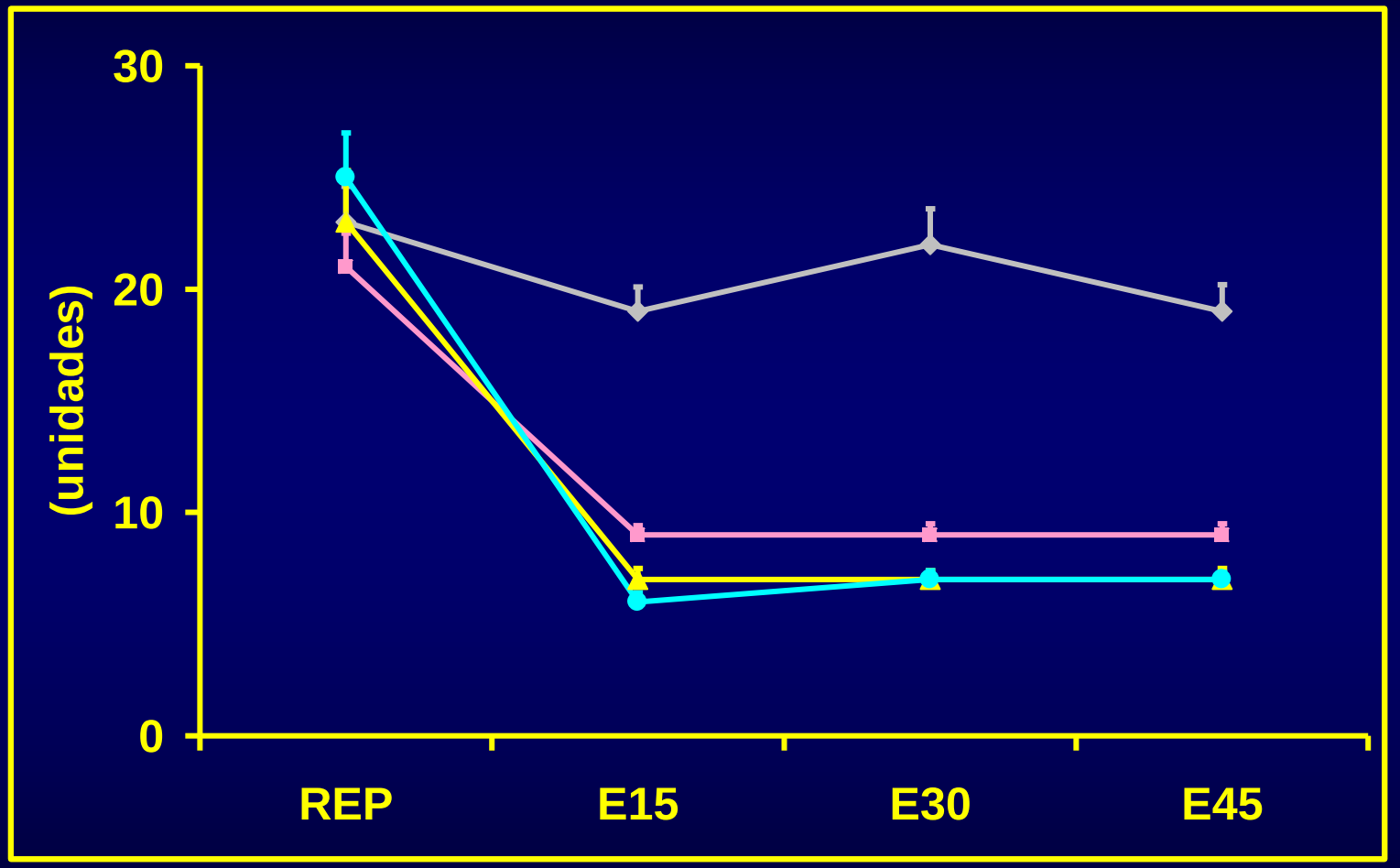
Neurais – Acetilcolina dos motoneurônios – via NO
Simpático Colinérgico – denerva fluxo igual
Simpático adrenérgico – beta – dilata
alfa - contrae

Hormonais – Adrenalina via receptor beta

RVP – Teste Ergométrico

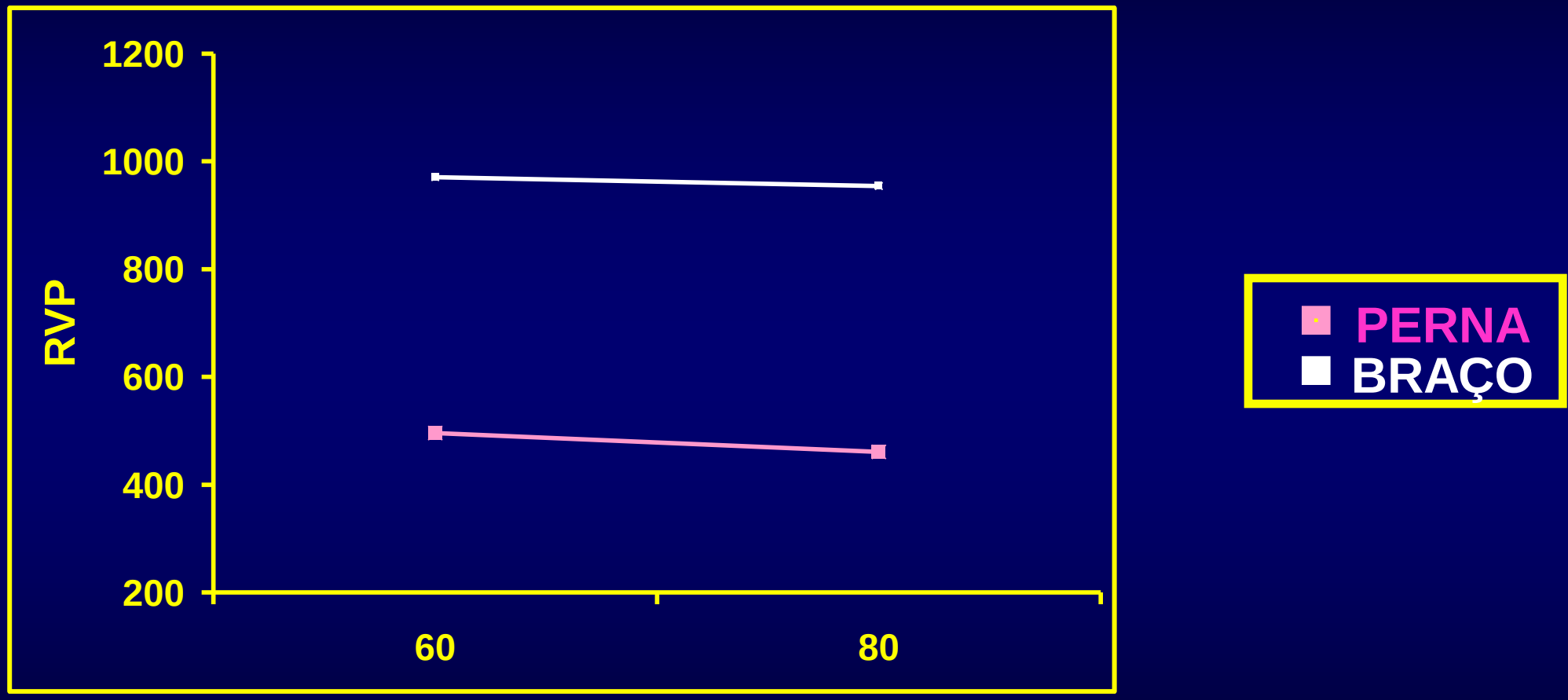


RVP



Controle 30%VO_2pico 50% VO_2pico 70%VO_2pico

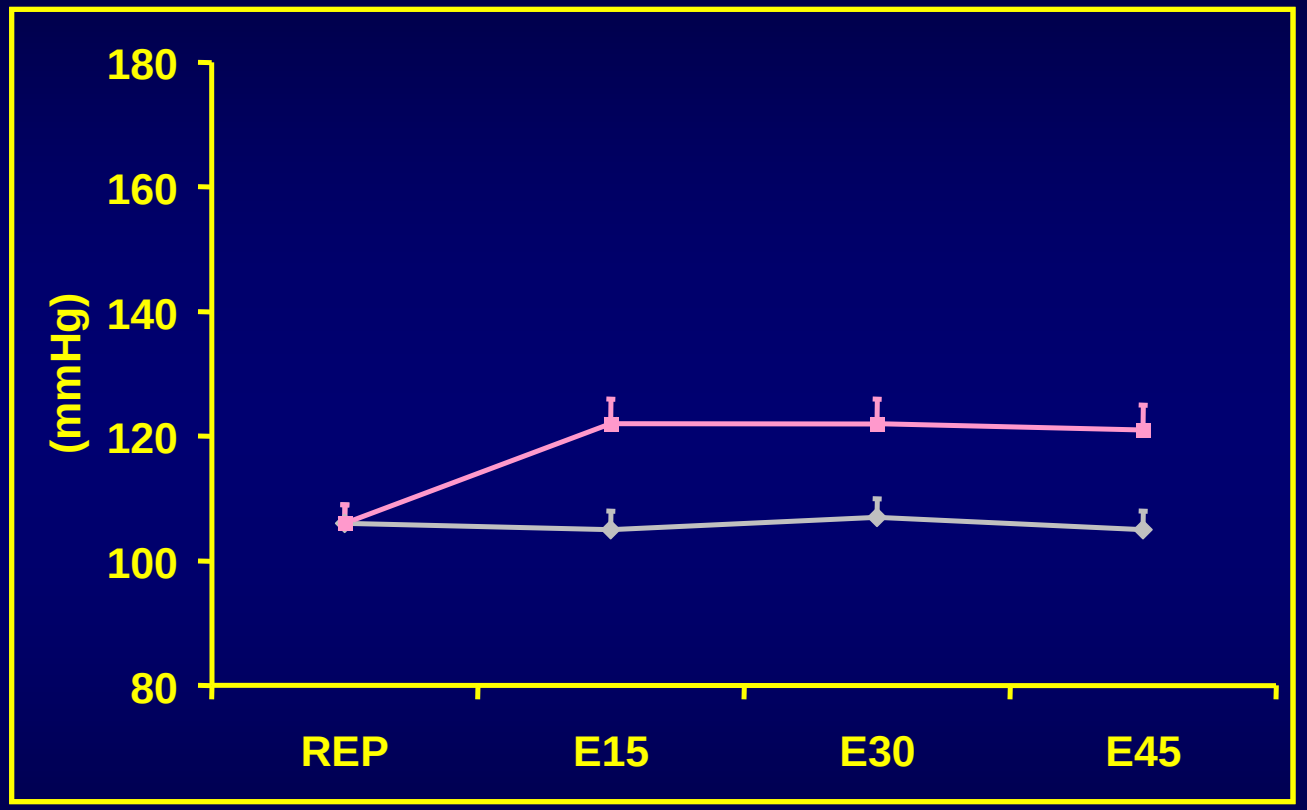
RVP – Massa Muscular



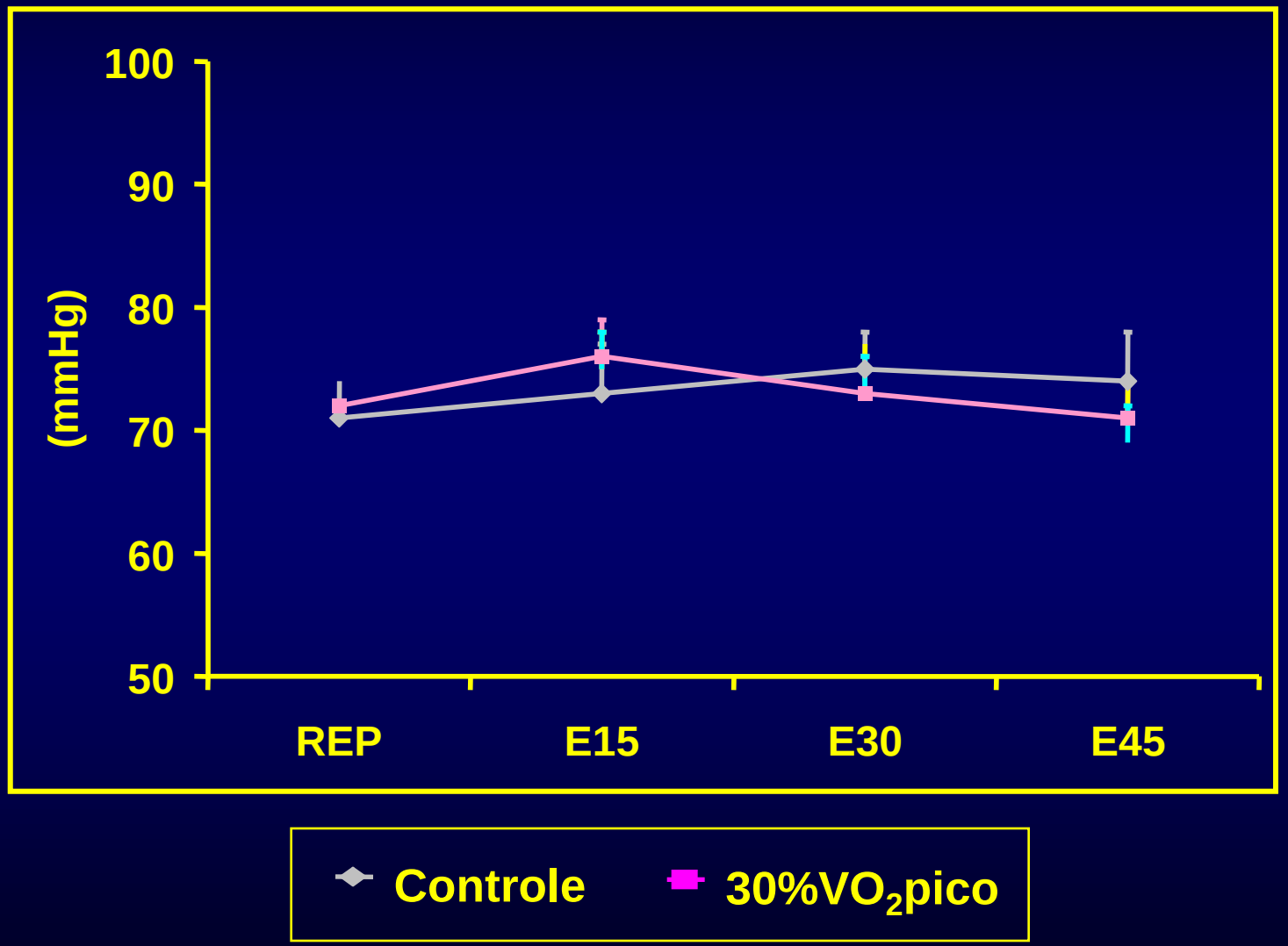
Adaptado de Bezucha et al. J. Appl. Physiol. 53:1589-93, 1982.

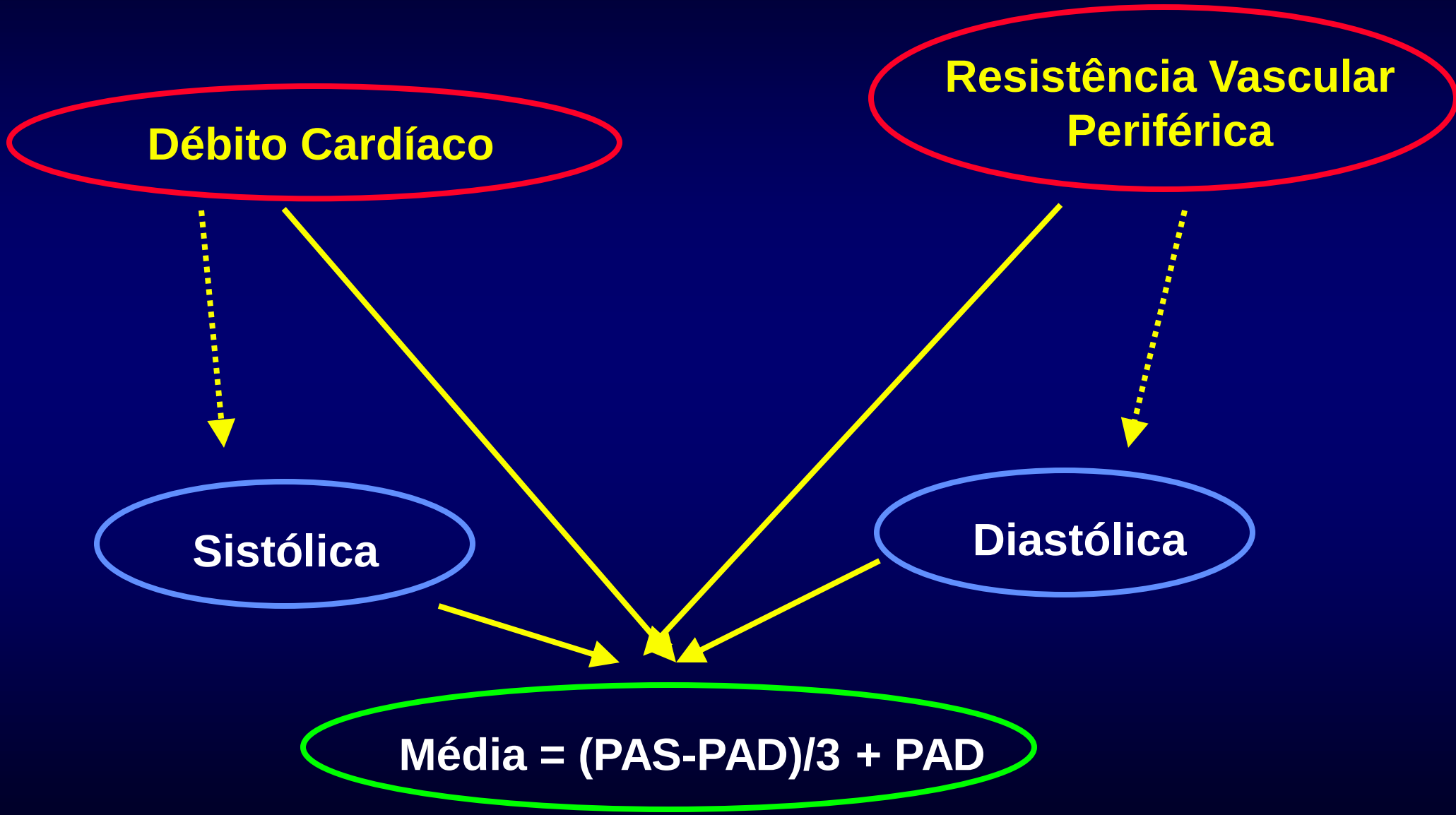
PRESSÃO ARTERIAL

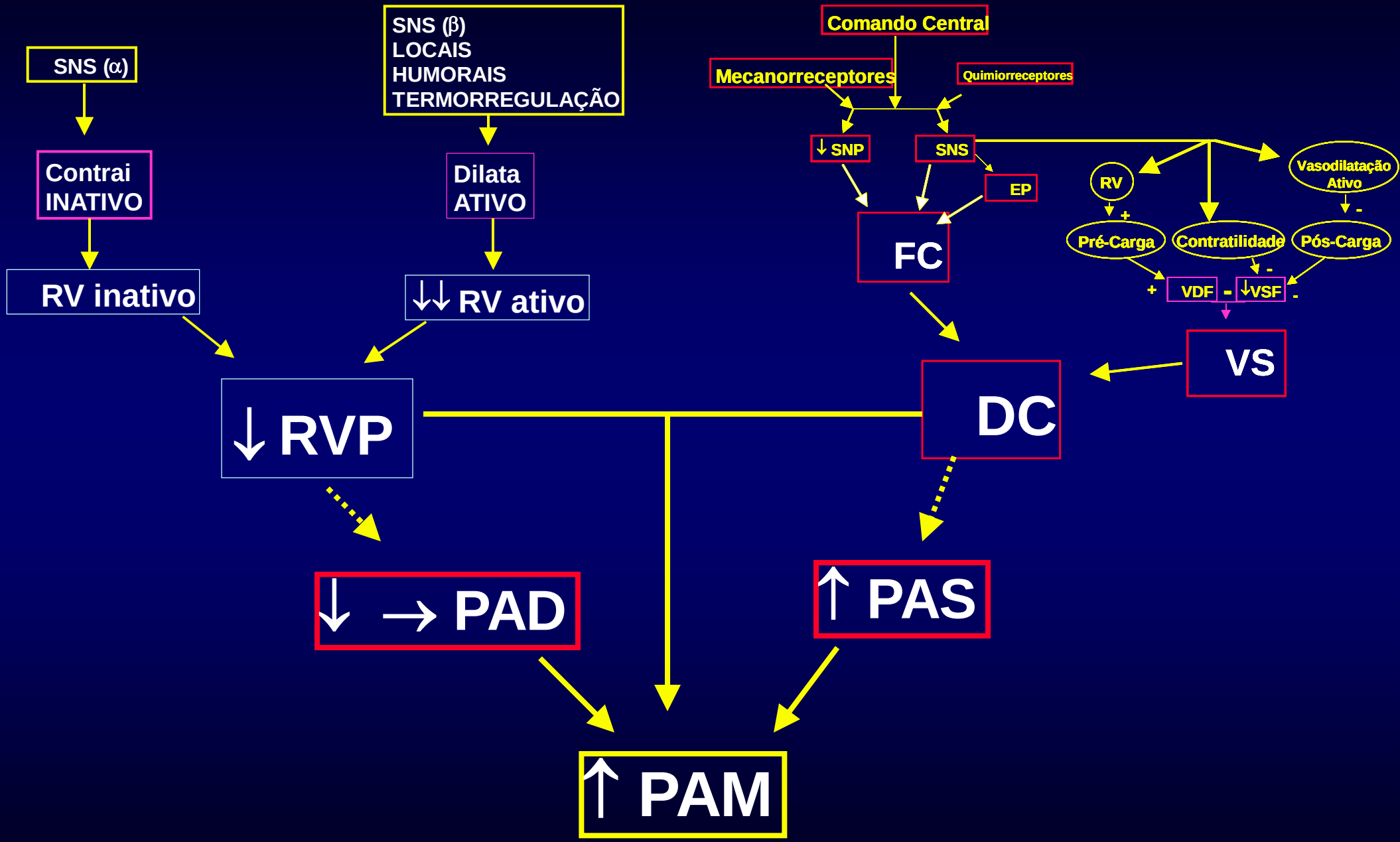
PAS


180
160
140
120
100
80
(mmHg)
REP
E15
E30
E45
Controle
30%VO2pico

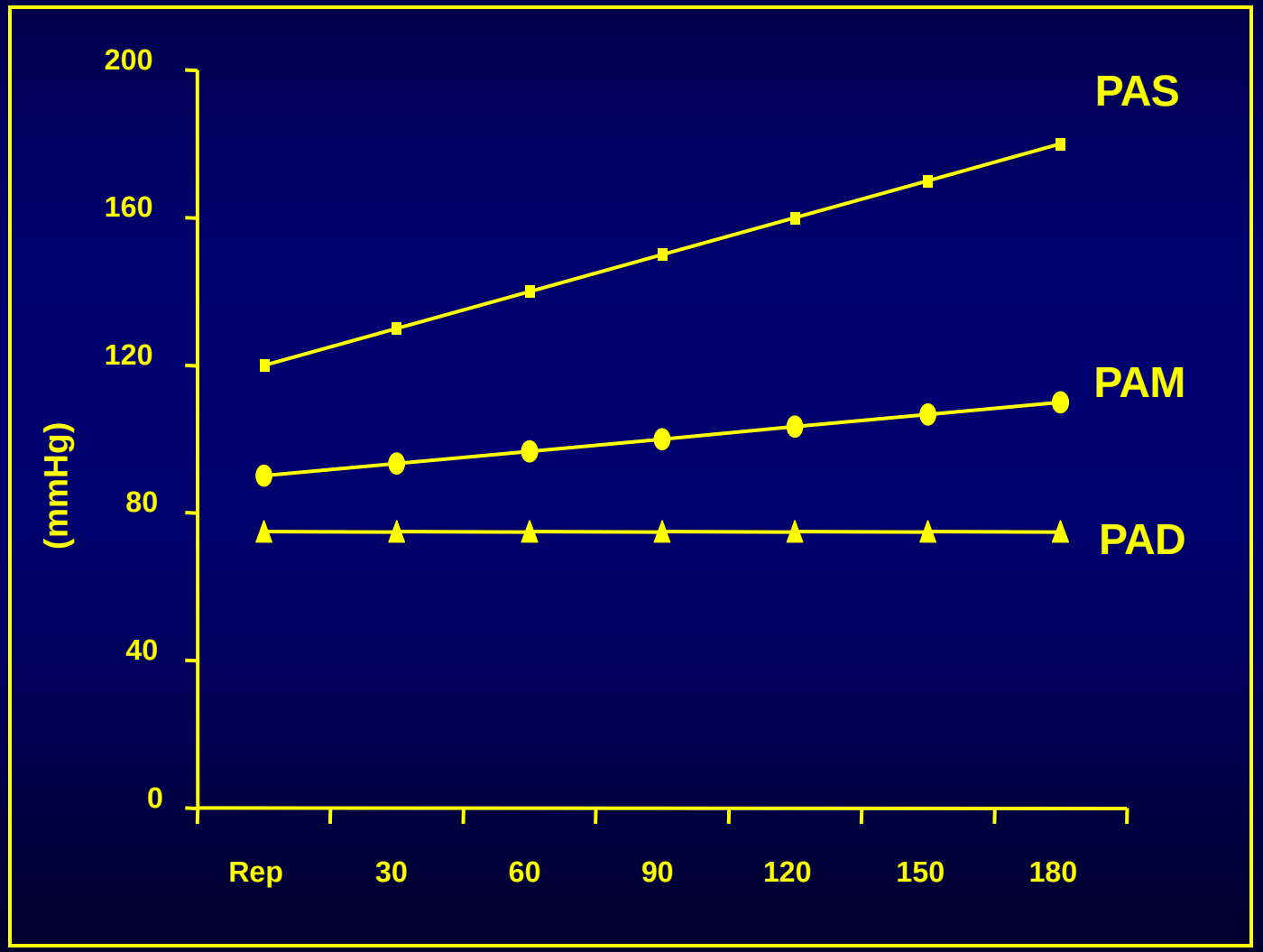
PAD




Débito Cardíaco
Resistência Vascular Periférica
Sistólica
Diastólica
Média = (PAS-PAD)/3 + PAD

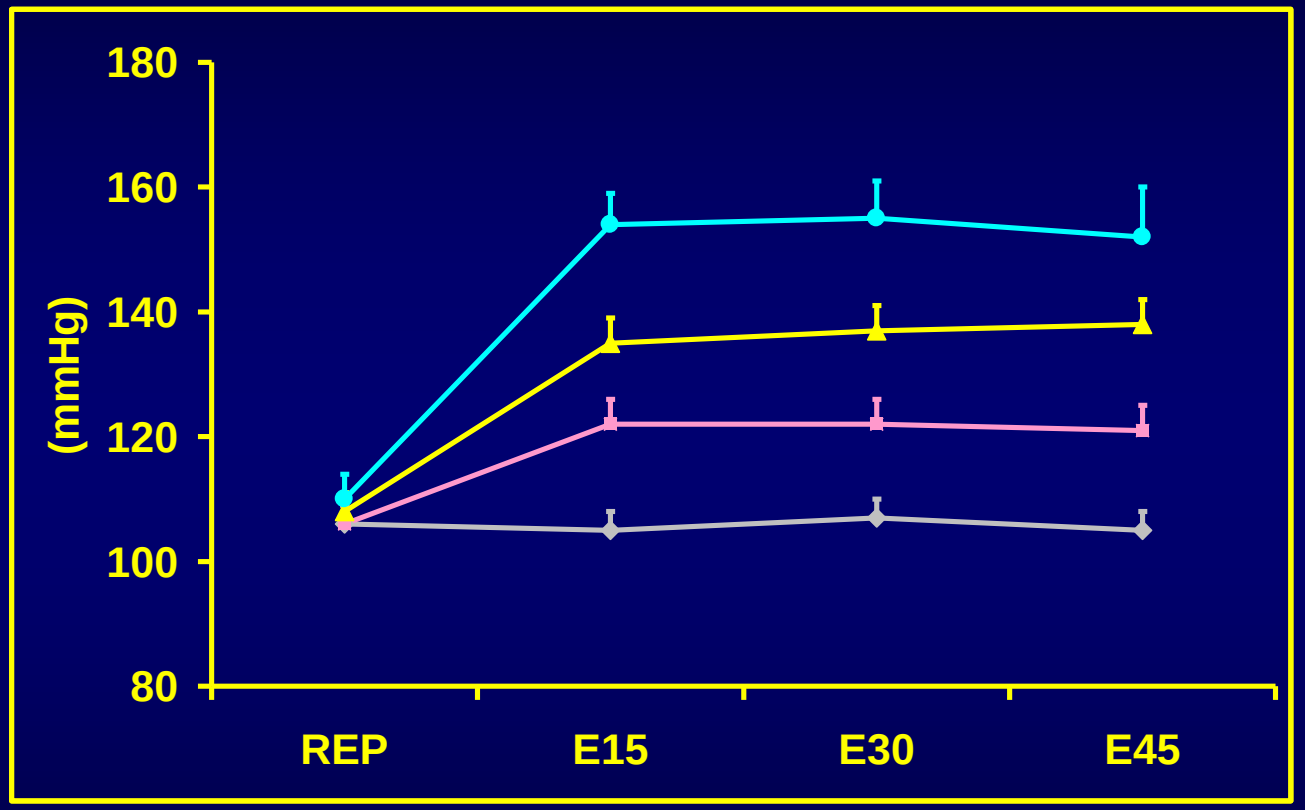

SNS (α)
Contrai
INATIVO
RV inativo
SNS (β)
LOCAIS
HUMORAIS
TERMORREGULAÇÃO
Dilata
ATIVO
↓↓ RV ativo
Comando Central
Mecanorreceptores
Quimiorreceptores
↓ SNP
SNS
EP
FC
RV
+
Pré-Carga
Contratilidade
-
Vasodilatação
Ativo
-
Pós-Carga
+
VDF
-
↓VSF
-
VS
↓ RVP
DC
↓ → PAD
↑ PAS
↑ PAM

RVP – Teste Ergométrico



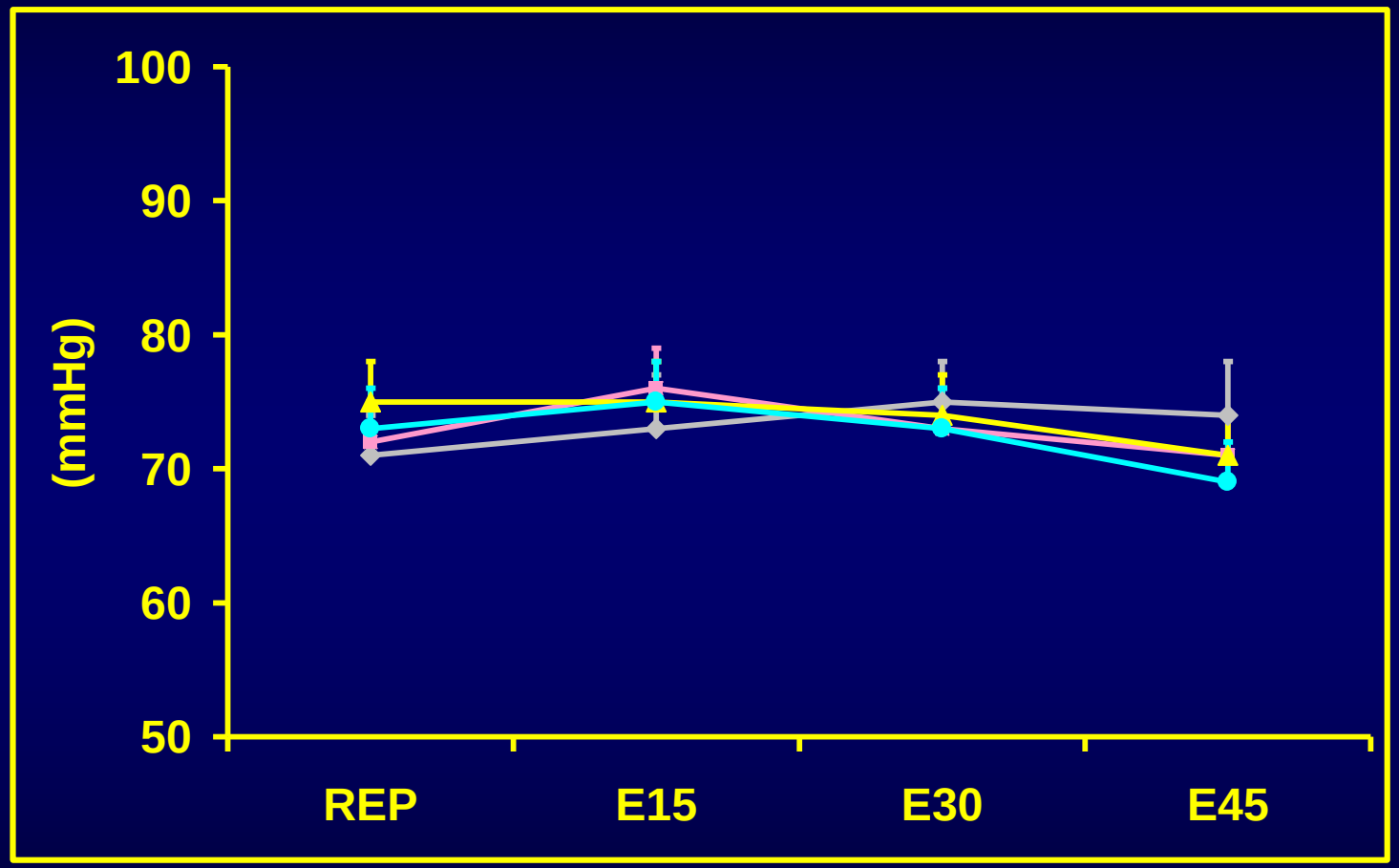
Normal
PAS ≤ 220 mmHg
PAD eleva até 15 mmHg

PAS



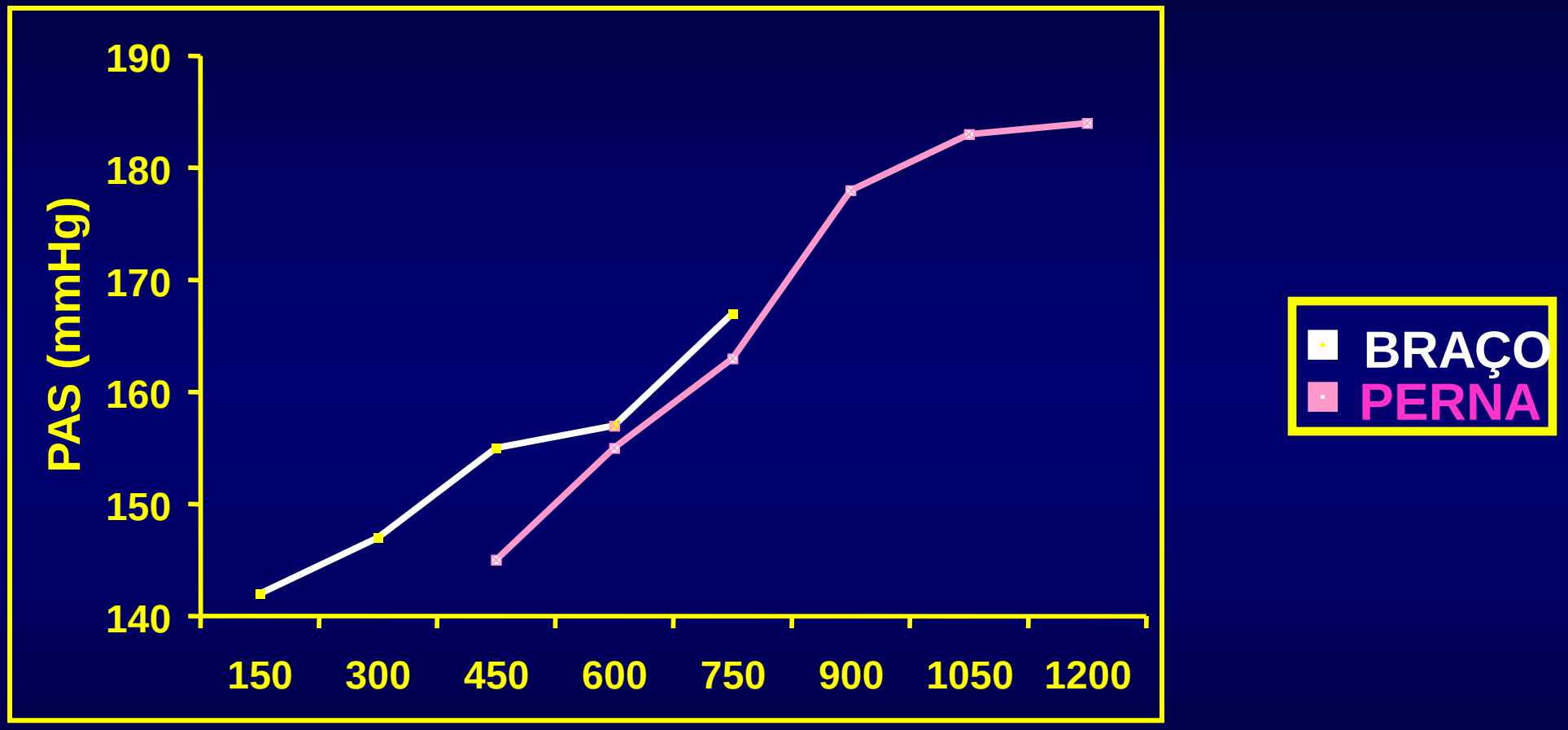
Controle 30%VO_2pico 50% VO_2pico 70%VO_2pico

PAD



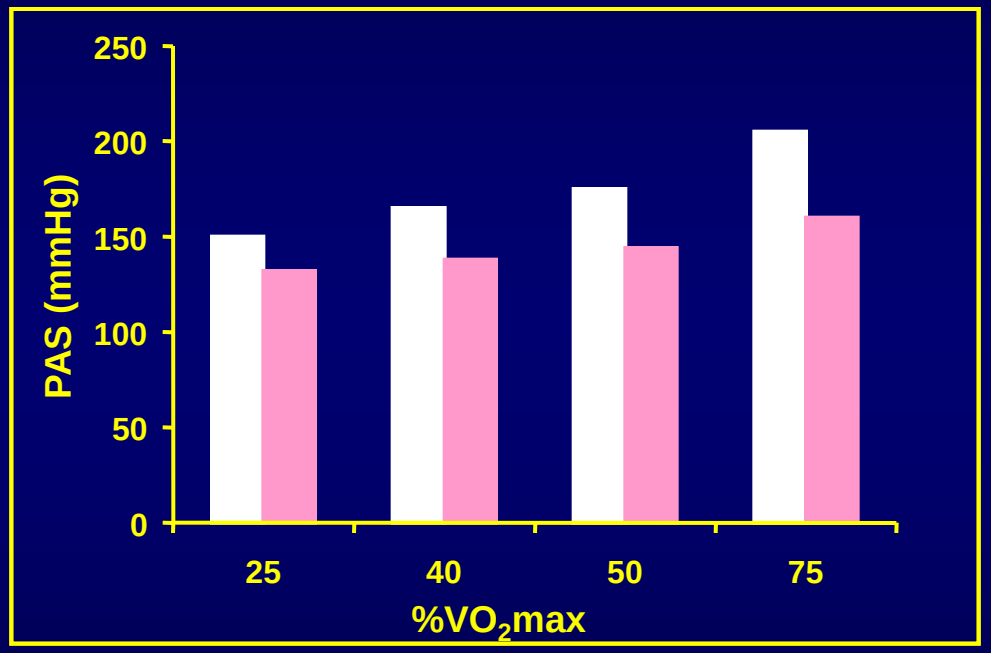
Controle 30%VO_2pico 50% VO_2pico 70%VO_2pico

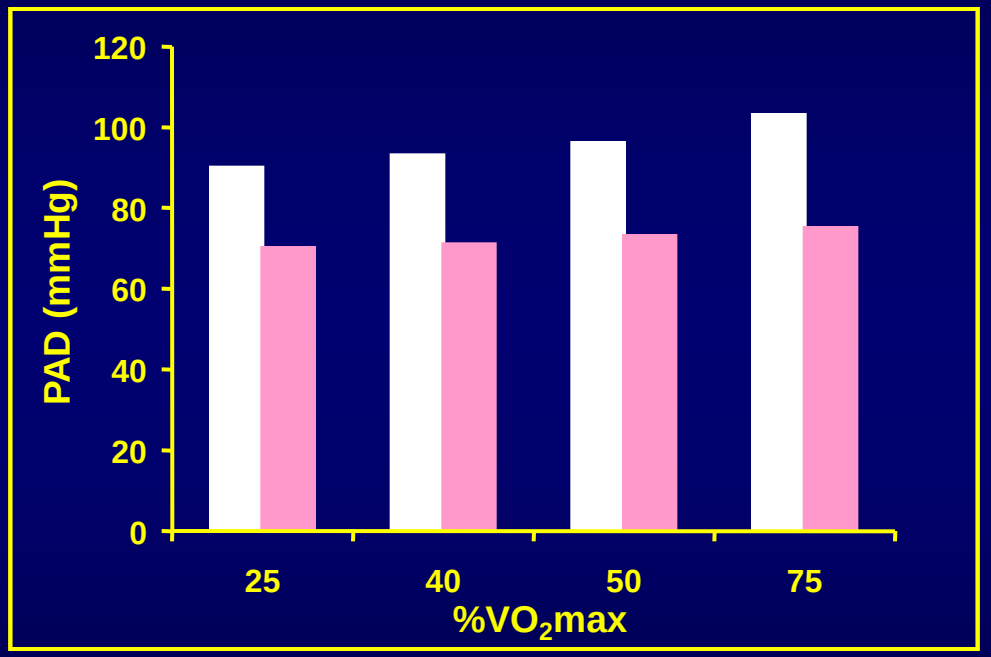
PA - MASSA MUSCULAR



Adaptado de DeBusk et al. Circulation 58: 368-75, 2000

PA - MASSA MUSCULAR





BRAÇO PERNA

Adaptado de McArdle et al. Exercise Physiology, 1996.

PA - MASSA MUSCULAR

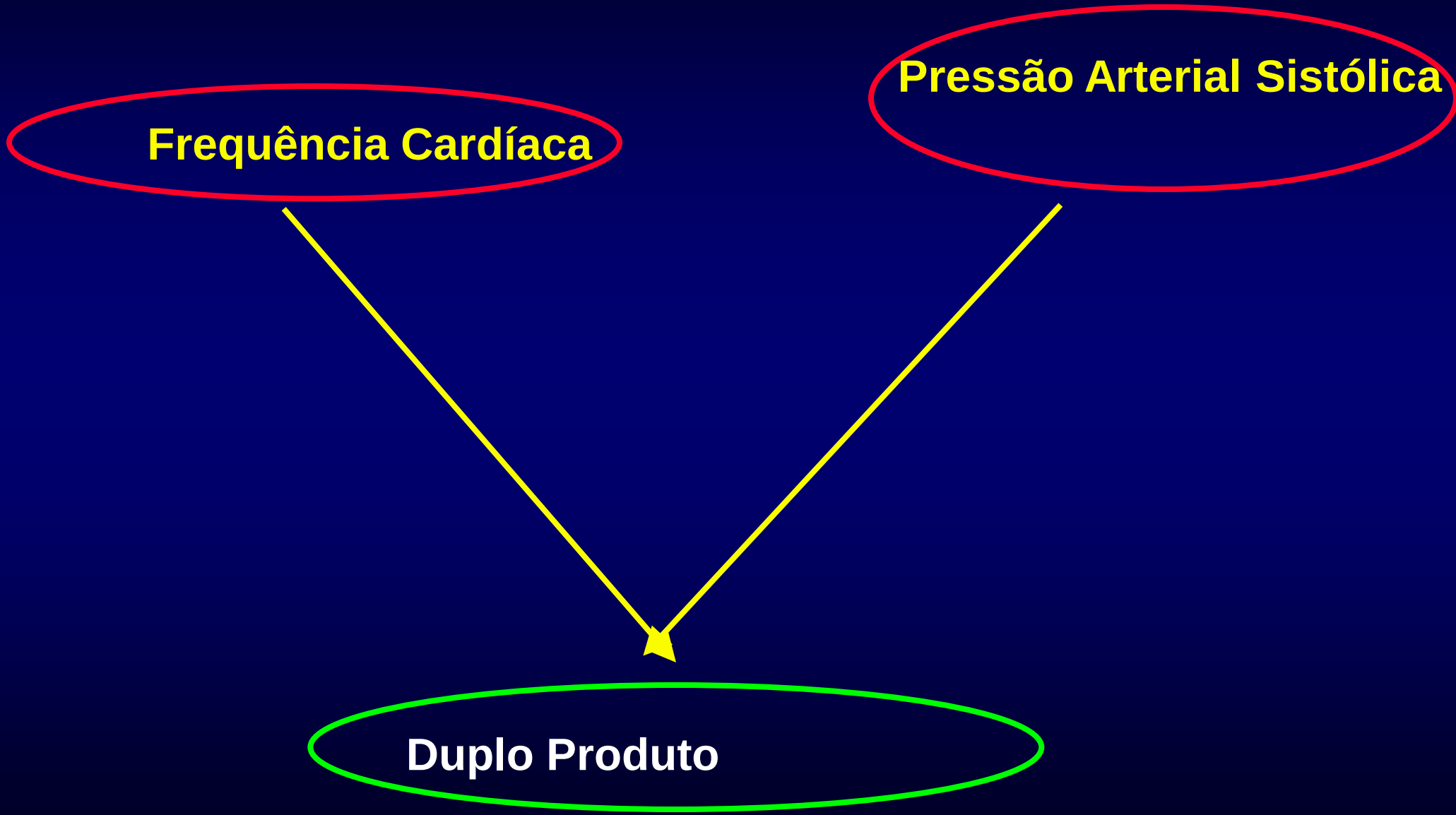
	VO_2	DC	FC	VS	RVP	PAM
Perna 58%VO_2max	1969	18,9	132	144	496	113
Braço 66%VO_2max	911	9,8	112	88	971	115
Perna 82%VO_2max	2758	21,9	164	131	461	124
Braço 79%VO_2max	1084	10,8	130	85	954	127

Adaptado de Bezucha et al. J. Appl. Physiol. 53:1589-93, 1982.

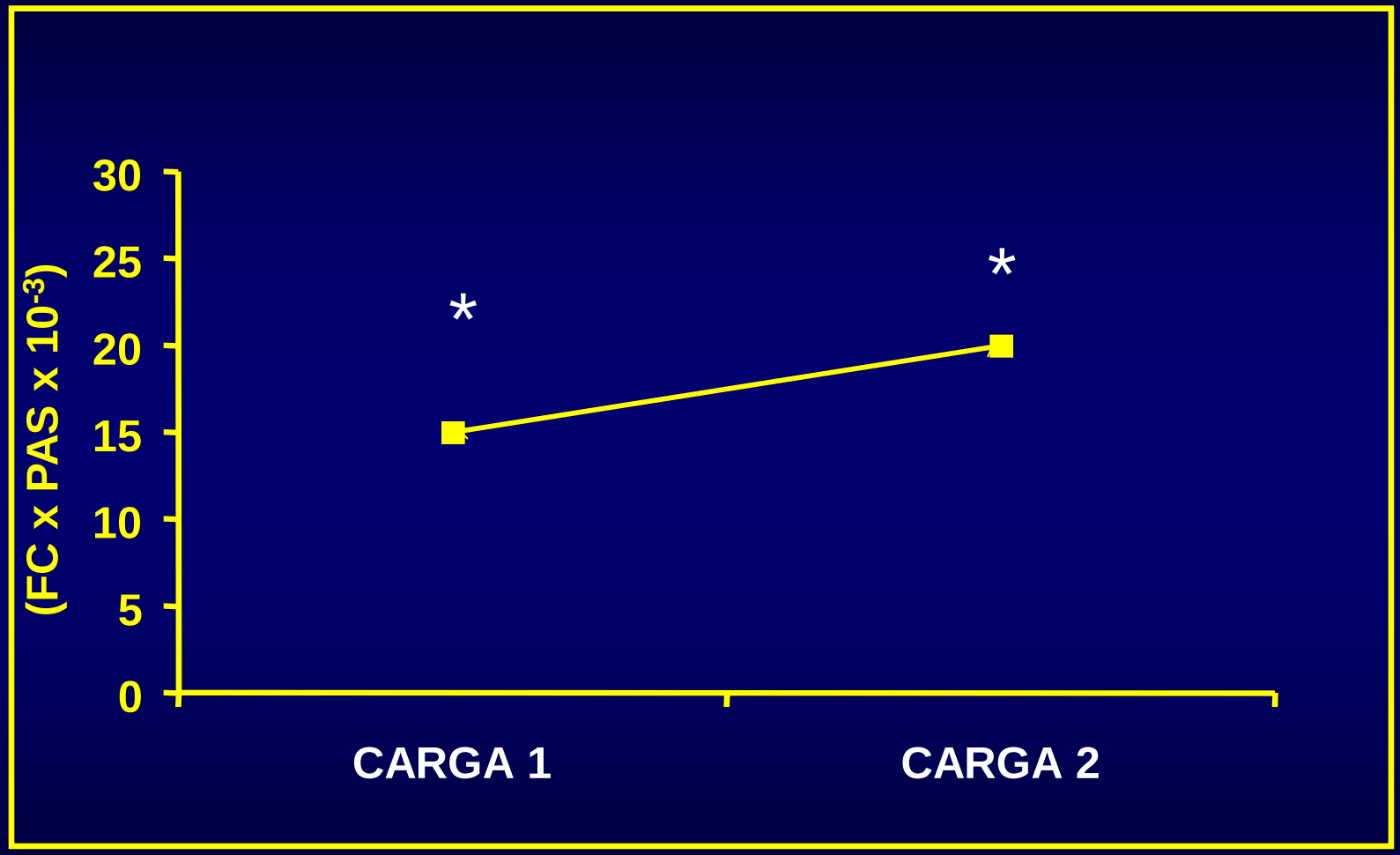
MEDIDA DA PRESSÃO ARTERIAL NO EXERCÍCIO DINÂMICO

- **PAS Válida**
- **PAD válida para clínica**
  não válida para pesquisa

DUPLO PRODUTO

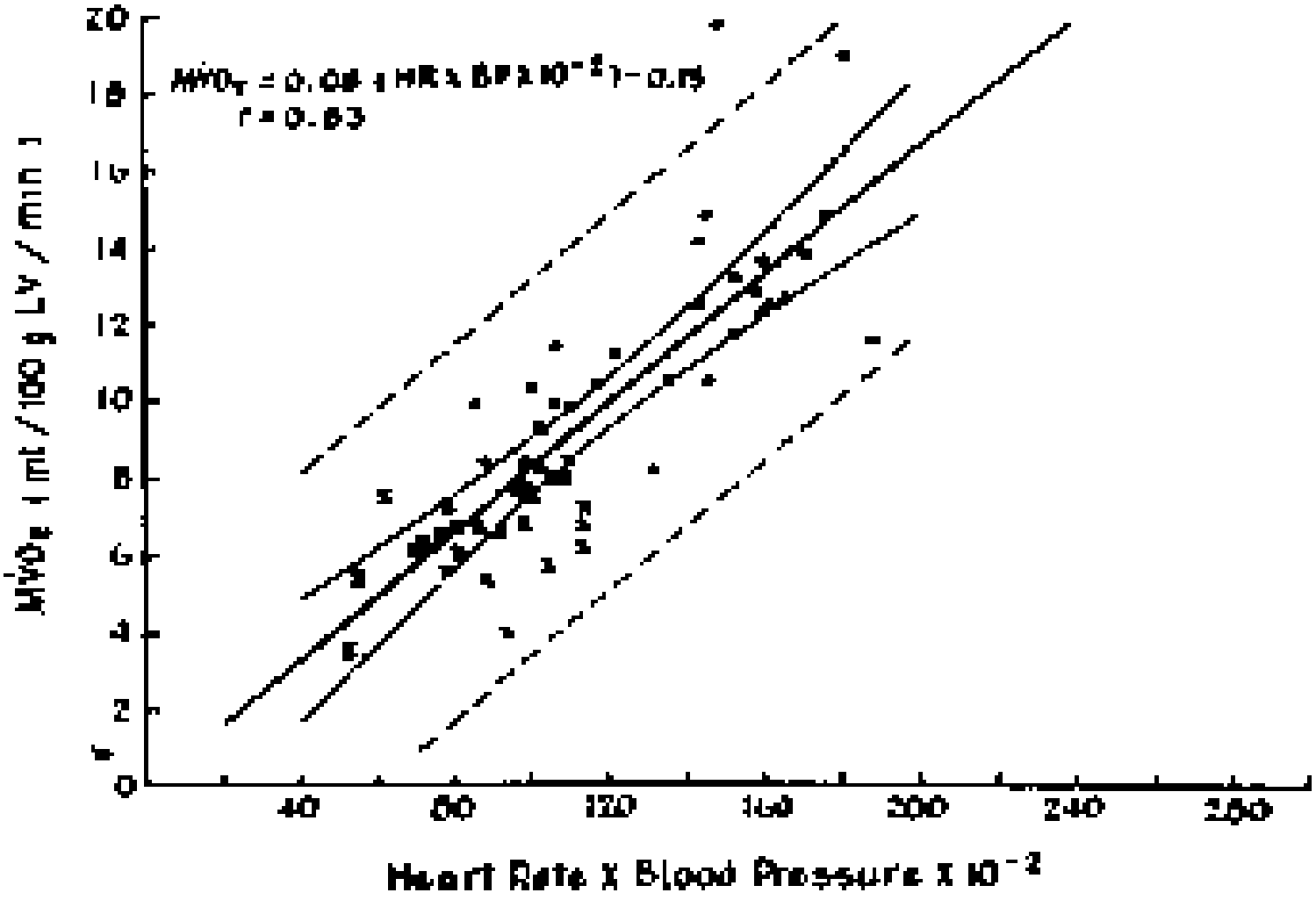

Frequência Cardíaca
Pressão Arterial Sistólica
Duplo Produto

DUPLO PRODUTO

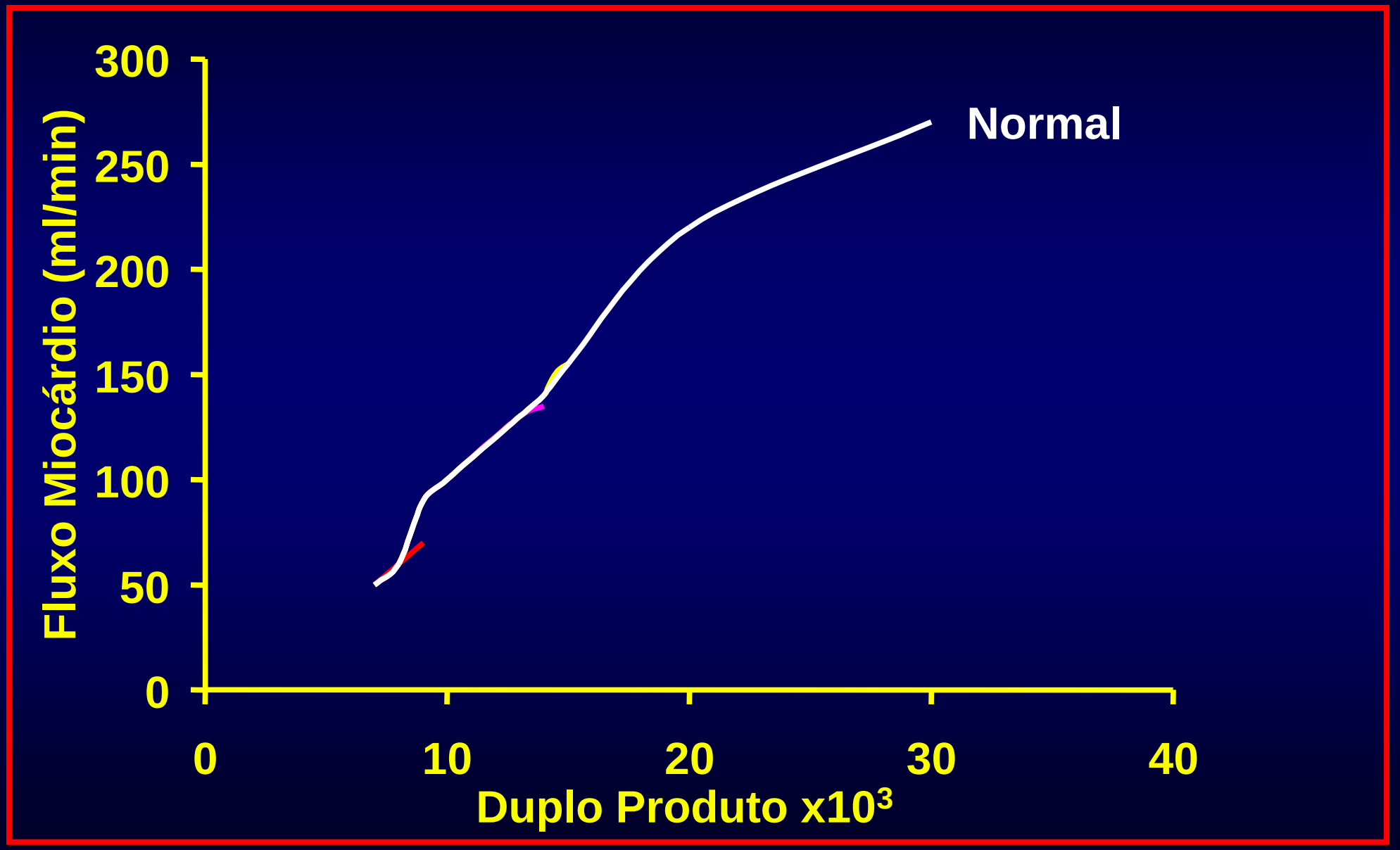


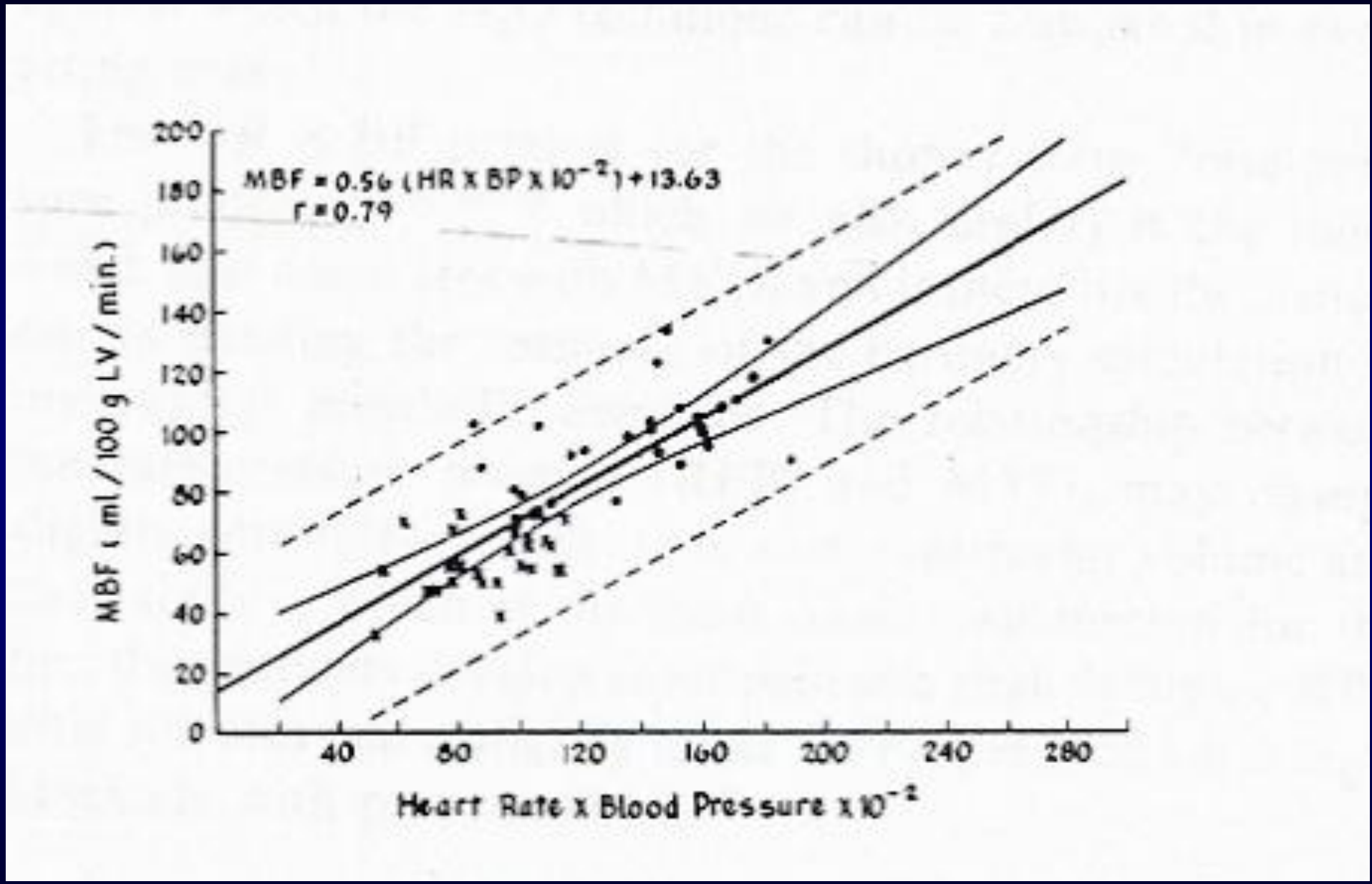
Pré

Ehsani et al. Circulation 64:1116-1124,1981



Gobel et al. Circulation 57:549-56, 1978.


Fluxo Miocárdio (ml/min)
300
250
200
150
100
50
0
Normal
0
10
20
30
40
Duplo Produto x10³



Gobel et al. Circulation 57:549-56, 1978.