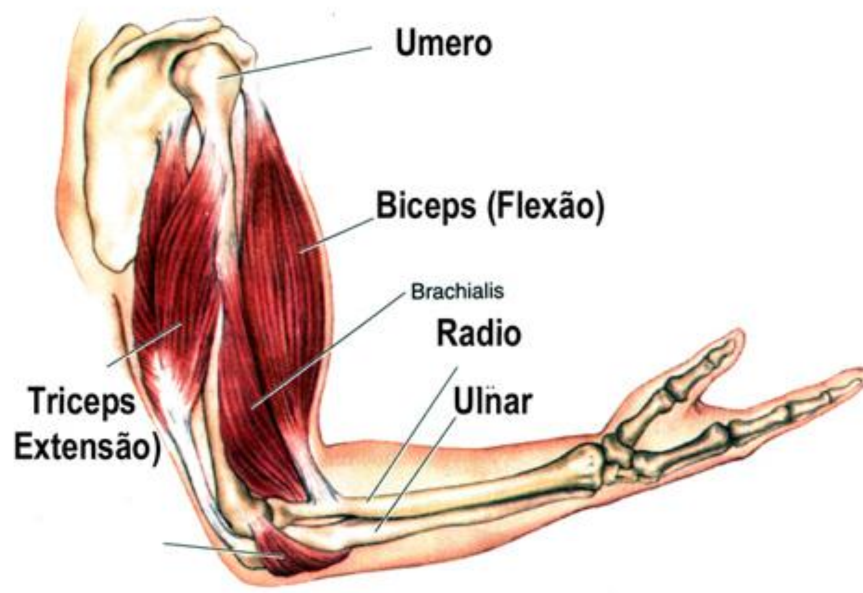
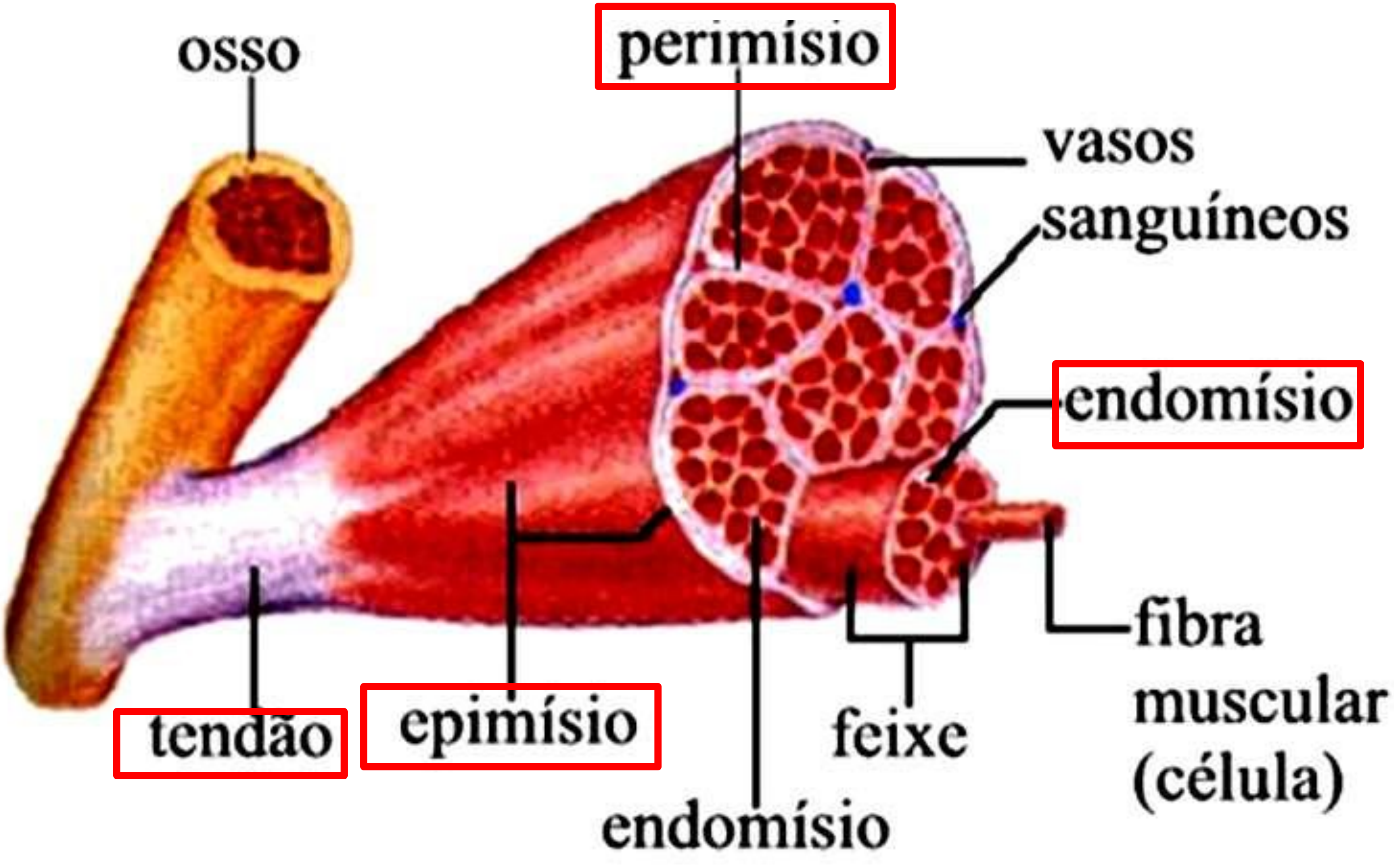
Estrutura muscular

MÚSCULO ESQUELÉTICO

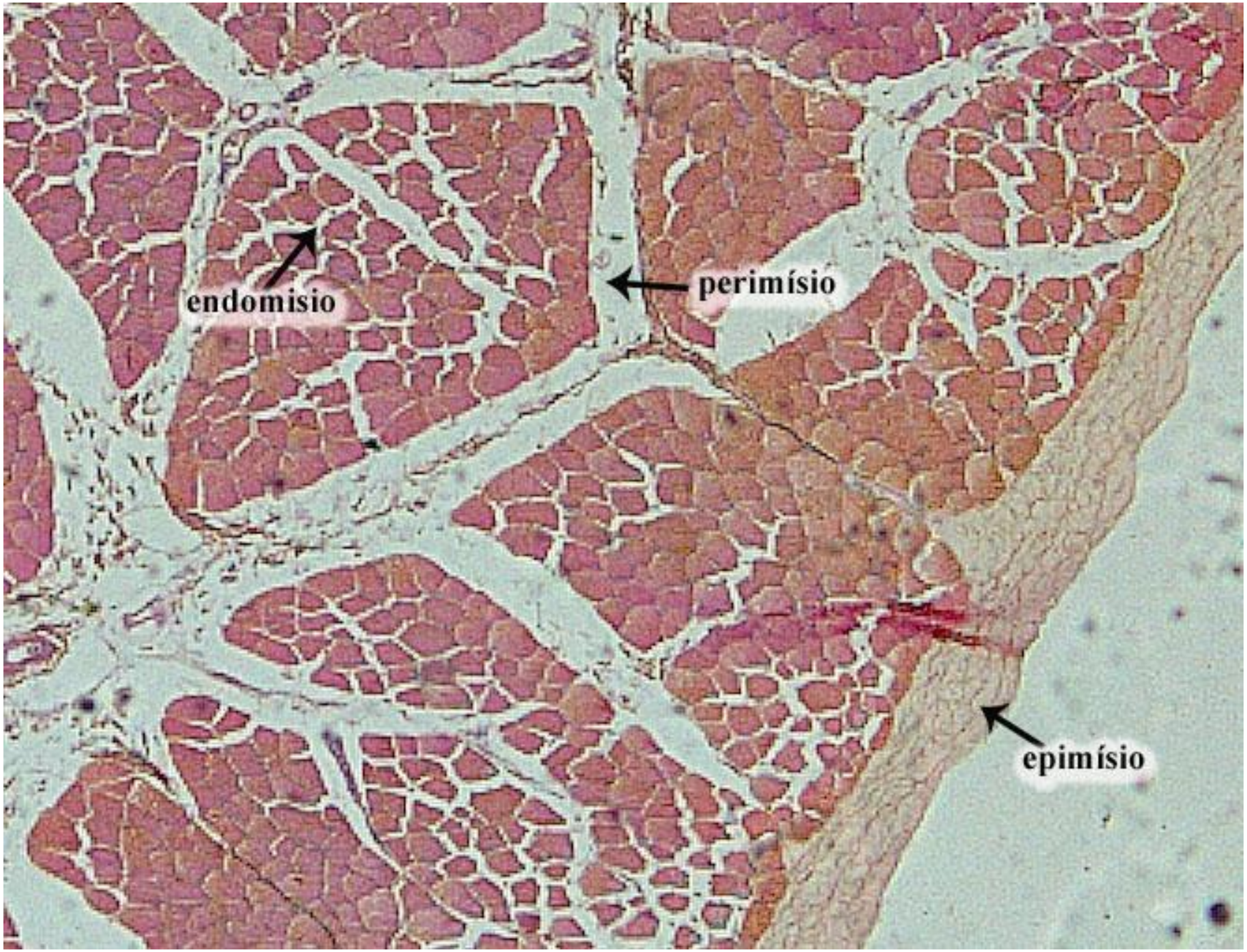
- Controle voluntário – (mais de 400 músculos) 40-50% peso corporal
- 3 Funções
  - Geração de força para locomoção e respiração
  - Geração de força para sustentação
  - Produção de calor



Macroestruturas



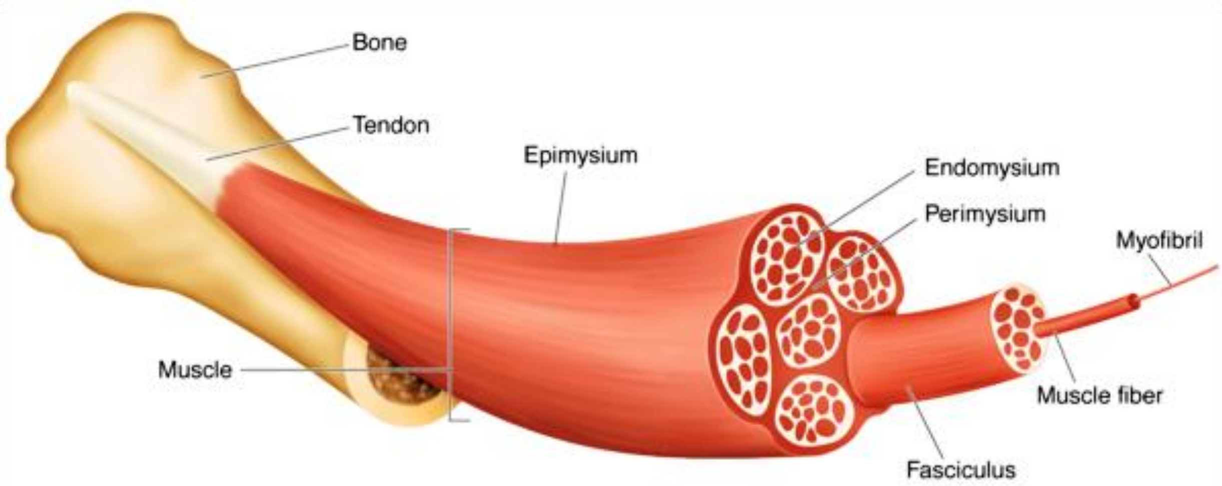
Macroestruturas

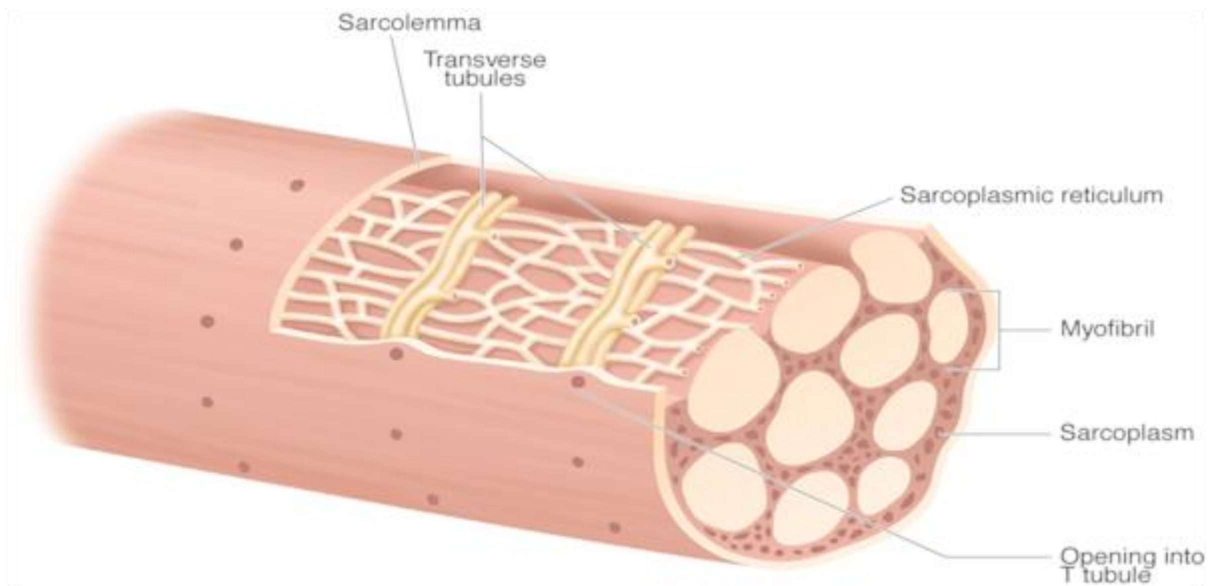


Macroestruturas

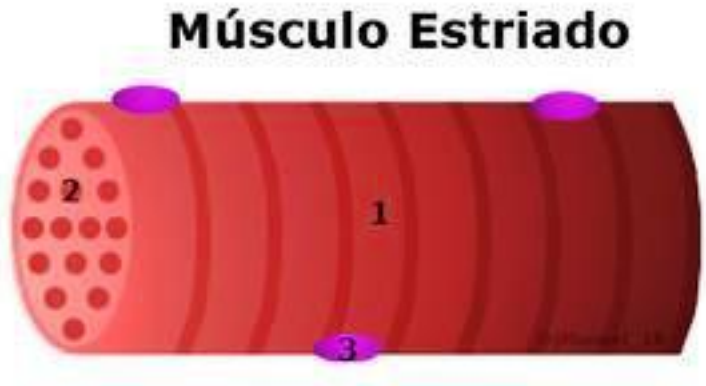
- **Tecido conjuntivo** mantém as fibras musculares unidas, além de:
- ✓ permitir que a força de contração, gerada por cada fibra, atue sobre o músculo inteiro;
- ✓ permitir que a força de contração do músculo seja transmitida a outras estruturas, tendões e ossos.
- ✓ permitir que vasos sanguíneos penetrem no músculo entre as fibras.
- ✓ possuir vasos linfáticos e nervos.

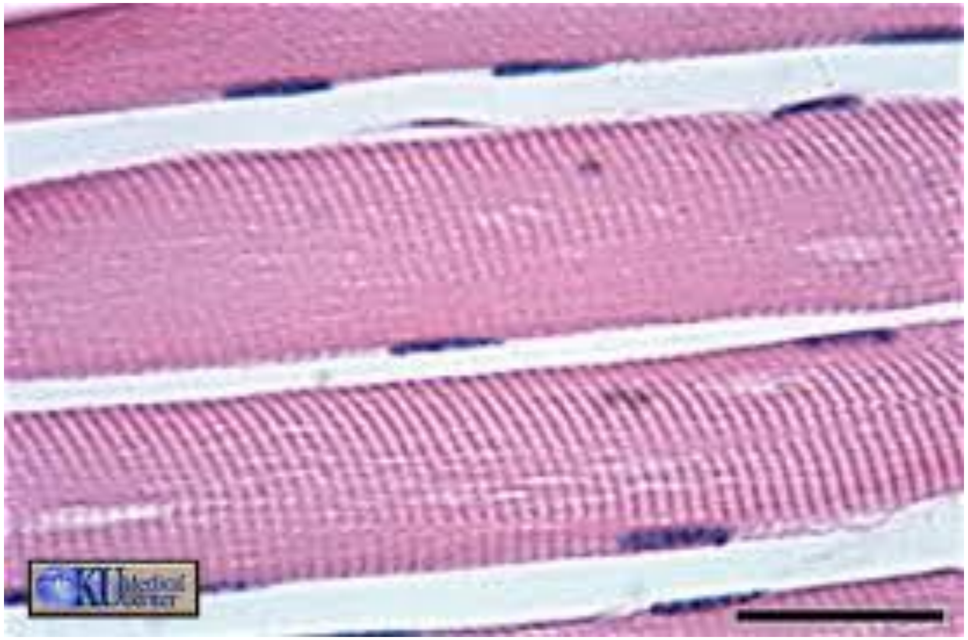
Fibra Muscular



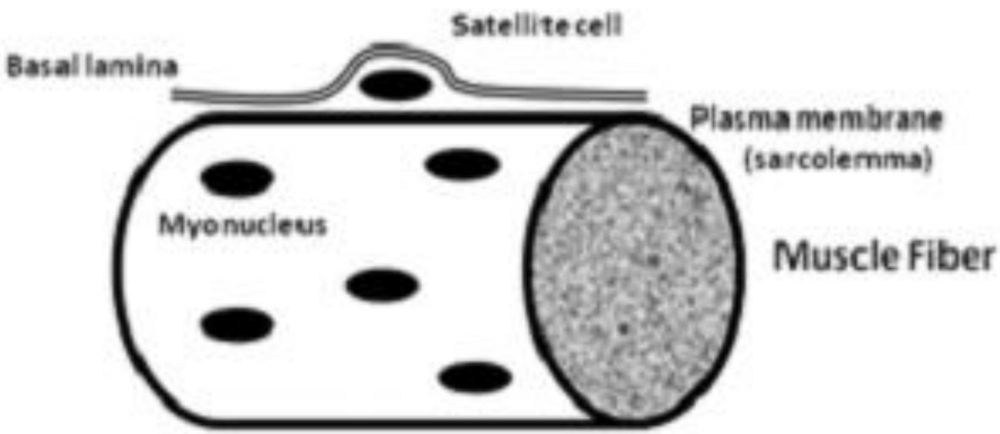


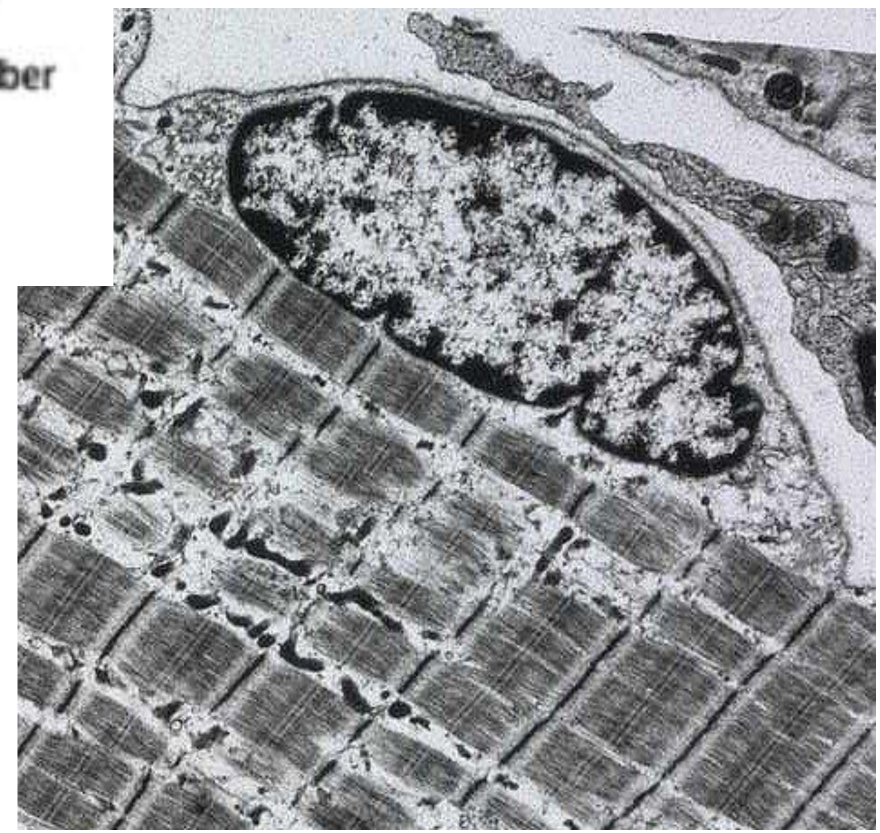
Multinuclear





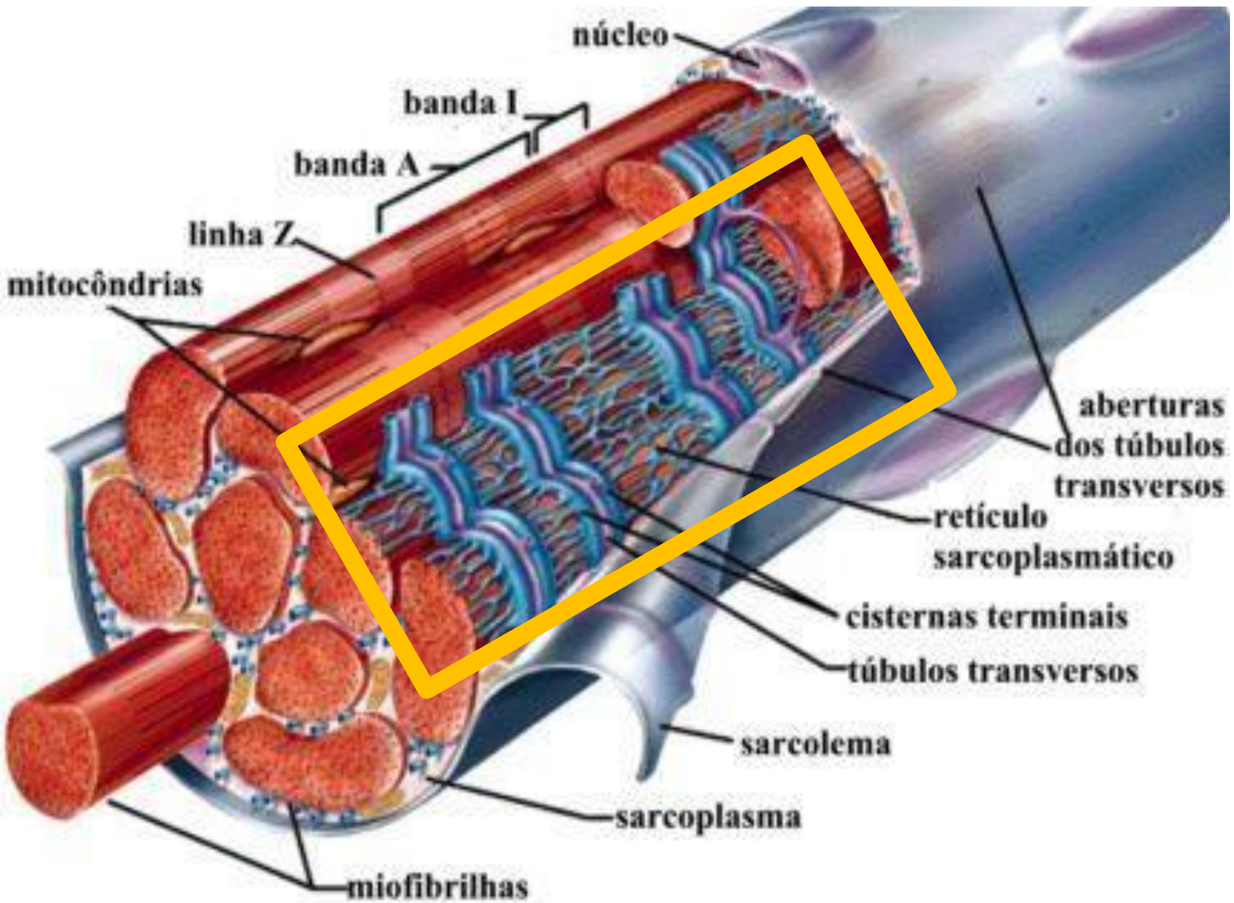
Células satélites

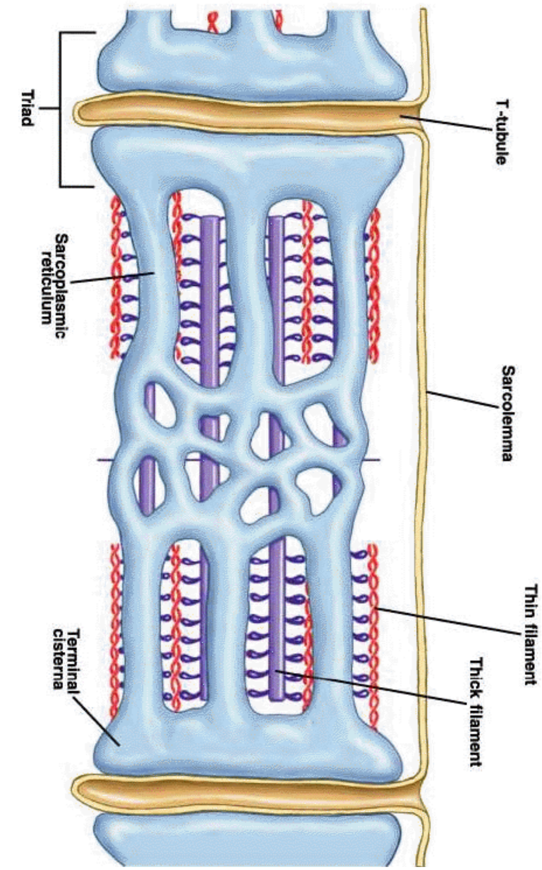




Retículo sarcoplasmático

- Armazena e regula o fluxo de íons Ca^{+2}.



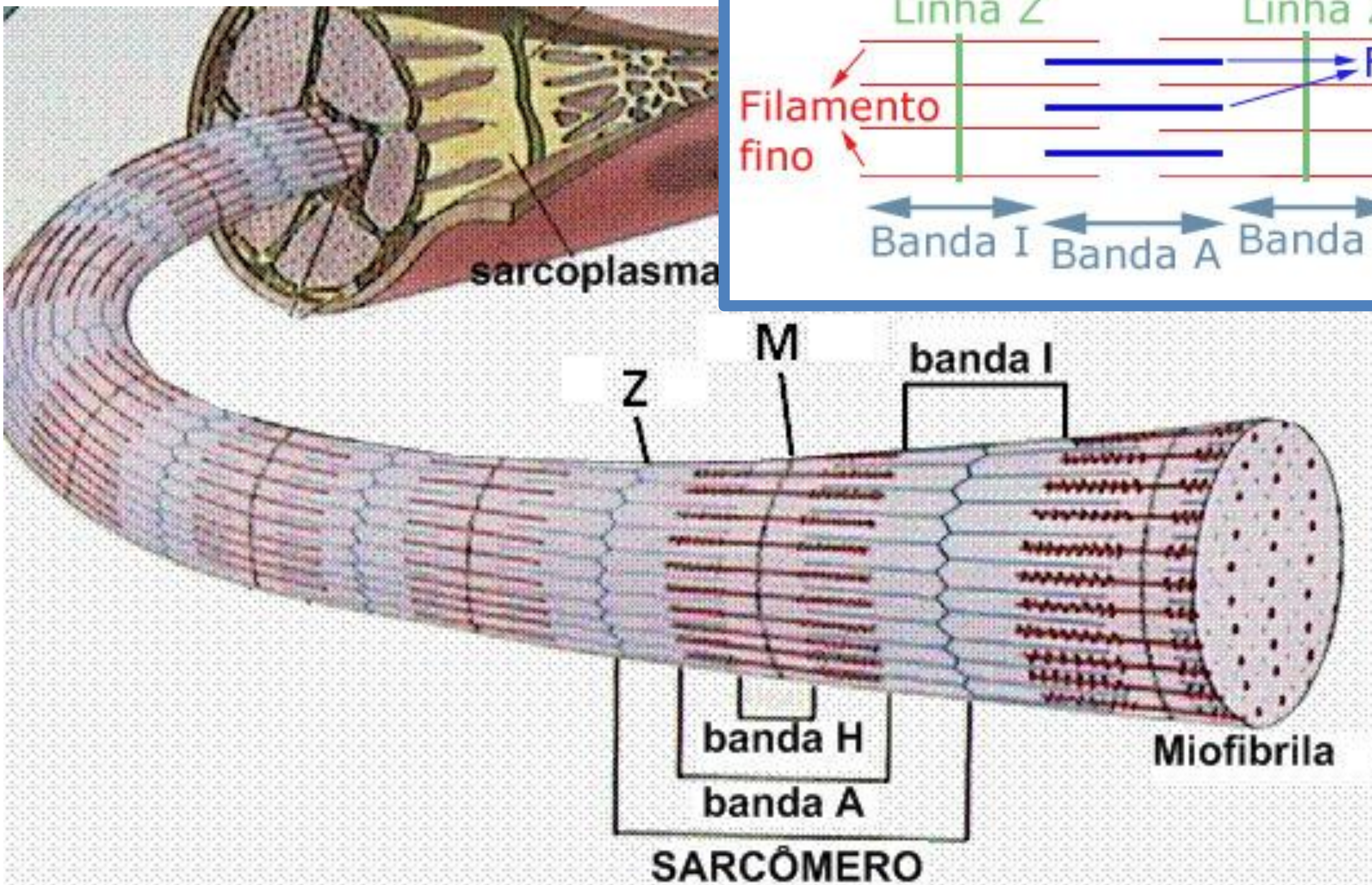


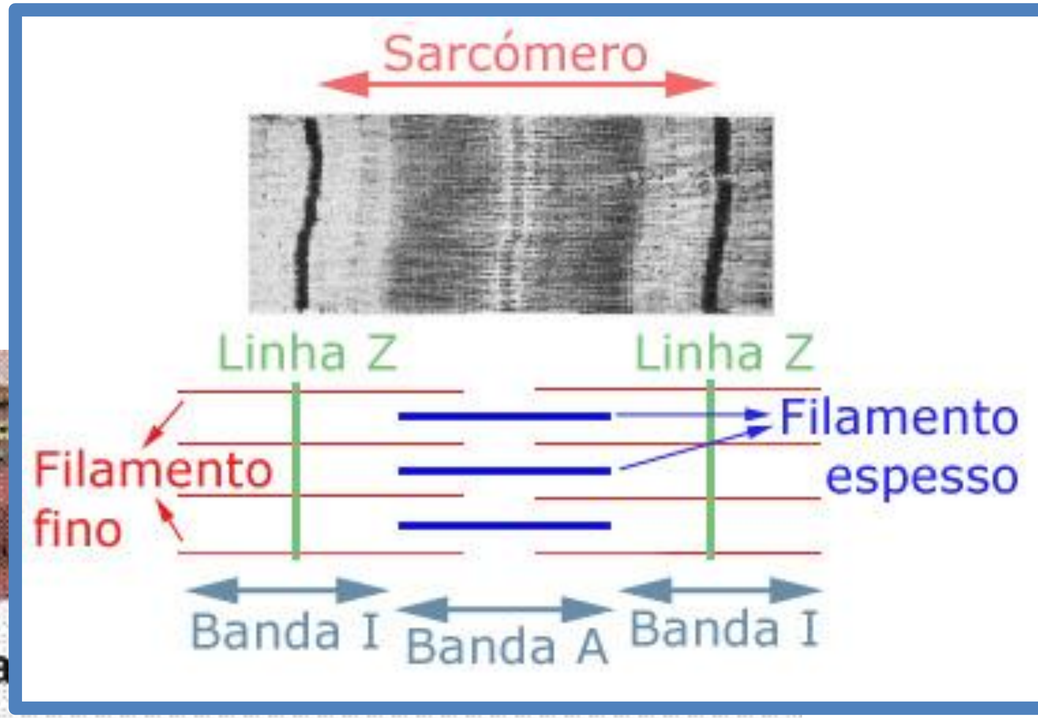
Microestrutura

- **Miofibrilas** – conjunto de sarcomeros organizados em série. As miofibrilas estão dispostas em paralelo dentro da fibra muscular

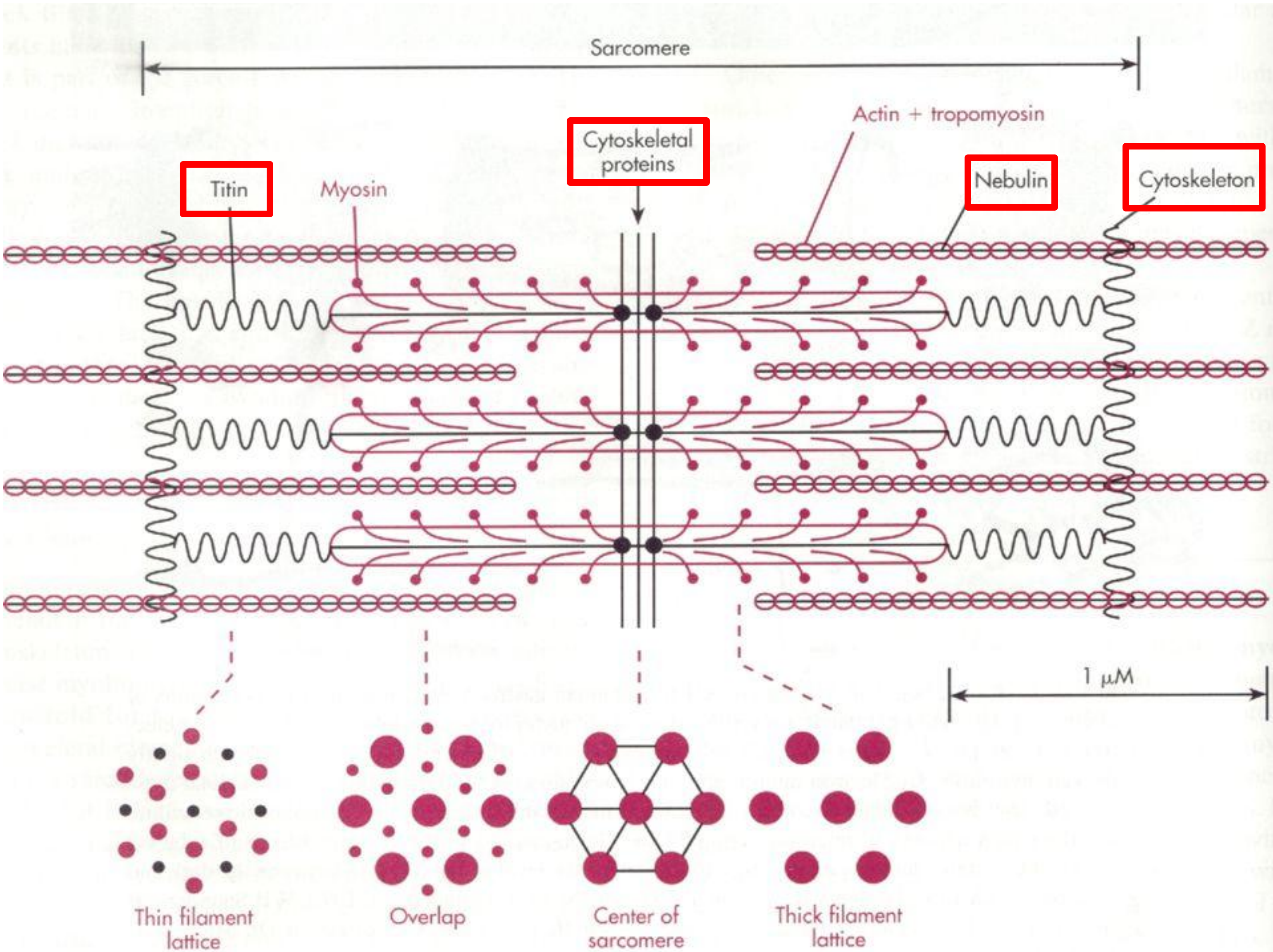
- **Miofilamentos** – componentes de um sarcômero

Microestrutura





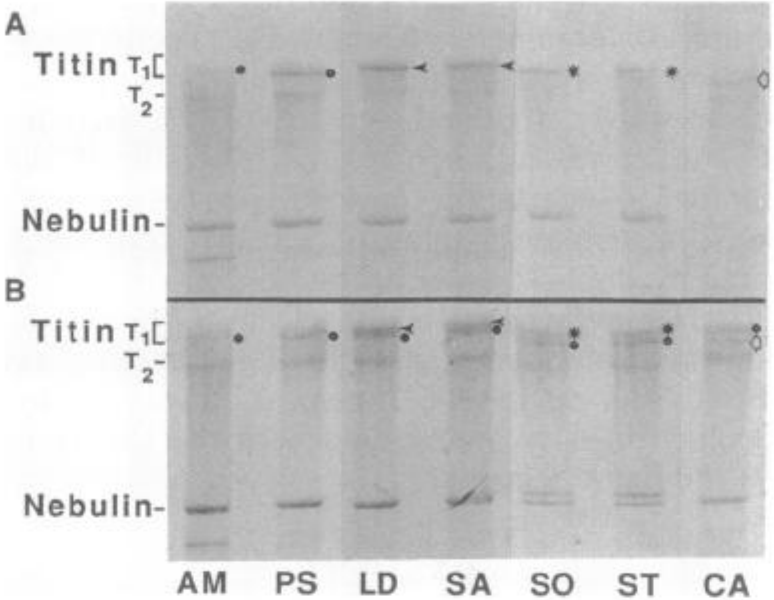
Microestrutura



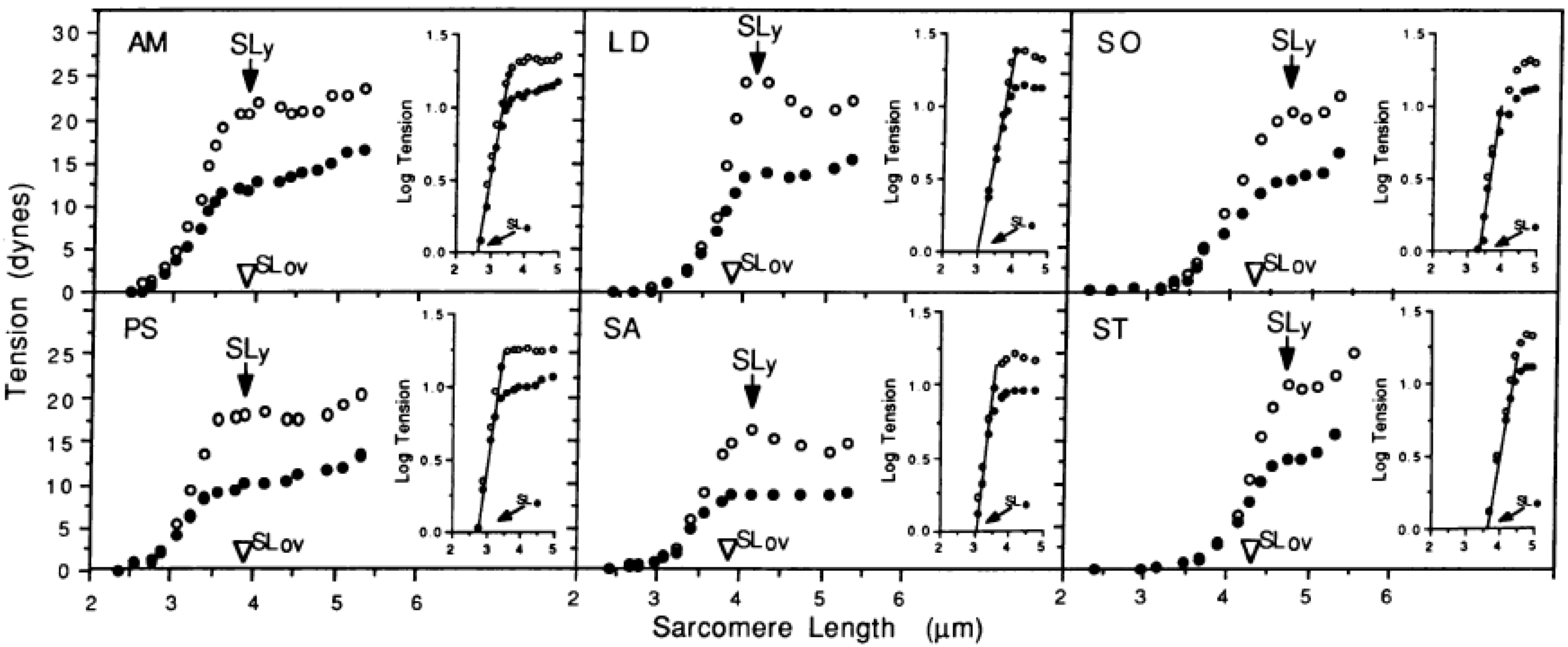
TITINA

- Miofibrila; 1µm de comprimento
- Rica em aminoácidos
- Estrutura em espiral
- Diferentes isoformas – genética e grupos musculares

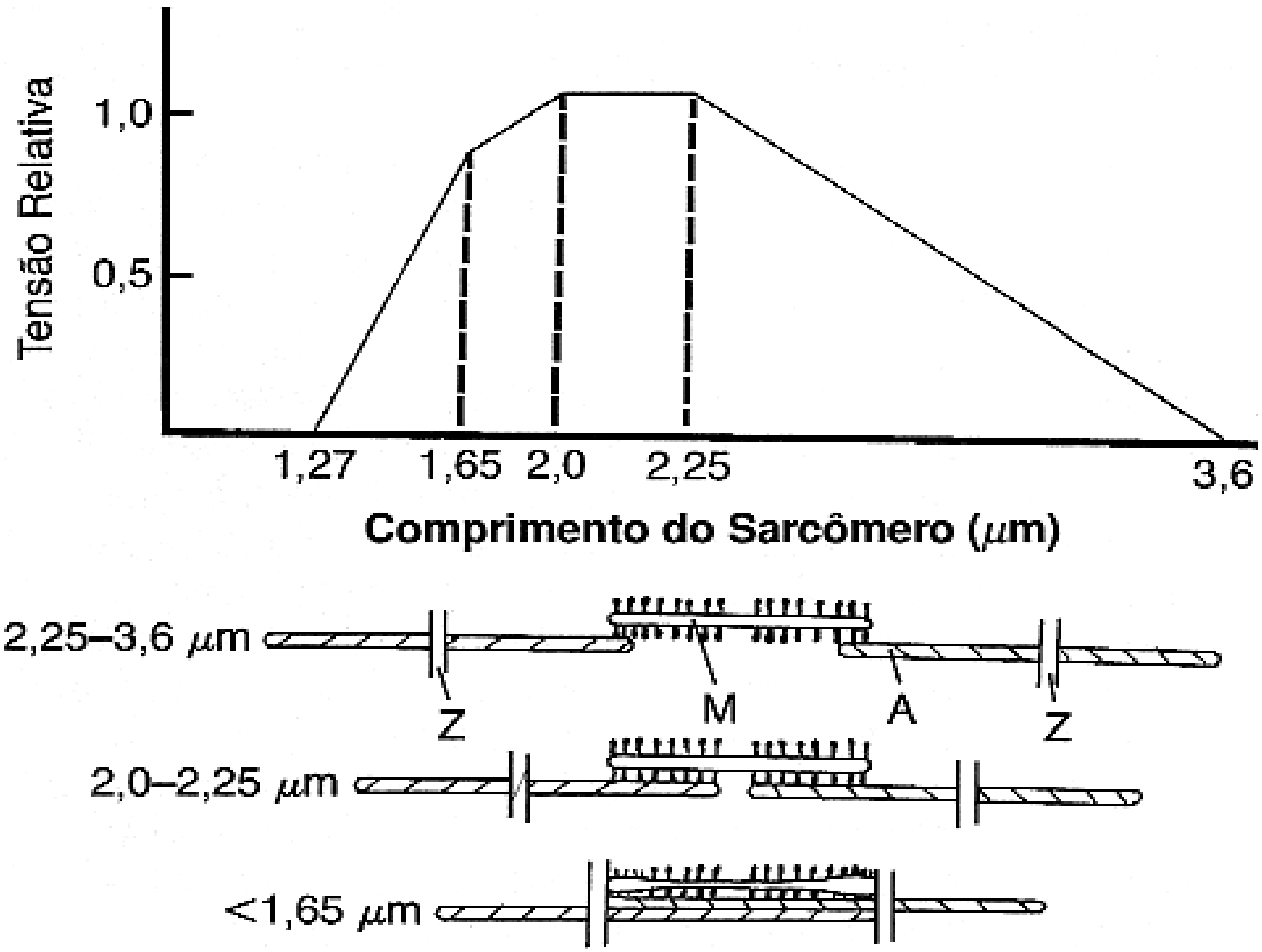
(Trinick, 1999)



Alterações nas isoformas de Titina



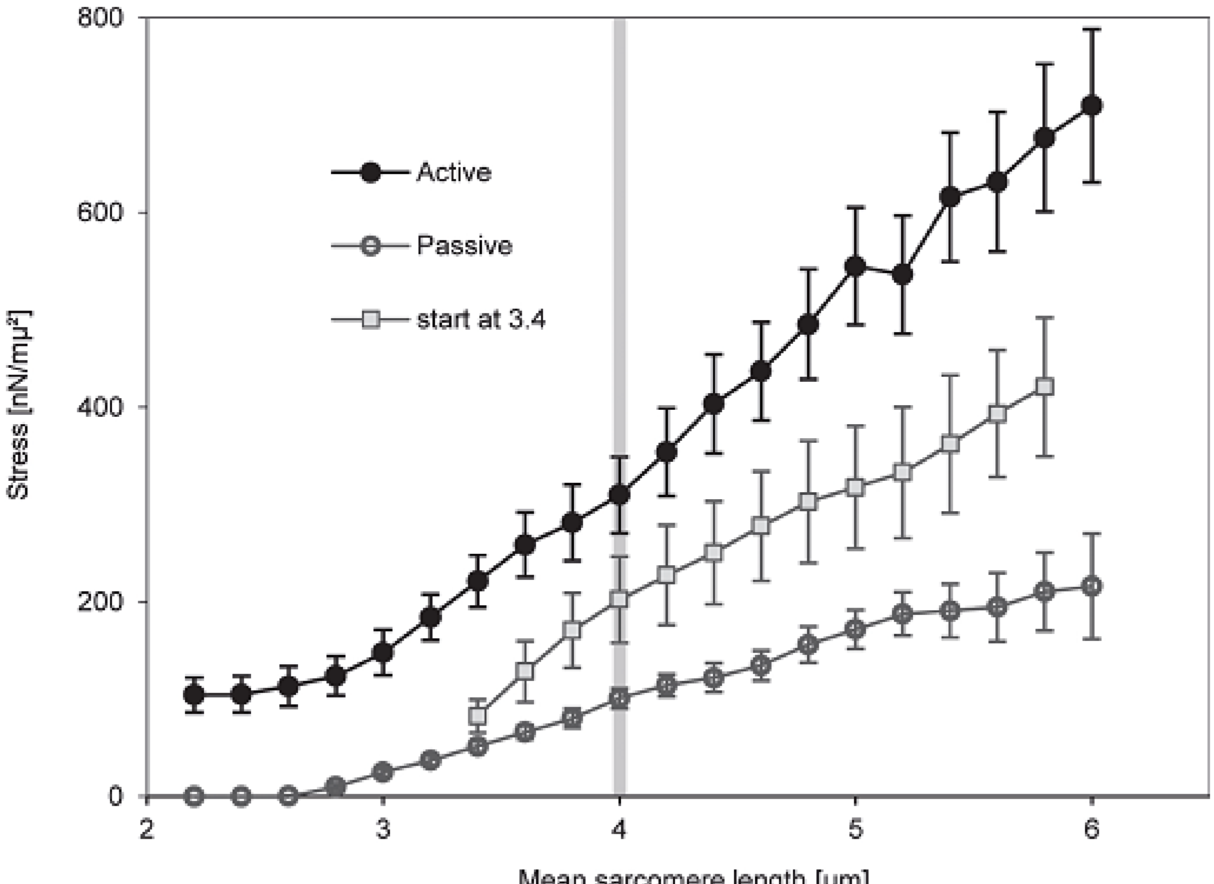
Comprimento ótimo



RESEARCH ARTICLE

A Novel Three-Filament Model of Force Generation in Eccentric Contraction of Skeletal Muscles

Gudrun Schappacher-Tilp[1]*, Timothy Leonard[2], Gertrud Desch[1], Walter Herzog[2]



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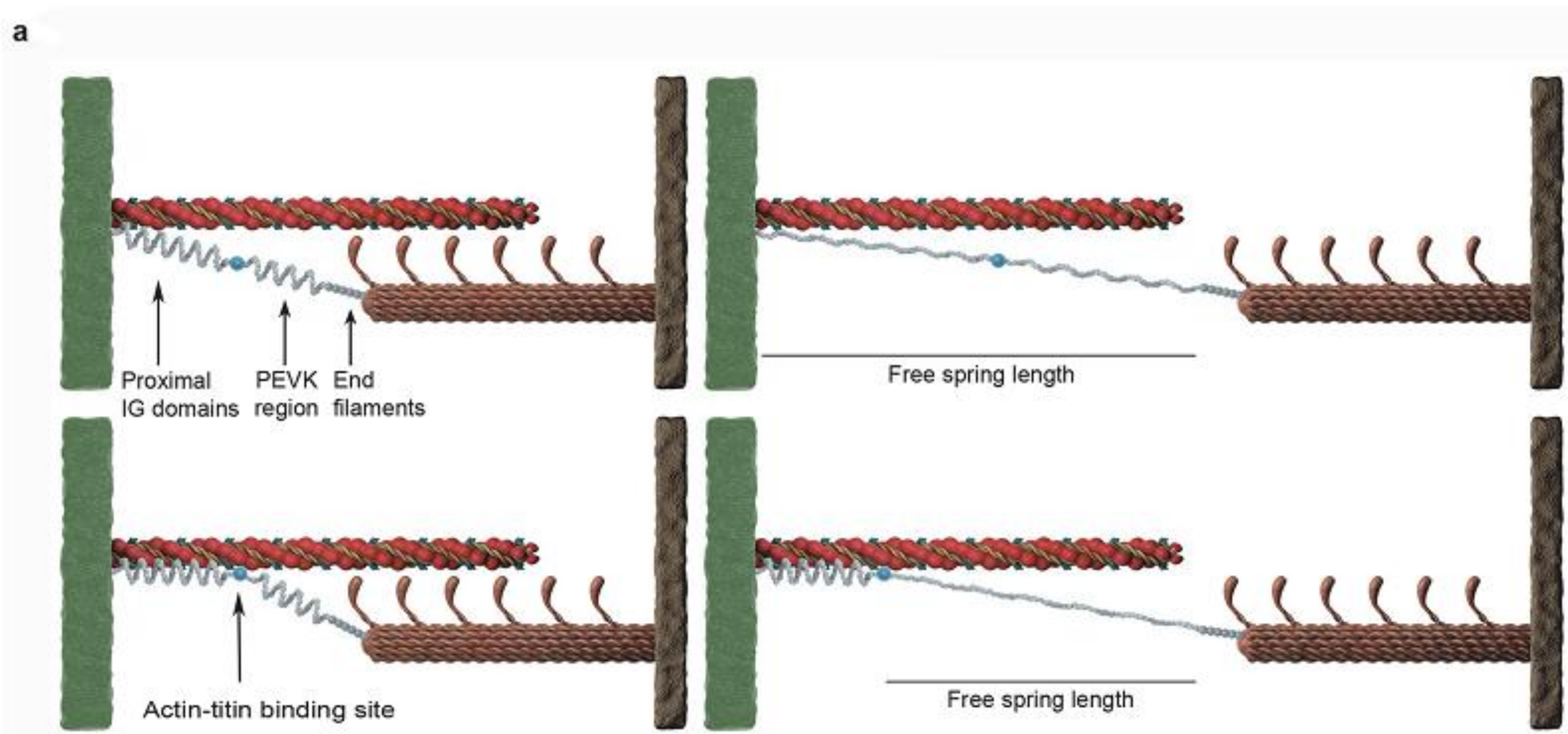
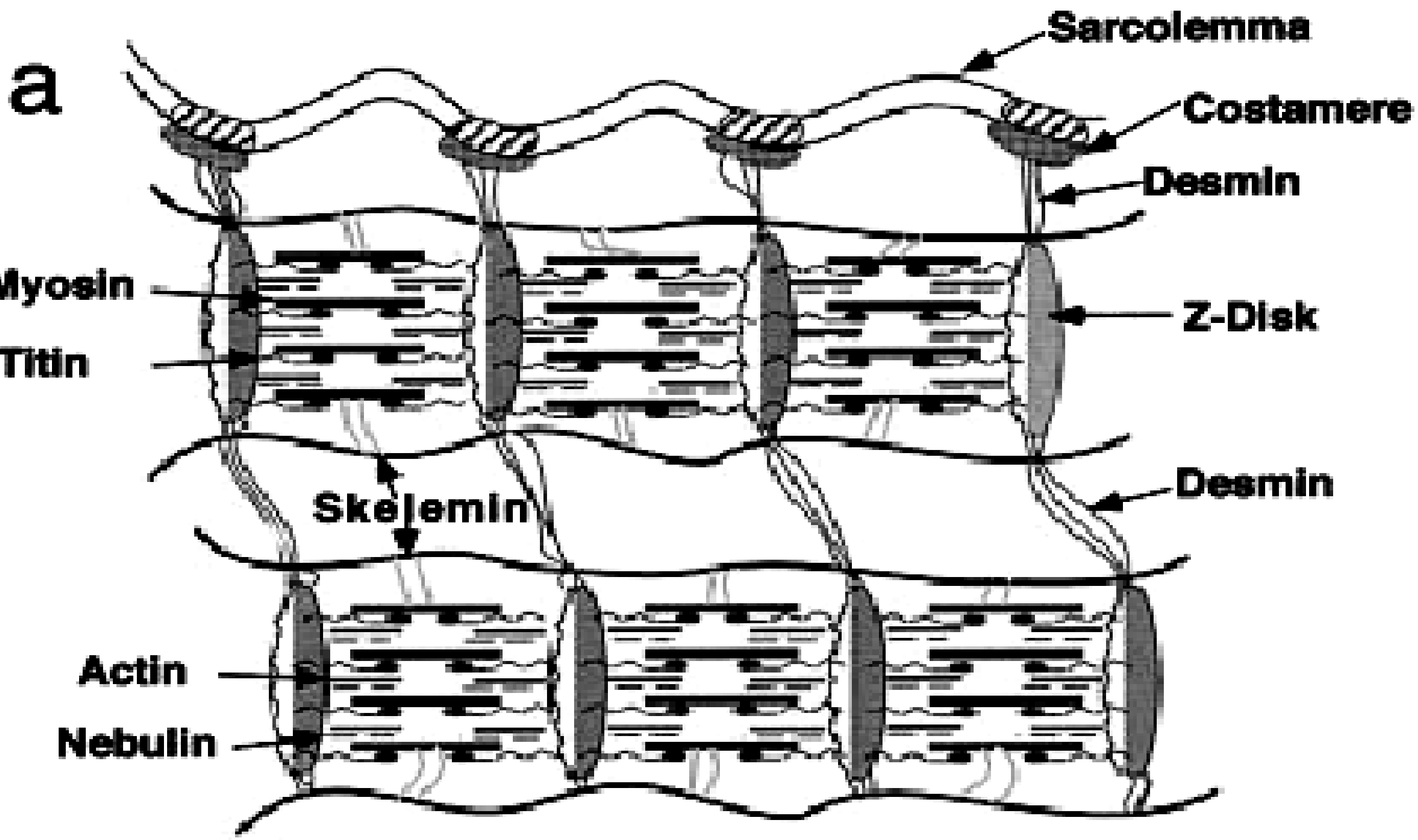
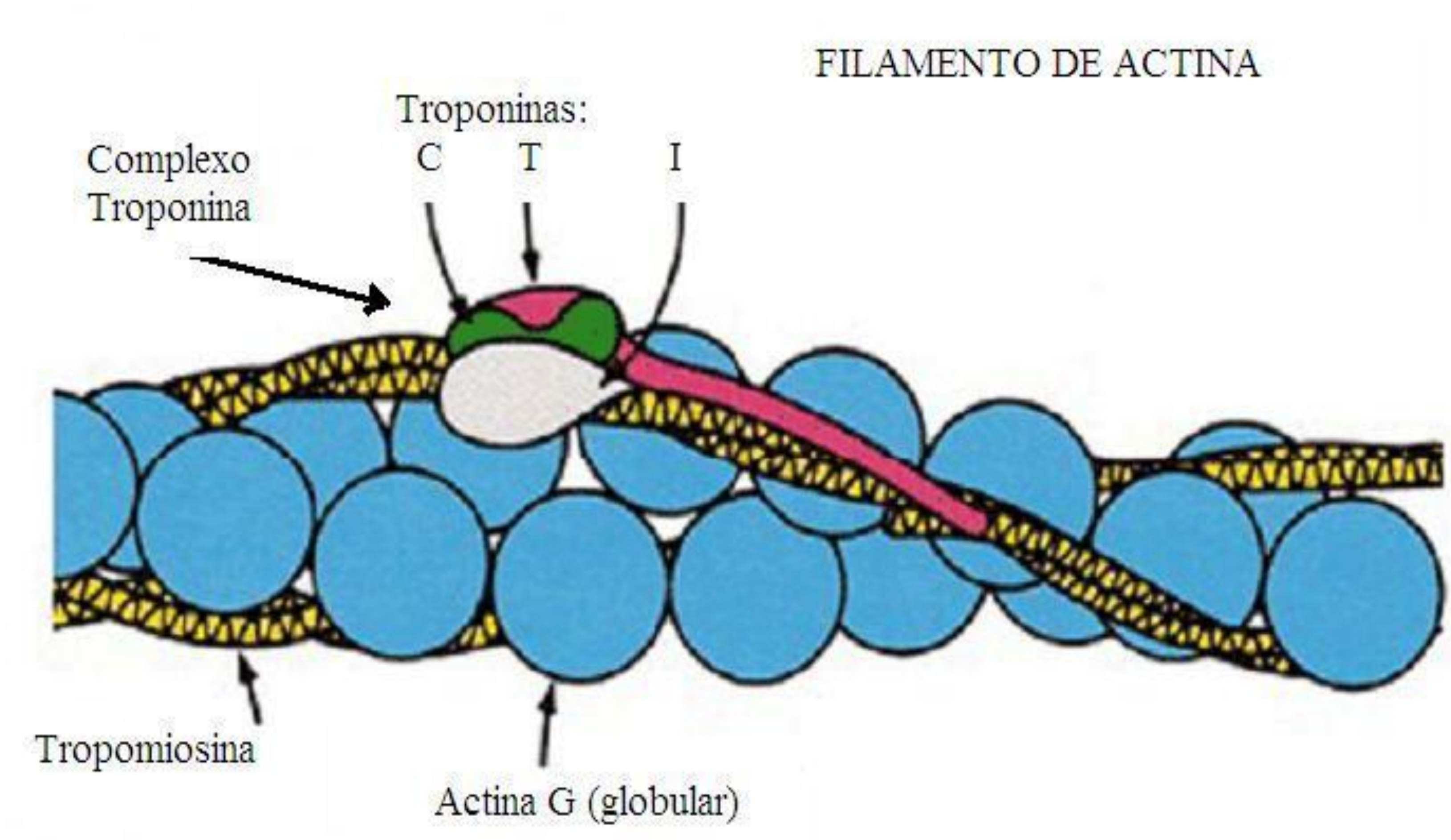


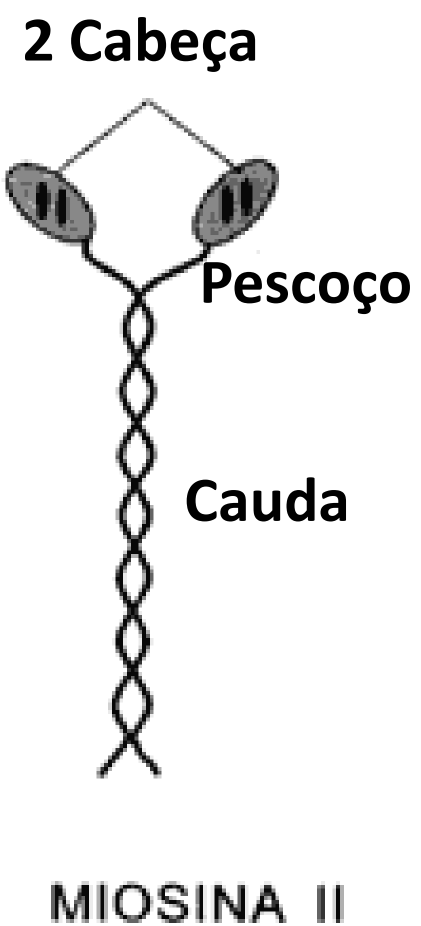
Microestrutura

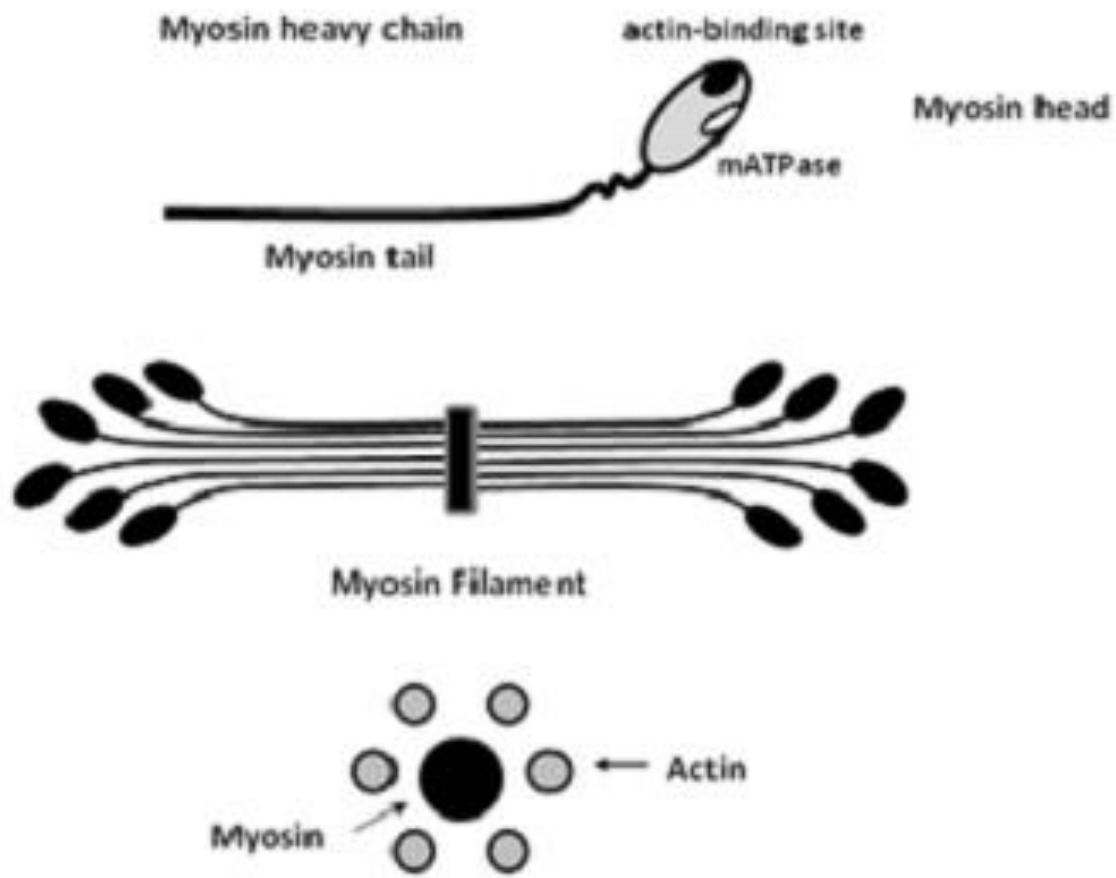


Microestrutura

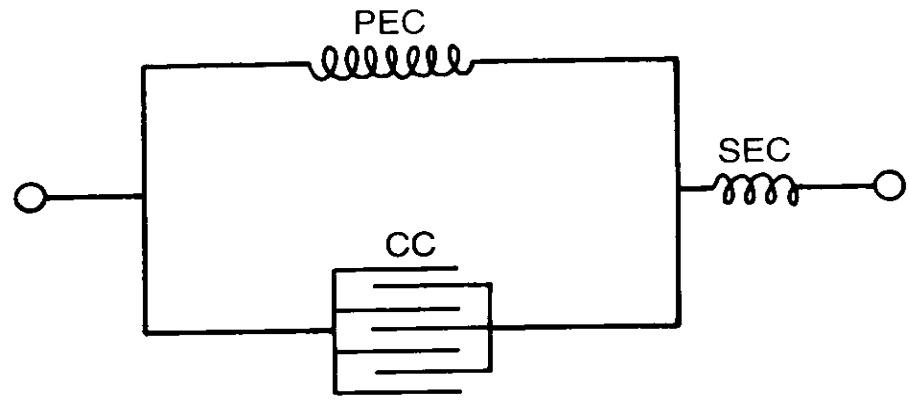


Microestrutura





Componentes do músculo



- **<u>Componentes contráteis</u> (CC):**
  - Actina e Miosina.
- **<u>Componentes elásticos em paralelo</u> (PEC):**
  - Endomísio (fibra)
  - Perimísio (fascículo)
  - Epimísio (músculo)
- **<u>Componentes elásticos em série</u> (SEC):**
  - Tendão.

Componentes do músculo

Característica PEC e SEC:

- **Resistem à tração**

- **Capacidade de acumular e restituir energia elástica.**

UNIDADE MOTORA

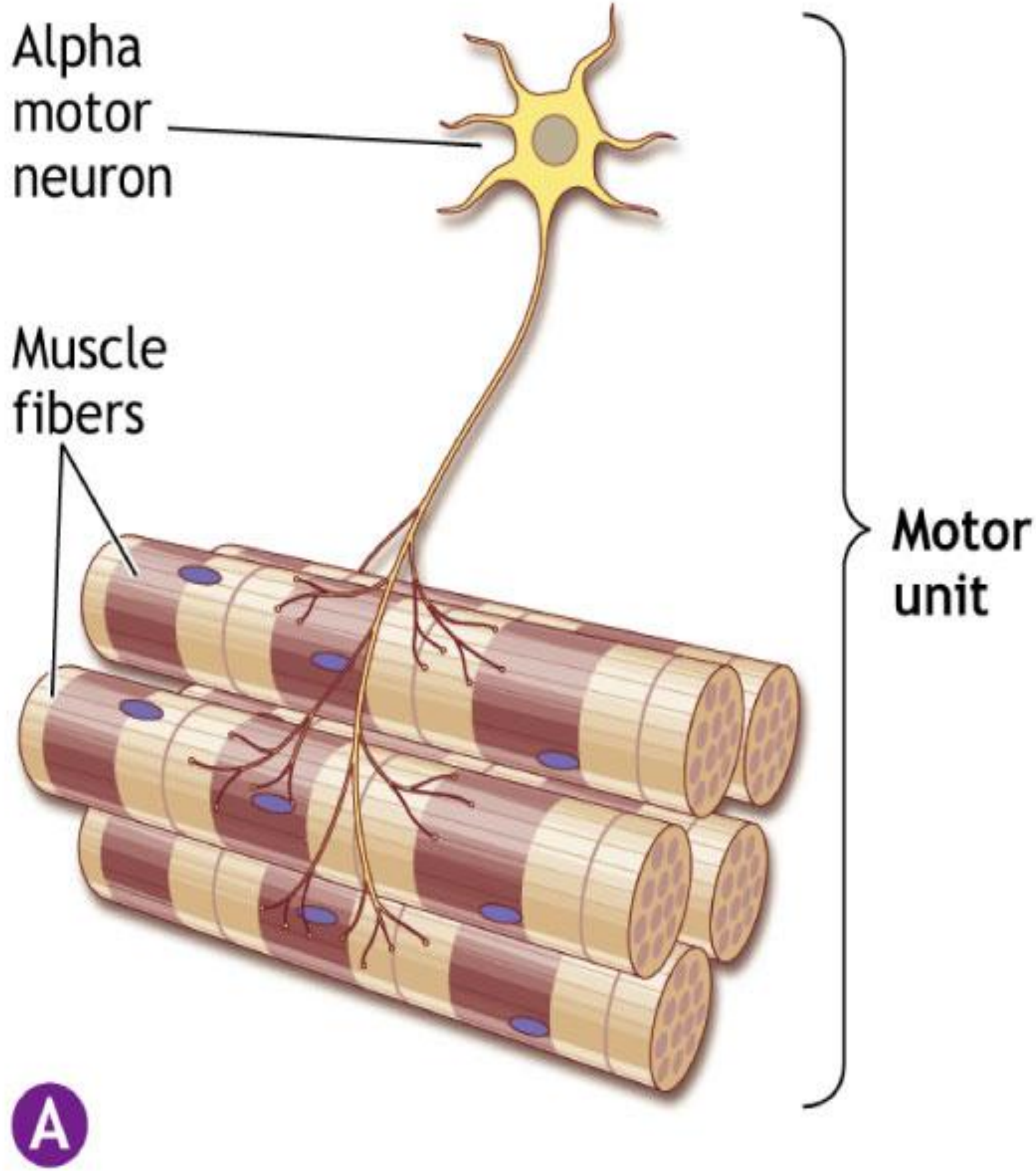
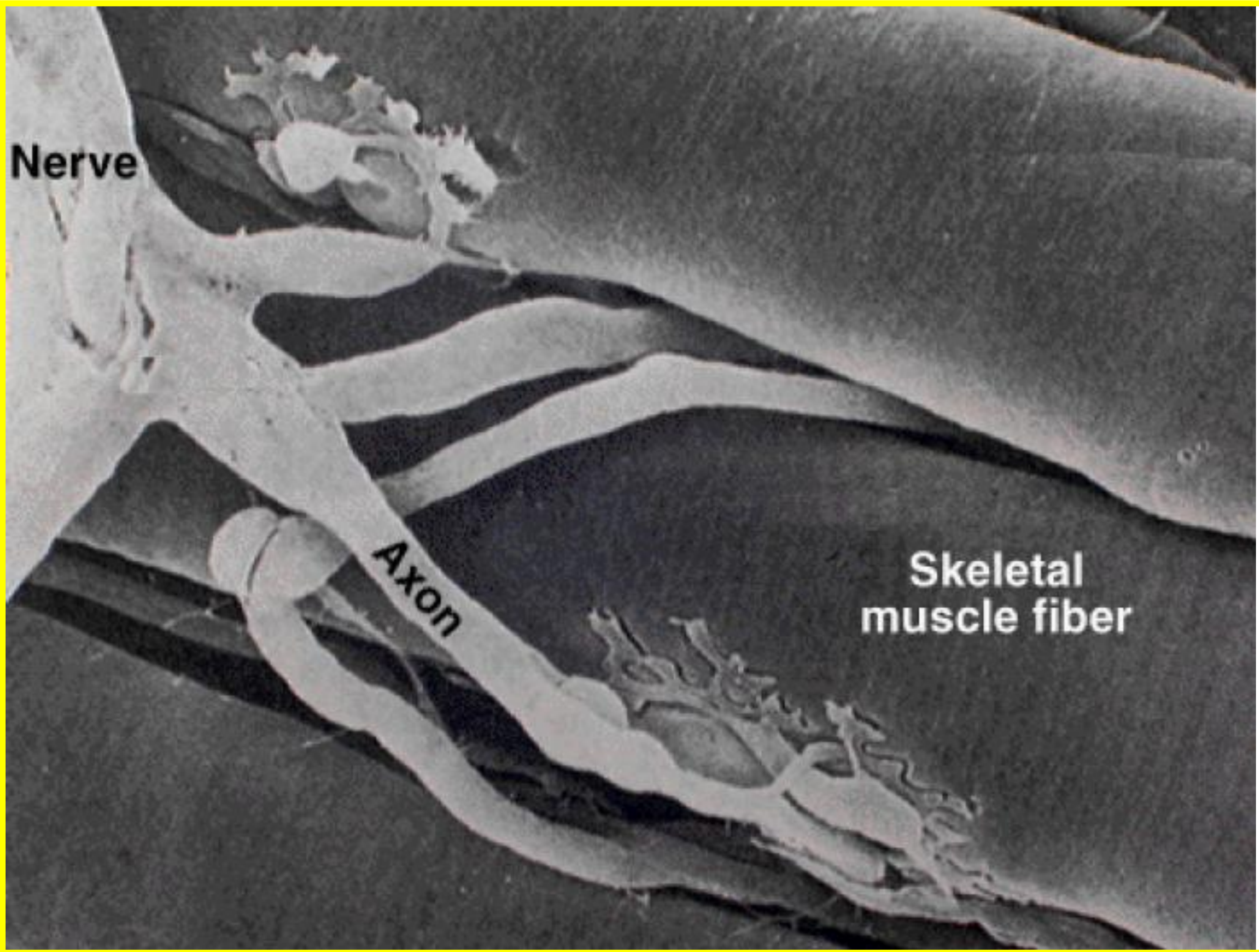


Figure 19.9. Motor unit and motor neuron pool. **A.** Motor unit represents an α-motoneuron and the fibers it innervates.

UNIDADE MOTORA



SINAPSE NEUROMUSCULAR

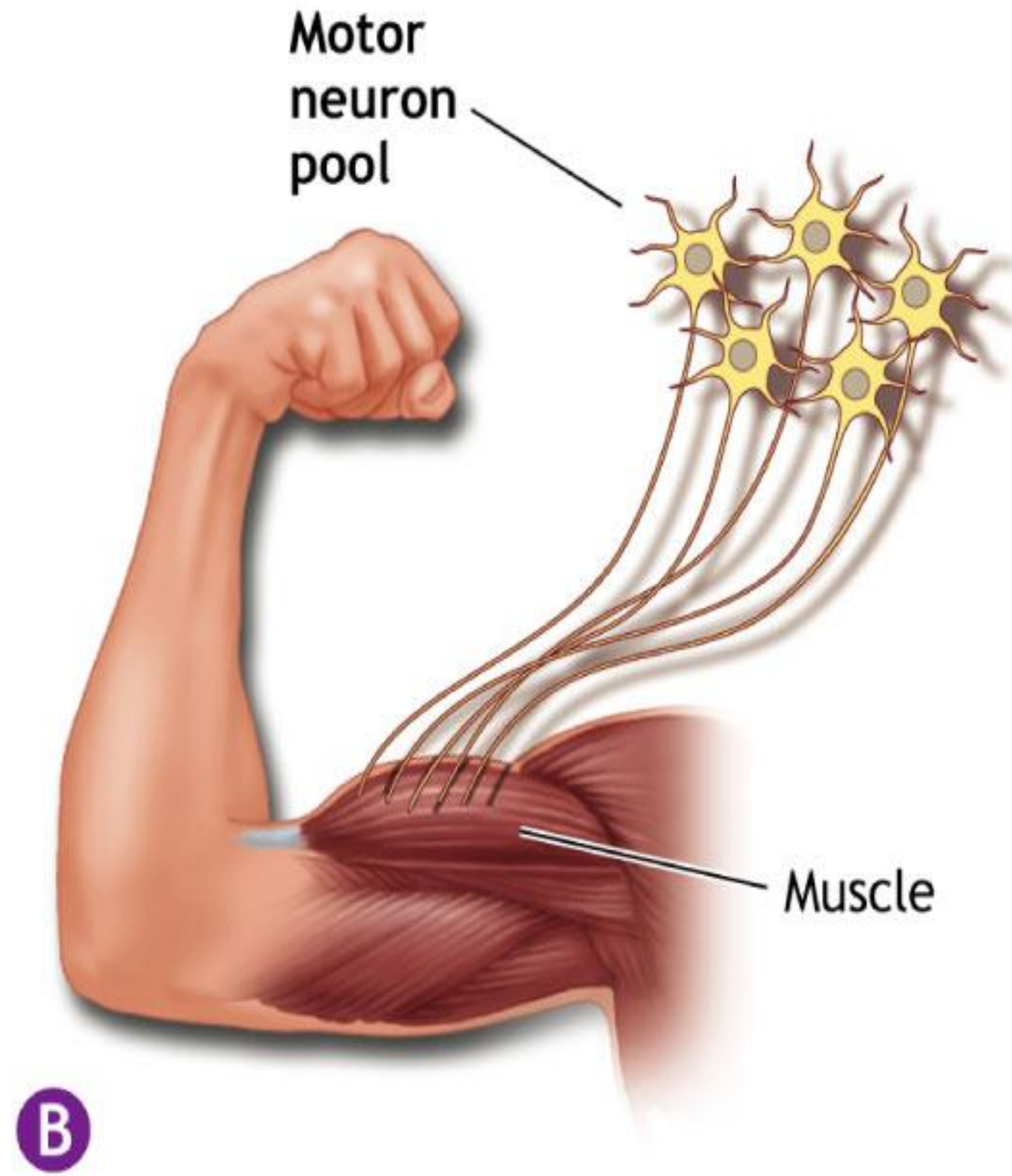
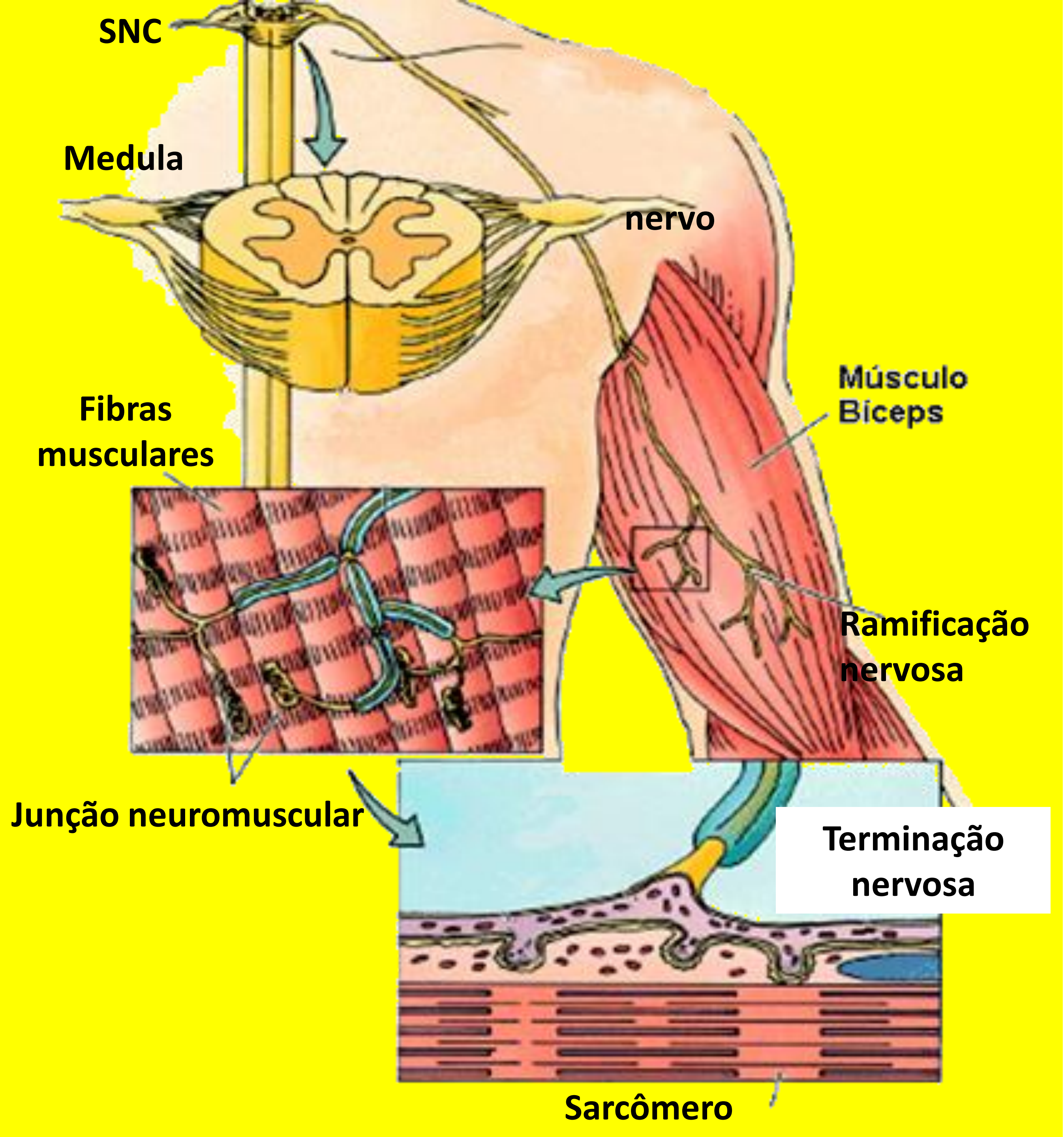
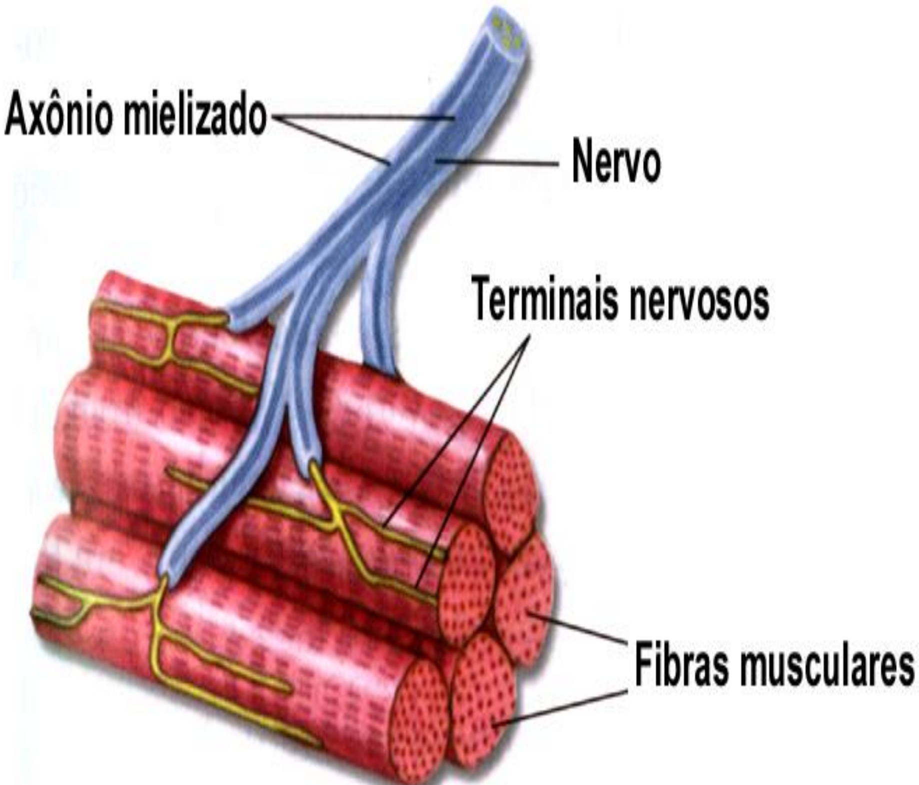
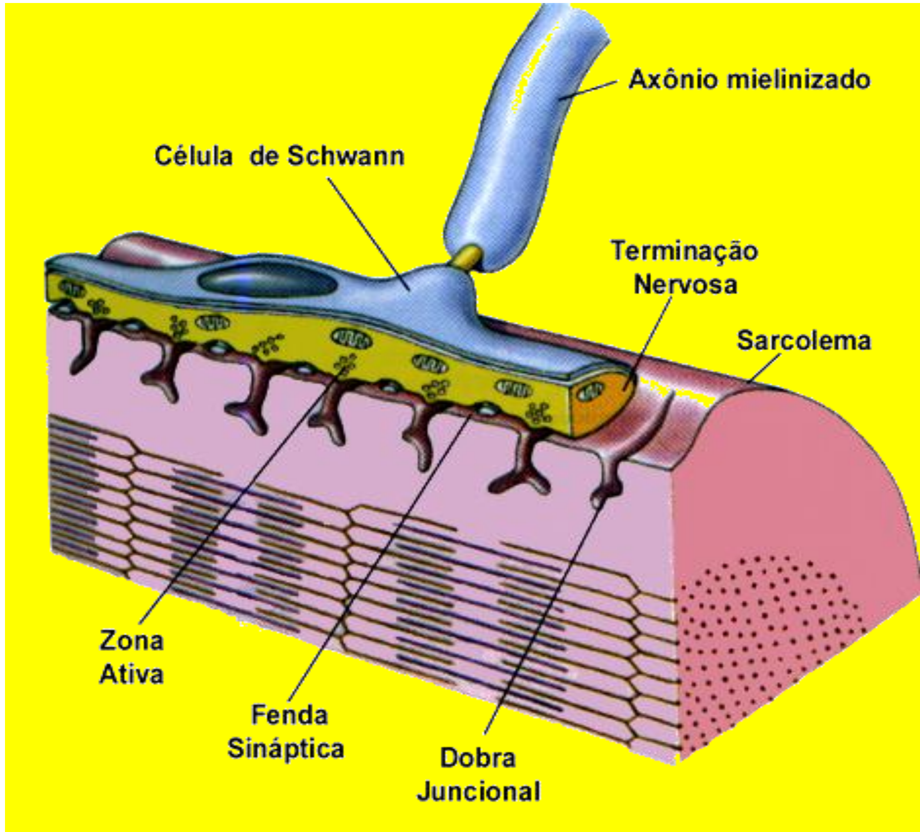


Figure 19.9. Motor unit and motor neuron pool. **B.** Motor neuron pool represents all the α motor neurons that innervate one muscle.


SNC
Medula
nervo
Músculo
Bíceps
Fibras
musculares
Ramificação
nervosa
Junção neuromuscular
Terminação
nervosa
Sarcômero

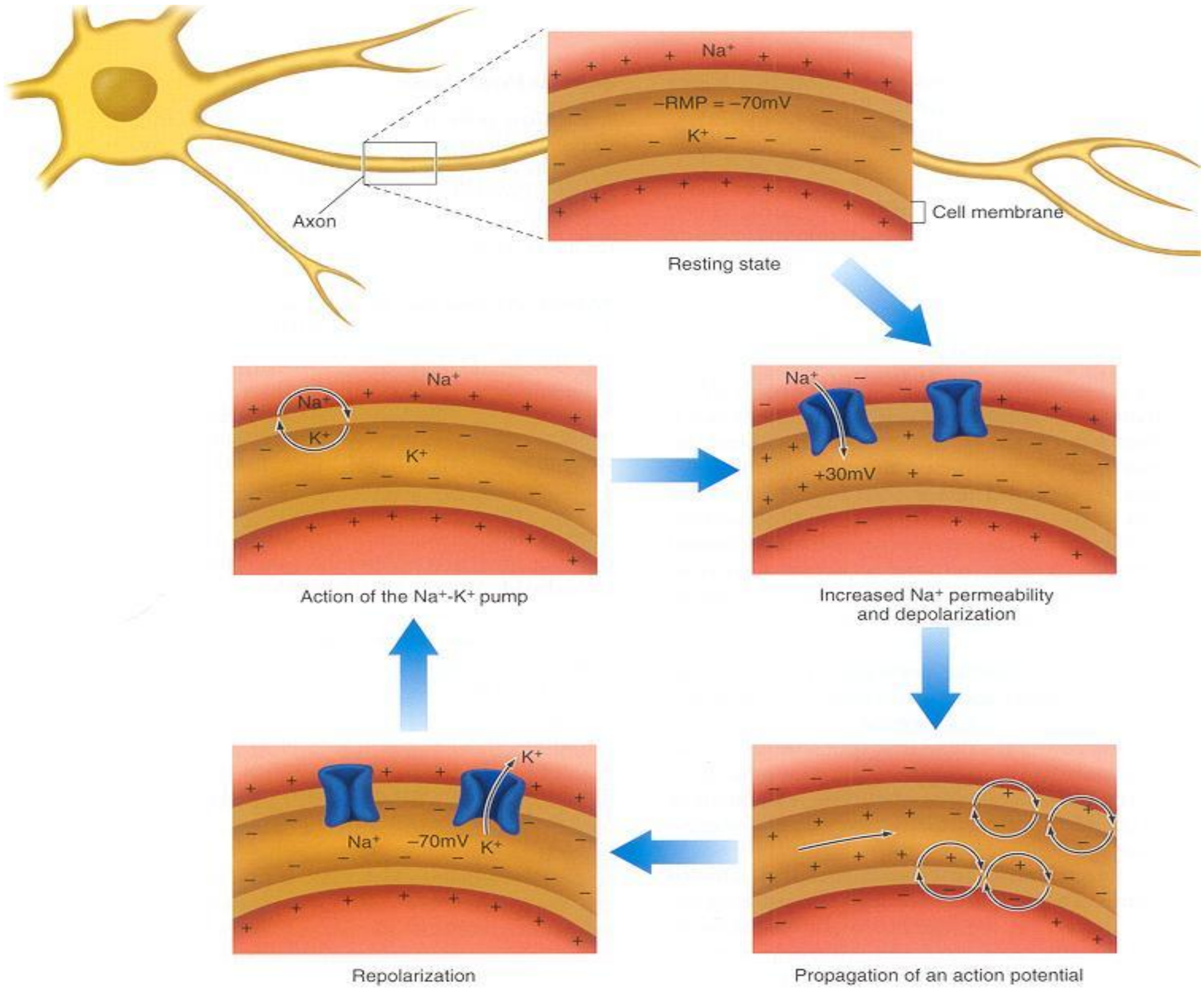
SINAPSE NEURO-MUSCULAR

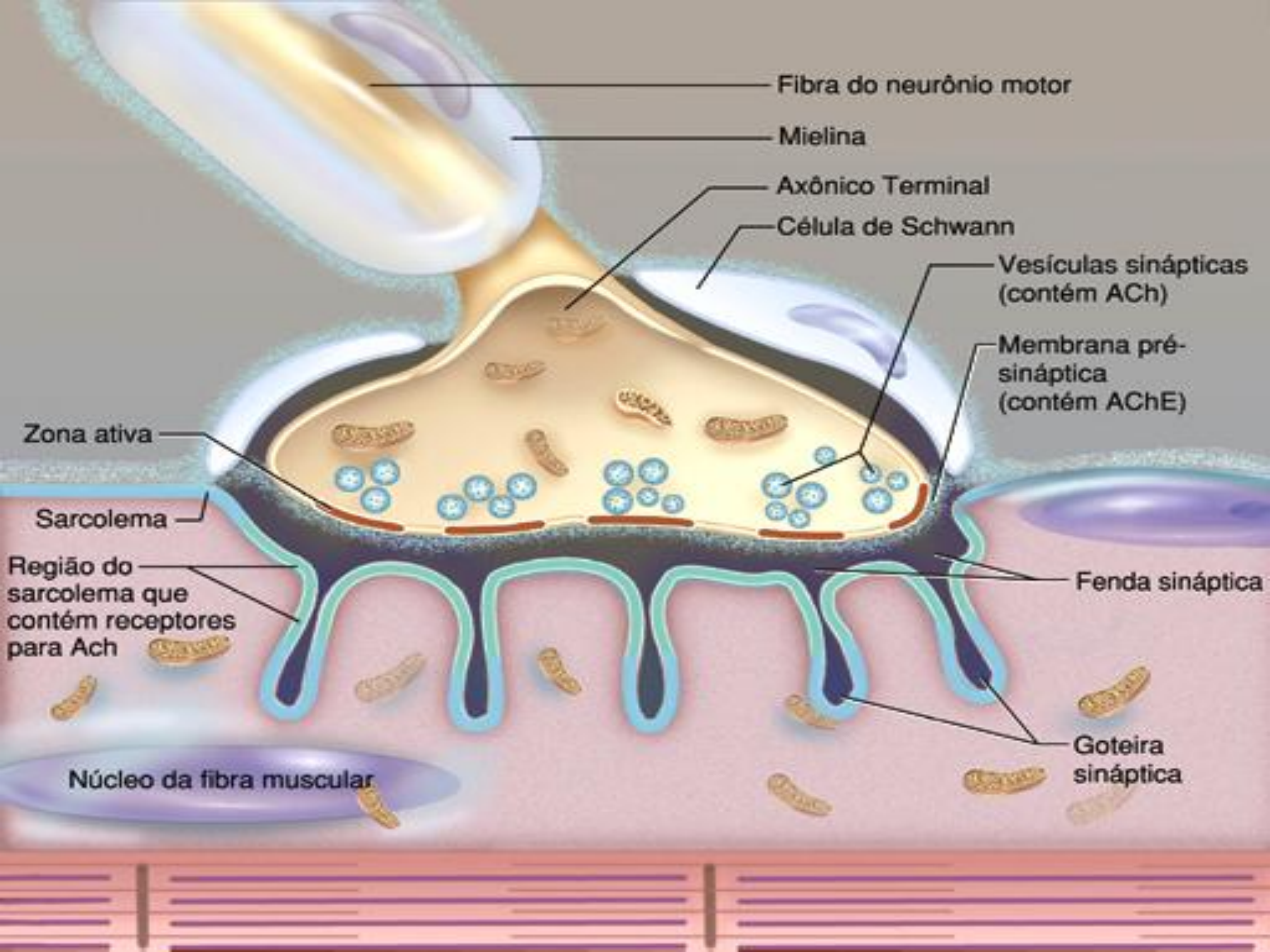


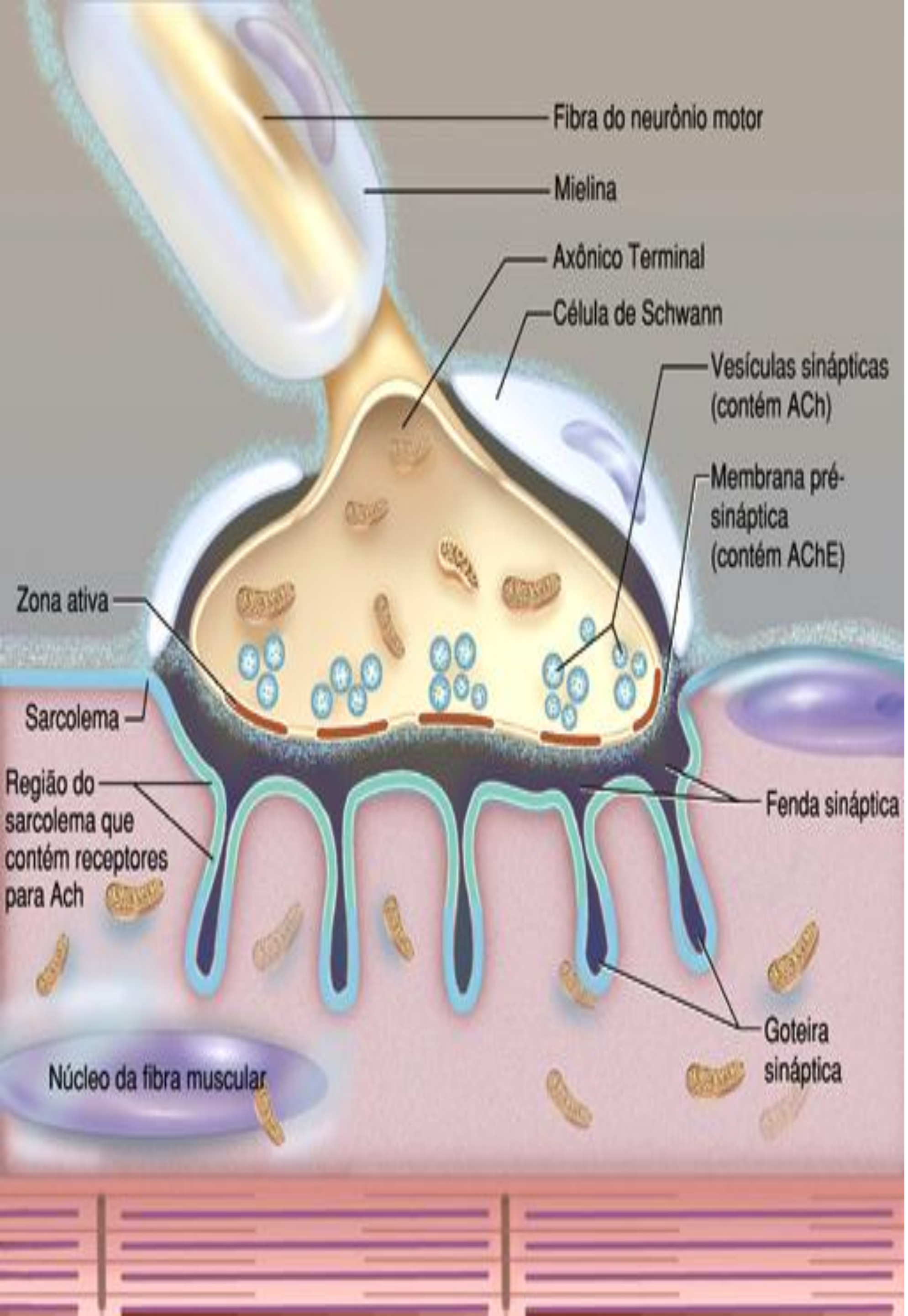


A sinapse neuromuscular ocorre na região do sarcolema denominada placa motora para onde os neurotransmissores (ACETILCOLINA) são liberados.

TUDO SE INICIA...(BOMBA DE Na+ e K+)




Fibra do neurônio motor
Mielina
Axônico Terminal
Célula de Schwann
Vesículas sinápticas (contém ACh)
Membrana pré-sináptica (contém AChE)
Zona ativa
Sarcolema
Região do sarcolema que contém receptores para Ach
Fenda sináptica
Goteira sináptica
Núcleo da fibra muscular



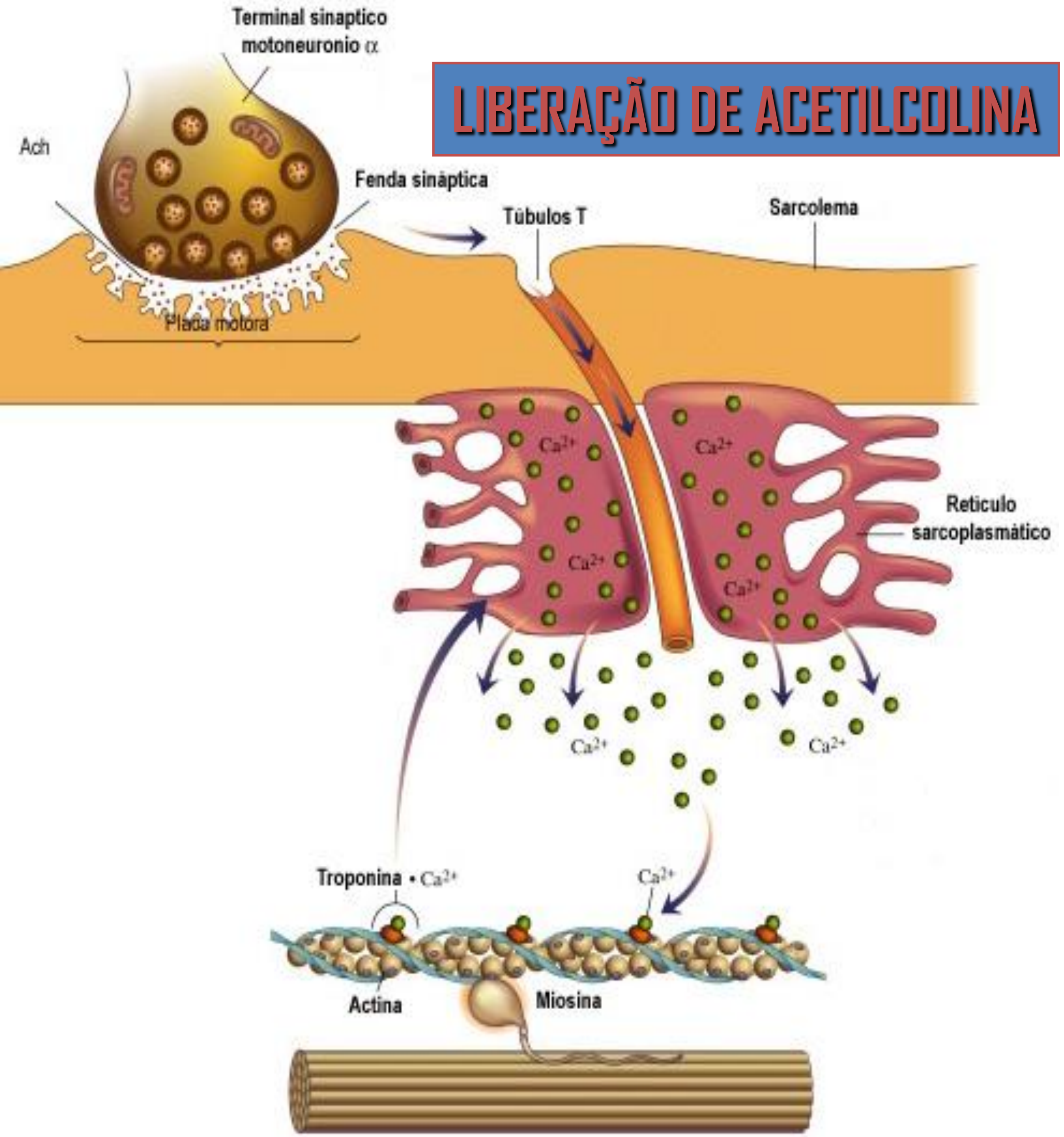
EVENTOS DA NEUROTRANSMISSAO

- Chegada do PA nos terminais
- Liberação de Acetilcolina
- Complexo receptor nicotinico-Ach
- Abertura de canais Na pós-sinápticos
- Potencial pós-sináptico (Potencial de Placa)
- Abertura de Canais Na e K voltagem dependentes no sarcolema
- Geração e propagação do PA pelo sarcolema

As fibras musculares são células excitáveis como os neurônios: geram PEPS (potencial de placa) e PA.

Forma rápida de transmitir os comandos neurais.

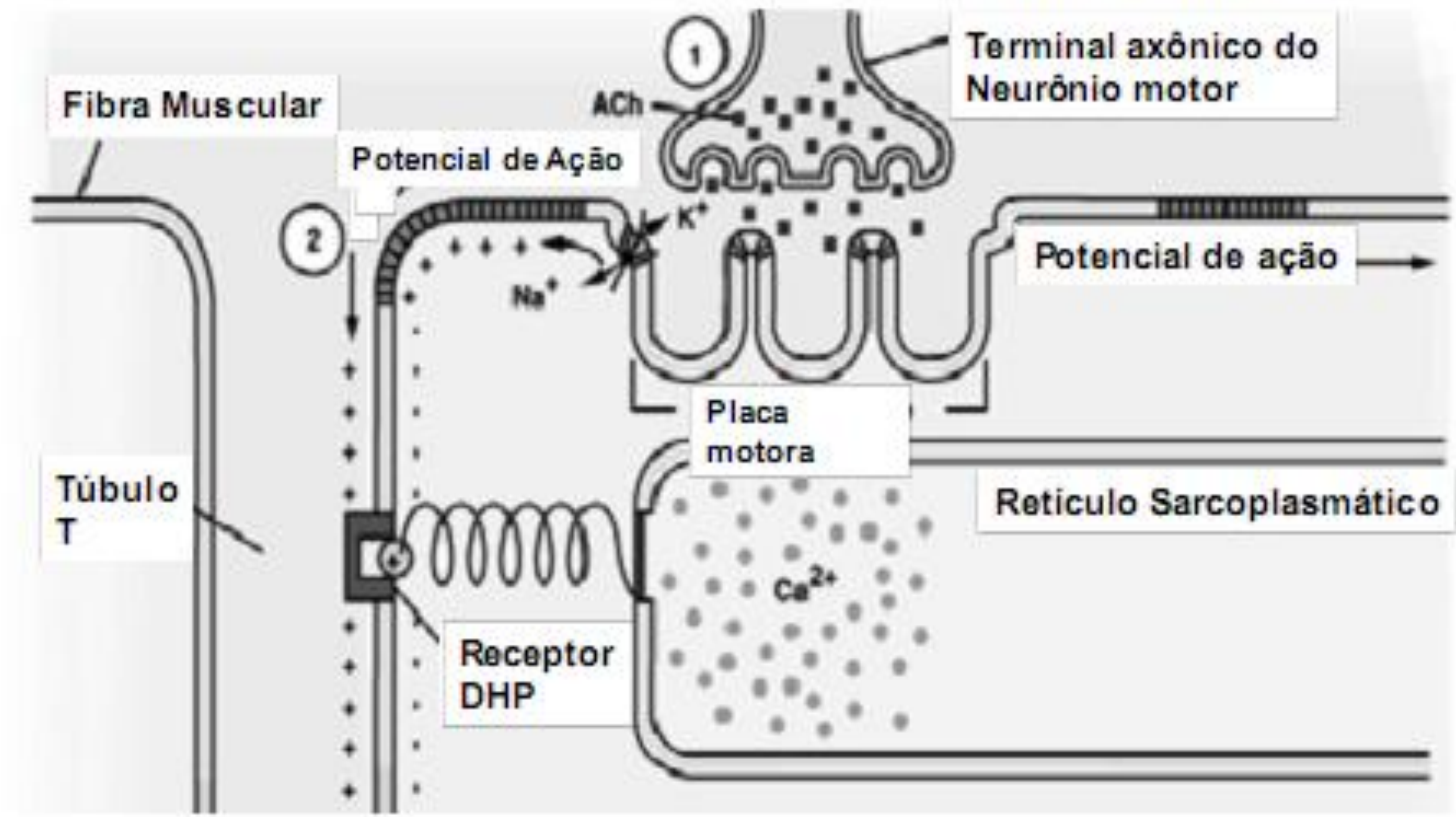
MECANISMO DA CONTRAÇÃO MUSCULAR



Para que servem os túbulos T? Os túbulos T conduzem a onda de despolarização até as cisternas do reticulo sarcoplasmático

1. Condução do PA pelo sarcolema
2. Despolarização dos Túbulos T
3. Abertura de Canais de Ca^{++} do retículo sarcoplasmático
4. Difusão de Ca^{++}
5. Aumento de $[Ca^{++}]$ no mioplasma
6. Inicio da contração muscular

Excitação-Contração



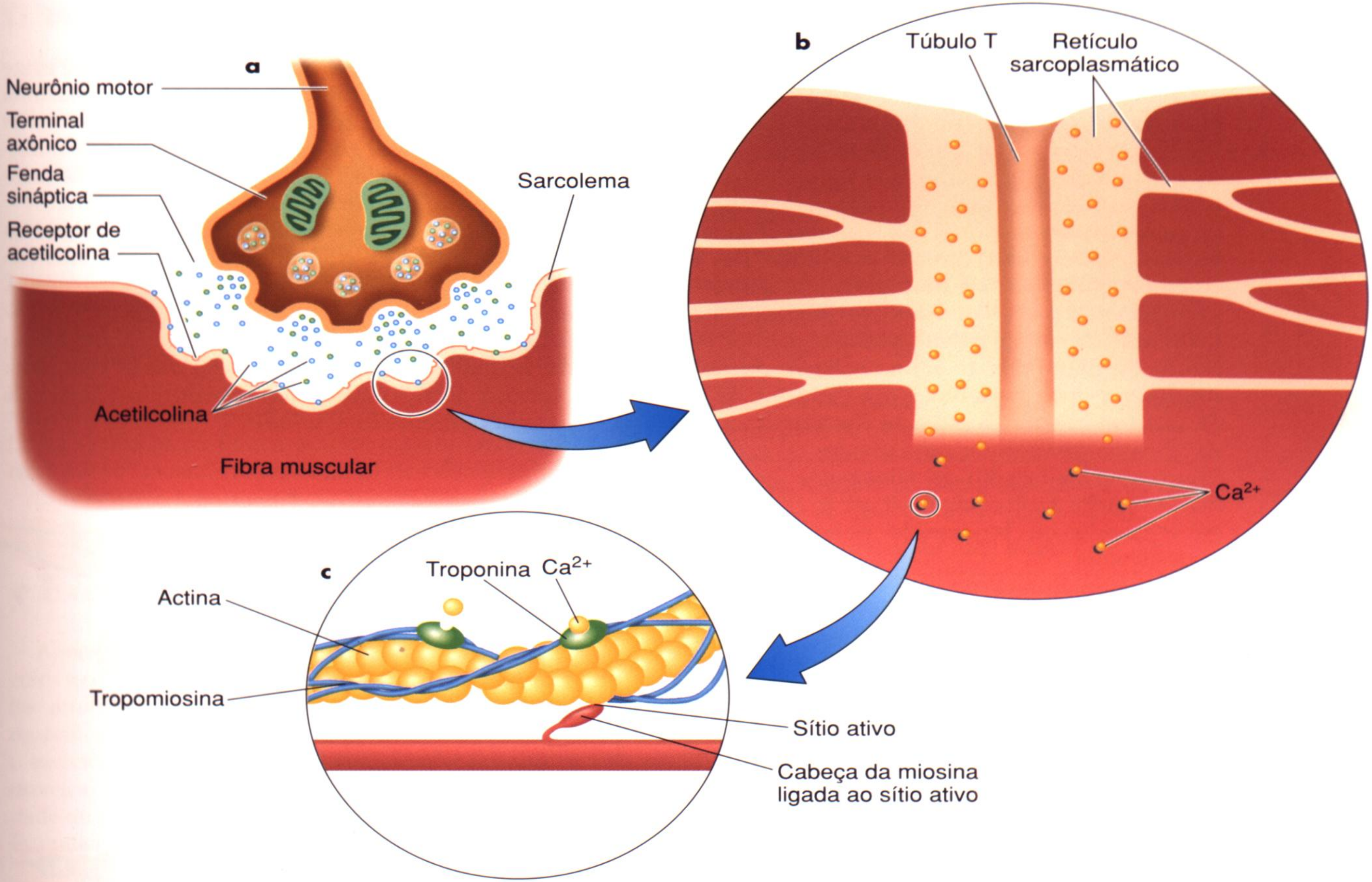
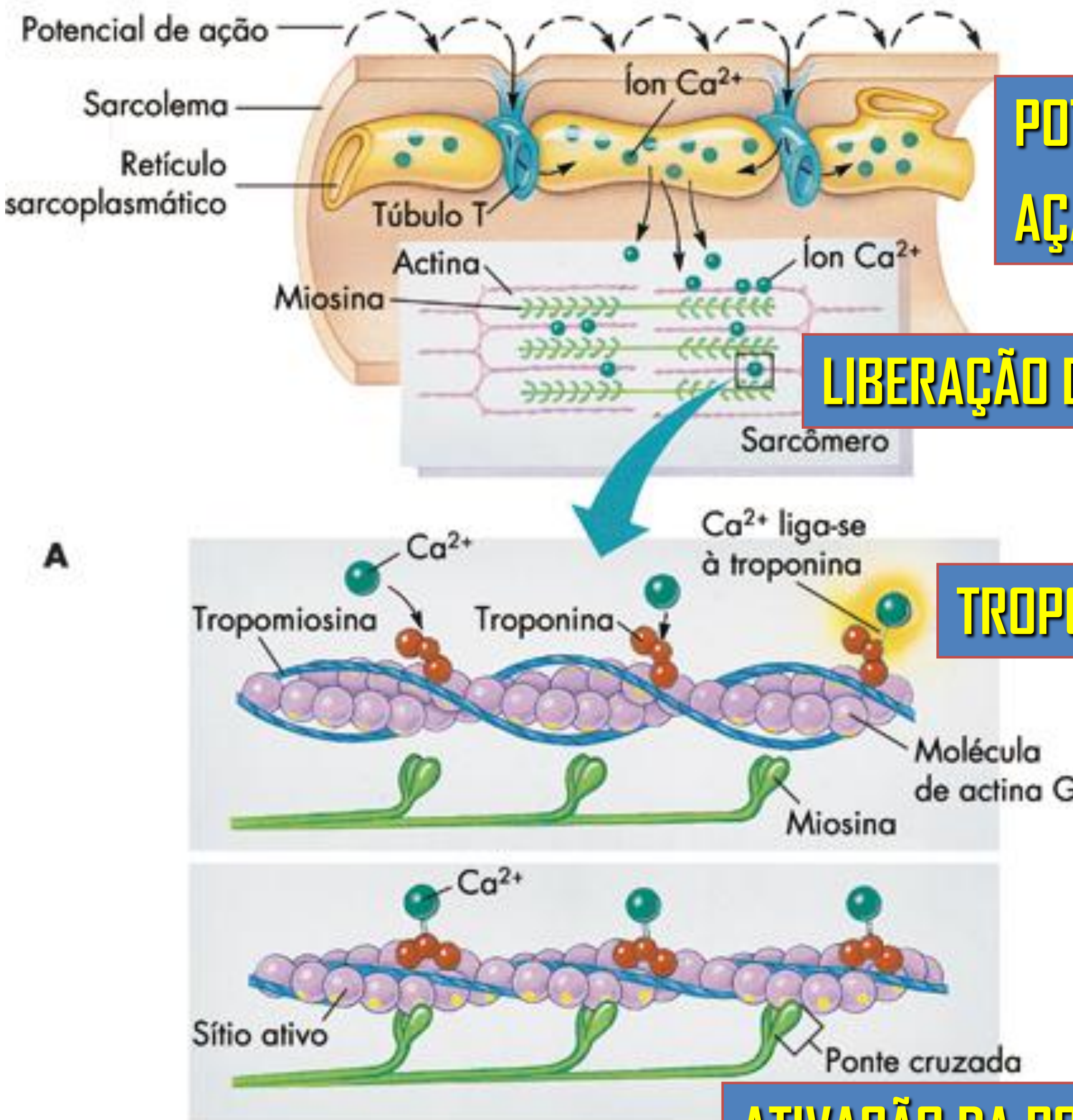


Figura 1.8 A seqüência de eventos que levam à ação muscular. (*a*) Um neurônio motor libera acetilcolina, a qual se liga aos receptores localizados sobre o sarcolema. Se uma quantidade suficiente de acetilcolina se ligar, é gerado um potencial de ação na fibra muscular. (*b*) O potencial de ação desencadeia a liberação de íons cálcio (Ca^{2+}) do retículo sarcoplasmático para o interior do sarcoplasma. (*c*) O Ca^{2+} se liga à troponina localizada no filamento de actina e a troponina traciona a tropomiosina de cima dos sítios ativos, permitindo que as cabeças da miosina se fixem no filamento de actina.

MECANISMO DA CONTRAÇÃO MUSCULAR



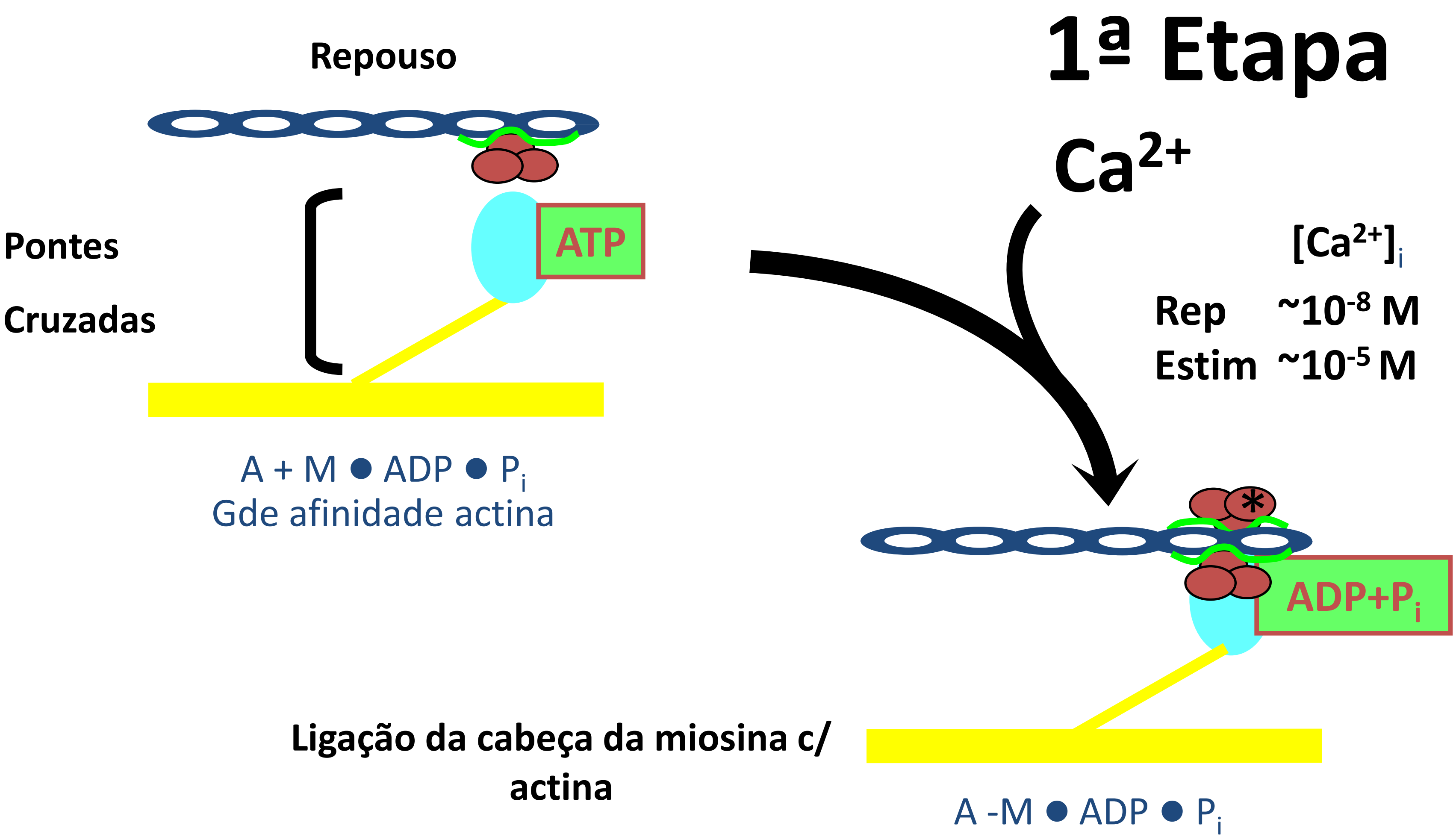
POTENCIAL DE AÇÃO NA FIBRA

LIBERAÇÃO DE Ca+

TROPONINA

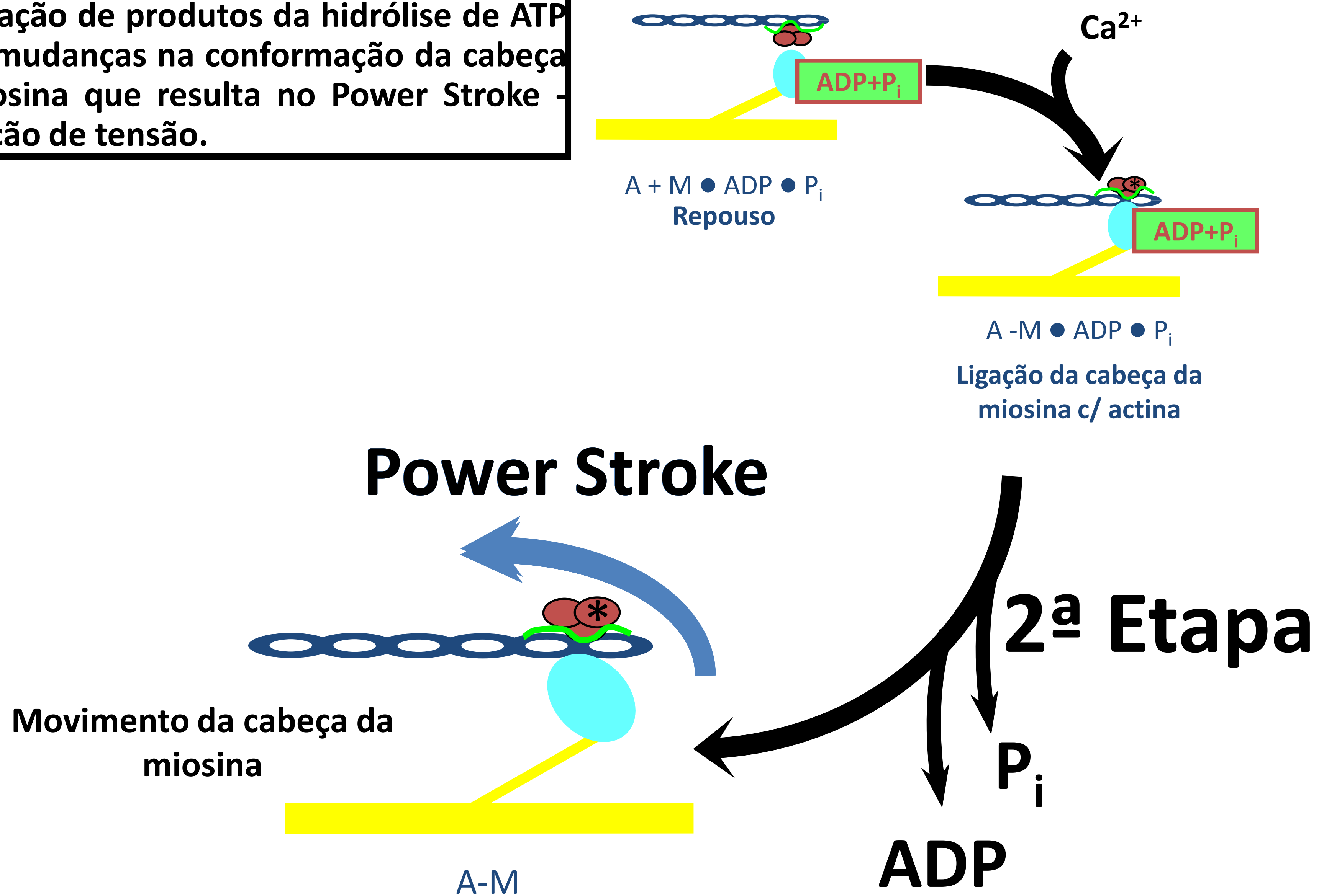
ATIVAÇÃO DA PONTE CRUZADA

<u>1ª Etapa</u>: Liberação de Ca^{2+}- mecanismo regulatório da ligação da cabeça da miosina com filamentos actina.



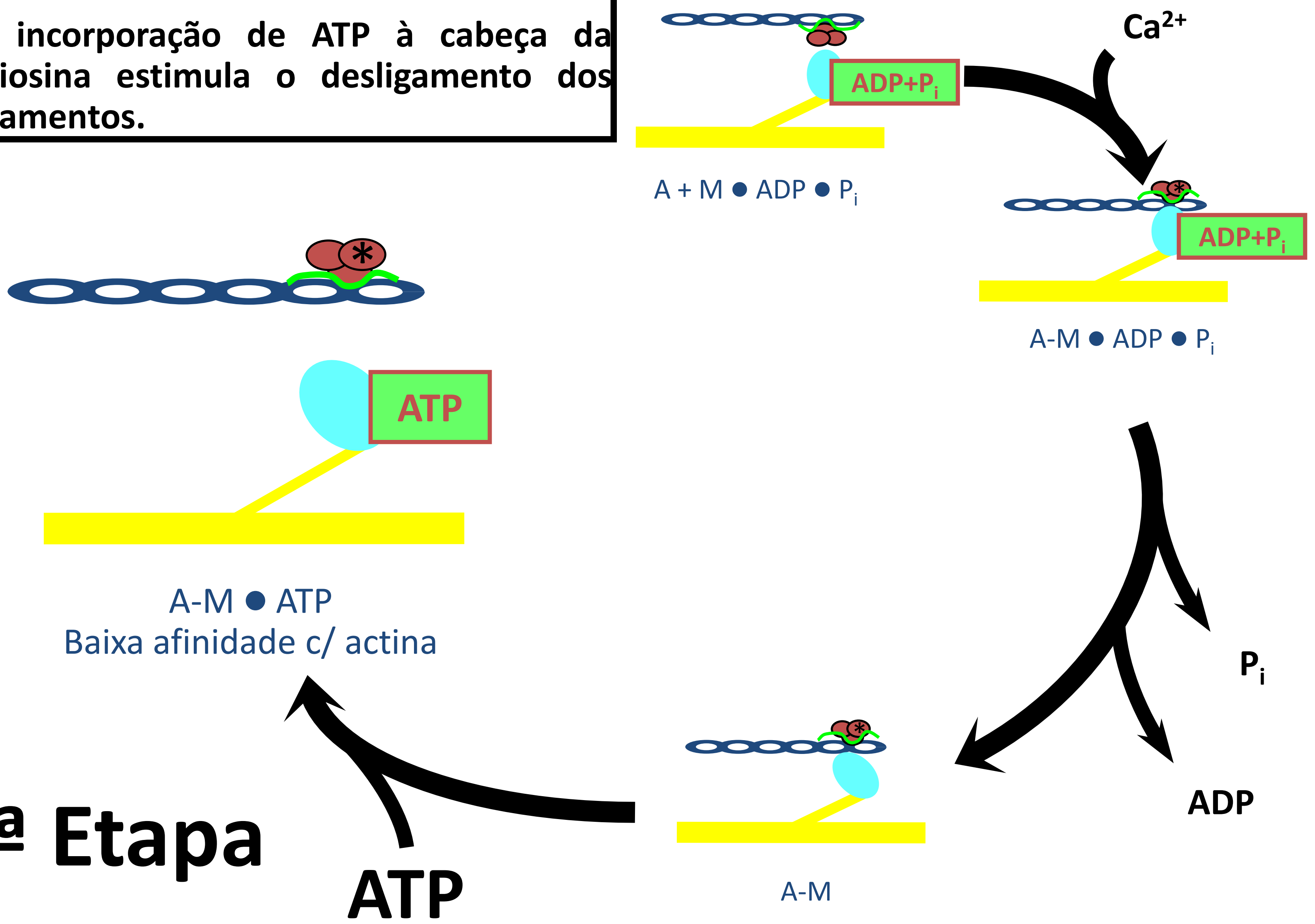
2ª Etapa :

A liberação de produtos da hidrólise de ATP causa mudanças na conformação da cabeça da miosina que resulta no Power Stroke - produção de tensão.

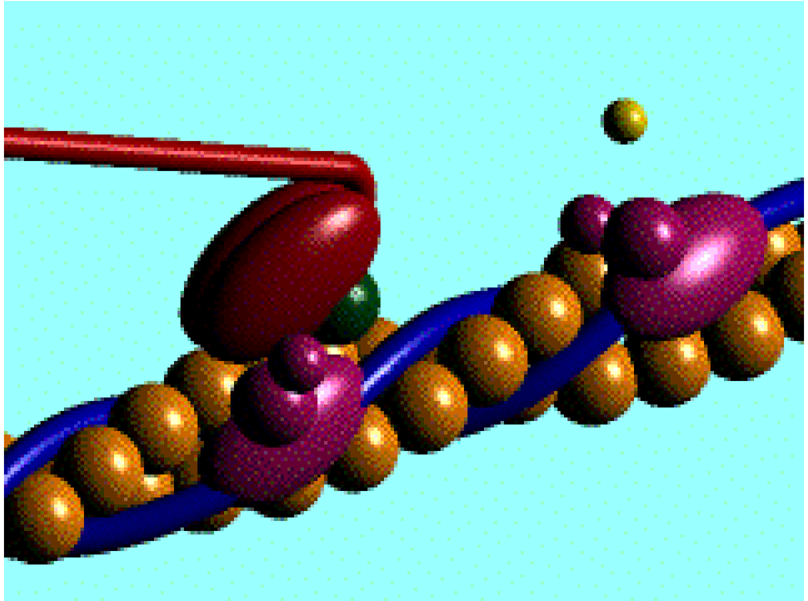


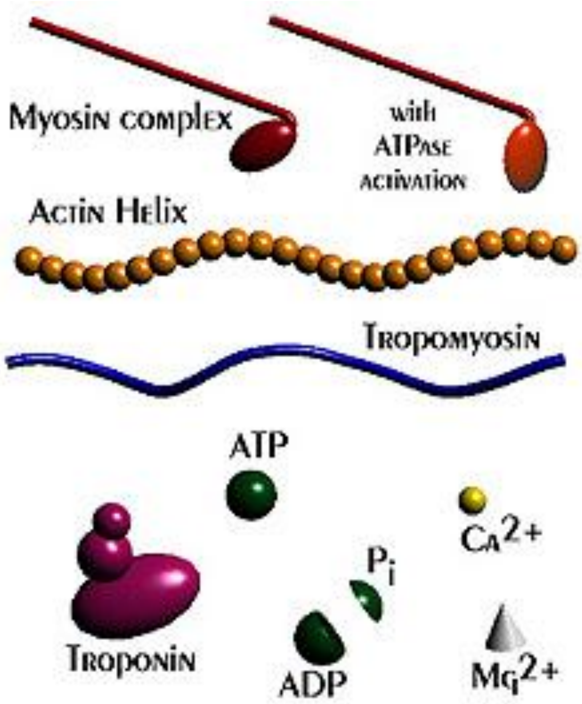
3ª Etapa :

A incorporação de ATP à cabeça da miosina estimula o desligamento dos filamentos.



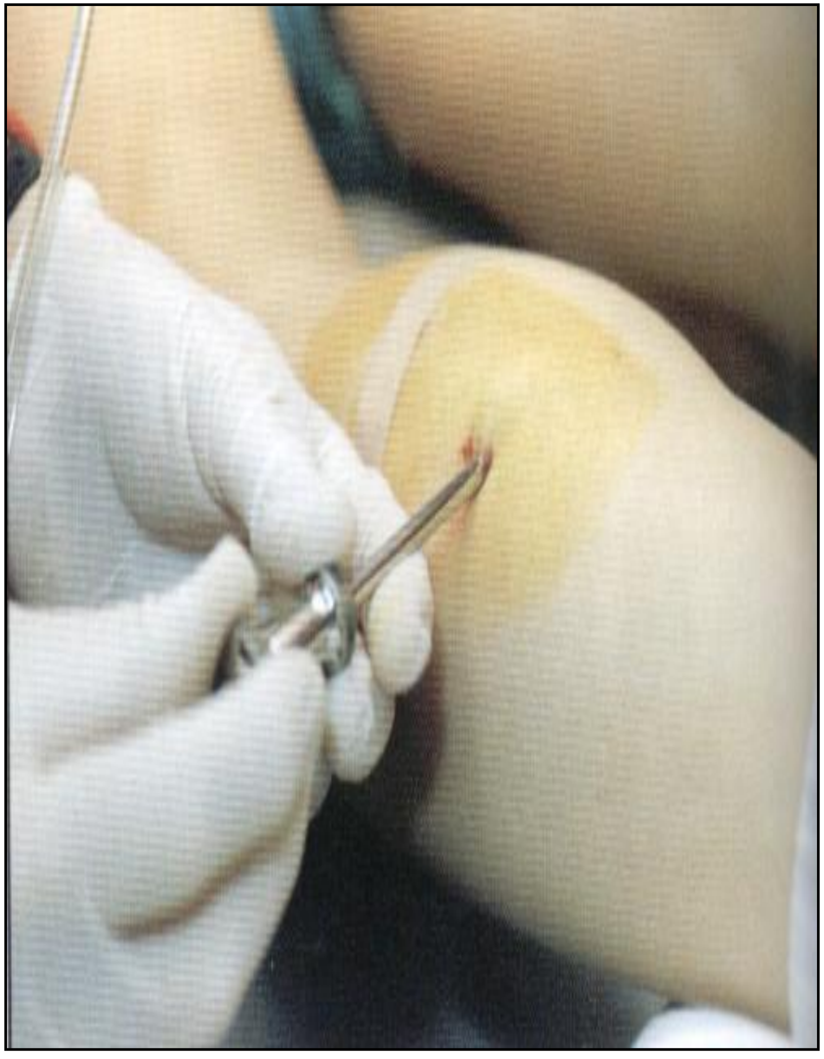
3ª Etapa

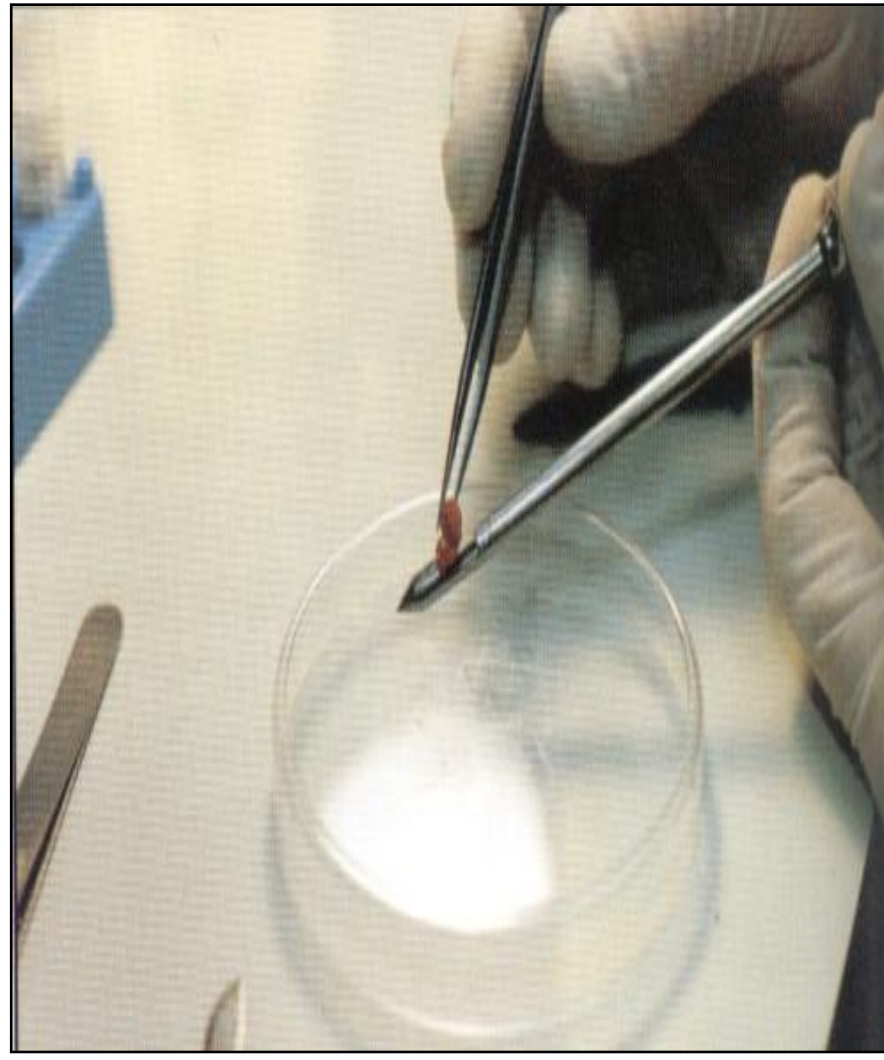



Myosin complex
with ATPase activation
Actin Helix
Tropomyosin
ATP
Ca2+
Pi
Troponin
ADP
Mg2+

Tipos de fibra

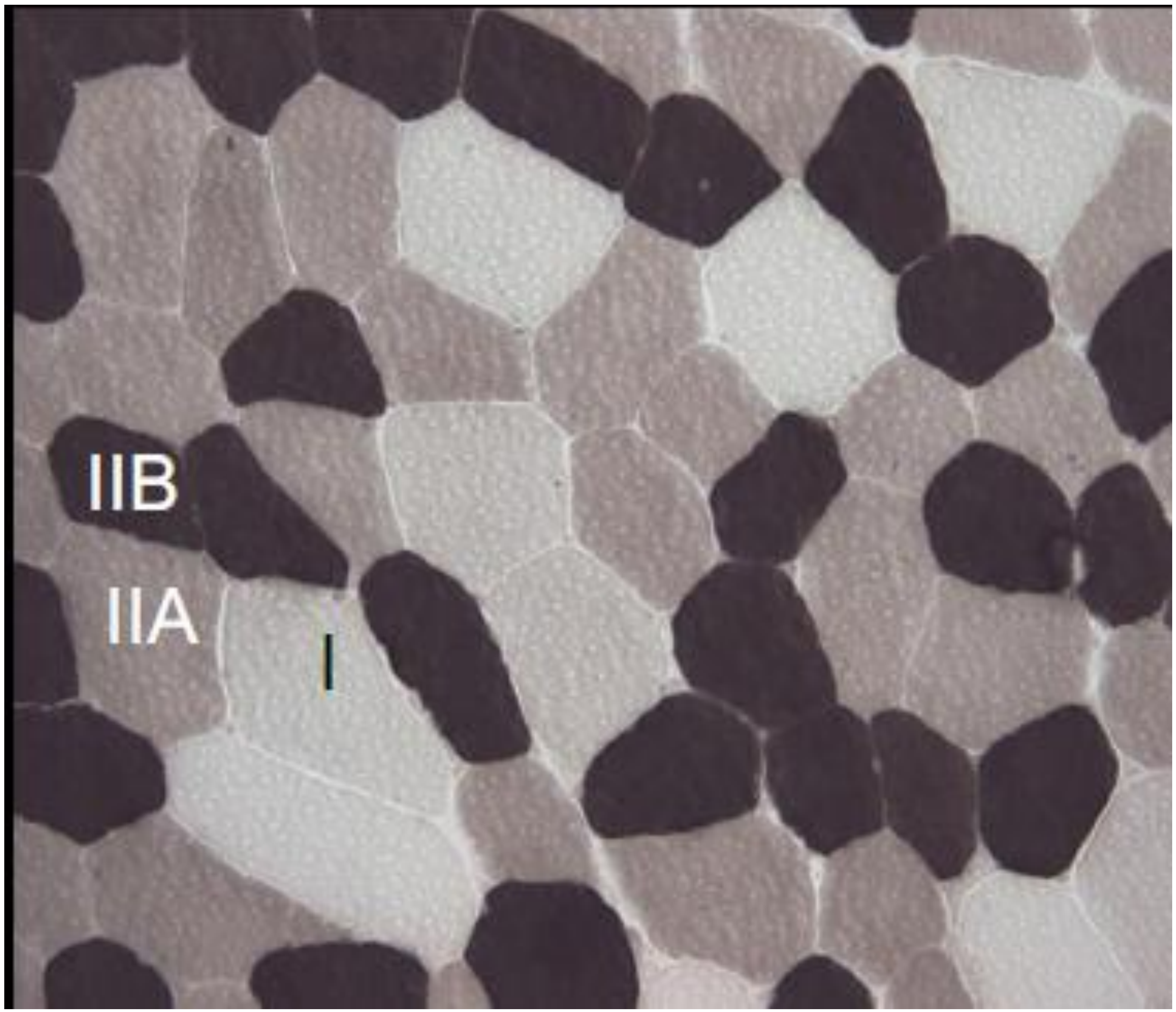
FIBRAS MUSCULARES



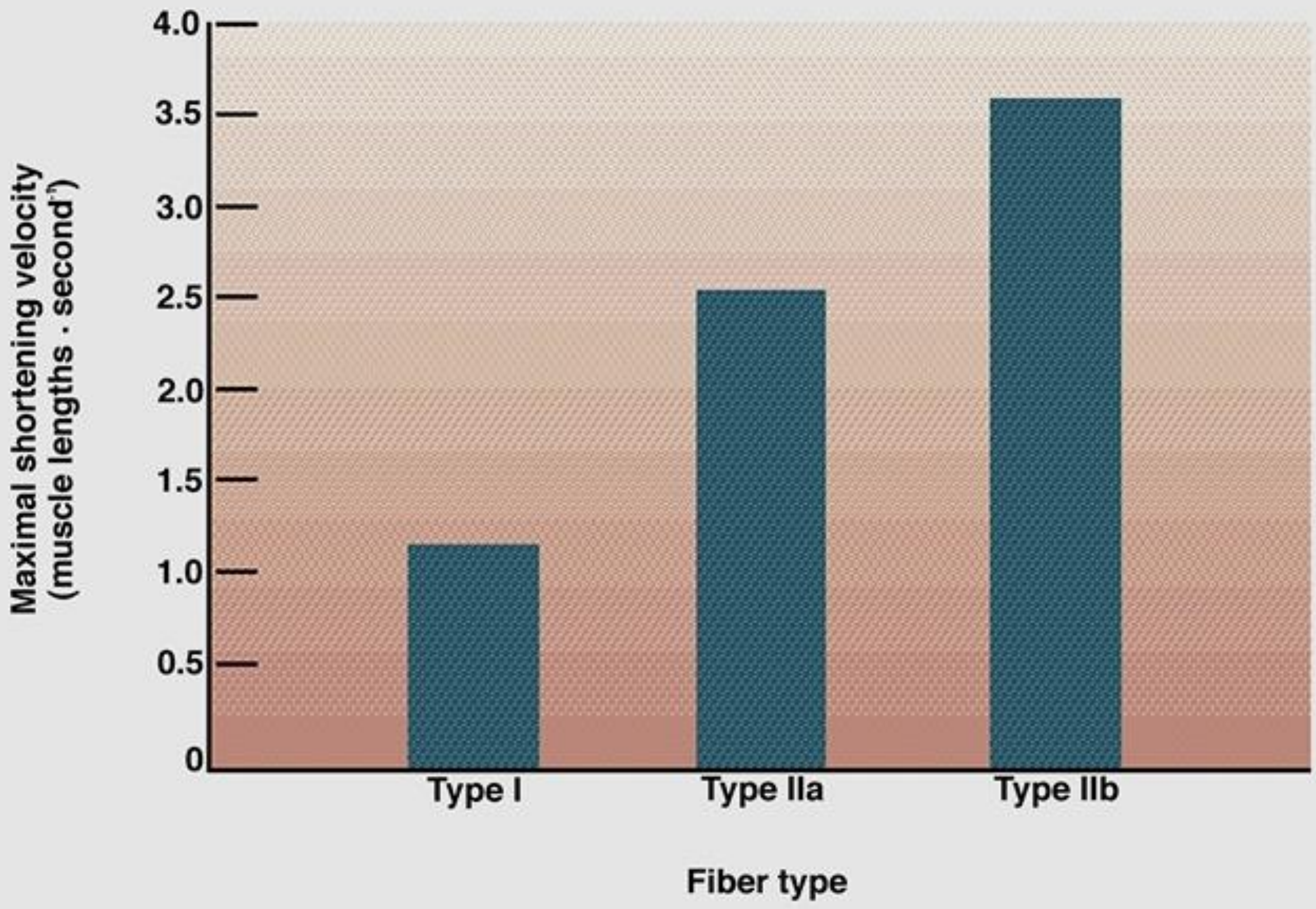


Histoquímica da ATPase muscular

Coloração da ATPase miosínica com pré-incubação em pH= 10.4



Atividade de ATPase



Botinelli et al 1994

Determinação do tipo de fibra

- **A inervação é determinada geneticamente**
- **Após inervadas, as fibras adquirem características inerentes a sua inervação**

Determinação do tipo de fibra

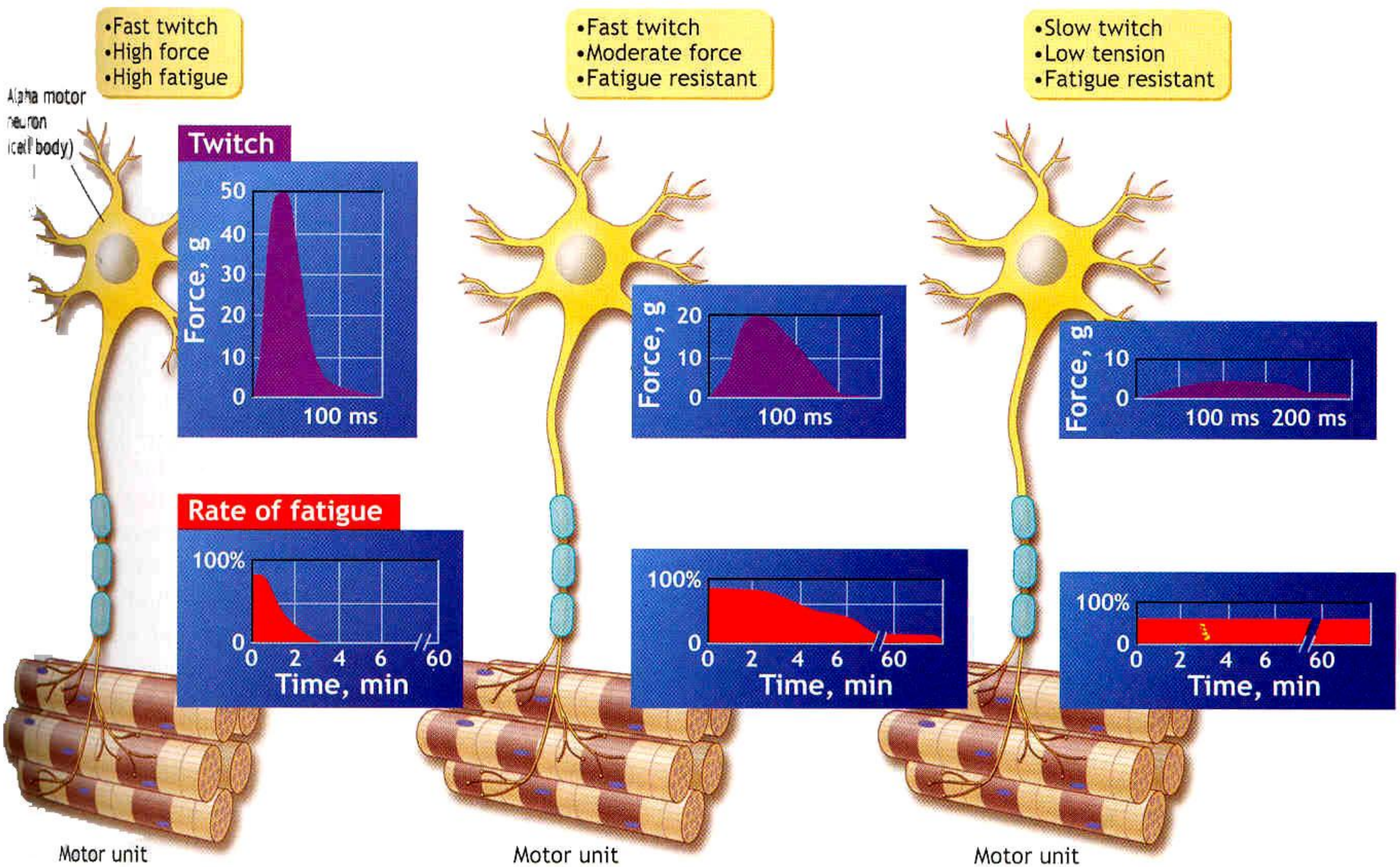
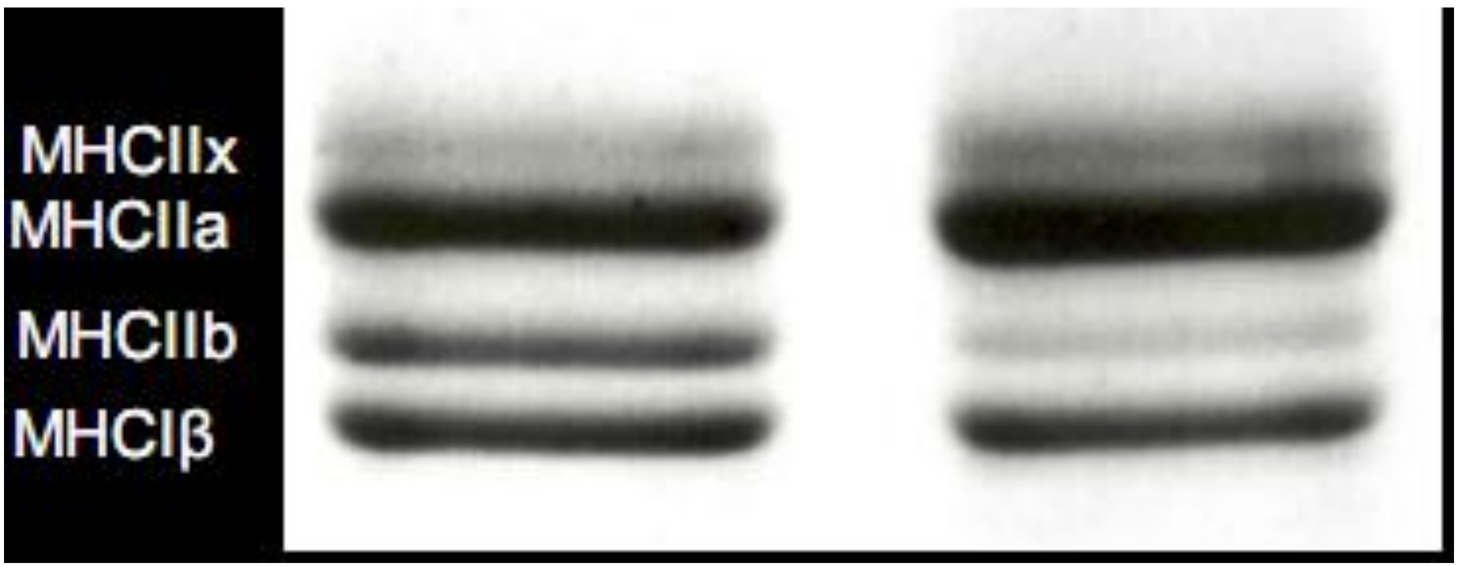


FIGURE 19.13 • Speed, force, and fatigue characteristics of motor units. "Phasic" motor neurons fire rapidly with short bursts; "tonic" motor neurons fire slowly but continuously.

Composição molecular MHC

Eletroforese



Fibras Puras x Híbridas

- As fibras musculares são distintas em:
  - Puras
  - Híbridas

Fibras Puras

- As fibras são puras quando expressam somente uma isoforma da miosina de cadeia pesada:

FIBRA	Isoforma MCP
– I	Iβ
– IIA	IIa
– IID/X	IId/x
– IIB	IIb (animais)

Fibras Híbridas

- As fibras são híbridas quando expressam mais de uma isoforma da miosina de cadeia pesada:

FIBRA	Isoforma MCP
– I C	Iβ > IIa
– II C	Iβ < IIa
– II AB	IIa > IIx
– II BA	IIa < IIx

MUDANÇAS NA TIPOLOGIA DA FIBRA

I ← IC ←$\overset{?}{}$ II C II AC II A II Ab II AB II Ab II B

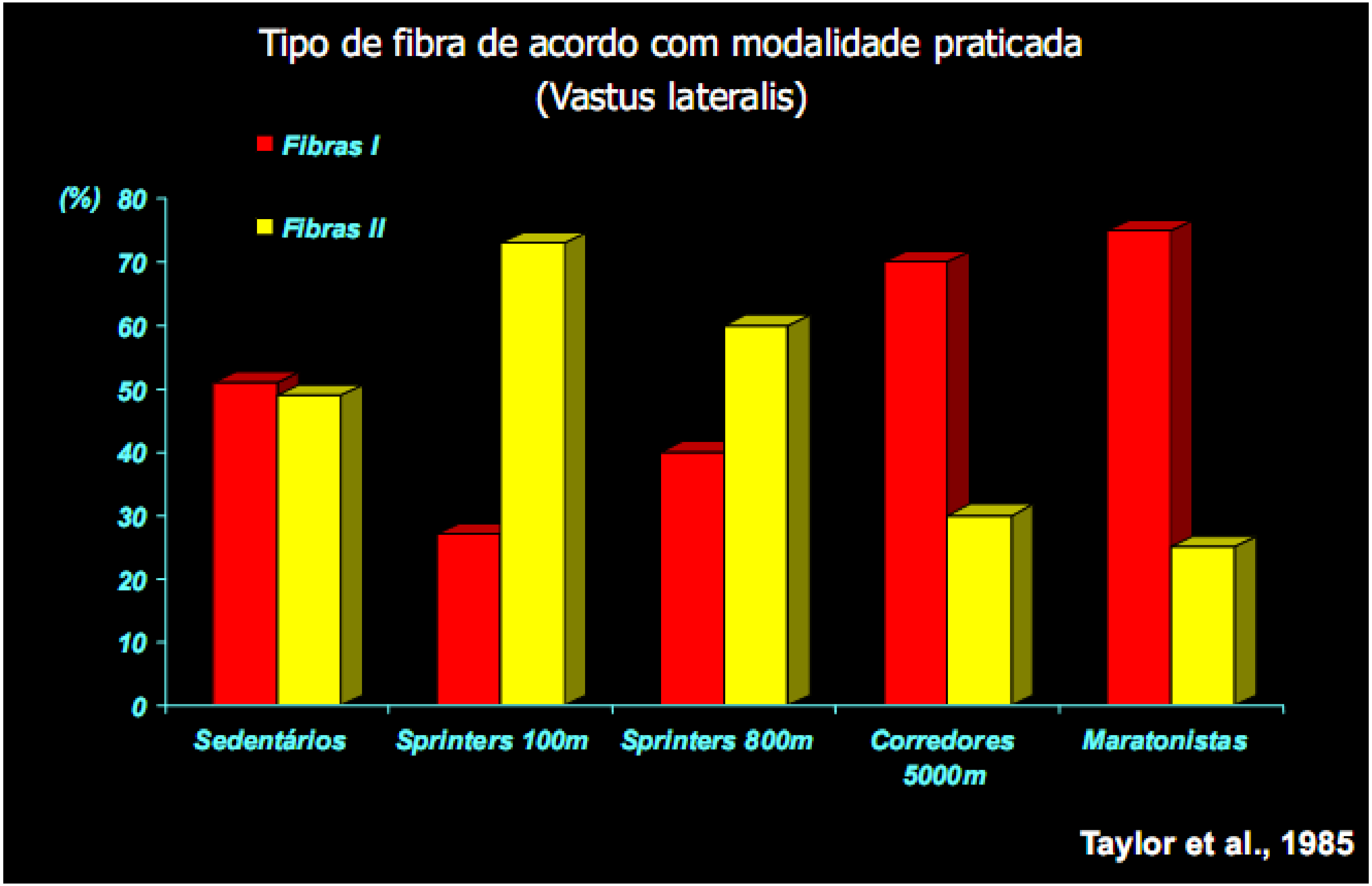
?

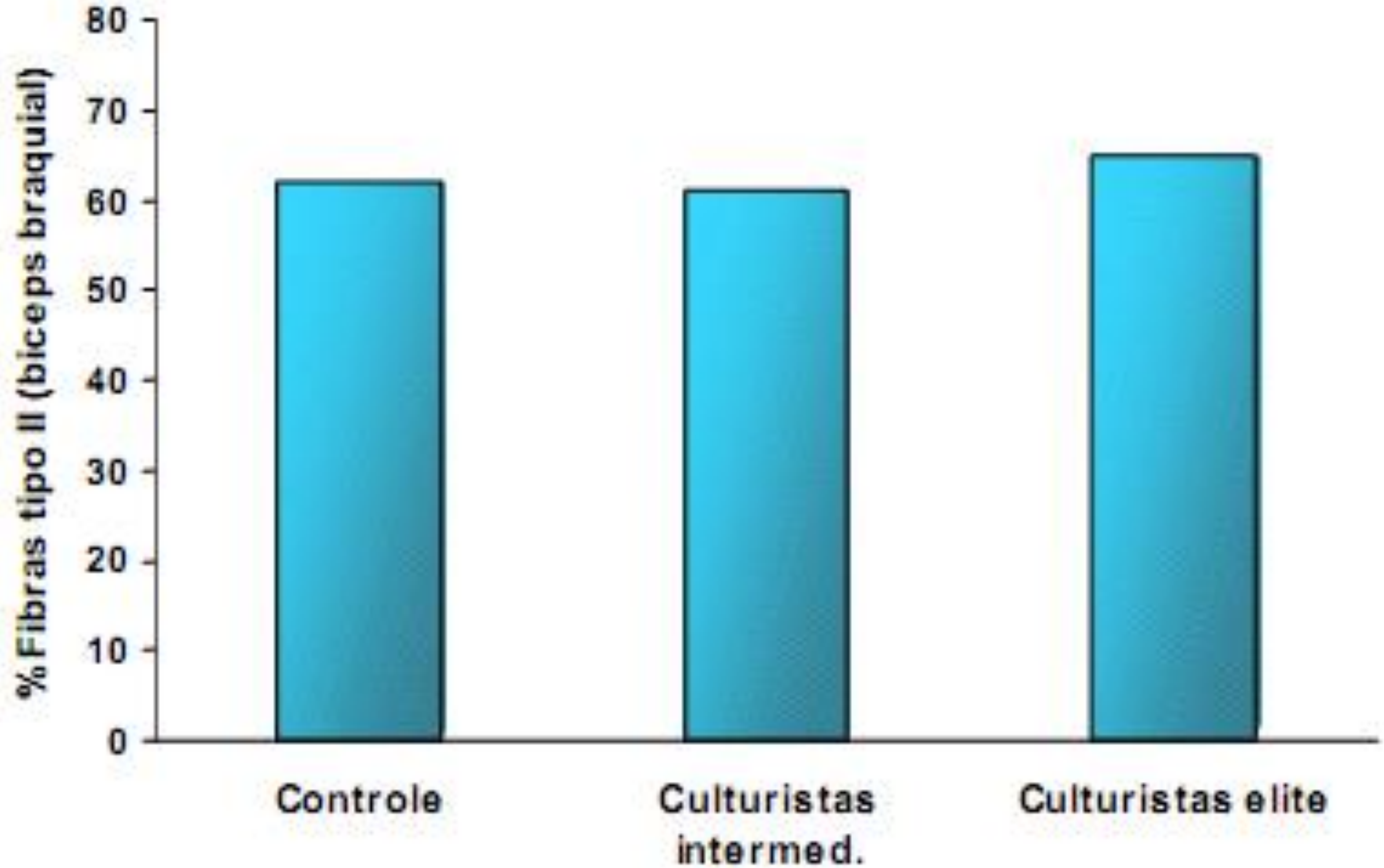
I ⟵ IC ⟵ II C ⟵ II AC ⟵ II A ⟵ II Ab ⟵ II AB ⟵ II Ab ⟵ II B

Fibras e treinamento

- Estudos transversais
- Estudos longitudinais

Fibras e treinamento





MacDougall 1984

Fibras e treinamento de força

Table 1 Physical characteristics of the subjects

	Number	Age (years)	Training experience (years)	Body weight (kg)	Height (cm)
Bodybuilders	8	26.1 ± 4.2*	8.5 ± 5.0	91.0 ± 6.2*	1.78 ± 5.1
Physical education students	7	20.6 ± 1.5	0.0	73.4 ± 8.5	1.78 ± 4.7

Values are means ± SD. * Statistically significant between the groups, $P < 0.05$

Table 2 Fibre type distribution determined by myofibrilar ATPase histochemistry

	I	IIC	IIA	IIAX	IIX
Bodybuilders	42.1 ± 13.3	6.7 ± 8.5	33.2 ± 16.4	16.5 ± 12.8	1.7 ± 3.3
Physical education students	37.5 ± 7.3	2.3 ± 3.2	36.2 ± 7.3	6.5 ± 6.0	17.0 ± 11.4*

Values are means ± SD. * Statistically significant between the groups, $P < 0.05$

Table 4 Fibre type composition, determined by MHC isoform analysis of single fibres

	I	I/IIA	IIA	IIA/IIX	IIX	I/IIA/IIX
Bodybuilders	35.1 ± 9.2	18.9 ± 11.0*	38.8 ± 6.9*	7.2 ± 10.0	0.0	0.0
Physical education students	40.3 ± 6.2	8.8 ± 4.4	30.7 ± 5.9	15.4 ± 8.1	4.1 ± 2.6*	0.7 ± 0.9*

Values are means ± SD. * Statistically significant between the groups, $P < 0.05$

Kessidis et al 2008

Fibras e treinamento de força

Table 1. *CSA of fibers obtained before and after 12 wk of resistance training*

MHC Isoform	No. of Fibers		Fiber CSA, μm^2	
	Pre	Post	Pre	Post
I	86 (42%)	69 (42%)	5,337 ± 152^{a}	6,933 ± 228*
I/IIa	8 (4%)	0	6,635 ± 332^{b}	
IIa	62 (30%)	90 (55%)	6,702 ± 178^{b}	8,691 ± 190*
IIa/IIx	45 (22%)	4 (3%)	6,683 ± 239^{b}	8,697 ± 526*
IIx	3 (2%)	0	7,436 ± 280^{b}	

Fiber cross-sectional area (CSA) values are means ± SE. No. of fibers indicates the number of fibers isolated from pre- and posttraining muscle biopsies with the corresponding percentage of total pre- or posttraining fibers in parentheses. *Significant difference ($P < 0.05$) between pre- and posttraining fibers containing similar myosin heavy chain (MHC) isoforms. For the pretraining fibers, any 2 means with different superscript letters are significantly different ($P < 0.05$).

Jefrey et al 2002

Fibras e treinamento de força

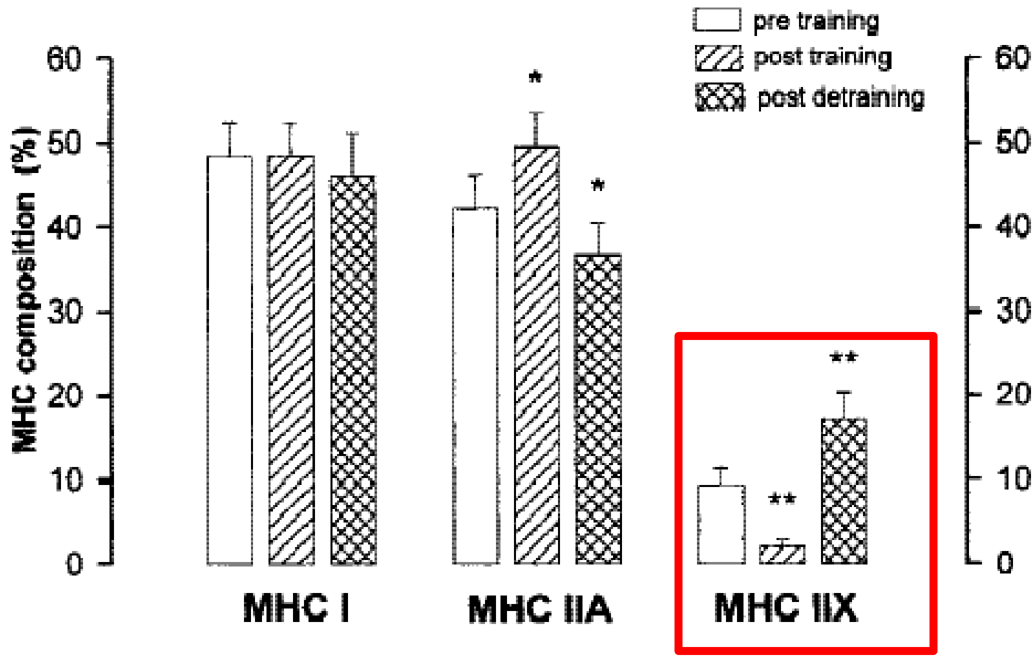


FIGURE 2. The relative distribution of MHC isoforms. Open bars: pretraining; hatched bars: post-resistance training; solid bars: post-detraining. Asterisk (*): significant difference for MHC IIA distribution, post-detraining < pretraining < post-resistance training ($P < 0.05$); double asterisk (**): significant difference ($P < 0.01$) for MHC IIX distribution, post-detraining > pretraining > post-resistance training. Values are mean ± SE ($N = 9$).

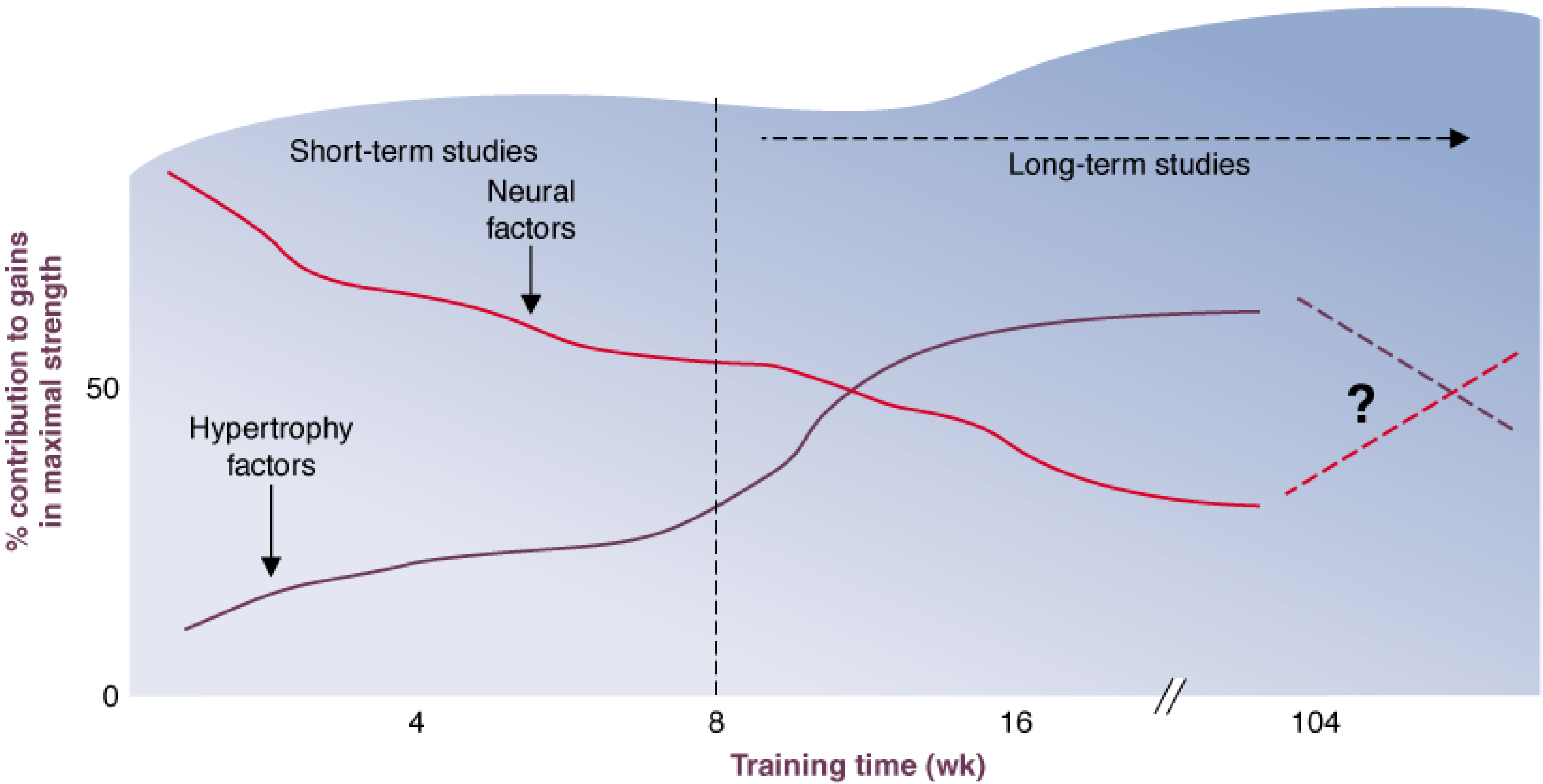
Andersen et al 200

Adaptações neuromusculares

ADAPTAÇÕES AO TREINAMENTO DE FORÇA

- Adaptações Neurais
  - Sistema Nervoso
  - Função

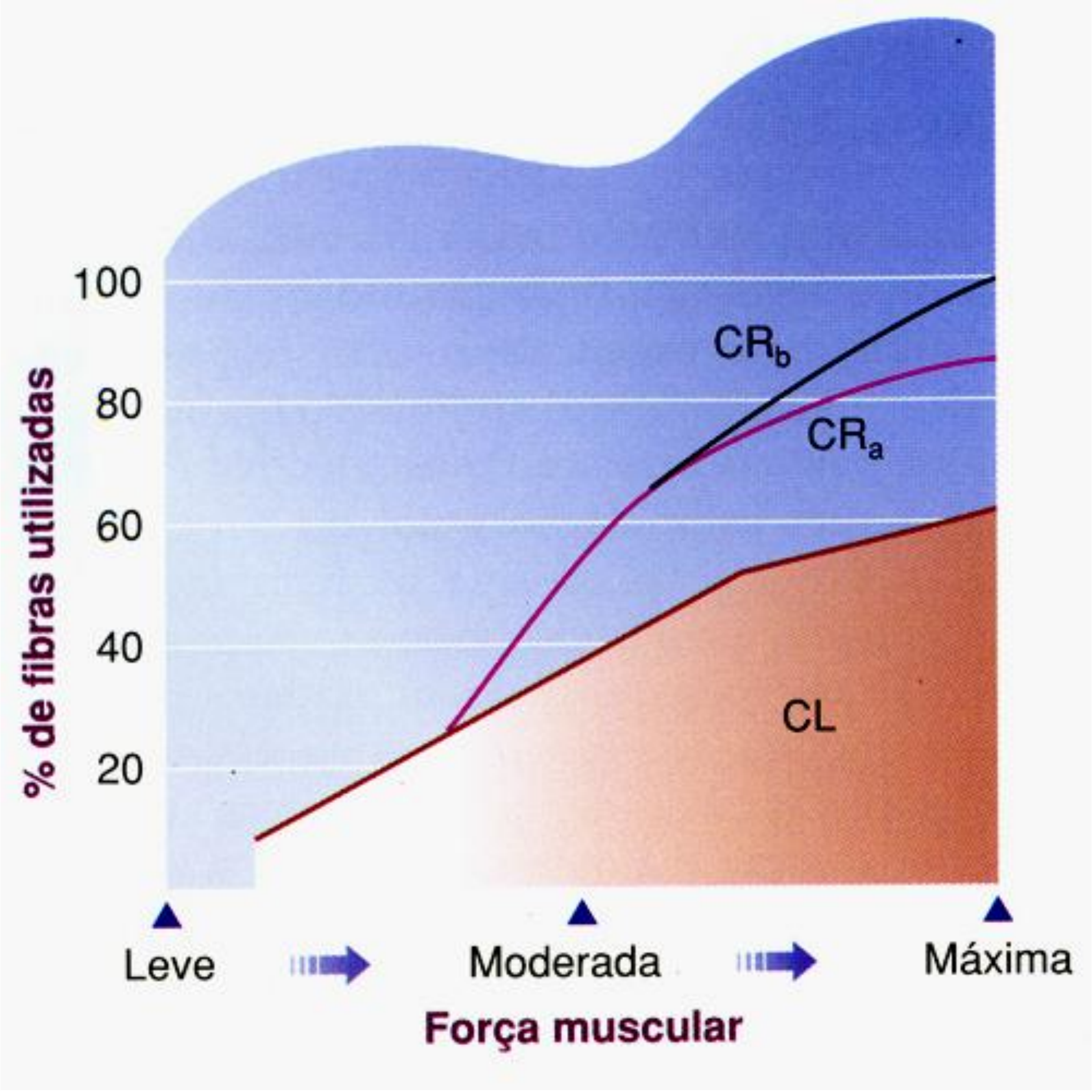
- Adaptações Morfológicas
  - Tecido Muscular
  - Estrutura


Short-term studies
Long-term studies
Neural factors
Hypertrophy factors
?
% contribution to gains in maximal strength
50
0
4
8
16
104
Training time (wk)

Adaptação Neural

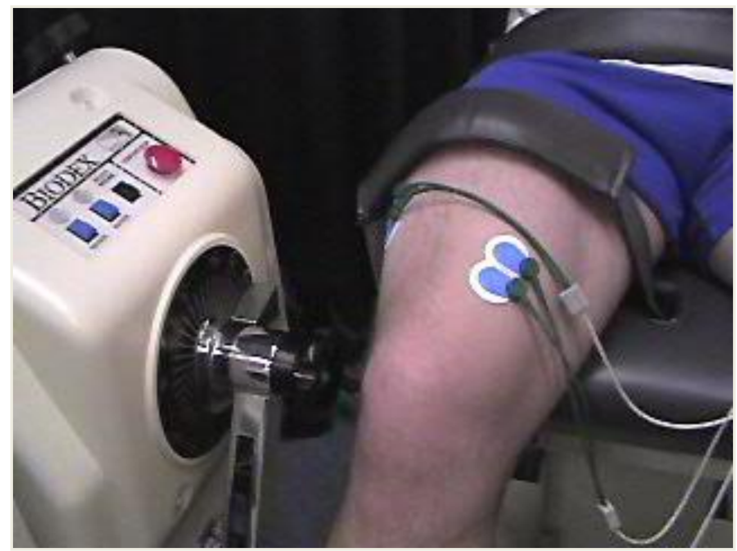
- Forma como o musculo é ativado
- Quantidade da musculatura
- Qualidade da musculatura

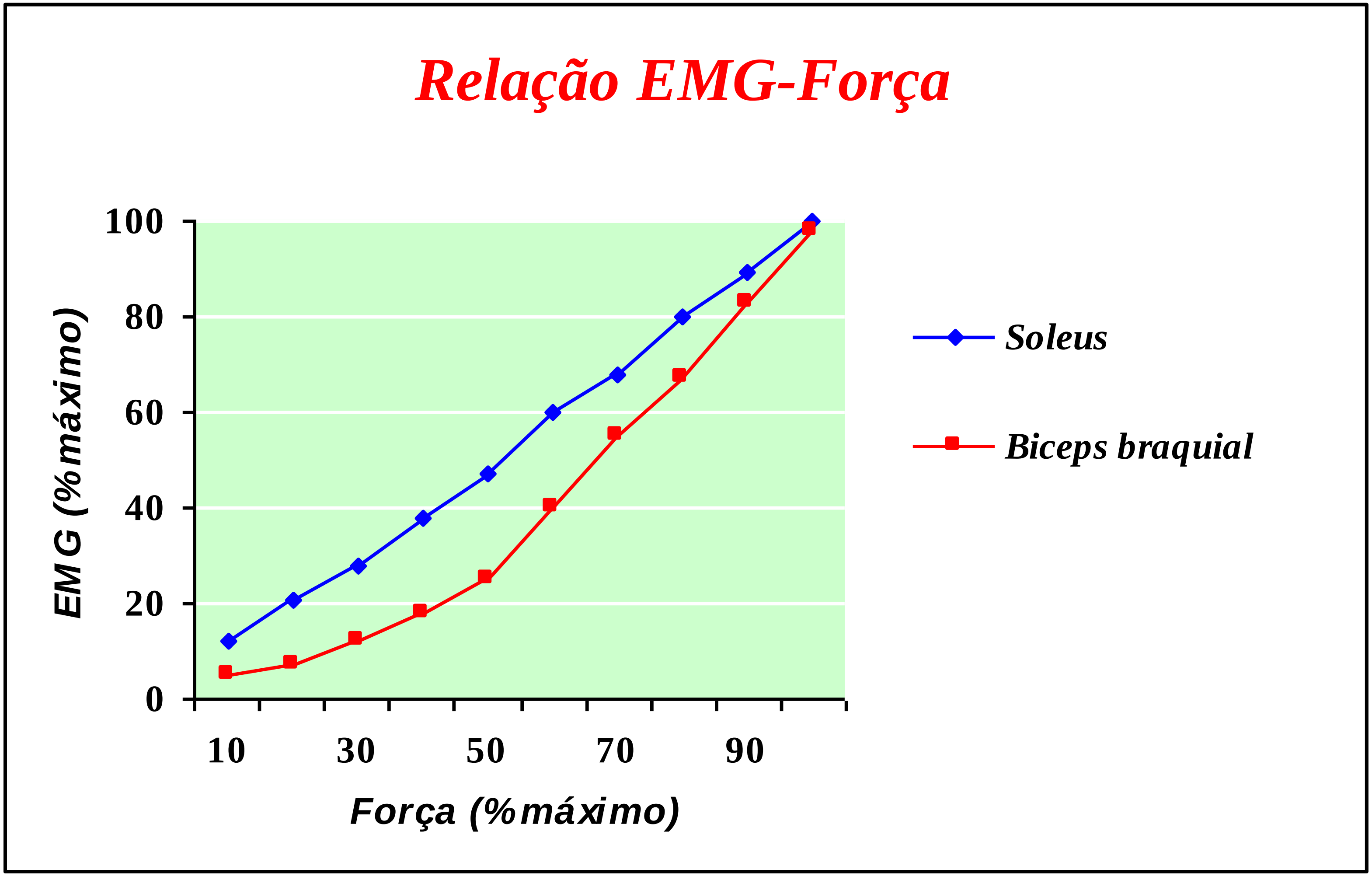
RECRUTAMENTO DAS FIBRAS



Atividade eletromiográfica (EMG)

"Soma da atividade elétrica das UMs recrutadas e de suas frequências de ativação"





Bigland-Ritchie (1981)

Adaptações neurais

Estágios iniciais do ganho de força

- *aumentos na atividade eletromiográfica*
- *alteração na co-contração dos músculos antagonistas*
- *alteração na ativação dos sinergistas*
- *aumento contralateral de força*

Adaptações neurais

- **Estágios iniciais do ganho de força**

aumentos na atividade EMG

- ➢14 semanas
- ➢>85% RM
- ➢Movimentos balísticos

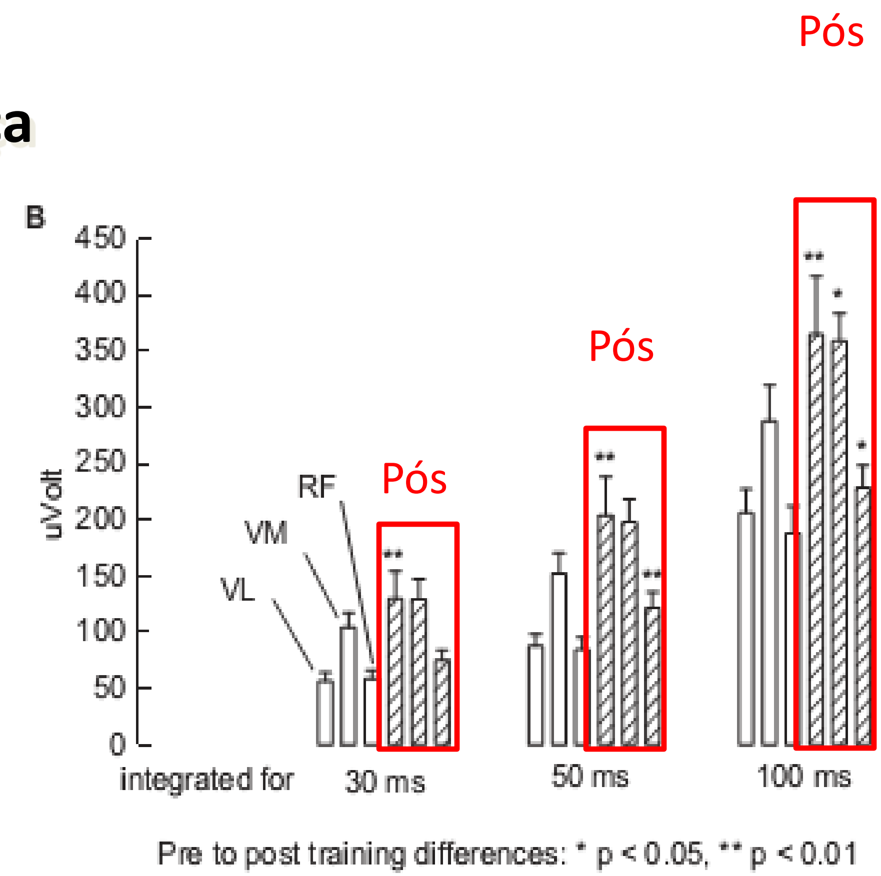


Figure 2.1.6 Contractile RFD (a) and neuromuscular activity (EMG amplitude) (b) obtained before (open bars) and after (hatched bars) 14 weeks of periodized heavy -resistance strength training. Open bars = before training, hatched bars = aftertraining. Post > pre: *P < 0.05, **P < 0.01. Note the gain in RFD following training, which was accompanied by marked increases in neuromuscular activity. Data adapted from Aagaard *et al.* (2002b)

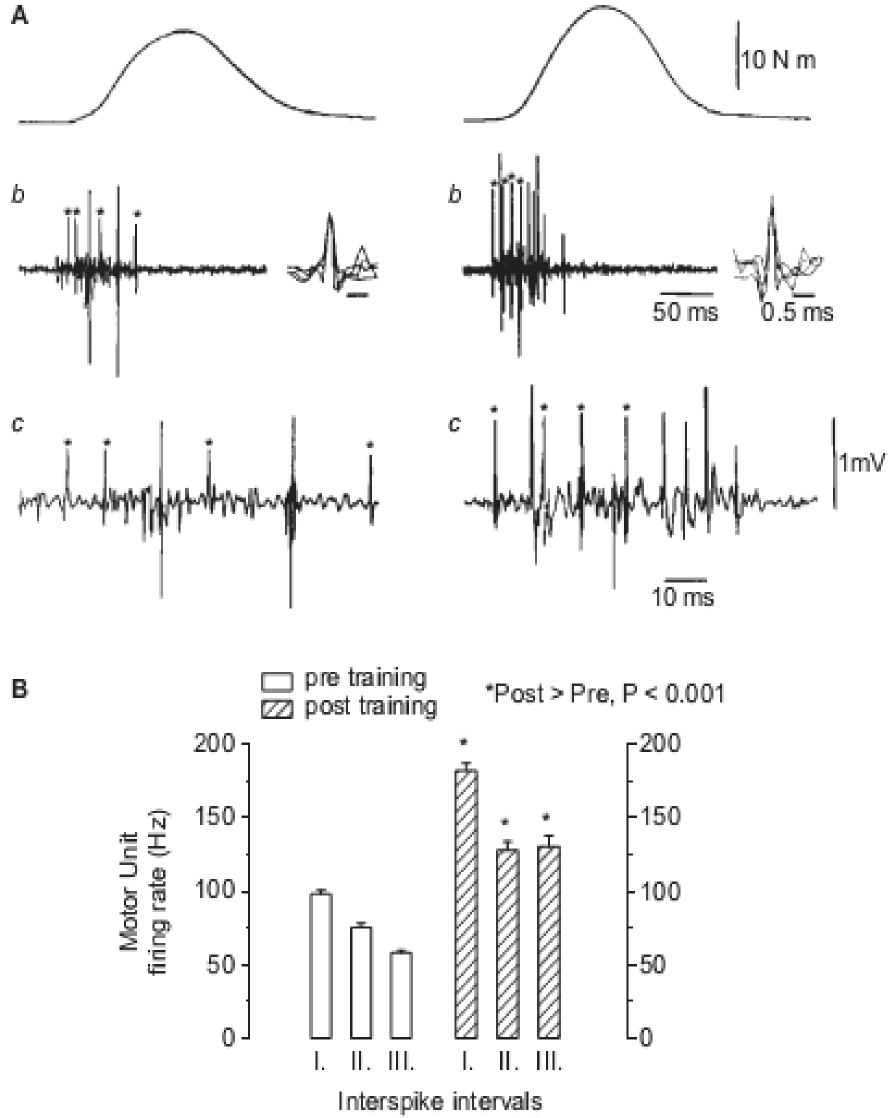
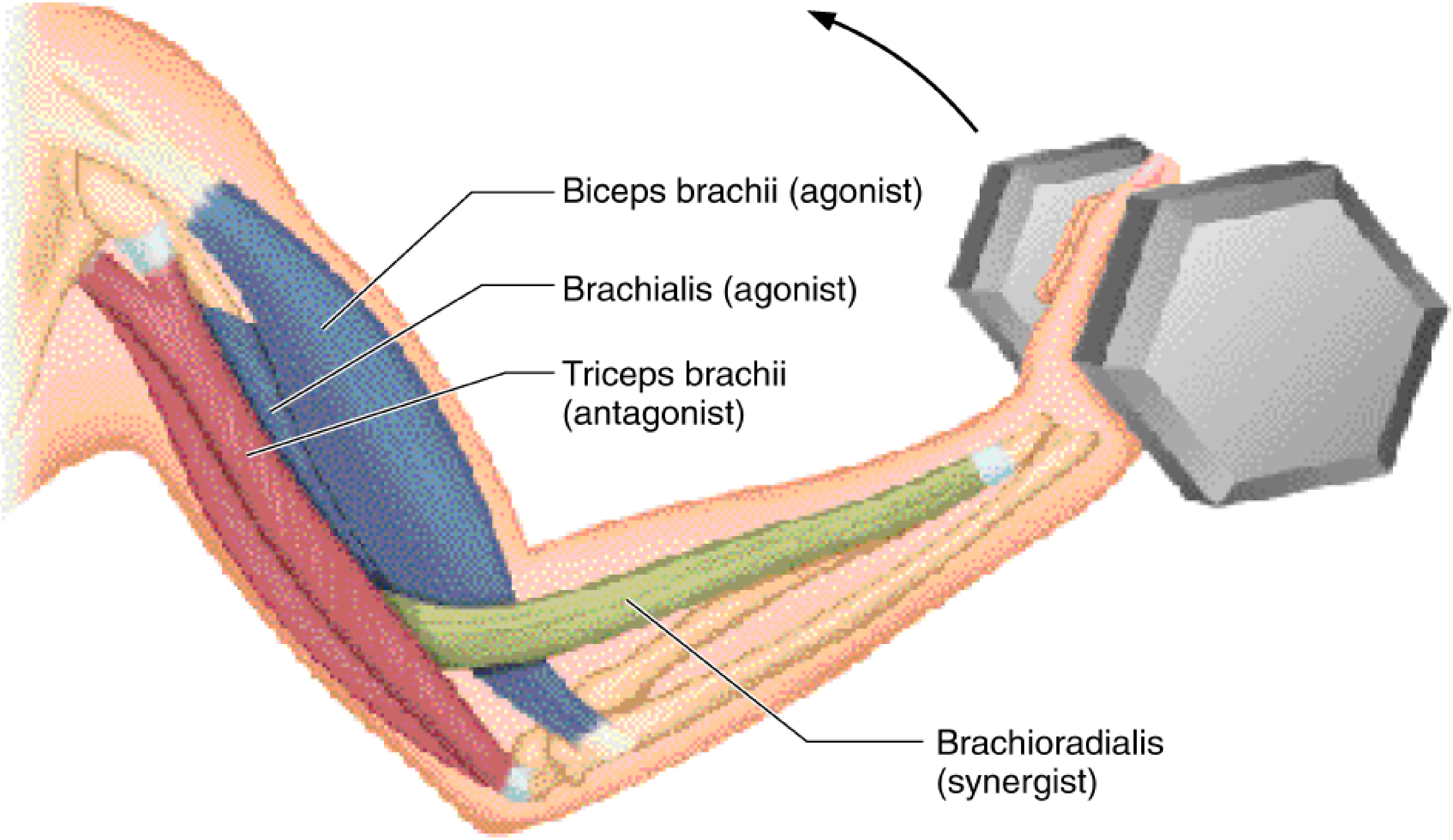
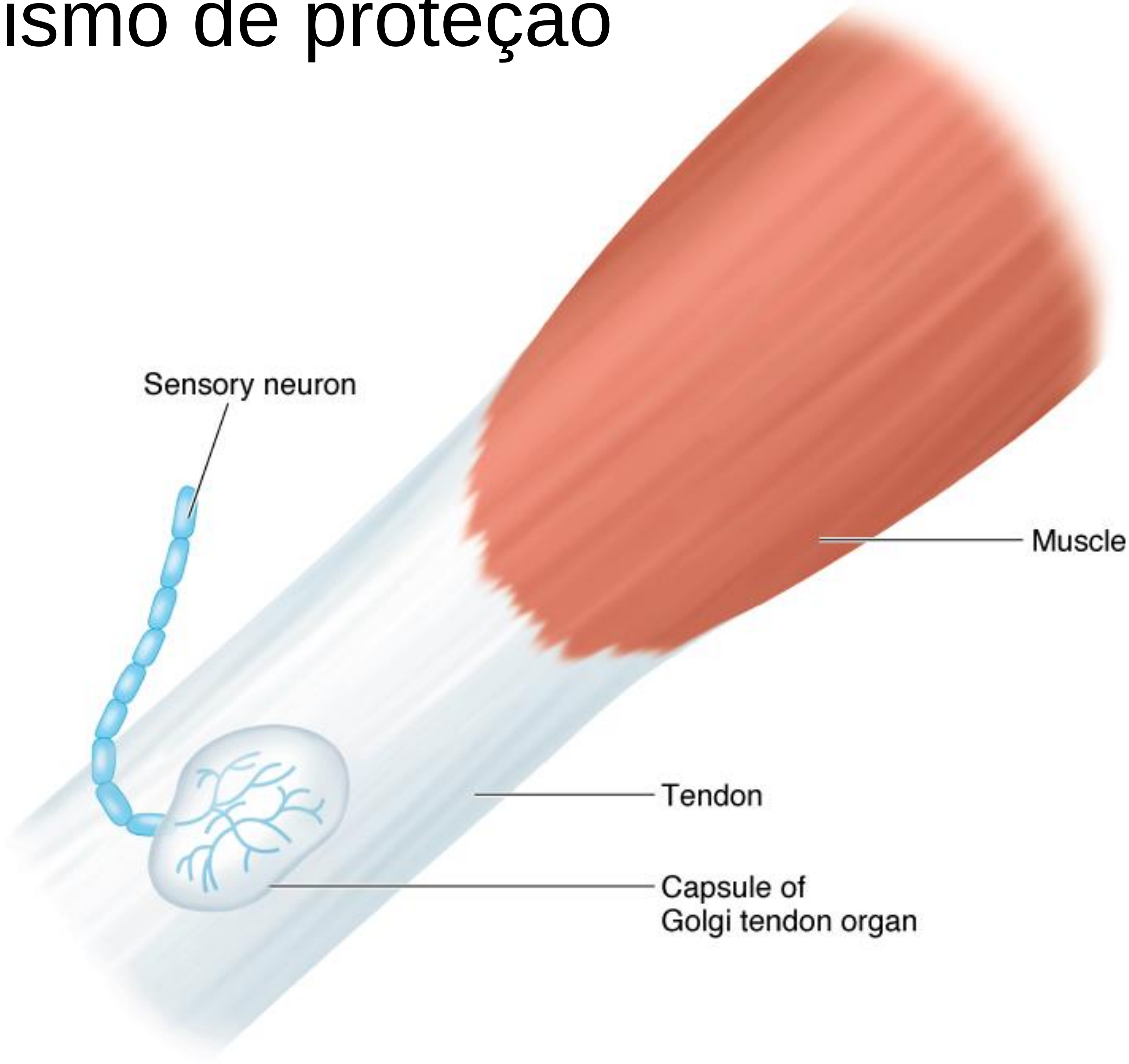


Figure 2.1.8 (a) Motor unit f ring patterns recorded in the ankle dorsif exor muscles (TA) during maximal ballistic dynamic contractions (40% MVC load) before (left-side graphs) and after (right -side graphs) 12 weeks of ballistic -type strength training. Note that shorter inter-spike intervals and a higher sustained f ring rate were observed following training. From Van Cutsem, Duchateau and Hainaut (1998). (b) Motor unit f ring rates measured at the onset of contraction before (open bars) and after (hatched bars) ballistic -type strength training. Note the marked increase (~100%) in motor unit f ring frequency. Data reported by Van Cutsem, Duchateau and Hainaut (1998)

Coordenação intermuscular



Mecanismo de proteção



Adaptações neurais

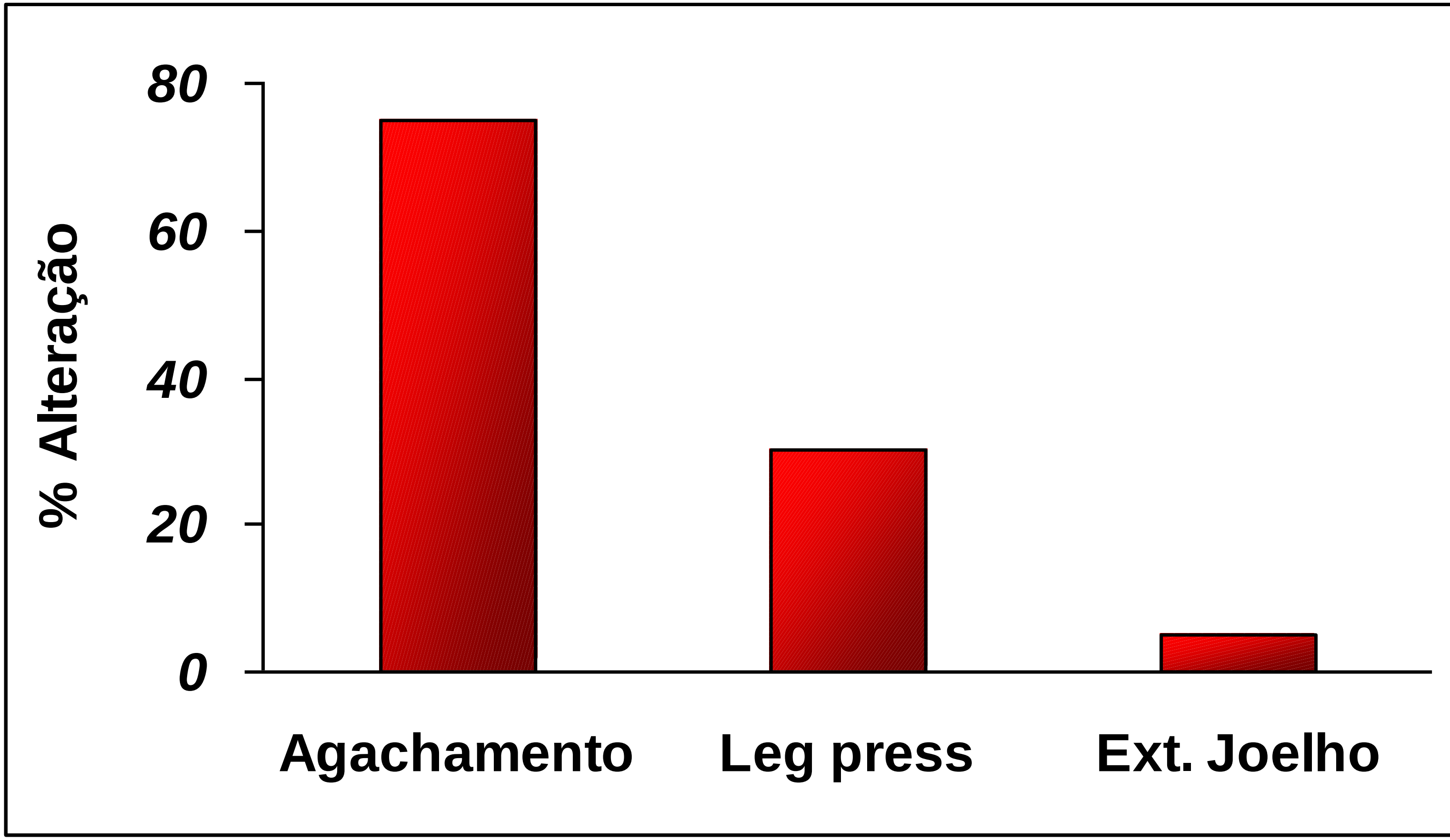
- Especificidade

  padrão de movimento

  posição

  tipo de contração

  velocidade de movimento

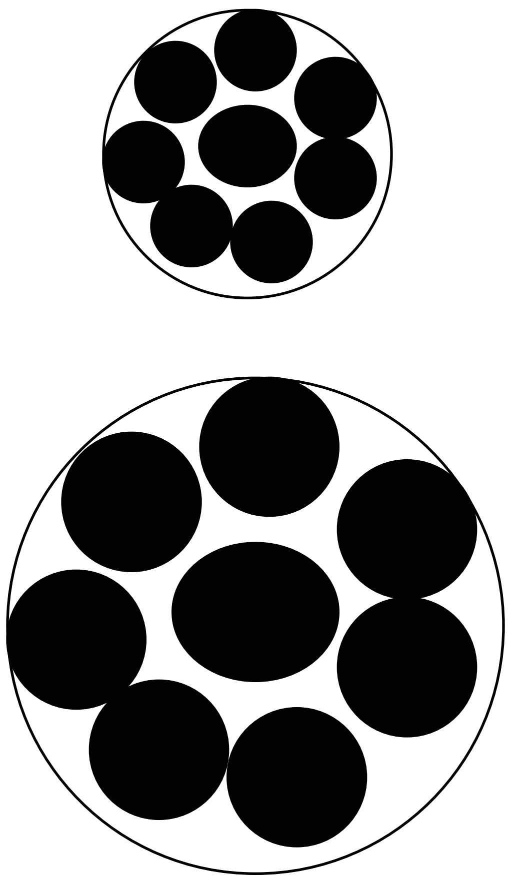


Sale (1980)

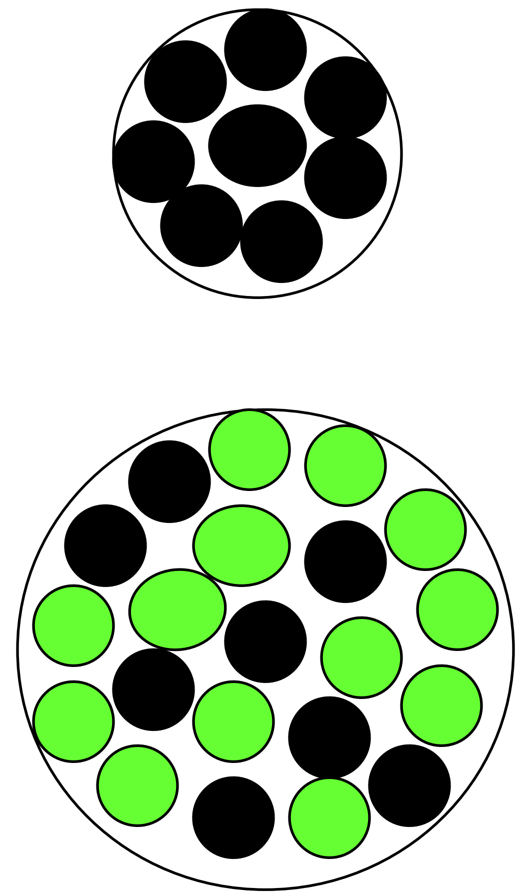
Hipertrofia e Hiperplasia

Hipertrofia e Hiperplasia

Hipertrofia



Hiperplasia



Hiperplasia?

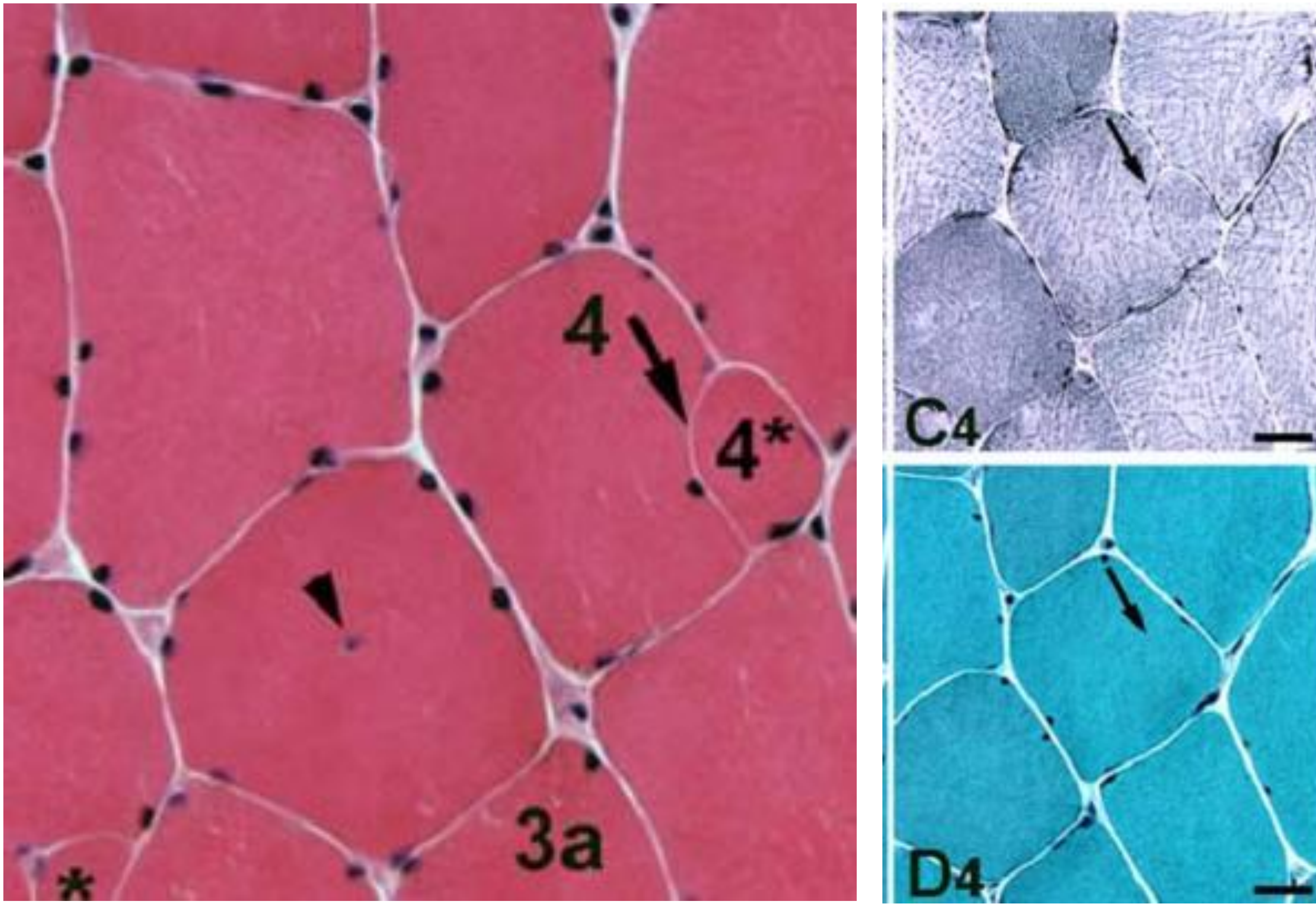
- Divisão da célula/fibra muscular e/ou proliferação de células satélites
- Modelos animais
- Humanos

HIPERPLASIA

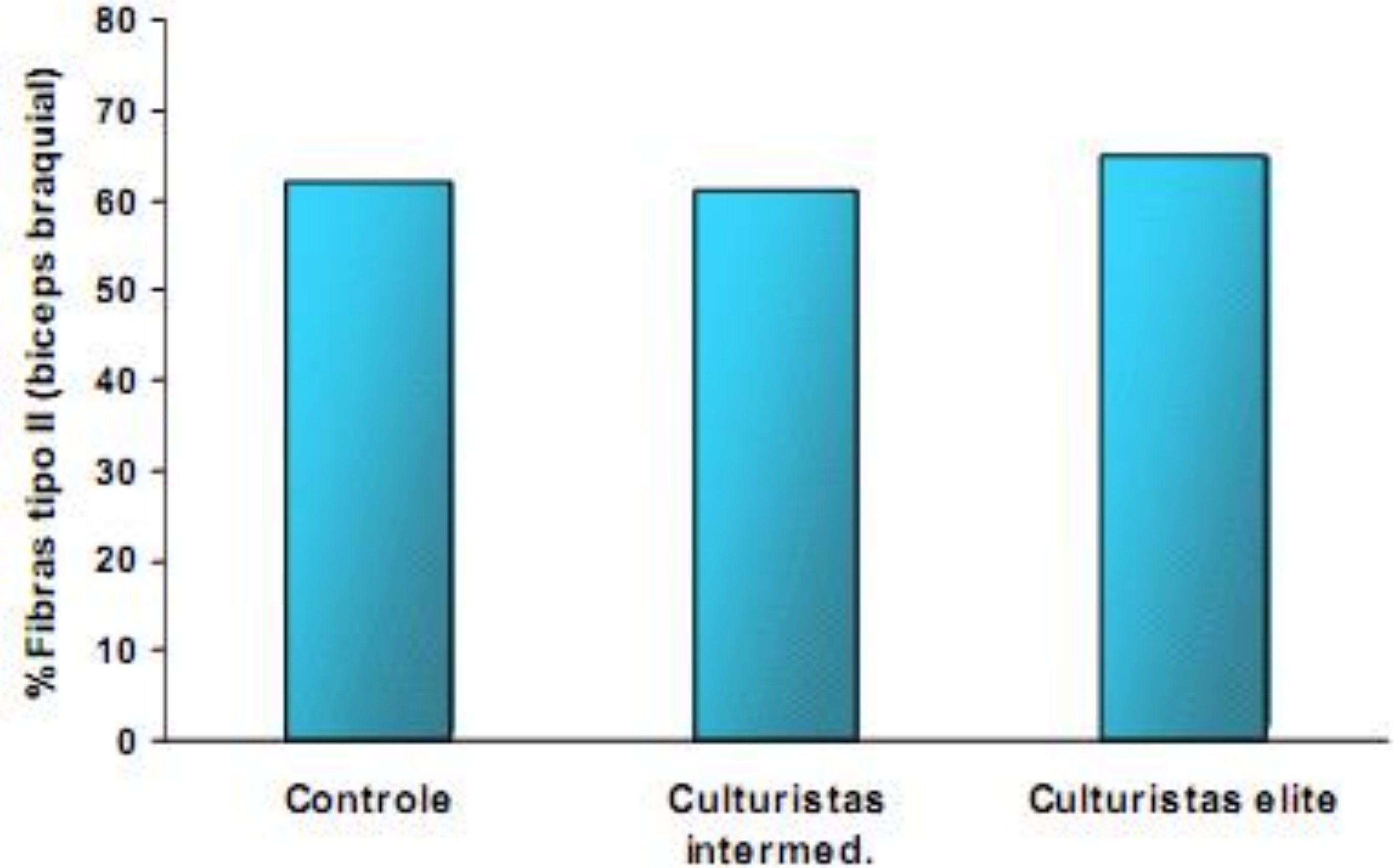
- Estudo com aves
  - Modelos não usuais (24h x 7d)

(GONYEA, 1980)

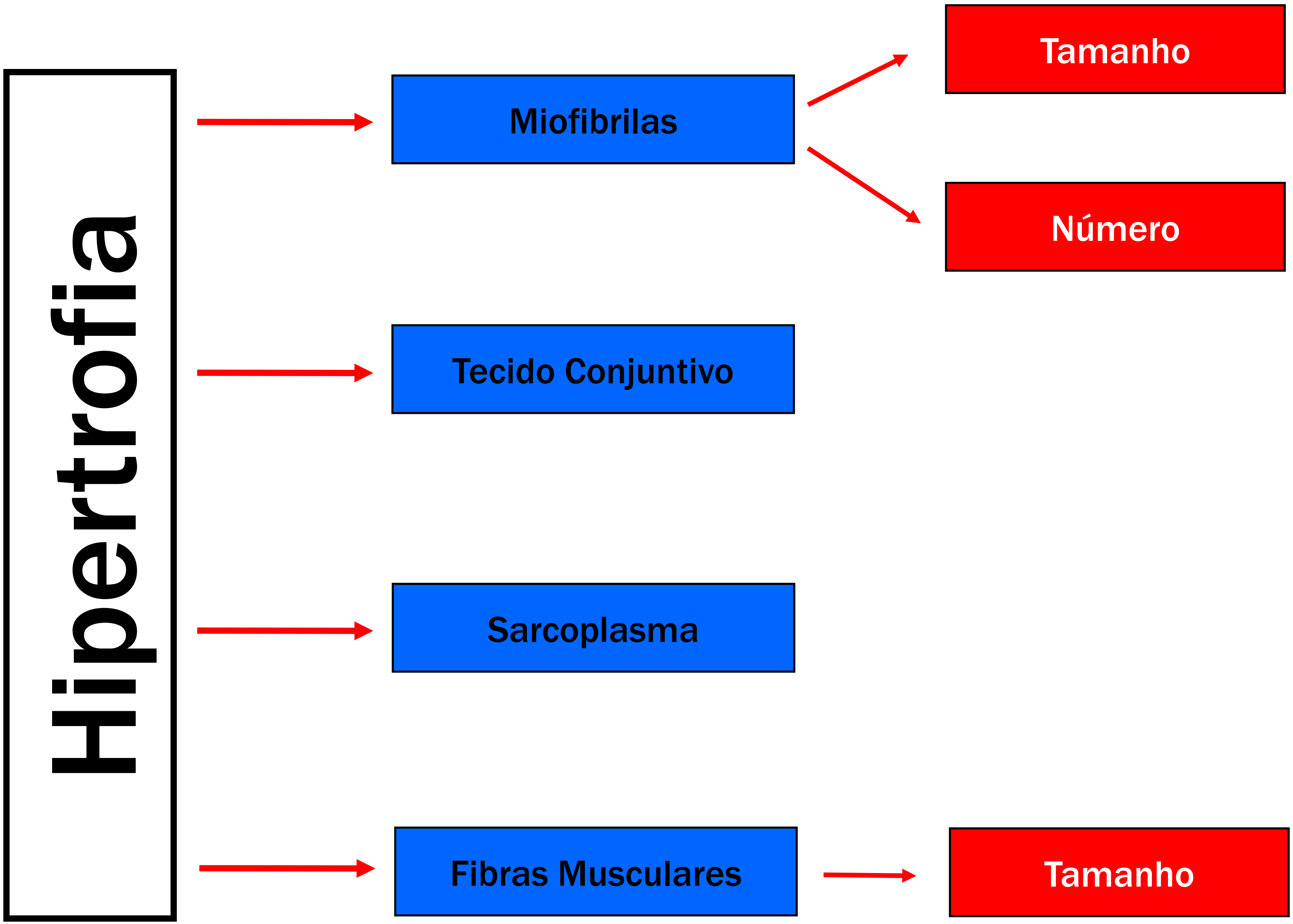
HIPERPLASIA



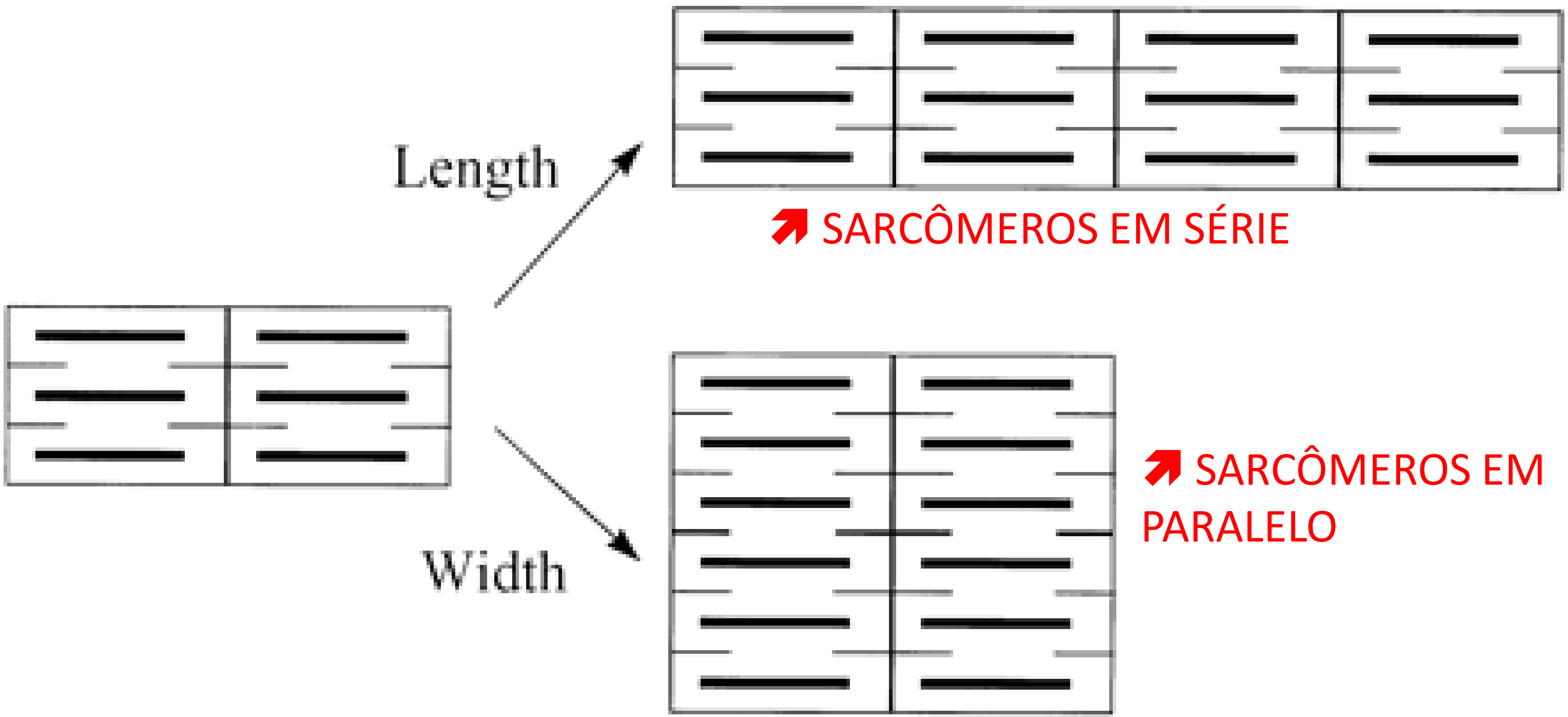
HIPERPLASIA



MacDougall 1984


Hipertrofia
Miofibrilas
Tamanho
Número
Tecido Conjuntivo
Sarcoplasma
Fibras Musculares
Tamanho

HIPERTROFIA



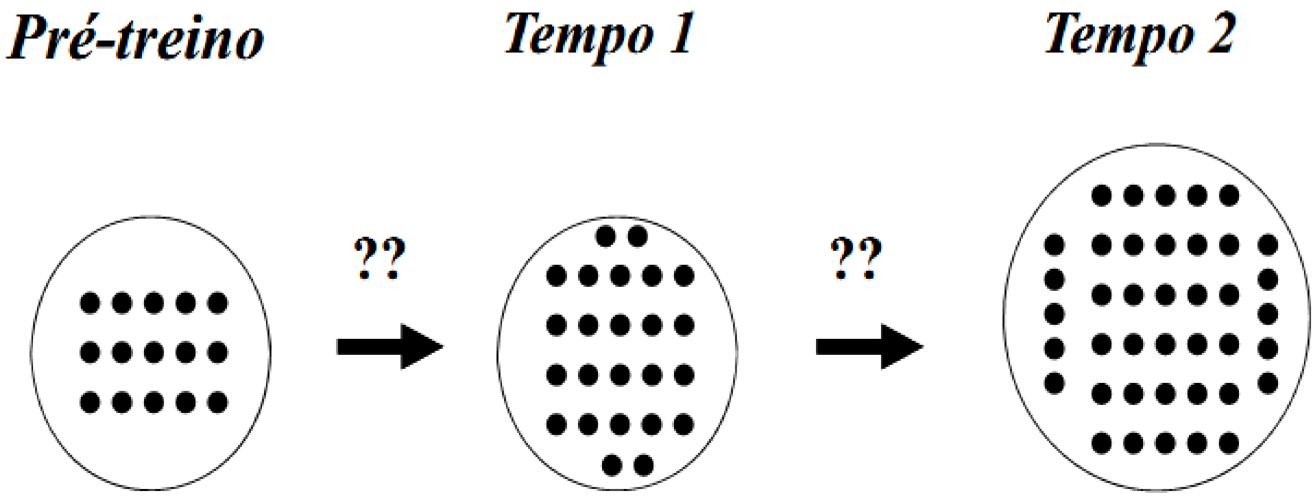
↗ SARCÔMEROS EM SÉRIE

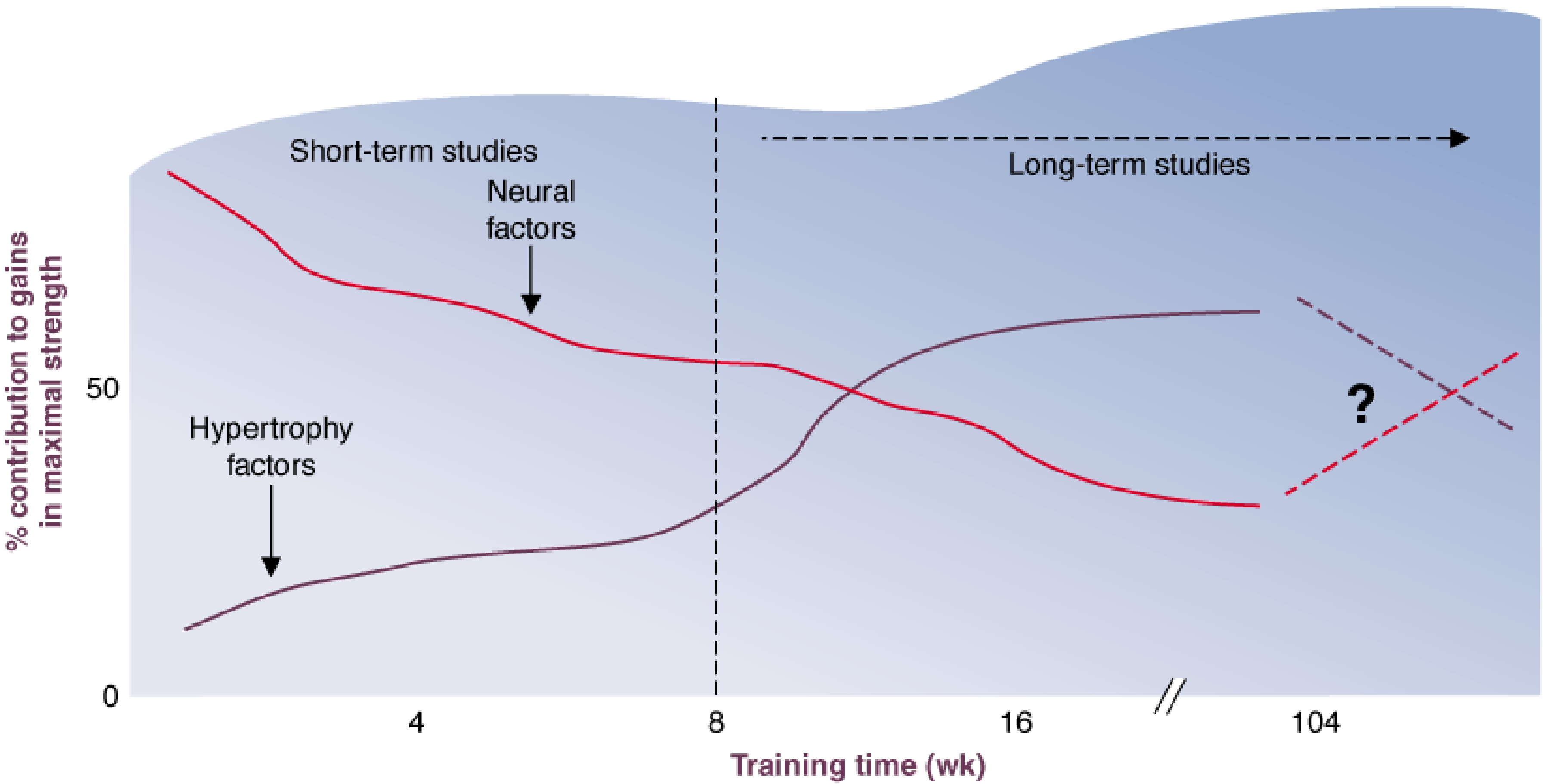
↗ SARCÔMEROS EM PARALELO

Hipertrofia

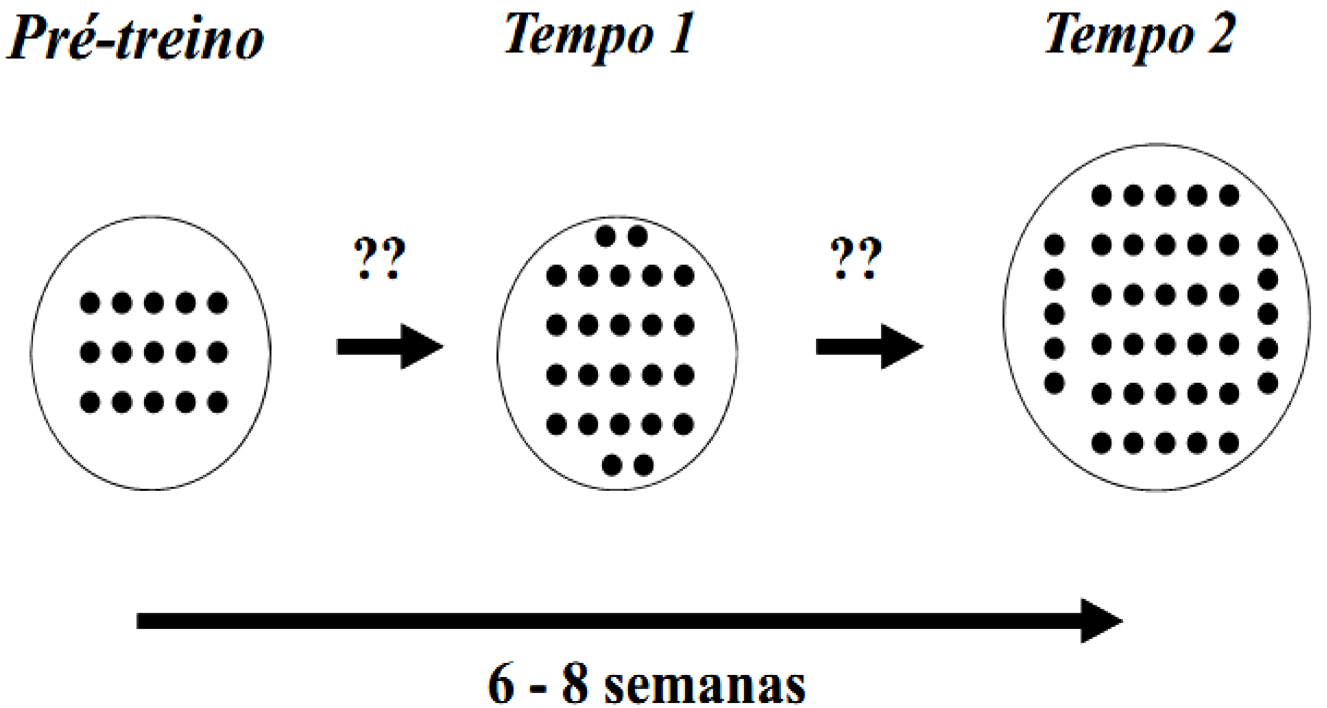
- Aumento do calibre e número das miofibrilas
- Aumento do número de sarcômeros
- Depende de um período prolongado de treinamento de força?
- Observável após 8 semanas de treinamento?.
- Aumento da síntese das proteínas

Hipertrofia




Short-term studies
Long-term studies
Neural factors
Hypertrophy factors
?
% contribution to gains in maximal strength
50
0
4
8
16
104
Training time (wk)

Hipertrofia

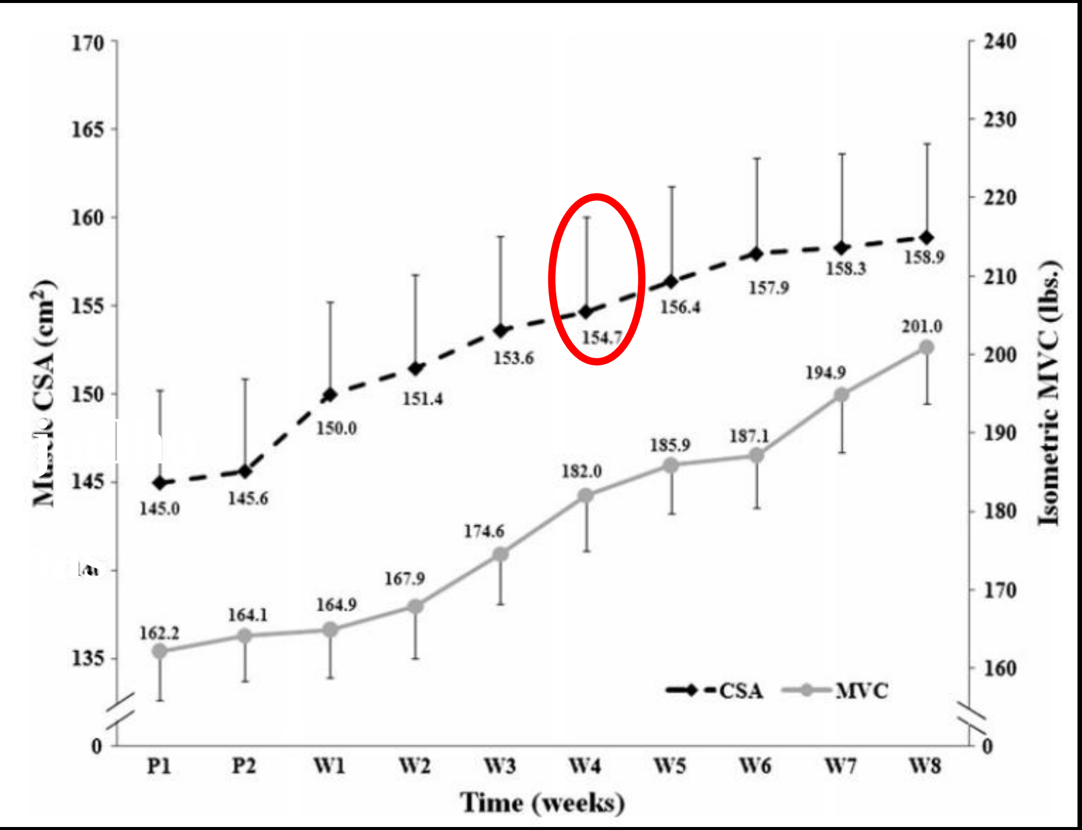


TEMPORALIDADE DA HIPERTROFIA

An examination of the time course of training-induced skeletal muscle hypertrophy

Jason M. DeFreitas · Travis W. Beck · Matt S. Stock ·
Michael A. Dillon · Paul R. Kasishke II

- **25 homens**
- **Destreinados**
- **Leg-press 45º, extensão de**
- **3 séries de 8-12 rep. Máxi**
- **3 vezes sem.**
- **Tomografia**



TEMPORALIDADE DA HIPERTROFIA

Early skeletal muscle hypertrophy and architectural changes in response to high-intensity resistance training

O. R. Seynnes, M. de Boer and M. V. Narici

J Appl Physiol 102:368-373, 2007. First published 19 October 2006;
doi:10.1152/japplphysiol.00789.2006

- **5 homens**
- **2 mulheres**
- **Recreativamente ativos**
- **Extensão de joelho 3 x sem**
- **4 séries de 7 rep. máximas**
- **Ergômetro independente d**
- **Ressonância magnética**

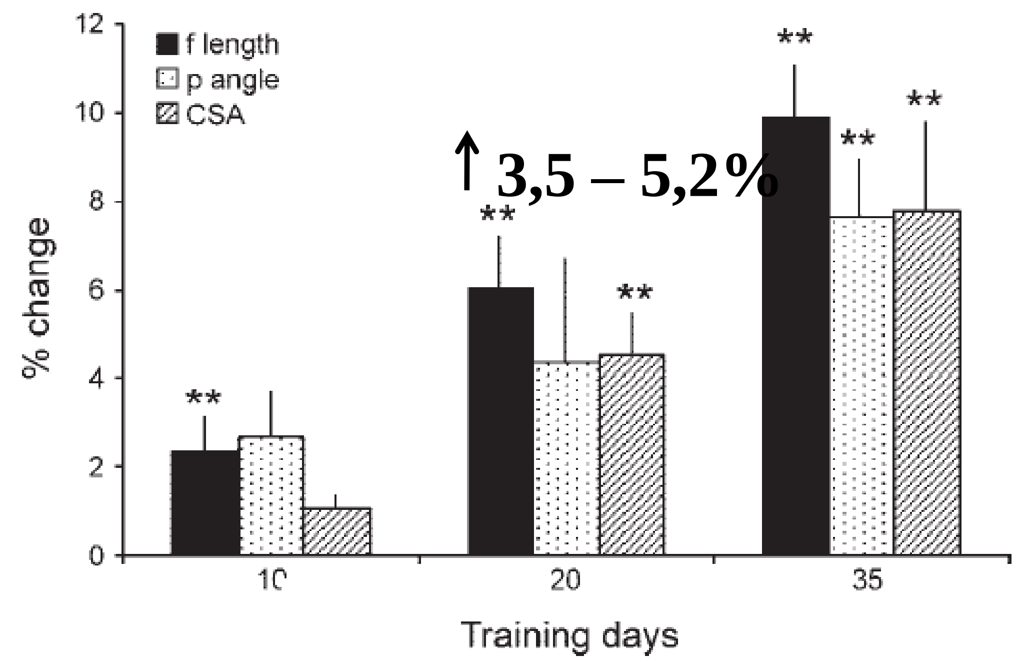


Fig. 3. Time course of structural changes in the vastus lateralis (VL) muscle. f length, Fascicle length; p angle, pennation angle. $^{**}P < 0.01$ vs. baseline.

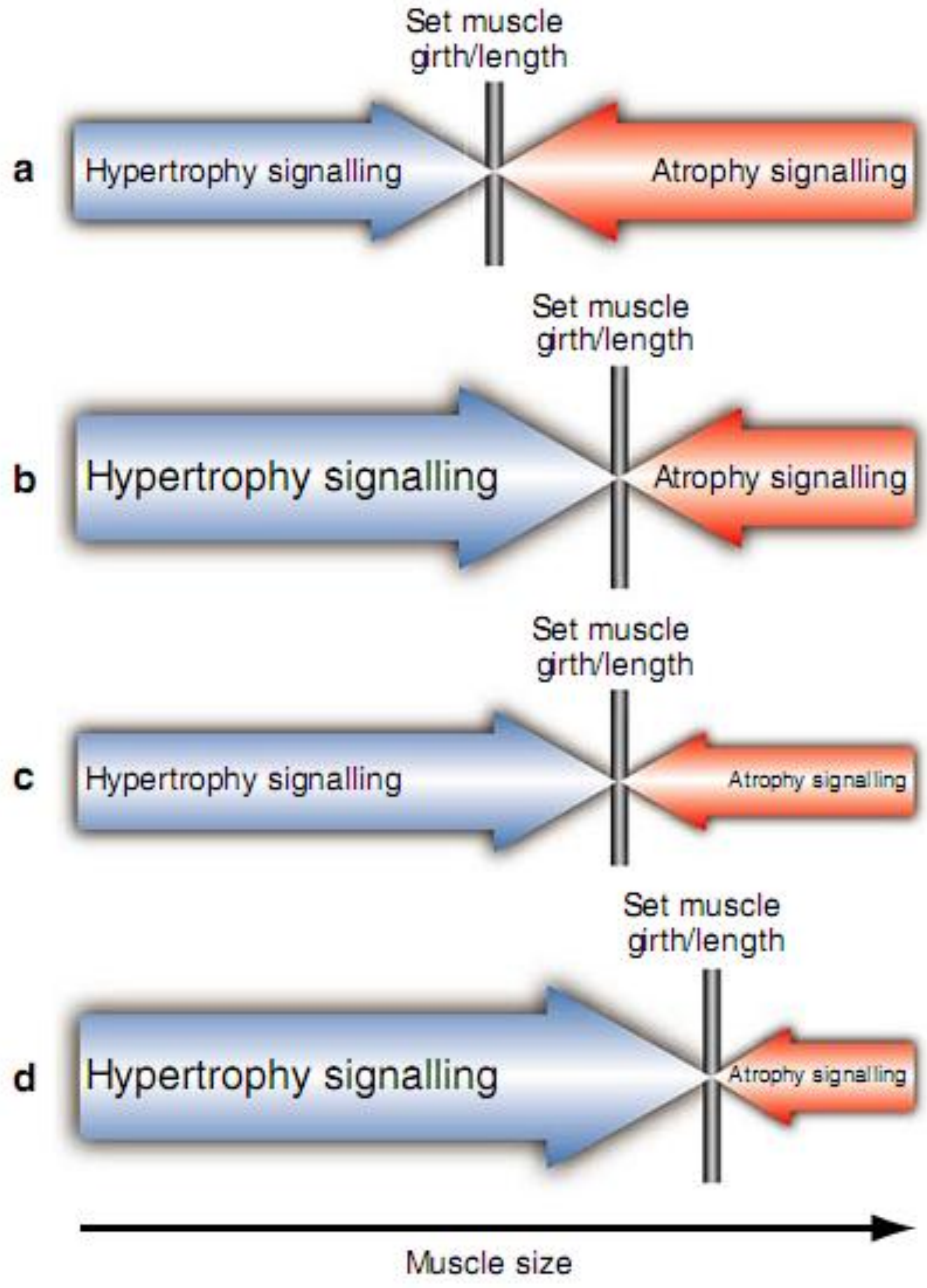
HIPERTROFIA

- Dois processos envolvidos:

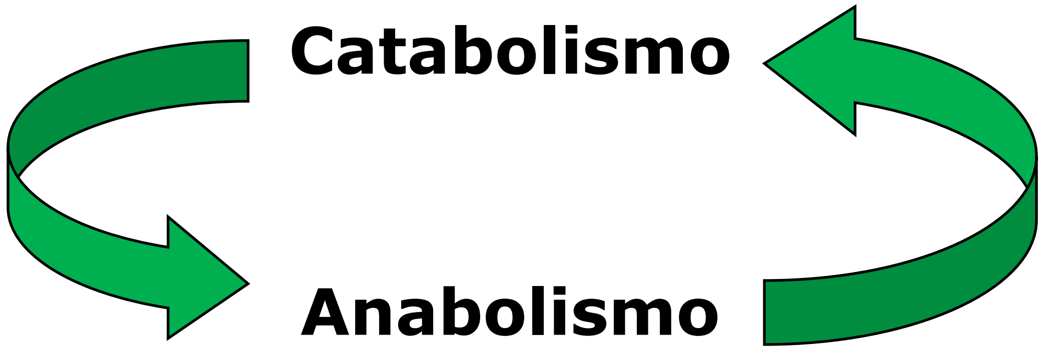
  – Acréscimo de proteínas (Supercompensação entre síntese e degradação)

  – Ativação e proliferação de células satélites

Hipertrofia



Síntese de Proteínas

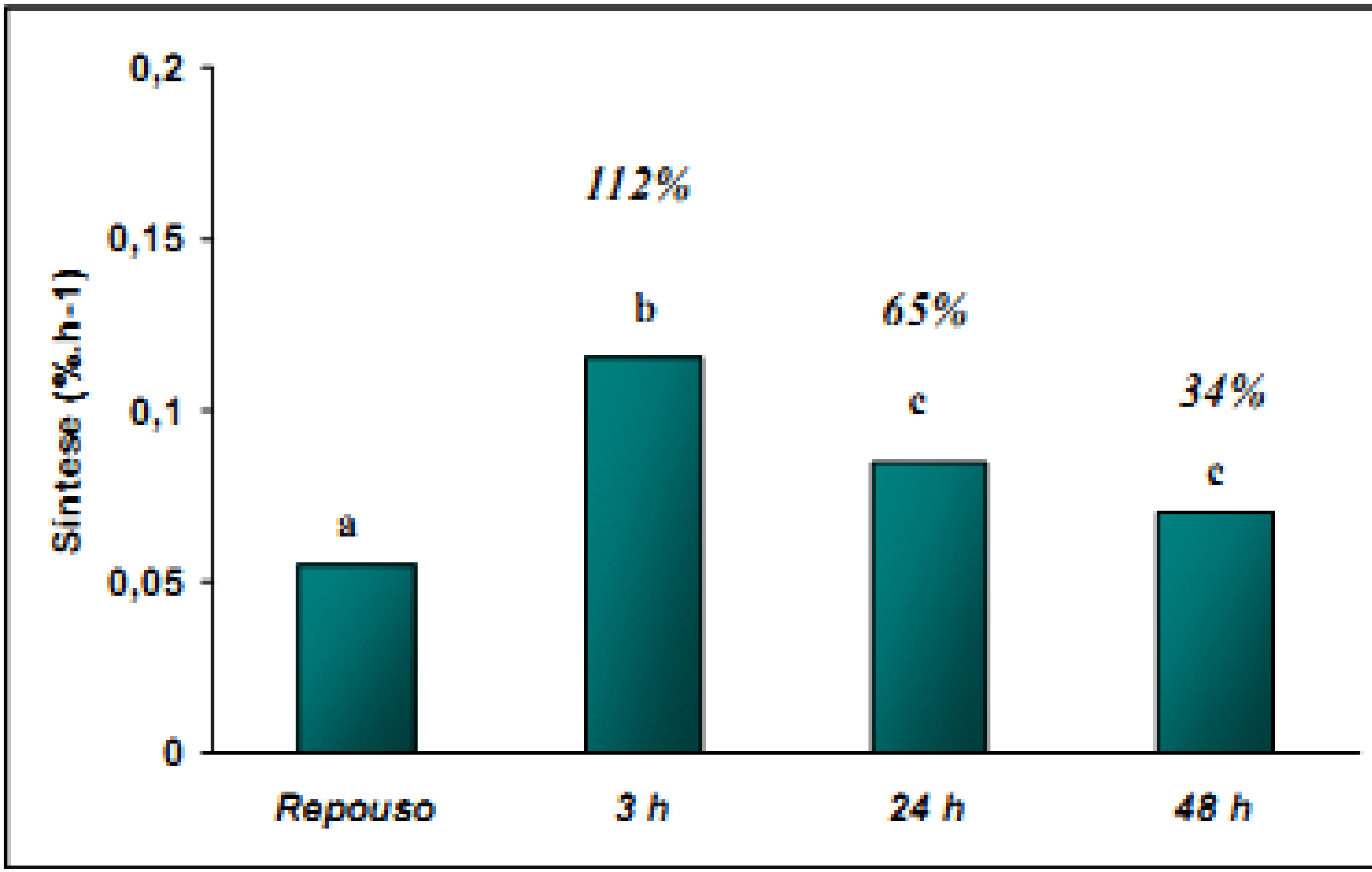


Anabolismo **Catabolismo**

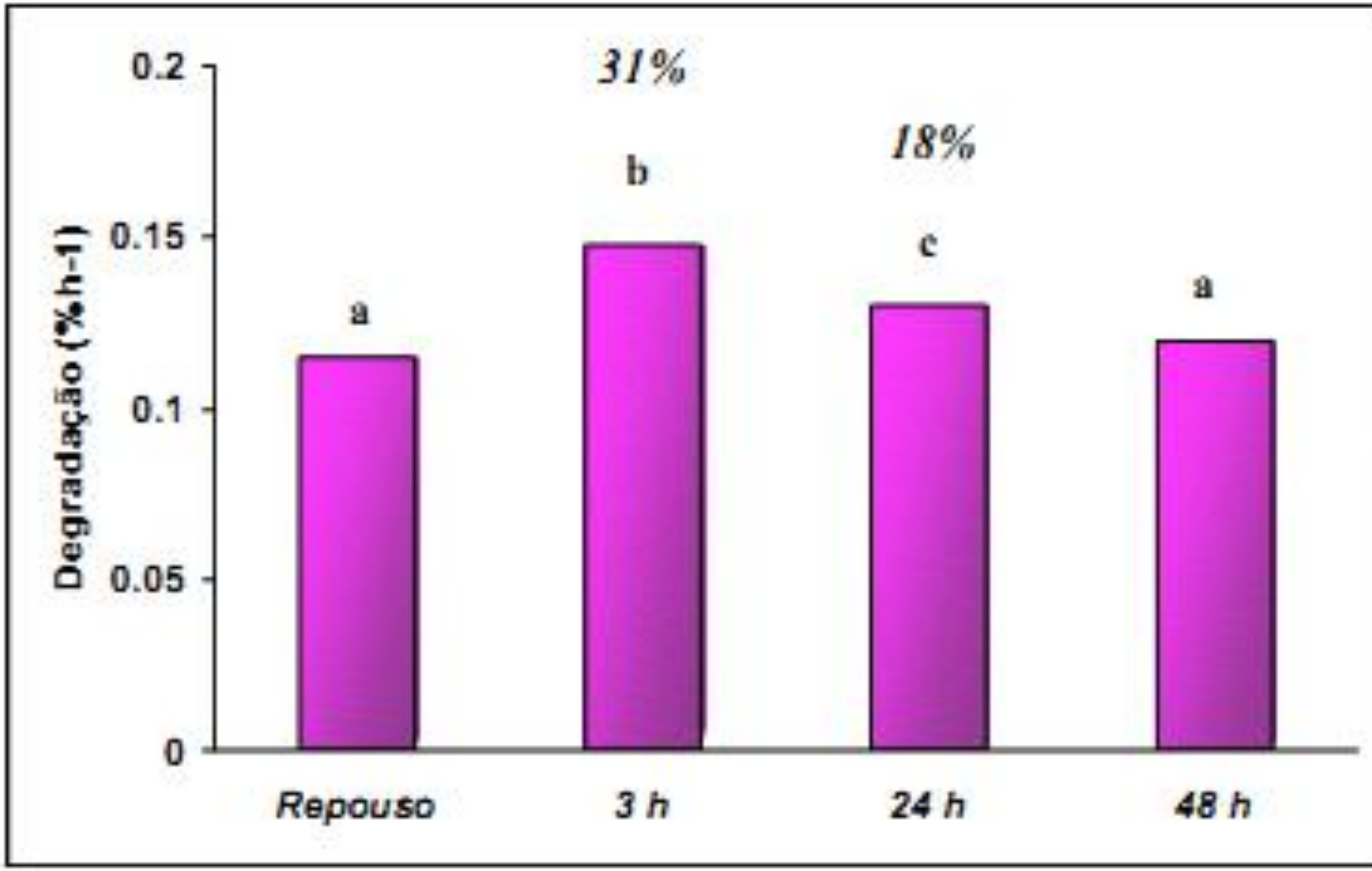
HIPERTROFIA

Hipertrofia

- Phillips e col. (1997)
  - 4 mulheres, 4 homens
  - extensão de joelho 80% 1RM
  - 8 séries x 8 reps

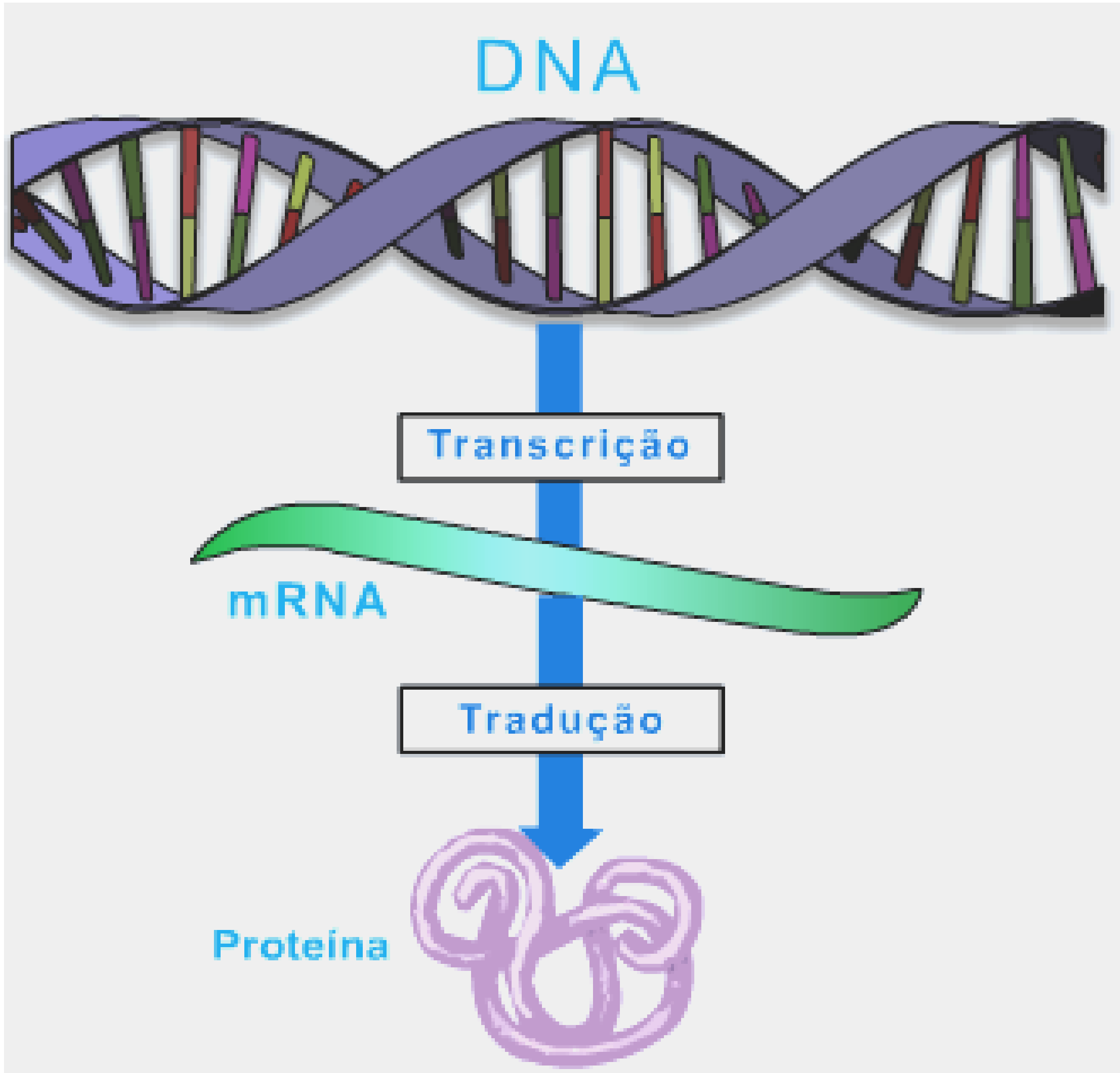


Phillips et al. (1997)



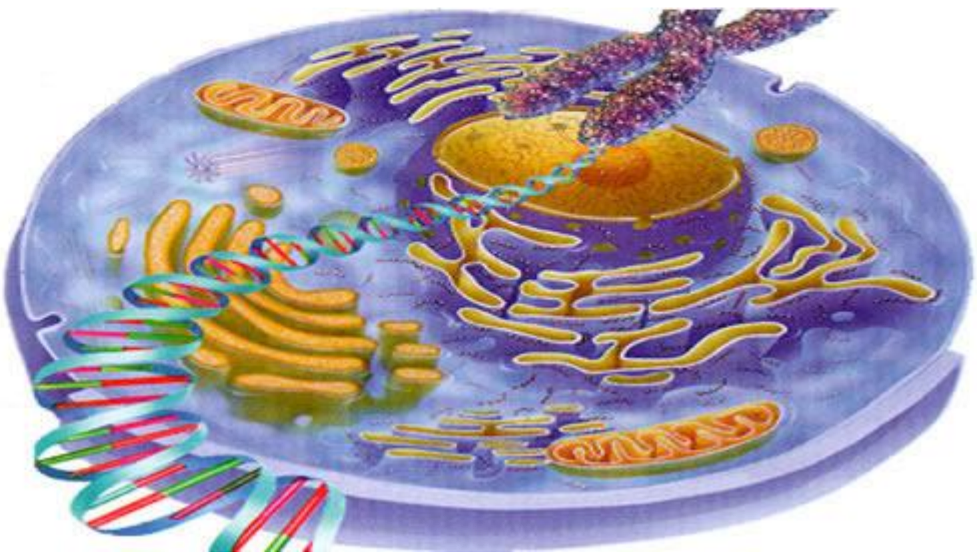
Phillips et al. (1997)

Síntese Proteica



Síntese Proteica

- Dieta
- Hormônio
- Treinamento



Hormônios

- Hormonal
  - Hormônios anabólicos
    - Testosterona
    - GH
    - Insulina
    - IGF-1
  - Hormônios Catabólicos
    - Cortisol

Sistemas Hormonais

- Endócrino
- Parácrino
- Autócrino

Hormônios Hidrossolúveis

Proteicos →

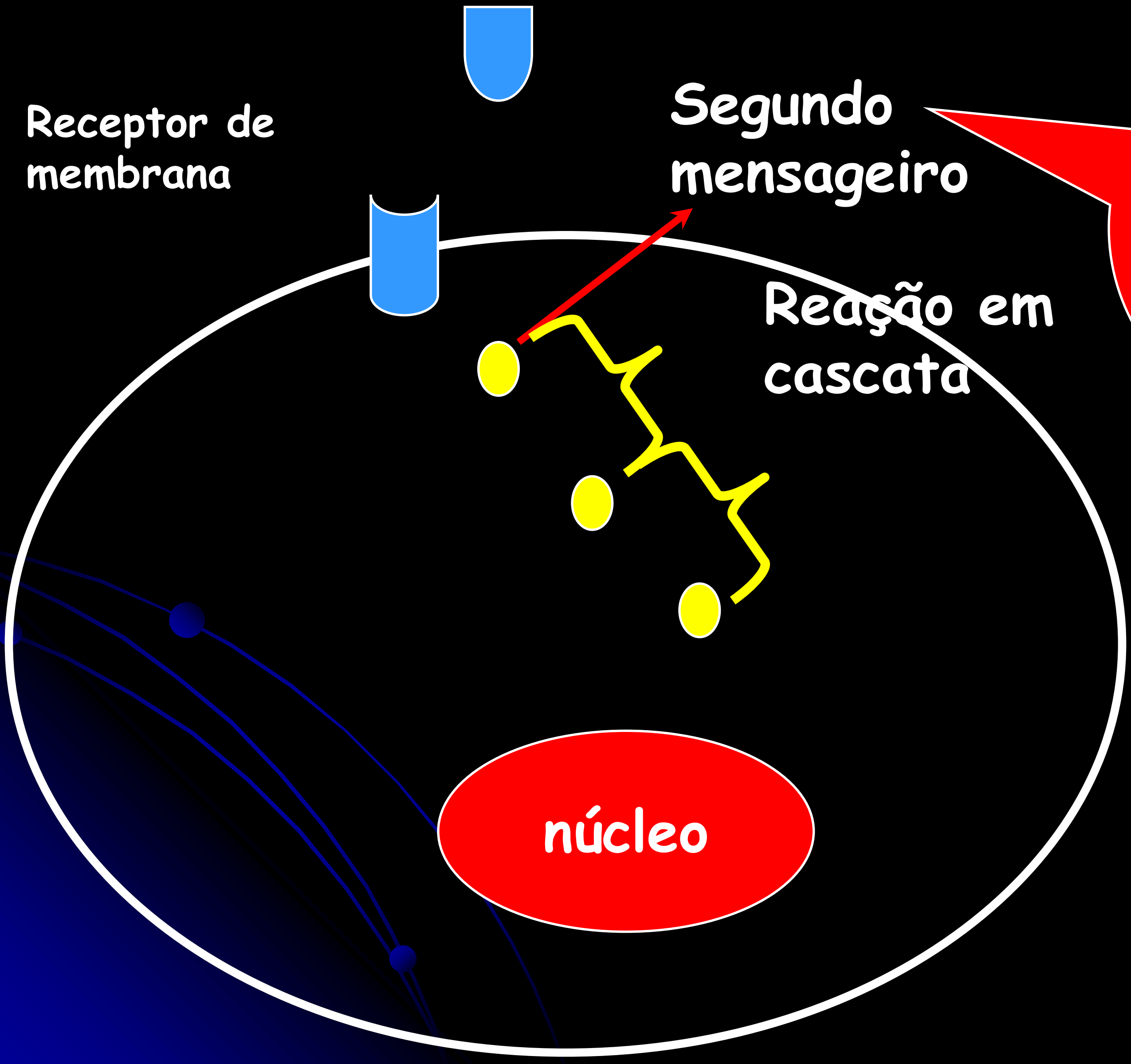
- Hormônio do crescimento GH)
- Hormônio semelhante a insulina (IGF)
- Insulina

Hormônios Lipossolúveis

Esteróides →

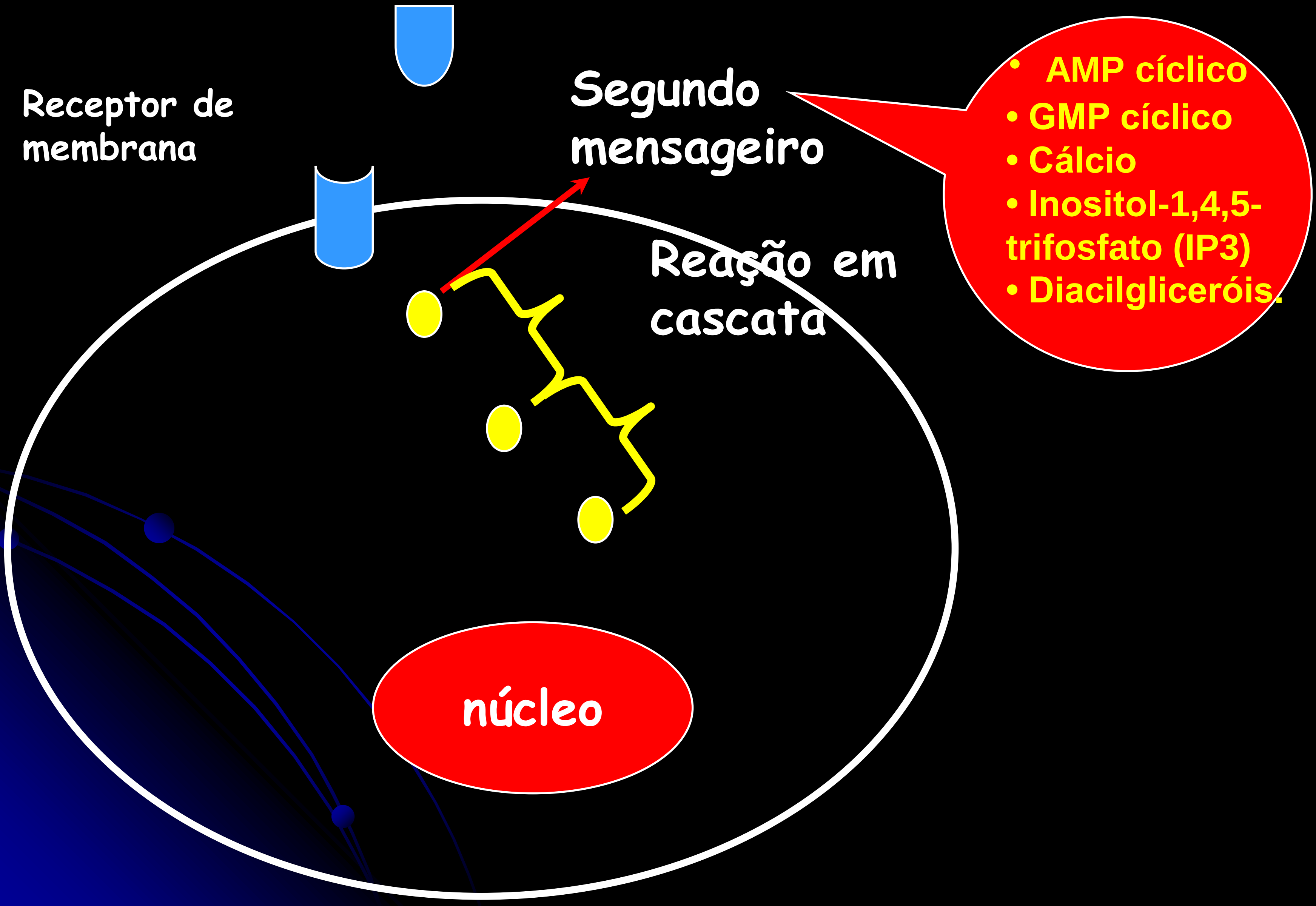
- Testosterona

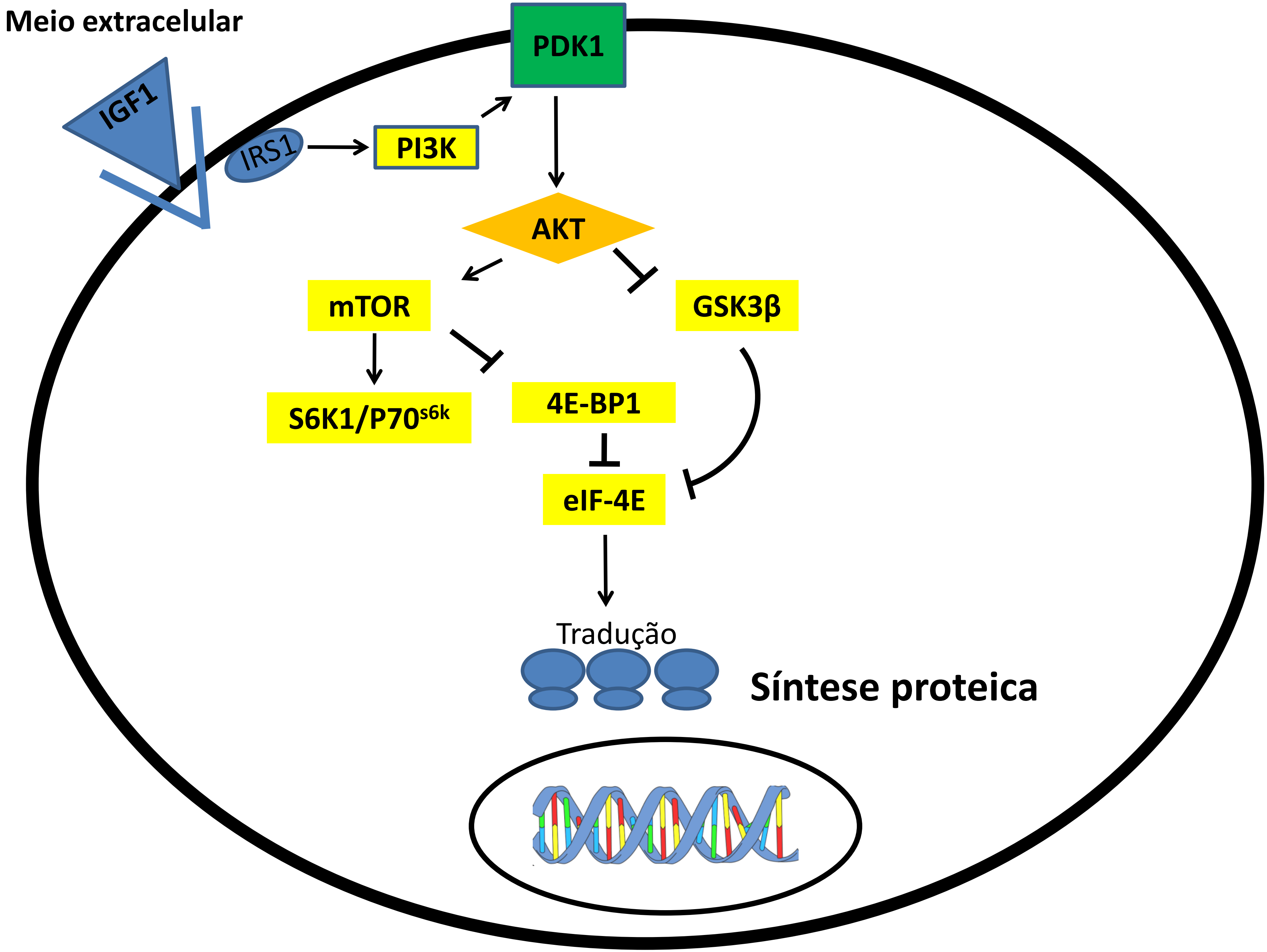
Segundo Mensageiro

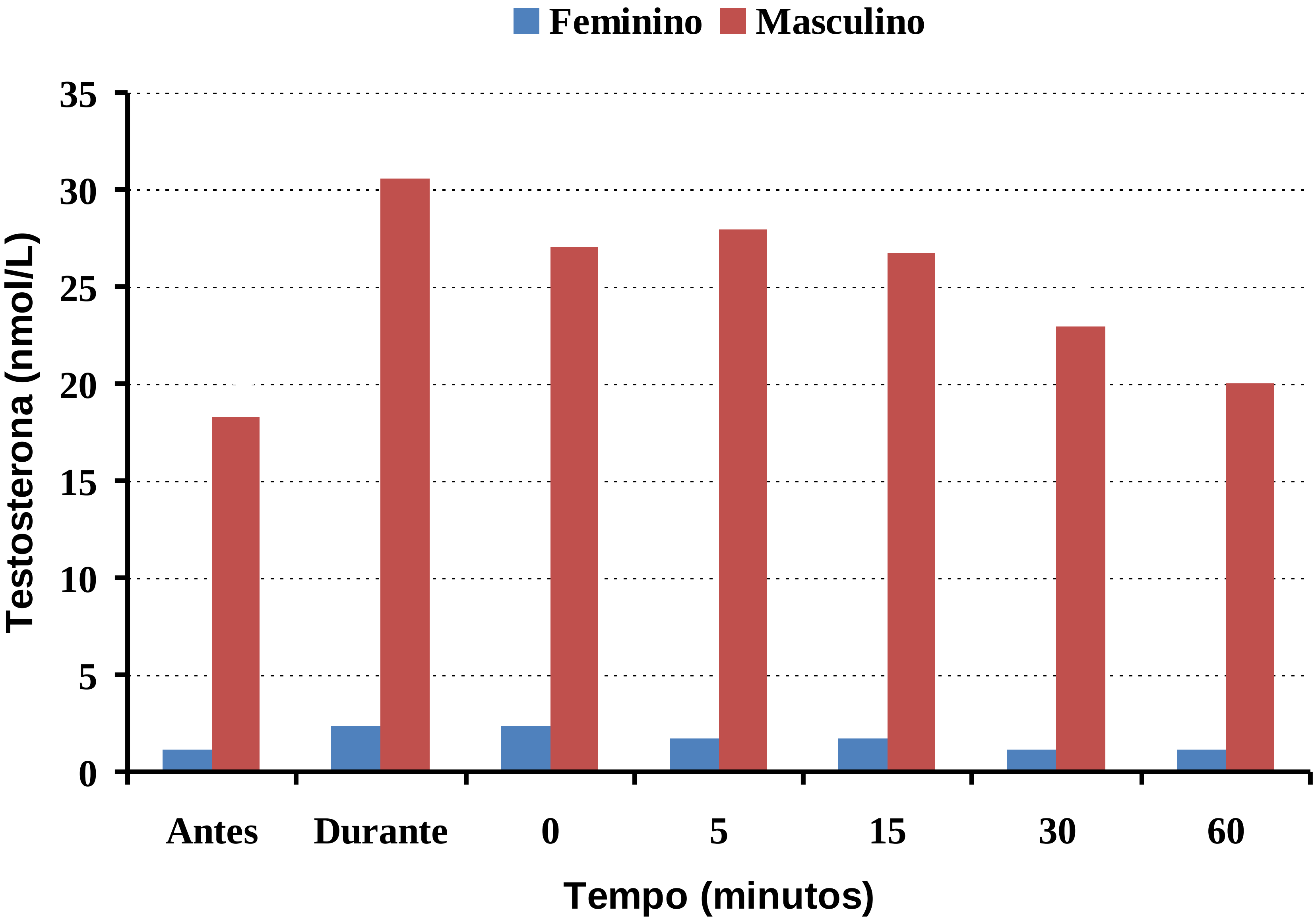


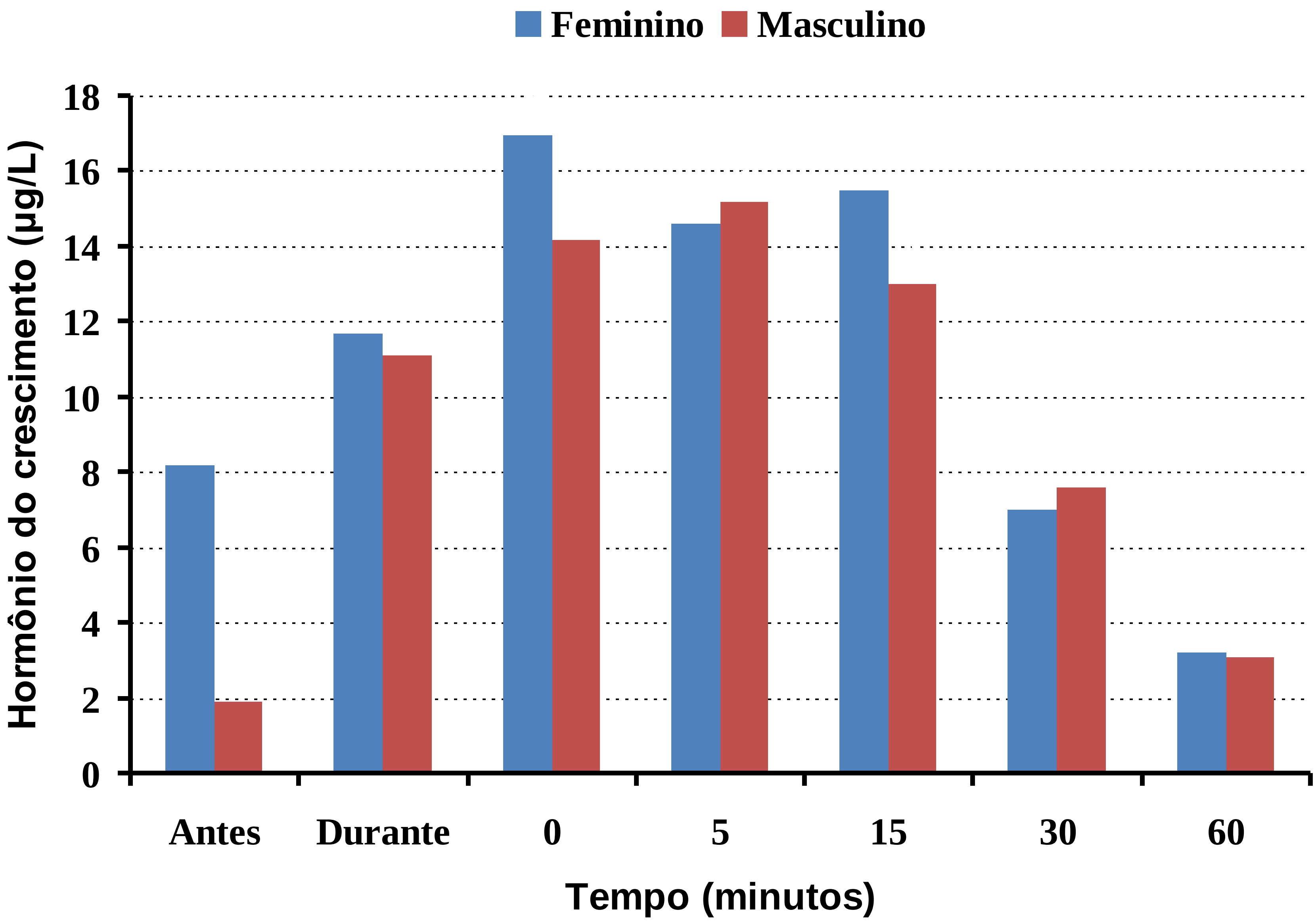
- AMP cíclico
- GMP cíclico
- Cálcio
- Inositol-1,4,5-trifosfato (IP3)
- Diacilgliceróis.

Segundo Mensageiro




Meio extracelular
IGF1
IRS1
PI3K
PDK1
AKT
mTOR
GSK3β
S6K1/P70s6k
4E-BP1
eIF-4E
Tradução
Síntese proteica

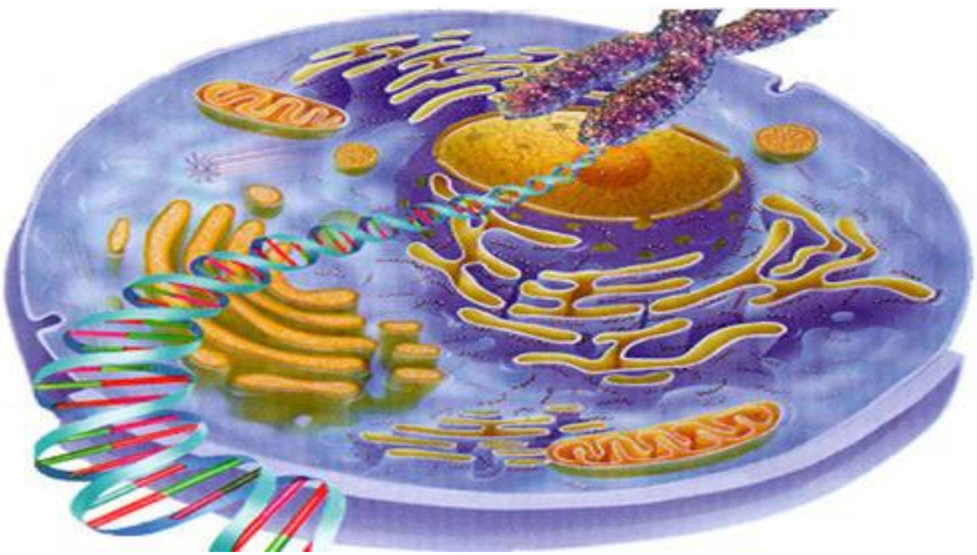

Feminino
Masculino
35
30
25
20
15
10
5
0
Testosterona (nmol/L)
Antes
Durante
0
5
15
30
60
Tempo (minutos)

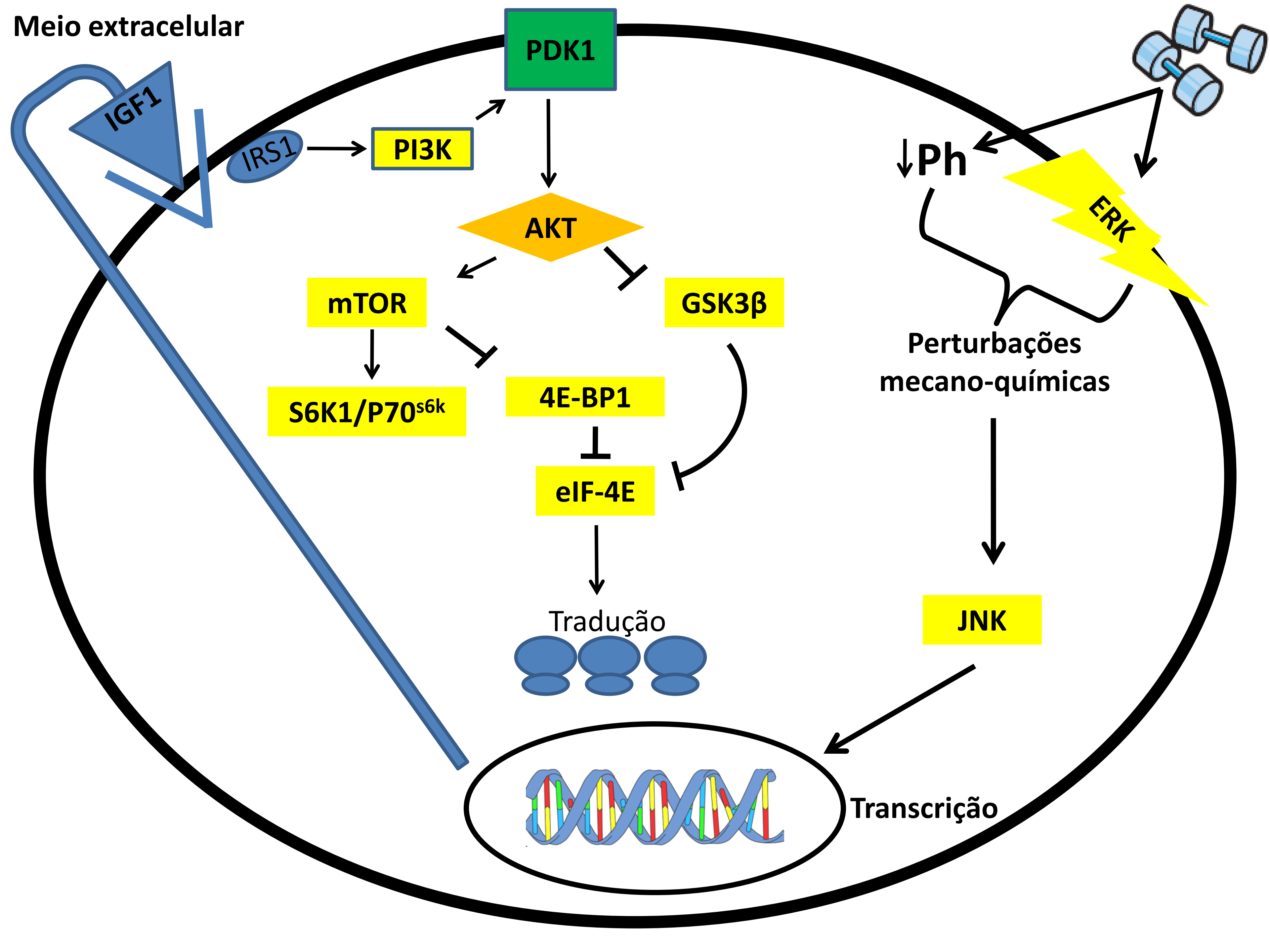


Feminino
Masculino
Hormônio do crescimento (µg/L)
0
2
4
6
8
10
12
14
16
18
Antes
Durante
0
5
15
30
60
Tempo (minutos)

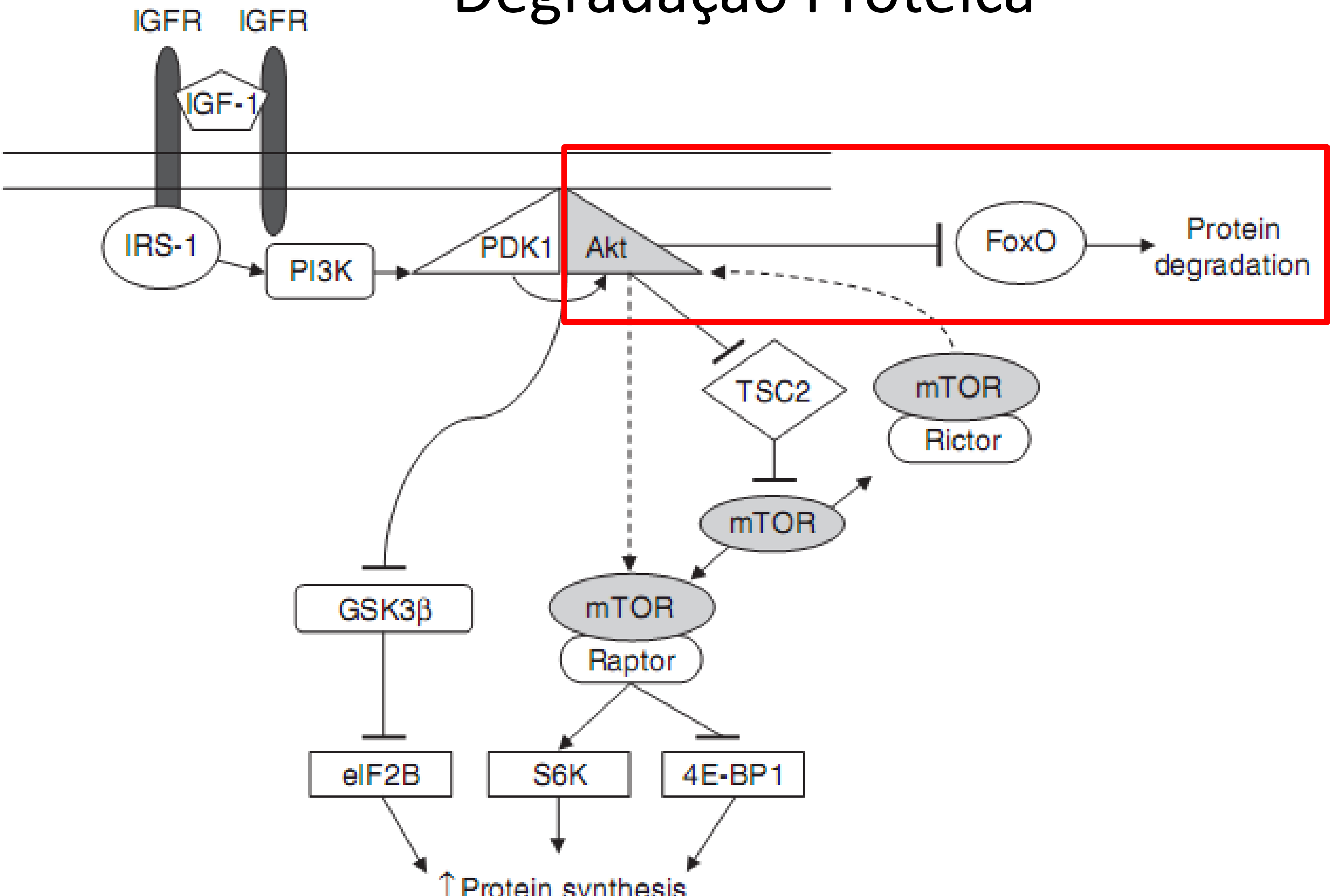
Síntese Proteica

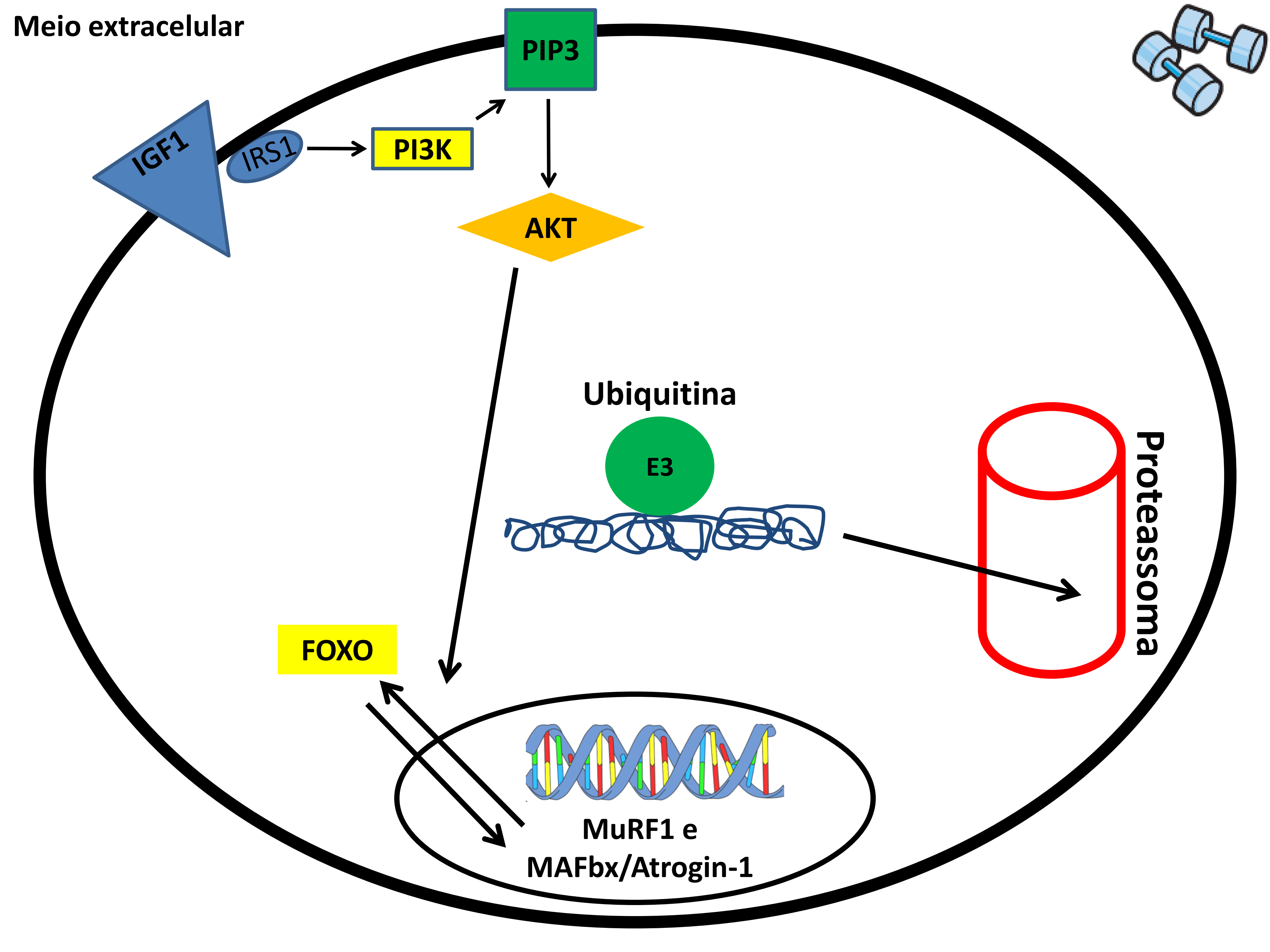
- Dieta
- Hormônio
- Treinamento

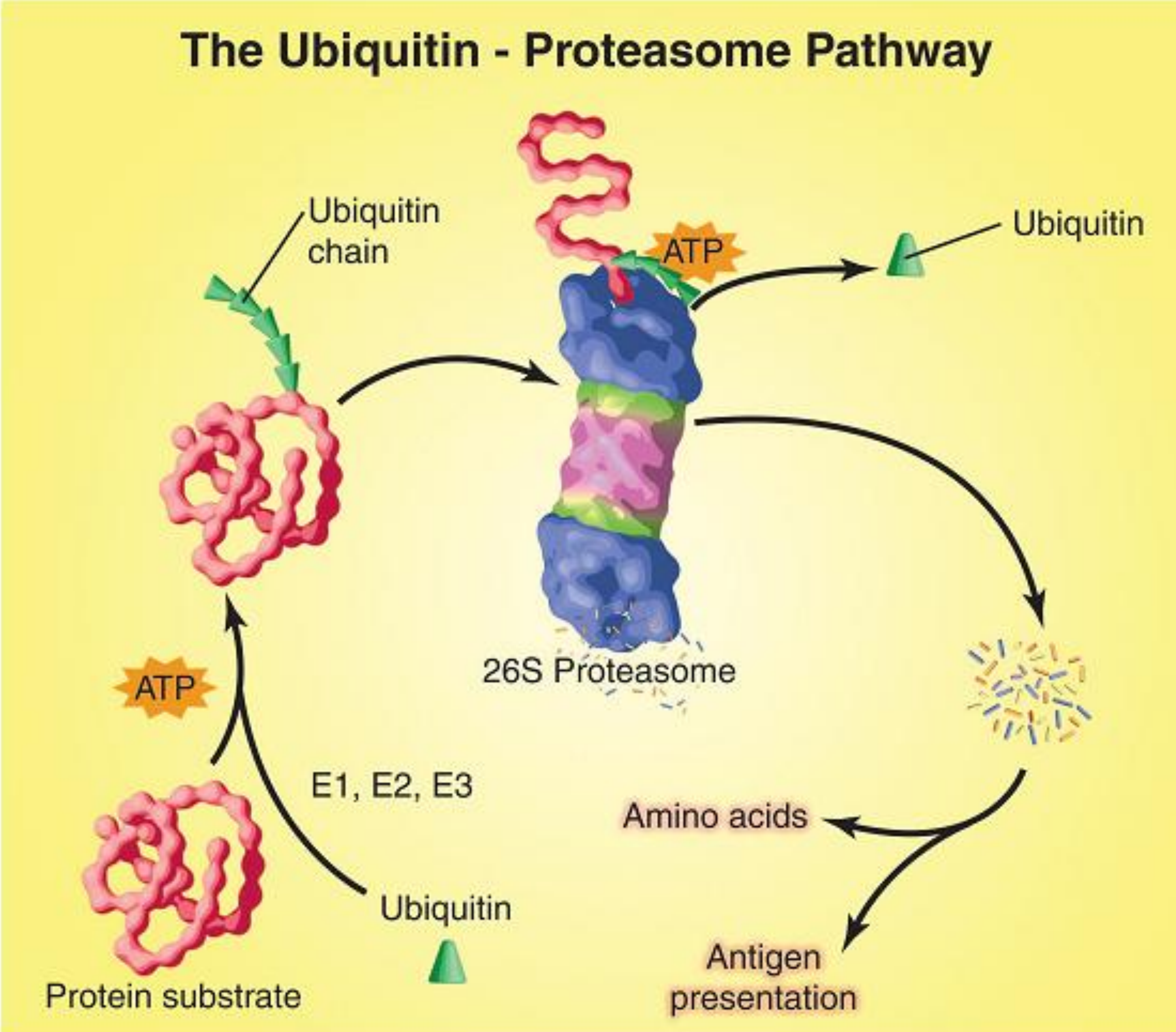



Meio extracelular
PDK1
IGF1
IRS1
PI3K
AKT
mTOR
GSK3β
S6K1/P70s6k
4E-BP1
eIF-4E
Tradução
↓Ph
ERK
Perturbações mecano-químicas
JNK
Transcrição

Degradação Proteica




Meio extracelular
PIP3
IGF1
IRS1
PI3K
AKT
Ubiquitina
E3
Proteassoma
FOXO
MuRF1 e
MAFbx/Atrogin-1



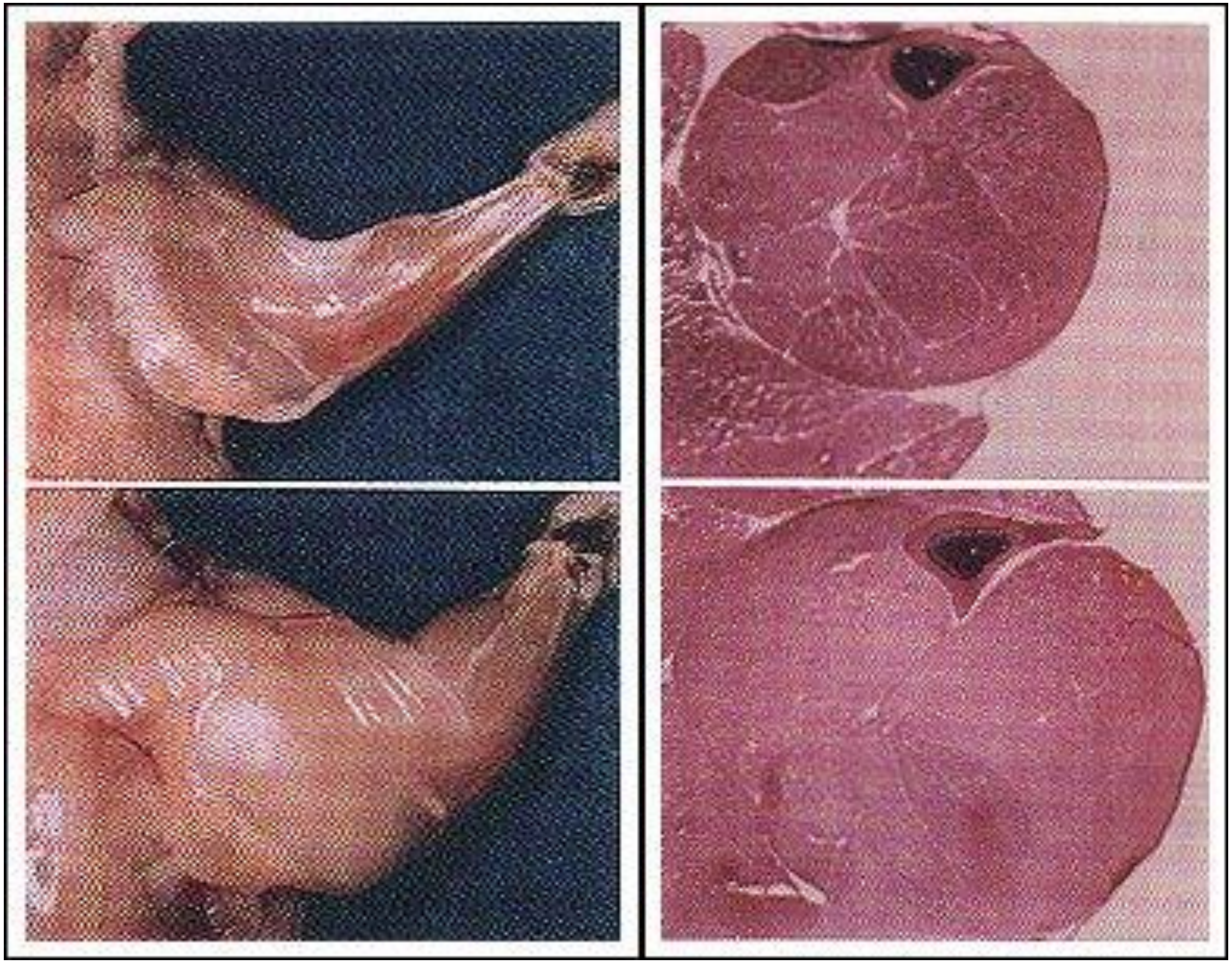
The Ubiquitin - Proteasome Pathway
Ubiquitin chain
ATP
Ubiquitin
26S Proteasome
ATP
E1, E2, E3
Amino acids
Ubiquitin
Protein substrate
Antigen presentation

Miostatina

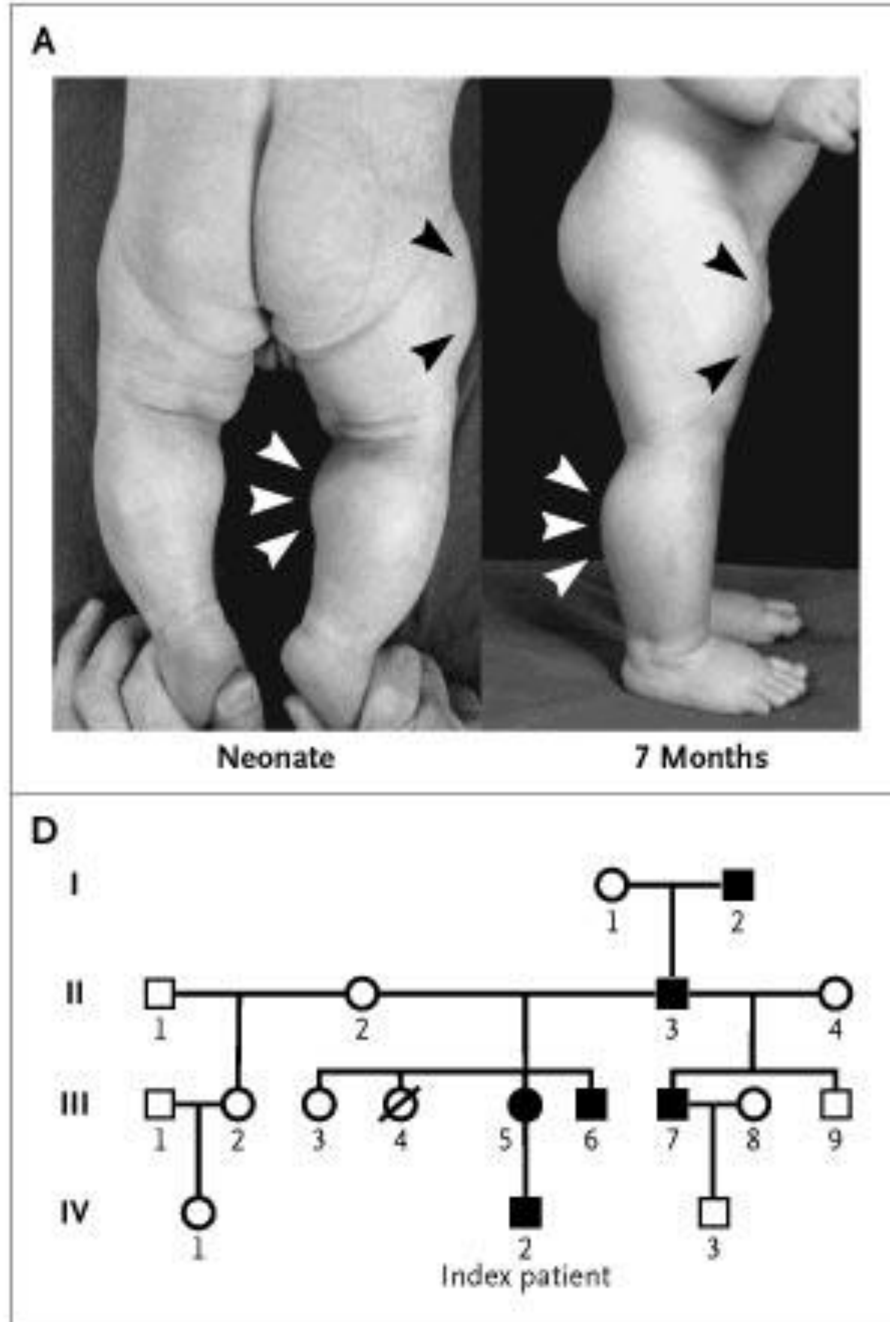
- Inibe divisão celular
- Inibe síntese protéica
- Animais nulos para miostatina
- Superexpressão
  - Caquexia

Belgian Blue

Manifestações da falta da miostatina em ratos.



Miostatina em humanos



Miostatina

- Inatividade
  - Aumento da miostatina

- Treinamento
  - Redução da miostatina

Myostatin Gene Expression Is Reduced in Humans with Heavy-Resistance Strength Training: A Brief Communication

STEPHEN M. ROTH,*,†,[1] Gregory F. Martel,†,‡ Robert E. Ferrell,* E. Jeffrey Metter,§ Ben F. Hurley,† and Marc A. Rogers†

2003

- ➤4 Homens, 4 mulheres (Jovens)
- ➤4 Homens, 4 mulheres (Idosos)
- ➤9 semanas de treino unilateral

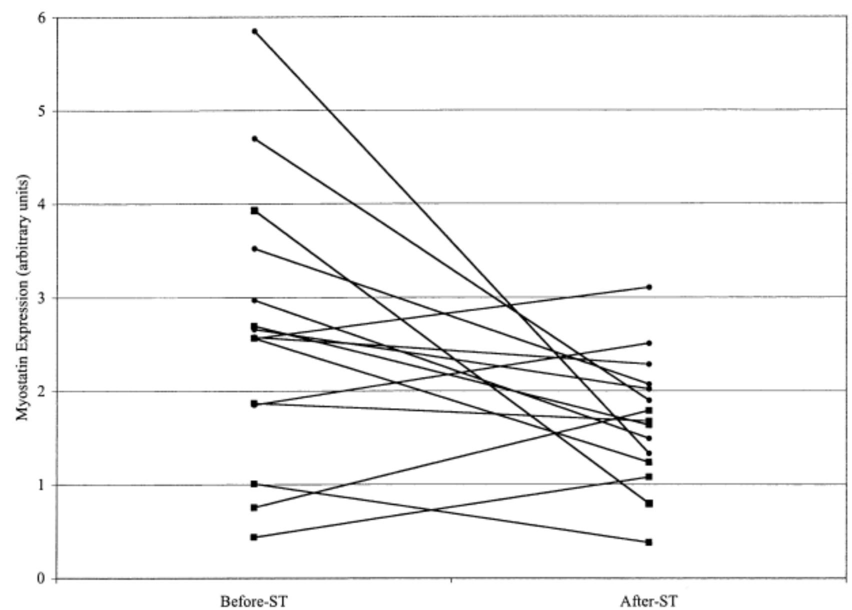
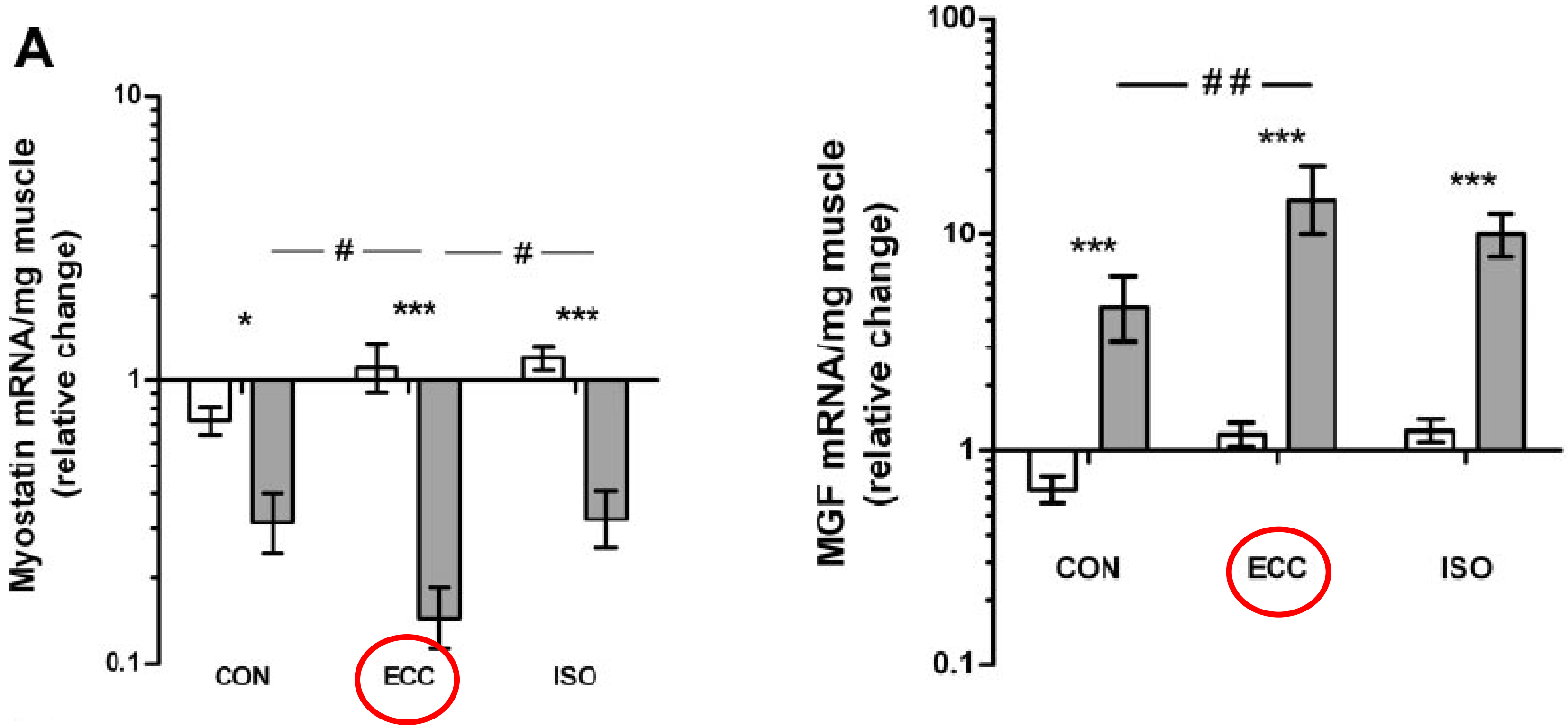


Figure 1. Myostatin expression levels (arbitrary units) for before ST ($n = 15$) versus after ST ($n = 15$) for each individual. ●, males; ■, females. A significant decrease in myostatin expression was observed in response to ST, $P < 0.05$, with no group differences.

Short-term strength training and the expression of myostatin and IGF-I isoforms in rat muscle and tendon: differential effects of specific contraction types

K. M. Heinemeier,[1*] J. L. Olesen,[1*] P. Schjerling,[3,4] F. Haddad,[2]
H. Langberg,[1] K. M. Baldwin,[2] and M. Kjaer[1]

[1]*Institute of Sports Medicine, Bispebjerg Hospital, Copenhagen;* [2]*Department of Physiology and Biophysics, University of California, Irvine, California;* [3]*Department of Molecular Muscle Biology, Copenhagen Muscle Research Centre, Rigshospitalet, Copenhagen; and* [4]*Department of Medical Biochemistry and Genetics, University of Copenhagen, Copenhagen Denmark*

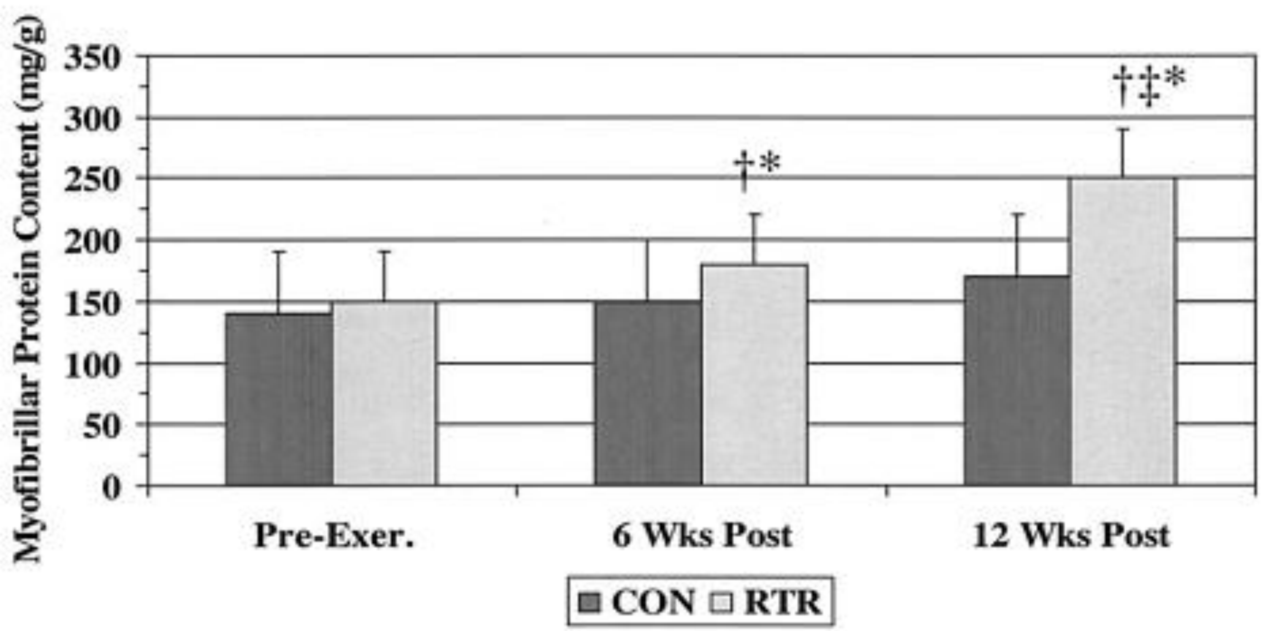


Eletroestimulação por 4 dias
2-4 séries de 10 estímulos

Effects of Heavy Resistance Training on Myostatin mRNA and Protein Expression

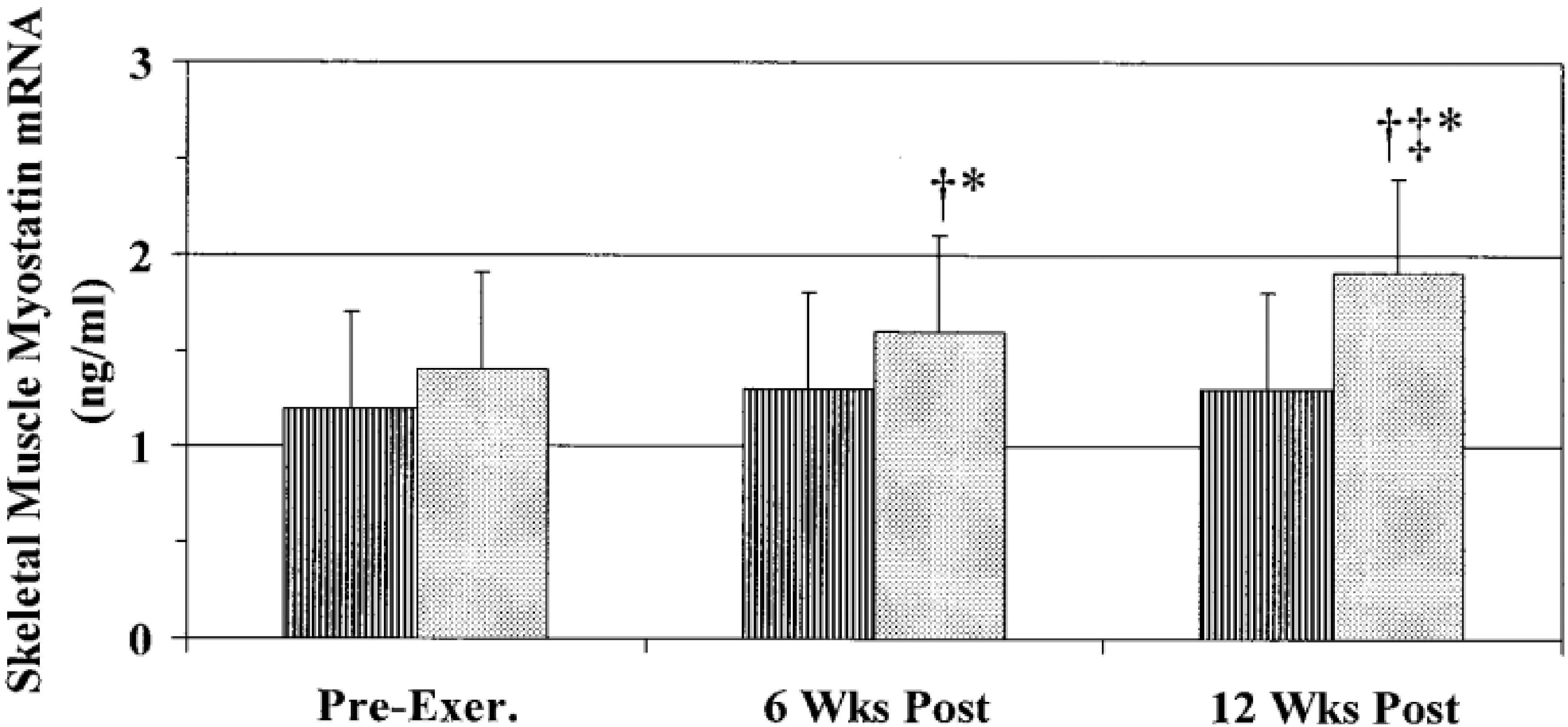
DARRYN S. WILLOUGHBY 2004

- 22 jovens
- 12 semanas
- 3 x semana
- 3 séries leg pres
- 85-90%RM



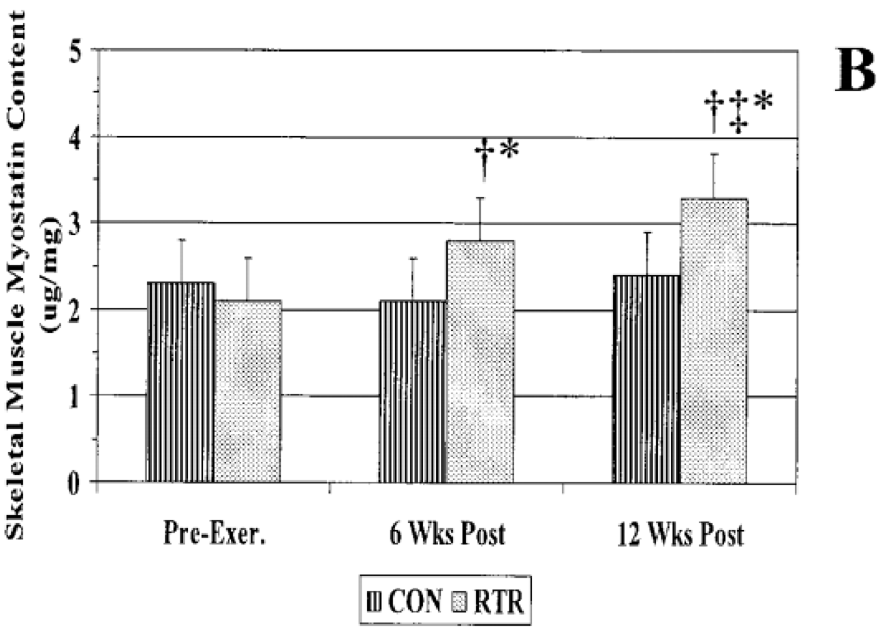
Effects of Heavy Resistance Training on Myostatin mRNA and Protein Expression

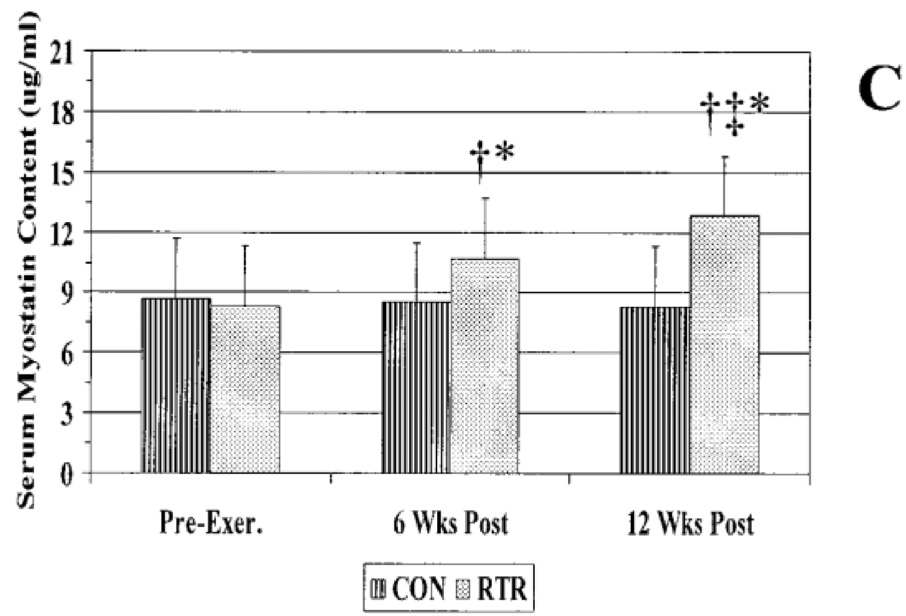
DARRYN S. WILLOUGHBY 2004

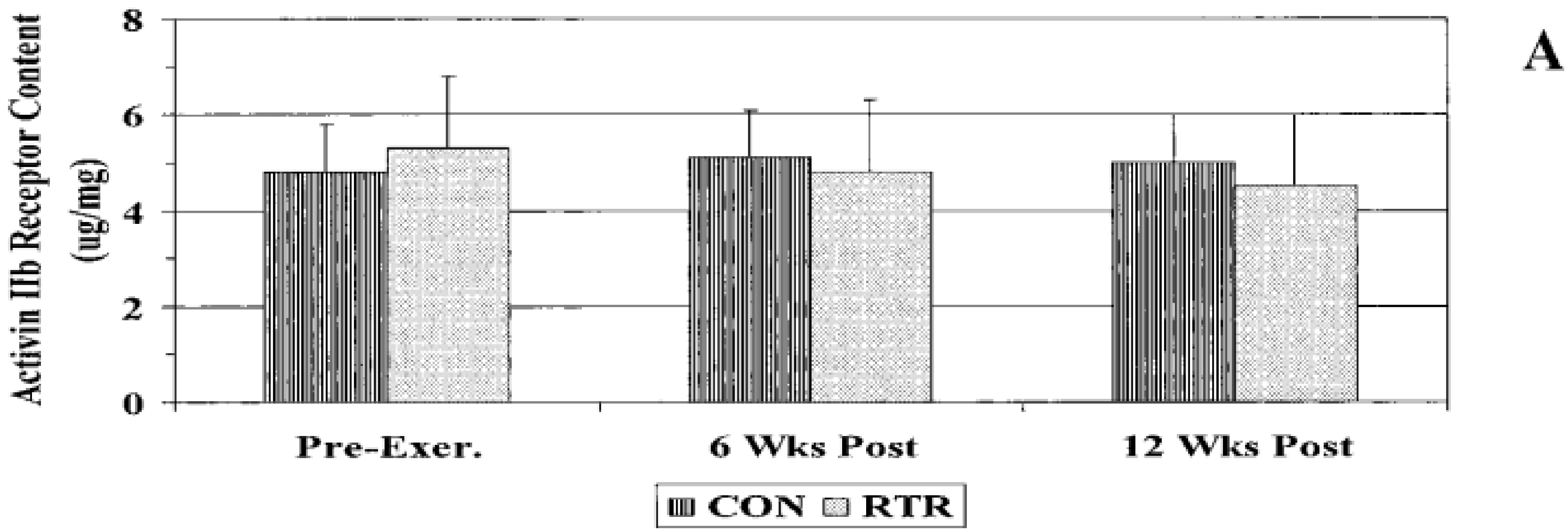


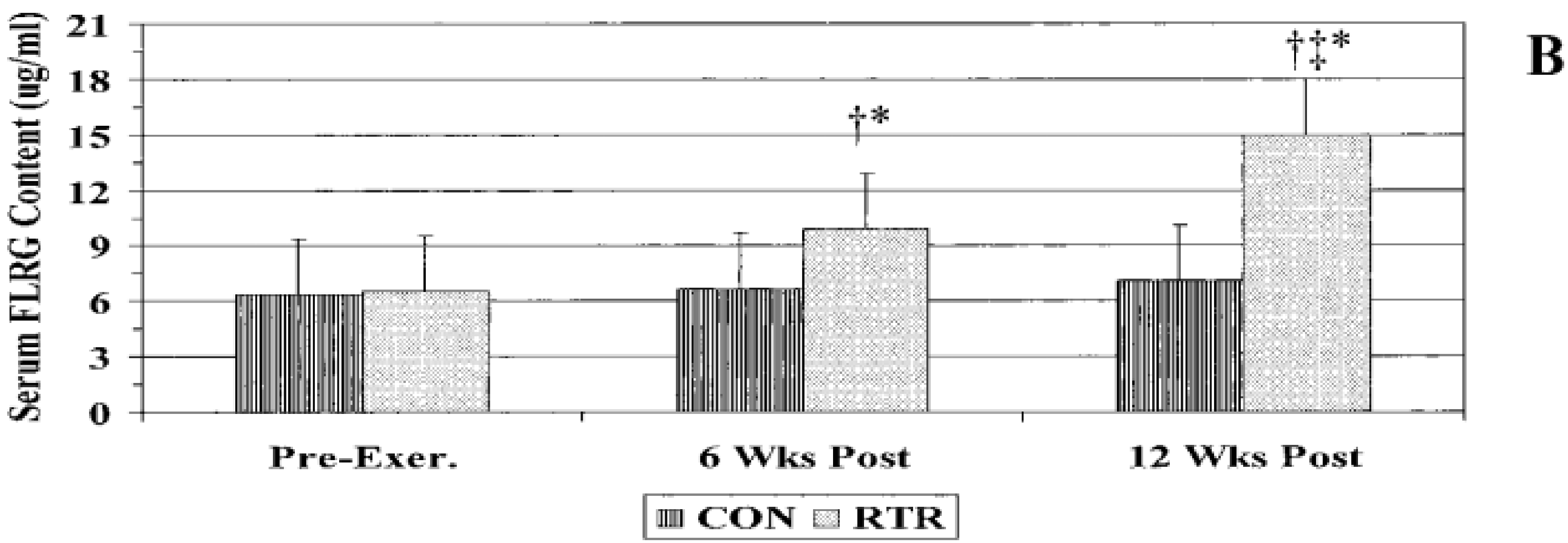
Effects of Heavy Resistance Training on Myostatin mRNA and Protein Expression

DARRYN S. WILLOUGHBY 2004






A
Activin IIb Receptor Content (ug/mg)
8
6
4
2
0
Pre-Exer.
6 Wks Post
12 Wks Post
CON
RTR

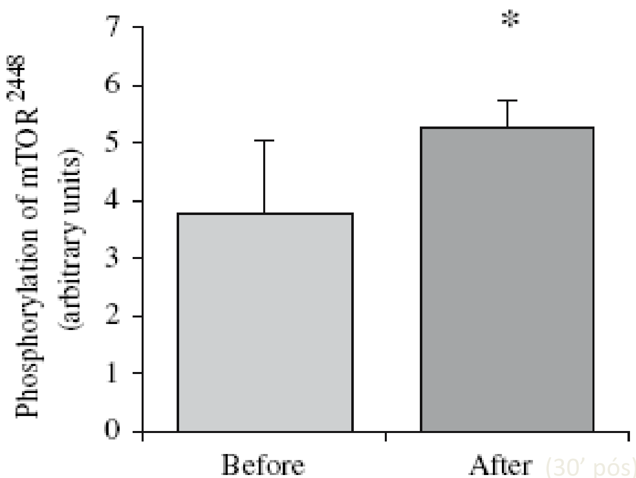

B
Serum FLRG Content (ug/ml)
21
18
15
12
9
6
3
0
†*
†‡*
Pre-Exer.
6 Wks Post
12 Wks Post
CON
RTR

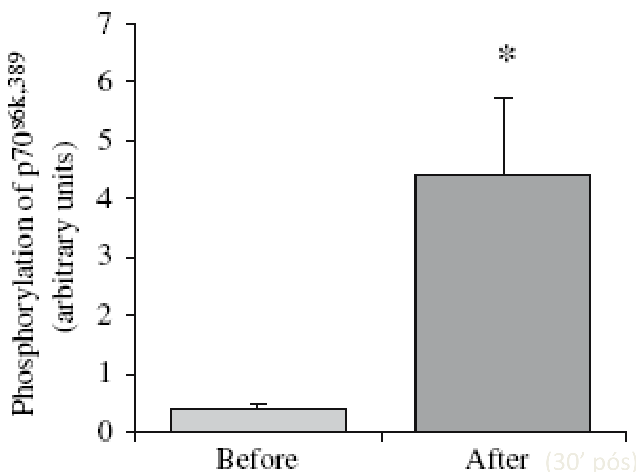
Vias de síntese e Hipertrofia

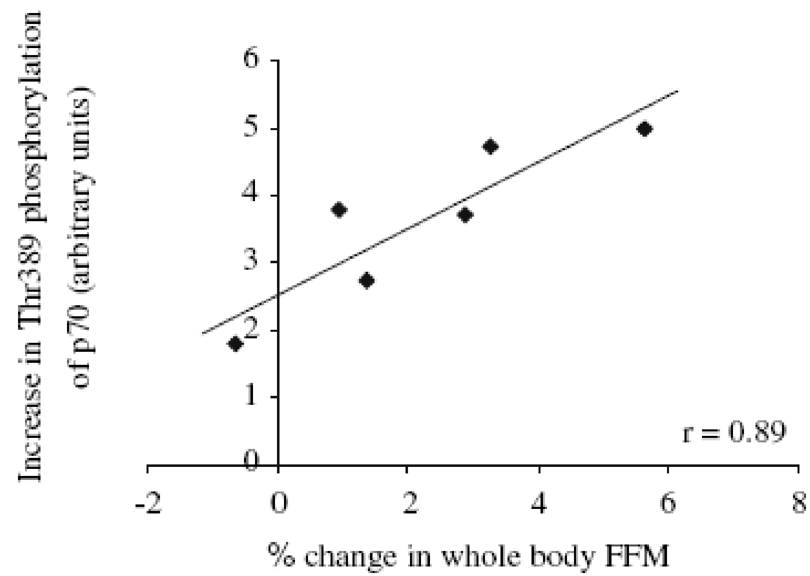
Respostas agudas e vias hipertróficas

Resistance exercise-induced increase in muscle mass correlates with p70S6 kinase phosphorylation in human subjects

Gerasimos Terzis · Giorgos Georgiadis · Grigoris Stratakos · Ioannis Vogiatzis · Stavros Kavouras · Panagiota Manta · Henrik Mascher · Eva Blomstrand

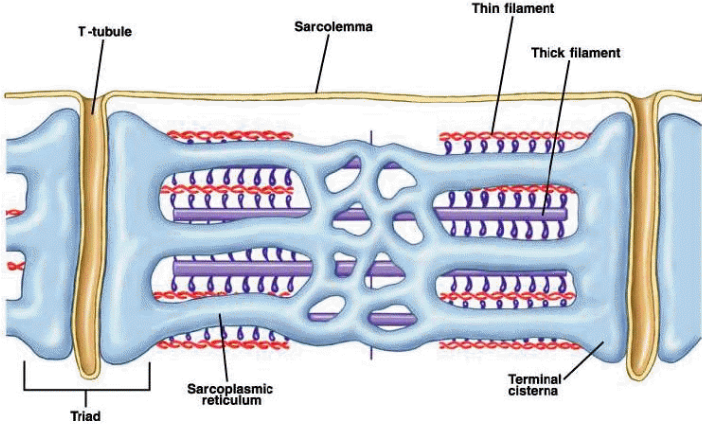


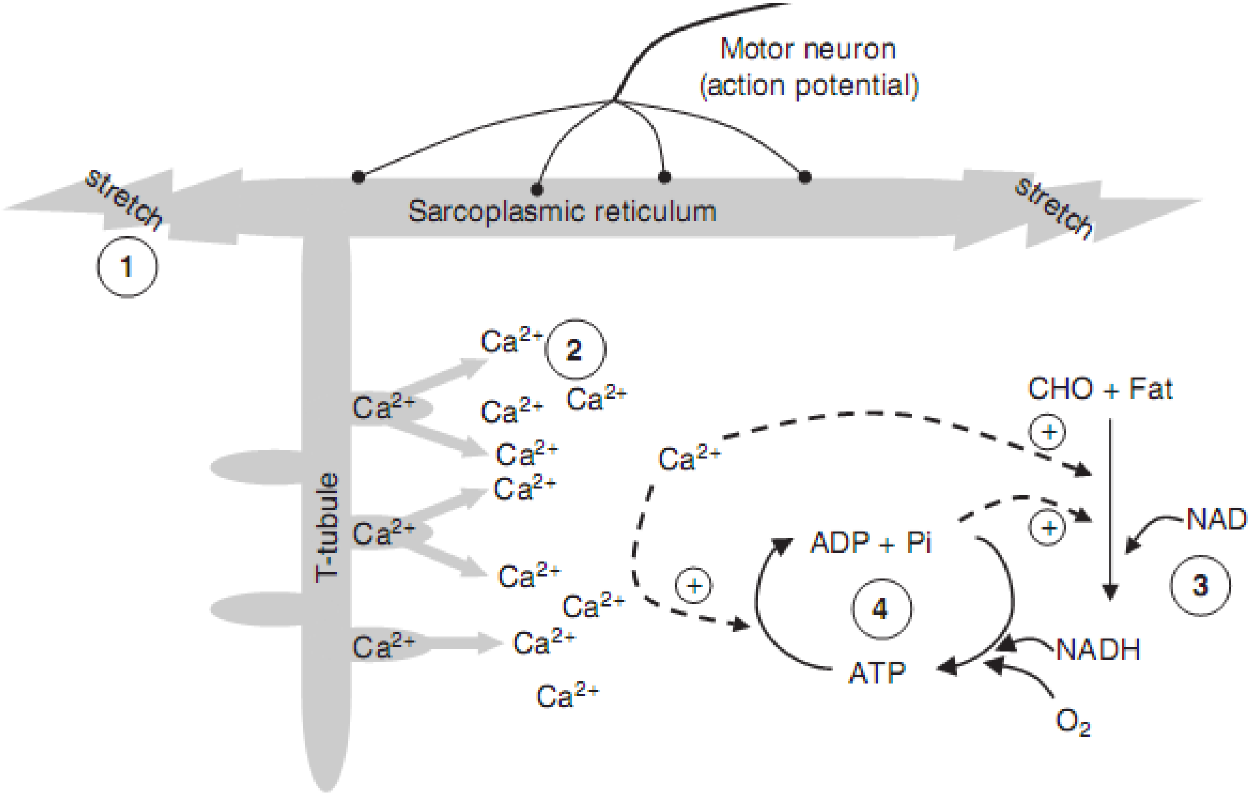




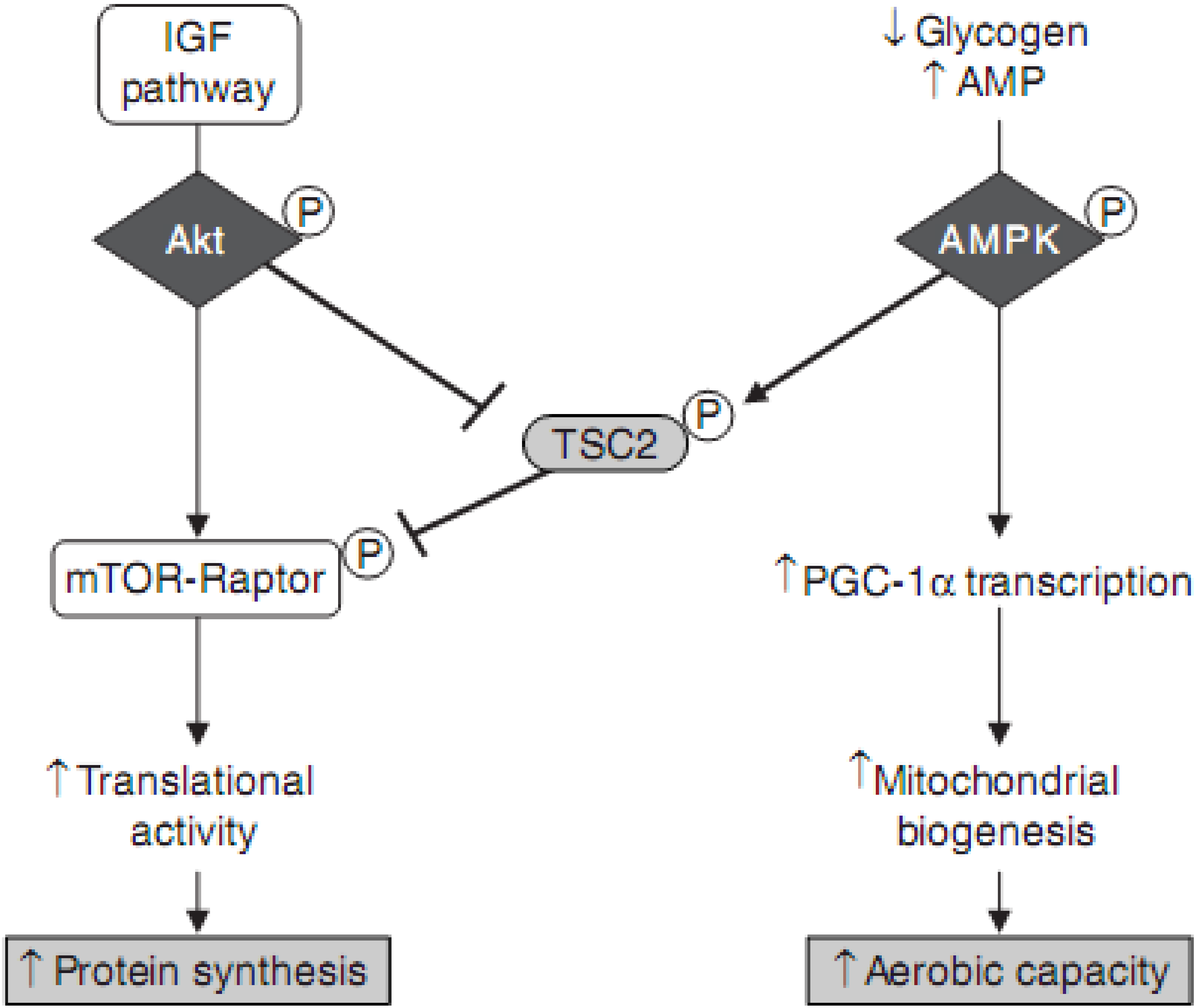
Exercícios variados (peso livre e máquinas)
2wk – 2 x 8-10RM 2d/wk
12wk – 3 x 6 RM 3d/wk

Durante o exercício





- Queda do ATP
- Aumento AMP
- Ativa AMPK
- Ativa Ubiquitina


IGF pathway
Akt
P
↓ Glycogen
↑ AMP
AMPK
P
TSC2
P
mTOR-Raptor
P
↑ PGC-1α transcription
↑ Translational activity
↑ Mitochondrial biogenesis
↑ Protein synthesis
↑ Aerobic capacity

J Physiol 576.2 (2006) pp 613–624

Resistance exercise increases AMPK activity and reduces 4E-BP1 phosphorylation and protein synthesis in human skeletal muscle

Hans C. Dreyer[1,4], Satoshi Fujita[2], Jerson G. Cadenas[2], David L. Chinkes[3], Elena Volpi[2]
and Blake B. Rasmussen[1,4]

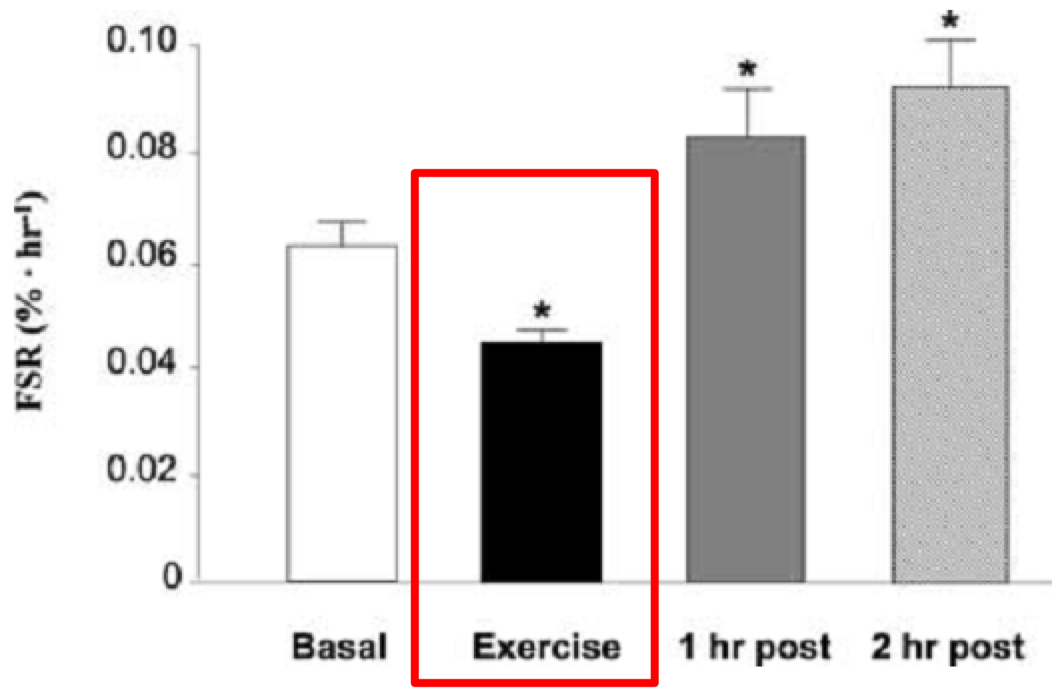


Figure 2. Muscle protein synthesis as expressed by the mixed muscle fractional synthetic rate (FSR) before, during, and after a bout of resistance exercise

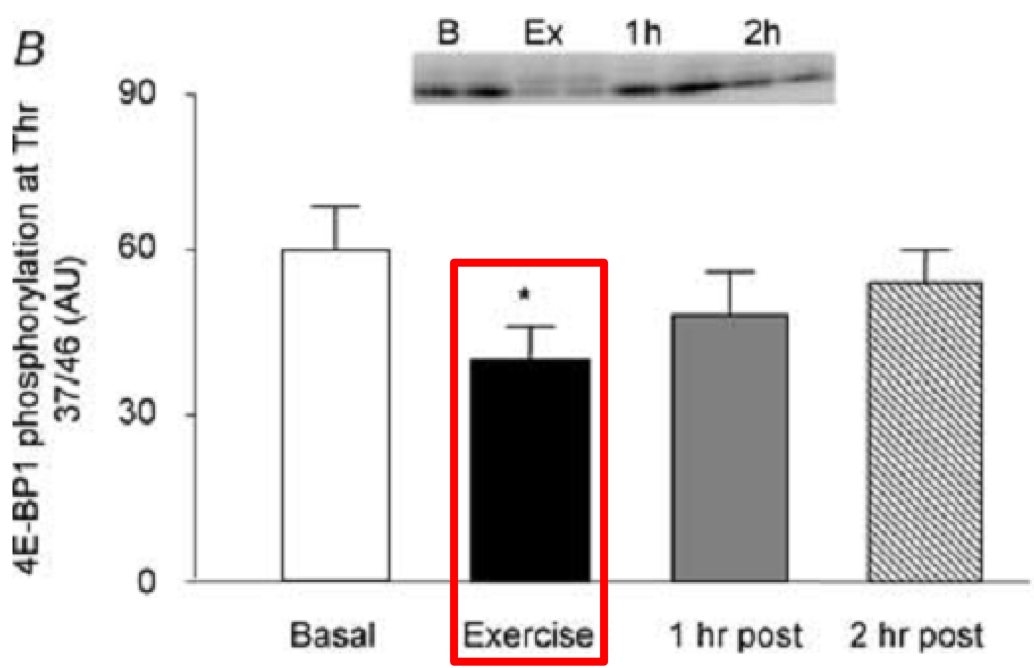
Data are expressed as means ± S.E.M., $n = 11$. *Significantly different from basal ($P < 0.05$).

J Physiol 576.2 (2006) pp 613–624

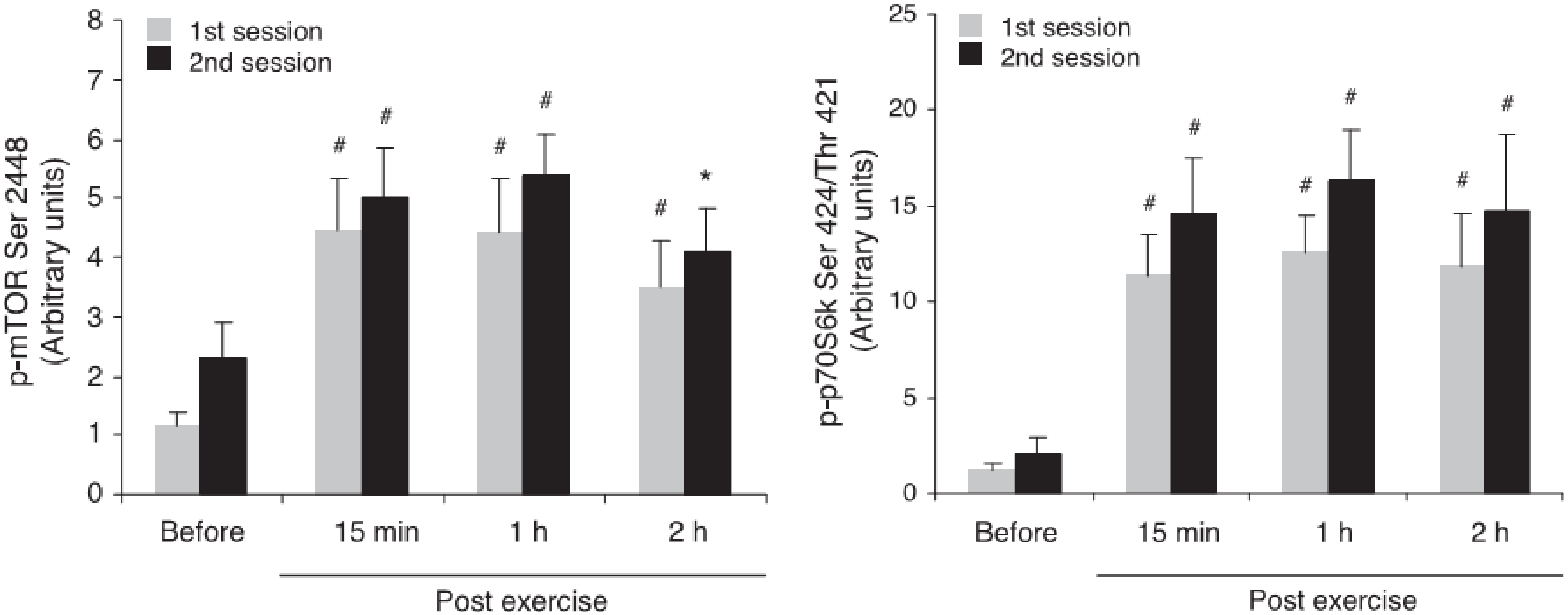
Resistance exercise increases AMPK activity and reduces 4E-BP1 phosphorylation and protein synthesis in human skeletal muscle

Hans C. Dreyer[1,4], Satoshi Fujita[2], Jerson G. Cadenas[2], David L. Chinkes[3], Elena Volpi[2] and Blake B. Rasmussen[1,4]

Figure 3. Muscle AMPKα2 activity before, during and after a bout of resistance exercise
Data are expressed as means ± S.E.M., $n = 11$. *Significantly different from basal ($P < 0.05$).

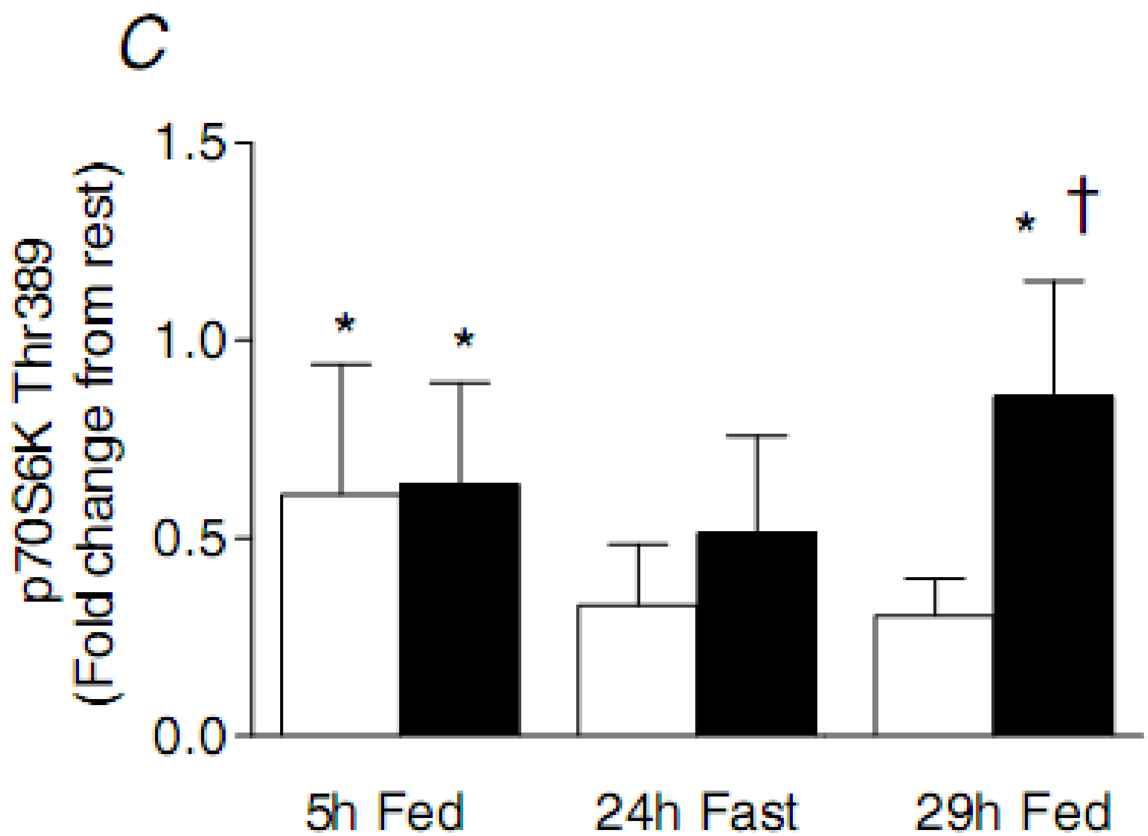


Imediatamente após o exercício

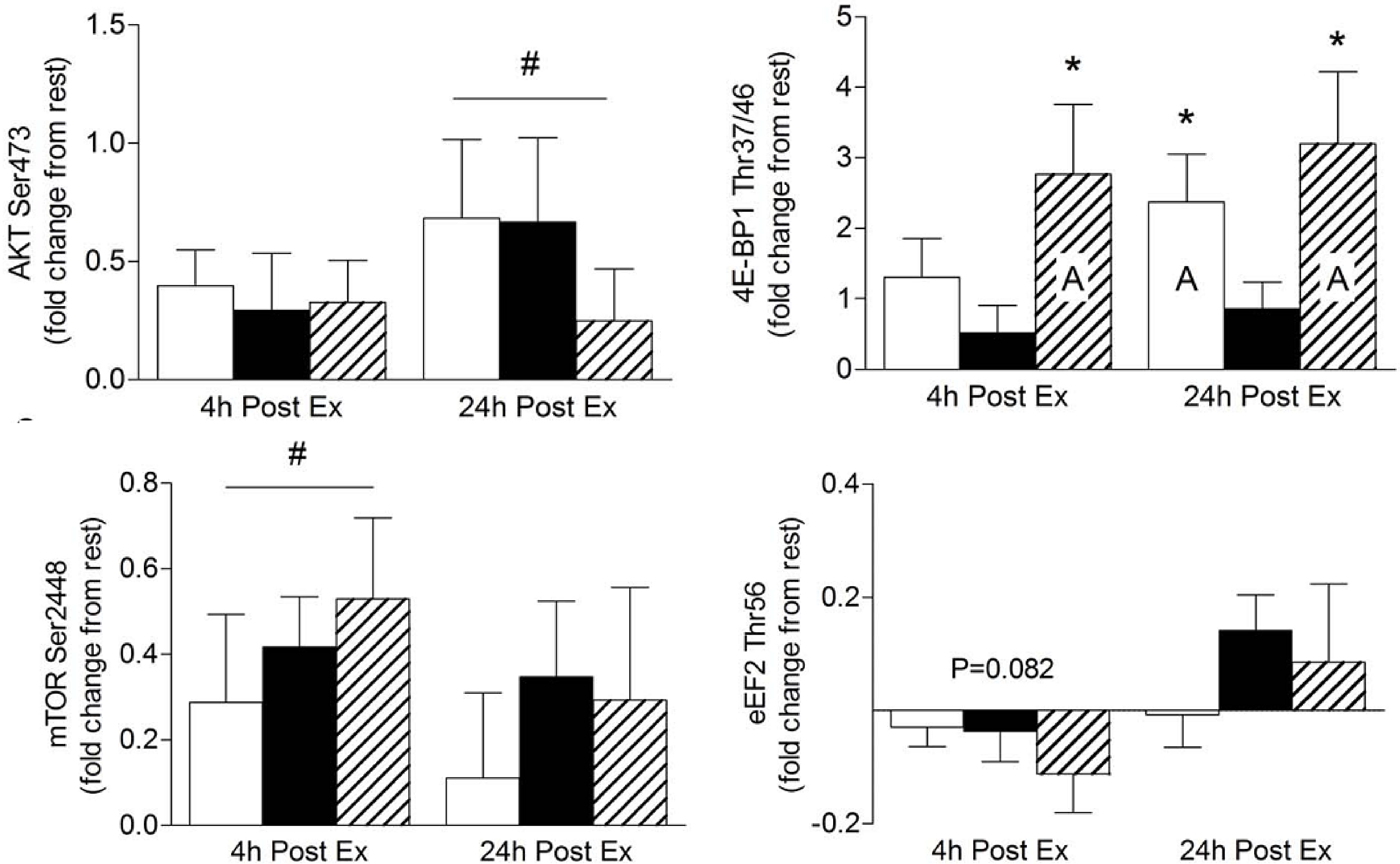


Mascher et al 2007

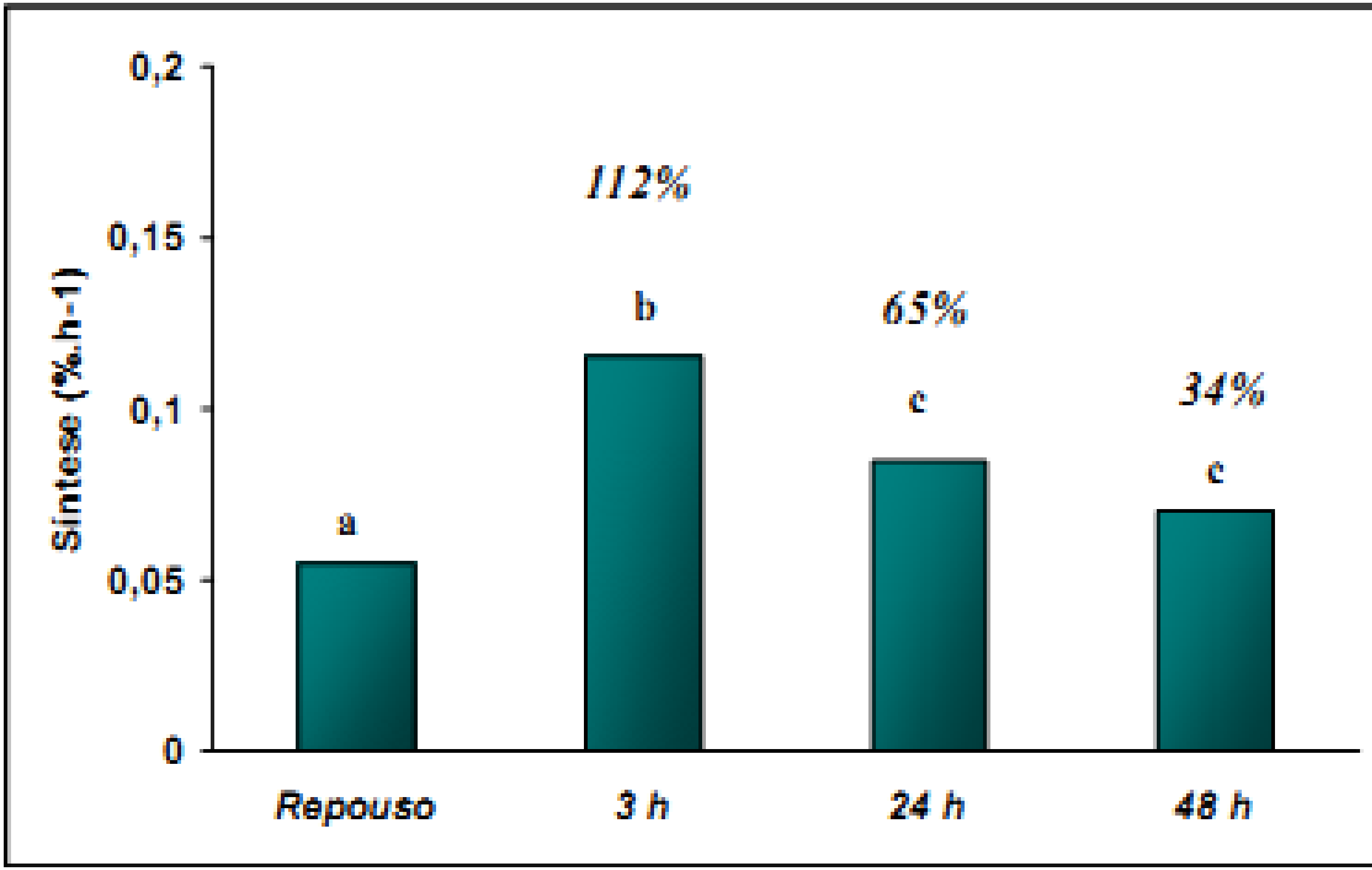
24 – 29h após o exercício



Burd et al 2010



Burd et al 2010



Phillips et al. (1997)

The Time Course for Elevated Muscle Protein Synthesis Following Heavy Resistance Exercise

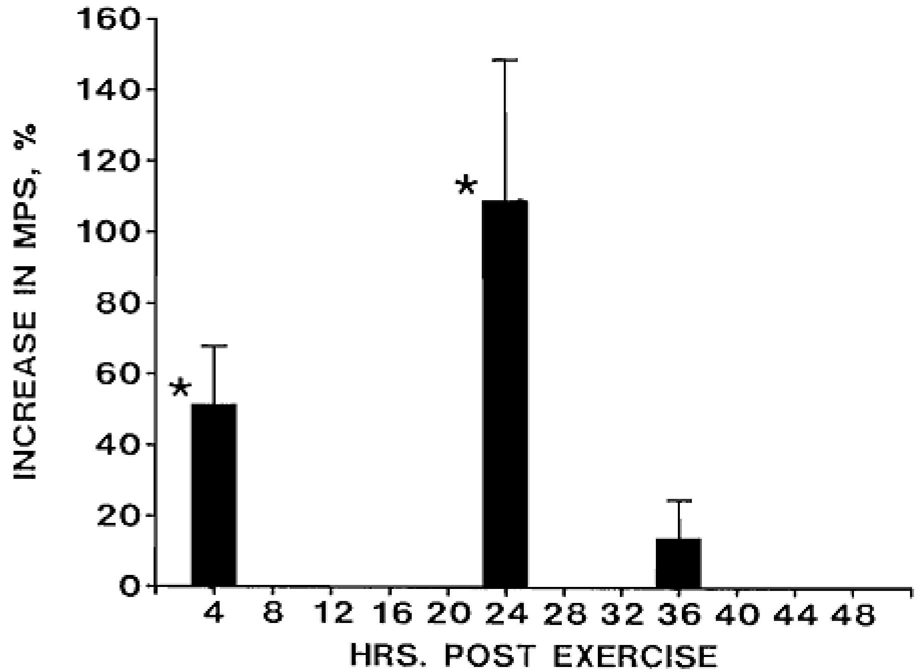
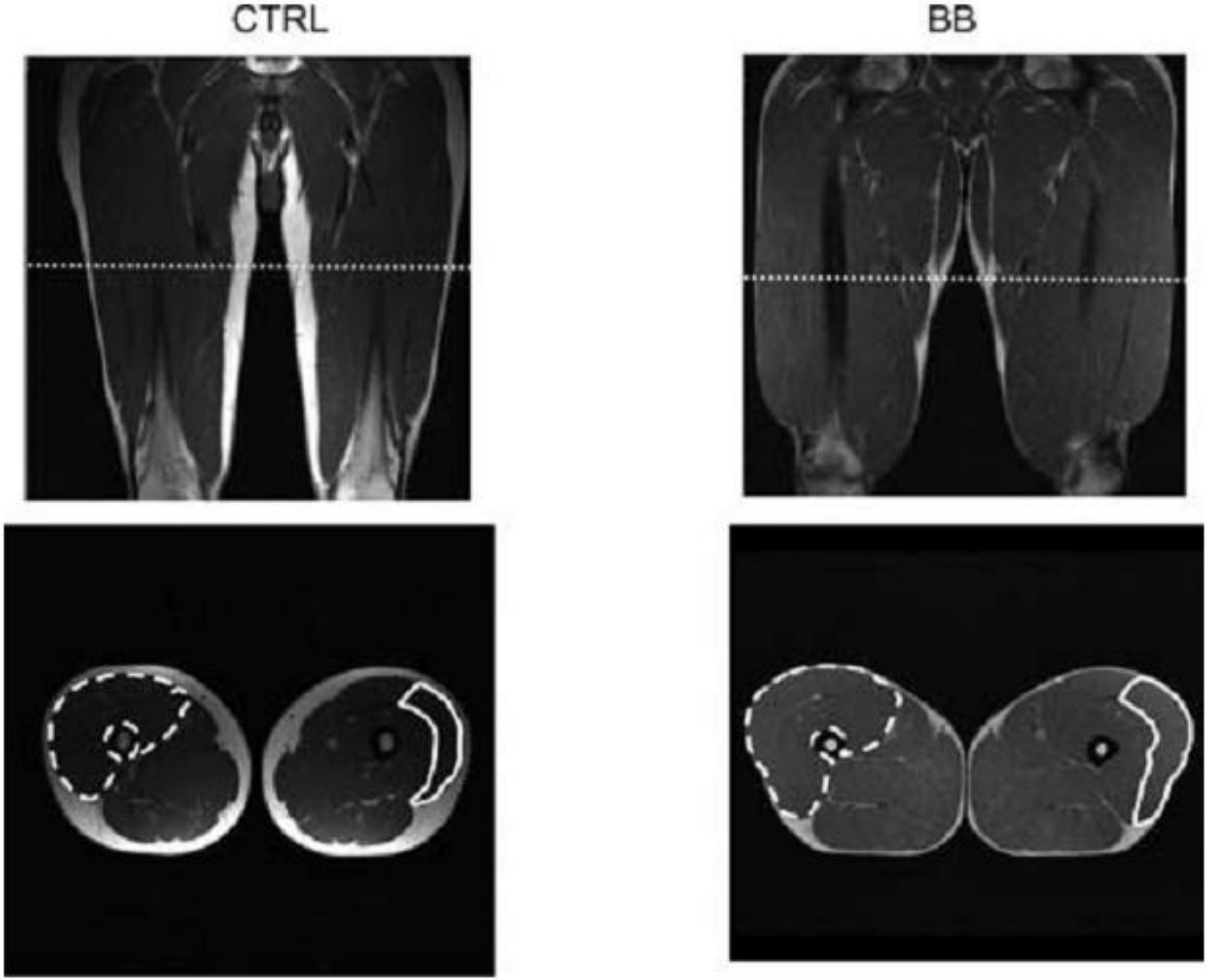


Figure 2. Increase in muscle protein synthetic rate 4, 24, and 36 hrs after a single resistance training bout. Values indicate the difference between MPS in the exercised and control arm. Data at 4 and 24 hrs are from a previous study (see text). *Significant at $p < 0.05$.

MacDougall et al 1995

Treinamento e Hipertrofia

HIPERTROFIA MUSCULAR



Porque ocorre a hipertrofia?

- **Estímulo hormonal**
- **Estímulo metabólico/Hipóxia**
- **Estímulo tensional/Dano muscular**

J Appl Physiol 108: 60–67, 2010.
First published November 12, 2009; doi:10.1152/japplphysiol.01147.2009.

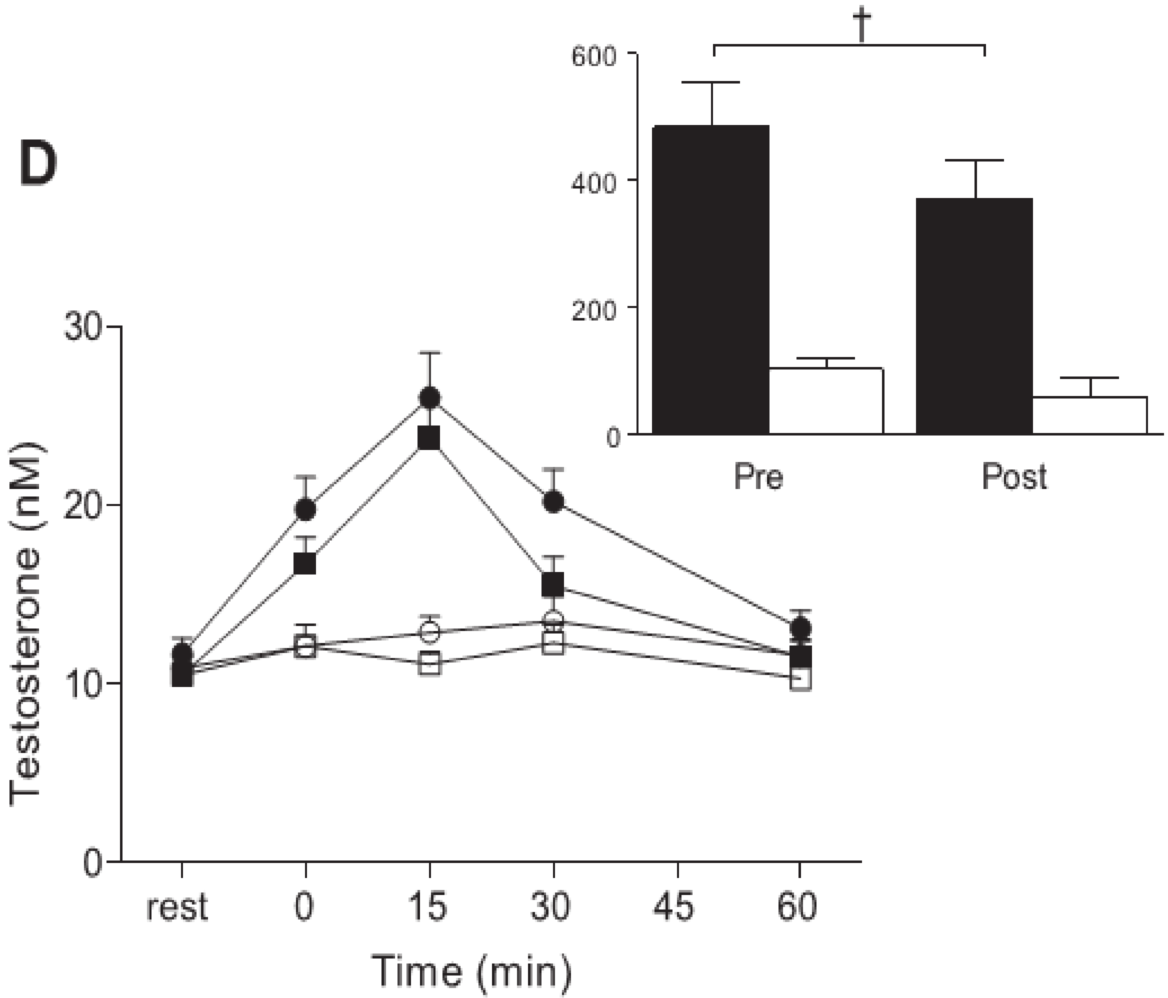
Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors

Daniel W. D. West,[1] Nicholas A. Burd,[1] Jason E. Tang,[1] Daniel R. Moore,[1] Aaron W. Staples,[1] Andrew M. Holwerda,[1] Steven K. Baker,[2] and Stuart M. Phillips[1]

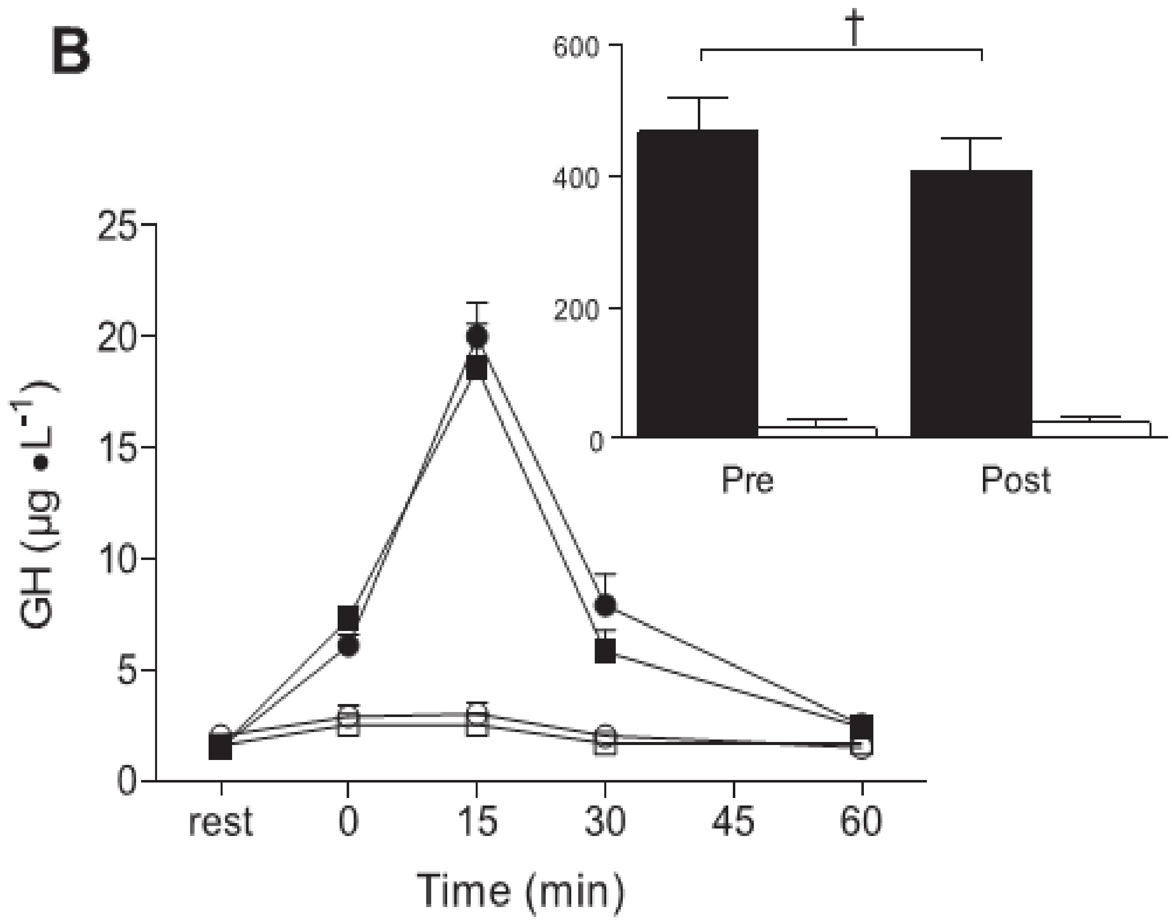
[1]*Exercise Metabolism Research Group, Department of Kinesiology; and* [2]*Department of Medicine, McMaster University, Hamilton, Ontario, Canada*

- Braço – Perna – HH
- Braço – LH

Testosterona

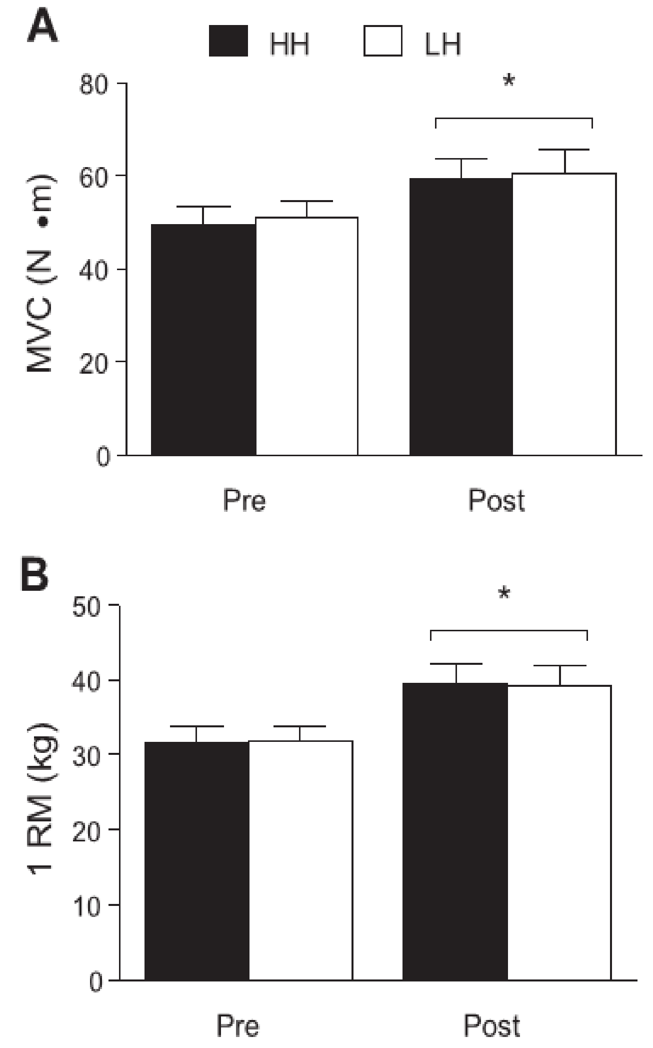


Hormonio do Crescimento



Força

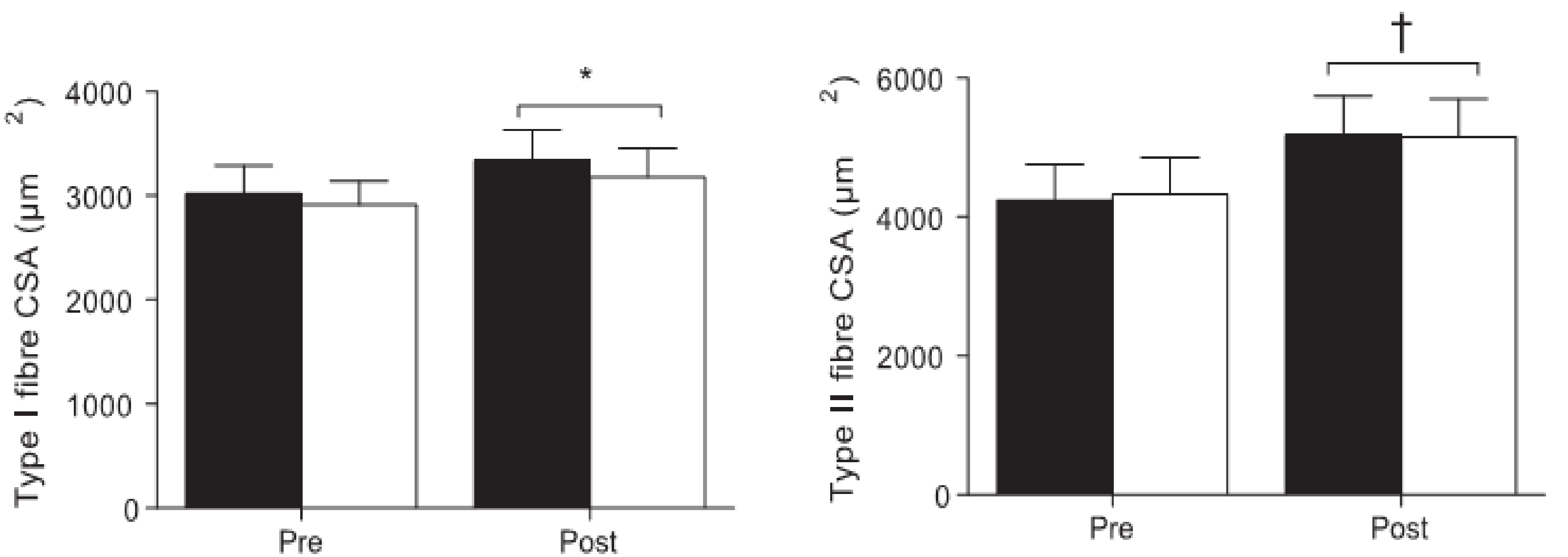
- Hormonal
  - Maior aumento de T, GH, IGF-1 no HH
  West et al. (2009)



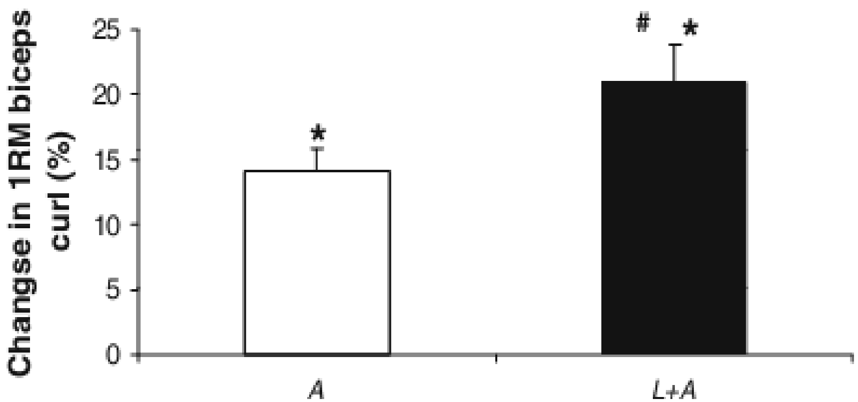
Hipertrofia

- Hormonal
  - Maior aumento de T, GH, IGF-1 no HH

West et al. (2009)



Hipertrofia



- A = Braço
- L+A = Perna + Braço

Ronnestad et al (2011)

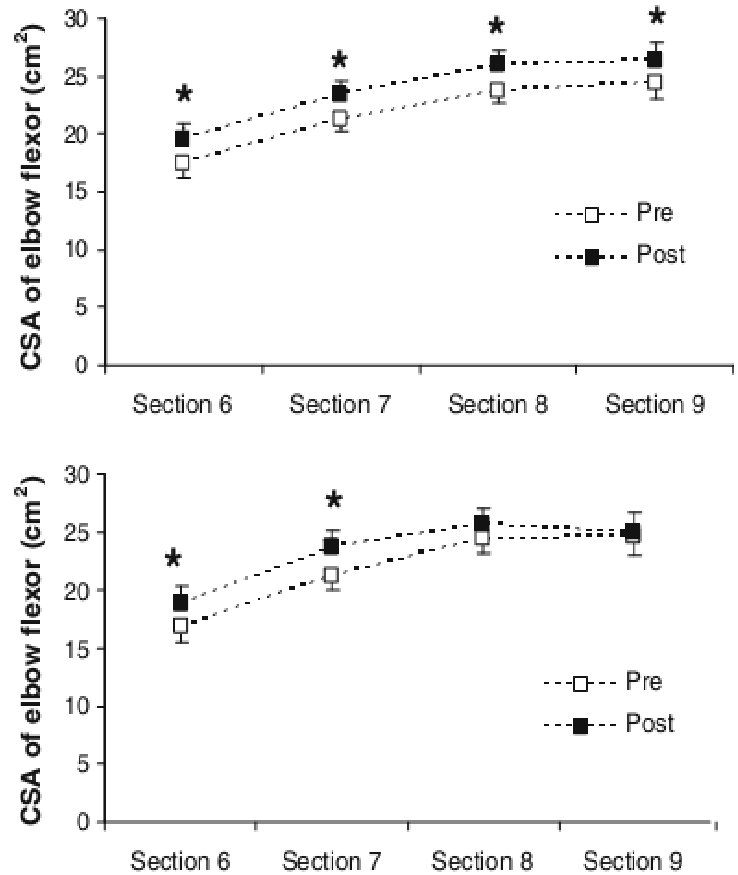


Fig. 6 Changes in CSA for the arm which was trained immediately after leg exercises ($L + A$; upper panel) and the arm which was trained without leg exercises before (A; *lower panel*) in different regions of the elbow flexors. Section 6 is most proximal and section 9 is most distal. The space between each section is 35 mm. *Different from pre ($p < 0.01$)

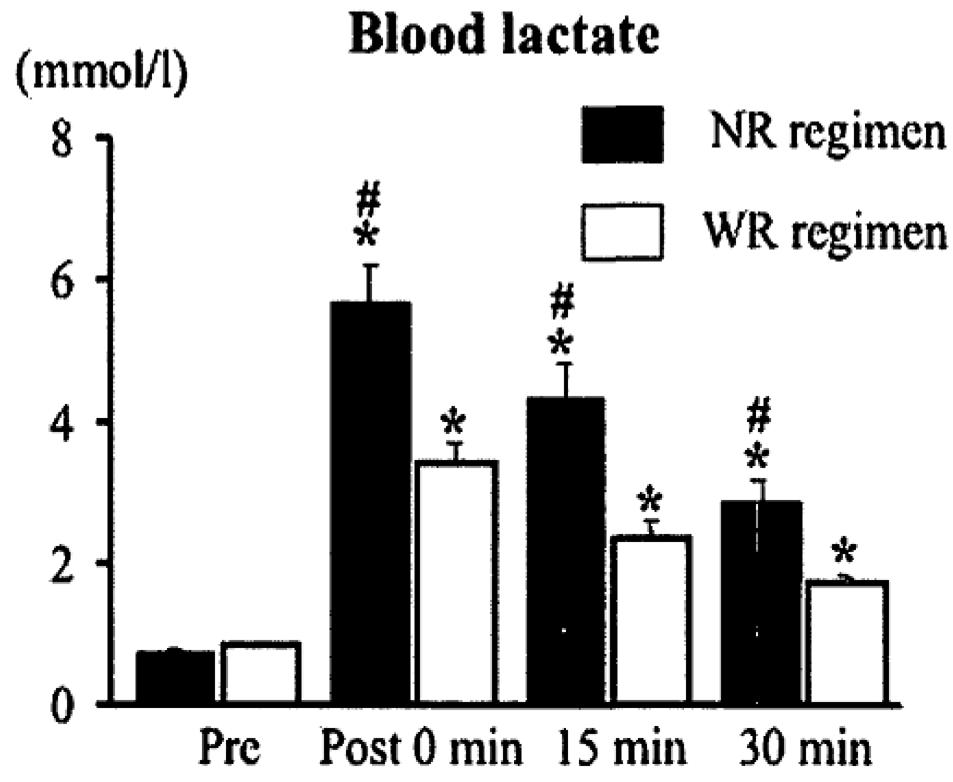
Hipertrofia

- Ronnestad x West
- Possível efeito da ordem dos exercícios
  - Grupos musculares maiores antes

SOBRECARGA METABÓLICA

- NR = Sem intervalo intra série
- WR = Com intervalo intra série

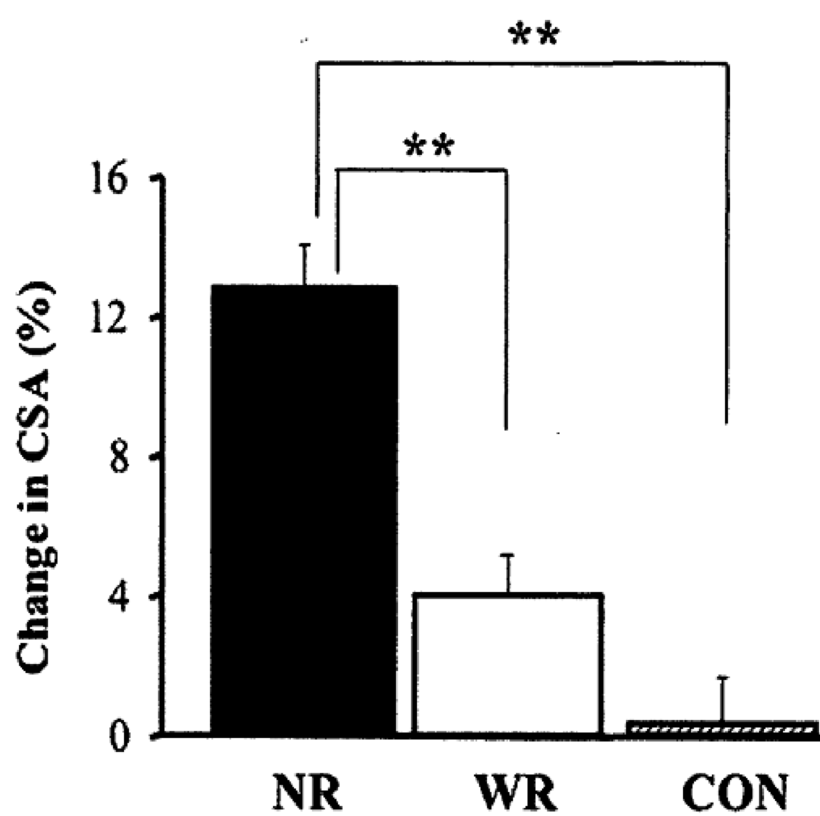
Goto et al (2005)



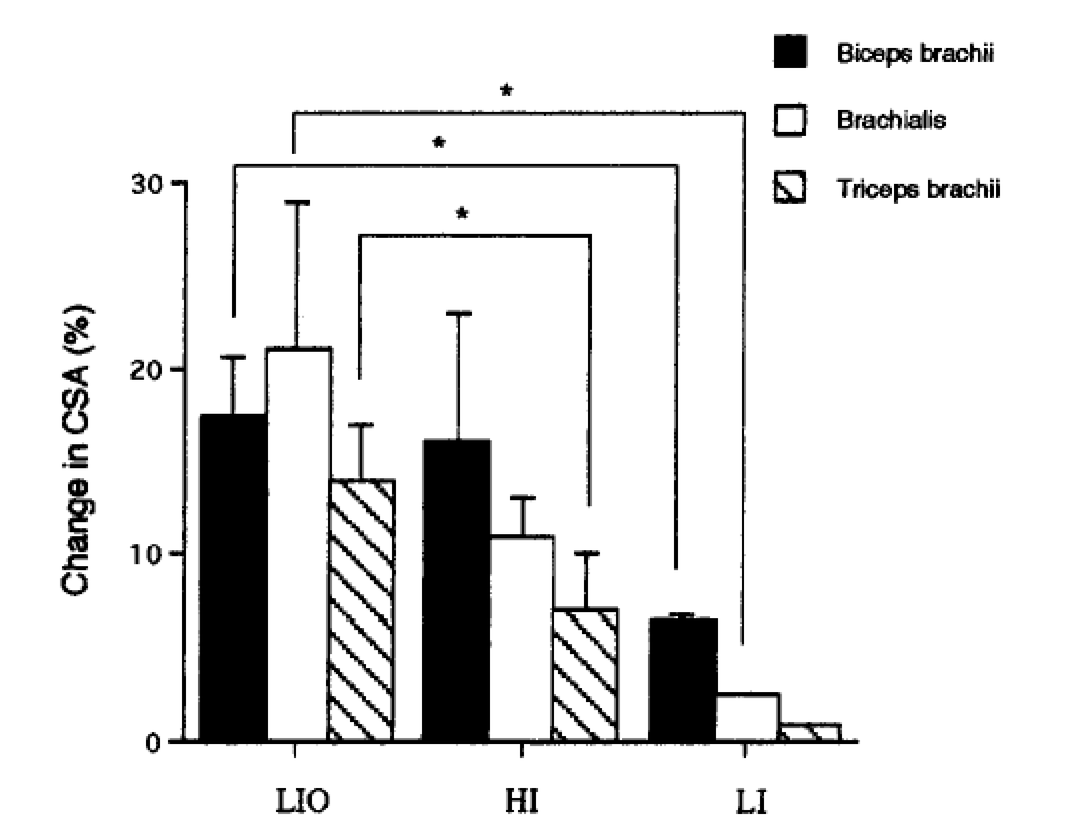
SOBRECARGA METABÓLICA

- NR = Sem intervalo intra série
- WR = Com intervalo intra série

Goto et al (2005)



HIPERTROFIA



80% 1RM = 20,3%

Bíceps braquial

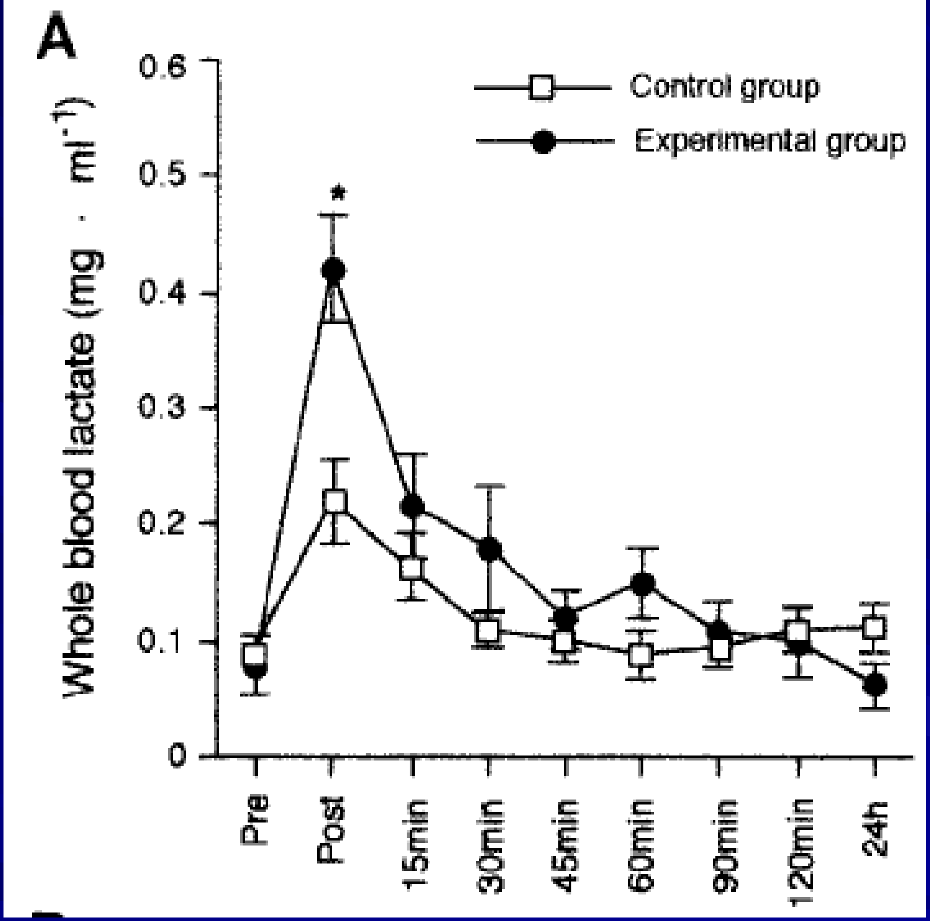
ns

50% + oclusão = 18,4%

50% sem oclusão = 6,9%
(n.s)

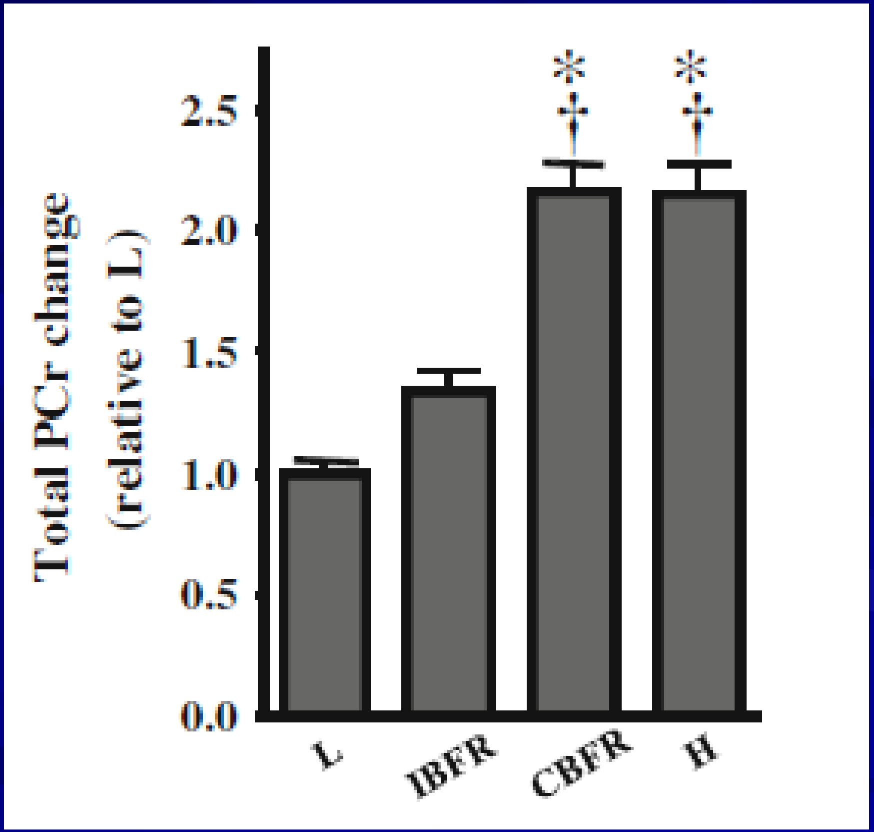
Takarada et al., 2000

TFRF – Lactato



Takarada et al. (2000)

Estresse Metabólico Intramuscular Similar ao TF de Alta Intensidade



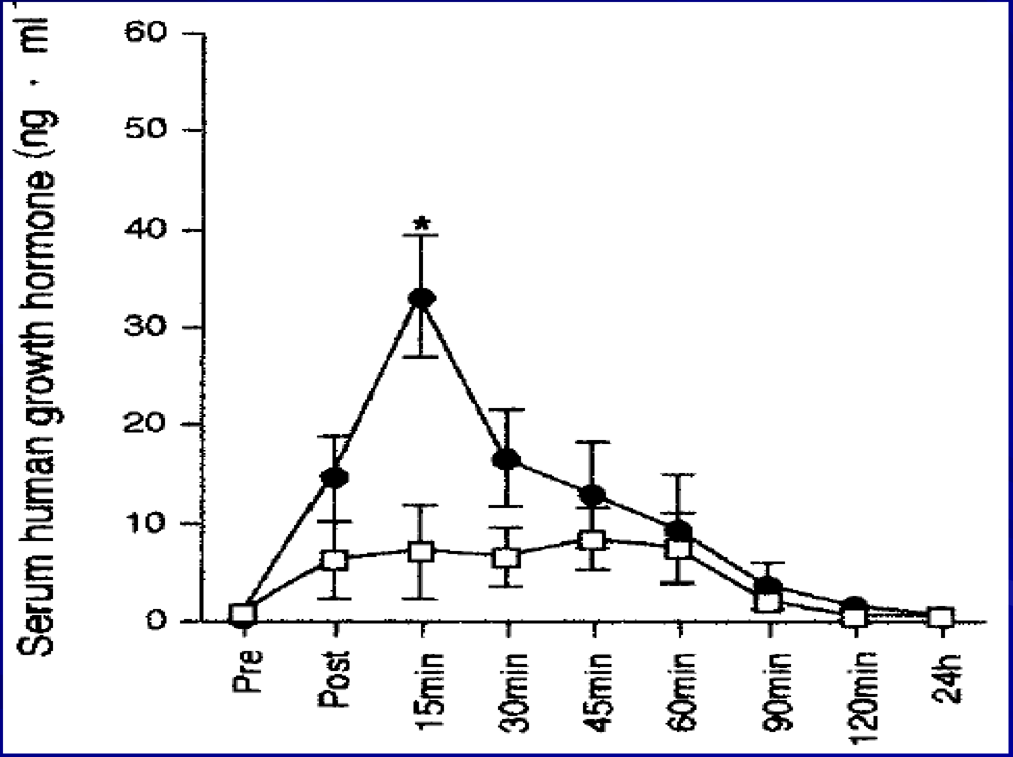
Suga et al. 2012 - Eur J Appl Phisiol

Rapid increase in plasma growth hormone after low-intensity resistance exercise with vascular occlusion

YUDAI TAKARADA,[1] YUTAKA NAKAMURA,[2] SEIJI ARUGA,[2]
TETUYA ONDA,[2] SEIJI MIYAZAKI,[2] AND NAOKATA ISHII[3]

~20% 1RM – 5 séries
até a fadiga (214 mmHg)

Extensão de joelho



J. Appl. Physiol.
88: 61–65, 2000.

Mecanismos de Ação

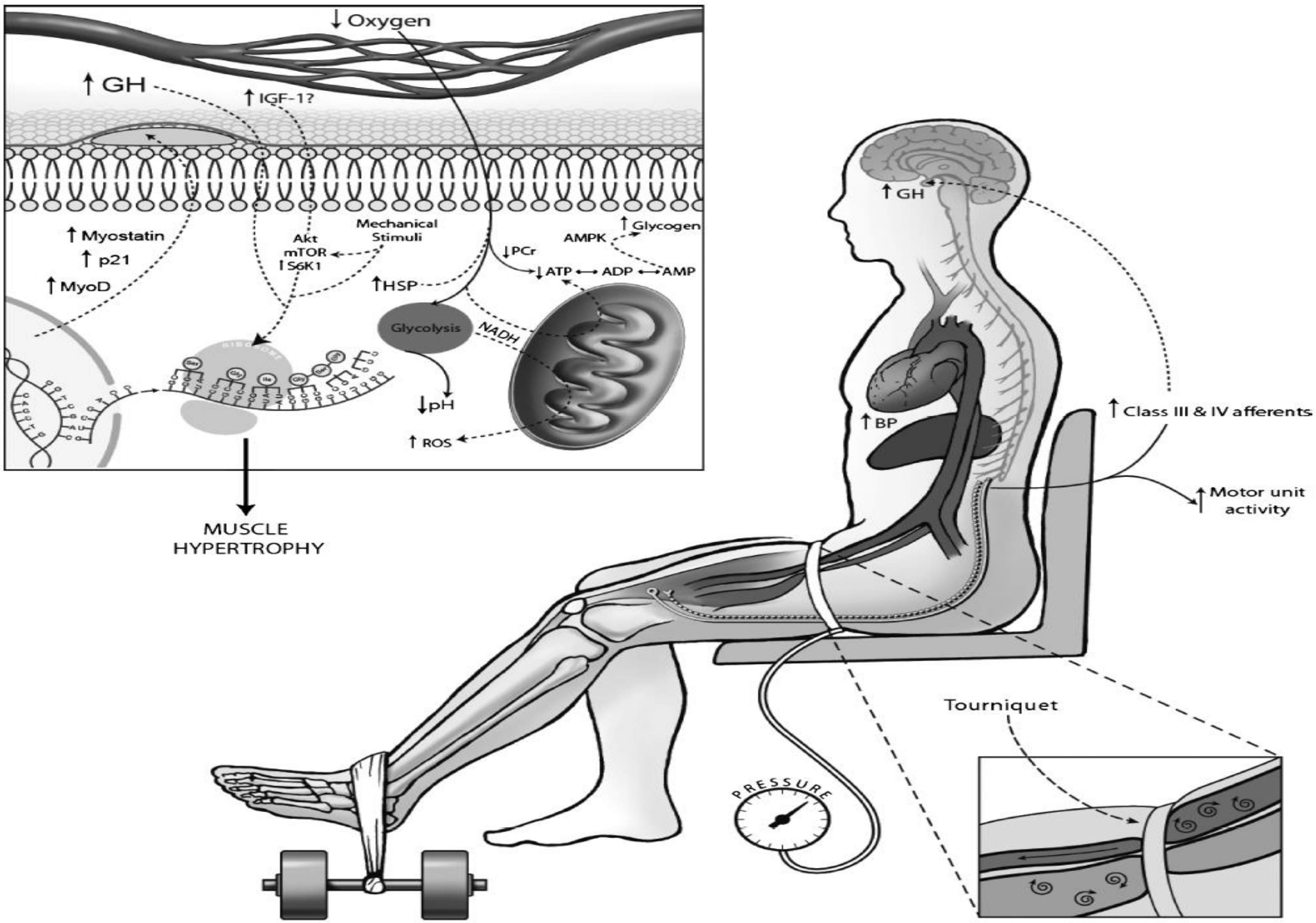


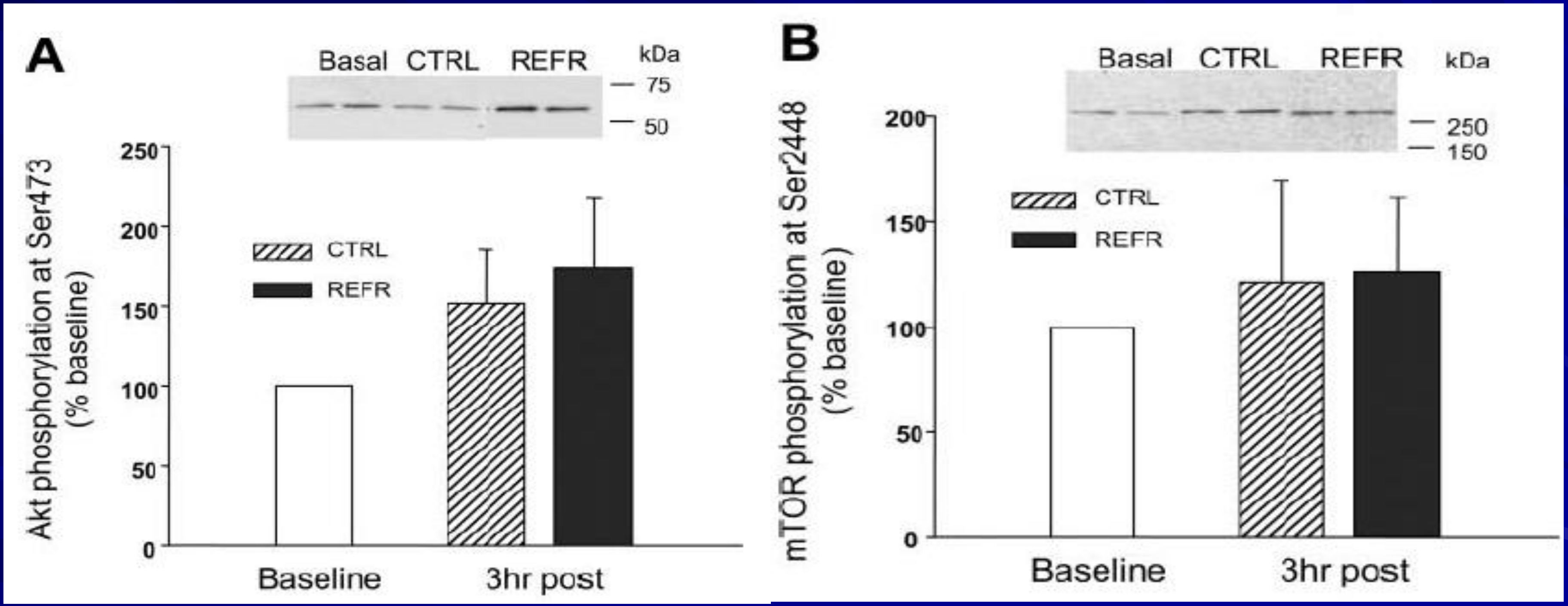
Figure 1. Conceptual model of the physiological responses to blood flow restricted exercise (BFR). GH indicates growth hormone; BP, blood pressure; O_2, oxygen; IGF-1, insulin-like growth factor-1; p21, cyclin-dependent kinase inhibitor 1A; mTOR, mammalian target of rapamycin; S6K1, ribosomal protein S6 kinase; HSP, heat shock protein; ROS, reactive oxygen species; ATP, adenosine triphosphate; ADP, adenosine diphosphate; AMP, adenosine monophosphate; AMPK, AMP-activated protein kinase.

Manini e Clark (2009)

Resposta Aguda TFRF – Akt/Mtor

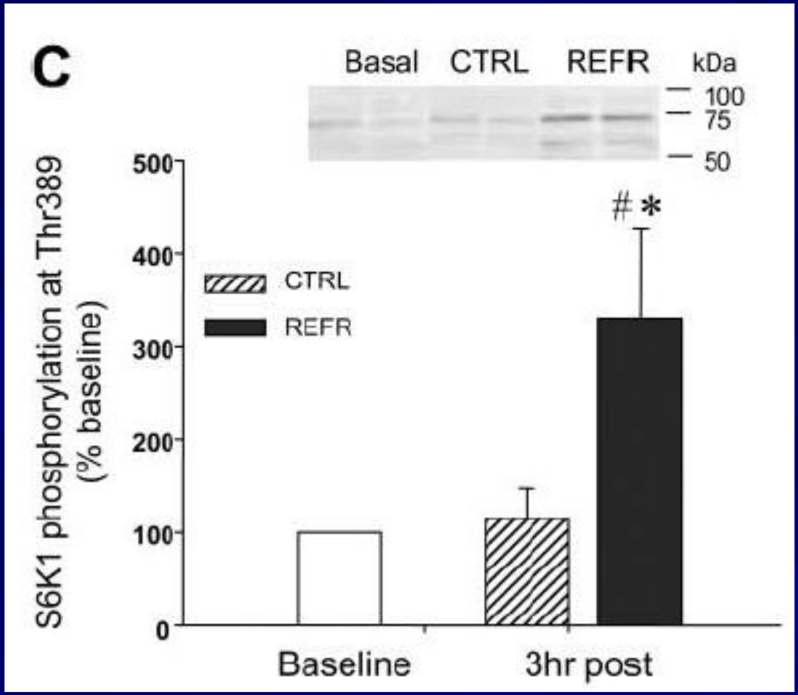
Blood flow restriction during low-intensity resistance exercise increases S6K1 phosphorylation and muscle protein synthesis

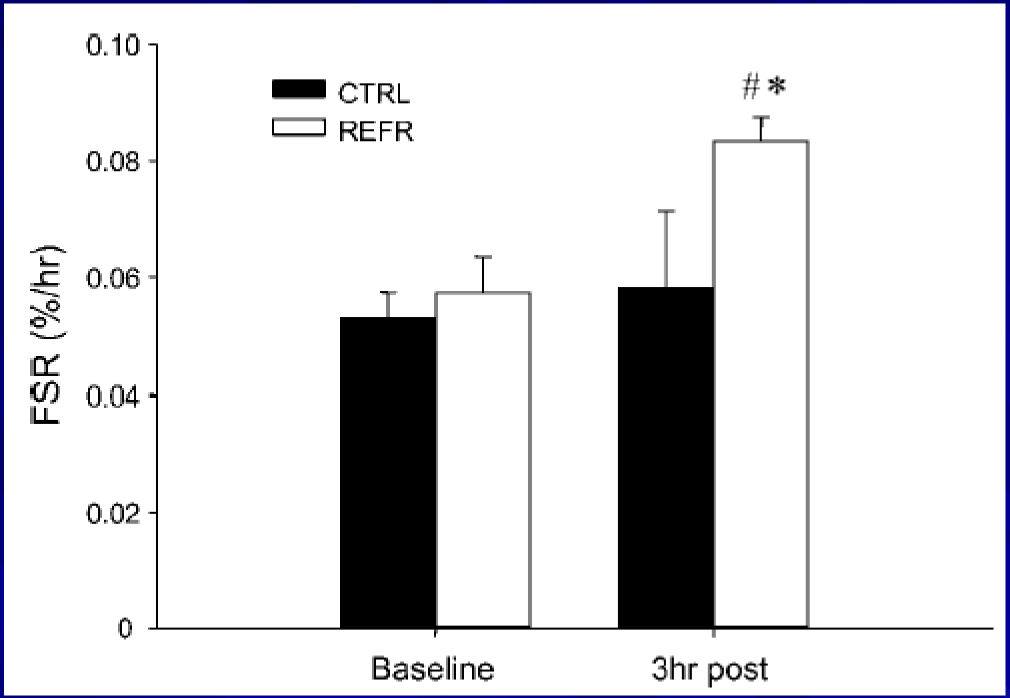
Satoshi Fujita,[1,4] Takashi Abe,[4] Micah J. Drummond,[2,3] Jerson G. Cadenas,[1] Hans C. Dreyer,[2,3] Yoshiaki Sato,[4] Elena Volpi,[1] and Blake B. Rasmussen[2,3]



J Appl Physiol 103: 903–910, 2007.

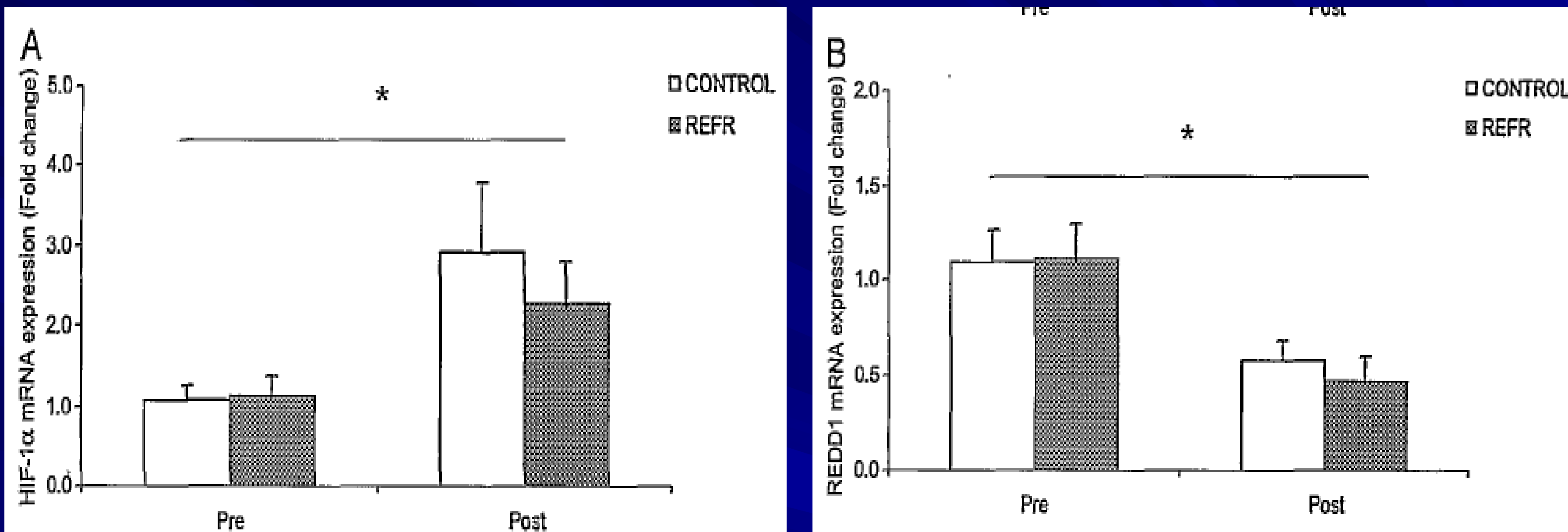
TF + Oclusão Vascular – S6K1/Taxa de Síntese de Proteína





- Condição Experimental = 1 série de 30 reps + 3x15RM a 20% de 1RM – Int 30”
- Pressão de oclusão = 200 mmHg – liberada ao final da sessão
- Condição Controle = sem oclusão

HIF-1 e REDD1 - Proteínas Específicas da Hipóxia



Resultados não esperados

DRUMMOND et al. (2008)

Strength Training with Blood Flow Restriction Diminishes Myostatin Gene Expression

GILBERTO CANDIDO LAURENTINO[1], CARLOS UGRINOWITSCH[1], HAMILTON ROSCHEL[1,2], MARCELO SALDANHA AOKI[3], ANTONIO GARCIA SOARES[4], MANOEL NEVES JR[2], ANDRÉ YUI AIHARA[5], ARTUR DA ROCHA CORREA FERNANDES[5], and VALMOR TRICOLI[1]

Grupo LI – 20% 1RM sem oclusão

Grupo LIR – 20% 1RM com oclusão

Grupo HI – 80% 1RM

Exercício de Extensão de Joelhos Bilateral

8 semanas de treinamento

Strength Training with Blood Flow Restriction Diminishes Myostatin Gene Expression

GILBERTO CANDIDO LAURENTINO[1], CARLOS UGRINOWITSCH[1], HAMILTON ROSCHEL[1,2], MARCELO SALDANHA AOKI[3], ANTONIO GARCIA SOARES[4], MANOEL NEVES JR[2], ANDRÉ YUI AIHARA[5], ARTUR DA ROCHA CORREA FERNANDES[5], and VALMOR TRICOLI[1]

Força

1RM

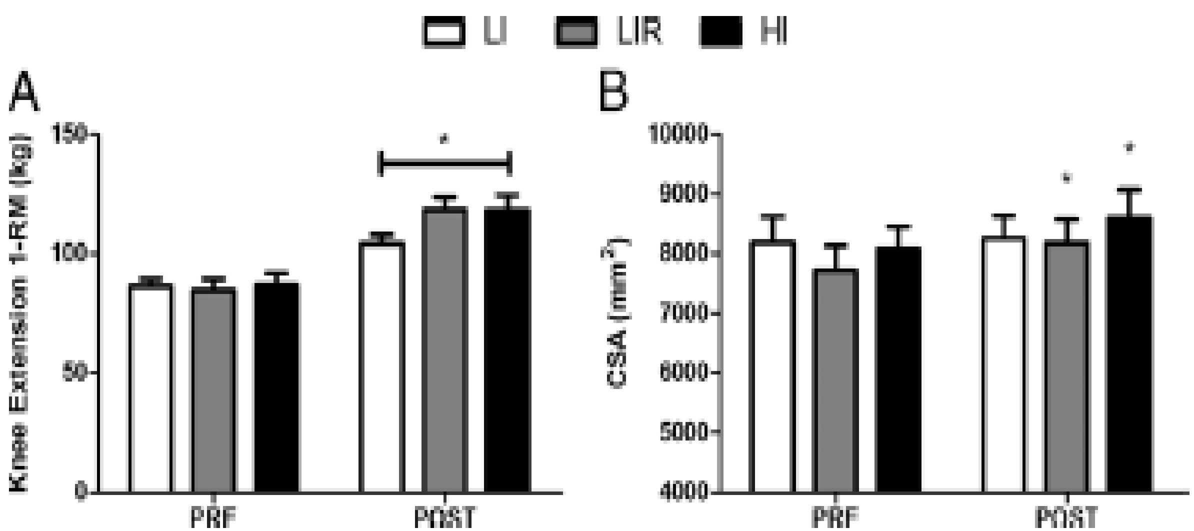


FIGURE 1—Maximum dynamic strength (knee extension 1RM) (A) and quadriceps CSA (B) before (PRE) and after (POST) the exercise training protocol. *$P < 0.05$ for within-group comparisons (PRE vs POST). LIR, LI combined with moderate blood flow restriction; HI, high-intensity resistance training.

AST

Quadríceps

Med Sci Sport Exerc: 44 (3) 406-412 (2012)

Strength Training with Blood Flow Restriction Diminishes Myostatin Gene Expression

GILBERTO CANDIDO LAURENTINO[1], CARLOS UGRINOWITSCH[1], HAMILTON ROSCHEL[1,2], MARCELO SALDANHA AOKI[3], ANTONIO GARCIA SOARES[4], MANOEL NEVES JR[2], ANDRÉ YUI AIHARA[5], ARTUR DA ROCHA CORREA FERNANDES[5], and VALMOR TRICOLI[1]

Grupo LI – 20% 1RM sem oclusão

Grupo LIR – 20% 1RM com oclusão

Grupo HI – 80% 1RM

Exercício de Extensão de Joelhos Bilateral

8 semanas de treinamento

Strength Training with Blood Flow Restriction Diminishes Myostatin Gene Expression

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Força

1RM

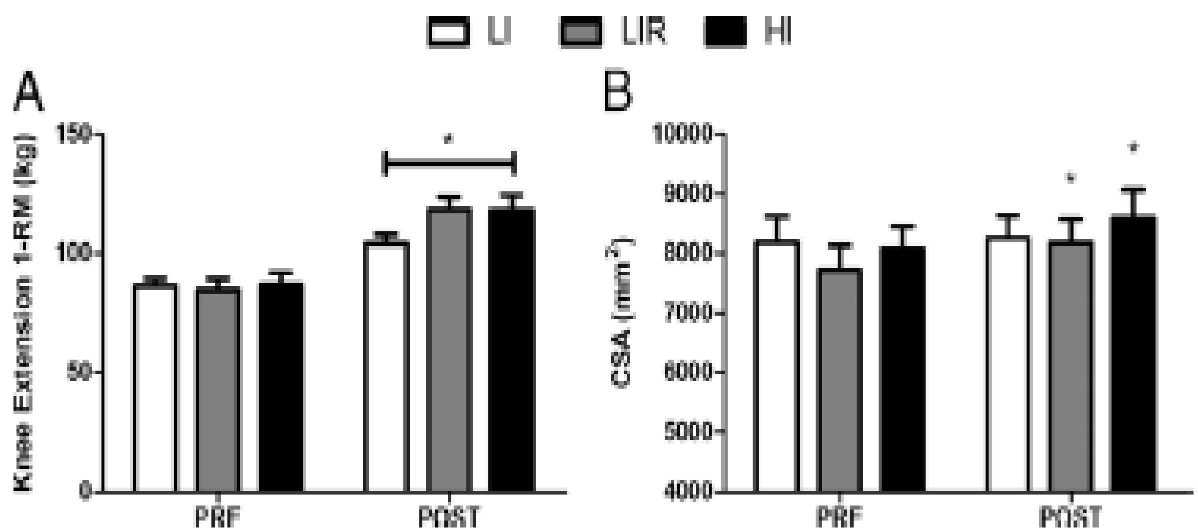


FIGURE 1—Maximum dynamic strength (knee extension 1RM) (A) and quadriceps CSA (B) before (PRE) and after (POST) the exercise training protocol. *$P < 0.05$ for within-group comparisons (PRE vs POST). LIR, LI combined with moderate blood flow restriction; HI, high-intensity resistance training.

AST

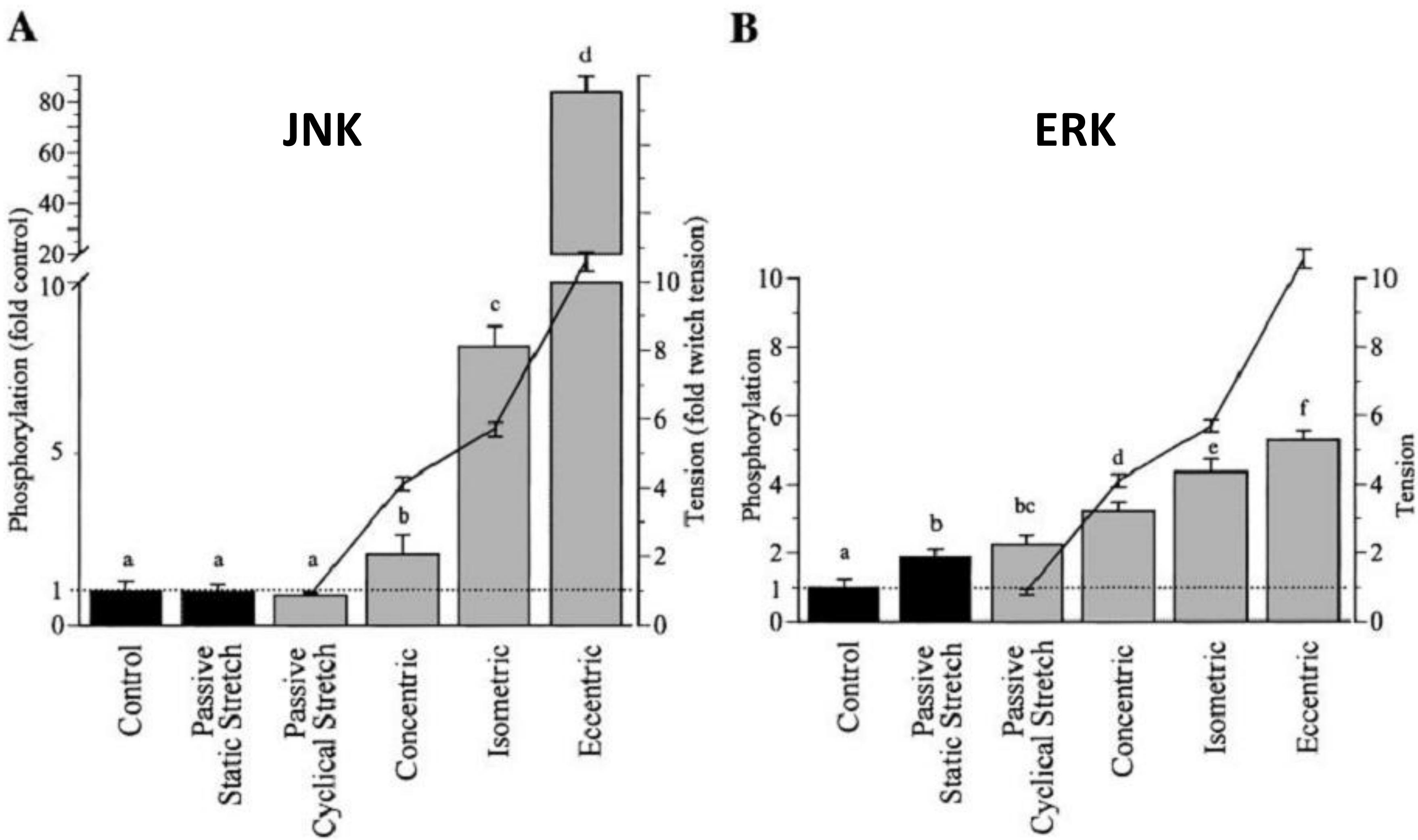
Quadríceps

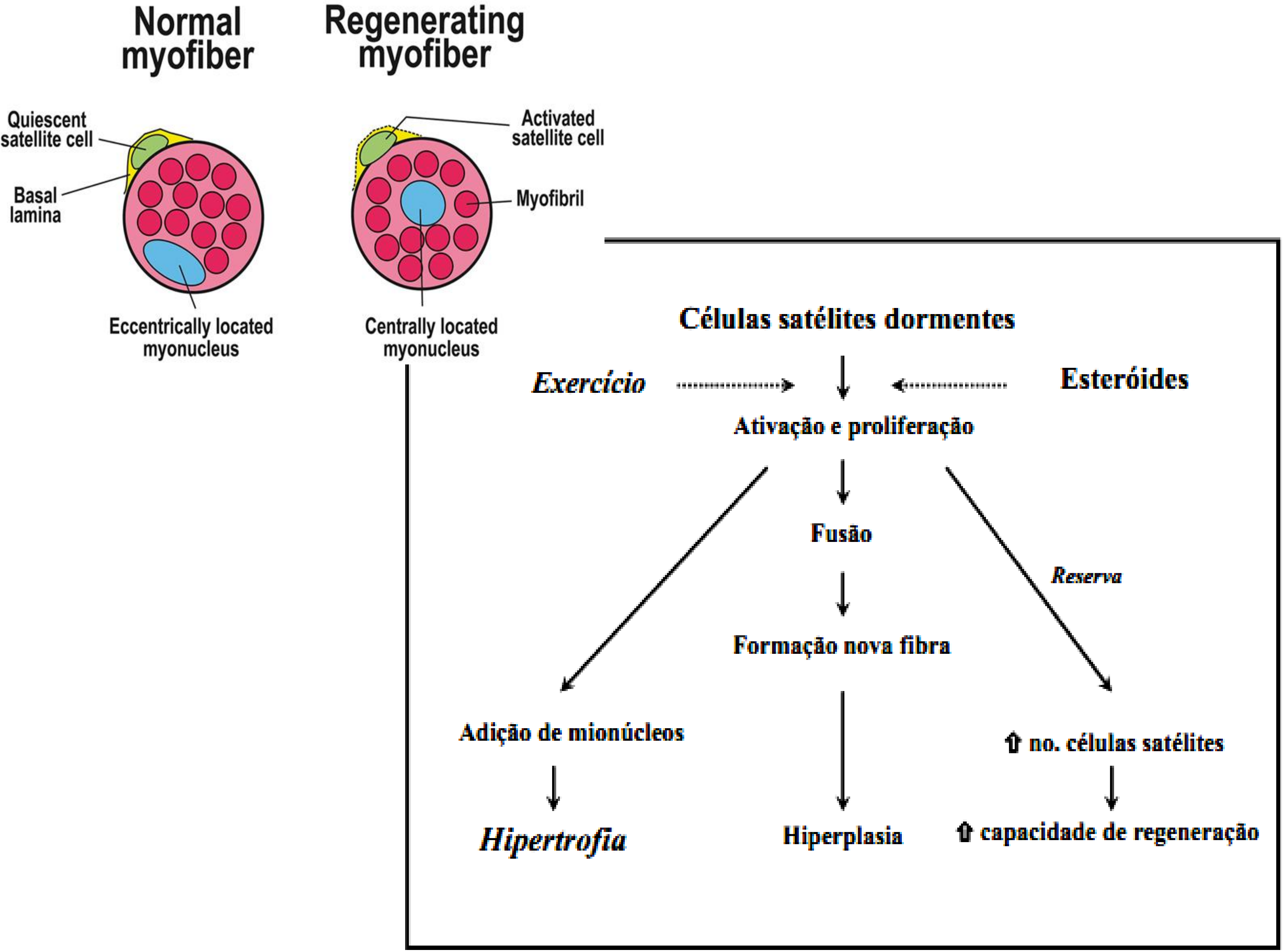
Med Sci Sport Exerc: 44 (3) 406-412 (2012)

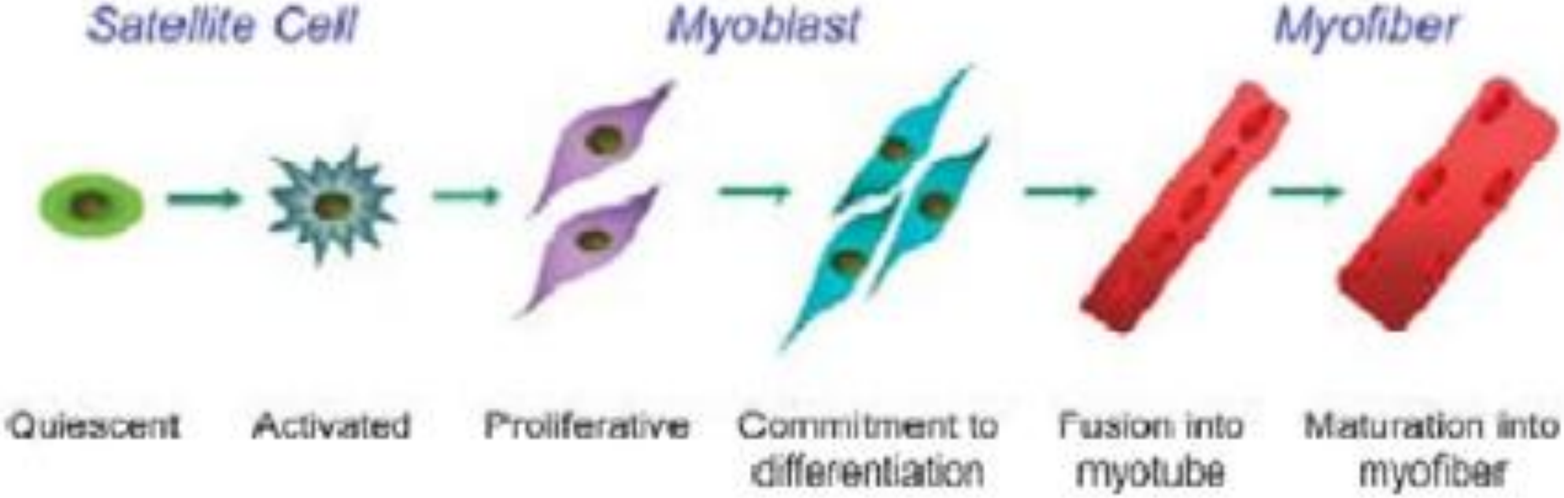
Insight into skeletal muscle mechanotransduction: MAPK activation is quantitatively related to tension

Louis C. Martineau and Phillip F. Gardiner

J Appl Physiol 91:693-702, 2001.

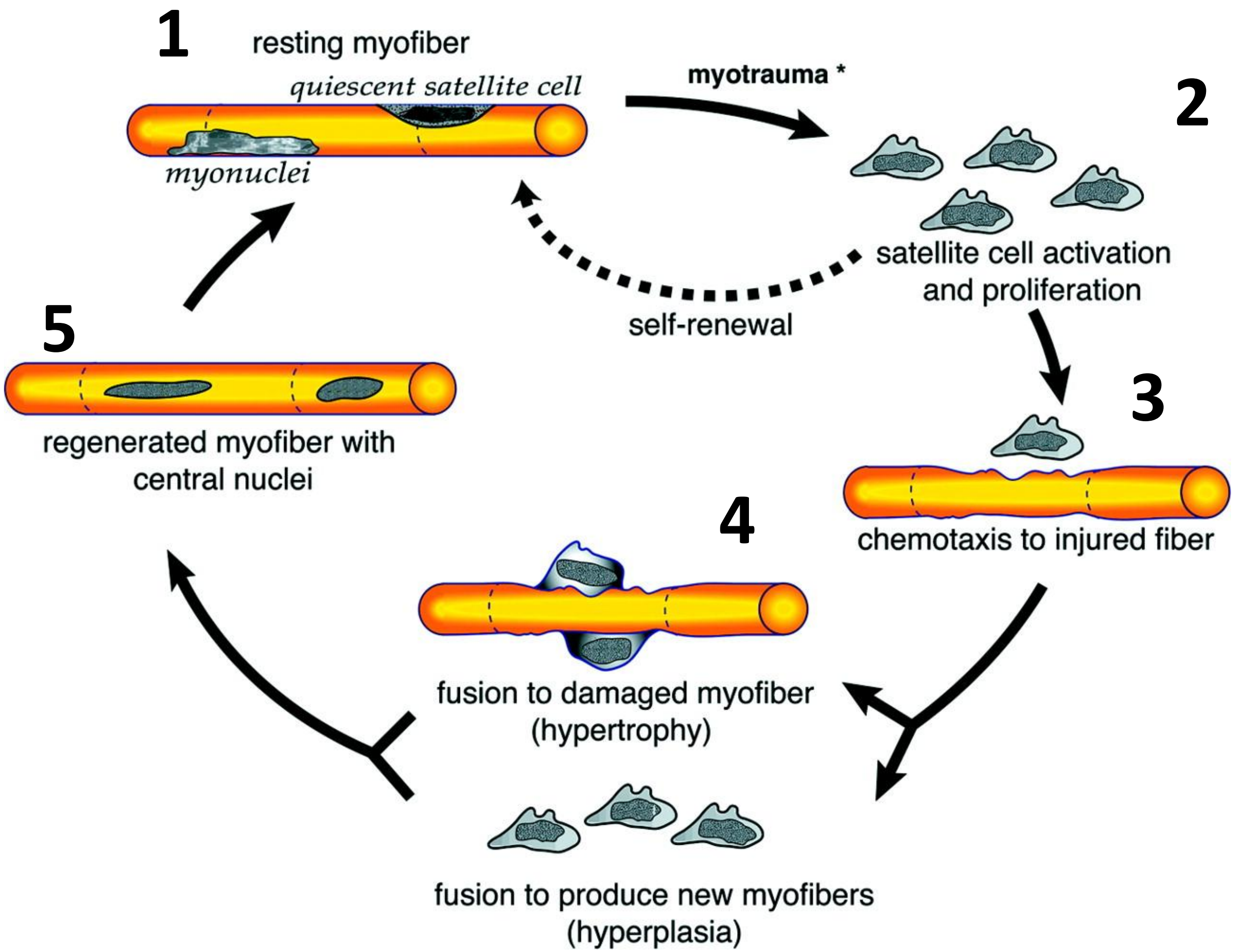



Normal myofiber
Regenerating myofiber
Quiescent satellite cell
Basal lamina
Eccentrically located myonucleus
Activated satellite cell
Myofibril
Centrally located myonucleus
Células satélites dormentes
Exercício
Esteróides
Ativação e proliferação
Fusão
Reserva
Formação nova fibra
Adição de mionúcleos
⇧ no. células satélites
Hipertrofia
Hiperplasia
⇧ capacidade de regeneração

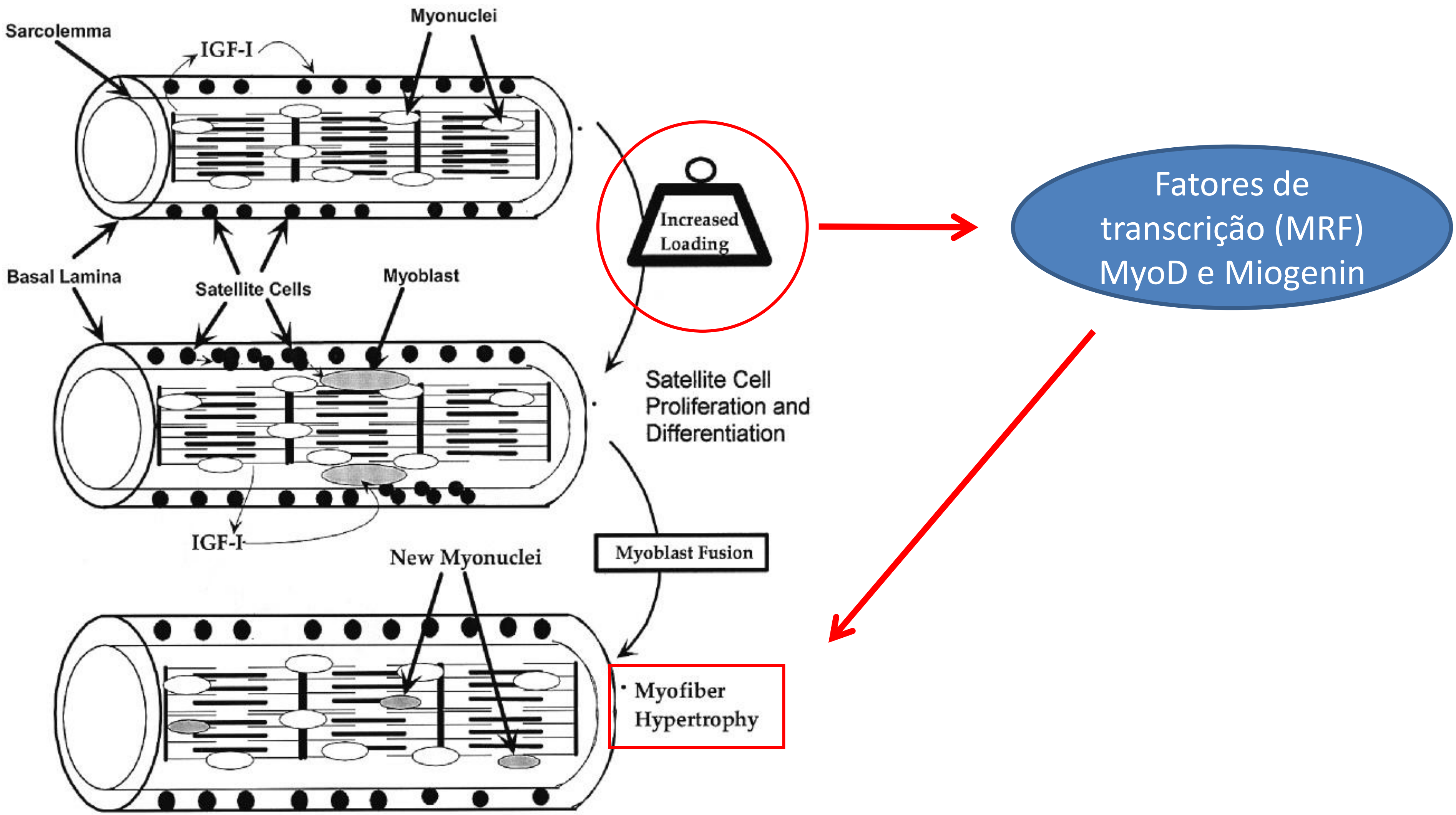


Zammit e col. (2006)

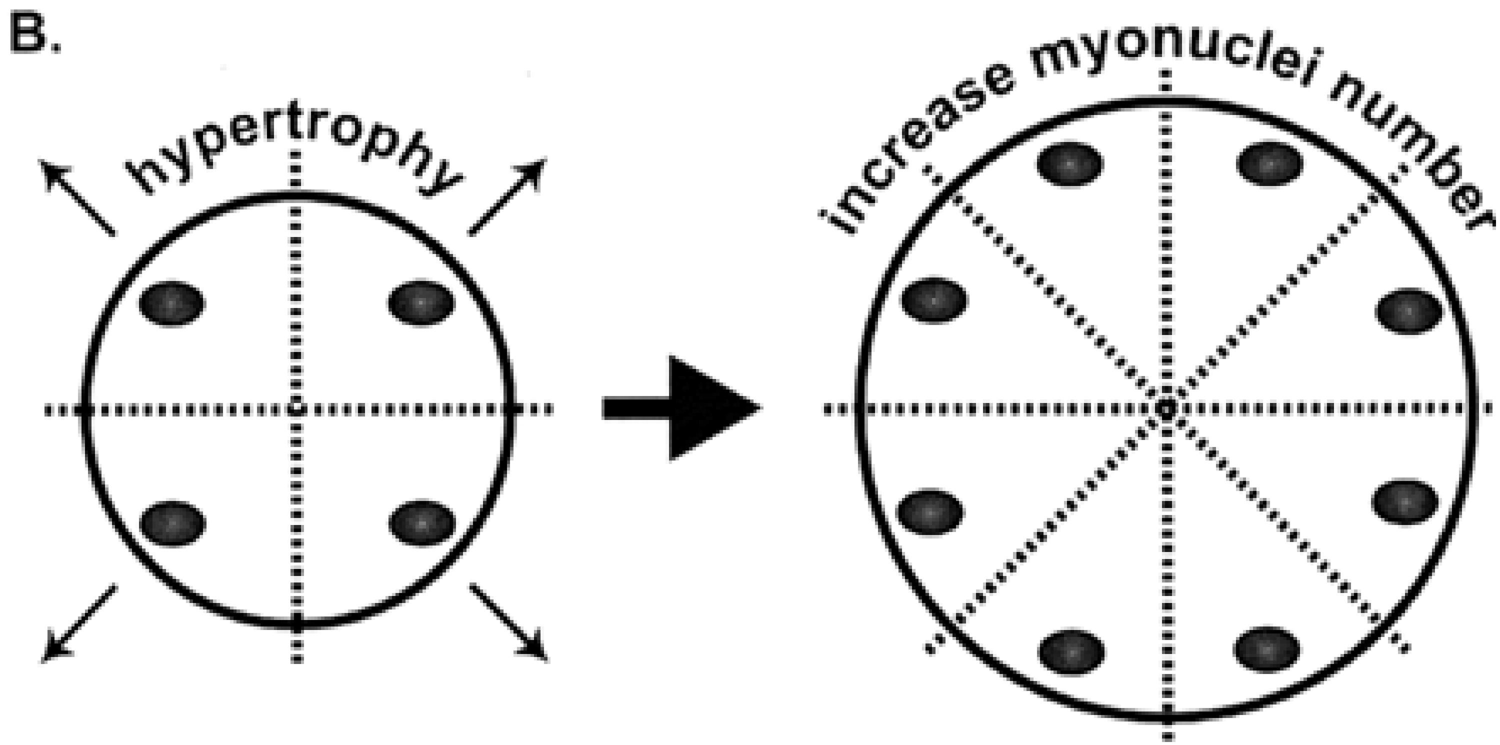
Células Satélites



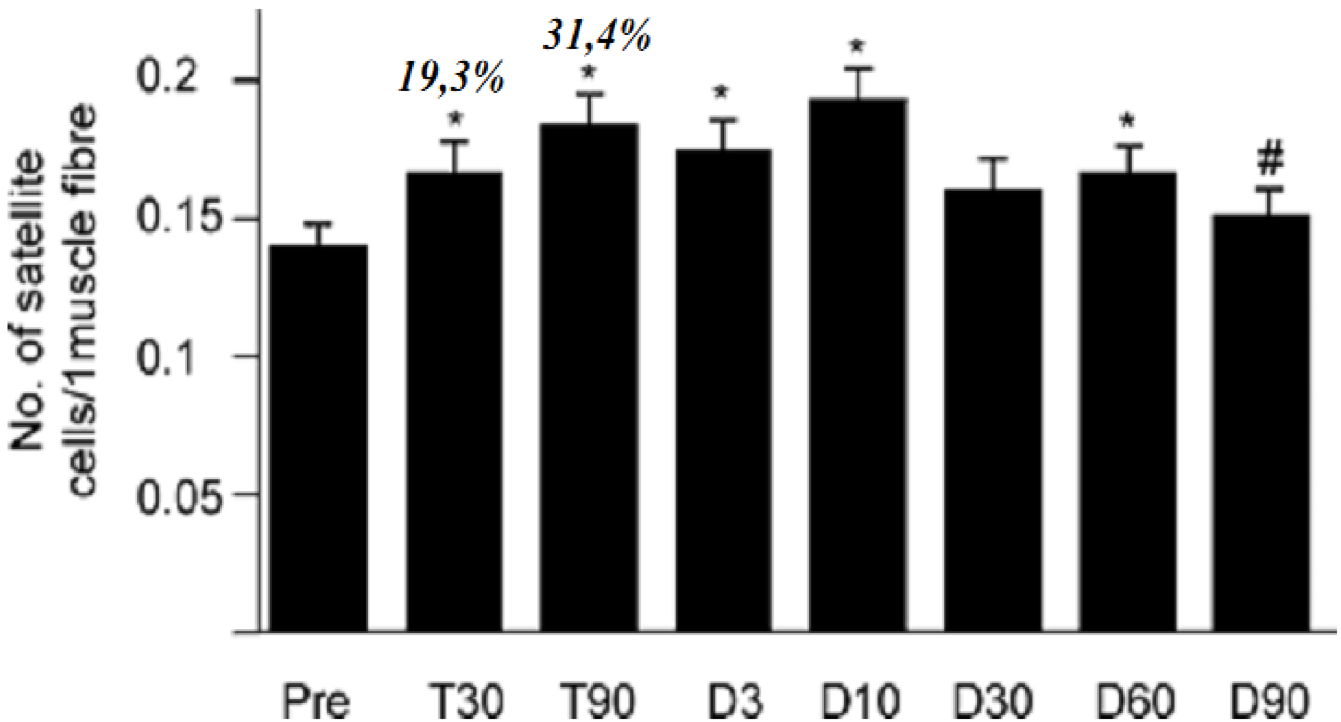
- Macrófagos
- Interleucinas


Sarcolemma
IGF-I
Myonuclei
Increased Loading
Fatores de transcrição (MRF) MyoD e Miogenin
Basal Lamina
Satellite Cells
Myoblast
Satellite Cell Proliferation and Differentiation
IGF-I
New Myonuclei
Myoblast Fusion
Myofiber Hypertrophy

Domínio mionuclear

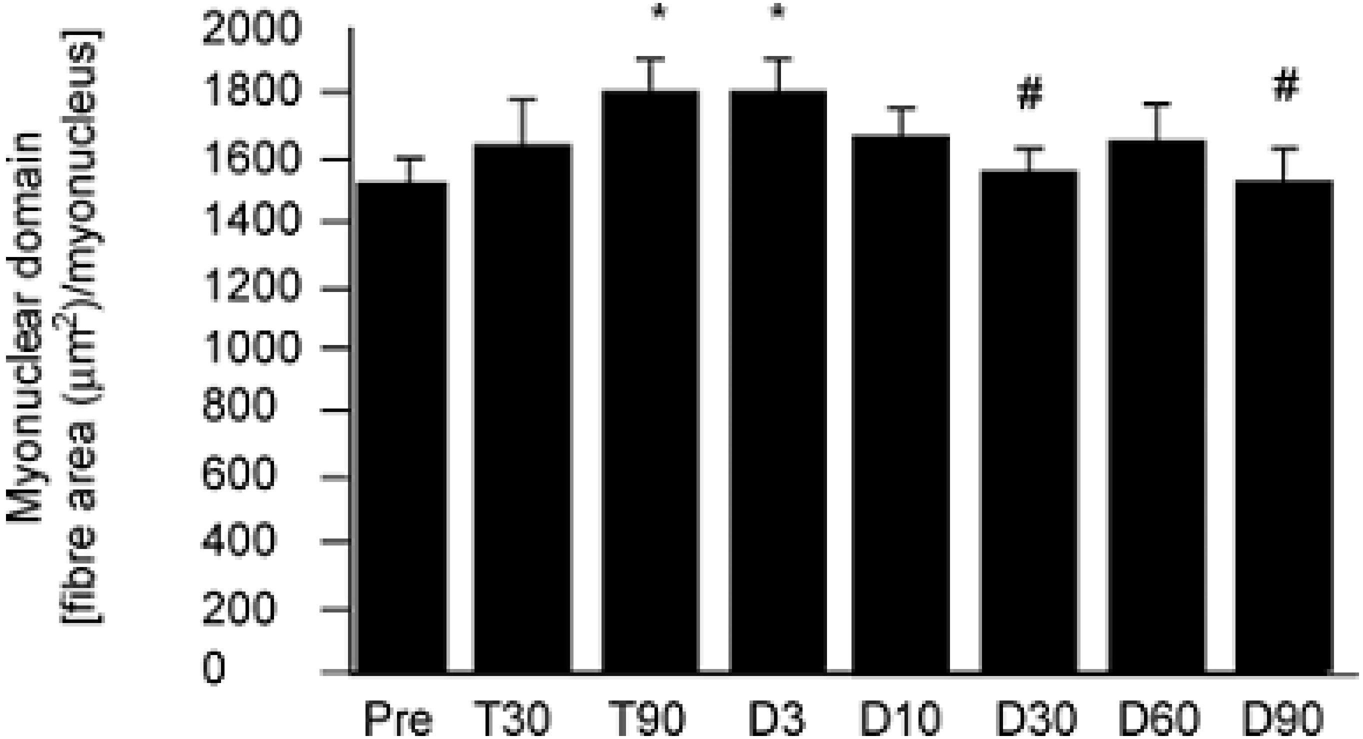


Número de células satélites



Kadi e col. (2004)

Domínio mionuclear



Kadi e col. (2004)

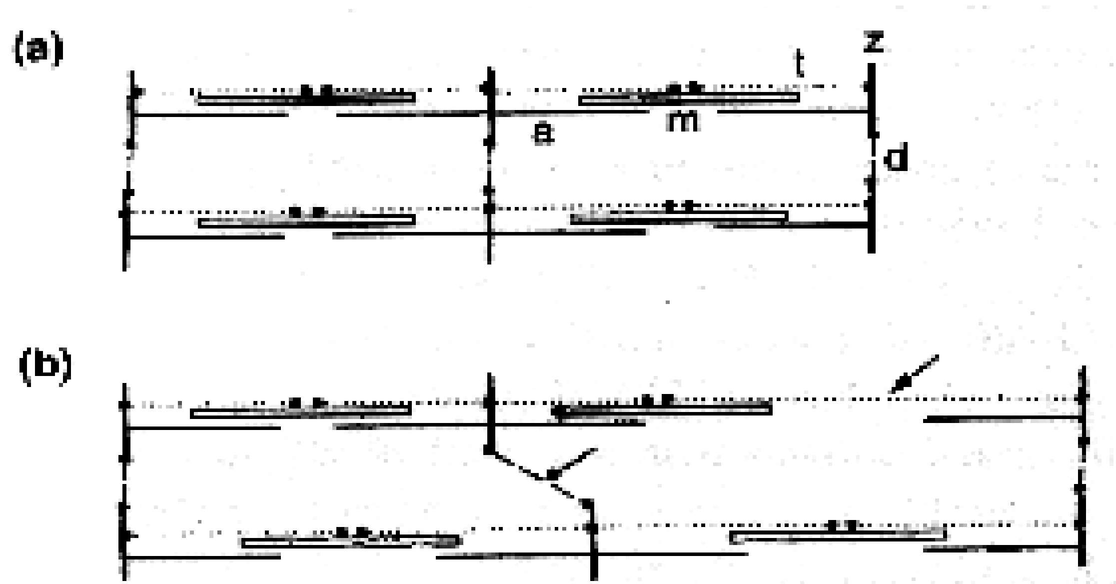
Ações Excêntricas e adaptações morfológicas

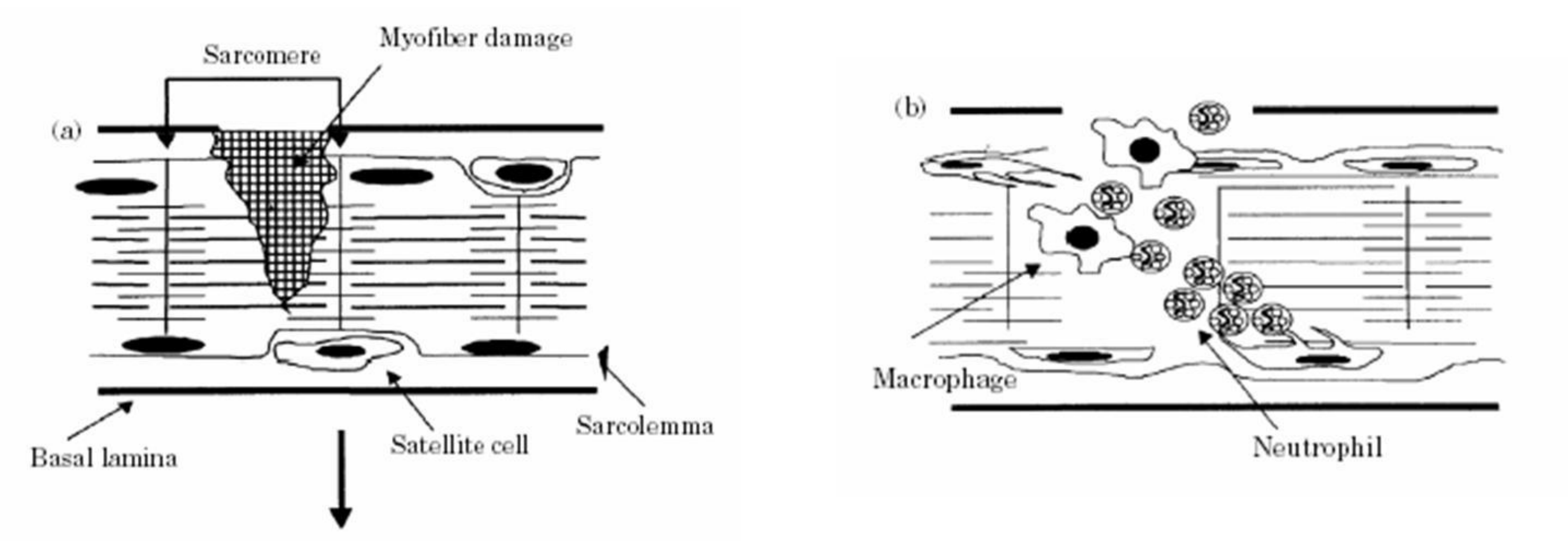
Contrações concêntricas vs. excêntricas

	Concêntricas	Excêntricas
Nº U.M. recrutadas	+	-
• Tensão/fibra	-	+
• Consumo de O_2	+	-
• Produção de lactato	+	-

Sobrecarga metabólica | **Sobrecarga mecânica**

Características Mecânicas das Ações Excêntricas





Ação Excêntrica

- A execução de ações excêntricas produz lesões nas fibras musculares

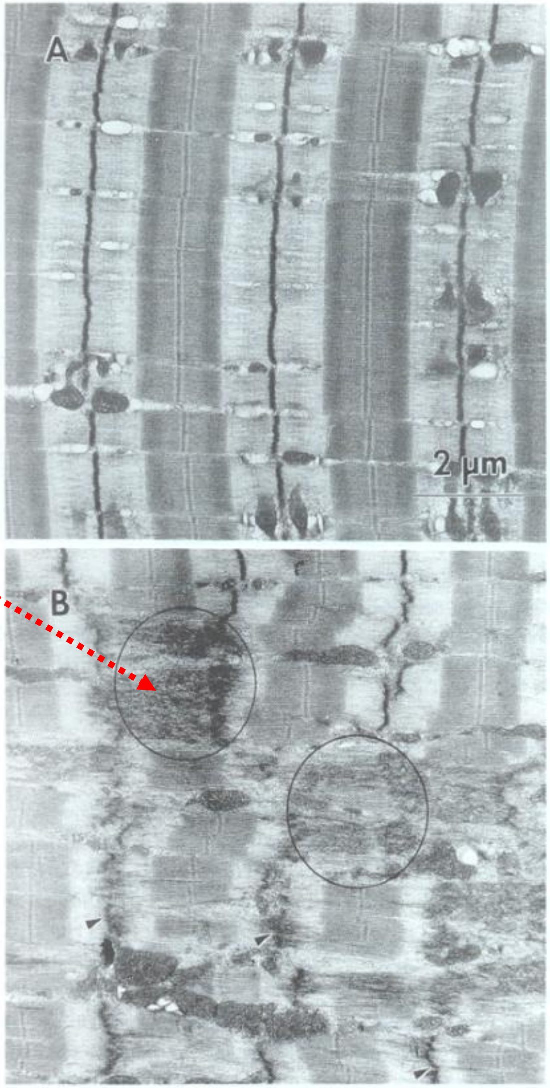


Figure 6.21. Longitudinal electron micrographs of rabbit TA. **A,** Sample from IC group, which shows normal striation pattern and Z-disks perpendicular to the long myofibrillar axis. **B,** Sample from EC group, which demonstrates various disrupted regions. Note streaming and smearing of the Z-disk material (*arrowheads*) and extension of the Z-disks into adjacent A-bands (*circled areas*). (From Lieber RL, Fridén JO, McKee-Woodburn TG. Muscle damage induced by eccentric contractions of twenty-five percent strain. J Appl Physiol 1991;70:2498–2507.)

Células Satélites

- Dano ativa células satélites
- Células doam seus núcleos as fibras musculares
- Possibilidade de aumento do volume muscular

Dano Muscular

- Dano muscular
  - Excêntrico - hipertrofia
  - Efeito da Carga Repetida

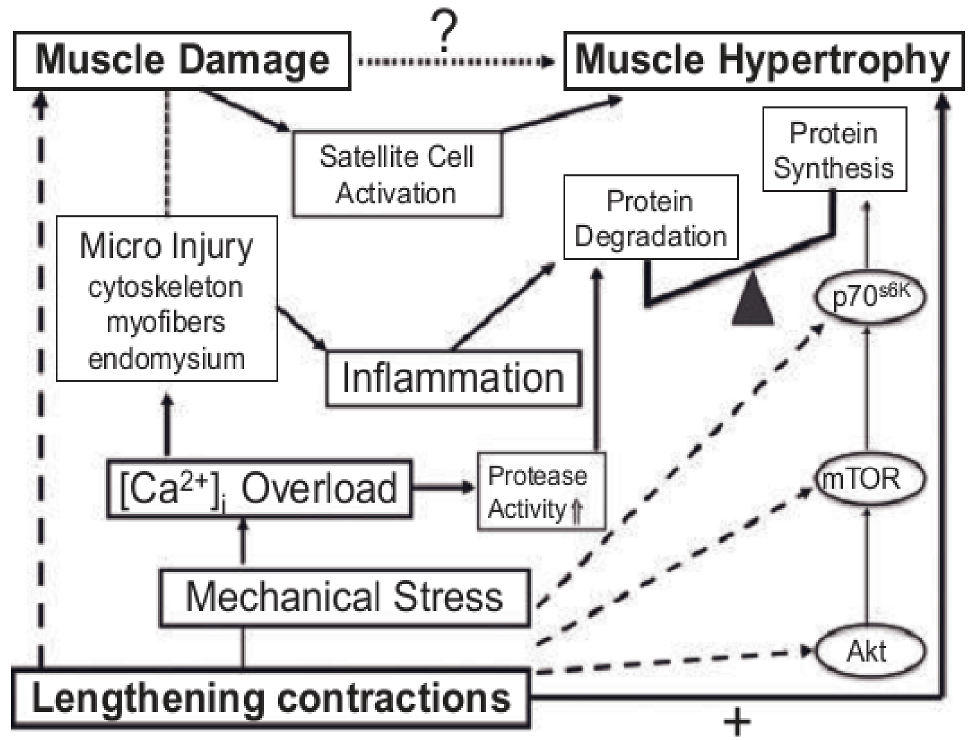
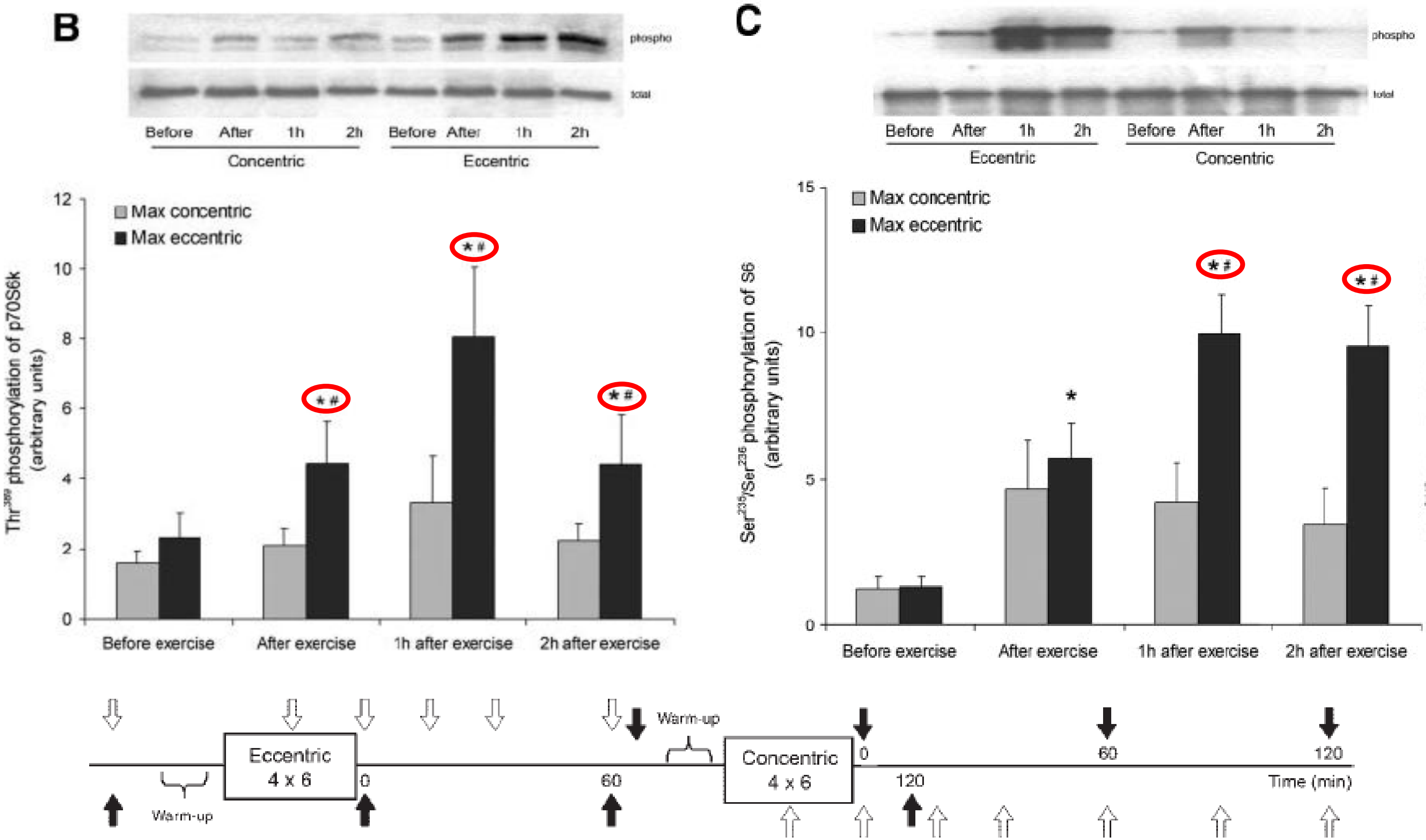


Figure 2.6.14 Relationship between muscle damage and muscle hypertrophy. Instead of muscle damage, lengthening contractions appear to be more potent stimuli for muscle hypertrophy

Maximal lengthening contractions increase p70 S6 kinase phosphorylation in human skeletal muscle in the absence of nutritional supply

Jörgen Eliasson,[1,2] Thibault Elfegoun,[1,2] Johnny Nilsson,[1]
Rickard Köhnke,[1] Björn Ekblom,[1,2] and Eva Blomstrand[1,2]
[1]*Åstrand Laboratory, University College of Physical Education and Sports; and*
[2]*Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden*



Adaptações Morfológicas - AE

- Fundamental para hipertrofia
  - Dudley et al., 1991

- Maior hipertrofia comparado com ações concêntricas
  - Higbie et al., 1996

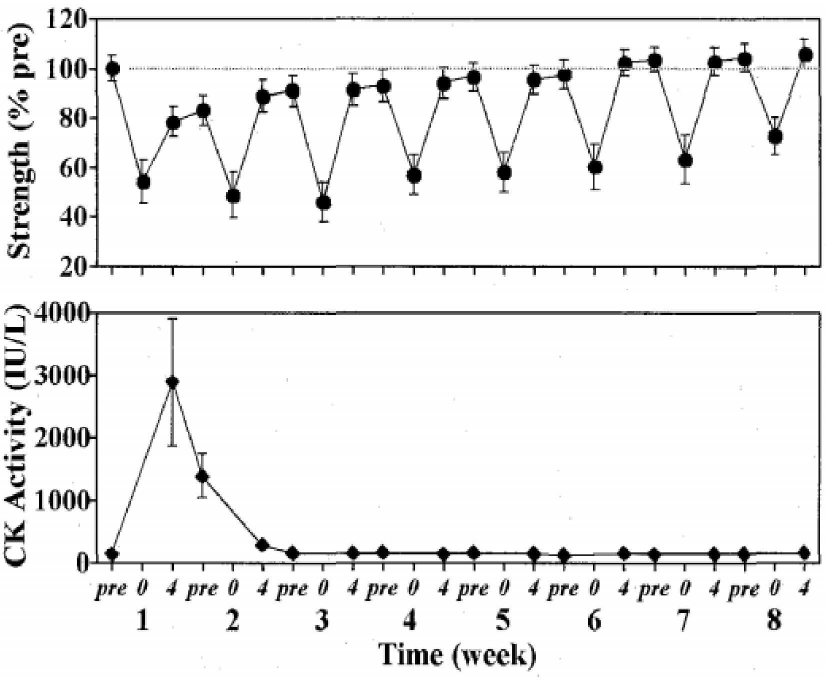
Table 3. *Cross-sectional area of quadriceps muscle (sum of 7 levels) at pretest and posttest*

Group	Pretest	Posttest	Mean Change	Mean % Change
CTG	295.4 ± 52.0	310.3 ± 56.2	15.0*	5.0
ETG	300.8 ± 41.3	320.7 ± 43.7	19.9*†	6.6
CG	323.7 ± 52.8	320.9 ± 53.0	−2.8	−0.9

Values are means ± SD in cm^2 of sum of cross-sectional areas from 7 levels (20–80% femur length). Based on group × time partial interaction from ANOVA: * significantly greater ($P < 0.05$) compared with CG; † significantly greater ($P < 0.05$) compared with CTG and CG.

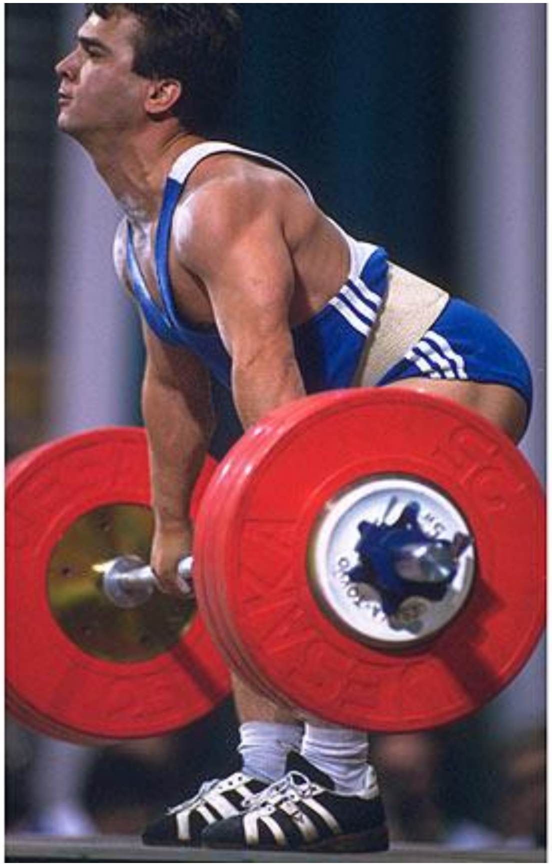
Dano Muscular

- Dano muscular
  - Excêntrico - hipertrofia
  - Efeito da Carga Repetida



Prescrição do treinamento de força, resposta hormonal e vias de sinalização

Força máxima



Potência

Resistência de força

AMERICAN COLLEGE of SPORTS MEDICINE

Progression Models in Resistance Training for Healthy Adults

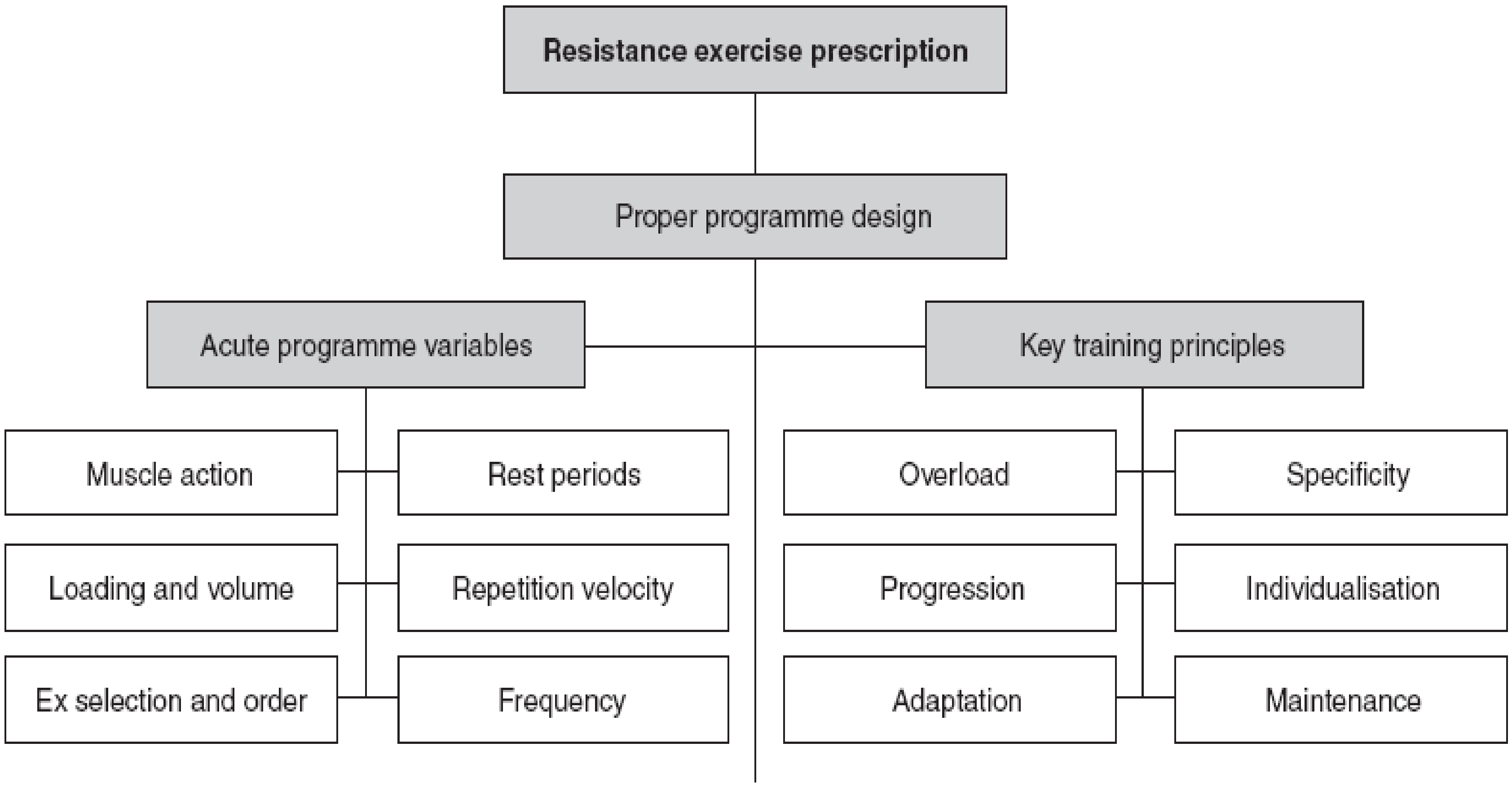
POSITION STAND

PRINCÍPIOS BÁSICOS DE PROGRESSÃO DO TREINAMENTO

- Três princípios gerais de progressão são:

1. Progressão da Sobrecarga
2. Especificidade
3. Variação

Princípios do treinamento de força muscular



Bird et al (2005)

ESPECIFICIDADE DO VOLUME E DA INTENSIDADE

PARA AS CAPACIDADES NEUROMUSCULARES

CAPACIDADE MOTORA	% CARGA	REPETIÇÕES	INTERVALO	VELOCIDADE	NÚMERO DE SÉRIES
Força	85-100 %	1 - 6	>3 min	Lenta	4 - 6
Hipertrofia	60 – 85 %	6 – 12	<2 min	Lenta	3 - 6
Força Explosiva	30 – 80%	6 - 8	> 3 min	Rápida	3 - 6
Resistência Muscular	40 – 60%	13-20	1 –2 min	Média	2 – 4

DETERMINAÇÃO DA CARGA DE TREINAMENTO

- A carga pode ser prescrita como um percentual de um determinado nº de RM (% RM). Por exemplo:
  - 50% 1RM, 90% 1RM.

DETERMINAÇÃO DA CARGA DE TREINAMENTO

- Também pode ser determinada como a carga que permite trabalhar dentro de uma determinada zona de repetições , por exemplo:
  - 3-6 reps
  - 8-12 reps
  - 15-20 reps

DETERMINAÇÃO DA CARGA DE TREINAMENTO

- A prescrição da carga depende do estado individual de treinamento.

- Indivíduos destreinados carga de 45-50% de 1RM pode ser eficiente para aumentar a FORÇA MÁXIMA.

- Em sujeitos sem muita experiência em treinamento de força, a FORÇA MÁXIMA também melhora com cargas em torno de 70-80% de 1 RM.

DETERMINAÇÃO DA CARGA DE TREINAMENTO

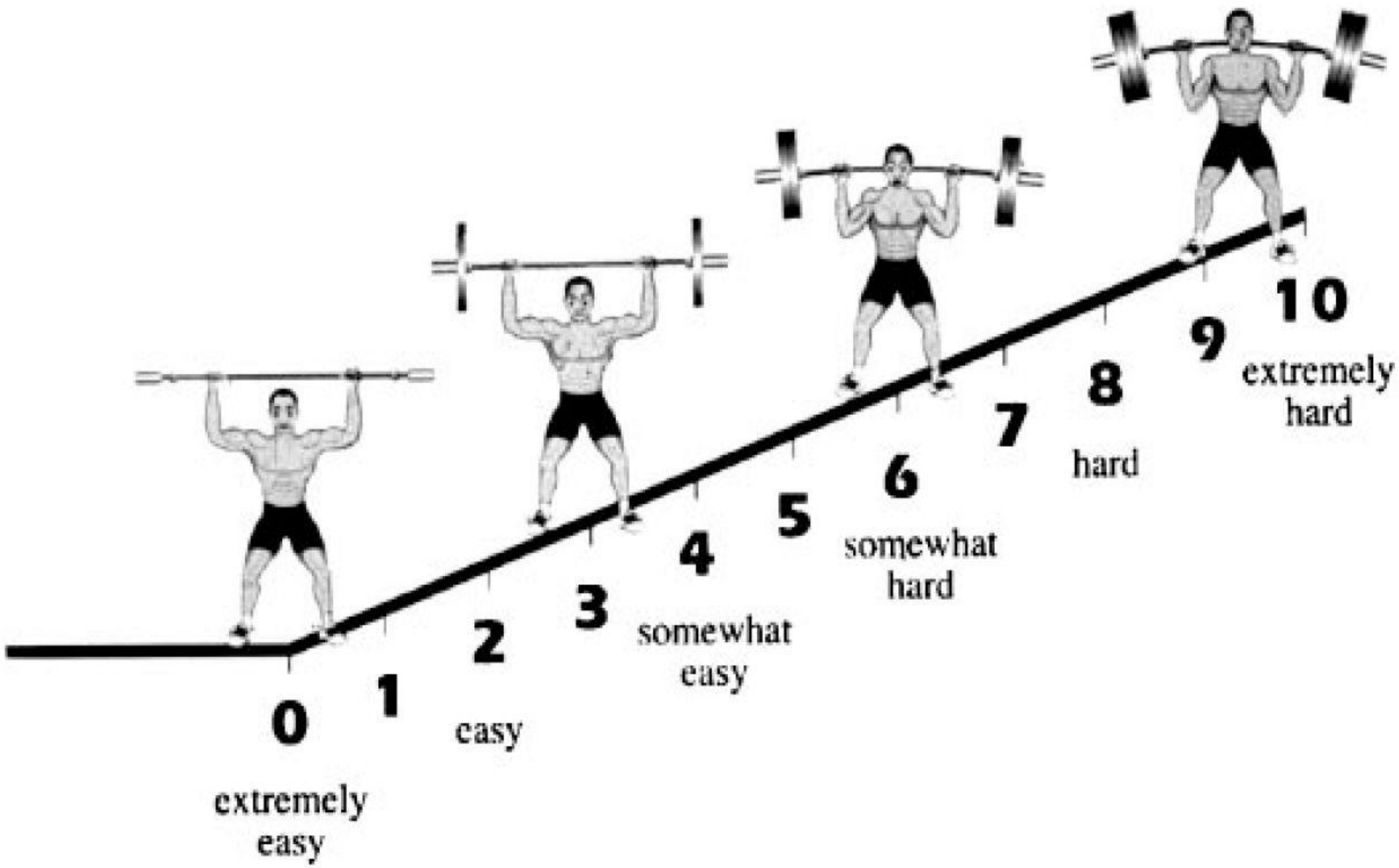


FIGURE 1. OMNI Perceived Exertion Scale for Resistance Exercise.

VOLUME DE EXERCÍCIOS

Existe um volume ideal?

- Nas estruturas em que se treina o corpo todo:
  - apenas 1 ou 2 exercícios por grupo muscular por sessão.

- Nas estruturas parceladas:
  - entre 3 e 4 exercícios por grupo muscular.

Volume

- Volume
  - Schoenfeld et al (2014)
  - Alegre et al (2014)
  - Sooneste et al (2013)
  - Burd et al (2010)
  - Kumar et al (2012)
  - Mitchell et al (2012)
  - Krieger (2010)

Hipertrofia muscular

Volume

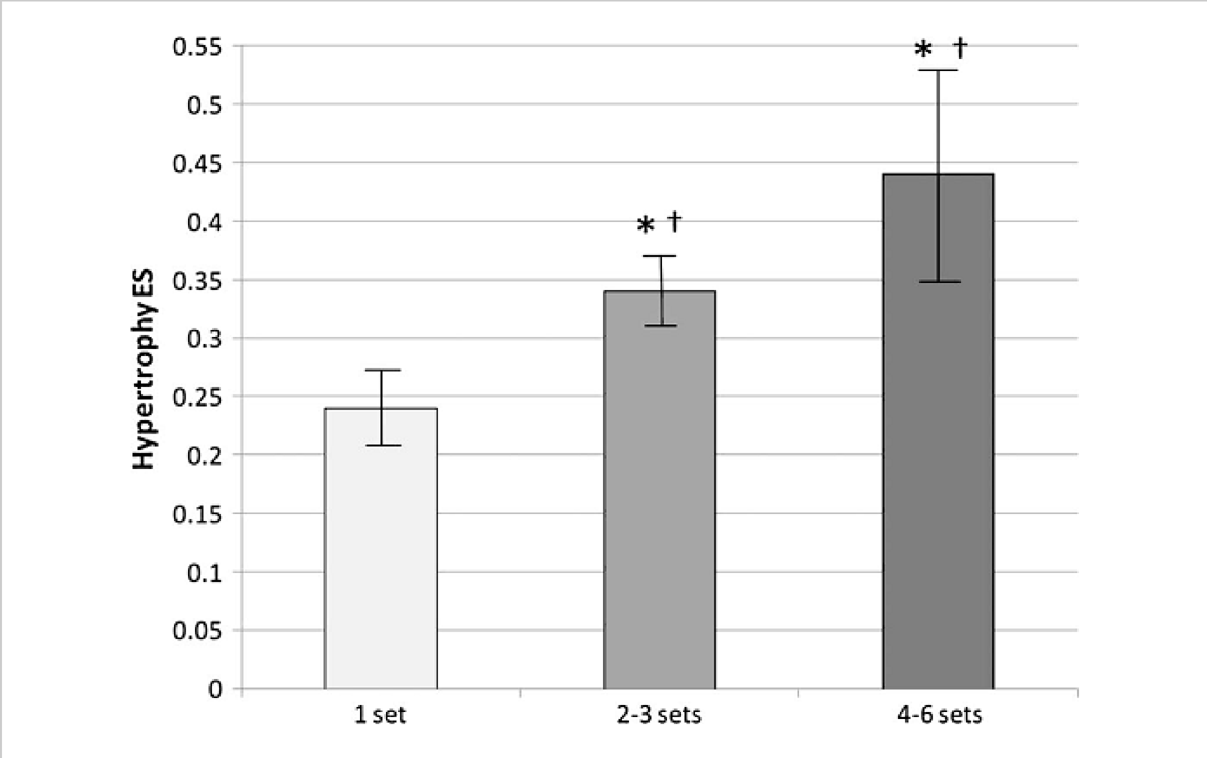


Figure 2. Dose–response effect of set volume on hypertrophy. Data are presented as means ± *SE*. ES = effect size. *Trend toward difference from 1 set per exercise according to Hochberg-adjusted standard *p* value ($p < 0.10$). †Significantly different from 1 set per exercise according to Hochberg-adjusted permutation *p* value ($p < 0.01$).

Krieger (2010)

Volume

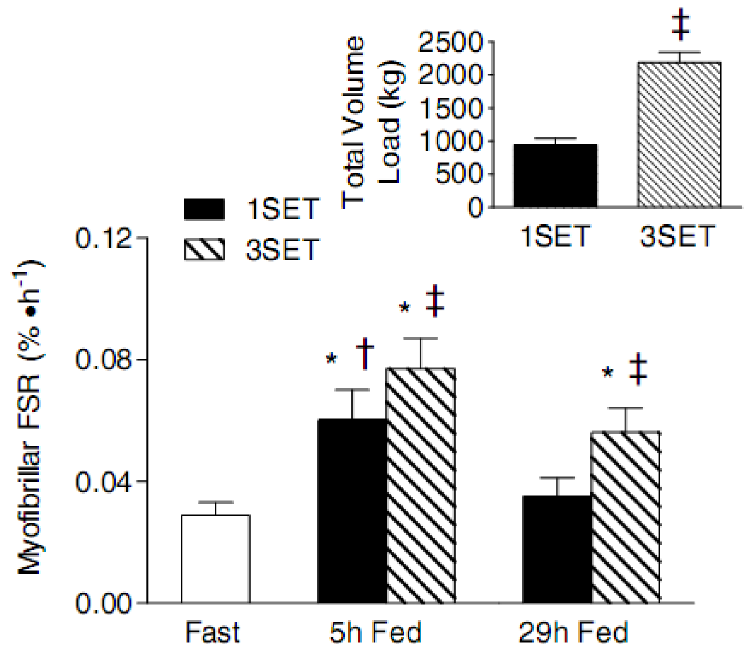


Figure 3. Myofibrillar protein fractional synthesis rate (FSR) at rest and 5 h after protein ingestion after one set (1SET) or 3 sets (3SET) of resistance exercise and 24–29 h later
Inset, volume load (kg times repetitions) performed during 1SET and 3SET of resistance exercise. *Significantly different from rest ($P < 0.05$). †Significantly different from 29 h ($P < 0.05$). ‡Significantly different from 1SET ($P < 0.05$).

Burd et al (2010)

Volume

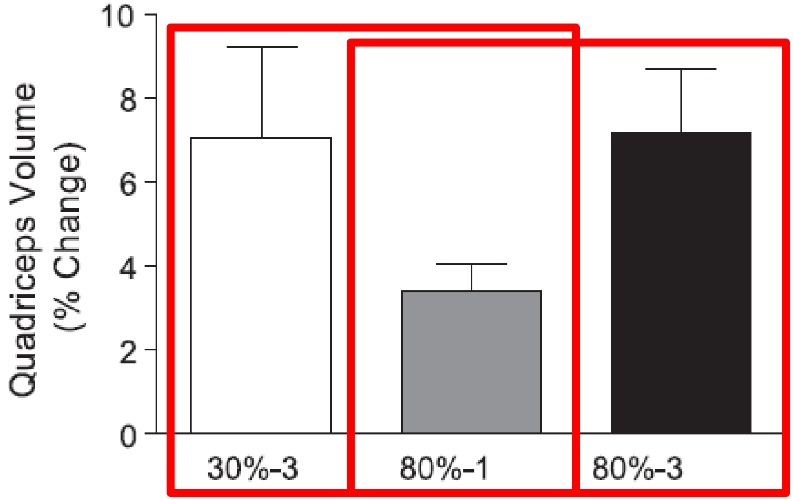


Fig. 1. Percentage change in quadriceps muscle volume following 10 wk of resistance training. The 3 training condition groups differed in contraction intensity [% of maximal strength (1 repetition maximum)] or contraction volume (1 or 3 sets of repetitions): 30%-3, 80%-1, and 80%-3. There was a significant main effect for time (increase in quadriceps volume pre- to post-training, $P < 0.0001$). $N = 12$ legs in each condition.

Mitchell et al (2012)

VOLUME X INTENSIDADE

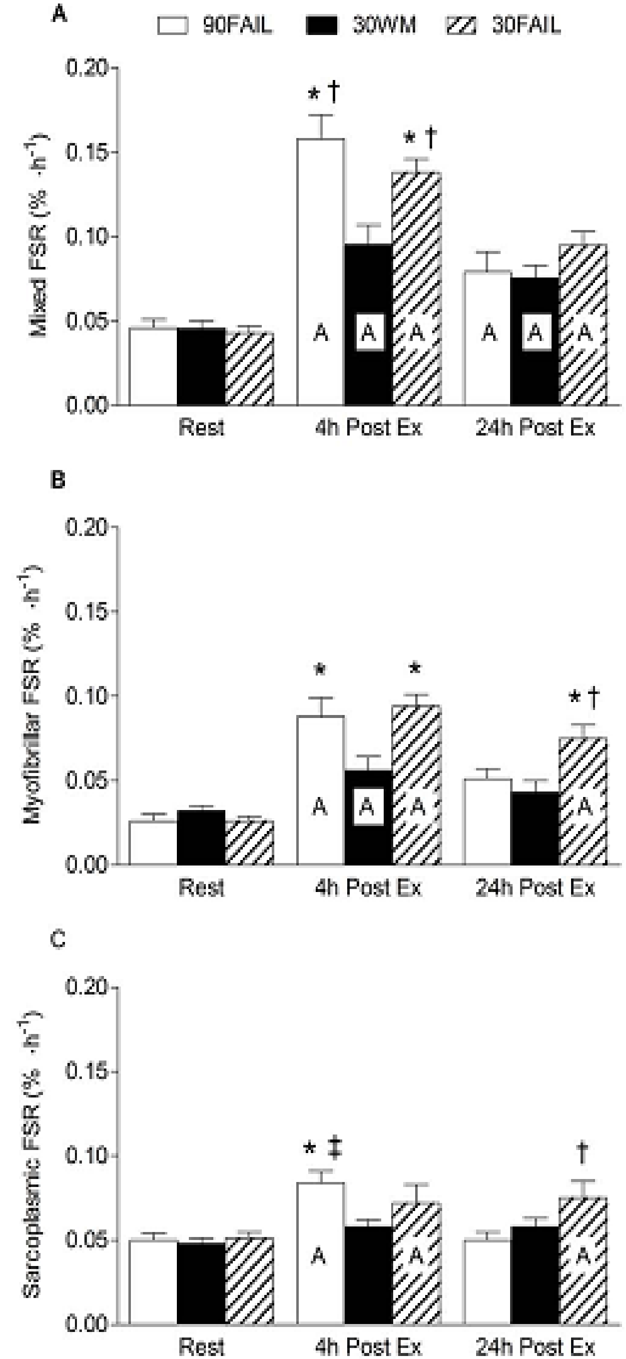


Table 2. Acute unilateral resistance exercise variables during the experimental exercise trial.

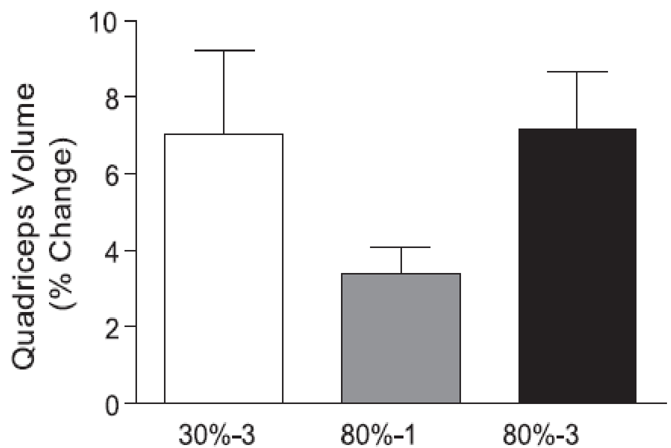
	90FAIL	30WM	30FAIL
Load (kg)	82±5*‡	28±4	28±3
Repetitions[a]	5±0.2	14±0.5†	24±1.1*†
Volume Load (kg)[ab]	710±30.0	632±28.4	1073±69.9*†
Time under tension (s)[a]	16.3±1.1	27.1±1.85†	43.3±1.9*†

VOLUME X INTENSIDADE

Resistance exercise load does not determine training-mediated hypertrophic gains in young men

Cameron J. Mitchell, Tyler A. Churchward-Venne, Daniel W. D. West, Nicholas A. Burd, Leigh Breen, Steven K. Baker and Stuart M. Phillips

J Appl Physiol 113:71-77, 2012. First published 19 April 2012;
doi: 10.1152/japplphysiol.00307.2012



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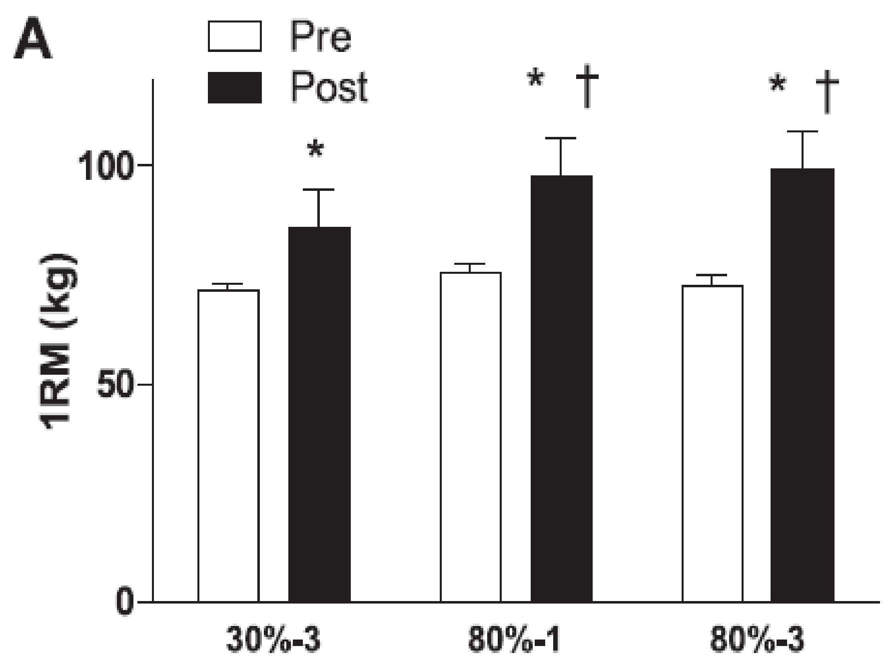
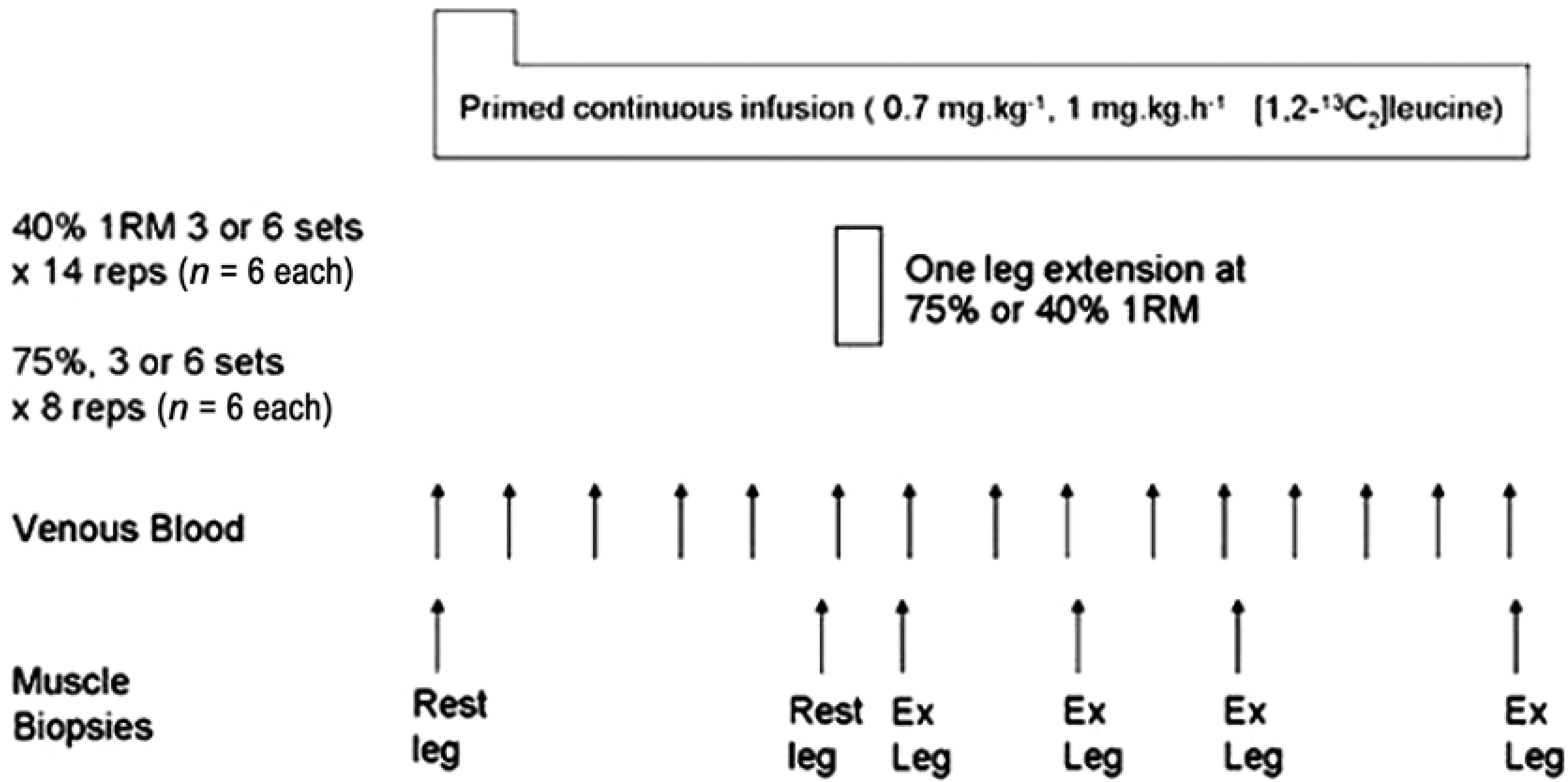


Muscle Protein Synthetic Responses to Exercise: Effects of Age, Volume, and Intensity

Vinod Kumar,[1,*] Philip J. Atherton,[1,*] Anna Selby,[1] Debbie Rankin,[1] John Williams,[1,3] Kenneth Smith,[1]
Natalie Hiscock,[2] and Michael J. Rennie[1]



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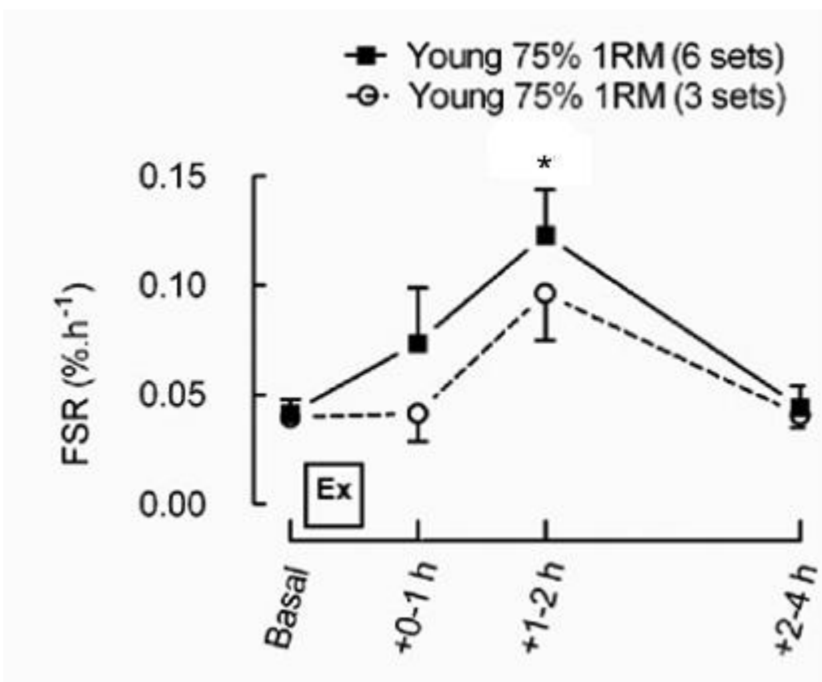

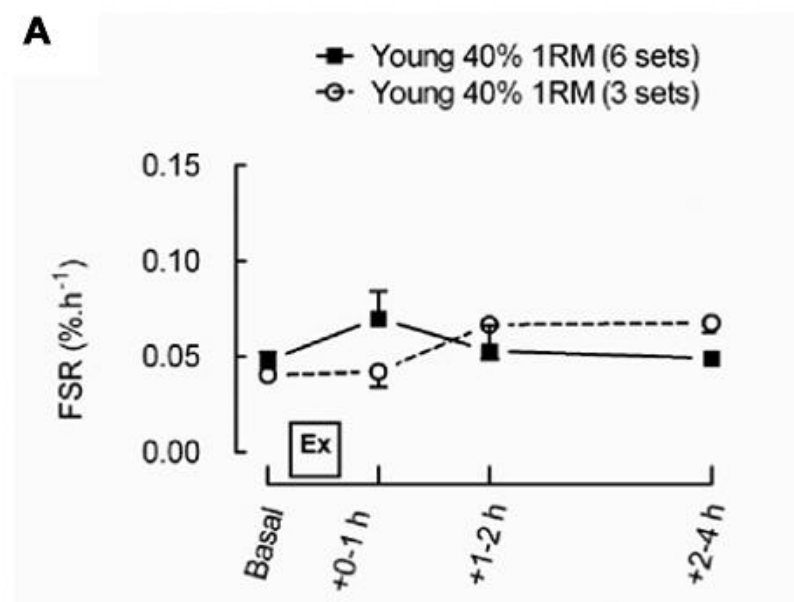

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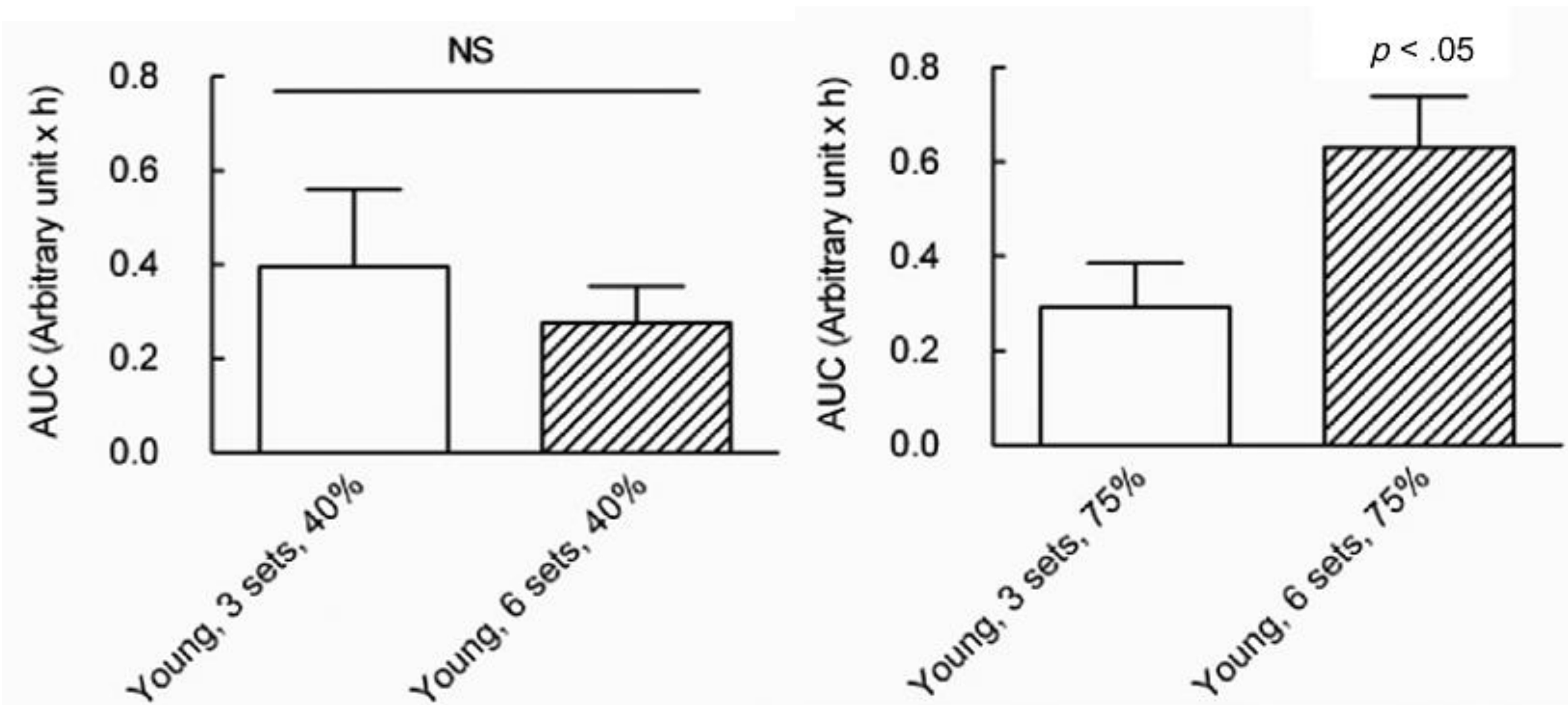
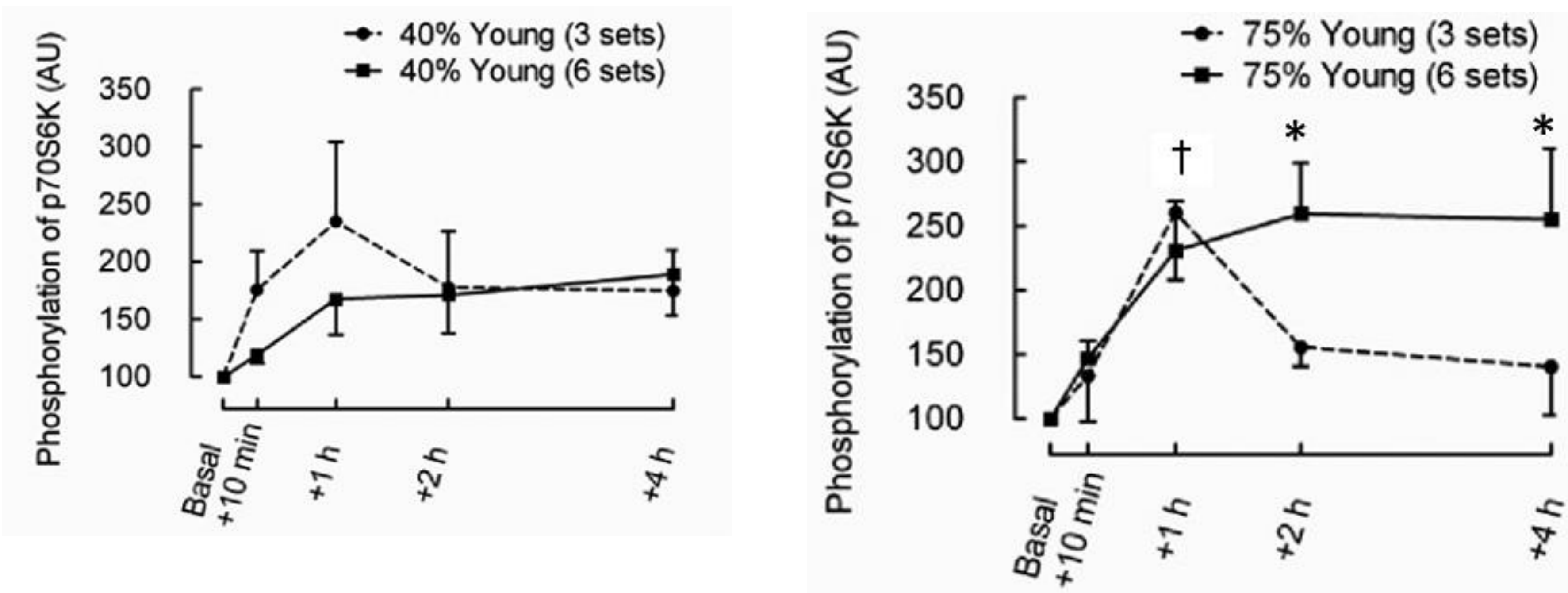




40% Young (3 sets)
40% Young (6 sets)
Phosphorylation of p70S6K (AU)
350
300
250
200
150
100
Basal
+10 min
+1 h
+2 h
+4 h
75% Young (3 sets)
75% Young (6 sets)
Phosphorylation of p70S6K (AU)
350
300
250
200
150
100
†
*
*
Basal
+10 min
+1 h
+2 h
+4 h

Volume

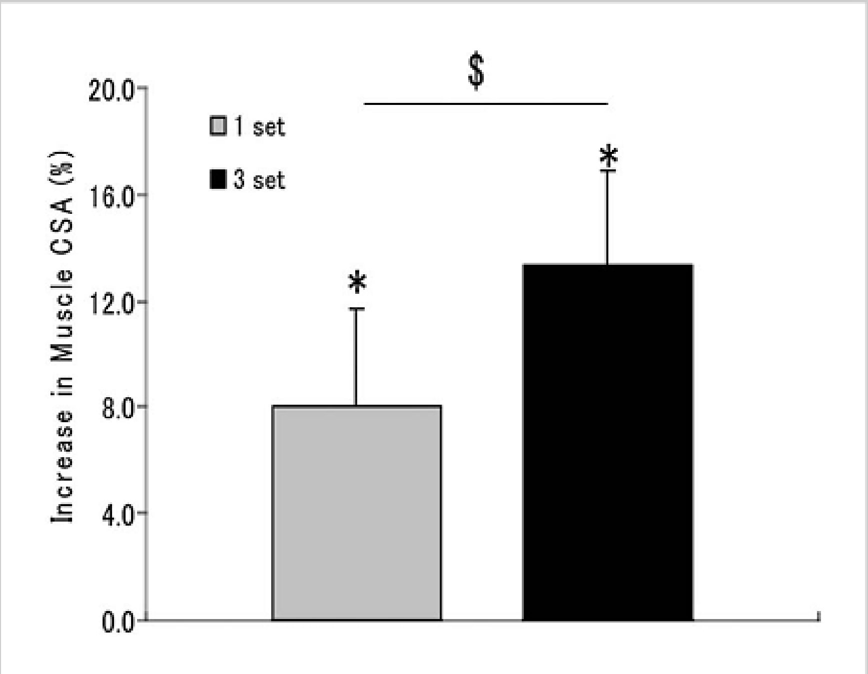


Figure 1. Comparison of percent gains in cross-sectional area (CSA) of elbow flexor muscles for the 1-set and 3-set arm groups (mean ± SD); $n = 7$. *Significant difference between pre- and posttraining values ($p < 0.05$). $Significant difference between groups ($p < 0.05$).

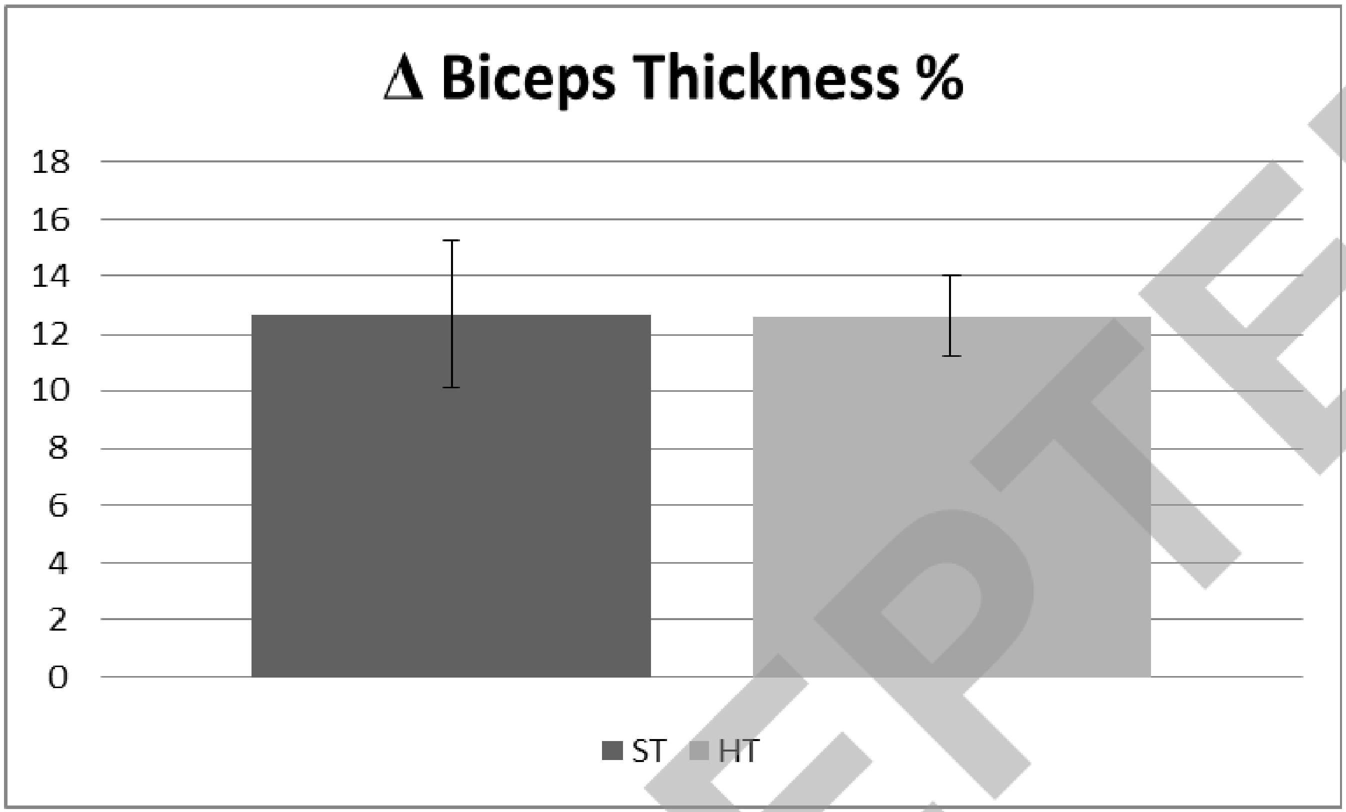
Sooneste et al (2013)

Volume

Protocol	Session 1	Session 2	Session 3
ST	**Exercises**: Incline barbell press, machine leg press, and wide grip lat pulldown **Sets**: 7 **Repetitions**: 3 **Rest Interval**: 3 minutes	**Exercises**: Flat barbell press, barbell back squat, and close grip lat pulldown **Sets**: 7 **Repetitions**: 3 **Rest Interval**: 3 minutes	**Exercises**: Hammer Strength chest press, machine leg extension, and cable seated row **Sets**: 7 **Repetitions**: 3 **Rest Interval**: 3 minutes
HT	**Exercises**: Incline barbell press, flat barbell press, and Hammer Strength chest press **Sets**: 3 **Repetitions**: 10 **Rest Interval**: 90 seconds	**Exercises**: Wide grip lat pulldown, close grip lat pulldown, cable seated row **Sets**: 3 **Repetitions**: 10 **Rest Interval**: 90 seconds	**Exercises**: Barbell back squat, machine leg press, and machine leg extension **Sets**: 3 **Repetitions**: 10 **Rest Interval**: 90 seconds

Schoenfeld (2014)

Volume



Schoenfeld (2014)

Experiência e TF

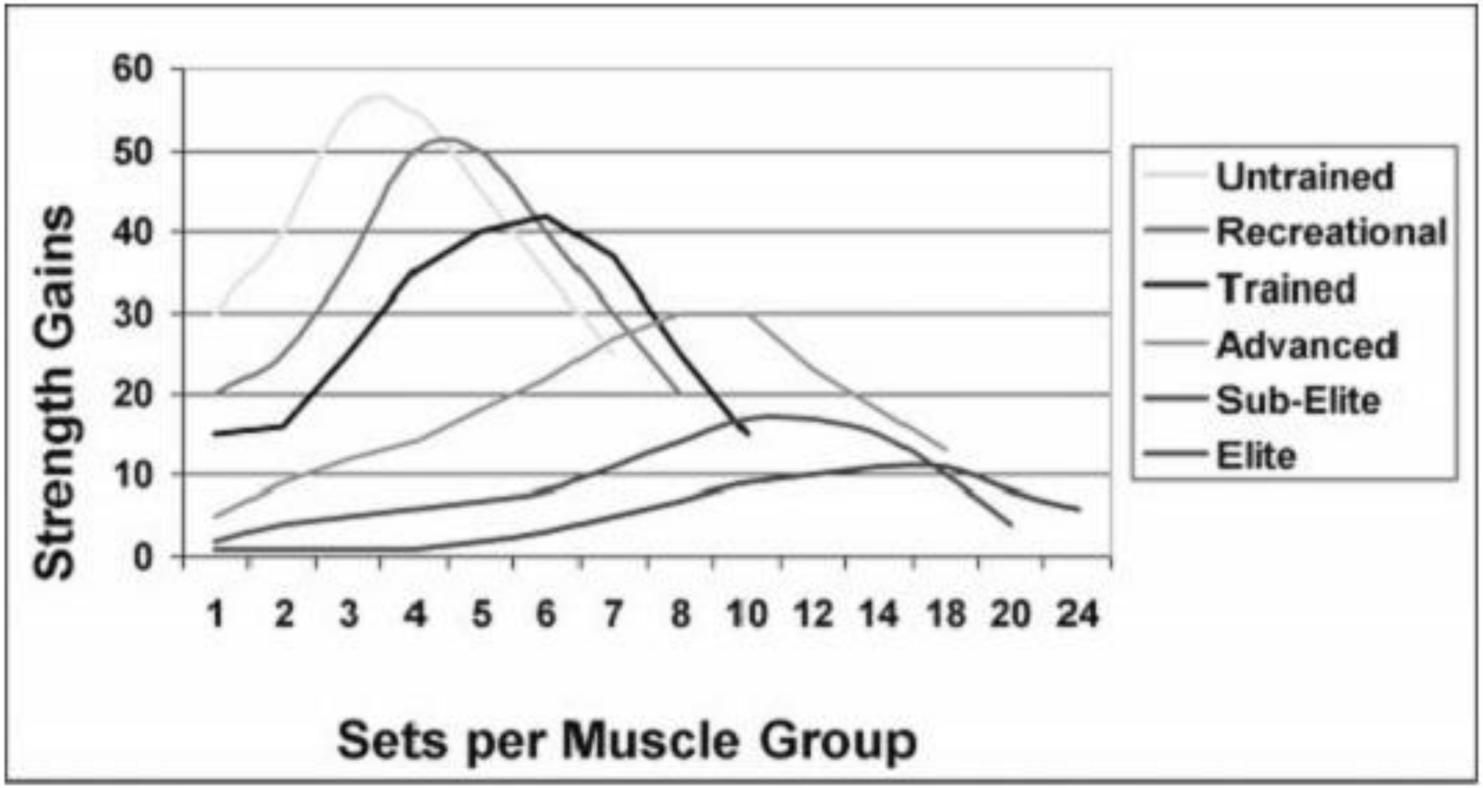


FIGURE 4. Theoretical dose-response progression continuum.

Peterson et al (2005)

Eur J Appl Physiol (2009) 105:695–704
DOI 10.1007/s00421-008-0951-z

ORIGINAL ARTICLE

Acute hormonal and neuromuscular responses to hypertrophy, strength and power type resistance exercise

Grant O. McCaulley · Jeffrey M. McBride ·
Prue Cormie · Matthew B. Hudson · James L. Nuzzo ·
John C. Quindry · N. Travis Triplett

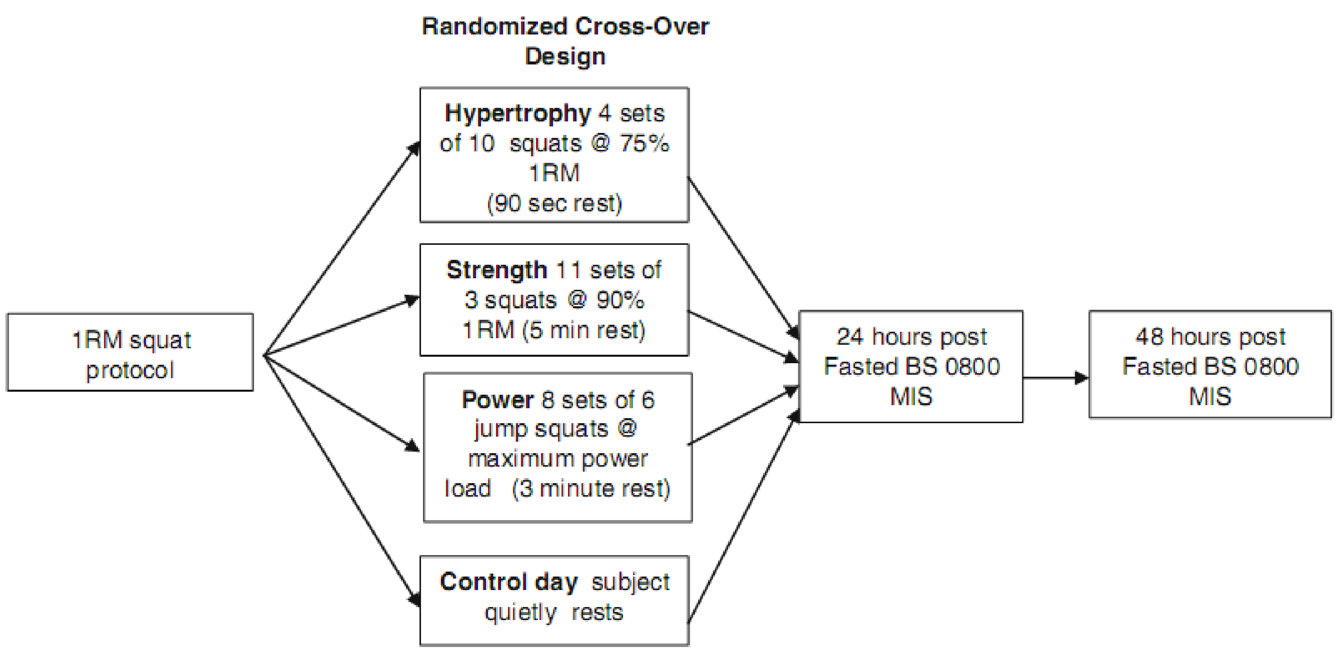
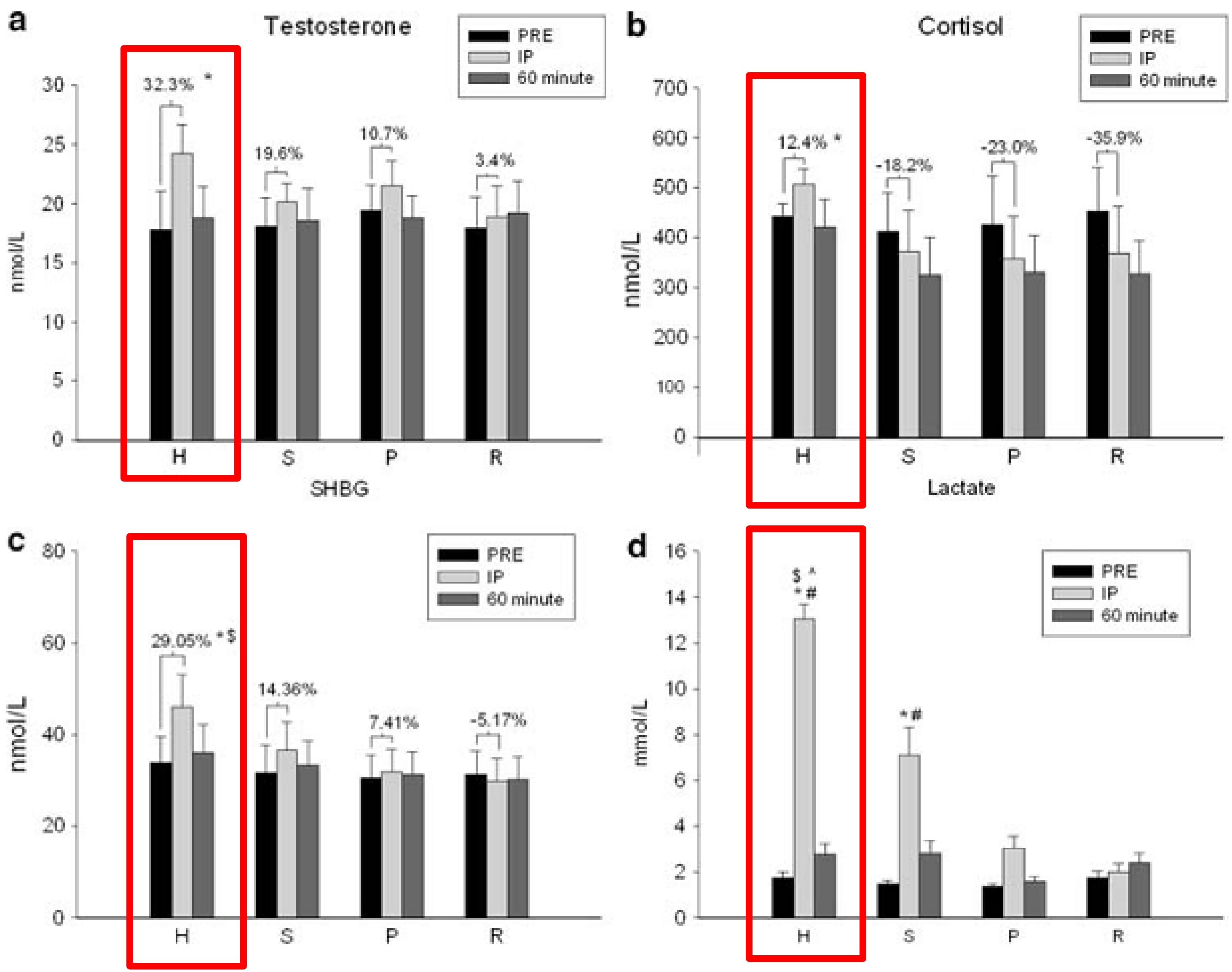


Fig. 1 A schematic of the experimental design for the study (blood samples (BS), maximum isometric squat (MIS), one repetition maximum in back squat (1RM))



a
Testosterone
PRE
IP
60 minute
32.3% *
19.6%
10.7%
3.4%
nmol/L
H
S
P
R
b
Cortisol
12.4% *
-18.2%
-23.0%
-35.9%
nmol/L
SHBG
c
29.05% * $
14.36%
7.41%
-5.17%
Lactate
d
$ ^
* #
* #
mmol/L

24 e 48h após o protocolo

	Hypertrophy	Strength	Power	Rest
T (nmol l^{-1})				
PRE	17.78 (3.27)	18.05 (2.42)	19.44 (2.13)	17.95 (2.60)
24P	20.31 (2.67)	17.61 (2.39)	17.75 (1.75)	20.22 (2.75)
48P	19.37 (2.67)	18.93 (3.06)	18.73 (1.87)	19.50 (2.99)
C (nmol l^{-1})				
PRE	443.51 (24.73)	413.05 (77.34)	426.10 (97.80)	453.13 (87.13)
24P	380.37 (34.54)	412.32 (100.45)	445.19 (71.04)	437.92 (114.23)
48P	364.49 (44.20)	394.51 (95.31)	400.12 (129.11)	378.37 (77.74)
SHBG (nmol l^{-1})				
PRE	33.83 (5.83)	31.69 (6.15)	30.48 (5.09)	31.31 (5.18)
24P	35.44 (5.17)	33.88 (5.29)	30.34 (4.64)	30.21 (4.60)
48P	30.29 (5.16)	33.51 (5.55)	28.00 (4.66)	29.45 (4.93)
T/C ratio (%)				
PRE	4.07 (0.76)	4.93 (1.03)	4.75 (0.67)	4.11 (0.64)
24P	5.91 (0.95)	4.14 (0.44)	4.03 (0.39)	4.52 (0.77)
48P	5.64 (0.86)	5.13 (0.99)	4.82 (0.53)	5.37 (813)

The Effect of Resistive Exercise Rest Interval on Hormonal Response, Strength, and Hypertrophy With Training

Robert Buresh,[1] Kris Berg,[2] and Jeffrey French[3]

[1]Department of Health, Physical Education, and Sport Science, Kennesaw State University, Kennesaw, Georgia;
[2]School of Health, Physical Education, and Recreation, University of Nebraska at Omaha, Omaha, Nebraska; and
[3]Department of Psychology, University of Nebraska at Omaha, Omaha, Nebraska

Table 2. Resistance training protocol.

Exercise session 1			Exercise session 2		
Exercise	Sets	Reps	Exercise	Sets	Reps
Squat	3	10	Pull-downs	3	10
Leg curl	3	10	Machine rows	3	10
Leg extensions	3	10	Machine bench press	3	10
Standing heel raise	3	10	Pec flies	3	10
Seated dumbbell press	2	10	Incline dumbbell curls	2	10
Dumbbell lateral raises	2	10	Machine biceps curls	2	10
Rear delts on Pec-Deck	2	10	Dumbbell kickbacks	2	10
Abdominal crunches	2	To fatigue			
Lying leg raises	2	To fatigue			

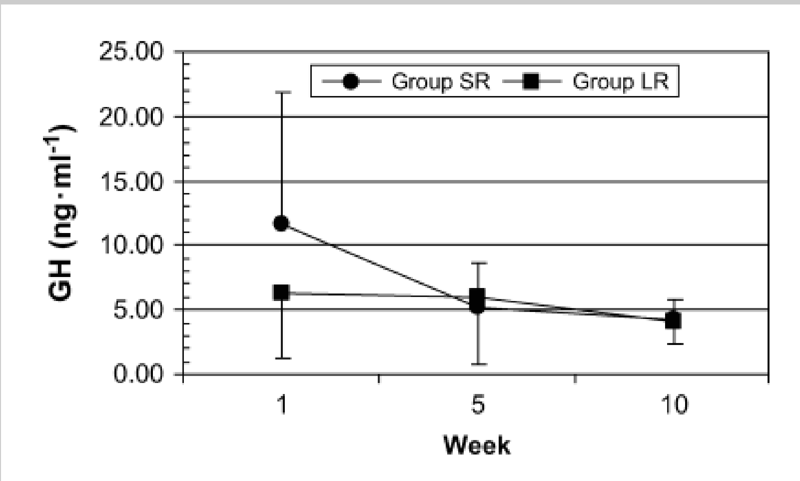


Figure 3. Postexercise plasma growth hormone.

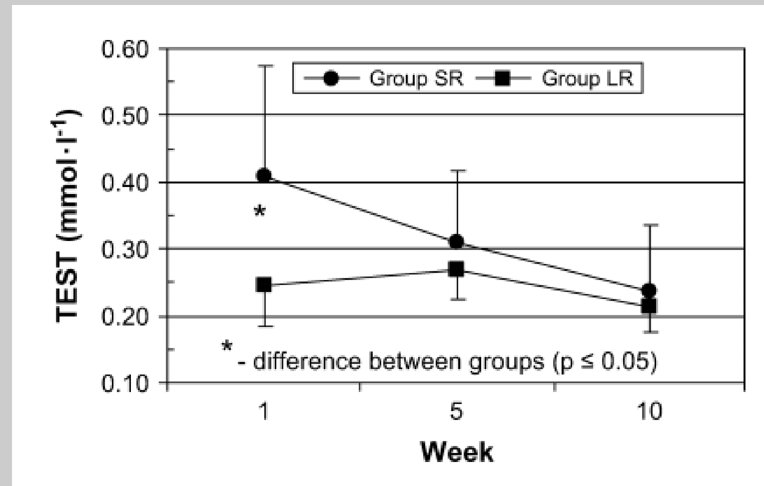
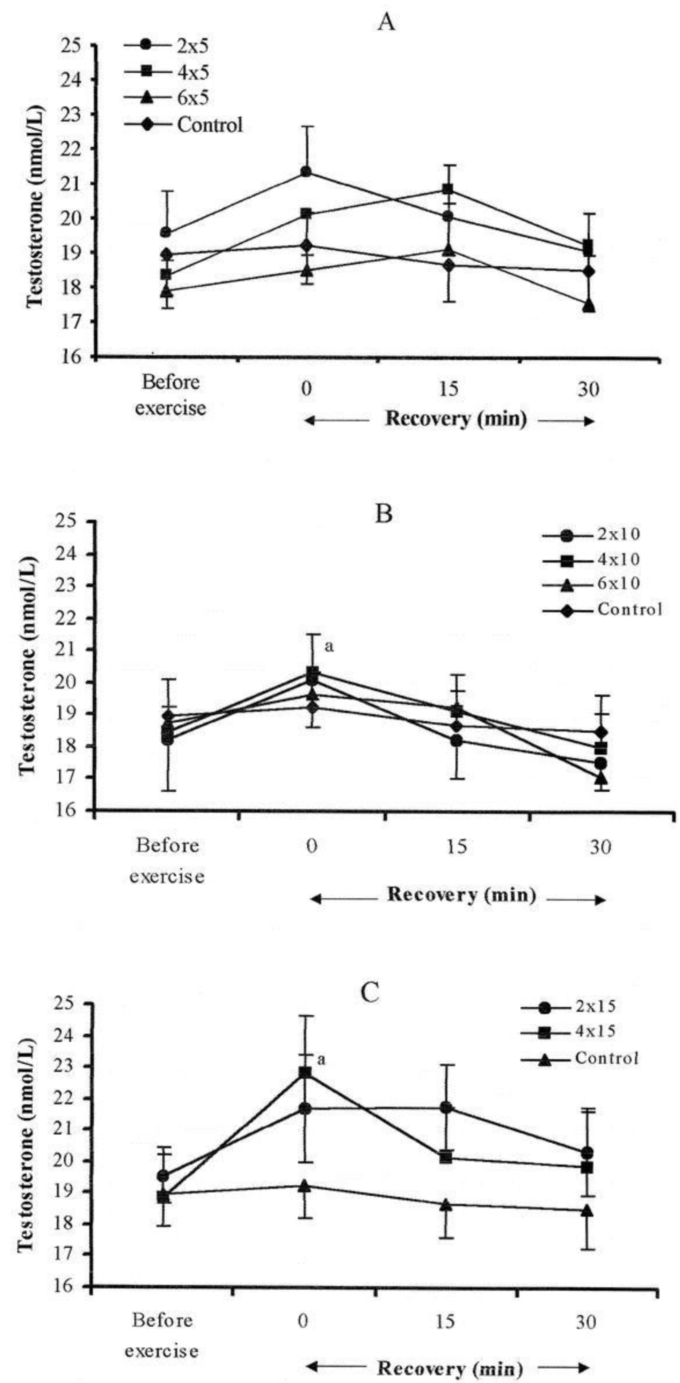


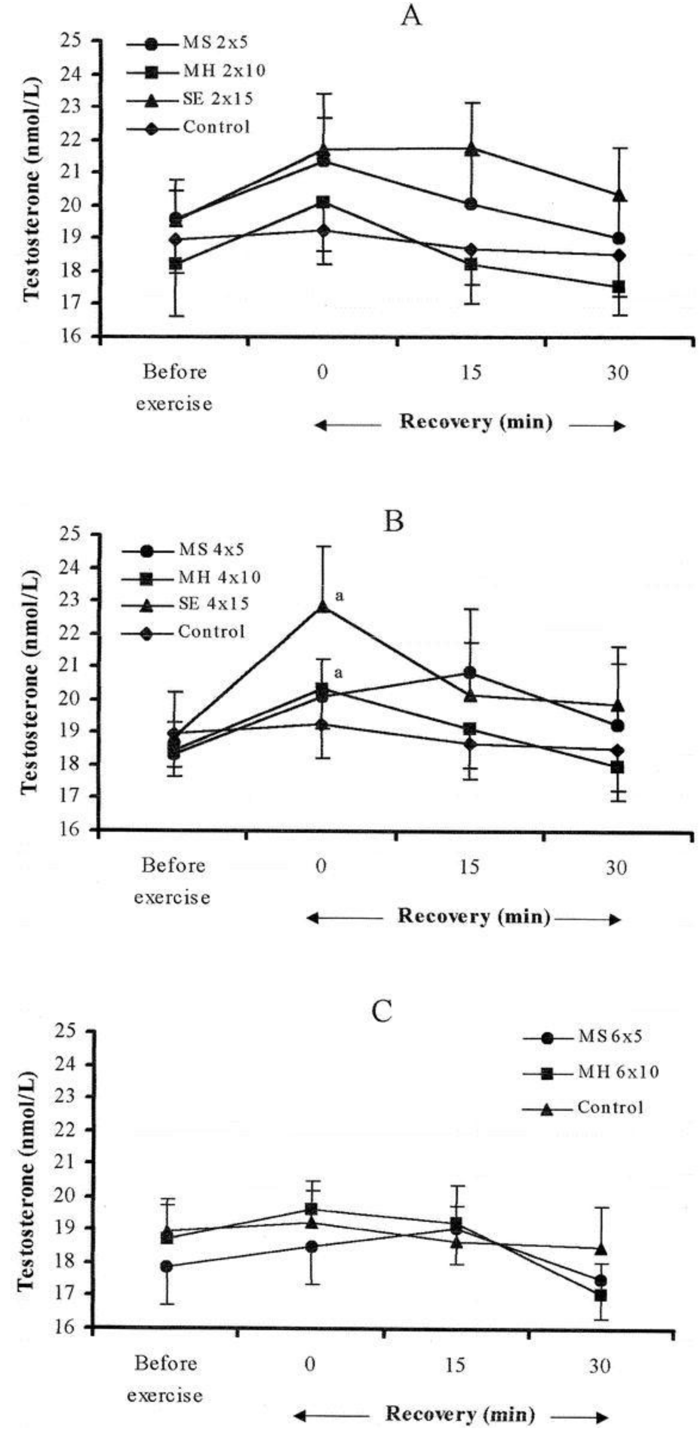
Figure 1. Postexercise plasma testosterone.

Testosterona x Séries

- O número de séries não parece afetar a liberação de testosterona de forma aguda
- O protocolo com 5 repetições não alterou a testosterona

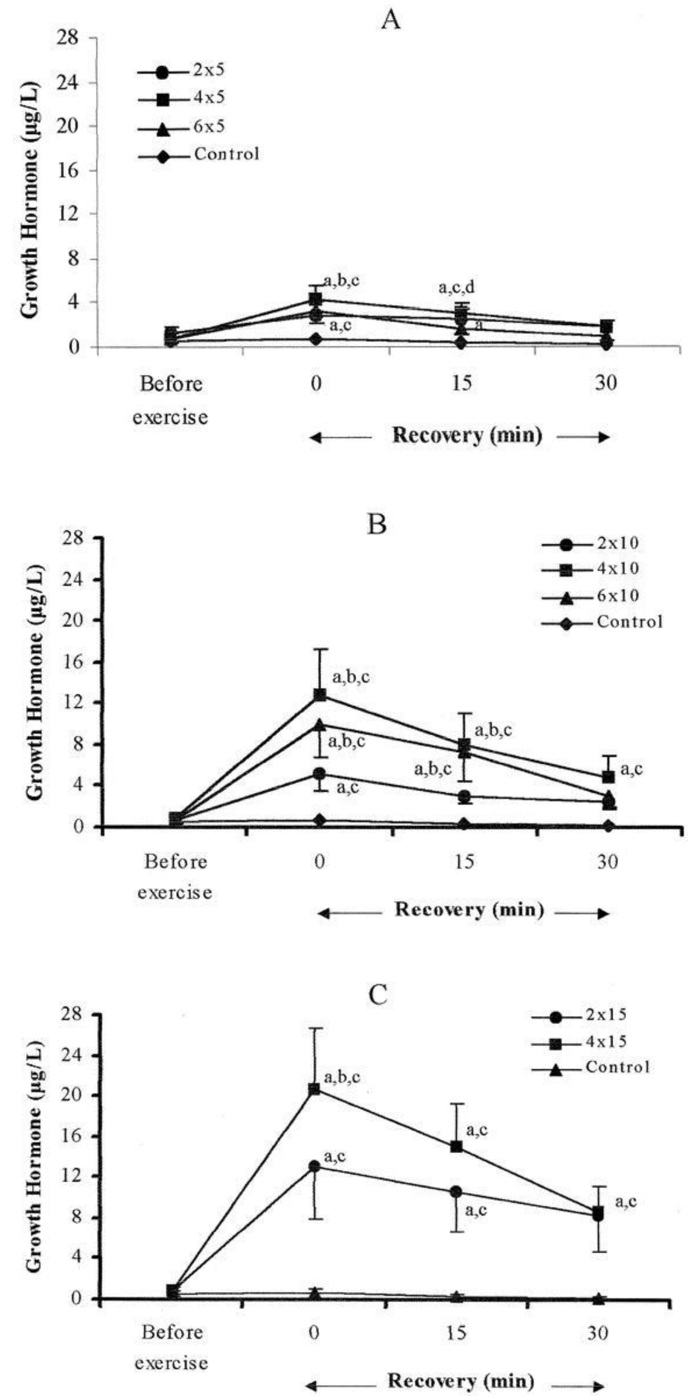


Testosterona x Repetições



GH x Séries

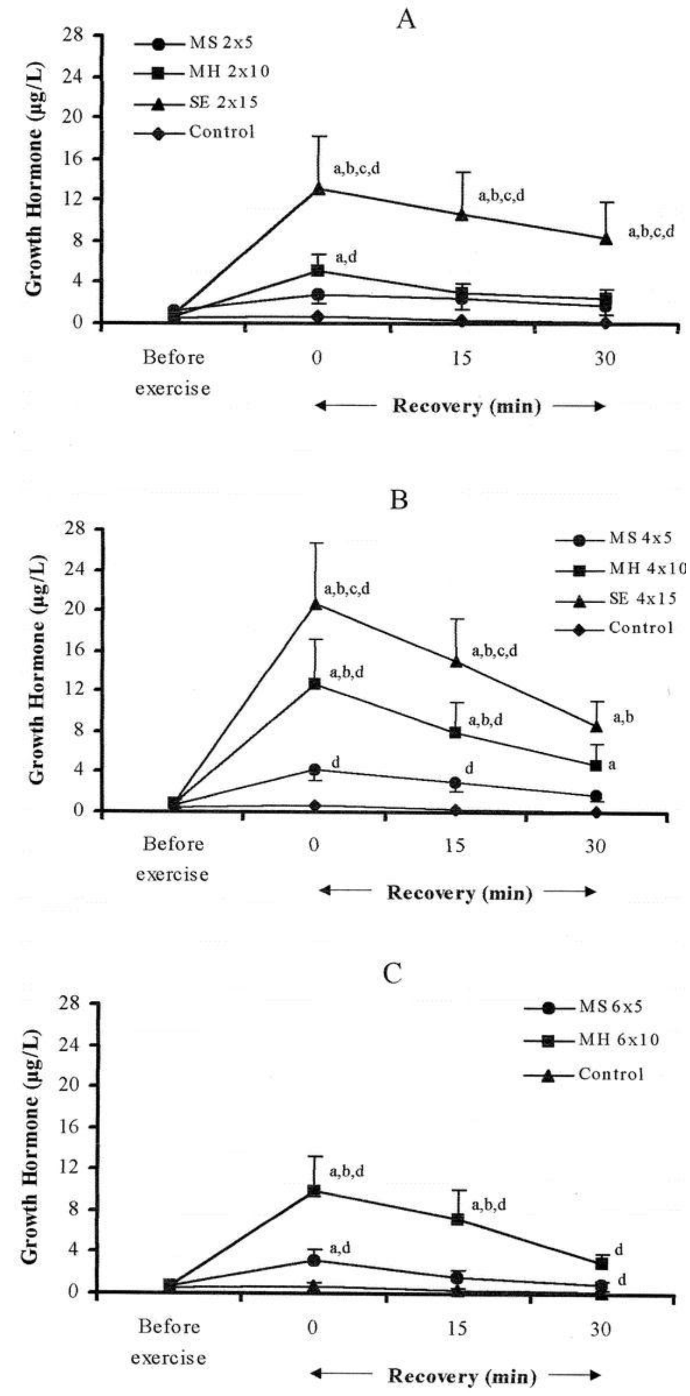
- Quando as séries tiveram 10 ou 15 repetições, o número das mesmas parece ter influenciado a liberação de GH após o treino.



GH x Repetições

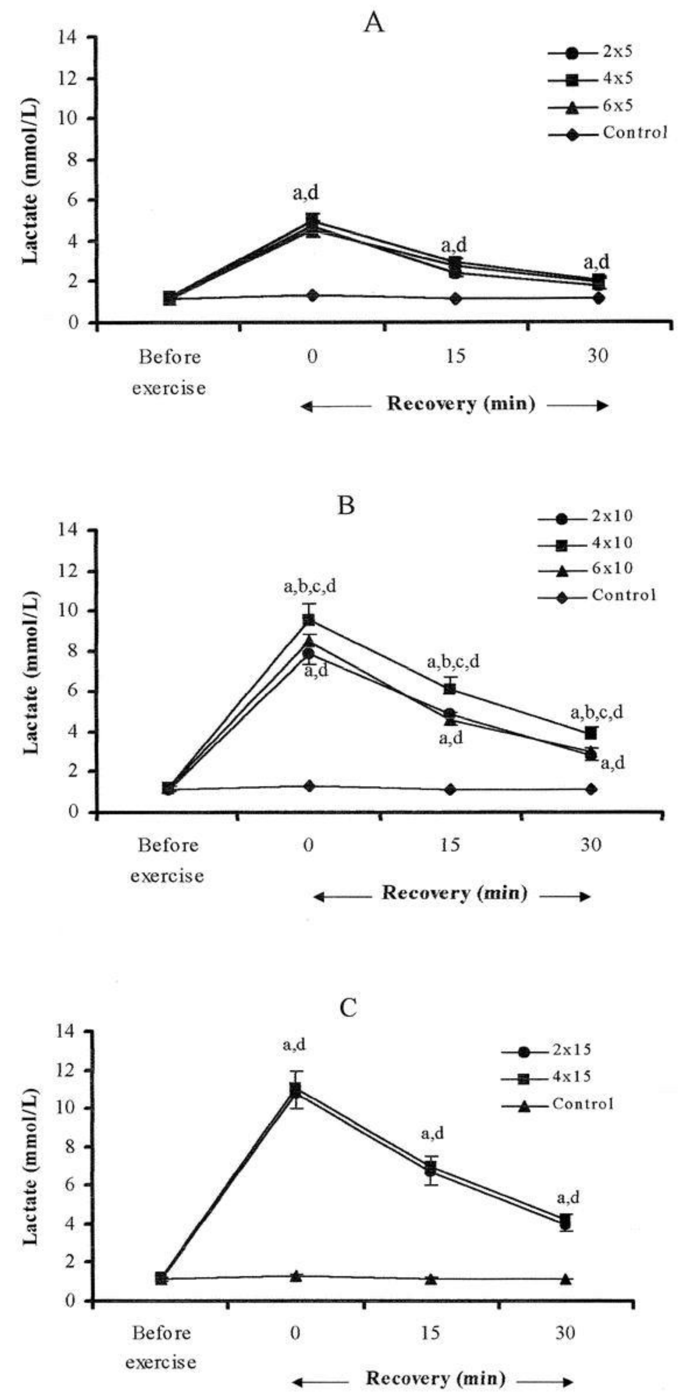
- Quanto mais alto o número de repetições maior é a liberação de GH agudamente

Smilios et al., 2003



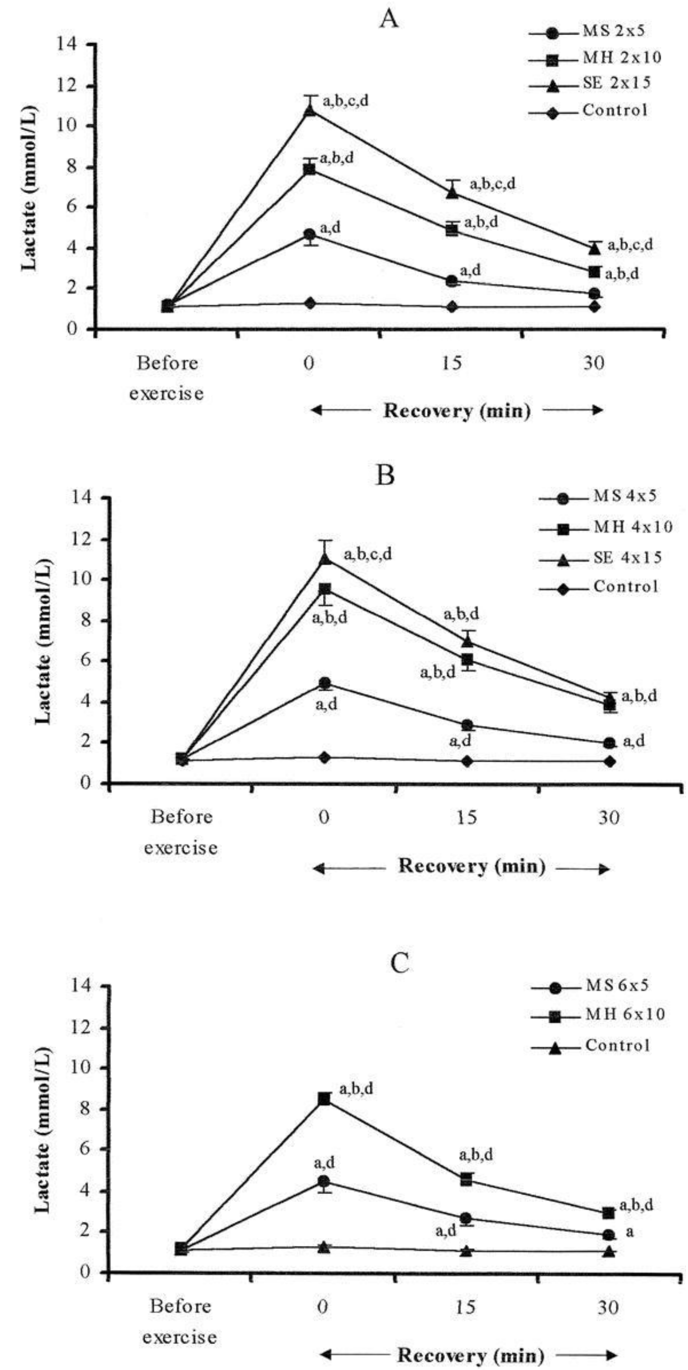
Lactato x Séries

- A quantidade de lactato produzida em uma sessão não parece ser afetada pelo número de séries

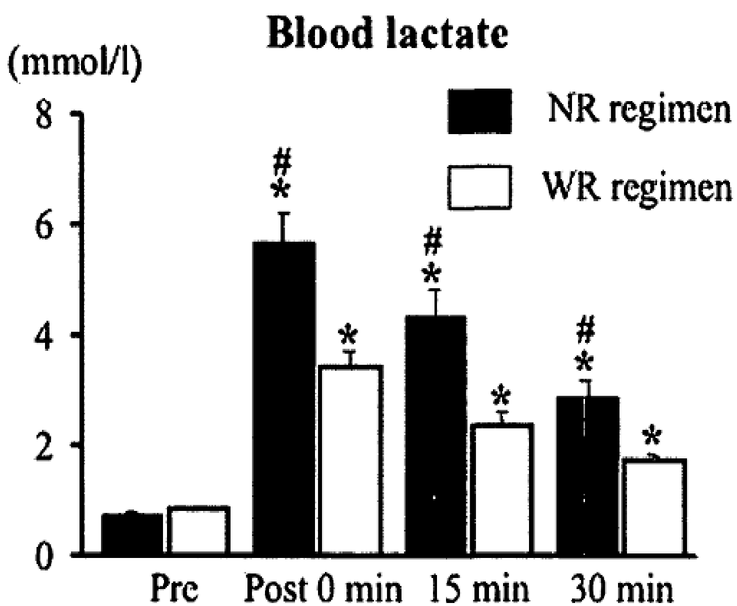


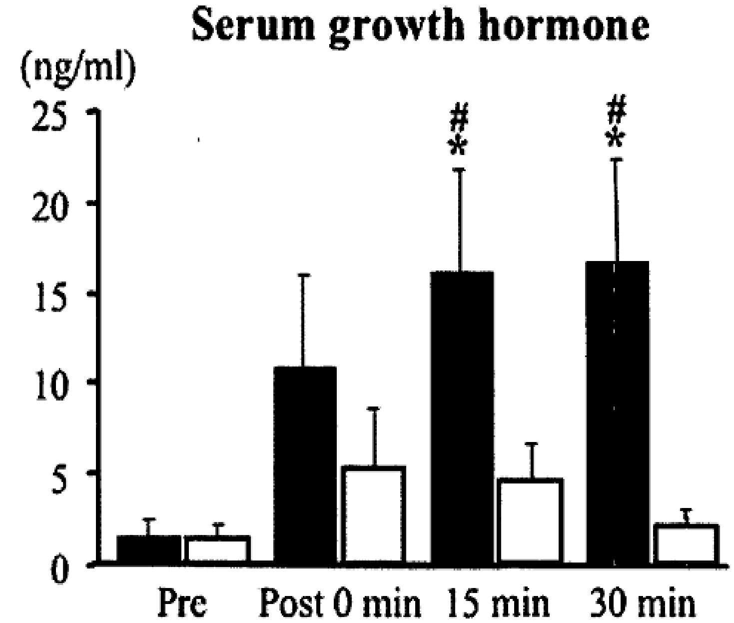
Lactato x Repetições

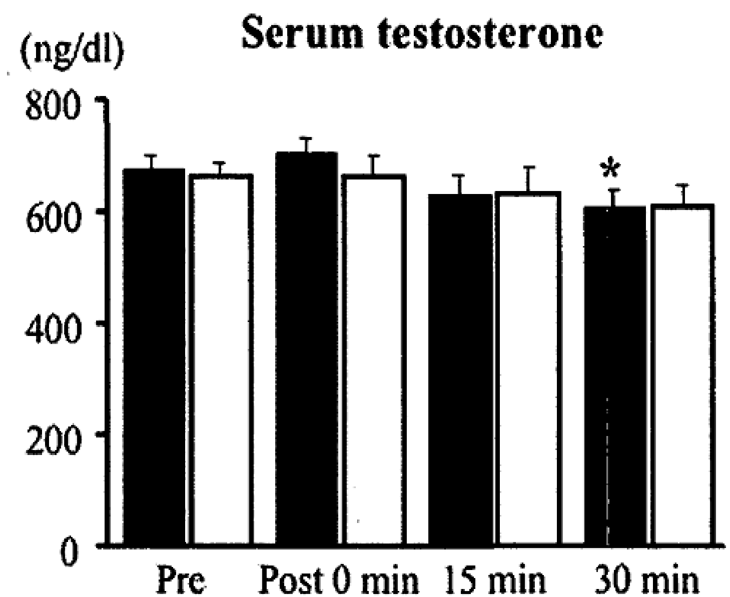
- Quanto maior o número de repetições na série maior é a concentração de lactato no sangue



GH x Lactato


Blood lactate
(mmol/l)
NR regimen
WR regimen
8
6
4
2
0
Pre
Post 0 min
15 min
30 min


Serum growth hormone
(ng/ml)
25
20
15
10
5
0
Pre
Post 0 min
15 min
30 min


Serum testosterone
(ng/dl)
800
600
400
200
0
Pre
Post 0 min
15 min
30 min

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