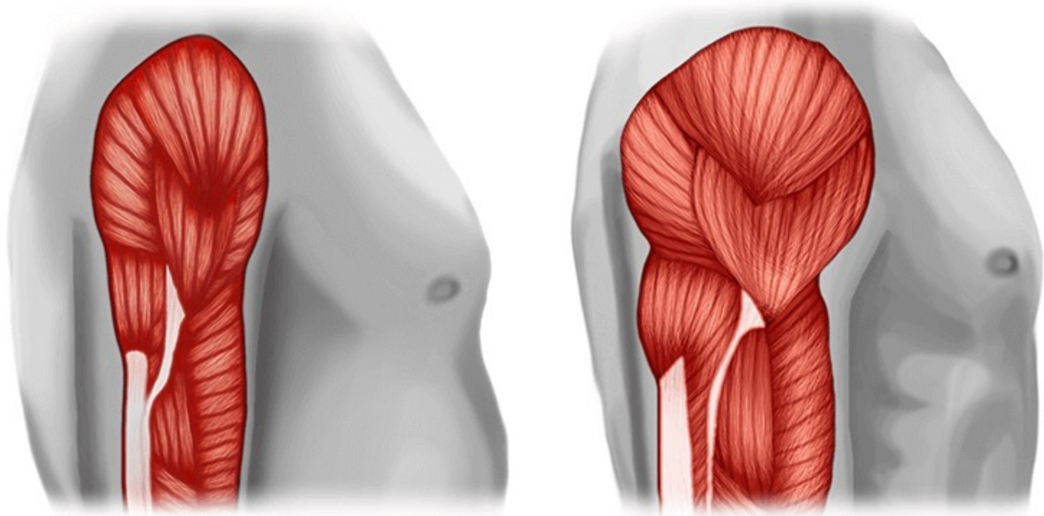


HIPERTROFIA MUSCULAR:
QUÉ ES, CÓMO SE PRODUCE Y CÓMO SE MAXIMIZA

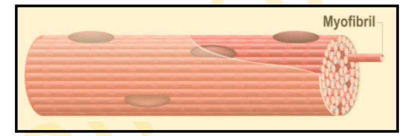
Alejandro Hernández Belmonte

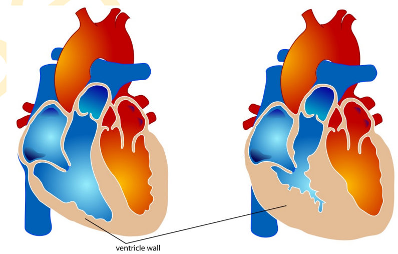
HIPERTROFIA MUSCULAR

- ¿Qué es la hipertrofia?
- Tipos de hipertrofia muscular
- ¿Es importante la hipertrofia muscular?
- Principales mecanismos de la hipertrofia muscular
- ¿Cómo maximizar la hipertrofia muscular?
  - Grado de fatiga
  - Volumen
  - Frecuencia
  - Intensidad
  - Ejercicios
  - Cadencia
  - Descanso
  - Acción muscular
  - Rango de movimiento
  - Entrenamiento concurrente

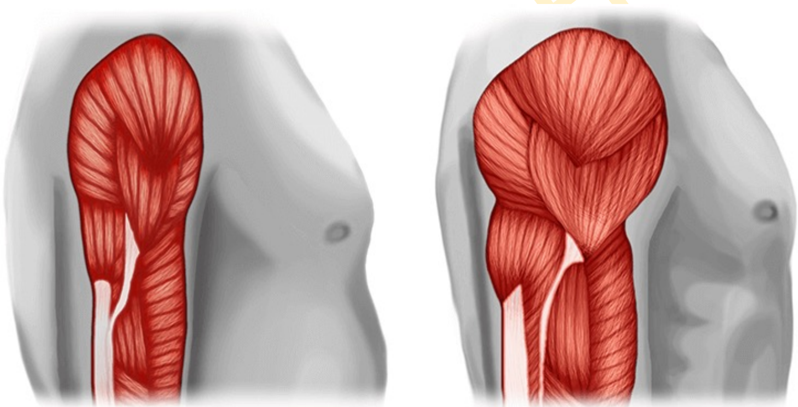
HIPERTROFIA MUSCULAR: ¿QUÉ ES?

Hipertrofia: Aumento del volumen de un ***tejido biológico*** debido a la ampliación de su componente celular.

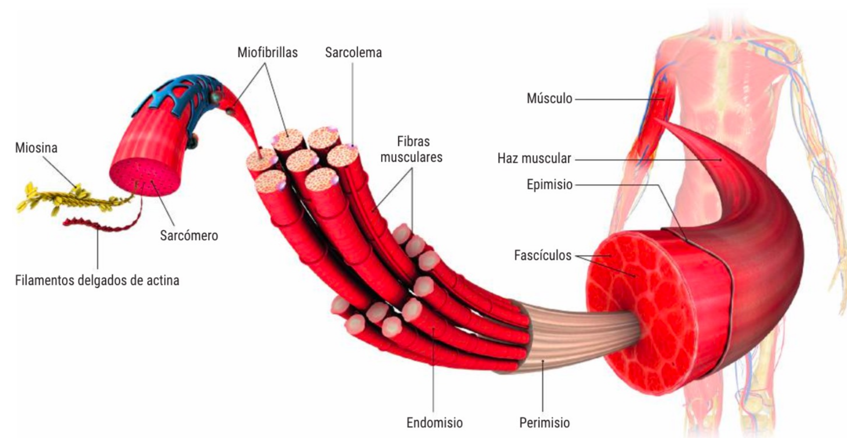




Hipertrofia muscular: Aumento del tamaño muscular



Macro y microestructuras del **músculo esquelético**



HIPERTROFIA MUSCULAR

- ¿Qué es la hipertrofia?

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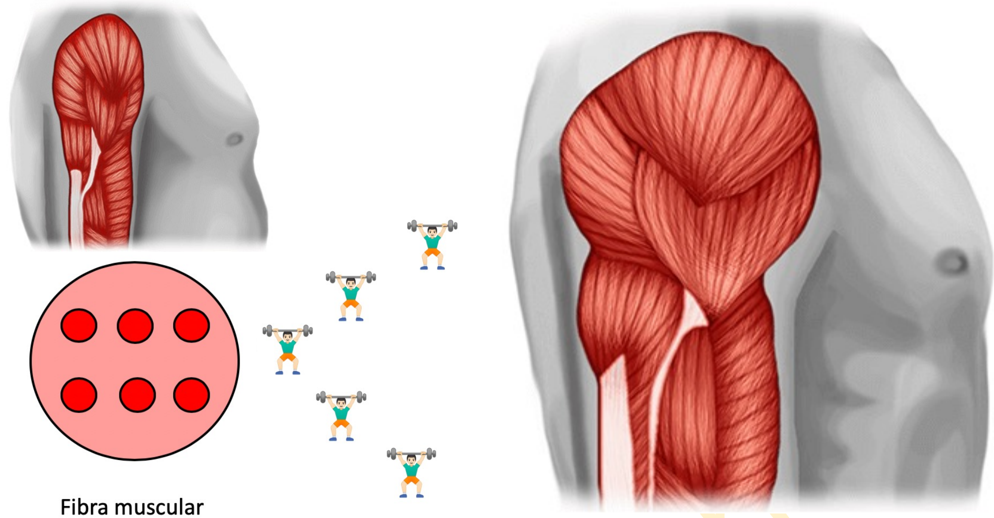
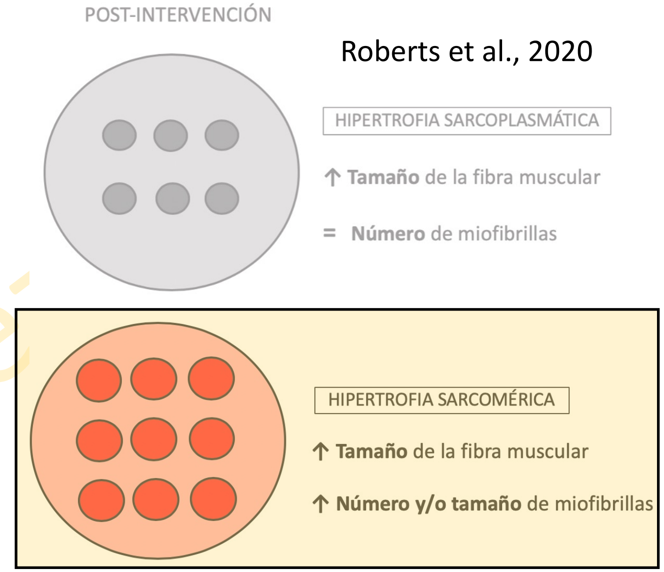
  Acción muscular
  Rango de movimiento
  Entrenamiento concurrente

HIPERTROFIA MUSCULAR: TIPOS

¿Hipertrofia **sarcomérica** y **sarcoplasmática**?



Fibra muscular



¿**Hiperplasia**?

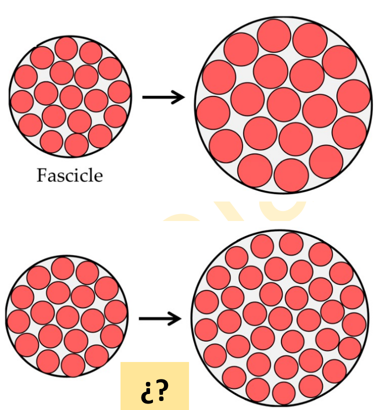


TABLE 2. *Fiber data from anterior latissimus dorsi before and after stretch* — Alway et al., (1990)

Days of Stretch	n	Control	Stretched	%Difference
		Total fiber number		
0	6			−1.5±0.2
1	5			4.0±1.0
2	5			6.5±2.7
3	4			7.4±3.2
4	4			14.9±4.1
5	4			25.1±5.8†
6	4			28.6±7.0†
7	5			27.3±3.0*

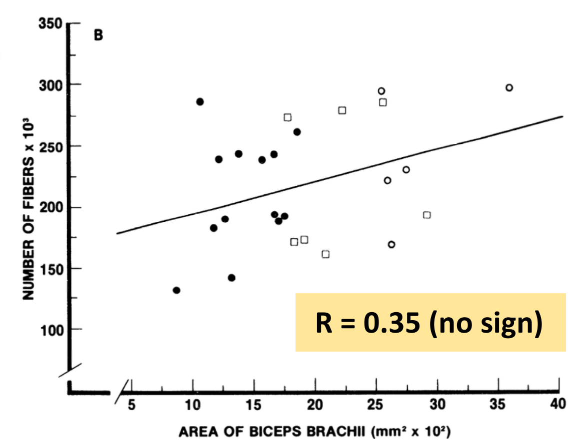
EXERCISE AND MUSCLE

Mechanical overload and skeletal muscle fiber hyperplasia: a meta-analysis

George Kelley

01 OCT 1996 // https://doi.org/10.1152/jappl.1996.81.4.1584

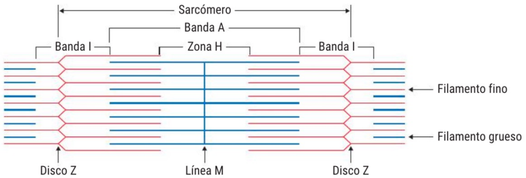
¿Y en **humanos**?



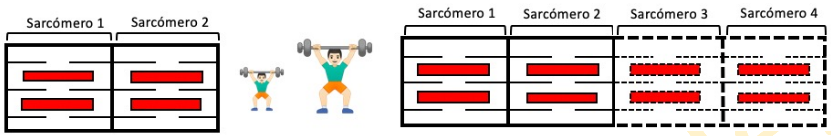
MacDougall et al., 1984

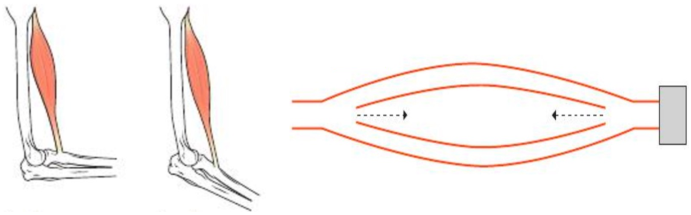
HIPERTROFIA MUSCULAR: TIPOS

Hipertrofia **sarcomérica**: Adhesión de nuevos sarcómeros

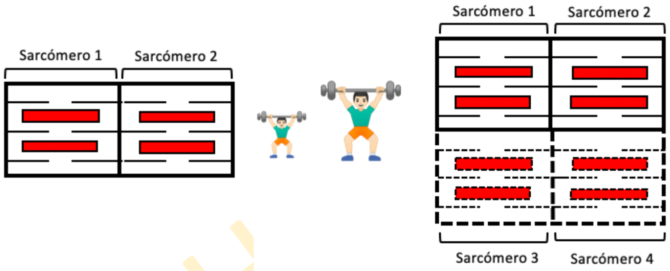


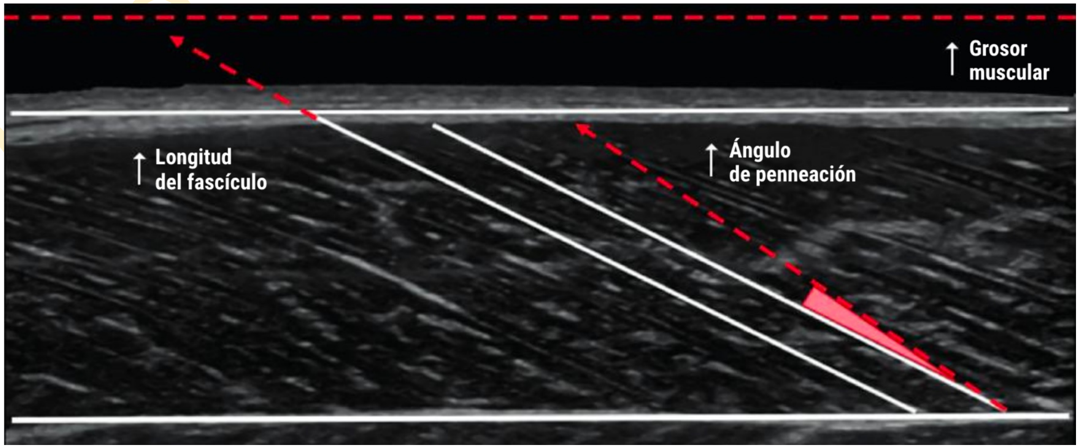
En serie





En paralelo





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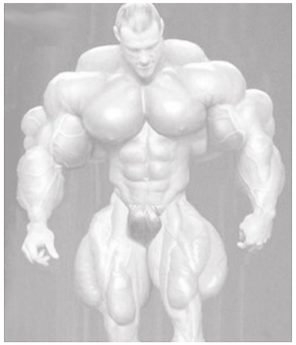
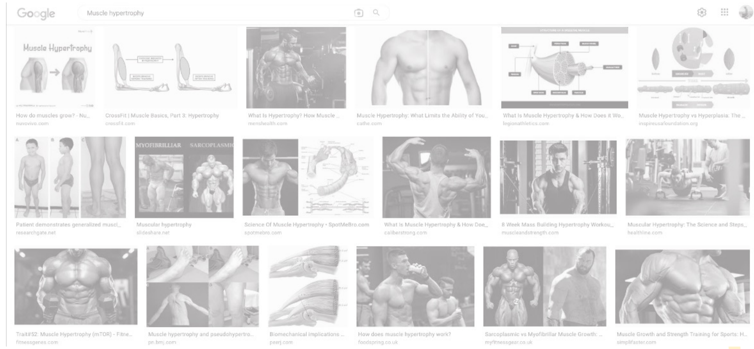
    Cadencia
    Descanso
    Acción muscular
    Rango de movimiento
    Entrenamiento concurrente

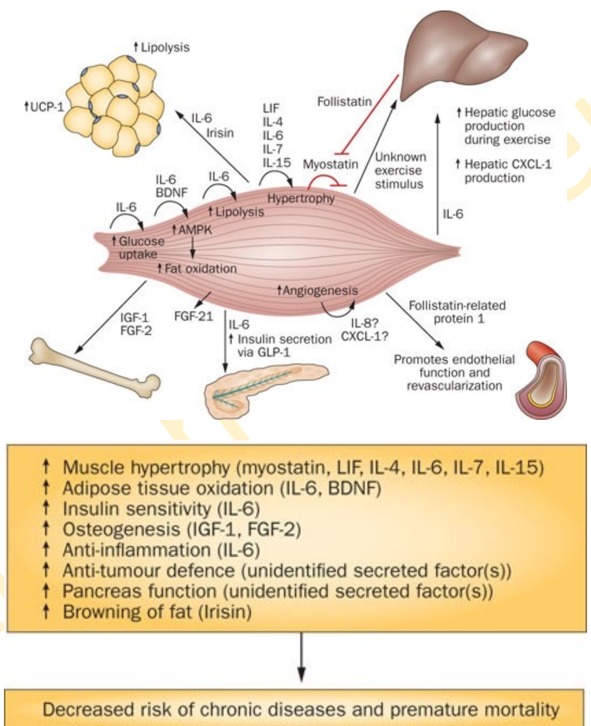
HIPERTROFIA MUSCULAR: ¿ES IMPORTANTE?





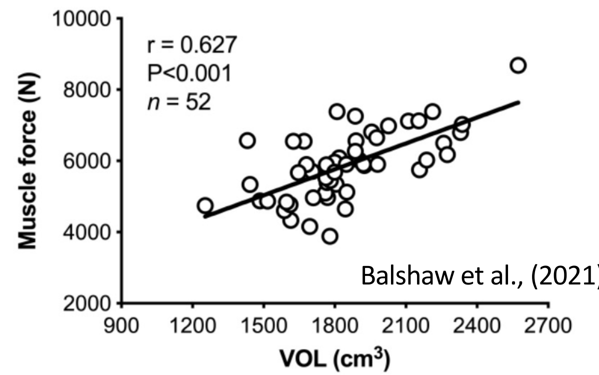
La importancia de la masa muscular va más allá de la estética

Músculo esquelético como **órgano secretor**

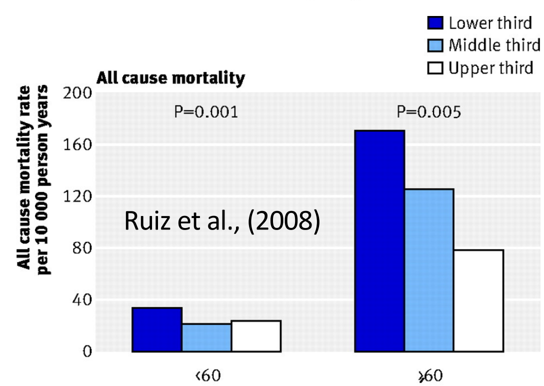


Pedersen & Febbraio (2012)

Músculo esquelético como **generador de fuerza**



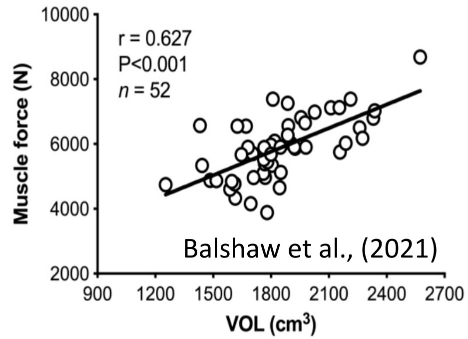
Balshaw et al., (2021)



Ruiz et al., (2008)

HIPERTROFIA MUSCULAR: ¿ES IMPORTANTE?

¿Y en el **deporte**?



Balshaw et al., (2021)

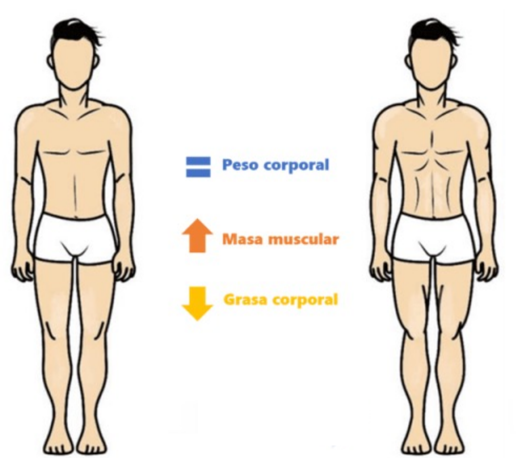
¡CUIDADO!

Tomada de Ismael Galancho

Capacidad para generar fuerza

¿? Capacidad para generar **fuerza específica**

Peso a mover en cada sprint, salto, COD



HIPERTROFIA MUSCULAR

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HIPERTROFIA MUSCULAR: PRINCIPALES MECANISMOS

Schoenfeld (2010)

Tensión mecánica

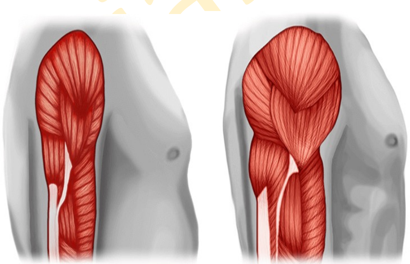
+

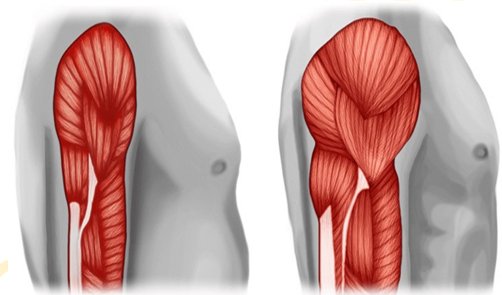
Estrés metabólico

+

Daño muscular

=





=

Daño muscular

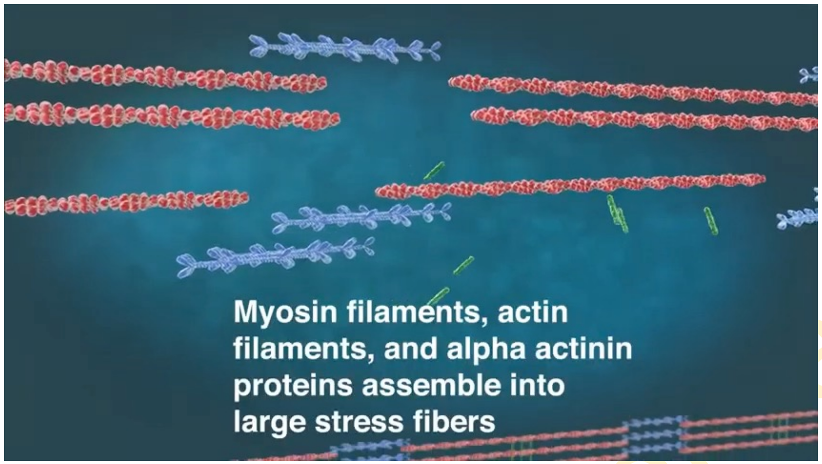
Estrés metabólico

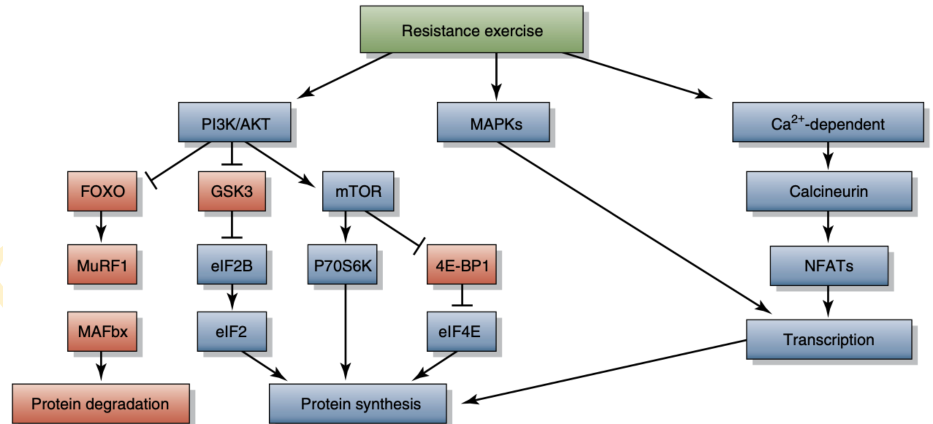
Tensión mecánica

HIPERTROFIA MUSCULAR: PRINCIPALES MECANISMOS

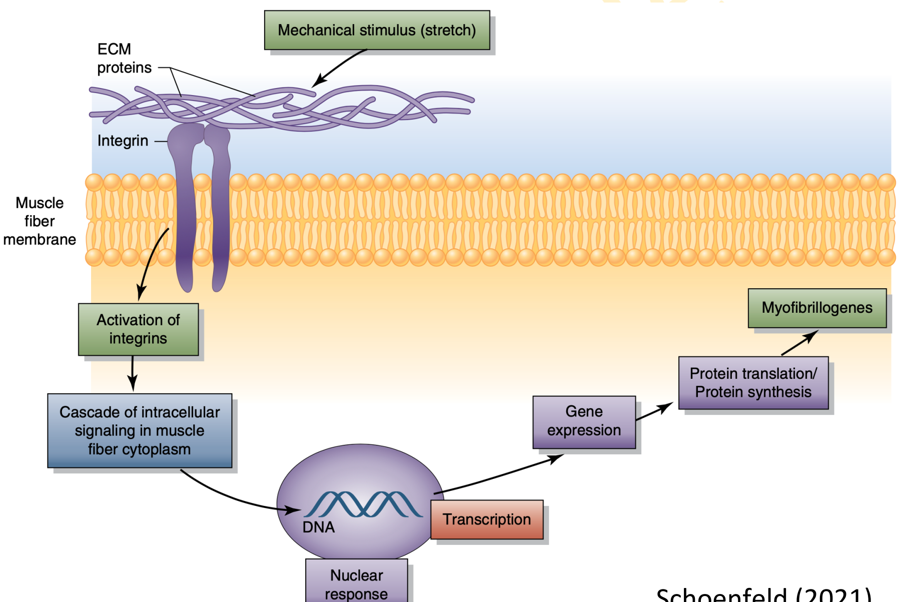
Tensión mecánica

Estímulos **mecánicos** se transforman en **estímulos químicos intracelulares**

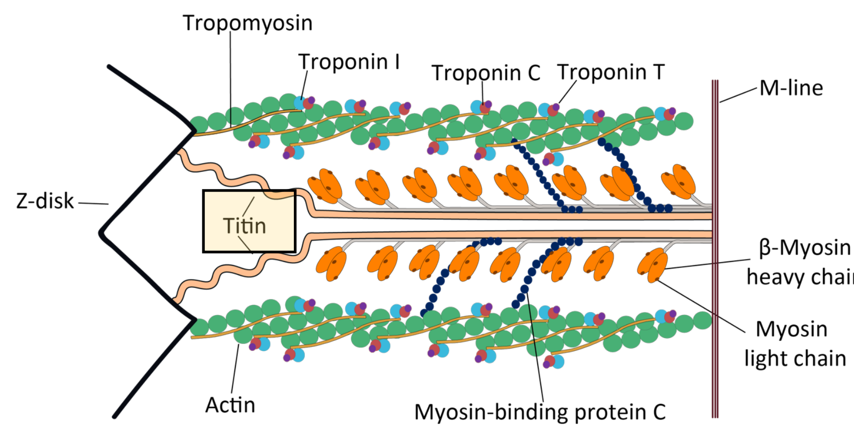




Schoenfeld (2021)



Schoenfeld (2021)

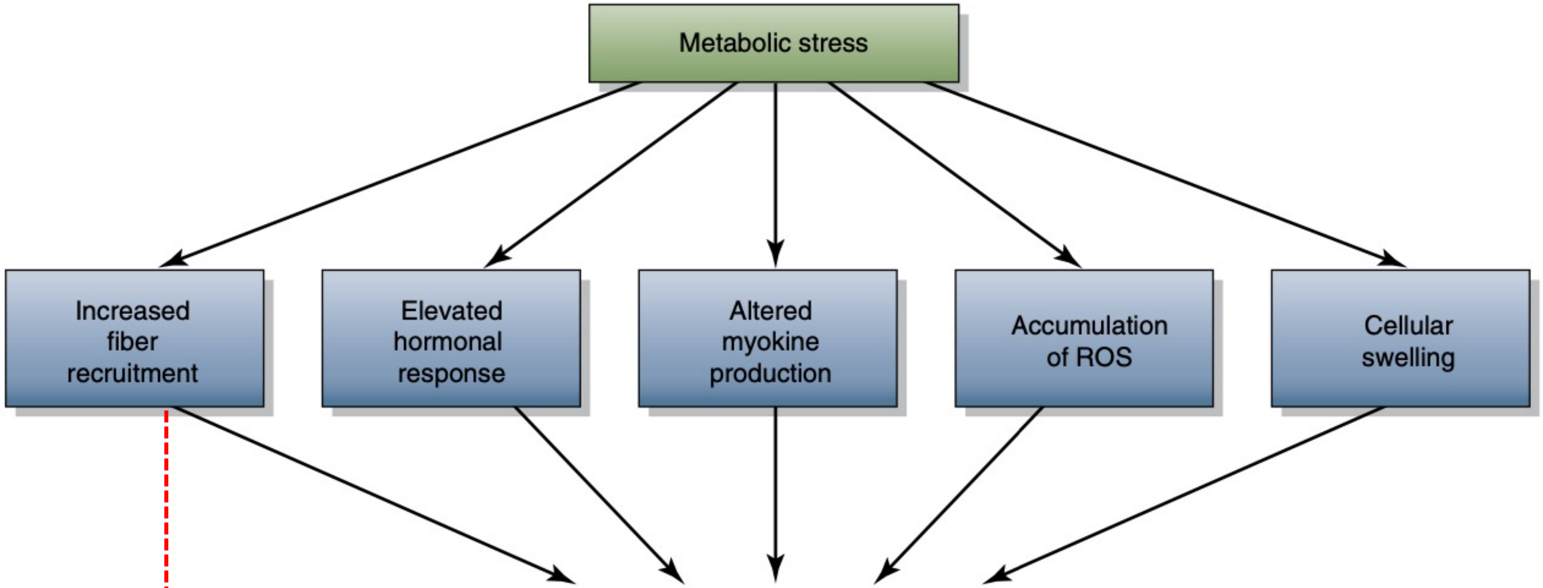


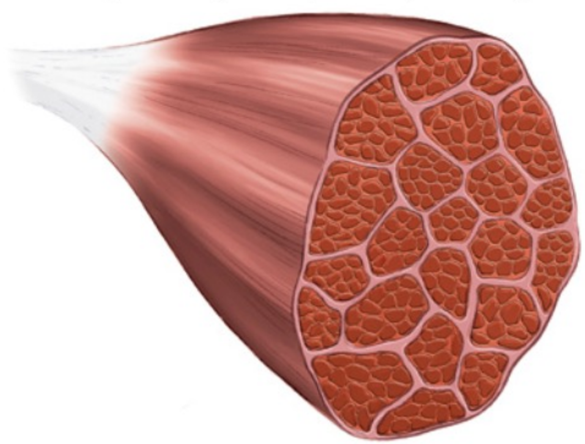
HIPERTROFIA MUSCULAR: PRINCIPALES MECANISMOS

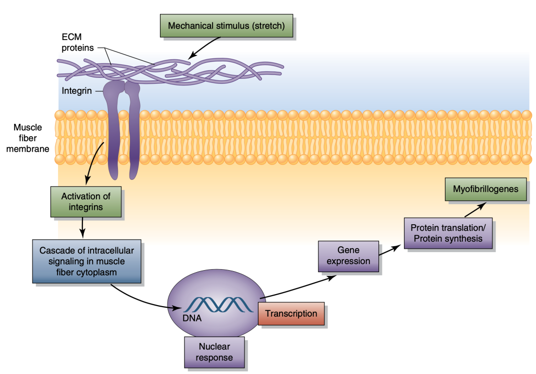
Estrés metabólico

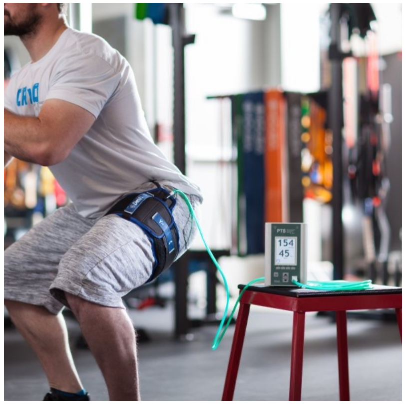
Acumulación de metabolitos: **Lactato, fosfato inorgático y H^+**

Schoenfeld (2021)





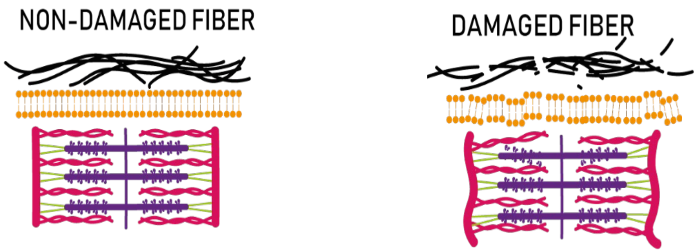


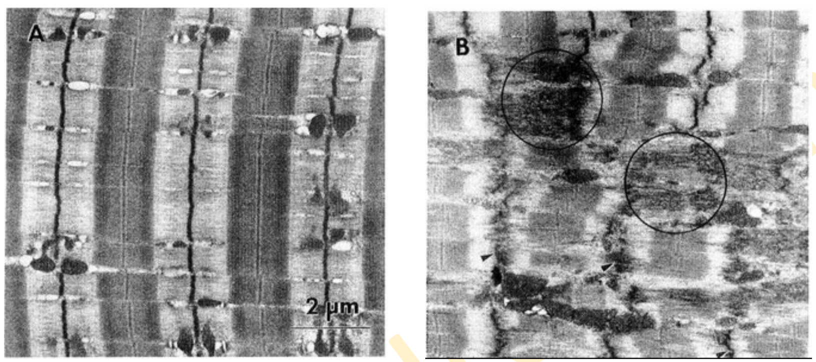


HIPERTROFIA MUSCULAR: PRINCIPALES MECANISMOS

Daño muscular

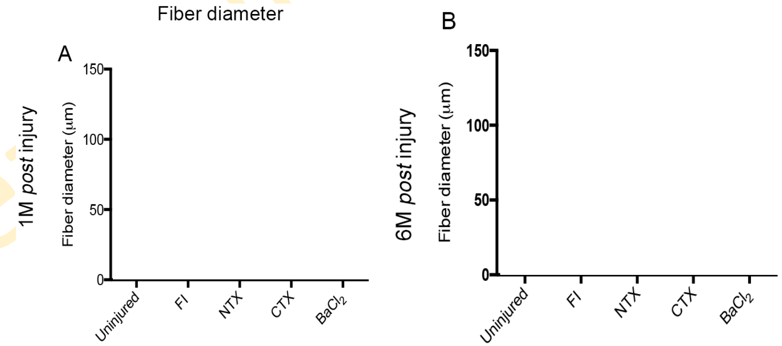
Alteración del estado normal de las microestructuras musculares





Lieber et al., (1991)

Hardy et al., (2016)



Muscle damage and muscle remodeling: no pain, no gain?

FREE

Kyle L. Flann, Paul C. LaStayo, Donald A. McClain, Mark Hazel, Stan L. Lindstedt

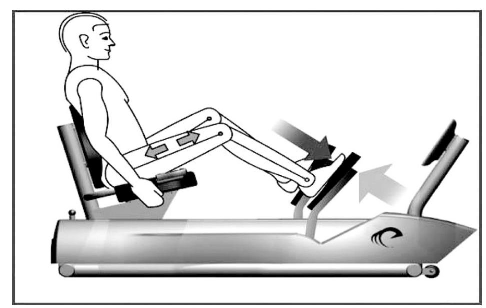
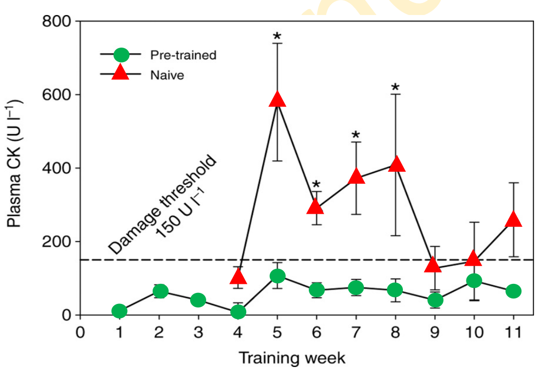
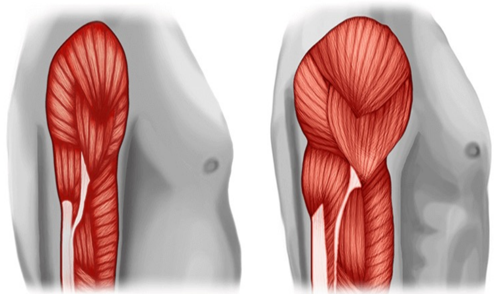


Table 2. Quadriceps muscle volume and isometric strength

	Pre-trained group (PT)			Naive group (NA)		
	Pre-training	Post-training	%Δ	Pre-training	Post-training	%Δ
Quadriceps volume (cm^3)	1651±145	1751±141	6.5*	1906±175	2041±176	7.5*
Quadriceps strength (N)	104.5±64.5	130.5±28.5	24.8*	108.4±81	136.4±118.6	25.8*



HIPERTROFIA MUSCULAR: PRINCIPALES MECANISMOS



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Daño muscular +¿?

Estrés metabólico ++

Tensión mecánica ++++

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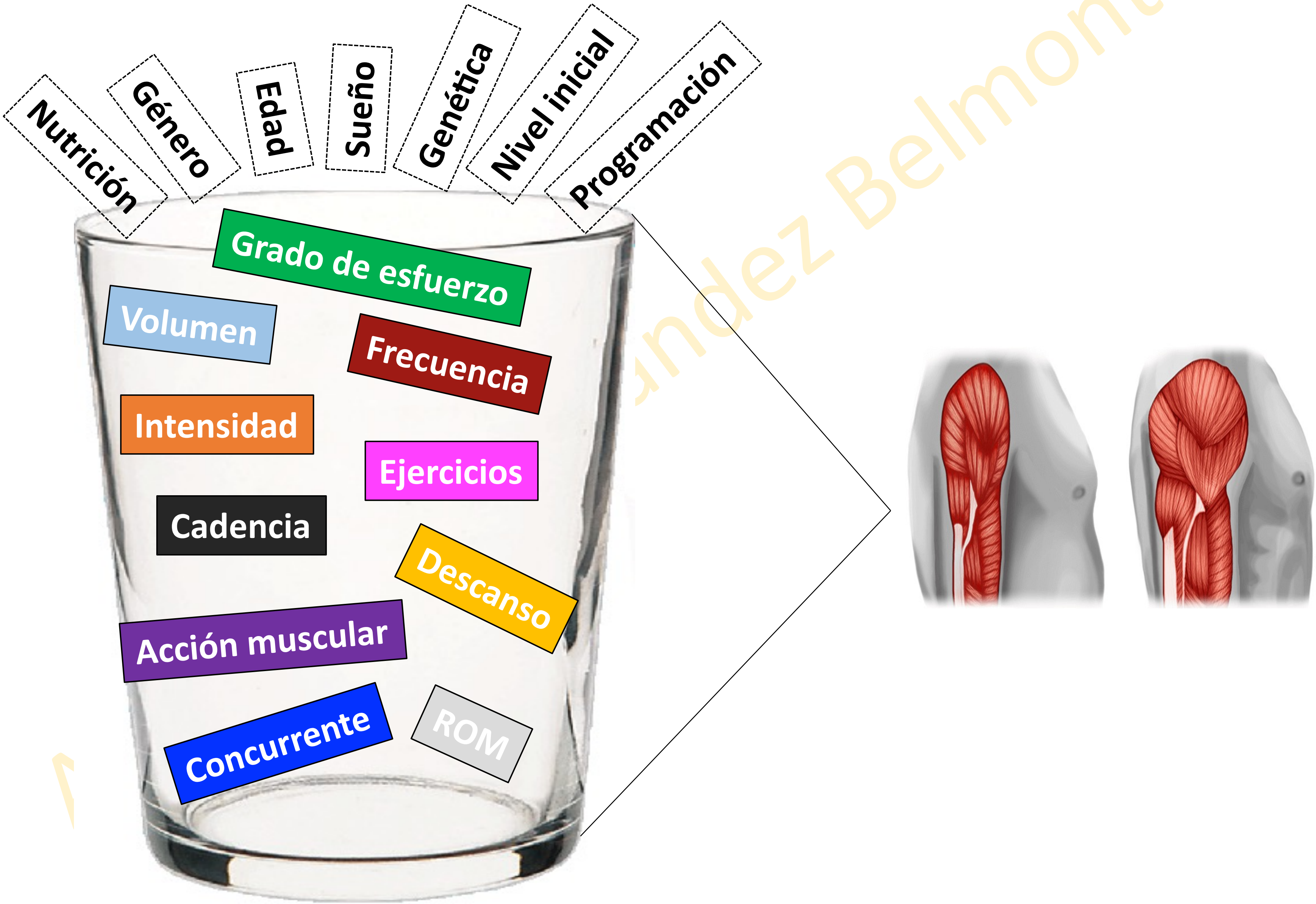
  Cadencia
  Descanso
  Acción muscular
  Rango de movimiento
  Entrenamiento concurrente

HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

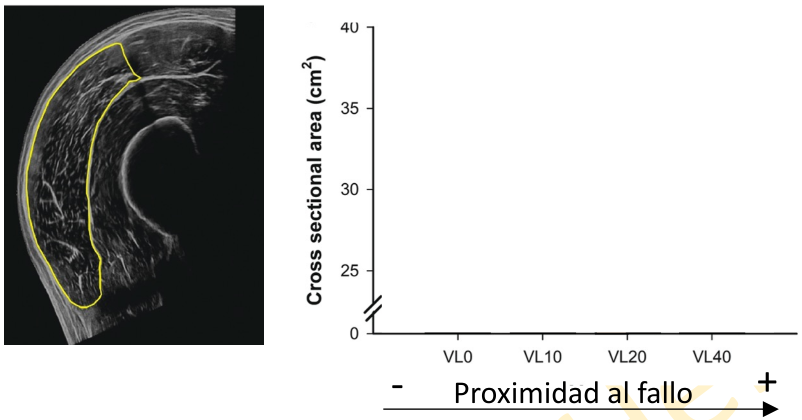


HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Grado de esfuerzo

Velocity Loss as a Critical Variable Determining the Adaptations to Strength Training

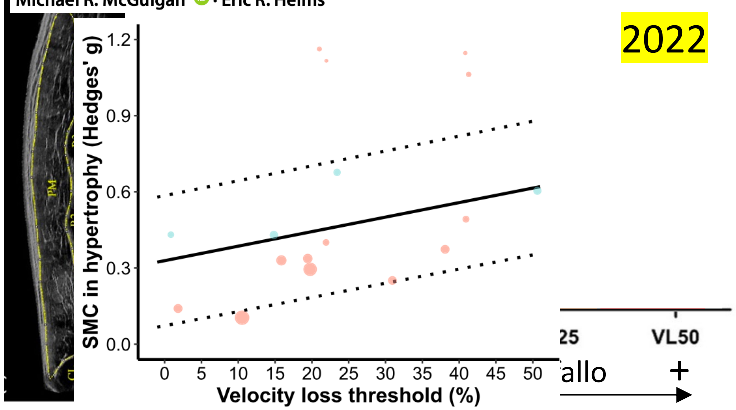
Pareja-Blanco et al., 2020



Eff **The Acute and Chronic Effects of Implementing Velocity Loss Thresholds During Resistance Training: A Systematic Review, Meta-Analysis, and Critical Evaluation of the Literature** gth
gai ly

Ivan Jukic[1,2] · Alejandro Pérez Castilla[3] · Amador García Ramos[3,4] · Bas Van Hooren[5] · Michael R. McGuigan[1] · Eric R. Helms[1]

2022

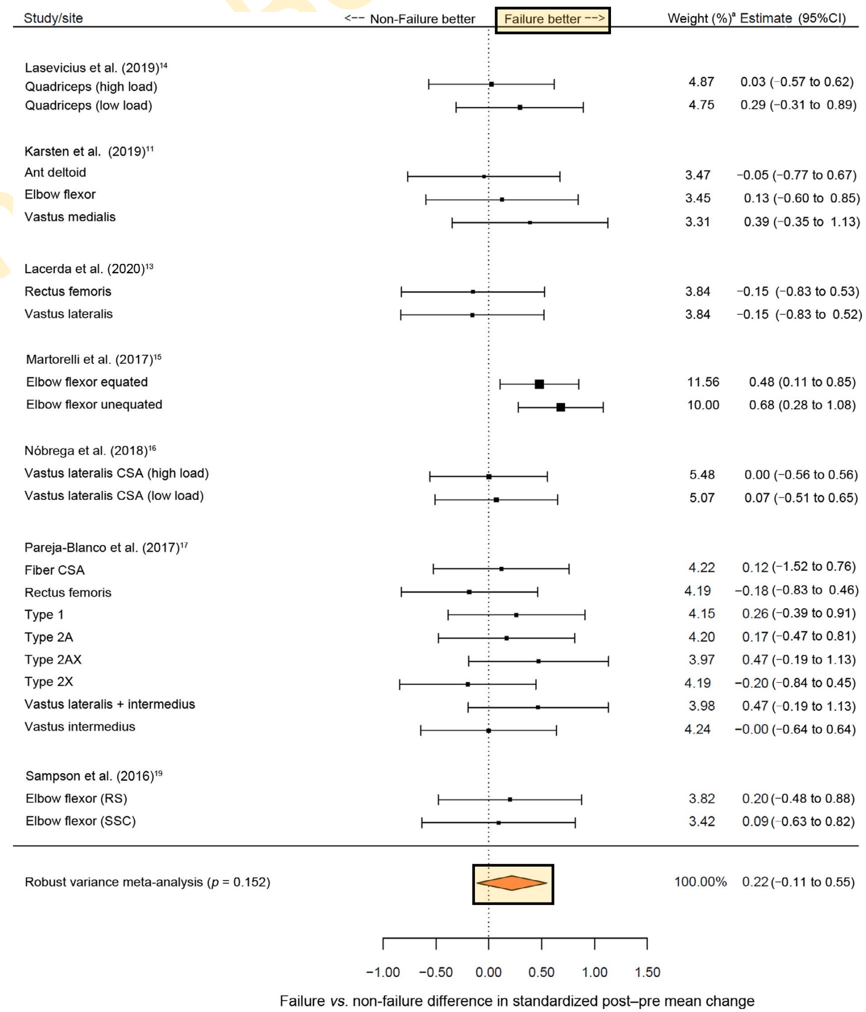


Proximidad al fallo muscular

Effects of resistance training performed to repetition failure or non-failure on muscular strength and hypertrophy: A systematic review and meta-analysis

Jozo Grgic [a], Brad J. Schoenfeld [b,*], John Orazem [c], Filip Sabol [d,e]

2021



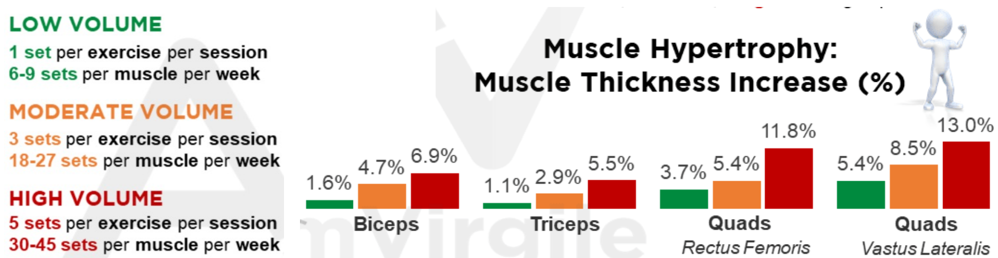
HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Volumen — Número de series realizadas por grupo muscular

Resistance Training Volume Enhances Muscle Hypertrophy but Not Strength in Trained Men

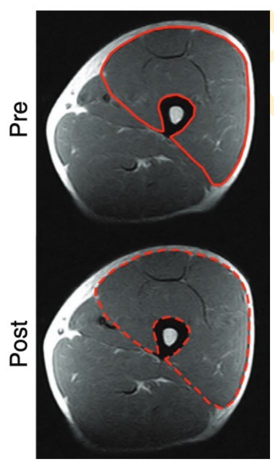
SCHOENFELD, BRAD J.[1]; CONTRERAS, BRET[2]; KRIEGER, JAMES[3]; GRGIC, JOZO[4]; DELCASTILLO, KENNETH[1]; BELLIARD, RAMON[1]; ALTO, ANDREW[1]

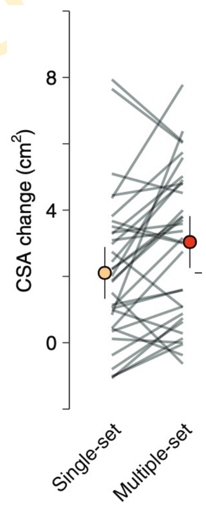
Adam Virgile



Benefits of higher resistance-training volume are related to ribosome biogenesis

Daniel Hammarström, Sjur Øfsteng, Lise Koll, Marita Hanestadhaugen, Ivana Hollan, William Apró, Jon Elling Whist, Eva Blomstrand, Bent R. Rønnestad, Stian Ellefsen

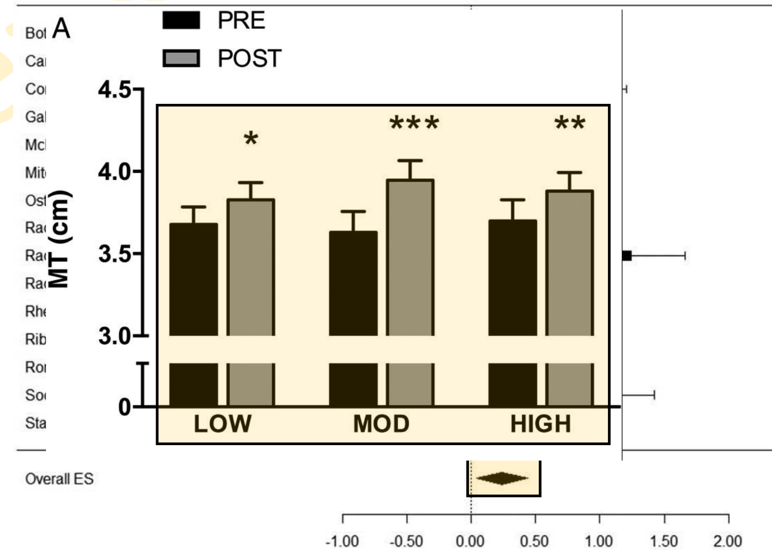




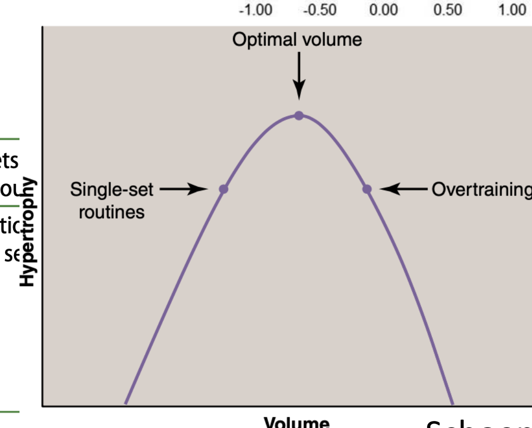
Dose-Response Relationship of Weekly Resistance-Training Volume and Frequency on Muscular Adaptations in Trained Men

2019

Samuel R Heaselgrave, Joe Blacker, Benoit Smeuninx, James McKendry, Leigh Breen



Weekly sets muscle grou	...uivalent ...ntage gain
Each additic weekly se	0.37
<5	5.4
5–9	6.6
10+	9.8
<9	5.8
9+	8.2



Schoenfeld (2021)

HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Frecuencia Número de sesiones de entrenamiento semanales

How many times per week should a muscle be trained to maximize muscle hypertrophy? A systematic review and meta-analysis of studies examining the effects of resistance training frequency

2018

Brad Jon Schoenfeld, Jozo Grgic & James Krieger

Frequency Category	All volume-equated studies		
	Estimate	95% CI	Percentage Gain
1 d/wk	0.37 ± 0.13	0.07, 0.66	4.1 ± 1.4
2 d/wk	0.32 ± 0.11	0.08, 0.56	4.3 ± 1.2
3 d/wk	0.49 ± 0.10	0.26, 0.72	6.3 ± 1.2
4–6 d/wk	0.39 ± 0.13	0.08, 0.70	5.1 ± 1.6

Effect of Resistance Training Frequency on Gains in Muscular Strength: A Systematic Review and Meta-Analysis

2018

Jozo Grgic[1] · Brad J. Schoenfeld[2] · Timothy B. Davies[3] · Bruno Lazinica[4] · James W. Krieger[5] · Zeljko Pedisic[1]

Frequency (times/week)	ES (mean ± standard error of the mean)	95% CI	*p* value
All studies			
1	0.74 ± 0.13	0.48–1.01	0.003
2	0.82 ± 0.13	0.55–1.09	
3	0.93 ± 0.13	0.65–1.21	
4+	1.08 ± 0.16	0.74–1.42	
Volume-equated studies			
1	0.53 ± 0.13	0.13–0.93	0.421
2	0.80 ± 0.33	−0.25 to 1.86	
3	0.64 ± 0.14	0.21–1.07	
4+	0.58 ± 0.04	0.45–0.72	

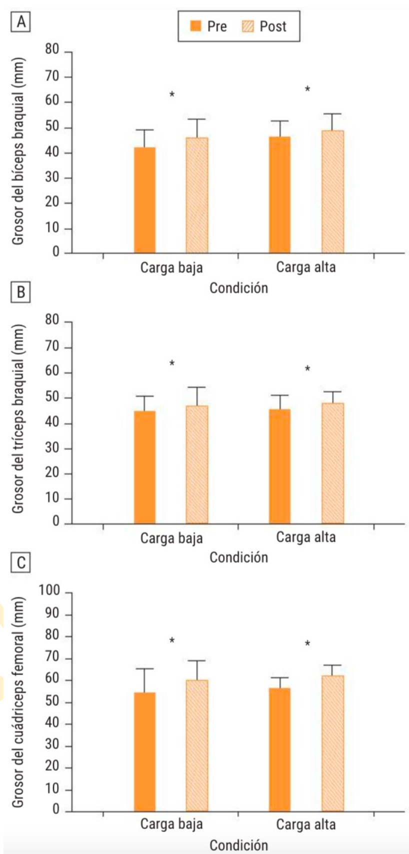
HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Intensidad Exigencia relativa que la carga supone con respecto a la máxima carga que podría levantar en una sola repeticón

Effects of Low- vs. High-Load Resistance Training on Muscle Strength and Hypertrophy in Well-Trained Men 2015

Brad J Schoenfeld [1], Mark D Peterson, Dan Ogborn, Bret Contreras, Gul T Sonmez

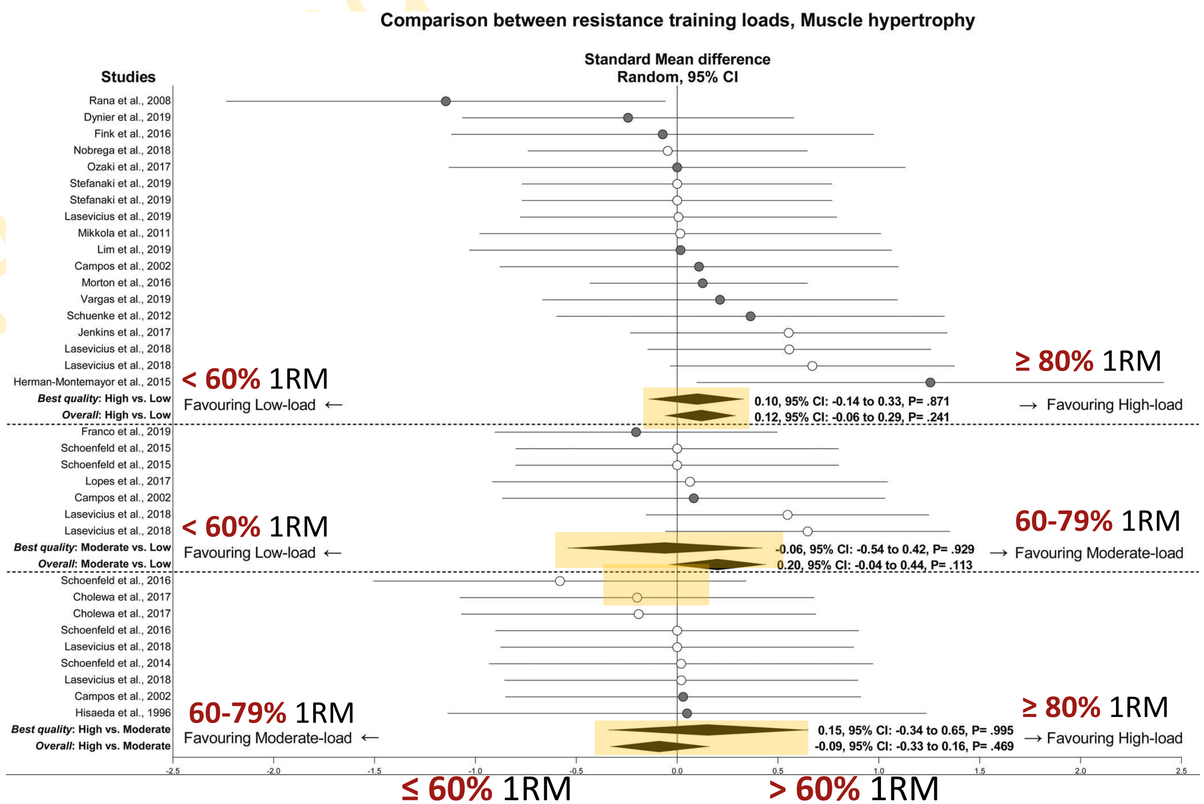
Carga baja = **30 – 50%** 1RM
Carga alta = **70 – 80%** 1RM



Resistance Training Load Effects on Muscle Hypertrophy and Strength Gain: Systematic Review and Network Meta-analysis 2021

Pedro Lopez, Régis Radaelli [1], Dennis R Taaffe, Robert U Newton, Daniel A Galvão, Gabriel S Trajano [2], Juliana L Teodoro [1], William J Kraemer [3], Keijo Häkkinen [4], Ronei S Pinto [1]

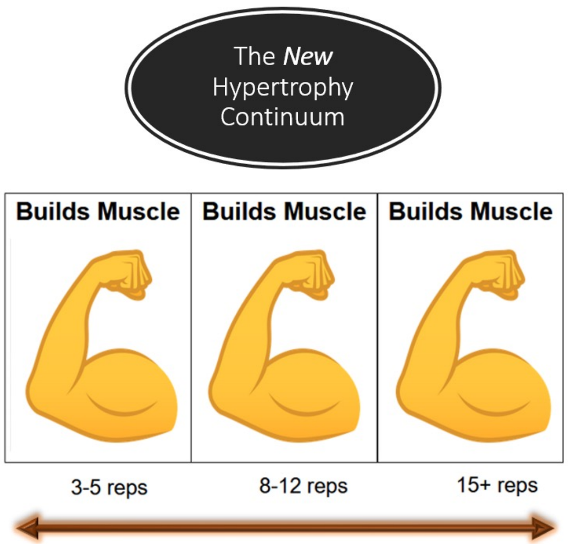
Brad J. Schoenfeld,[1] Jozo Grgic,[2] Dan Ogborn,[3] and James W. Krieger[4]



HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Intensidad

Brad Schoenfeld, PhD
@BradSchoenfeld



Tensión mecánica ++++

Estrés metabólico +

Tensión mecánica +++

Estrés metabólico +++

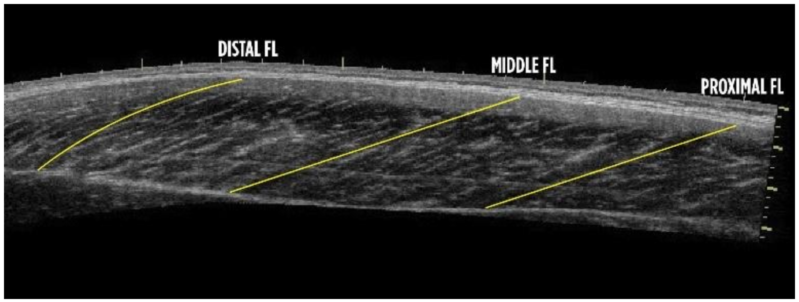
Tensión mecánica +

Estrés metabólico ++++

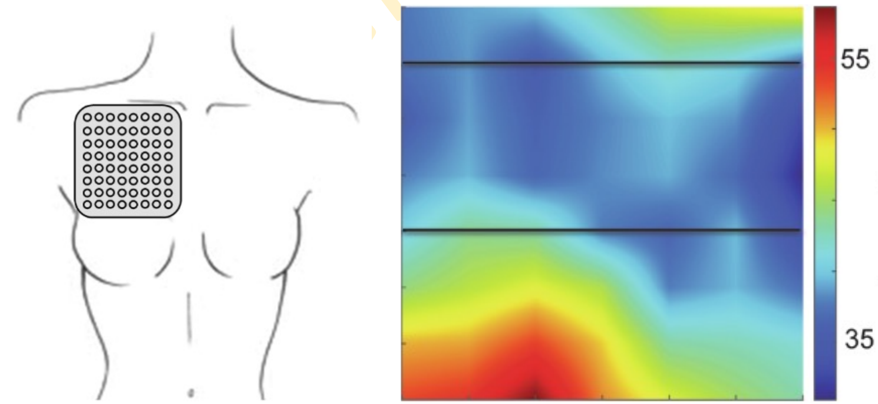
HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Ejercicios

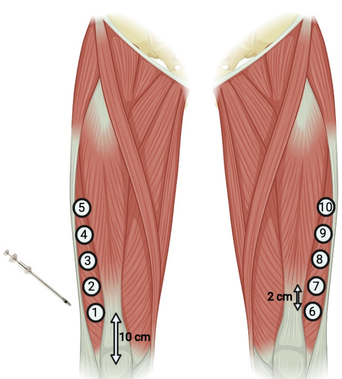
Vía utilizada para aplicar el estímulo de entrenamiento

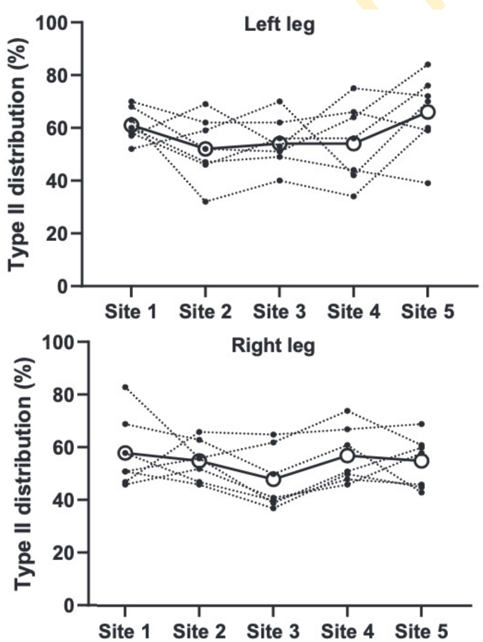


Oranchuk et al., (2019)

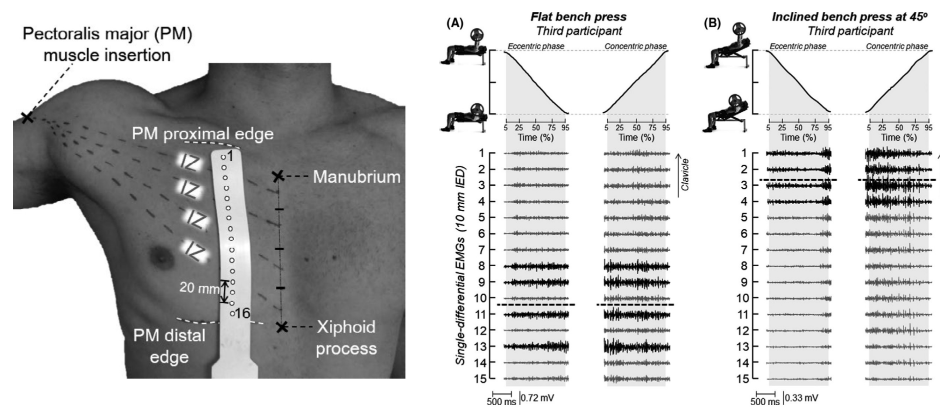


Lulic-Kuryllo et al., (2022)





Horwath et al., (2021)



Cabral et al., (2022)

HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

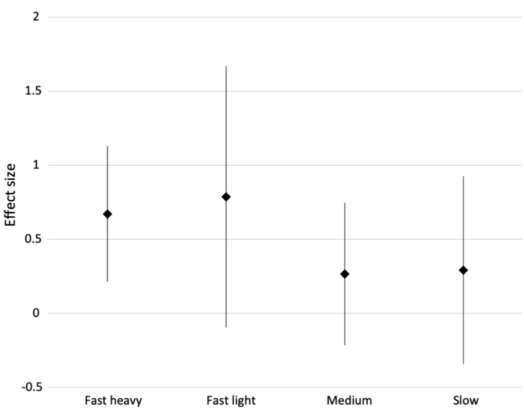
Cadencia

Intencionalidad de las fases excéntrica y concéntrica

Effect of Repetition Duration During Resistance Training on Muscle Hypertrophy: A Systematic Review and Meta-Analysis

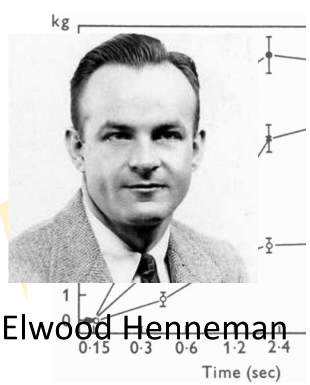
Brad J. Schoenfeld · Dan I. Ogborn · James W. Krieger

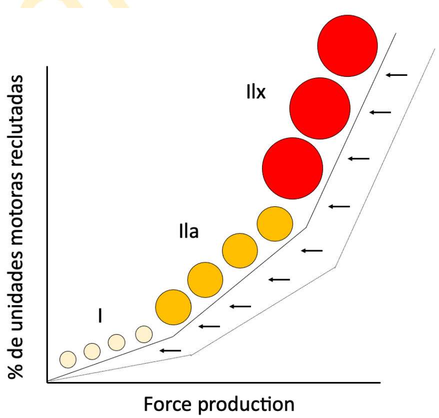
2015



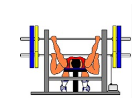
0.5 - 4 s | 0.5 - 4 s | 4 - 8 s | > 8 s

Fase concéntrica + excéntrica





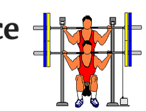
Maximal intended velocity training induces greater gains in bench press performance than deliberately slower half-velocity training



Juan José González-Badillo[a], David Rodríguez-Rosell[a], Luis Sánchez-Medina[b], Esteban M. Gorostiaga[b] & Fernando Pareja-Blanco[a]

	MaxV	HalfV
Lactate (mmol·L^{-1})		
Rest	1.3 ± 0.4	1.1 ± 0.3
3 × 8 with 0.79 m·s^{-1} load (~60% 1RM)	4.7 ± 1.5	3.8 ± 1.2
3 × 6 with 0.62 m·s^{-1} load (~70% 1RM)	4.2 ± 1.0	3.4 ± 1.1
3 × 3 with 0.47 m·s^{-1} load (~80% 1RM)	2.5 ± 0.8*†	2.4 ± 0.9*†
Ammonia (µmol·L^{-1})		
Rest	33.0 ± 10.2	28.7 ± 9.3
3 × 8 with 0.79 m·s^{-1} load (~60% 1RM)	47.8 ± 13.5	38.2 ± 19.0
3 × 6 with 0.62 m·s^{-1} load (~70% 1RM)	38.2 ± 12.8	37.7 ± 10.8
3 × 3 with 0.47 m·s^{-1} load (~80% 1RM)	15.8 ± 4.0*†	18.1 ± 8.4*†
Pre–post change (%) in velocity against the V_1 load		
3 × 8 with 0.79 m·s^{-1} load (~60% 1RM)	7.6 ± 6.7	1.4 ± 7.5
3 × 6 with 0.62 m·s^{-1} load (~70% 1RM)	7.1 ± 5.5	3.9 ± 5.1
3 × 3 with 0.47 m·s^{-1} load (~80% 1RM)	0.5 ± 6.5*	1.2 ± 3.5

Effect of movement velocity during resistance training on neuromuscular performance



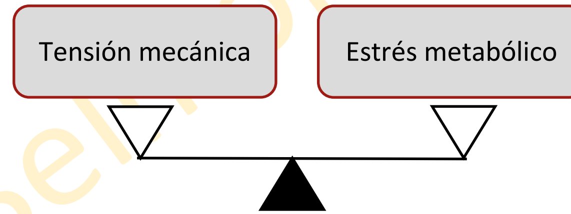
F Pareja-Blanco [1], D Rodríguez-Rosell [1], L Sánchez-Medina [2], E M Gorostiaga [2], J J González-Badillo [1]

	MaxV	HalfV	P-value
		Lactate (mmol·L^{-1})	
Rest	1.1±0.3	1.0±0.3	NS
3×8 with 0.98 m·s^{-1} load (~60% 1RM)	4.7±2.0	3.2±1.7	<0.001
3×6 with 0.82 m·s^{-1} load (~70% 1RM)	3.9±1.2	3.1±1.4	<0.05
3×3 with 0.68 m·s^{-1} load (~80% 1RM)	2.0±0.7 #§	1.8±0.7#§	<0.05
		Ammonia (µmol·L^{-1})	
Rest	31.0±9.3	26.7±9.4	NS
3×8 with 0.98 m·s^{-1} load (~60% 1RM)	40.8±5.3	18.0±4.2	<0.001
3×6 with 0.82 m·s^{-1} load (~70% 1RM)	39.4±11.2	28.4±7.1 #	<0.05
3×3 with 0.68 m·s^{-1} load (~80% 1RM)	22.1±5.0 #§	18.0±4.3 §	NS
		Uric Acid (µmol·L^{-1})	
Rest	299.5±76.0	315.0±58.8	NS
3×8 with 0.98 m·s^{-1} load (~60% 1RM)	314.3±66.8	334.1±65.5	NS
3×6 with 0.82 m·s^{-1} load (~70% 1RM)	323.0±64.3	302.0±79.7	NS
3×3 with 0.68 m·s^{-1} load (~80% 1RM)	325.6±70.3	289.3±63.0	NS
		Pre-post change (%) in velocity against the V_1 load	
3×8 with 0.98 m·s^{-1} load (~60% 1RM)	0.5±5.6	3.4±4.3	NS
3×6 with 0.82 m·s^{-1} load (~70% 1RM)	3.7±3.9	3.4±5.5	NS
3×3 with 0.68 m·s^{-1} load (~80% 1RM)	5.0±3.8	0.8±3.7	NS
		Pre-post change (%) in CMJ height	
3×8 with 0.98 m·s^{-1} load (~60% 1RM)	13.1±5.1	9.7±3.3	<0.05
3×6 with 0.82 m·s^{-1} load (~70% 1RM)	14.2±4.1	11.7±5.4	<0.05
3×3 with 0.68 m·s^{-1} load (~80% 1RM)	10.4±3.6	8.3±5.2	NS

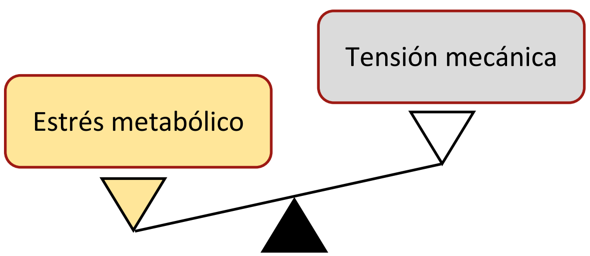
HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Descanso

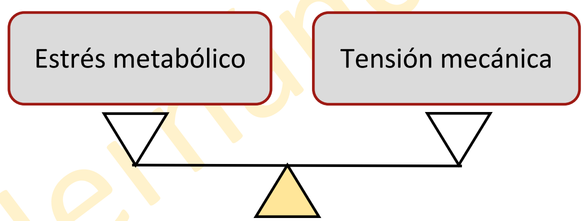
Intervalo de tiempo entre series de entrenamiento del mismo grupo muscular



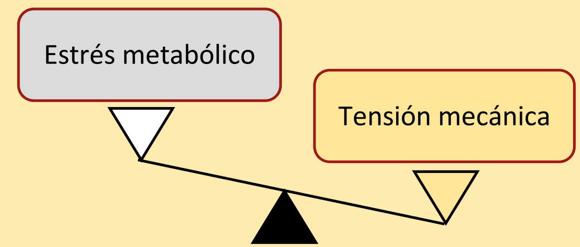
Cortos < 30 s



Moderados 60 s – 120 s



Largos > 2 min

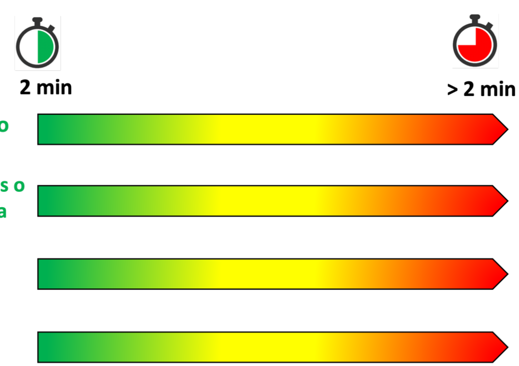


The effects of short versus long inter-set rest intervals in resistance training on measures of muscle hypertrophy: A systematic review

Jozo Grgic [1], Bruno Lazinica [2], Pavle Mikulic [3], James W Krieger [4], Brad Jon Schoenfeld [5]

2017

used human participants without known chronic disease or injury. Current evidence indicates that both short and long inter-set rest intervals may be useful when training for achieving gains in muscle hypertrophy. Novel findings involving trained participants using measures sensitive to detect changes in muscle hypertrophy suggest a possible advantage for the use of long rest intervals to elicit hypertrophic effects. However, due to the paucity of studies with similar designs, further research is needed to provide a clear differentiation between these two approaches.



Grado de esfuerzo medio	Grado de esfuerzo alto
Ejercicios mono-articulares o baja complejidad técnica	Ejercicios multi-articulares o alta complejidad técnica
Recuperación activa	Recuperación pasiva
Deportista con menor masa muscular	Deportista con mayor masa muscular

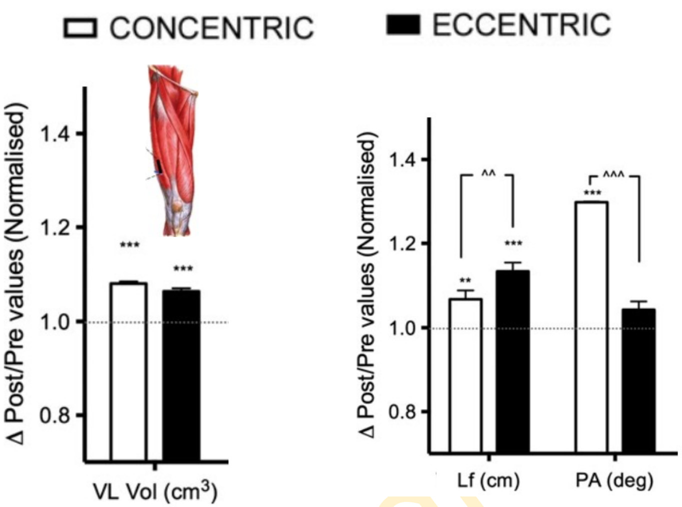
HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

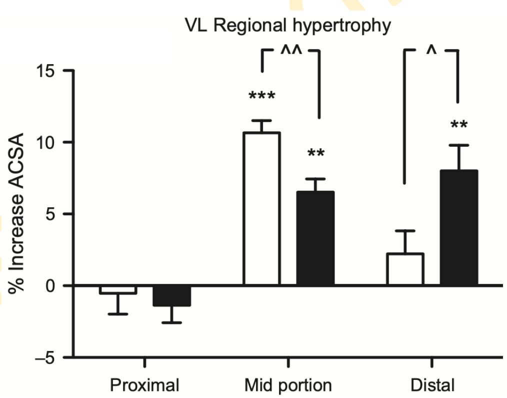
Acción muscular

Movimiento de las microestructuras a lo largo de la repetición

Architectural, functional and molecular responses to concentric and eccentric loading in human skeletal muscle 2014

M. V. Franchi,[1,2] P. J. Atherton,[1] N. D. Reeves,[2] M. Flück,[3] J. Williams,[1] W. K. Mitchell,[1] A. Selby,[1] R. M. Beltran Valls[1] and M. V. Narici[1]





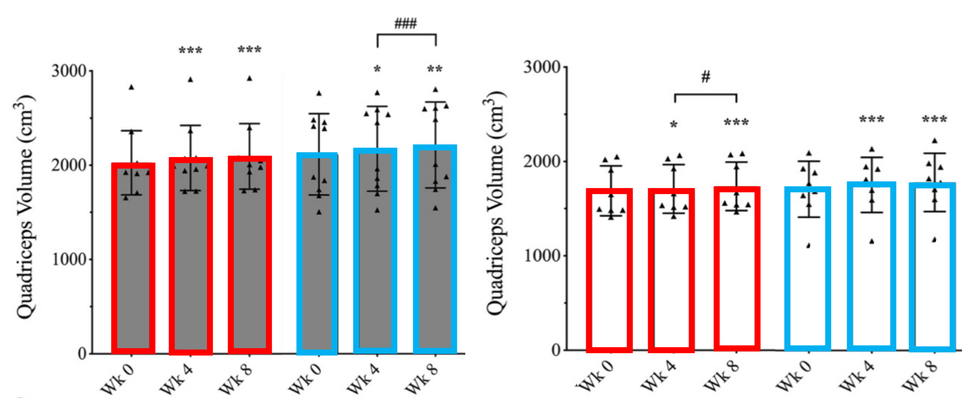
Skeletal Muscle Remodeling in Response to Eccentric vs. Concentric Loading: Morphological, Molecular, and Metabolic Adaptations 2017

Martino V Franchi [1 2], Neil D Reeves [3], Marco V Narici [1]

We conclude that, when matched for either maximum load or work, similar increase in muscle size is found between ECC and CON RT. However, such hypertrophic changes appear to be achieved through distinct structural adaptations, which may be regulated by different myogenic and molecular responses observed between lengthening and shortening contractions.

Muscle and tendon adaptations to moderate load eccentric vs. concentric resistance exercise in young and older males 2021

Jonathan Iain Quinlan · Martino Vladimiro Franchi · Nima Gharahdaghi · Francesca Badiali · Susan Francis · Andrew Hale · Bethan Eileen Phillips · Nathaniel Szewczyk · Paul Leonard Greenhaff · Kenneth Smith · Constantinos Maganaris · Phillip James Atherton · Marco Vincenzo Narici

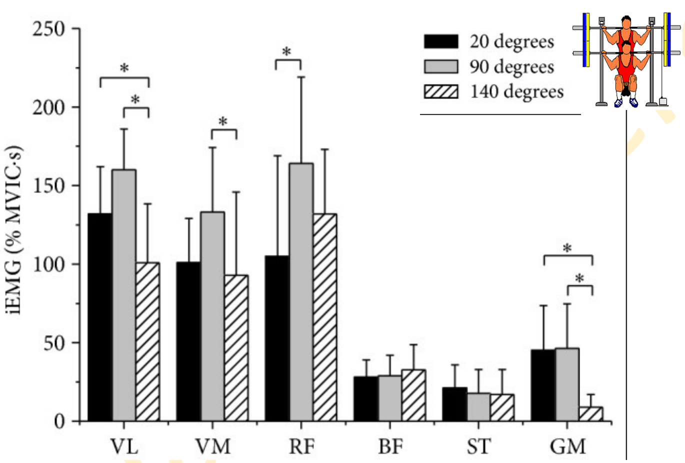


HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

ROM Grado de movimiento que se produce en una articulación específica durante la ejecución de un ejercicio

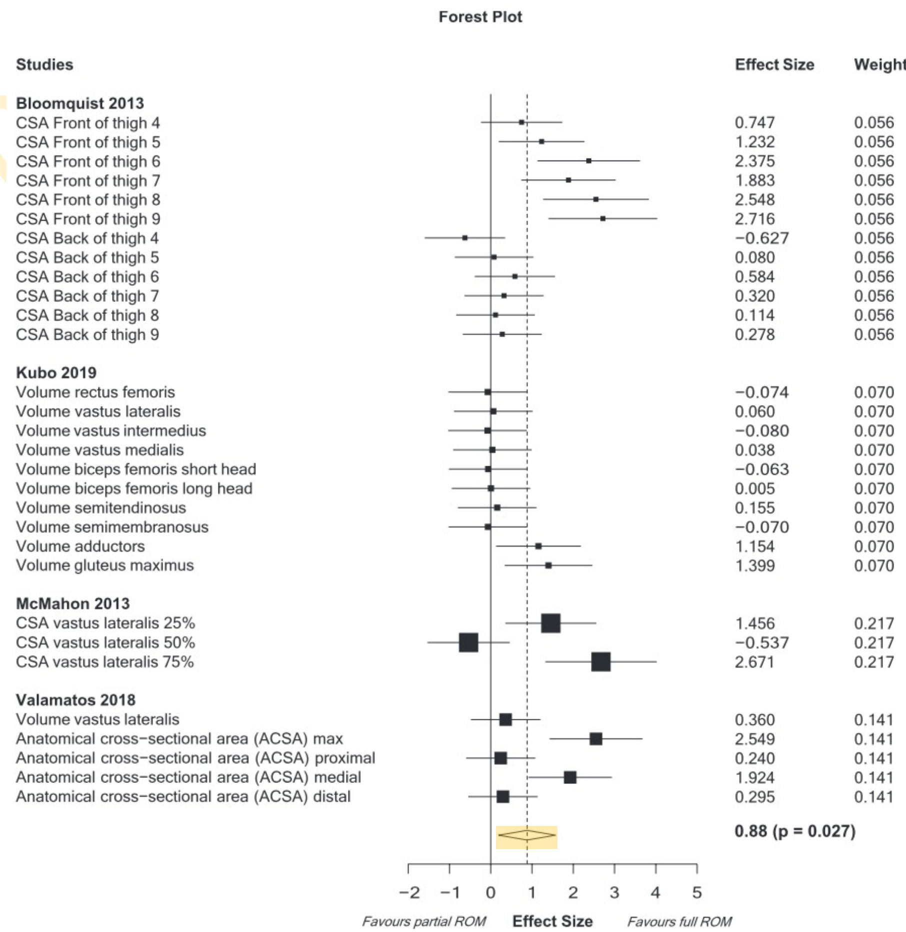
Muscle Activation Differs between Three Different Knee Joint-Angle Positions during a Maximal Isometric Back Squat Exercise

Paulo Henrique Marchetti [1], Josinaldo Jarbas da Silva [2], Brad Jon Schoenfeld [3], Priscyla Silva Monteiro Nardi [4], Silvio Luis Pecoraro [2], Julia Maria D'Andréa Greve [4], Erin Hartigan [5]



Effects of range of motion on resistance training adaptations: A systematic review and meta-analysis 2021

Jesús G. Pallarés[1] | Alejandro Hernández-Belmonte[1] | Alejandro Martínez-Cava[1] | Tomas Vetrovsky[2] | Michal Steffl[2] | Javier Courel-Ibáñez[1]



HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

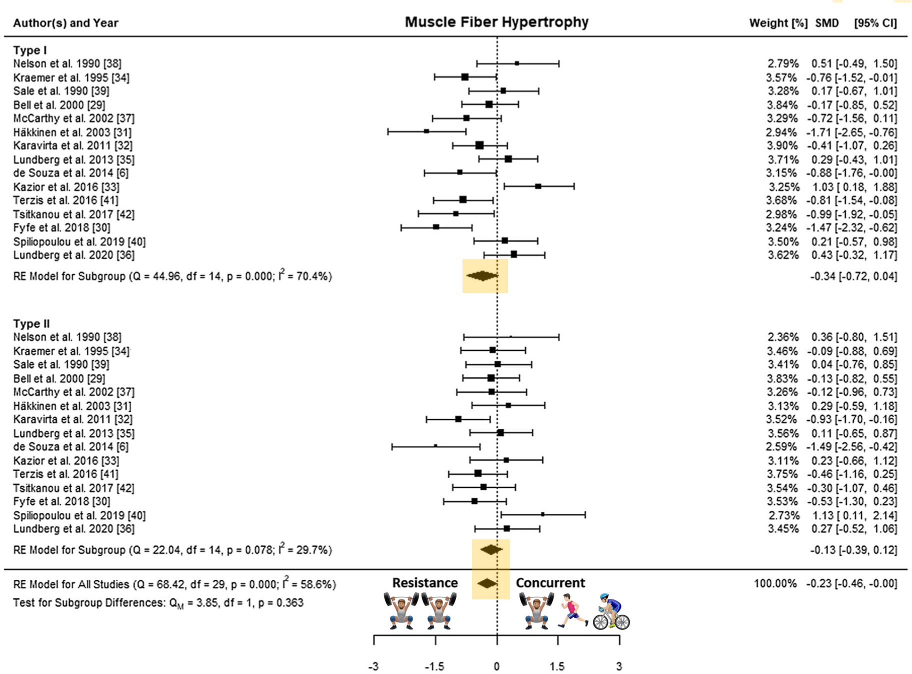
Entto concurrente

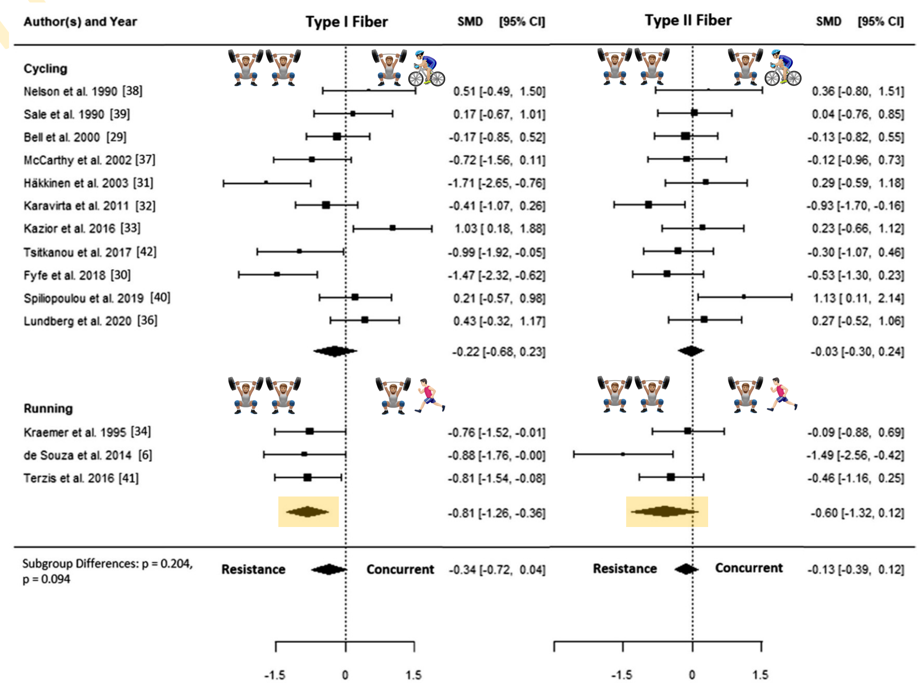
Combinación de entrenamiento orientado a la hipertrofia con entrenamiento aeróbico

The Effects of Concurrent Aerobic and Strength Training on Muscle Fiber Hypertrophy: A Systematic Review and Meta-Analysis

2022

Tommy R. Lundberg[1,2] · Joshua F. Feuerbacher[3] · Marvin Sünkeler[3] · Moritz Schumann[3]





HIPERTROFIA MUSCULAR: CÓMO MAXIMIZARLA

Grado de esfuerzo	Finalizar la serie **cerca del fallo** muscular, incluso alcanzarlo en ciertas ocasiones.
Volumen	Variable **dosis-respuesta**, hasta umbral máximo. Comenzar con ~10 series semanales.
Frecuencia	**No** es una **variable clave**. Aumentar frecuencia a medida que se incrementa el volumen.
Intensidad	Hipetrofia con **todo el espectro de intensidades**. Intensidades moderadas: 8 – 12RM.
Ejercicios	**Variar** el espectro de ejercicios para estimular las diferentes regiones musculares.
Cadencia	Fase concéntrica a la **máxima velocidad** podría proporcionar beneficios adicionales.
Descanso	Descansos **moderados** (2 min) o **largos** (> 2 min) en función del estímulo precedente.
Acción muscular	Acciones concéntricas y excéntricas **hipertrofia similar**, pero diferente mecanismo.
ROM	Utilizar **rango de movimiento completo** durante las fases excéntrica y concéntrica.
Concurrente	Efecto de **interferencia**, especialmente cuando el trabajo aeróbico se hace en carrera.