Allenamento della forza e funzione neuromuscolare

Nicola A. Maffiuletti
Human Performance Lab, Schulthess Clinic, Zurigo (Svizzera)

L'allenamento neuromuscolare della forza – Ancona, 21 settembre 2019

Preambolo

Prospettiva personale:
- ricercatore funzione neuromuscolare
- forte interesse allenamento forza

Evidenze, osservazioni, considerazioni:
- nessuna pretesa/provocazione
- spunti di riflessione
- almeno una cosa utile

Allenamento neuromuscolare forza

① Considerazioni iniziali

② Prospettiva neuro-cognitiva

③ Considerazioni pratiche

Allenamento forza • definizione

Esercizio ripetuto e strutturato con **resistenza**
- peso corpo, carichi liberi, macchinari, elastici, ipergravità …

FORZA	Massimale	Esplosiva
	▼	▼
Determinanti	⅔ PCSA ⅓ fattori neurali	⅔ fattori neurali ⅓ miotipologia

Allenamento forza • linee guida

FORZA	Massimale	Esplosiva
Carico	60-70% 1 RM (n) 80-100% 1 RM (a)	30-60% 1 RM (u) 0-60% 1 RM (l)
Volume	1-3 sets 8-12 reps 2-6 sets 1-8 reps	1-3 sets 3-6 reps
Recupero	1-2 min 2-3 min	1-2 min 2-3 min

AMERICAN COLLEGE of SPORTS MEDICINE. LEADING THE WAY

Allenamento forza • validità

Principi fondamentali

- progressività
- variabilità
- dosabilità
- meccanismo azione

Effetti desiderati

- performance → effetti **prestativi**
- (pre-)infortunio → effetti **preventivi**
- post-infortunio → effetti **riabilitativi**

Allenamento forza • caratteristiche

FORZA	Massimale	Esplosiva
AZIONE	• Isometrica • Concentrica • Eccentrica • Eccentrica+Concentrica	
RESISTENZA	• Costante • Adattata • Variabile	

Allenamento forza • problemi

Nonostante questa relativa chiarezza…

ambito contraddittorio, instabile con ∞ teorie, possibilità e mode dettate da:

- ⇢ campo ≠ laboratorio
- ⇢ pseudo-ricercatori (poco buon senso)
- ⇢ venditori (troppa tecnologia)
- ⇢ sportivi vincenti (importanza forza?)

Allenamento forza • campo

Ultimi 2-3 decenni :

- susseguirsi frenetico (e controproducente) di mentalità, mode, metodiche, macchinari
- quando si comprendo effetti e meccanismi (+10 anni), la moda è già passata

Elettrostimolazione

Un cattivo esempio su tutti:

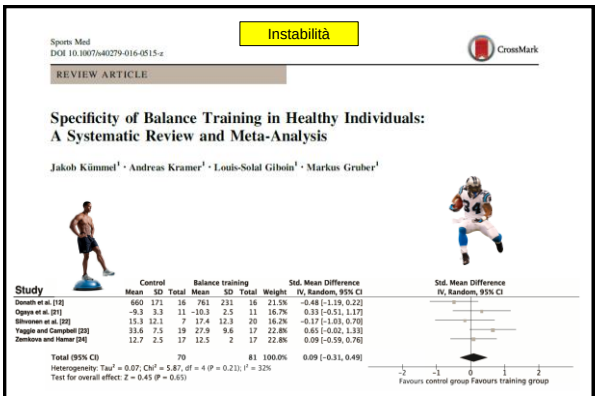
anni 90 ⇢ diffusione ambito sportivo

anni 2000 ⇢ consapevolezza e declino

anni 2010 ⇢ ritentata diffusione ambito sportivo

- recupero
- senza fili/dinamico
- corpo intero

Instabilità



Sports Med
DOI 10.1007/s40279-016-0515-z

REVIEW ARTICLE

Specificity of Balance Training in Healthy Individuals: A Systematic Review and Meta-Analysis

Jakob Kümmel[1] · Andreas Kramer[1] · Louis-Solal Giboin[1] · Markus Gruber[1]

Study	Control Mean	Control SD	Control Total	Balance training Mean	Balance training SD	Balance training Total	Weight	Std. Mean Difference IV, Random, 95% CI
Donath et al. [12]	660	171	16	761	231	16	21.5%	−0.48 [−1.19, 0.22]
Ogaya et al. [21]	−9.3	3.3	11	−10.3	2.5	11	16.7%	0.33 [−0.51, 1.17]
Sihvonen et al. [22]	15.3	12.1	7	17.4	12.3	20	16.2%	−0.17 [−1.03, 0.70]
Yaggie and Campbell [23]	33.6	7.5	19	27.9	9.6	17	22.8%	0.65 [−0.02, 1.33]
Zemkova and Hamar [24]	12.7	2.5	17	12.5	2	17	22.8%	0.09 [−0.59, 0.76]
Total (95% CI)			70			81	100.0%	0.09 [−0.31, 0.49]

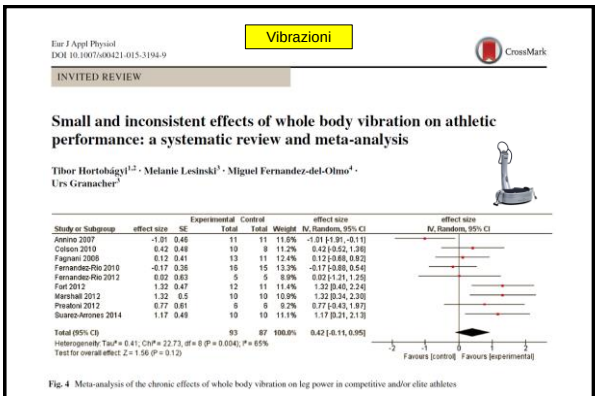
Heterogeneity: Tau² = 0.07; Chi² = 5.87, df = 4 (P = 0.21); I² = 32%
Test for overall effect: Z = 0.45 (P = 0.65)

Std. Mean Difference IV, Random, 95% CI

−2 −1 0 1 2
Favours control group Favours training group

Kümmel et al. *SM* 2016

Vibrazioni



Eur J Appl Physiol
DOI 10.1007/s00421-015-3194-9

INVITED REVIEW

Small and inconsistent effects of whole body vibration on athletic performance: a systematic review and meta-analysis

Tibor Hortobágyi[1,2] · Melanie Lesinski[3] · Miguel Fernandez-del-Olmo[4] · Urs Granacher[3]

Study or Subgroup	effect size	SE	Experimental Total	Control Total	Weight	effect size IV, Random, 95% CI
Annino 2007	-1.01	0.46	11	11	11.6%	-1.01 [-1.91, -0.11]
Colson 2010	0.42	0.49	10	9	11.2%	0.42 [-0.52, 1.36]
Fagnani 2008	0.12	0.41	13	11	12.4%	0.12 [-0.68, 0.92]
Fernandez-Rio 2010	-0.17	0.36	15	15	13.3%	-0.17 [-0.88, 0.54]
Fernandez-Rio 2012	0.02	0.63	5	5	8.9%	0.02 [-1.21, 1.25]
Fort 2012	1.32	0.47	12	11	11.4%	1.32 [0.40, 2.24]
Marshall 2012	1.32	0.5	10	10	10.9%	1.32 [0.34, 2.30]
Preatoni 2012	0.77	0.61	6	6	8.2%	0.77 [-0.43, 1.97]
Suarez-Arrones 2014	1.17	0.49	10	10	11.1%	1.17 [0.21, 2.13]
Total (95% CI)			93	87	100.0%	0.42 [-0.11, 0.95]

Heterogeneity: Tau² = 0.41; Chi² = 22.73, df = 8 (P = 0.004); I² = 65%
Test for overall effect: Z = 1.56 (P = 0.12)

effect size IV, Random, 95% CI

-2 -1 0 1 2
Favours [control] Favours [experimental]

Fig. 4 Meta-analysis of the chronic effects of whole body vibration on leg power in competitive and/or elite athletes

Hortobagyi et al. *EJAP* 2015

Isoinerziale

Review

Skeletal muscle functional and structural adaptations after eccentric overload flywheel resistance training: a systematic review and meta-analysis

Sergio Maroto-Izquierdo[a,*], David García-López[b], Rodrigo Fernandez-Gonzalo[c], Osvaldo C. Moreira[a], Javier González-Gallego[a], José A. de Paz[a]

Journal of Science and Medicine in Sport
Volume 21, Issue 1, January 2018, Pages 75-83

Review

Is inertial flywheel resistance training superior to gravity-dependent resistance training in improving muscle strength? A systematic review with meta-analyses

J. Vicens-Bordas [a, b, *], E. Esteve [a, b], A. Fort-Vanmeerhaeghe [c, b], T. Bandholm [d], K. Thorborg [d, e]

Conclusion

Based on the available data, inertial flywheel resistance training was not superior to gravity-dependent resistance training in enhancing muscle strength. Data for other strength variables and other muscular adaptations was insufficient to draw firm conclusions.

Why screening tests to predict injury do not work—and probably never will…: a critical review

Roald Bahr[1,2]

What are the findings?

- To date, there is no screening test available to predict sports injuries with adequate test properties and no intervention study providing evidence in support for screening for injury risk.

BJSM 2016

Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis

Robert W Moran,[1,2] Anthony G Schneiders,[3] Jesse Mason,[4] S John Sullivan[1]

What are the new findings?

- The strength of association between FMS composite scores and subsequent injury was not sufficient to recommend use as an injury prediction tool in the sports reviewed.

FMS

BJSM 2017

Allenamento forza • laboratorio

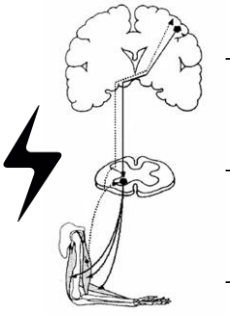
Ultimi 2-3 decenni :

↓ pertinenza/utilità

↑ ricerca applicata

↓ qualità scientifica

Sistema neuromuscolare



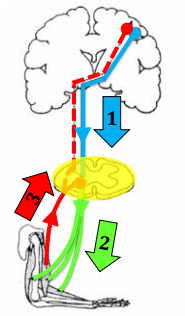
→ Sovraspinale

→ Spinale

Neurale

→ **Muscolare**

Midollo spinale = importante crocevia

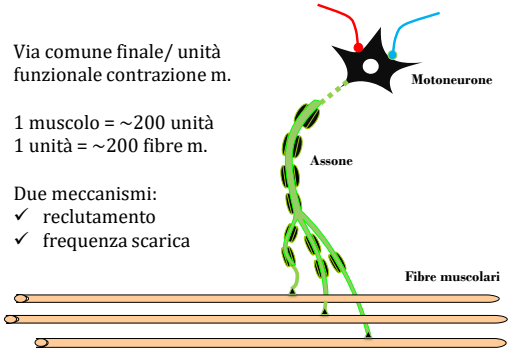


Impulsi elettrici/inputs:

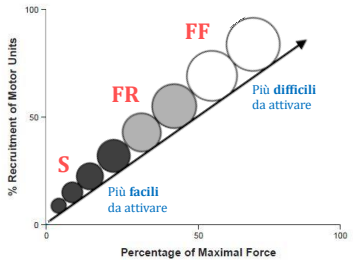
- da centri **sovraspinali** (1)
- verso muscolo (2)
- da afferenze **sensoriali** (3)

Unità motoria

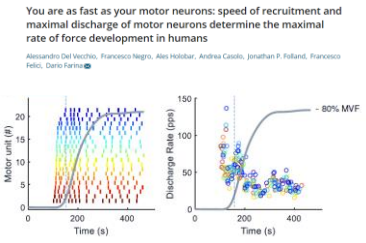
- Via comune finale/ unità funzionale contrazione m.
- 1 muscolo = ~200 unità
- 1 unità = ~200 fibre m.
- Due meccanismi:
  - ✓ reclutamento
  - ✓ frequenza scarica



Reclutamento ordinato (dimensione)



↑ frequenza scarica = ↑ forza esplosiva



You are as fast as your motor neurons: speed of recruitment and maximal discharge of motor neurons determine the maximal rate of force development in humans

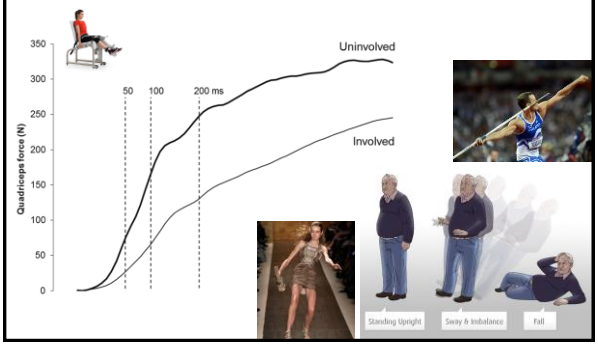
Alessandro Del Vecchio, Francesco Negro, Ales Holobar, Andrea Casolo, Jonathan P. Folland, Francesco Felici, Dario Farina

From 'De Motu Animalium' (1680) to 'De Velocitate Neuron-Motorium' (2019): towards a better understanding of how the nervous system drives muscles

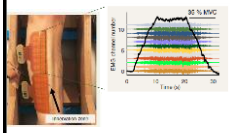
Nicola A. Maffiuletti

The Journal of Physiology 2019 A Publication of The Physiological Society JP

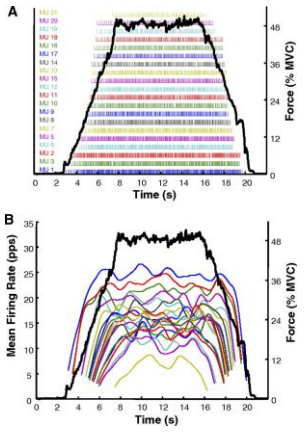
"Rate of Force Development" • rilevanza



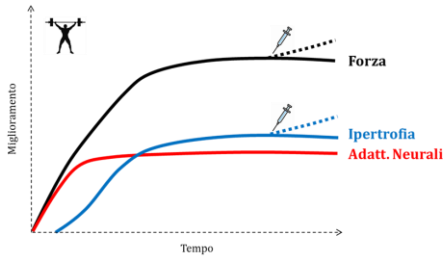
Reclutamento



Frequenza scarica



Adattamenti neurali • 1988



Sale *MSSE* 1988

Adattamenti neurali • interesse crescente

Training-Induced Changes in Neural Function

Per Aagaard

Resistance Training: Cortical, Spinal, and Motor Unit Adaptations

Lisa Griffin[1] and Enzo Cafarelli[2]

Neural Adaptations to Resistance Training

Implications for Movement Control

Timothy J. Carroll, Stephan Riek and Richard G. Carson

The sites of neural adaptation induced by resistance training in humans

Timothy J. Carroll, Stephan Riek and Richard G. Carson

Neural Adaptations to Resistive Exercise

Mechanisms and Recommendations for Training Practices

David A. Gabriel,[1] Gary Kamen[2] and Gail Frost[1]

Review

The role of neuromuscular inhibition in hamstring strain injury recurrence

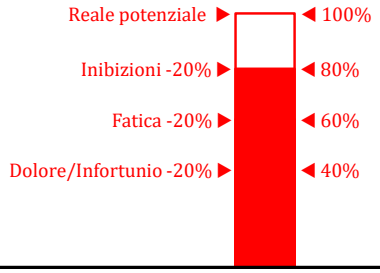
Jackson J. Fyfe [a,d], David A. Opar [a,b], Morgan D. Williams [c], Anthony J. Shield [a,*]

Adattamenti neurali • interessi pratici

- ✓ Adattamenti ultra-precoci
- ✓ Margini di miglioramento ∞
- ✓ Meccanismo azione identificato (soprattutto in caso infortunio)
- ✓ Concetti fisiologici validi ed invariati
- ✓ Modalità accessibili e poco dipendenti tecnologia
- ✓ Determinanti forza esplosiva

Fattori neurali e cognitivi

Azioni umane (soprattutto max) ⇢ governate da molteplici processi mentali ⇢ dominate da inibizioni



Sports Med (2015) 45:1589–1602
DOI 10.1007/s40279-015-0356-1

SYSTEMATIC REVIEW

A Systematic Review of the Effect of Cognitive Strategies on Strength Performance

David Tod[1] · Christian Edwards[2] · Mike McGuigan[3] · Geoff Lovell[4]

Key Points

Cognitive strategies of various types influence muscular strength performance.

Participant skill level does not appear to moderate the cognitive strategy and strength performance relationship.

No explanation for why cognitive strategies enhance muscular strength has substantial support, but initial evidence supports continued examination of cognitive variables.

Sports Med (2015) 45:997–1015
DOI 10.1007/s40279-015-0319-6

SYSTEMATIC REVIEW

Psychological Determinants of Whole-Body Endurance Performance

Alister McCormick · Carla Meijen · Samuele Marcora

↑ attivazione per ↑ forza esplosiva

Goal: migliorare abilità di attivare i muscoli rapidamente, in particolare nella primissima fase della contrazione

Contrazioni **esplosive**
Accelerazione intenzionale massimale del carico durante fase concentrica

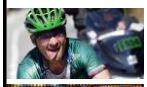
Contrazioni **balistiche**
Tempo di contrazione brevissimo con alto rate of force development seguito da rilassamento muscolare (importanza dell'intenzione !)

Caserotti et al. *SJMSS* 2008 - Hermann et al. *O&C* 2016

Altre strategie "neurali"

- ✓ Effetto "startle"
- ✓ Stimolazione transcranica
- ✓ Muscolo controlaterale
- ✓ Bio-feedback
- ✓ Carichi sconosciuti
- ✓ Training visuo-motorio
- ✓ Consolidazione
- ✓ Immaginazione motoria

Strategie "cognitive"



- ✓ Goal setting
- ✓ Self talk
- ✓ Arousal/Psych up
- ✓ Emozione
- ✓ Motivazione
- ✓ Ricompensa
- ✓ Priming
- ✓ …

Allenamento neuro-cognitivo-muscolare

6 serie - X reps
XX% 1RM
rec. X min

Comando motorio
- ❑ ❑ ❑ ❑ ❑ ❑ Grido
- ❑ ❑ ❑ ❑ ❑ ❑ Imprecazione
- ❑ ❑ ❑ ❑ ❑ ❑ Emozione
- ❑ ❑ ❑ ❑ ❑ ❑ Ricompensa
- ❑ ❑ ❑ ❑ ❑ ❑ Self-talk
- ❑ ❑ ❑ ❑ ❑ ❑ Sorpresa
- ❑ ❑ ❑ ❑ ❑ ❑ Rumore
- ❑ ❑ ❑ ❑ ❑ ❑ Stimolazione transcranica

Frequenza scarica
- ❑ ❑ ❑ ❑ ❑ ❑ Balistico
- ❑ ❑ ❑ ❑ ❑ ❑ Intenzione
- ❑ ❑ ❑ ❑ ❑ ❑ Esplosivo

Feedback sensoriale
- ❑ ❑ ❑ ❑ ❑ ❑ Angolo
- ❑ ❑ ❑ ❑ ❑ ❑ Velocità
- ❑ ❑ ❑ ❑ ❑ ❑ Tensione
- ❑ ❑ ❑ ❑ ❑ ❑ Equilibrio
- ❑ ❑ ❑ ❑ ❑ ❑ Controlaterale
- ❑ ❑ ❑ ❑ ❑ ❑ Feedback tecnico

GRAZIE

Nicola A. Maffiuletti
Human Performance Lab
Schulthess Clinic, Zurich
mna@kws.ch

schulthess klinik

Human Performance Lab