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Effects of High Intensity Exercise on Central Neural Drive in Healthy Populations

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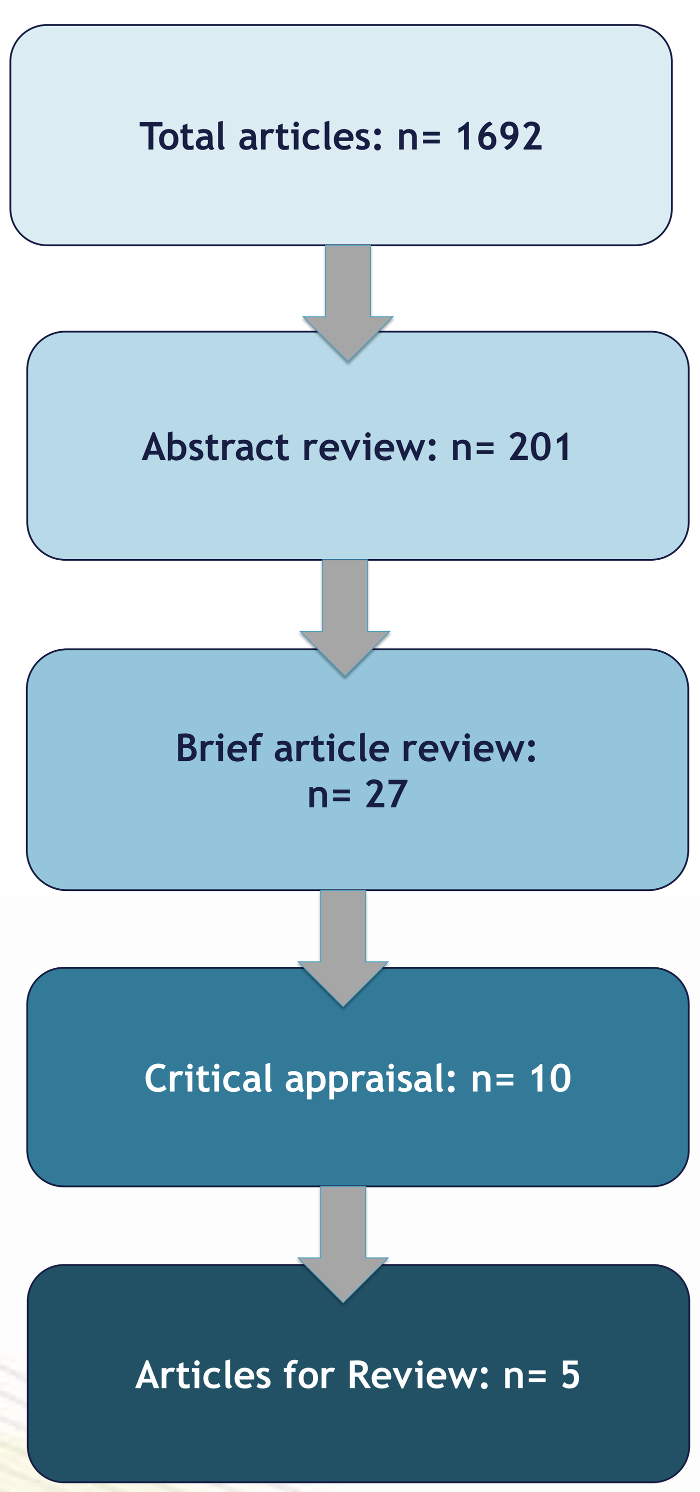
Background

Current research suggests that strength gains related to central neural adaptation occur more rapidly than peripheral mechanisms[5]. Central neural drive (CND) is the measure of cortical output that coordinates up-regulation of agonist contraction and inhibition of antagonist musculature in voluntary muscle contractions[2]. Two common techniques for measuring CND are twitch interpolation and motor evoked potential from transcranial magnetic stimulation.

Methods

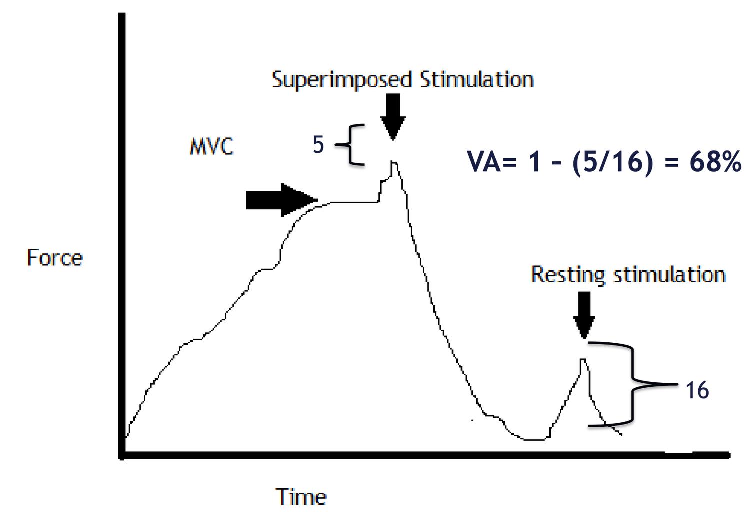
Literature search performed June 2015

Databases searched: PubMed, OVID, CINAHL, Cocharan, Scopus
Keywords: "motor drive and exercise", "motor evoked potential and exercise", "voluntary activation and exercise", "motor drive and high intensity", "voluntary activation and high intensity", "motor evoked potential and high intensity"
Inclusion Criteria: high intensity strength training, protocols including multiple sessions over time

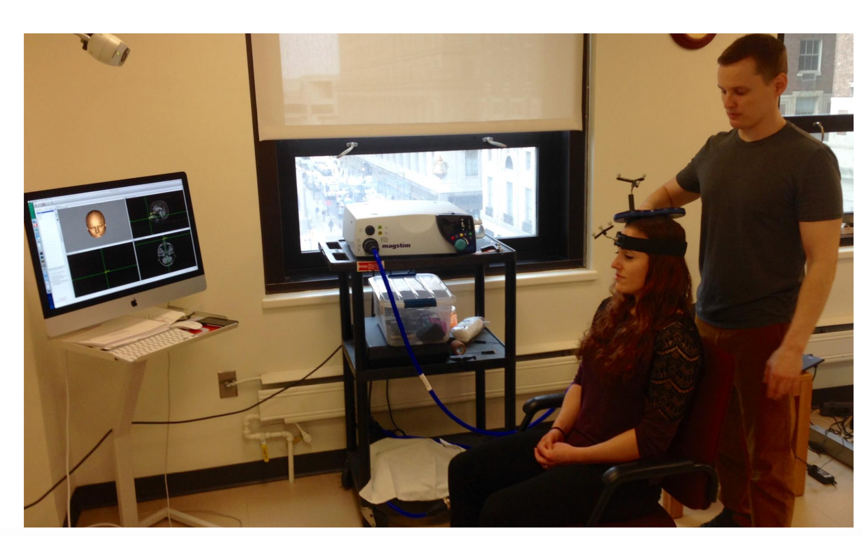


Results

Citation	MacDermid score[8]/ Sackett rating	Participants	Training Protocol	Instrumentation	Key findings
Carroll, 2009	28/48 1B	17 participants aged 19-35 without a significant history of neurologic disease.	Control group- non resistance movements only Training group- 4 weeks of traditional radial deviation and wrist extensor high -intensity strength training.	Electromyography and Transcranial Magnetic Stimulation	Training group showed a significant increase in TMS-induced twitches in both wrist extension and radial deviation at the end of 4 weeks
Ekblom, 2010	28/48 1B	20 healthy participants (12M 8W) with no history of resistance training or exercise >3days/week	Control group- no change in daily activity Training group- 3 times a week high intensity eccentric plantar flexor training for 5 weeks	Twitch interpolation	Training group demonstrated improved central neural drive and increased plantar flexor strength at the end of 5 weeks
Goodwill, 2012	34/48 1B	14 university participants (7 men, 7 women) age range 18-35	Control group-no training Training group- unilateral strength training sessions over 3 weeks for the right quadriceps	Transcranial Magnetic Stimulation	Training group showed significant increases in strength, decreases in SICI, and increases in cortico-motor excitability in both the trained and untrained limb at the end of 3 weeks
Kidgell, 2010	32/48 1B	23 healthy participants (10 men, 13 women, 26.8 +/- 7.3)	Control group-no training Training group-4 week progressive overload strength training of the right biceps brachii	Electromyography and Transcranial Magnetic Stimulation	Training group showed significant increase in 1RM strength in absence of muscle hypertrophy. Increase in MEP amplitude at and above AMT at the end of 4 weeks
Pucci, 2006	29/48 1B	20 male participants (25+/- 5.5) from the university population	Control group-no training Training group-3 week quadriceps isometric training program	Twitch interpolation	Training group demonstrated significant increase in knee extensor MVC and an increase in percentage maximal activation after 4-5 training days. Insignificant increase in twitch amplitude by day 9



Twitch interpolation:
A supramaximal electrical stimulus is applied during a voluntary contraction. Those motor units that have not already been recruited generate a twitch response demonstrating untapped potential for motor unit recruitment[9].



Transcranial magnetic stimulation:
Magnetic stimulation is applied over the primary motor cortex eliciting a peripheral motor response termed motor evoked potential (MEP). This response is a measure of cortical excitability[9].

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Summary of Key Findings

These studies demonstrated strength increases in healthy individuals as early as 10 days and within 5 weeks of high intensity strength training without muscle hypertrophy. TMS and twitch interpolation techniques provide evidence that these strength gains can be attributed to central mechanisms.

Clinical Applications

For patients with an inability to train both sides of the body, there is potential for an overflow effect into the immobilized side when the non-affected side is trained.

High intensity training may be used to capitalize on rapid cortical adaptations in patients that need strength gains in a limited time frame (e.g. preoperatively).

Additional research is needed to further explore the effects of high intensity exercise on CND, including investigation of effects in neuro-compromised individuals.

Conclusions

Current understanding of neural adaptation suggests a central component to muscle activation separate from peripheral mechanisms. Moderate evidence suggests that high intensity exercise results in rapid increases in strength through central mechanisms in the absence of muscle hypertrophy.

Abbreviations:
HIST - High Intensity Strength Training
MVC - Max Volitional Contraction
CND - Central Neural Drive
TMS - Transcranial Magnetic Stimulation
MEP - Motor Evoked Potential
SICI - Short-latency Intra-Cortical Inhibition
AMT - Active Muscle Threshold