Welcome to the February 2018 edition! As always, the edition is divided into three parts. It starts with reviews of studies of general strength training, moves onto reviews of investigations into sprinting and athletic performance, and finishes with a section on hypertrophy.

This month includes amazing studies in every section, some of which you will have probably already seen being discussed on social media. However, others will almost certainly have flown under the radar, as their importance is not immediately obvious until we unpack the findings in the context of the existing literature.

The key study in this edition compared the effects of motor skill training (visuomotor tracking), metronome-paced strength training (MPT), and self-paced strength training (SPT) on changes in strength and corticospinal excitability. This allowed the researchers to assess the similarities and differences between strength training and skill training. After all, strength coaches often say that “strength is a skill” so it was high time that this claim was put to the test! Yet, the researchers found that strength training only involves similar adaptations to skill training when it involves a slow, controlled tempo, and that this slow speed leads to inferior strength gains compared to a self-paced tempo. Thus, the neural adaptations leading to optimal strength gains seem to be different to skill training, and may in fact be a separate category of adaptations all of their own...

Hypertrophy enthusiasts will be greatly rewarded for their long-suffering patience in this edition, as researchers have finally managed to link the accumulated amount of mechanical loading over a training program to muscle growth, albeit only in a rodent model. I hope you enjoy reading this edition. See you next month!
Strength training

1. Is strength training really the same as motor skill training?
2. Comparing the Nordic hamstring curl and the stiff-leg deadlift
3. Measuring the load-velocity profile of the overhead press
4. How do tendons change in size and stiffness after strength training?

Sprinting

5. How does leg stiffness affect athletic performance in soccer players?
6. How can professional soccer athletes improve sprinting performance?

Hypertrophy

7. Does concurrent training reduce anabolic signaling in trained individuals?
8. Does muscle fiber type differ between compartments of the same muscle?
9. Does a higher level of mechanical loading lead to greater hypertrophy?
10. Do different exercises cause damage to different regions of a muscle?
This sample only includes one study review. To read the full edition with 10 study reviews, click HERE and create a subscription.
Is strength training really the same as motor skill training?

It is very common to hear strength coaches and some researchers say that “strength is a skill” and some research does indicate that strength training and motor skill training do display similar features, at least in terms of the neural adaptations that occur. The literature indicates that skill training (such as hand-eye coordination) and metronome-paced strength training both display increases in corticospinal excitability. Yet, self-paced strength training (which is the most common way of performing strength training) does not.

Key findings
Metronome-paced (tempo) strength training and visuomotor skill training each caused increases in corticospinal excitability, decreases in corticospinal inhibition, and reductions in visuomotor skill tracking error. Self-paced strength training did not cause any of these neural adaptations, but did cause a greater increase in strength.

Practical implications
Self-paced strength training leads to greater strength gains compared to tempo training, and the neural adaptations that occur after training with a fixed tempo may only enhance the ability to lift and lower a weight slowly, under control. Using a set tempo during strength training is likely to be detrimental to athletes.

Training adaptations in the central nervous system can occur in the motor cortex and in the spinal cord, but differ according to the type of training.

**Central adaptations**

- **Motor cortex**
  - **Skill training**
  - **Strength training**
  - **Endurance training**

- **Spinal cord**
  - **Skill training**
  - **Strength training**
  - **Endurance training**

**Learning motor skills may involve changes in connectivity between groups of neurons with similar inputs and outputs. This involves an ↑ in the number of synapses, an ↑ in synaptic strength, and an ↑ in the size of the movement representations in those parts of the motor cortex that relate to the muscles used in that movement.**

**Strength training may cause adaptations in the motor cortex. However, it is unclear if these adaptations are solely related to the movement pattern, or whether they are also related to the level of force produced.**

**Endurance training leads to cerebral angiogenesis, which ↑ the blood flow to the brain, specifically the motor cortex. This is believed to occur in order to meet the ↑ metabolic demands of the working cortical neurons. Endurance exercise also ↑ levels of Brain Derived Neurotrophic Factor (BDNF), which promotes cortical plasticity, although it does not produce alterations in cortical connectivity.**

**Most research into the contribution of central adaptations to learning motor skills has focused on the motor cortex, and the role of the spinal cord is less clear. Yet, it is known that adaptations can occur in the spinal stretch reflex. Long-term training of this reflex can produce faster and better movement corrections in response to sudden, unexpected perturbations.**

**Strength training may cause adaptations in the spinal cord, including an ↑ in the number of synapses. This may cause an ↑ in spinal excitability that could contribute to the subsequent strength gains.**

**The effects of endurance training on adaptations in the spinal cord is unclear. Some research indicates that the size of spinal stretch reflexes ↑ from sedentary to active individuals. On the other hand, some athletes display ↓ stretch reflexes. This may reflect the confounding effects of combined skill, strength, and endurance training undertaken by these individuals.**

**SUMMARY**

- Most new movements or exercises involve elements of skill, strength, and endurance. This makes it very difficult to discern between the adaptations produced in response to skill, strength, or endurance training.

**Long-term skill training, strength training, and endurance training each produce adaptations in the central nervous system (motor cortex and spinal cord). Some of these adaptations are overlapping, but they are not identical.**

**OBJECTIVE**

To compare the effects on corticospinal excitability of skill training (ST) (visuomotor tracking), metronome-paced strength training (MPT), and self-paced strength training (SPT), in untrained subjects.

**INTERVENTION**

Subjects in the training groups did 3 training sessions per week for 4 weeks. Each MPT workout involved 4 sets of 6 – 8 reps of a standing one-arm biceps curl with 80% of 1RM, paced to a metronome (3-second concentric and 4-second eccentric), with 3 minutes rest between sets. Each SPT workout involved 4 sets of 6 – 8 reps of a standing one-arm biceps curl with 80% of 1RM at a self-selected tempo. Each ST workout involved 4 sets of 56 seconds of visuomotor tracking involving elbow flexion and extension movements, through a range of motion of 30 – 140°.

**POPULATION**

44 subjects, aged 26.1 \(\pm\) 6.8 years (24 males and 20 females), allocated into 4 groups, being a control group, and groups that did ST, MPT and SPT for 4 weeks.

**MEASUREMENTS**

<table>
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<tr>
<th>Objective</th>
<th>Description</th>
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<td><strong>Maximum strength:</strong></td>
<td>By 1RM standing dumbbell biceps curl.</td>
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<tr>
<td><strong>Skill:</strong></td>
<td>By tracking errors in 3 visuomotor tracking tasks of 10 seconds in length. Each task involved standing upright to perform elbow flexion and extension to track the motion of an object on a screen.</td>
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<td><strong>Corticospinal excitability:</strong></td>
<td>By using transcranial magnetic stimulation (TMS) to produce motor evoked potentials (MEPs) during a low-level isometric contraction of the biceps brachii at 90° elbow flexion, and subsequently calculating the total area under the recruitment curve (AURC).</td>
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<tr>
<td><strong>Corticospinal inhibition:</strong></td>
<td>By using paired pulse TMS during a low-level isometric contraction of the biceps brachii at 90° elbow flexion to record short-interval intra-cortical inhibition (SICI).</td>
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**RESULTS**

Although 1RM increased after both SPT (by 22%) and MPT (by 16%), the increase after SPT was greater. There were no changes in 1RM after ST or in the control group.

Visuomotor tracking error reduced after ST (by 58%) and also after MPT (by 24%) but not after either SPT (by 13%) or in the control group (by 14%).

Corticospinal excitability, as measured by AURC, increased similarly after ST and MPT (by 29% and 40%, respectively). There were no changes in AURC after SPT, or in the control group.

Corticospinal inhibition, as measured by SICI, decreased similarly after MPT and ST (by 61% and 33%, respectively). There were no changes in SICI after SPT, or in the control group.

**SUMMARY**

Metronome-paced (tempo) strength training and visuomotor skill training each caused increases in corticospinal excitability, decreases in corticospinal inhibition, and reductions in visuomotor skill tracking error. Yet, self-paced strength training did not affect corticospinal excitability, corticospinal inhibition, or visuomotor skill tracking error.
This study reported that metronome-paced (i.e. tempo) strength training and visuomotor skill training both increased corticospinal excitability, decreased corticospinal inhibition, and reduced visuomotor skill tracking error. Yet, self-paced strength training did not affect corticospinal excitability, corticospinal inhibition, or visuomotor skill tracking error. While this finding is important, it is not too surprising, as it is supported by previous literature. Earlier studies have shown that skill training involving visual or audible cues does increase corticospinal excitability (1,2,3), and that this effect is enhanced when the task is more complex (3). This may happen because highly-controlled movements activate specific areas of the sensorimotor cortex, premotor cortex and supplementary motor brain areas (4,5,6).

In contrast, self-paced movements do not appear to produce these same specific effects, and brain activation is more widespread (4,5,6). Similarly, the strength training literature shows that metronome-paced strength training routinely increases corticospinal excitability (7,8,9,10), while self-paced strength training does not (9,11). The effects of self-pacing or metronome-pacing on corticospinal inhibition are similar. Skill training does not reduce corticospinal inhibition when it is self-paced (12), but does with metronome-pacing (9). Strength training also only reduces corticospinal inhibition when it is metronome-paced (8,13). Thus, the results of this study clarify the findings of the previous literature and demonstrate that increases in corticospinal excitability and decreases in corticospinal inhibition after strength training likely only arise when the training involves a set tempo.
This study reported that self-paced strength training caused greater gains in maximum dynamic strength (1RM) than metronome-paced strength training. This happened even though metronome-paced strength training caused increased corticospinal excitability and decreased corticospinal inhibition, while self-paced strength training did not. This suggests that the strength gains that occurred in this study (which were likely to be largely neural, because of the short-duration and the lack of change in isometric strength) were not particularly affected by the changes in corticospinal excitability and inhibition. In contrast, there was a parallel change in visuomotor skill tracking error in the visuomotor skill training and metronome-paced strength training groups, which occurred alongside the changes in corticospinal excitability and inhibition.

This suggests that the changes in corticospinal excitability and inhibition recorded in this study actually relate to movement control during lifting and lowering, and not to maximum force production. However, whether this means that the adaptations that contribute to strength gains occur at the spinal level (14) is unclear.

This has important implications for training. It indicates that the neural adaptations after training with a slow tempo might be detrimental for increasing maximum strength, and may only improve control over a load at slow speeds. This may partly explain why the literature is consistent in showing that strength gains are greater after training with a maximal bar speed (15), compared to after training with a submaximal tempo, although clearly other factors such as the level of rate coding and motor unit recruitment are likely to be relevant.

Effects of no training, visuomotor skill training, metronome-paced strength training, and self-paced strength training on changes in maximum dynamic strength (1RM) and isometric strength (MVIC)

The lack of an ↑ in maximum isometric strength indicates that strength gains achieved in this short-duration training program were very specific. Thus, it is unlikely that any hypertrophy occurred.

Strength gains after self-paced strength training were ↑ than after metronome-paced strength training.
Conclusions
Metronome-paced (tempo) strength training and visuomotor skill training each caused increases in corticospinal excitability, decreases in corticospinal inhibition, and reductions in visuomotor skill tracking error. Yet, self-paced strength training did not affect corticospinal excitability, corticospinal inhibition, or visuomotor skill tracking error. Despite the greater effect of metronome-paced strength training on these neural adaptations, strength gains were greater after self-paced strength training.

Practical implications
The neural adaptations that occur after training with a set tempo may only improve the ability to lift and lower a weight slowly and under control. They do not appear to contribute to gains in maximum strength. Moreover, training with a set tempo leads to smaller strength gains compared to training with a self-paced tempo. Together, this suggests that athletes should avoid using set tempos for strength training where possible, and should at least use self-paced bar speeds, if not maximum bar speeds.


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