THE

S&C RESEARCH REVIEW

MONTHLY

By Chris Beardsley

JULY 2019 EDITION

July 2019 Edition

Editorial by Chris Beardsley

Welcome to the July 2019 edition! In this month, I have reviewed a couple of important new studies relating to central nervous system (CNS) fatigue, which is often (wrongly) dismissed or ignored by many other strength training experts. The lead article records how a high volume squat workout caused CNS fatigue that lasted for 72 hours in both trained and untrained lifters. Thus, the claim that the repeated bout effect might cause CNS fatigue to become less relevant for trained individuals is unfounded. Although muscle damage does seem to be the main driver of CNS fatigue after a workout, this relationship also seems to alter with training.

Another important study in this edition investigating CNS fatigue assessed the "non-local" component. This is the element of CNS fatigue that affects other muscles in addition to the one being trained. Contrary to popular belief, CNS fatigue does not necessarily affect all muscles in the body equally. It likely has a bigger effect on the trained muscle than on untrained muscles.

Another key theme in this edition was maximum strength. A couple of studies afforded the opportunity to discuss the various mechanisms that underpin this quality, while looking at the differences between the effects of training with heavy, moderate, and light loads on long-term gains in muscle size and strength and also in post-workout signaling responses.

As always, there are a range of other studies covered in this monthly review, including investigations into eccentric tempo durations and inter-set rest periods during strength training, sprinting, change of direction, and blood flow restriction (BFR) training. Whether you are interested in strength training for athletic performance, for strength sports, or for bodybuilding, there are plenty of new findings to read about. See you next month!

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Assessing recovery after high volume squat workouts in trained lifters

After a bout of very muscle-damaging exercise, strength takes at least several days to recover. Strength recovery occurs as peripheral fatigue, central nervous system (CNS) fatigue, and muscle damage dissipate. However, the rate of recovery of each of these types of fatigue is still unclear, and it is also unknown whether young and middle-aged individuals display different recovery rates. However, research indicates that the recovery rates of untrained lifters are slower than those of trained lifters, because of the repeated bout effect.

Key findings

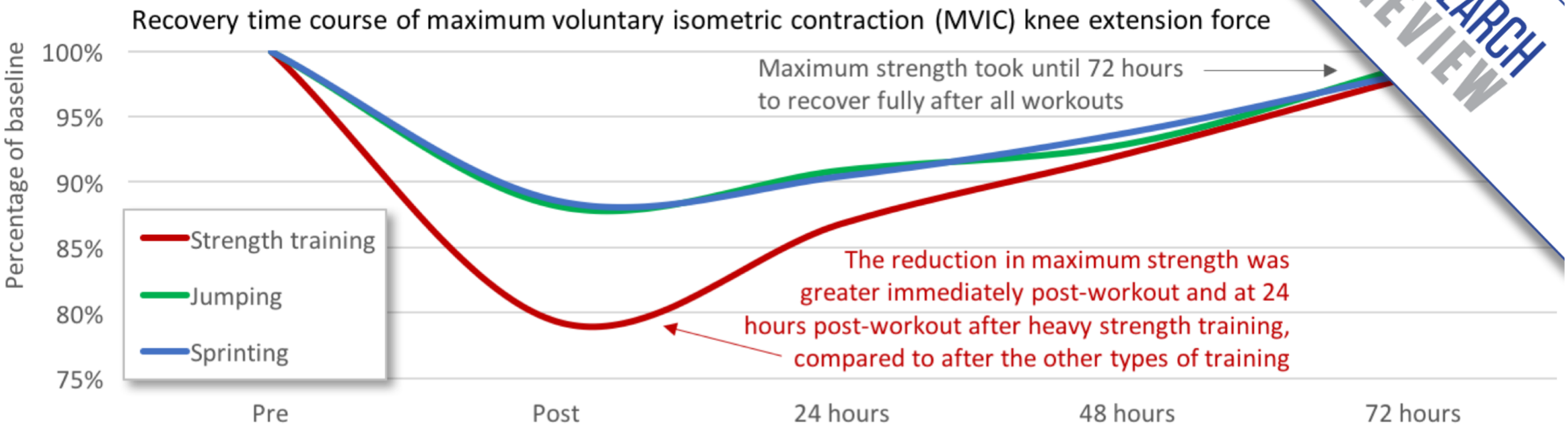
After a high volume squat workout, both trained and untrained subjects display central nervous system (CNS) fatigue that lasts for at least 72 hours. Compared to similarly-aged trained subjects, untrained subjects displayed some signs of greater muscle soreness and damage, but strength recovery was similar. The middle-aged trained males took longer to recover strength than the young trained males.

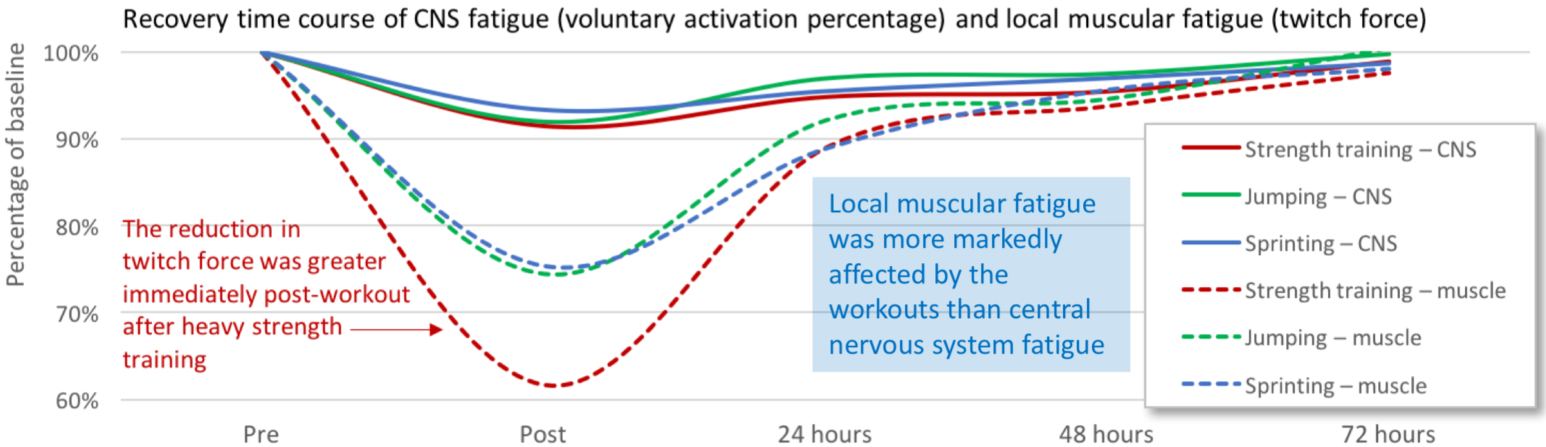
Practical implications

High volume, muscle-damaging workouts should not be done more often than twice a week, allowing at least three days of recovery time between them, otherwise CNS fatigue could impair the resulting adaptations, and lead to wasted training time. This applies to both trained and untrained lifters to a similar extent.

Exercise-Induced Muscle Damage and Recovery in Young and Middle-Aged Males with Different Resistance Training Experience. Fernandes, J. F., Lamb, K. L., & Twist, C. (2019). *Sports*, 7(6), 132.

High volume strength training, jumping, and sprinting workouts take 72 hours to recover from, due to fatiguing processes inside the muscle and also in the central nervous system





🔎 Subjects did 3 different workouts on separate days. The heavy strength training workout = 10 sets of 5 reps of the back squat with 80% of 1RM. The jumping workout = 10 sets of 5 reps of jump squats, using the heaviest load that could be used and still achieve a jump height within 5% of unloaded jump height (average load used = 10 ± 5 kg). The sprinting workout = 15 maximal sprints over 30m. All reps in all workouts were performed with maximal intent.

SUMMARY

High volume heavy strength training, jumping, and sprinting workouts all caused fatigue that took 72 hours to dissipate. Fatigue involved changes in the central nervous system (CNS) and inside the muscle. Twitch force (the indicator of local muscular changes) recovered only at 72 hours after all workouts. Voluntary activation (the indicator of CNS fatigue) ↓ after all workouts, and remained depressed for 48 hours after strength training and for 24 hours after jumping and sprinting.

Based on: Thomas, K., Brownstein, C. G., Dent, J., Parker, P., Goodall, S., & Howatson, G. (2018). Neuromuscular Fatigue and Recovery after Heavy Resistance, Jump, and Sprint Training. *Medicine & Science in Sports & Exercise*.

OBJECTIVE

To assess recovery from peripheral and central nervous system (CNS) fatigue after a squat workout in trained young, and both trained and untrained middle-aged males.

INTERVENTION

Subjects did a squat workout comprising 10 sets of 10 reps of squats with 60% of 1RM, with 2 minutes of rest between sets. Measurements of fatigue were taken before the workout and also at 24 and 72 hours after the workout, to assess the rate of recovery.

POPULATION

9 young trained males, age 22.3 ± 1.7 years, 9 trained middle-aged males, aged 39.9 ± 6.2 years, and 9 untrained middle-aged males, aged 44.4 ± 6.3 years

MEASUREMENTS	RESULTS
Strength recovery: By maximal voluntary isometric contraction (MVIC) single-leg knee extension force at 80° knee flexion, using a dynamometer.	Changes in MVIC force were very likely moderate and likely small at 24 and 72 hours, respectively. Differences between untrained and trained middle-aged subjects were unclear at 24 and 72 hours. Reductions in MVIC force were likely and very likely moderately greater in middle-aged trained subjects than in young trained subjects at 24 and 72 hours, respectively.
Muscle damage markers: By perceived muscle soreness, using a visual analog scale (VAS) and creatine kinase (CK) levels, from capillary blood samples.	Muscle soreness increased post-workout at both 24 and 72 hours, but differences between trained young and middle-aged subjects were unclear. Muscle soreness was likely moderately higher in untrained middle-aged subjects than in trained middle-aged subjects at 24 and 72 hours. CK levels also increased post-workout. Increases were moderate after 24 hours and small after 72 hours. Differences between trained young and middle-aged subjects were unclear. CK levels were likely moderately higher in untrained than in trained middle-aged subjects at 24 (but not at 72) hours.
Peripheral fatigue: By electrically-stimulated mean doublet force after an MVIC.	The changes in mean doublet values were likely small and unclear at 24 and 72h hours, respectively.
CNS fatigue: By voluntary activation during an MVIC, using the interpolated twitch method.	Voluntary activation decreased in all groups post–workout, and was very likely decreased at 24 and 72 hours.

SUMMARY

After a high volume squat workout, both trained and untrained subjects display central nervous system (CNS) fatigue that lasts for at least 72 hours. Compared to similarly-aged trained subjects, untrained subjects displayed some signs of greater muscle soreness and damage, but strength recovery was similar. Middle-aged trained males took longer to recover strength than young trained males.

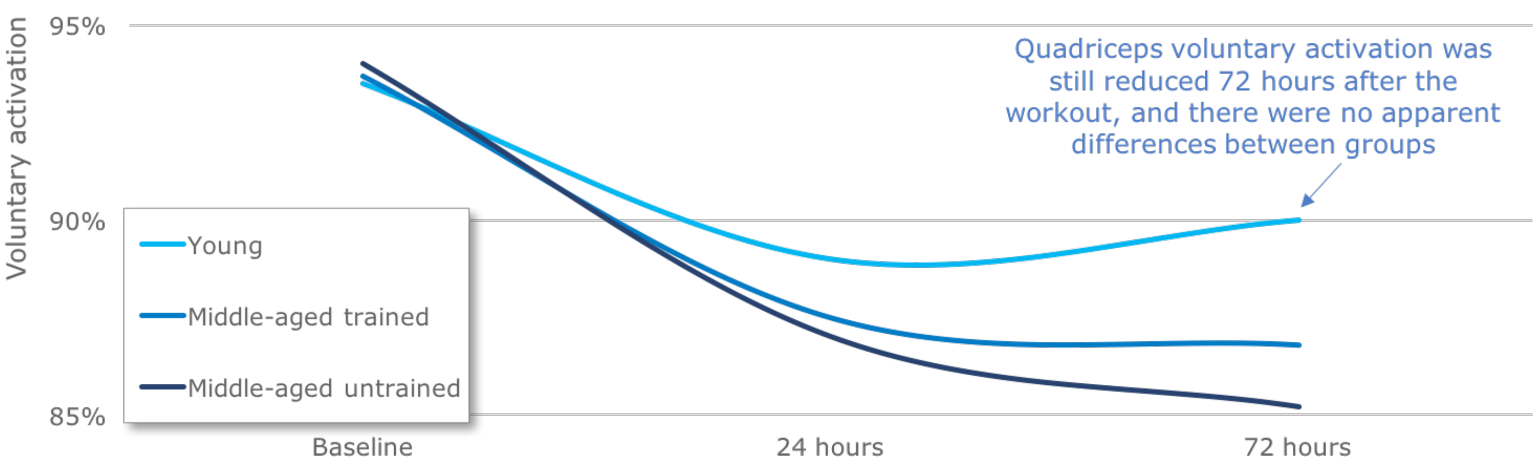
This study reported that after a high volume, muscle-damaging squat workout, both trained and untrained subjects display central nervous system (CNS) fatigue that lasts for at least 72 hours. Although this will be surprising to many, this finding is actually in agreement with the rest of the literature, which shows that CNS fatigue is substantial after muscle-damaging strength training workouts (1 – 4) and other exercise involving eccentric contractions (5,6) whereas it is minimal after less damaging training sessions (7,8,9).

Exactly why muscle damage is relatively closely linked to the amount of CNS fatigue that occurs is not clear. One idea was that muscle damage caused soreness and that this soreness impairs our ability to recruit motor units (10). While superficially plausible, this hypothesis was soon rejected.

Indeed, the time course of recovery of voluntary activation after a workout and the time course of muscle soreness are totally different. Voluntary activation is reduced most immediately after a workout, and tends to recover gradually. In contrast, the muscle soreness response is delayed and peaks a day or two after the workout.

It seems more likely that an inflammatory response triggers CNS fatigue after a workout, since the inflammatory response follows a similar time course to CNS fatigue (11). In this hypothesis, muscle damage after a workout triggers inflammation, and this inflammation then stimulates the brain to reduce voluntary activation levels, either directly by muscle afferent nerves detecting the inflammation (12,13), or indirectly by inflammatory agents crossing the blood-brain barrier (3,14).

Voluntary activation before and at two time points during recovery from a high-volume squat workout, in trained young males, trained middle-aged males, and untrained middle-aged males



In this study, while central nervous system (CNS) fatigue was similarly reduced in all three groups, indirect muscle damage markers were slightly greater in untrained subjects than in trained subjects of the same age. Similarly, previous research has found that untrained lifters experience greater muscle damage than trained lifters (15). This could be interpreted as a challenge to the hypothesis of muscle damage causing inflammation which then triggers CNS fatigue, as the untrained subjects who experienced greater markers of muscle damage did not also experience greater CNS fatigue. Yet, it has been found that as lifters become adapted by the repeated bout effect, the amount of inflammation that is caused by a given level of muscle damage increases (16). Thus, the amount of CNS fatigue would be greater for trained lifters for a given level of muscle damage, which is exactly what this study found.

A previous study in trained individuals found that the time course of strength recovery is similar between middle-aged and young males (17). In contrast, this study found that middle-aged individuals took longer to recover strength after a high volume, muscle–damaging workout than their younger counterparts. This finding does not seem to be related to the level of volume used in the study, as both studies used high numbers of sets. Nor does it seem to be related to training status, since both studies involved trained subjects. The literature assessing differences in muscle damage between untrained younger and older individuals is conflicting, and does not provide much insight (18,19). Even so, the lack of difference in CNS fatigue between the middle-aged and young males in this study indicates that the mechanism is related to muscle damage, so may be caused by a slower rate of muscle repair.

Conclusions

After a high volume squat workout, both trained and untrained subjects display central nervous system (CNS) fatigue that lasts for at least 72 hours. Compared to similarly-aged trained subjects, untrained subjects displayed some signs of greater muscle soreness and damage, but strength recovery was similar. The middle-aged trained males took longer to recover strength than the young trained males.

Practical implications

High volume, muscle-damaging workouts should not be done more often than twice a week, allowing at least three days of recovery time between them, otherwise CNS fatigue could impair the resulting adaptations, and lead to wasted training time. This applies to both trained and untrained lifters to a similar extent.

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