HOW TO STUCTURE YOUR WORKOUTS

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Contents

In this module you'll learn how to structure your workouts. The two key components of your workout structure are your exercise order and the time between your exercises, which we call your rest intervals. At the end of this module, you should understand that the underlying mechanism of both components of your workout structure are the same. Let's start with your rest intervals.

➢ Lecture

How to structure your workouts

This lecture is optional: all contents are covered in the text.

Rest intervals

How long should you rest in between your sets? Traditional bro wisdom holds short inter-set rest periods of around 1-3 minutes are optimal for bodybuilding and long rest periods of 3+ minutes are optimal for powerlifting. There didn't seem to be much of a formal argument for why other than that people traditionally trained this way. The real reason was probably that bodybuilders chased muscular sensations associated with fatigue and powerlifters chased performance.

Metabolic stress

In 2010, Brad Schoenfeld popularized the term 'metabolic stress' and proposed that rest periods of 60-90 seconds resulted in the most anabolism by serving as a sweet spot between total work output and high metabolic stress. The theory of metabolic stress was still more of a rationalization of chasing the pump and the burn than an evidence-based theory, because there wasn't a single study actually finding more muscle growth with shorter rest periods.

- In 2005, Ahtiainen et al. found similar muscle growth and a trend for better strength development when training with 5- vs. 2-minute rest periods. Importantly, this study was work-equated, which meant the shorter rest period group performed an average of one extra set for each exercise to compensate for their lower work capacity.
- In 2009, Buresh et al. found *greater* muscle growth in a strength training program with 2.5-minute rest periods than the same program performed with 1-minute rest periods. There was also greater strength development with the longer rest periods, but this did not reach statistical significance, probably because the study was statistically underpowered, as noted by the authors.

- In 2010, De Souza et al. had found similar strength and muscular development in a group resting a consistent 2 minutes compared to a group gradually cutting their rest periods down to 30 seconds over the course of the program. These results were replicated by Souza-Junior et al. in 2011.
- Later in 2014, Schoenfeld et al. compared 2 work matched programs: a ‘powerlifting type’ program of 7 sets of 3 reps with 3-minute rest periods and a more traditionally bodybuilding type program of 3 sets of 10 reps with 1.5-minute rest periods. Both resulted in similar muscle growth, but the higher-intensity, longer-rest group achieved better strength development.

For strength development, the consensus was clearly that long rest periods allowing (near) full recovery and high performance are optimal, especially in trained individuals. Maximum strength requires maximal force production and fatigue prevents you from achieving this, so complete recovery is ideal. As a rule of thumb, recovery of the ATP-CP system takes around 3 minutes (see carbohydrates module). If the ATP-CP system does not recover in between sets, your force output will be limited by substrate availability rather than contractile strength.

For muscle growth, total mechanical tension is what matters. The studies above support that given the same total intensity and work, and thereby mechanical tension and time under tension, muscle growth will be similar. However, when work is not equated, like in Buresh et al.’s study, longer rest periods result in more work being done, more tension put on the muscle fibers and therefore more muscle growth. Yet despite the complete lack of evidence for the superiority of short rest periods for muscle growth, the dominant view up until this time was still that bodybuilders should train with short rest periods. Several reviews recommended rest periods of 30-60 seconds and the American College of Sports Medicine recommended 1-2-minute rest periods with some exceptions up to 3 minutes.

So in 2014 Menno wrote a review paper critiquing the theory of short rest periods for muscle growth and metabolic stress, to which he invited Brad Schoenfeld to make a case for the theory. In addition to a formal overview of the literature showing no empirical evidence that short rest periods maximize muscle growth, Menno's critique was, in short, as follows. The benefits of short rest periods were theorized to result primarily from increased anabolic hormone production. However, production of the key anabolic hormone testosterone is overall unaffected by rest interval length. It is only growth hormone production that increased and only with rest intervals below 1 minute. Problematically, resting less than 2 minutes also increases cortisol production and thereby worsens the T:C ratio. There is evidence the T:C ratio is related to muscle growth, whereas growth hormone is not anabolic in muscle tissue and mostly related to anaerobic fuel mobilization (see module on understanding muscle growth). Consequently, the hormonal milieu resulting from short rest intervals is more likely to be detrimental than advantageous for muscle growth.

To settle the matter, in 2015 Brad Schoenfeld et al., including Menno, performed a randomized controlled trial comparing strength training programs with 1- and 3-minute rest intervals. The 3-minute rest group achieved greater strength development and muscle growth. While the 1-minute rest group may have achieved greater metabolic stress, it was evidently not enough to compensate for the reduced work capacity and lower mechanical tension. These results support the earlier findings of Buresh et al.

Subsequent research also confirmed that resting only a single minute compared to 5 minutes between sets of leg extensions blunts anabolic signaling and acute myofibrillar protein synthesis in the muscle cells despite higher metabolic stress in the short-rest group.

Paradoxically, in 2015, Villanueva et al. found greater muscle growth as well as greater strength development in elderly men resting 1 minute compared to 4 minutes between sets. However, total repetition volume and set volume were equated between groups. So the 1-minute group was performing the same total number of reps in a quarter of the time as the 4-minute group. They were thus simply training harder, reaching higher levels of mechanical tension in their sets and, guess what, hard work pays off.

In further support of the importance of volume rather than metabolic stress, Fink et al. (2016) showed that when total work is equated, resting only 30 seconds with 20RM loads is just as effective for muscle growth (but not strength) as resting 3 minutes with 8RM loads. The short rest group experienced greater muscle swelling and growth hormone production post-workout, but this was not correlated with muscle growth. Fink et al. (2017) didn't even find that shorter rest periods increase metabolic stress, although the study was probably underpowered due to its small sample (N = 21) of non-strength-trained individuals. For what it's worth, they found similar muscle growth and even strength development in a training program with a 40% intensity and either 0.5- or 2.5-minute rest intervals. Metabolic stress as judged by growth hormone and IGF-1 levels was also similar between the groups, again showing that it's not metabolic stress per se that drives muscle growth.

Vargas et al. (2019) found a trend for lower muscle growth with 3 sets of 20-25 reps to failure with 1 minute rest between sets compared to 3 sets of 6-8 reps to failure with 3 minutes rest between sets. Since intensity does not affect muscle growth in this range in other research (see course module on training intensity), the short rest interval was the likely reason for the potentially lower muscle growth.

In 2022, Longo et al. provided strong further confirmation that total workload rather than rest interval length per se influences muscle growth. The researchers found that long rest intervals resulted in more muscle growth than short rest intervals when they performed the same number of sets. A group that used short rest intervals but did extra sets to equate total work with the long rest interval group gained a similar amount of muscle as the long rest interval group. A group that used long rest intervals but did fewer sets to equate total work with the short rest interval group gained a similar amount of muscle as the short rest interval group. In other words, the rest interval itself doesn't seem to matter directly: it only matters because it influences how many reps you can do afterwards, as those reps provide the mechanical stimulus for muscle growth.

Strength development was not significantly different between groups, supporting previous research that volume is more important for muscle growth than strength. See the graph below for the study data, if you're interested in the details.

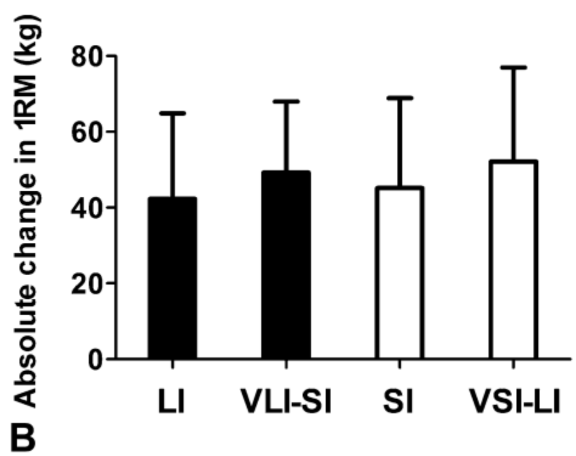


Figure 2. A) Maximum dynamic strength (1RM, in kg) before (PRE) and after (POST) a 10-week unilateral resistance training program in the long resting interval (LI), volume-matched long resting interval with a short interval (VLI-SI), short resting interval (SI), and volume-matched short resting interval with a long interval (VSI-LI) protocols. B) Absolute change in 1RM in the LI, VLI-SI, SI, and VSI-LI protocols. *Significant within-protocol effect ($p < 0.05$). 1RM = one repetition maximum.

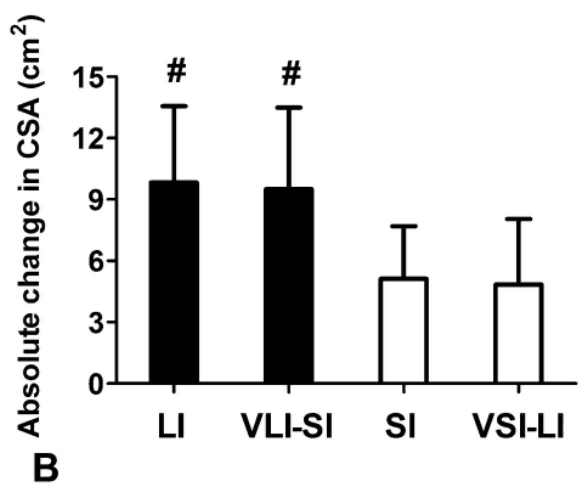


Figure 3. A) Quadriceps cross-sectional area (QCSA, in cm^2) before (PRE) and after (POST) a 10-week unilateral resistance training program in the long resting interval (LI), volume-matched long resting interval with a short interval (VLI-SI), short resting interval (SI), and volume-matched short resting interval with a long interval (VSI-LI) protocols. B) Absolute change in CSA in the LI, VLI-SI, SI, and VSI-LI protocols. *Significant within-protocol effect (at $p < 0.05$); #significant between-protocol effect compared with SI and VSI-LI ($p < 0.05$).

In 2024, a meta-analysis confirmed that rest periods below a minute result in less muscle growth than longer rest periods. Unfortunately, there were not enough comparable data points to reliably conclude how much more rest was ideal.

All these data support that metabolic stress is irrelevant for muscle growth. What matters is time under mechanical tension. Longer rest → more repetitions → greater time under tension → more muscle protein synthesis → more muscle growth.

In conclusion, the increased metabolic stress from training with short rest periods in between sets doesn’t result in muscle growth. It does decrease work capacity and the resulting lower repetition volume can reduce the stimulus for muscle growth and especially that for strength development. For both strength development as well as muscle growth, an absolute minimum of 1 minute of rest is thus advisable.

The exception to the rule

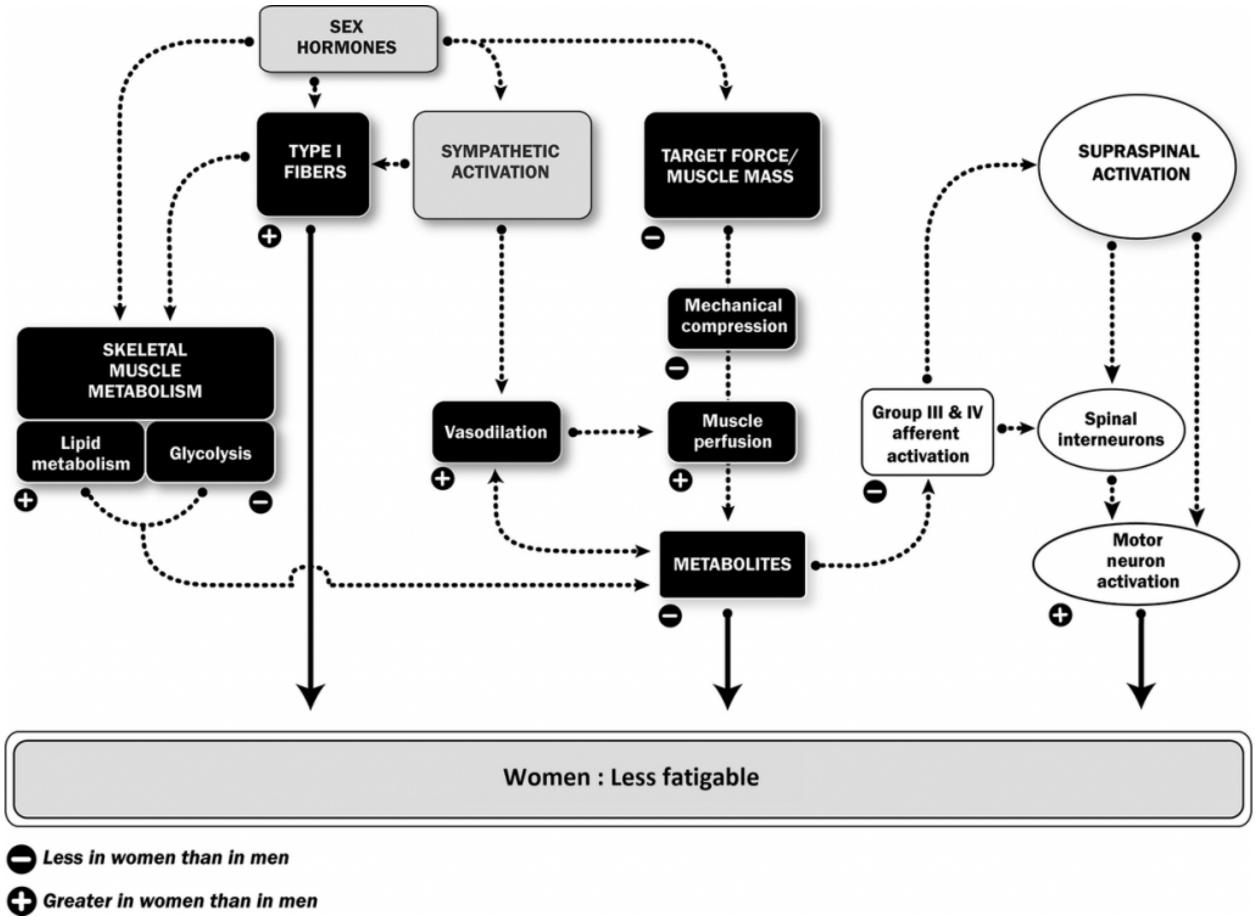
Dring antagonist supersets, it seems you can get by with shorter rest periods and still get the same amount of volume in. However, this comes at the expense of greater neuromuscular fatigue. The fatigue is probably the reason why performance can be sustained with shorter rest, since fatigue is crucial for the performance enhancing effect of antagonist supersets (see the section on exercise ordering).

Practical implementation of rest intervals

For maximal muscle growth and strength development, your rest periods in between sets should practically always be longer than a minute in duration. Ideally, we want to rest until we've completely recovered. Resting longer increases your work capacity and thereby your repetition training volume, which in turn increases the stimulus for muscle growth and strength development. So unless you compensate for the reduced work capacity of insufficient rest between sets by performing more sets, it is beneficial to allow considerable recovery in between each set. How long you should rest exactly depends on your recovery speed, which in turn depends on many factors, notably the following.

Biological sex

The following graphic from Hunter (2014) summarizes the reasons why women don't fatigue as much as men. With all of this in mind, it shouldn't be a surprise that women recover faster after a set than men [3].



Training intensity

[Recovery is typically slower after higher intensity training, though with 90-100% intensities short rest periods can sometimes suffice, as there's not much fatigue at all with such low work outputs.]() For high-intensity training, recovery of the ATP-CP system in between is particularly important to maintain high performance across sets. Lower-intensity training can be fueled by the glycolytic and aerobic systems to a greater extent. The associated metabolic stress is not detrimental for low-intensity training, as it lowers the recruitment threshold of the higher-threshold motor units.

Strength

Stronger individuals have poorer work capacity than weaker ones and thus need longer rest periods to achieve similar training volumes [2]. Some trainees get concerned when they see their work capacity decrease over time, but this is a normal result of getting stronger. You can produce more force, but this comes at the expense of greater fatigue.

Exercise order

Exercise order: exercises performed later in a workout typically need more rest. The accumulated fatigue delays inter-set recovery.

Autoregulation

Fortunately, we are intuitively reasonably in tune with the above factors, so rather than use your phone to time your rest periods, in practice you can simply rest until you feel recovered enough to complete your next set with maximal effort, which should correspond with good strength recovery [2, 3, 4, 5]. At a minimum, you should rest until you have caught your breath. You may have seen athletes use slow breathing techniques to catch their breath extra fast, but the available research does not find significant effects of breathing speed on inter-set recovery.

If you have no feeling at all yet on how to autoregulate your rest intervals, start with 2+ minute rest periods for isolation work and 3+ minute rest periods for compound exercises. Resting until complete recovery is also acceptable, but in contrast to many armchair experts, complete recovery often requires well over 5 minutes of rest in strong men after a maximal effort set, if it occurs at all that workout, as there should be muscle damage after each set that you won't recover from in that workout.

A study by Buskard et al. (2017) found that recovery of your heart rate is a reasonable indicator of how long you need to rest in between sets to maintain reasonable performance levels. However, this study compared resting only 1 minute compared to resting until the participant's heart rate had returned to the level it was at 45 seconds after the first set. The researchers for some reason did not report the rest periods of the heart rate group, so it's likely they just rested longer and therefore performed more repetitions in their workout. You can use your heart rate as some indicator of your readiness to perform your next set, but this probably shouldn't be the only indicator you use, because your heart rate is much more closely related to your cardiovascular fitness and recovery than your neuromuscular fatigue. You can get your heart rate up a lot with bodyweight squats without much neuromuscular fatigue, whereas a 5RM of biceps curls shouldn't do nearly as much to your heart rate while stimulating a lot more neuromuscular fatigue.

Time efficiency

One pitfall you should beware of when autoregulating your rest interval is resting too long. Low motivation to exercise or getting distracted can make workouts last much longer than needed. Mental recovery (RPE) after a hard set can take longer than the actual recovery in physical performance. So when time is limited, you should program in fixed rest intervals. It's generally most time-efficient not to rest until full recovery and to try to perform as many sets rather than as many reps per set as possible [2] because there are diminishing returns to your rest intervals for performance. The first minute after a set, you recover a significant amount of your performance already. After about 3 minutes when your ATP-CP system has recovered, each additional minute of rest increases your next set's reps progressively less. The main objective when pressed for time is often to accumulate as many total reps as possible in the time you have. Rest periods of 1-2 minutes, just enough to catch your breath and recover from the worst fatigue, are often ideal in this scenario.

If you value time-efficiency a lot, you can also actively train yourself to get used to shorter rest periods to some extent. De Souza et al. (2010, 2011) found you can gain similar levels of size and even strength when progressively reducing your rest periods to as little as 30 seconds per set compared to resting 2 minutes. Resting less will be mentally challenging at first, but your work capacity will improve over time.

Active recovery

When you've determined your rest intervals, the next question is: what should you do within these rest periods? Here active recovery comes in. The idea is that by staying active, you can speed up your recovery by increasing blood flow and the removal of metabolic waste products.

Indeed, active recovery in the form of light exercise for the fatigued muscle groups helps speed up the removal of metabolic byproducts from exercising and thereby increases performance [2]. The active recovery should ideally involve the fatigued musculature: walking does not improve the rate of recovery of your upper body muscles significantly. Promoting active recovery can slightly enhance work capacity, resulting in a greater total work output, reduced neuromuscular fatigue as measured by movement velocity loss and lower perceived exertion [2, 3]. A greater training volume may in turn increase muscle growth and strength development.

However, it's very easy to overdo active recovery. In several studies, active 'recovery' within a training session doesn't improve recovery within or after the training and it can easily increase the perceived effort of the training (RPEs). In general, overdoing the active recovery will decrease your performance compared to passive recovery [2, 3]. Bodyweight squats are too intensive to constitute active recovery, for example, and can decrease lower body work capacity.

The sweet spot intensity for active recovery is very low: walking is probably the right intensity for most of the body. Since perceived effort tends to increase before performance objectively deteriorates, you can go by feel here. The active recovery should not be strenuous or effortful, so if after a heavy set of squats, you feel like you're about to pass out, feel free to sit down. If you feel like you're more at risk of getting cold or you've got an extreme muscle pump, walk around and do some similarly low intensity upper body movements, such as gentle arm swings.

The type of activity you do probably doesn't matter much, provided it has a very low intensity and involves the target body parts. Different types of active recovery on the treadmill and static stretching seem to work equally well (or poorly). Foam rolling in between sets can also increase how many reps you do across sets, and it doesn't matter whether you foam roll the muscle you're exercising, its antagonist or both, indicating it's likely just the effect of staying active, rather than a special effect of foam rolling per se, that promotes the greater work capacity.

Exercise ordering

Exercise order is an often-overlooked aspect of program design. This is perhaps not surprising, given that there is no obvious reason why our exercise order per se would affect our gains. However, our exercise order affects our rest intervals and the level of fatigue we have accumulated by the time we get to a particular exercise. These factors can influence how much mechanical tension the involved musculature can produce during the exercise and thereby our results. Let's look at the effects of neuromuscular fatigue.

The effects of neuromuscular fatigue

Every trainee has experienced fatigue. In addition to the subjective sensation of fatigue, you can readily observe its objective effect: you get weaker. Your maximal repetitions decrease across sets along with 1RM strength.

What you cannot observe is what happens within your muscles. As you start a strength training workout, metabolic stress accumulates in your blood and muscle fibers get damaged. The neuromuscular fatigue you accumulate during strength training impairs neuromuscular functioning, sometimes including a reduction in the muscle activity levels you can achieve [2]. This is the reason you get weaker.

Fatigue does not just impair muscular activation, neuromuscular efficiency and thereby force production but joint stability and how you perform your exercises, because fatigue impairs proprioception [2]. Proprioception is your sense of where your body parts are in space and what they're doing. Your brain can integrate sensory neural input from your inner ear and proprioceptors and stretch receptors in your muscles to form a representation of your body's position even without visual feedback. That's why you can touch your nose with your eyes closed, unless you're drunk, and why you can walk up stairs at night reasonably well.

Our exercise order determines in large part how fatigued our muscles are by the time we perform an exercise. This fatigue affects our ability to impose high mechanical tension on our muscle fibers, which is their primary stimulus for growth. Knowing this, we can derive principles of how to order our exercises in a workout.

1. Order by priority

Program your most important exercises first in a workout.

A 2020 meta-analysis by Nunes et al. found that exercises performed first in a workout gain strength faster than those performed later. The later you perform an exercise in a workout, the more fatigued you are, especially if previous exercises involved the same musculature. So for strength, it's clear that priority exercises should be done first. Powerlifters, for example, should virtually always start their workouts with a squat, bench press or deadlift movement, not an overhead press.

For muscle growth, there was no significant effect of exercise order. However, the literature is almost exclusively limited to comparisons of starting with multi-joint vs. starting with single-joint exercises for one specific muscle group (see table overview below if you're interested in the study details). If you perform 5 hamstring exercises, it doesn't matter much in which order you perform them for hamstring growth, as the cumulative stimulus for muscle growth and the accumulated fatigue correlate virtually perfectly.

Table 1. Characteristics of the included studies on resistance exercise order.

Studies	Sample: Characteristics	Sample: n	Duration	RT program	Exercises and EO according to groups	
Assumpção et al. (2013)	Trained young men	MJ-SJ = 8	6 weeks	A-B2x/wk, 3 sets of 8-12RM	MJ-SJ	BP*, IBP, PD, MTE, TE* - LPD*, CLPD, SR, MBC, BC*
		SJ-MJ = 8			SJ-MJ	MTE, TE*, BP*, IBP, PD - MBC, BC*, LPD*, CLPD, SR
Avelar et al. (2019)	Untrained young men	MJ-SJ = 19	6 weeks	3x/wk, 3 sets of 8-12RM	MJ-SJ	BP, LPD, UR, SP, TE, BC, LP, KE, LC, CR
		SJ-MJ = 17			SJ-MJ	BC, TE, SP, UR, LPD, BP, CR, LC, KE, LP
Cardozo et al. (2019)	Untrained older women	MJ-SJ = 15	12 weeks	2x/wk, 3 sets of 8-10RM (circuit training)	MJ-SJ	LP*, LPD*, KE, PD, CR*, TE*
		SJ-MJ = 15			SJ-MJ	TE*, CR*, PD, KE, LDP*, LP*
Dias et al. (2010)	Untrained young men	MJ-SJ = 16	8 weeks	3x/wk, 3 sets of 8-12RM	MJ-SJ	BP*, LPD*, SP*, TE*, BC*
		SJ-MJ = 17			SJ-MJ	BC*, TE*, SP*, LPD*, BP*
Fisher et al. (2014)	Trained middle-age adults	MJ-SJ = 8	12 weeks	2x/wk, 1 set of 8-12RM	MJ-SJ	BP, LP, LPD, PD, KE, PO, ABD, LU
		SJ-MJ = 17			SJ-MJ	PD, BP, KE, LP, PO, LPD, ABD, LU
Nazari et al. (2016)	Untrained young women	MJ-SJ = 8	6 weeks	3x/wk, 4 sets of 3-15RM (linear periodization)	MJ-SJ	BP*, LPD*, TE*, BC*
		SJ-MJ = 8			SJ-MJ	BC*, TE*, LPD*, BP*
Pina et al. (2013)	Trained older men	MJ-SJ = 9	7 weeks	3x/wk, 2 sets of 10-15RM	MJ-SJ	BP, LPD, TE, BC, KE, LC, HAB, HAD
		SJ-MJ = 9			SJ-MJ	BC, TE, LPD, BP, HAD, HAB, LC, KE
Saraiva et al. (2014)	Judo male athletes	UB-LB = 13	12 weeks	3x/wk, 3 sets of 10-12RM	UB-LB	BP*, LPD*, SP*, BC*, SQ*, LP*, KE*, LC*
		LB-UB = 13			LB-UB	SQ*, LP*, KE*, LC*, BP*, LPD*, SP*, BC*
Simão et al. (2010)	Untrained young men	MJ-SJ = 9	12 weeks	2x/wk, 2-4 sets of 3-15RM (linear periodization)	MJ-SJ	BP*, LPD*, TE*, BC*
		SJ-MJ = 9			SJ-MJ	BC*, TE*, LPD*, BP*
Spineti et al. (2010)	Untrained young men	MJ-SJ = 11	12 weeks	2x/wk, 2-4 sets of 3-15RM (undulating periodization)	MJ-SJ	BP*, LPD*, TE*, BC*
		SJ-MJ = 10			SJ-MJ	BC*, TE*, LPD*, BP*
Tomeleri et al. (2019)	Untrained older women	MJ-SJ = 14	12 weeks	3x/wk, 3 sets of 10-15RM	MJ-SJ	BP*, SR, TE, BC*, LP, KE*, LC, CR
		SJ-MJ = 15			SJ-MJ	BC*, TE, SR, BP*, CR, LC, KE*, LP

Notes. MJ-SJ: group that performed the exercises in a multi- (MJ) to single-joint (SJ) order. SJ-MJ: group that performed the exercises in a single- to multiple-joint order. UB-LB: group that performed the exercises in an upper- (UB) to lower-body (LB) order. LB-UB: group that performed the exercises in an upper- to lower-body order. RM: repetition maximum. ABD: abdominal flexion. BC: biceps curl. MBC: machine biceps curl. BP: bench press. IBP: incline bench press. CR: calf raise. HAB: hip abduction. HAD: hip adduction. KE: knee extension. LC: leg curl. LPD: lat-pulldown. CLPD: close-grip lat-pulldown. LP: leg press. LU: lumbar extension. PD: pecdeck. PO: lat-pullover. SP: shoulder press. SQ: squat. SR: seated row. TE: triceps extension. MTE: machine triceps extension. UR: shoulder upright row. * exercise used for strength testing (if no asterisk is noted in any of the exercises, the study did not assess changes in muscular strength).

However, unless you're doing a bro body part split where every exercise in a workout trains the same muscle group(s), you'll also have exercises for different muscle groups in a workout. To the extent that these also accumulate fatigue, this can affect the muscle growth stimulus of subsequent exercises. Performing overhead presses, for example, may reduce the stimulus your chest will receive afterwards from bench presses if your triceps and delts have become a limiting factor. In practice, exercise order can also affect muscle growth by affecting motivation. Less than super motivated trainees may skimp on the last exercises in a workout, even if unintentionally. This is frequently the fate of calf and forearm exercises when placed at the end of a workout: they're often done with low focus and motivation as an afterthought or they get skipped altogether.

So in practice you still generally want to place your priority exercises for muscle growth earlier in a workout, just like for strength.

However, be very careful of what you label a priority exercise. Many guys thinks their ‘upper chest is lacking’, for example, and you’ll almost never hear someone who thinks their middle traps or any other non-mirror-muscles are lacking. Rather than go purely by subjective assessment, you can perform a more objective assessment with our relative muscular development calculator (see course module on customized program design for more details on lagging body parts).

People that haven’t been very lean before also typically confuse fat with muscle. People at higher body fat levels often believe their thigh muscles are sufficiently well developed so they don’t want more growth there, when in reality they’re just fatter than they’d like. As a rule of thumb, if you can’t see muscle striations or at least some separation of muscle heads, you’ll lose a lot of volume from fat in that body part with fat loss.

When there are no glaring muscle imbalances and no clear desire to develop certain exercises more in strength than others, you’re generally best off ordering your exercises based on the following principles to maximize whole-body muscle hypertrophy.

2. Compound exercises first

Given equal priority, perform compound exercises before isolation exercises targeting the same muscle groups.

The technique of pre-fatiguing is based on the Pre-exhaust Principle coined by old school bodybuilders Bob and Robert Kennedy. It's basically a fancy term for doing an isolation exercise for a given muscle group (the agonist) before you do a compound exercise involving that same muscle group. Examples of pre-fatigue training are doing triceps extensions before bench presses for the triceps, doing hip abductions before squats for the glutes, and doing pec deck flys before the bench press for the pecs. Pre-fatiguing has become popular in bro bodybuilding culture, because it gives you a good pump and burn and it makes you feel that muscle group more during the compound exercise.

While the sensation of fatigue may give you the intuitive impression you're stimulating a lot of muscle growth, fatigue is logically only detrimental. Pre-fatiguing a muscle does not increase its muscle activity during the subsequent exercise [2, 3, 4] and in some cases pre-fatiguing a muscle group *reduces* its muscle activity during the subsequent compound exercise or that of its very close synergists. For example, Fujita et al. (2022) found that pre-fatiguing the lats with a set of pull-overs before a set of seated rows did not affect EMG muscle activity of the biceps, lats or posterior delts in either direction but decreased activity in the teres major. Fatigue normally decreases muscle activity and force production capacity, so it makes sense that pre-fatiguing a muscle can reduce its stimulation during subsequent exercise. Muscles grow from exposure to high mechanical tension, not from fatigue.

Ironically, it's the muscle activity of unrelated synergists that may increase after pre-exhaustion to compensate for the weakened agonist. For example, triceps activation in the bench press has been found to increase after pre-exhaustion with the pec deck. There was a similar but non-significant trend of increased activity for the front delts. This may be because we intuitively perform the bench press in a more triceps-dominant fashion when our pecs are fatigued and/or because the bench press does not fully stimulate the triceps normally, so the triceps have room to contribute more. As such, it's questionable if this finding can be extrapolated to other exercise combinations.

In line with the electromyography (EMG) data on muscle activity, a 2020 meta-analysis by Nunes et al. found that agonist muscle growth is the same regardless of whether you start with compound or isolation exercises for that muscle. Pre-fatiguing does not increase muscle growth in the pre-fatigued muscle. You'll achieve the same growth by starting with compound exercises.

When we look at the effect of pre-fatiguing on other muscles than the target agonist, the data clearly favor starting with compound exercises. Pre-fatiguing a muscle induces a weak link in the subsequent compound exercise. The pre-fatigued muscle can become a limiting factor and sabotage the stimulation of all muscle groups. By putting an isolation exercise before a compound exercise of the same muscle group, you generally decrease total work capacity in the training session for that muscle group [1, 2, 3, 4]. For example, Simao et al. (2013) compared an exercise order starting with compound exercises and ending with isolation work to the reverse order, starting with isolation work and ending with compound exercises. As you can see in the table below, total volume load was over 50% higher in the compounds-first sequence.

Table 1. Total exercise repetitions and total volume for sequence A and sequence B (mean ± standard deviation).

	Bench press	Lat pull down	Shoulder press	Biceps curl	Triceps extension	Total volume (kg)
Sequence A	26.7±2.8*	28.1±5.1*	21.3±5.2	18.6±6.2*	18±6.3*	22683±8.583*
Sequence B	14.1±5.8	19.1±4.0	26.6±8.1	27.4±3.2	26.8±4.2	13684±5.632

*$p \leq 0.05$ vs. sequence B.

Trindade et al. (2020) even found that you achieve less total training work volume if you perform a set of leg extensions before 3 sets of leg presses (pre-fatigue), compared to just performing 3 sets of leg presses. This means the set of leg extensions was likely wasted effort.

Less total work done by the muscles generally means less strength development and muscle growth for a given number of sets. For strength, the data are pretty clear that the exercises you perform first in a workout develop faster. Since most people care mostly about strength in compound exercises, it makes sense to perform your compound exercises before isolation exercises and not doing any pre-fatiguing. For non-agonist muscle growth though, we have only very limited studies on the effect of exercise order.

- Pina et al. (2013) compared body composition changes in a full-body program performed by strength-trained elderly men starting either with compound exercises or isolation exercises. Neither group achieved major body recomposition and there were no statistically significant between-group differences. However, the group starting with compound exercises gained some lean mass and lost some fat, whereas the group starting with isolation exercises lost some muscle and gained some fat. Thus, this study provides tentative support for placing compound exercises before isolation exercises in your workouts.

- [Cardozo et al. (2019)] performed a similar study as Pina et al. in untrained elderly women, but no exercises involving overlapping musculature were performed directly after each other and the untrained, elderly women probably didn't go near failure, so both groups managed to perform the same total volume and, unsurprisingly then, total lean body mass growth was similar between groups. This study supports that it's the total volume that matters for full-body muscle growth, but in practice serious strength trainees will not be able to manage the same total volume when starting with isolation exercises.
- [Avelar et al. (2019)] again compared a compound-isolation (MJ-SJ) vs. an isolation-compound (SJ-MJ) exercise order. Unfortunately, it was only a 6-week study in untrained young men and no statistically significant differences in muscle growth appeared. However, if you look at the table below with the muscle growth findings, you can see that while the limbs grew similarly regardless of whether they were trained first with compound or isolation exercises, trunk lean mass grew over 3 times as much in the group starting with compounds. Isolation exercises were only performed for the limbs, so this study tentatively supports that arm isolation exercises impair the effectiveness of upper body compound exercises for the trunk, as you'd expect from their reduced performance.

Table 2. Muscle thickness and lean soft tissue according to groups at pre and post training (6 weeks). Data are presented as mean and standard deviation.

	MJ-SJ (n = 19)			SJ-MJ (n = 17)			*P*-value		
	Pre	Post	Change (95% CI)	Pre	Post	Change (95% CI)	Time	Group	Interaction
Biceps brachii (mm)	26.7 ± 5.7	30.5 ± 5.4	3.76 ± 2.9 (2.3, 5.1)	26.8 ± 4.4	30.5 ± 4.9	3.64 ± 3.0 (2.0, 5.2)	<0.001	0.96	0.90
Mid-thigh (mm)	34.8 ± 7.4	37.3 ± 6.7	2.50 ± 2.6 (1.2, 3.7)	35.7 ± 8.1	37.1 ± 6.6	1.40 ± 3.2 (-0.2, 3.1)	<0.001	0.88	0.29
ULLST (kg)	7.0 ± 1.5	7.4 ± 1.2	0.35 ± 1.7 (-0.5, 1.2)	6.9 ± 0.9	7.5 ± 0.9	0.52 ± 0.2 (0.3, 0.6)	0.03	0.80	0.76
LLLST (kg)	20.0 ± 3.1	20.1 ± 2.2	0.14 ± 2.8 (-1.2, 1.5)	19.8 ± 1.9	20.2 ± 2.4	0.35 ± 1.0 (-0.1, 0.8)	0.39	0.99	0.92
TLST (kg)	26.4 ± 6.4	28.3 ± 7.3	$\boxed{1.88}$ ± 5.4 (-0.7, 4.5)	26.0 ± 1.8	26.4 ± 1.6	$\boxed{0.45}$ ± 1.1 (-0.1, 1.0)	0.07	0.69	0.28

Note: MJ-SJ = multi-joint to single-joint exercises order. SJ-MJ = single-joint to multi-joint exercises order. ULLST = upper limb lean soft tissue. LLLST = lower limb lean soft tissue. TLST = trunk lean soft tissue.

- Tomeleri et al. (2020) also found a non-significant trend for better results when performing multi-joint exercises before single-joint exercises. As you can see in the table below, while none of the differences reached statistical significance, the group of older women performing multi-joint exercises first achieved greater effect sizes for all measures of strength development, total work and muscle growth, except upper limb soft tissue change, which was identical in both groups.

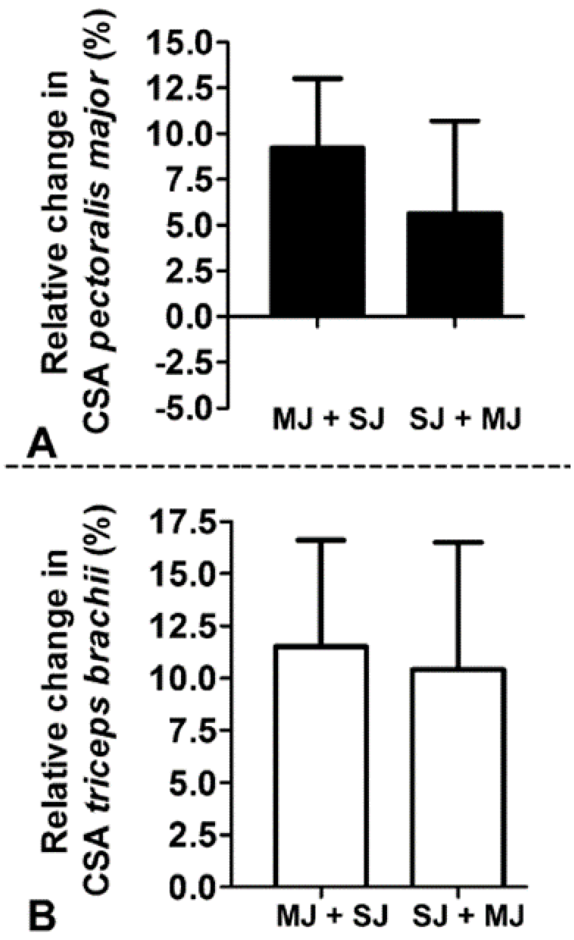
Table 4

Effects size values of muscular strength, LST, and anabolic hormones according to training groups.*†

	MJ-SJ (n = 15)	SJ-MJ (n = 14)	Difference
Chest press	0.75	0.58	0.17
Knee extension	1.00	0.74	0.26
Preacher curl	0.70	0.55	0.15
Upper limb LST	0.60	0.60	0.00
Lower limb LST	0.48	0.30	0.18
Trunk LST	0.48	0.38	0.10
Testosterone	0.24	0.08	0.15
IGF-1	−0.21	−0.01	−0.20

*LST = lean soft tissue; IGF-1 = insulin-like growth factor 1; MJ-SJ = group that performed RT in a multijoint to single-joint order; SJ-MJ = group that performed RT in a single-joint to multijoint order.

- Brandao et al. (2020) studied the effect of exercise order on muscle growth in the pecs and triceps. One group performed barbell bench presses first (MJ + SJ) and another group performed barbell skull-crushers first (SJ + MJ). The exercise order did not significantly affect muscle growth in either muscle, but in absolute terms, performing bench presses first resulted in considerably more growth in the pecs without reducing triceps gains: see the data below.



- [Dib et al. (2020)]() found no effect of exercise order on body recomposition or strength development, but the study wasn't very relevant for serious strength trainees. The nearly untrained (only pre-conditioned) elderly women in this study did not train with maximal effort and had considerable rest periods in between exercises with overlapping musculature in all groups. As a result, there was no significant difference in total training tonnage between the 3 groups with different exercise orders and all groups achieved only 'trivial to moderate' effect size increases in their fitness. Over 12 weeks, strength gains consisted of a paltry few kilograms per exercise and there was no muscle growth to speak of. Since putting compound exercises before isolation exercises is expected to be beneficial because it increases total work capacity when you train hard, it makes sense that the exercise order in this study was irrelevant.

- Cunha et al. (2022) found no effect of exercise order on muscular development in barely trained elderly women. It didn't matter if the women started their workouts with compound or isolation exercises or upper vs. lower body exercises: DXA body composition and 1RM strength results were similar. However, the fact even 1RM strength gains were similar for exercises regardless of when they were done in the workout, in contrast to studies on trained lifters, indicates these women were likely reaching a 'newbie gains' ceiling effect in getting back to a healthy muscle mass level. Consequently, this study is again of questionable relevance for serious strength trainees.

In sum, while most studies find no statistically significant effects of exercise order, the limited data we have partially support the mechanistic evidence and theory that it's best to do compound exercises first, especially for strength development and plausibly for muscle growth, because doing isolation exercises first induces a weak link that prevents subsequent compound exercises from maximally stimulating other involved muscles.

A similar principle might apply to muscle size: training larger muscle groups before smaller muscle groups might slightly optimize total work capacity. Muscle groups seem to differ in terms of how hard it is for the nervous system to activate them. Most people cannot voluntarily activate their quads to the same extent as their biceps or calves. Why that is and which muscles are easiest to activate we don't know exactly, but muscle size is a plausible explanation. Larger muscles have more motor units to coordinate. The more difficult it is for the nervous system to control a muscle, the more that muscle group's performance will likely suffer due to neuromuscular or mental fatigue. For example, training the quads induces more central nervous system fatigue than training the biceps. Correspondingly, Nunes et al. (2019) found older women report lower rating of perceived exertion (RPE) values when they start their workouts with lower body instead of upper body exercises.

So given equal priority, it may be optimal to train the quads before the biceps. This aligns well with the common practice that squats and deadlifts should generally be performed first in a workout. They're highly compounded, they involve large muscle groups and they are relatively technical in execution. Many trainees have found that these exercises therefore suffer more than other exercises if they are performed in a fatigued state.

Not all research shows that pre-exhausting a muscle group decreases work capacity. If you don't do much volume, the overlap between exercises isn't too large and you have long enough rest periods, your work capacity may not suffer from pre-fatiguing. So again, if you have good reason to put an isolation exercise first, that may still be the best option. However, most trained individuals will find training the same muscle group with 2 exercises in quick succession impairs total work capacity.

In conclusion, to maximize total work capacity and thereby likely training adaptations, more compounded exercises should generally be performed before isolation exercises. This particularly holds for compound and isolation exercises involving the same muscle groups, but it may even hold for exercises without overlapping muscle groups.

Optional: Curious study results from Brazil

Interestingly, 2 Brazilian studies found that pre-exhaustion *increases* total body work capacity during tri-sets (which we'll discuss in more detail later). Performing leg extensions first in a tri-set with squats and leg presses resulted in more total work than perform the squats first. Similarly, performing the pec deck first in a tri-set with the bench press increased total load lifted compared to starting with the bench press. However, the pec deck and leg extension loads in these studies were unnaturally high, close to the loads used during squatting and bench pressing. If we cut these loads in half, as is more likely with common gym equipment, these studies confirm that most people can lift more total tonnage when starting with compound lifts and performing isolation work later.

3. Start heavy

Given the same priority for a given muscle group, perform your lower rep exercises before your higher rep exercises.

Bro wisdom holds that lower rep sets induce more neuromuscular fatigue than higher rep sets because of neural fatigue. This is false. It's in fact completely the other way around. A given number of higher rep sets induces more neuromuscular fatigue than the same number of lower rep sets [2, 3, 4] and requires higher subjective effort. Even performing 15 1RMs does not induce as much neuromuscular fatigue as 5 sets of 10 reps. You already accumulate greater neuromuscular fatigue after a single 10RM or 20RM set than after a 5RM set.

It's perfectly logical that high rep sets induce more fatigue than low rep sets. Let's compare 3 reps with your 3RM, 90 kg, vs. 10 reps with your 10RM, 75 kg. After both sets you cannot complete another rep. However, after the 3-rep set that means you cannot lift 90 kg anymore, whereas after the 10-rep set you cannot even lift 75 kg anymore. Thus, the muscles are evidently more fatigued after the 10RM set. The reason the muscles are more fatigued is because they have completed more work. Higher and lower rep sets induce the same amount of neuromuscular fatigue when total work is the same in both cases (sets x reps x weight). Some research also finds similar neuromuscular fatigue after 5 sets of 3 reps vs. 3 sets of 12 reps.

In the programs you learn to design in this course, you often start heavy automatically, because you generally perform compound exercises before isolation exercises and you perform the compound exercises with a higher intensity than the isolation exercises.

4. Implement antagonist supersets when feasible

When possible without interfering with total work capacity, try to superset exercises stimulating muscles with opposing functions.

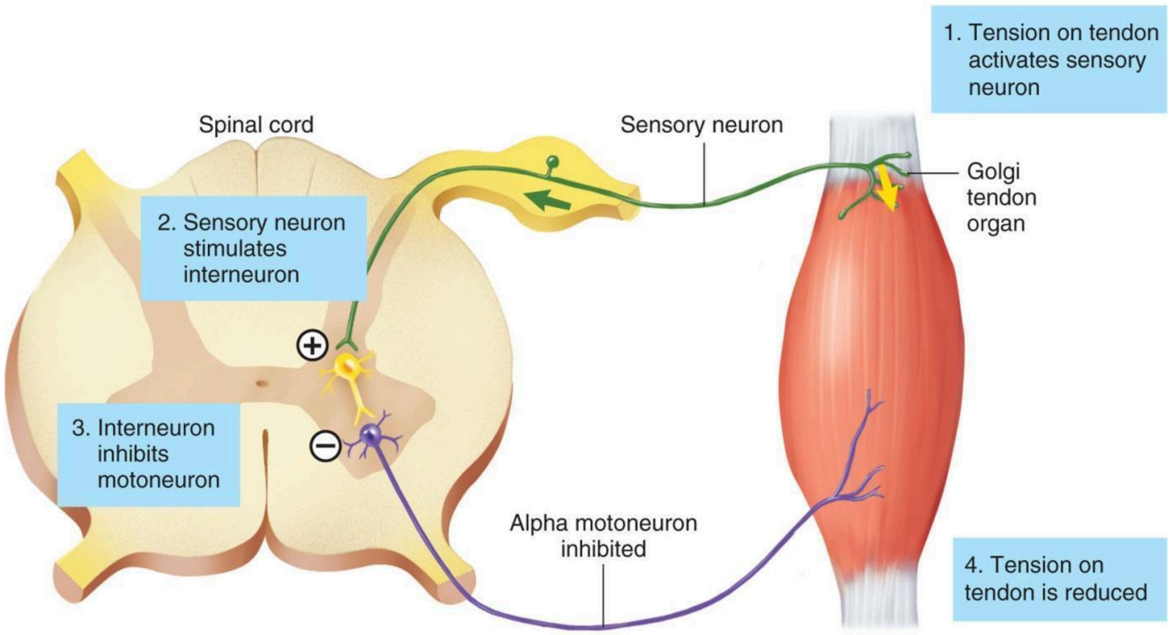
Rest normally increases performance by allowing recovery from fatigue. However, in the case of antagonistic supersets, shorter rest periods can *enhance* performance.

An antagonistic superset is when you perform 2 exercises involving muscles with opposing functions back-to-back without rest in between them. Think biceps curls and triceps extensions, bench presses and horizontal rows or leg extensions and leg curls. More technically, an antagonist is a muscle that moves a joint in the opposite direction of the agonist, which is a muscle that causes movement. During a biceps curl, for example, the biceps is an agonist and the triceps is an antagonist, because the triceps can perform elbow extension, the opposite movement of the elbow flexion that occurs during the biceps curl.

To understand the effects and mechanisms, first the effects of antagonist *stretching* will be discussed. The mechanism is important, because if it's not neuromuscular, it is very doubtful if any increased performance will translate into considerable long-term benefits for muscle growth. Passive or purely mechanical benefits like energy storage in the tendon complex can increase strength acutely, but they won't change the effectiveness of the training for your muscles.

Antagonist stretching & mechanism of action

Stretching your pecs before doing rows increases rowing performance [2]. Pec activity was unaffected, so reduced antagonist co-activation does not appear to be the mechanism of action of antagonist stretching. Lat activity was significantly higher and interestingly, biceps activity slightly increased as well during the rows. Greater muscle activity suggests a neuromuscular benefit, which would be good for muscle growth. Static stretching of the hip flexors and dorsiflexors has also been found to acutely improve subsequent jump height, and stretching the hamstrings can potentiate leg extension strength. In this study, there was an increase in quad activity and a reduction in hamstring activity during the leg extensions, but neither effect came close to reaching statistical significance. The precise mechanism of action of antagonist stretching remains unknown, but it does not appear to be passive. Antagonist stretching does not reduce passive resistance from connective tissues during agonist movement. It thus seems like the muscles are doing more active work after antagonist stretching, so this should benefit muscular adaptations. One hypothesis is that antagonist stretching inhibits the Golgi tendon organ and muscle spindles, which would essentially 'take the brakes off the muscle', as illustrated below.



The Golgi tendon organ and muscle spindles are similar receptors that monitor tension and stretch, respectively, of your muscles. When these receptors activate, they can limit muscle contractions for your safety. Thus, deactivating these receptors can increase muscle activity and strength.

Fortunately, stretching isn't the only way to potentiate antagonist muscles. Dynamic muscle contractions work even better, suggesting that the mechanism is related to fatigue of the antagonist.

The effects of antagonist supersets

Multiple studies find antagonist supersets can improve performance over performing the same exercises as straight sets, given the same rest between exercises of the same muscle group, thus saving a lot of time with the antagonist supersets.

- When you perform a set of bench presses right before you do a set of seated rows, lat and even biceps activity increase and you can perform more reps during the seated row.
- Performing a whole-body workout as antagonist supersets increases total work output compared to performing the workout as straight sets [2].
- Doing rows before bench throws increases power output.
- In another study, performing rows immediately after bench presses also increased performance in **both** exercises across sets. However, the greater performance here could simply be the result of resting longer in between sets. The rest interval was 2 minutes between paired sets compared to 2 minutes between sets in the traditional set-up. That means the paired group had a longer rest period between sets of bench presses and rows equal to the time it took them to perform the antagonist set.

Interestingly, the order of the antagonist superset matters. One study found that benching first compared to rowing first led to greater rowing performance with no effect on bench press performance of either order. It seems performing the bench press first works better than rowing first, perhaps because the pecs are more fast-twitch dominant in most people, because a similar asymmetry in ordering effectiveness has been found in the lower body. Doing leg curls before leg extensions increases performance while decreasing perceived exertion compared to the other way around. So it's better to put the hamstrings before the quads in the antagonist superset. Perhaps fast-twitch muscles benefit more from antagonist fatigue.

Timing is another crucial factor that determines how effective antagonistic supersets are. The potentiating effect of the antagonist training rapidly decreases within the first minute. When the rest interval exceeds 2 minutes between antagonist sets, there is no longer any acute or long-term benefit in strength, size, power, endurance or muscle activity.

Interestingly, antagonist supersets and stretching do not seem to enhance muscle activity or performance in isokinetic machines, which maintain a constant movement velocity throughout an exercise, as much as with free weights. In one study, pre-fatiguing the hamstrings *decreased isokinetic* leg extension performance by increasing hamstring co-activation without affecting quadriceps activity. In other words, the fatigued hamstrings were overly active during the leg extensions, resulting in impaired performance even though the quads were doing their job. In another study there was only a potentiating effect when the participants performed the isokinetic leg curl right before the leg extension and there was no difference between the antagonist superset group and the traditional set group. Eccentric, isokinetic hamstring strength also doesn't seem to benefit from antagonist stretching. The first study above found that the decrement in performance was worse the slower the repetitions were performed. Other research found that antagonist stretching only increases performance of fast and not of slow repetitions or not at all. This means antagonist supersets benefit from a more explosive repetition tempo. These effects may be mediated by muscle spindles, which are stretch receptors that register the rate at which muscle length changes (as well as muscle length itself).

Since antagonist supersets may increase strength, power production and muscle activity, at least with conventional strength training equipment, they should result in greater long-term muscle growth and strength development when properly implemented. However, the effect seems to be too small to detect in the limited, short-term studies we have.

- Robbins et al. (2009) had strength trained men perform an 8-week strength training program composed as either straight sets or antagonist supersets. Unfortunately, the superset group performed pulling exercises before pushing exercises, so they didn't use the ideal order. As a result, they didn't achieve increased muscle activity and unsurprisingly then, there was no significant difference in strength or power development between groups.
- Burke et al. (2024) compared antagonist paired supersets vs traditional straight sets in 43 strength-trained men and women. The supersets were: 1) lat pulldown → bench press, 2) leg curl → leg extension, and 3) biceps curl → triceps pushdown. After 8 weeks, there were no significant differences between the groups in strength development, muscle growth, power or strength-endurance. There was also no difference between the groups in total volume load. However, one important limitation of the study is that the ordering of the antagonist paired sets varied based on equipment availability, so again they may not have been using the ideal orders. The superset group completed their workouts in 36% less time.

Other studies [2] on antagonist paired sets equated the training volume between groups, which defeats the purpose of using antagonist pairings. Unsurprisingly, these studies didn't find significant effects of antagonist supersets on the participants' gains, although one of them found the antagonist superset group achieved a greater increase in strength-endurance (reps to failure at 60% of 1RM), suggesting supersets may improve fatigue resistance.

All in all, we don't know exactly why antagonist supersets can enhance performance, but the worst-case scenario is that they save you a lot of time without any downsides. Best-case scenario, both exercises in the superset achieve higher muscle activity and performance levels, which should translate into slightly increased muscle growth and strength development.

Application

With no downsides and potential benefits, the rational decision is to implement antagonist supersets when conveniently possible. However, it's not very often that you happen to have 2 potential exercise candidates for antagonist supersets in the same workout and you can hog the required equipment so that you can perform them back-to-back with minimal rest.

When you do have this option, it's good to put exercises that train opposing muscle groups in antagonist supersets. Try to minimize the rest periods in between these exercises and perform them with explosive concentric contractions for maximal benefit. Putting the exercises that train the more fast-twitch or explosive muscles first may increase the superset effectiveness further.

Remember that the primary purpose of antagonist supersets is to increase total training volume. So if you're completely exhausted after a set of bench presses, you may not want to stumble on to perform a set of chin-ups immediately if this limits how many reps you can do. Performing the same number of sets in a whole-body workout all as antagonist supersets can decrease total work capacity compared to performing the whole workout as straight sets. The decreased work capacity is probably the result of increased exertion and cardiorespiratory demands. It does cut the workout duration practically in half, but the stimulus for muscle growth is probably impaired in this scenario. To get around this problem, either rest a little between antagonist supersets or rest a bit longer after the superset.

5. Use combo sets

String together exercises in your program that don't train overlapping musculature and perform those as circuits while catching your breath in between sets.

Supersets. Judging by the name, you should be doing them. Indeed, if they are antagonist supersets, as we discussed above, they may be worthy of the name. But what about when you string exercises together that train non-antagonist and non-overlapping muscle groups?

First, definitions. As usual, not everybody agrees on them, but these are the ones that many people will understand and make sense. A superset is when you perform multiple exercises involving unrelated body parts back-to-back before resting. For example, instead of bench press, rest, bench press, rest, leg extension, rest, leg extension, you do bench press, leg extension, rest, bench press, leg extension, rest. If you string 3 exercises together it's a tri-set. Any more than that is generally called a giant set or circuit training. Cool terminology aside, do supersets and derivatives actually achieve anything special for your muscles when you're not pairing up antagonistic muscle groups?

In short, no, but you save a whole lot of time by overlapping your rest intervals. Most studies have found that supersets and the like don't significantly differ from straight sets in the muscular gains they stimulate, but they can decrease the workout time by up to 50% [1, 2, 3, 4, 5, 6]. For example, Alcarez et al. (2011) compared full-body strength training workouts organized as either straight sets or tri-sets in untrained men. The tri-set group strung together leg curls, bench presses and calf raises and later lat pulldowns, squats and biceps curls with 35 seconds of rest in between sets, only enough to move from one exercise to the next. The straight set group performed the same exercises in the same order but with 3 minutes of rest in between sets. The programs had progressive overload at 6RM loads. Both groups had similar gains in terms of lean mass, fat loss, power and strength. The tri-set group finished their workouts 20 minutes earlier. García-Orea et al. (2023) also found similar muscle growth and strength development in strength-trained men performing squats and bench presses either as 'supersets' (with 45 s rest between sets) or as traditional sets, but the 'superset' group cut their workout time roughly in half. The interpretation is simple: same total work done, same results.

And if you have limited time to train, supersets and derivatives are arguably the single most effective strategy to increase your gains, as you can get a whole lot more sets done in the same time [2, 3].

However, being able to perform the same amount of work with supersets as with straight sets is not a given. Performance often suffers when there is no rest in between sets of compound exercises, especially in stronger individuals (see section on rest intervals). A study by Iversen et al. (2024) found supersets reduced strength gains. The researchers compared 2 groups of novice lifters doing either traditional straight sets or supersets of bench presses with rows and leg presses with pulldowns at 6-12RM. The superset group rested 2.5 mins after each paired superset, whereas the traditional group rested 2.5 mins after each set and finished all sets before moving on to the next exercise. After 10 weeks, the straight set group experienced significantly greater strength gains in the pulldowns and a trend for greater strength gains in the rows. Both groups built a similar amount of lean body mass and lost a similar amount of fat (based on InBody scans). The lower strength gains were likely the result of the lower training volumes of the pulling exercises when they were performed in a fatigued state, although these differences didn't reach statistical significance.

So what if you want to cut your workout length in half but you don't want to sacrifice gains? Fortunately, there is a very simple solution to the problem of impaired work capacity during supersets. Many people are stuck with the idea that you must either do supersets or traditional sets, but you can get the best of both worlds: ‘supersets’ with rest in between exercises. Menno has coined these combo sets. combo sets. Combo sets are like supersets or circuit training, except that you do catch your breath in between sets and the ordering of the combo is flexible. The exercises you combo together should not involve significant overlapping musculature. An example combo could be squats, overhead presses and chin-ups. The more exercises you combine, the more time you save, because your rest intervals are used for multiple exercises at once instead of just one. If you cannot do one exercise because the equipment is occupied, you just do the next one that's available.

Full-body workouts with combo sets are insanely time- and space-effective. You can often do your whole workout as 1 big combo set and easily cut its length in half compared to straight sets. Plus, if everybody trained this way, equipment would only be occupied for the actual duration of exercise instead of also the rest interval. Currently, most equipment is occupied while not being used most of the time, which is only reasonable for heavily loaded barbells and the like.

Another benefit of combo sets is that they allow you to prioritize multiple exercises and allow more balanced physique and strength development. As discussed above, the exercises you perform first are the ones that will progress most. By stringing together, say, bench presses, squats and chin-ups, you can give maximum effort for practically the whole body, whereas if you’d perform all your sets of squats and then all your sets of bench presses, you may not be able to get maximum performance anymore for your chin-ups and thus you’ll inadvertently deprioritize back development in your program.

With combo sets, large combinations can also improve work capacity. If you combine 3 or more unrelated exercises, this typically increases your rest intervals between sets for the same muscle group. With 3 exercises in a combo, even with just 1-minute rest in between sets and 30 second sets, by the time you're back to the first exercise, you'll have rested those muscles for 4 minutes. That's generally enough for significant recovery. Kadota et al. (2024) found that combo sets (which they called paired sets) increased how many reps per set their participants could do compared to traditional sets done over the same time. As such, a strong case can be made for 'circuit training with rest'. Circuit training has become fashionable mostly among novice women that aren't motivated enough to train without the social pressure of a group class, but unlike most advanced techniques that some famous bodybuilder pulled out of thin air because they seemed cool, circuit training was designed by Morgan & Anderson at the University of Leeds in 1953. It is an extremely time-efficient way to train. Just ignore the part about not resting at all in between sets: do combo sets instead of circuits.

In terms of fat loss, many people *feel* like they burn more energy with supersets than with traditional sets, but what you feel is stress on your cardiorespiratory system. You're out of breath and your heart rate is elevated. Because you're effectively doing light cardio and strength training at the same time, you may also expand more *mental* energy. However, mental energy is better described as motivation in this case. Calories are measured by physical energy. In physics, energy is measured as work. Work is equal to the product of force and displacement ($W = f * d$). Time doesn't enter into it. You're lifting the same weights in the same manner for the same distance. Thus the same workout burns the same amount of energy regardless of whether it's performed traditionally as straight sets or with supersets, antagonistic supersets or in a circuit. There is a tiny bit of extra EPOC with supersets compared to traditional sets, but it's trivial: 18 kcal for a full-body workout. As we discuss in the Energy and Cardio modules, EPOC in general is overrated and normally doesn't rise above 100 kcal. As a result, fat loss will not be meaningfully affected by your exercise order, given a certain total work volume.

Summary on exercise ordering

- When a muscle suffers neuromuscular fatigue, its motor skills decrease along with muscle activity and total work capacity. As such, fatigued muscles may not adapt as well to being trained as fresh muscles. The earlier in a workout you perform an exercise, the more it will progress in strength. So put your most important exercises first, especially when there is overlap between the target musculature of the different exercises.
- When there is no difference in importance of the exercises, total work capacity should be maximized. Assuming you can recover from it, a greater training volume should increase muscle growth and strength development.
- When you do compound and isolation work for the same body part in the same session, doing the compound work first will generally maximize total work capacity. If you perform the isolation exercise first, the fatigued muscle can become a limiting factor during the subsequent compound exercise, thereby potentially limiting the stimulation of the other involved muscles. Pre-fatiguing a muscle does not improve its muscle activity or growth.
- When you perform higher and lower rep sets for a muscle, performing the lower rep sets first will generally maximize work capacity, because higher rep sets induce more neuromuscular fatigue than lower rep sets.
- Given the same total work, supersets and circuit training result in the same energy expenditure, fat loss, muscle growth and strength development.
- Supersets and circuit training can save you a lot of time in the gym, allow you to prioritize multiple exercises and maximize total work capacity by allowing long rest periods between sets for the same muscle group. However, remember that the goal is to maximize total work capacity, not to test your endurance, so you should rest in between all sets, even in between different exercises. We call these circuits with rest in between all sets combo sets.

- Antagonist supersets are the exception to the rule of avoiding supersets. When practical, employ them and place more fast-twitch muscle groups first in the antagonist superset.