Sex-specific programming

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Contents

Most of the things you learned in the course apply to both sexes alike. However, there are a few considerations that influence program design specifically for women. Some of these are obvious, such as pregnancy, whereas others are more subtle. In this module you'll learn about sex differences that are relevant for strength training and how to manage female-specific phenomena like menopause.

➢ Lecture

Sex-specific programming

There are no exclusive contents in the lecture, so you can skip the lecture if you prefer reading.

The natural muscular potential of women

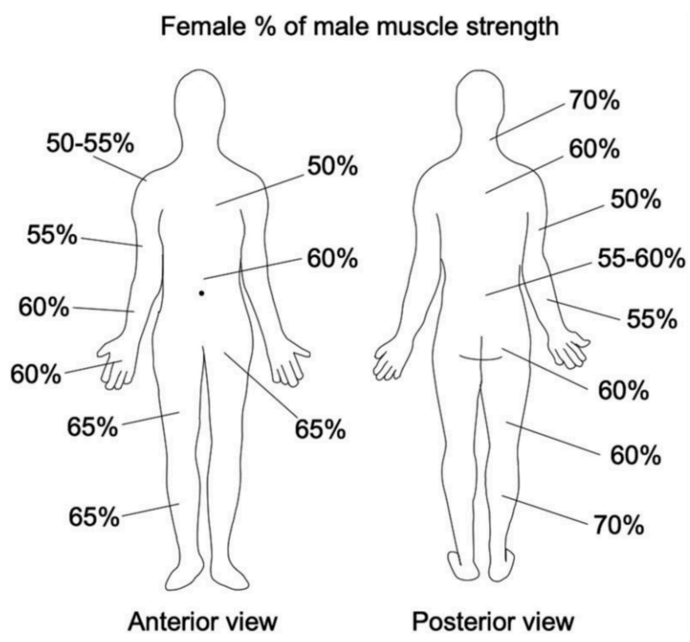
What can you achieve as a female lifter? There seem to be 2 camps. The general public thinks a woman that touches a loaded barbell will wake up the next day as the She-Hulk.

People with a bit more understanding of exercise physiology realize that this is obviously nonsense. Take a look around you in the average gym and it's clear that getting seriously big is difficult even for men. The statistic that women have ~15 times less testosterone than men is often quoted to explain that as a woman, you can't grow much muscle anyway. So the common recommendation in today's fitness circles is that women should train like men and should expect not to see much muscle growth.

Let's look at how the natural muscular potential of women compares to that of men in scientific research. Percentage wise, how much muscle can a woman build compared to a man? Does it scale with testosterone so that women can build only ~7% as much muscle as men? Is it about half?

It's 100%. Women gain the same percentage of muscle mass as men from weight training. And women tend to gain *more* relative strength than men from strength training [2, 3, 4, 5, 6, 7]. A man and a woman starting with the same baseline muscle mass and strength should thus be able to gain muscle and strength at the same rate.

The only difference is the starting point. Men start off with more muscle mass and more strength, especially in the upper body (see graphic below), as well as greater strength for their muscle mass [2]. Therefore, the absolute amount of muscle and strength built in kilos or pounds is generally greater in men, but the relative (%) increase in muscle size and strength is the same between men and women (or even greater for women for strength).



Source

Research on protein metabolism comes to the same conclusion. Women build just as much muscle protein after training and after meals as men. One study even found that given the same level of muscle mass, women have a higher rate of muscle protein synthesis than men.

Women vs. men in elite sports

If you think this is all just silly theory from lab coats studying beginners, consider this. Elite, natural female athletes have 85% as much muscle as elite male athletes. The studied sports include Olympic weightlifting and powerlifting.

In line with this, cross-sectional comparison of high-level natural physique competitors suggests the upper fat-free mass index achievable by women is about 20 compared to 25 for men, a mere 20% difference.

The 15-20% difference in muscular achievement between men and women can easily be explained by 3 factors.

1. Women have a genetically higher body fat percentage. Women have ~12% essential body fat to regulate their hormones compared to just ~3% fat in men. Even intramuscular fat levels are higher in women. The higher essential body fat stores can aid survival and provide reserves for pregnancy. And, you know, boobs.
2. Many people have lower expectations of women, even most women themselves underestimate what they can achieve physically compared to men. In a famous study, simply telling people they were on steroids increased their strength gains by 321%. These were advanced trainees already benching and squatting over 300 pounds (137 kg) before taking the fake steroids. Moreover, the androgenic-anabolic steroid protocol in question was just 70 mg of Dianabol per week. Giving that same dosage of actual Dianabol to advanced trainees

improves strength by only a few percent. So what do you think it does to women when you tell them they have 15 times less testosterone?

3. There are significantly more men in sports, so at the elite level, the selection to get to the top level is stronger. Elite male athletes are likely the best the male race has to offer. For women there may be more potential world record holders that will never know it, because they don't try.

What about testosterone?

Within an individual, more testosterone means more muscle mass. There is little doubt about that. Between sexes, however, the relation becomes much weaker. In their study of elite athletes, Healy et al. concluded that "The difference in lean body mass is sufficient to account for the observed differences in strength and aerobic performance seen between the sexes without the need to hypothesize that performance is in any way determined by the differences in testosterone levels."

How can this be? First, testosterone functions differently in men and women, so a given amount of hormone may have stronger effects in women than in men. In animals we have a decent understanding of why testosterone is not needed for muscle development in females: muscle growth is not as dependent on androgen receptor activation. It seems growth factors like IGF-1 and growth hormone take over the anabolic role that testosterone has in men. IGF-1 correlates better with strength in women than in men. Since women have just as much IGF-1 as men and women produce ~3 times as much growth hormone as men, this may explain in part why having less testosterone does not limit how much muscle they can build. To make matters more complex, the sex hormones and growth factors interact and all these hormones also interact with your genes.

Second, women do generally have a lower starting muscle mass than men, corresponding to their lower testosterone levels. The testosterone difference just doesn't affect the *rate* of gains. This may be true in men as well. In the available research, there's no clear interaction effect between strength training and taking up to 600 mg testosterone per week (see module on dietary fat for more details). Testosterone causes standalone gains, as does strength training, but testosterone doesn't seem to amplify the gains from strength training.

Anecdotally, based on their responsiveness to androgenic-anabolic steroids, women benefit more from a given dosage of androgens than men. Women often benefit considerably from dosages of 5-10 mg per day of a given AAS, which in men is barely enough to suppress natural functioning.

In short, saying women have less potential to build muscle mass because they don't have as much testosterone as men is shortsighted, as there are significant sex differences in steroid metabolism.

The other sex hormone

Not only is testosterone not the great savior, estrogen is not the bad guy (girl?). Many people, including women, believe estrogen is bad for your body composition. The bad reputation of estrogen likely originated largely from male androgenic-anabolic steroid users, for whom estrogen elevations cause severe water retention and edema, as well as the potential for gyno ('man boobs': see the AAS module). Or maybe it's just that people intuitively think that if testosterone is good for muscle growth, then estrogen must have the polar opposite effect. Setting aside the side-effects (in men) of supraphysiological estrogen levels, estrogen has many positive effects for strength trainees.

- Estrogen aids in muscle repair.
- Estrogen is anti-catabolic and can prevent muscle loss [2].
- Estrogen protects your joints, bones and tendons from injury. During menopause, the decrease in estrogen coincides with greater susceptibility to muscle damage and injury.
- Estrogen may slightly help with fat loss. Low estrogen levels decrease women's resting energy expenditure and may decrease women's appetite, though estrogen's regulation of appetite is highly complex and often does not seem to result in fat loss. Estrogen also decentralizes your body fat distribution, making your waist slightly slimmer.

These aren't a few obscure and dubious findings. Hundreds of studies have demonstrated the anabolic effects of estrogen.

Why women aren't living up to their potential

If women have the same relative natural muscular potential as men, why don't we see more muscular women?

- Women are underrepresented in sports and in the gym. Even at the Olympic level there are fewer female participants. It is even true in science. There are over 50% fewer female participants in scientific studies than men.
- Many women in the gym spend their time on the treadmill or playing with pink dumbbells, because they are deluded into thinking they'll get too big otherwise.
- Cultural expectations differ for women. If a man benches a lot, that's often seen as a sign of social dominance and it's applauded. If a woman benches a lot, many men feel their pride sting and shrivel and she may be regarded as a freak.

- The women that train seriously despite the stigma often train like men, which doesn't align with their physiological strengths, especially not if they don't desire male muscular proportions. Women have a different physiology than men and should therefore train a bit differently than men. We'll go into sex differences in training and nutrition programming in the next section.

Sex-differences

Training

To understand why women should not train like men, it helps to understand the evolution of sex differences. Throughout evolution, a classical division of labor between men and women has existed. While this may suggest a stereotype of women as inactive, just-stay-at-home mothers with no physical prowess, this is unjustified. The activities of hunter-gatherer women would in our modern times be regarded as heavy manual labor. To quote a review on this topic by Keefe et al. (2011):

"…walking sometimes for hours to find, retrieve, and carry home items such as food, water, and wood. Women would also help to carry butchered game back to camp. These foraging efforts often demanded digging, climbing, bending, and stretching and frequently involved carrying heavy loads back to camp.
In addition, these hunter-gatherer women often had to carry their children for long distances. The average forager-mother carried her child until he or she was about 4 years, covering upwards of 3,000 miles with the child in her arms or on her back during this interval of time.
Other routine female responsibilities included shelter construction and butchering."

The more endurance type tasks women performed for millions of years resulted in significant differences in what the sexes are best adapted to. Overall, women have adapted to better handle more endurance-based exercise, whereas men have better adapted to explosive exercise. Here are the key physiological differences to consider when designing a woman's training program.

Fatigue resistance

Women are more resistant to fatigue than men [2, 3, 4, 5, 6, 7, 8], even when women and men with the same strength level are compared. You can often readily observe this in the gym: women can generally do more reps at a given percentage of 1RM than men, especially at lower training intensities [2, 3, 4, 5, 6, 7, 8, 9, 10]. In other words, women tend to have greater strength-endurance than men. The magnitude of difference varies per exercise.

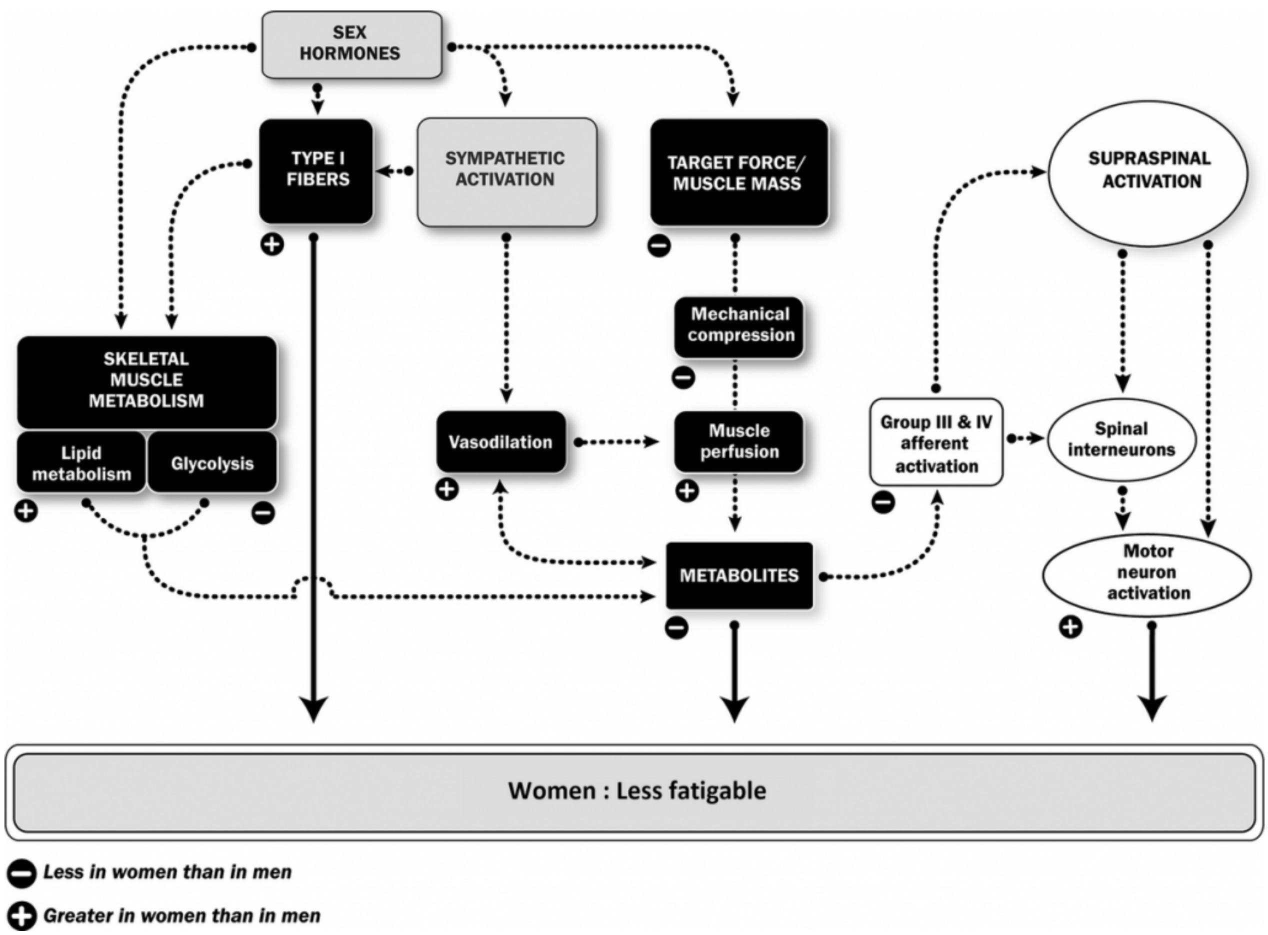
Women also lose fewer reps across sets than men [2, 3, 4, 5]: they have better work capacity.

However, the greater strength-endurance and work capacity of women disappear with near-maximal weights, around 80% of 1RM [2]. We'll go into this more in the next section on motor coordination.

There are multiple reasons why women accumulate less fatigue than men. First, women tend to have a higher proportion of type I muscle fiber volume [2, 3]. While untrained men and women have a similar fiber type distribution, this often changes with training: in strength training women, muscle fibers are converted to type I fibers or don't convert at all, whereas in men they generally change to type IIa fibers [2, 3]. A 2023 meta-analysis also found that women on average have a greater proportion of type I fibers than men.

Second, women accumulate less metabolic stress than men, particularly in type I fibers. Women have lower arterial blood pressure during exercise, so they can get more blood and oxygen to their muscles than men. Less metabolic byproducts accumulate in the blood, so the muscles are capable of functioning for a longer time under stress than in men. Women's greater resistance to neuromuscular fatigue may disappear during blood flow occlusion training according to some research though not all [2], suggesting women clear metabolic waste more effectively from their muscles than men.

The following graphic from Hunter (2014) summarizes the reasons why women are more resistant to fatigue than men and are better suited for endurance exercise.



Women should probably train to their strengths: in contrast to men, in some research women seem to gain slightly more muscle mass from (very) high rep training than medium rep training. Most research has not found different muscle growth rates from the use of different rep ranges (in between 5-30) though.

Women likely also recover faster than men in the day(s) after the workout, just like they do in between sets. The faster recovery seems to primarily be attributable to lesser neuromuscular fatigue rather than a significantly faster rate of recovery of that fatigue.

- It takes male athletes significantly longer to recover their bench press strength after a given bench press workout than female athletes, even when matched for relative strength.
- When matched for neuromuscular fatigue within a bench press workout, trained women recover equally fast as trained men despite having to perform roughly double the repetition volume to achieve the same fatigue state.
- Amdi et al. (2021) found that women recover much faster than men after 5 sets of 5 squats at 80% of 1RM, based on squat velocity measured in the 72 hours after the workout. Women did not recover faster after 5 sets to failure at 4-6RM, but they could complete these at a higher intensity than men and the protocol was confounded by the women having to perform more near-maximal warm-up sets of 7 reps to find their 4-6RM, so effectively, the women recovered just as fast despite training with a higher volume and intensity. However, the women had a lower relative strength level than the men, so this may also have been a reason for their faster recovery.

Not all studies find that women recover significantly faster than men though.

- One unpublished study by Baggett (2015) found no difference in repetition performance recovery between men and women when trying to repeat a high-volume workout within 24 hours, but neither group achieved full recovery, so the study cannot tell us which group recovered faster in the end.
- Lewis et al. (2022) found no significant difference in the recovery of total repetition volume across 4 sets of leg extensions and biceps curls to failure in men vs. women. However, the data was incredibly noisy with inconsistent patterns of recovery over the 3 tested recovery periods (4, 24 and 48 h). In fact, there were no significant differences in performance over time, which would

suggest there was no fatigue at all. Thus, looking for any 2- or 3-way interaction effects was rather futile and this study cannot tell us much about possible sex differences. In absolute terms, it actually looked like the women recovered and supercompensated within 24 h after the biceps curls, whereas the men needed 48 h just to recover. For leg extensions, there was no clear difference in recovery: both groups seemingly supercompensated in 24 h.

All other studies have looked at more artificial measures of recovery than strength training performance, such as creatine kinase levels or isometric maximum voluntary isometric force production. The artificial training programs and measures make the practical relevance of most studies questionable, but the overall trend supports that women recover somewhat faster than men, probably in large part due to suffering less neuromuscular fatigue acutely. With one exception, all studies found that women recover faster than men (the majority) or at an equal rate [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. The most relevant studies are probably those by Häkkinen et al. (1993, 1994), which found female athletes suffer significantly less loss of force production and muscle activation (EMG) after 10-20 sets of squats and afterwards recovered faster, though the recovery difference wasn't significant at all time points. The exception is Davies et al. (2018), in which the women probably achieved a higher total work output and that resulted in greater fatigue and more prolonged recovery.

Women may also benefit from their higher estrogen levels in terms of protection from muscle damage vs. men, but most research finds no difference between men and women in direct measures of muscle damage. The anti-catabolic benefit of higher estrogen may be cancelled out by testosterone or other factors.

In addition to differences in training methods, participant training history and the measure of recovery status, many research findings are confounded by not controlling for menstrual cycle phase and the use of contraceptives. Minahan et al. (2015) compared the recovery profiles of men, women taking oral contraceptives (OCs) and women not taking OC. Compared to the men and OC taking women, the OC-free women experienced far less muscle damage post-workout. (We'll get back to the effects of contraceptives on strength trainees later.)

In practice we are interested only in force production during strength training exercises and the data on this support women suffer less from fatigue than men. Other measures of recovery capacity are academic. Women's resistance to neuromuscular fatigue should allow them to train with a higher volume or frequency than men. We don't have any direct research on the sex interaction in the dose-response curve of training volume or frequency, but if we compare similar studies in men and women, there is a tentative trend for women to handle higher training stresses better than men.

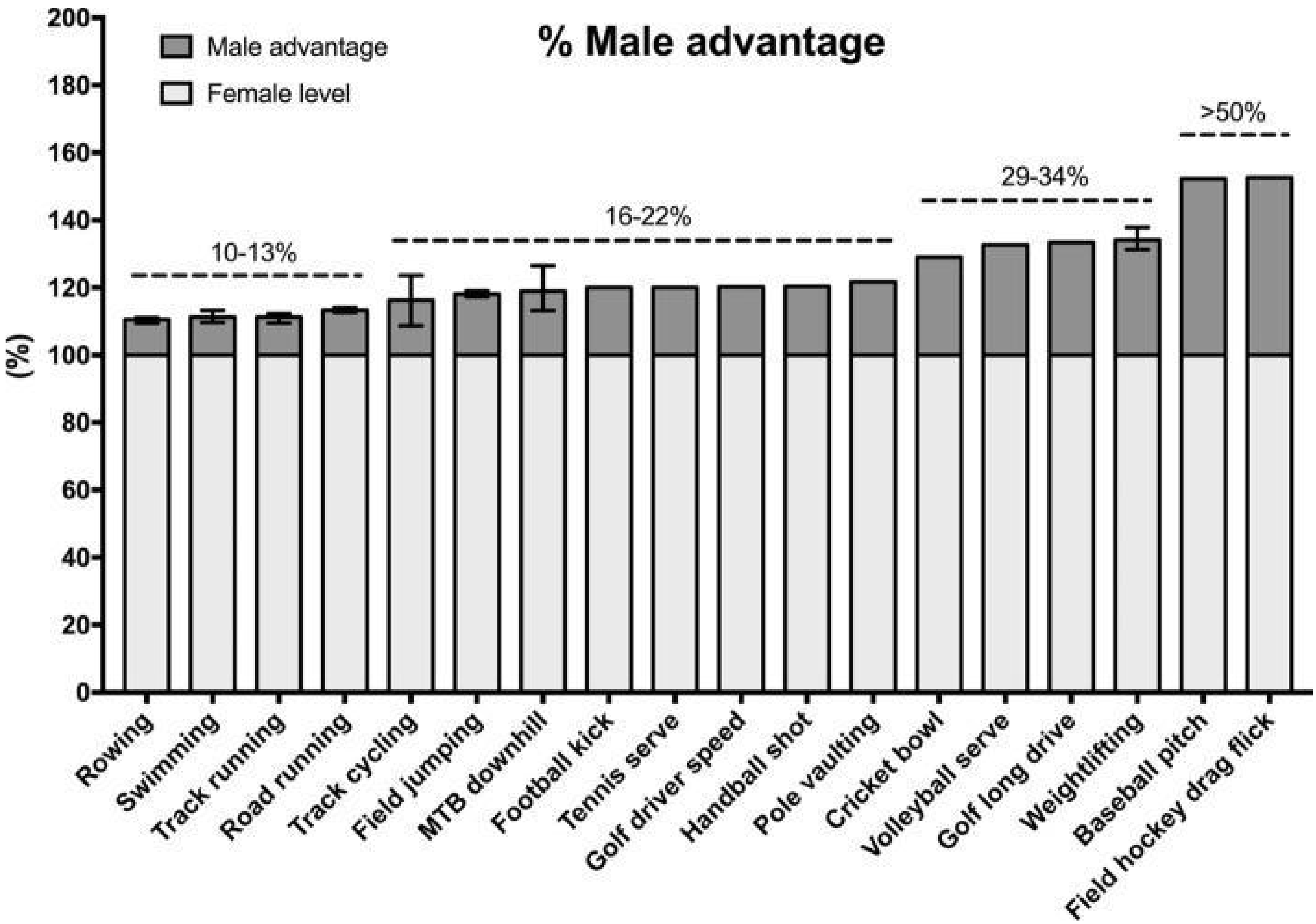
- Some meta-analytic research indicates women benefit from higher training frequencies than men.
- Massey et al. (2004) & (2005) compared the effect of training with a full vs. partial range of motion in men and in women. In men, the difference in strength gains did not reach statistical significance but in women it did. Women may have tolerated the higher stress from full ROM training better. The strength difference between groups was similar in both sexes though.
- Paulsen et al. and Rønnestad et al. didn't find more strength or size gains in the upper body when performing 3 compared to 1 set in men. New, still unpublished research from Vikmoen et al. from the *Norwegian School of Sports Sciences* has replicated this research in women. This time the 3-set group gained significantly more strength than the 1-set group. The women training with more volume also gained 62% more muscle mass on their arms, but this difference failed to reach statistical significance.

- In a study of accommodating resistance training, women gained more strength than men. There was also a consistent albeit statistically insignificant trend for greater muscle growth. Accommodating resistance training results in high muscle damage, as we'll discuss in the topics on exercise selection and advanced training techniques. It would make sense if women tolerate this damaging type of exercise better than men.
- In a study of how close to failure men and women should train, Rissanen et al. (2022) found tentative (not statistically significant) evidence that women benefit more from training closer to failure than men: "subtle but potentially meaningful greater gains in strength and lifting velocity were observed following 40% velocity-loss training in women, which was absent in comparison between men groups. It may be that women require a greater velocity loss (i.e., within-set fatigue) than men, especially in bench press, to maximize strength and power development. It, therefore, appears that programming of power training in women should consist of higher volume than currently used to induce adaptations in men."

In conclusion, women don't have to worry about neuromuscular fatigue as much as men.

Motor coordination

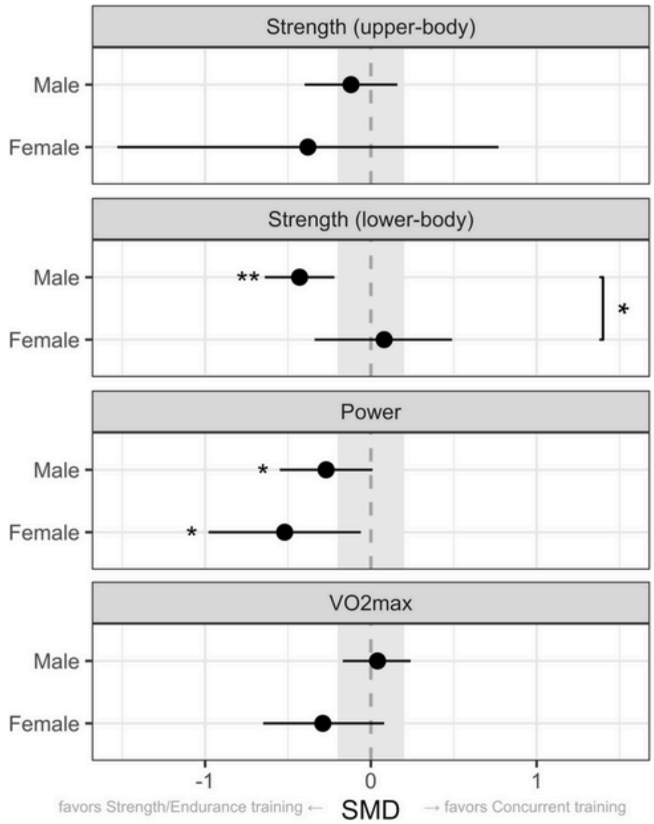
The superior work capacity of women disappears when training with weights close to their maximum strength (1RM). While women's muscles have great endurance, the female motor system is not as efficient as that of men. Men are more explosive than women: they can generate force quicker. The area in the brain that controls movement (the motor cortex) is in fact literally larger in men, even after correcting for height. During explosive exercise at very high training intensities (90+%), like powerlifting, men can sometimes even perform slightly more reps than women on average. A more efficient motor cortex is part of the reason men tend to do better in explosive sports.



Performance in sports for men relative to women according to sports federation databases and tournament records. Source

The interference effect

When you have strength and endurance training in the same program, especially if it's in the same workout, this can reduce the gains in endurance, strength, size and power compared to doing only strength or endurance training. This is called the interference effect or the concurrent training effect (see cardio module for more details). According to a 2023 meta-analysis, the interference effect may be less of an issue for women. The researchers found that the interference effect only exists in men, not in women, for the lower body. However, for the upper body, power and VO2max, there were no significant sex differences: see the data below.



Theoretically, women's greater fatigue resistance could explain the reduced interference effect. Women may suffer less fatigue and muscle damage from endurance training and thereby less interference. However, the above comparisons are made with far fewer data for women than for men. When making multiple comparisons with noisy data, there is a considerable chance of accidentally labeling some differences as statistically significant, when in reality there is no sex difference. Thus, the lower susceptibility for interference effects should be viewed as preliminary until we have more data from RCTs that directly compare men and women.

Application

There is a lack of empirical data showing exactly how the optimal program design from women differs from that of men, so we mostly need to rely on theory. For that reason, it's advisable to rely mostly on autoregulation principles to customize women's training programs after starting with a template that is like what you'd design for a male with the same specifics. Women should emphasize the following autoregulation strategies.

First, women should use the muscle-specific hypertrophy method from the course module on training intensity. Women then tend to automatically perform more reps per set than men. This increase in total work done may be beneficial for long-term muscle growth, especially in type I fibers. One large-scale RCT from 2023 by Cavalcante et al. found older women gain more muscle from training in the 10-15RM range than the 8-12RM range, despite gaining more strength with the heavier weights. However, it's unclear if this isolated finding resulted from the biological sex or the age of the participants. There was also a greater increase in hydration status in the higher-rep group, rendering it questionable if they really gained more muscle or just more water for some reason. Most research finds that men and women gain similar amounts of muscle from higher and lower reps in the 5-30RM range (see course module on training intensity). Regardless, the muscle-specific hypertrophy method should automatically optimize any sex-difference related to the optimal number of repetitions to perform per set.

More importantly, higher reps also tend to make strength progression more practical for women, because with typical gym increments of 5 lb. or 2.5 kg women have a hard time increasing the weight on exercises without immediately being close to 1RM weights. Going up in reps is generally easier for them. (We'll discuss progressive overload in greater detail in the module on periodization.)

Second, women should evaluate their work capacity to see if it's as high as expected. If it is, you can likely increase training volume in terms of the set number per muscle group per week. In practice, you can also start with a slightly higher training volume and only adjust it down in the unlikely scenario the woman has poor work capacity. This strategy is implied with the training volume calculator you received in the course module on program design fundamentals: it automatically assigns a slightly higher volume to women than to men.

In the topic on rest intervals, we'll go into autoregulation strategies to determine the inter-set rest interval. These are particularly useful for women, as women generally don't need as much rest as men.

Some meta-analytic research indicates women benefit from higher training frequencies than men. This tends to go hand in hand with their greater total volume tolerance. As such, you can be liberal with higher training frequencies for women. The same could be said for men though and any direct effect on muscle growth and strength development will generally be small, as you learned in the course module on training frequency.

Finally, women *may* suffer less from the interference effect caused by performing strength and endurance training in the same program. The cost-benefit of adding cardio to a strength training program may thus be more positive in women than in men.

Sex-differences in nutrition

Women burn more fat, less carbohydrate and less protein than men at the same exercise intensity. Since they rely less on carbohydrate as fuel, they also don't store as much glycogen during carb refeeds.

Both differences in the nervous system and the hormonal system, including estrogen, are responsible for women's lesser reliance on glycogen. For example, the fight-or-flight hormone adrenalin burns more fat in women than men. A more obvious is explanation is that women normally have a considerably higher fat percentage than men of the same weight, not only on their body but also within their muscles, so it makes sense to use this as the primary energy source.

Basically, women have a glycogen and protein sparing metabolism. This means women don't need as much carbohydrate or protein in their diet as men to fuel their exercise sessions.

The lesser need for carbohydrates frees up calories to consume as fat. Fats have very positive effects on the hormonal and cardiovascular health of women. In general, the more fat women eat, the more estrogen and testosterone they produce (see the course module on dietary fat). Testosterone and estrogen are both anabolic hormones, despite the broscience you often hear about estrogen.

Low-fat diets might even reduce breast size, in part likely due to the low sex hormone production, since estradiol and IGF-1 levels significantly correlate with breast size in women that aren't on the pill for birth control.

A high fat diet may also be easier to adhere to for women than men. Dietary fat is 15% more satiating in women than in men according to some research.

Women also have less to fear from potential negative effects of a low-carb, high-fat diet (which are already rare). Fats don't decrease insulin sensitivity as much in women as in men. Estrogen plays a large role here. It helps to keep inflammation in check, burn fat and preserve insulin sensitivity. Lower inflammation means polyunsaturated fats are less susceptible to oxidation, so they can exert their anabolic effects. Women in general have much better metabolic health than men and have a healthier body fat distribution.

In case you're worried about breast cancer, the relation between fat intake and breast cancer risk is found in poor epidemiological studies of inactive, overweight women eating processed junk fats, like processed red meats. Even then the relation is weak and controversial. Fats like olive oil seem to protect you from cancer. If you're lean, you don't smoke, don't go binge drinking too often, eat a healthy diet and you exercise, research has found time and again and again and again that you have nothing to fear from a high fat diet.

Back on topic, several studies have found that women with polycystic ovary syndrome lose more fat and less muscle on a low-carb diet compared to a low fat diet, even when protein and energy intake are tightly controlled. Several studies by Jeff Volek et al. have found similar results in overweight and healthy women, but these studies were confounded by more protein in the low-carb diets. An unpublished study from Trexler et al. found that women with more fat in their diet burn more calories during exercise, have higher bench press strength and are leaner. In Menno's experience with female clients, the benefits of fats vs. carbs depend on the woman's carb tolerance. However, the bro bodybuilding very-high-carb-almost-zero-fat diets are very unpleasant in the long-term for most women.

Women *theoretically* also don't need as much protein as men for several reasons.

1. Women oxidize less protein during exercise than men.
2. Women also burn less protein while fasted or after meals than men.
3. Due to their higher essential fat mass, women generally have less lean body mass than men of the same weight.

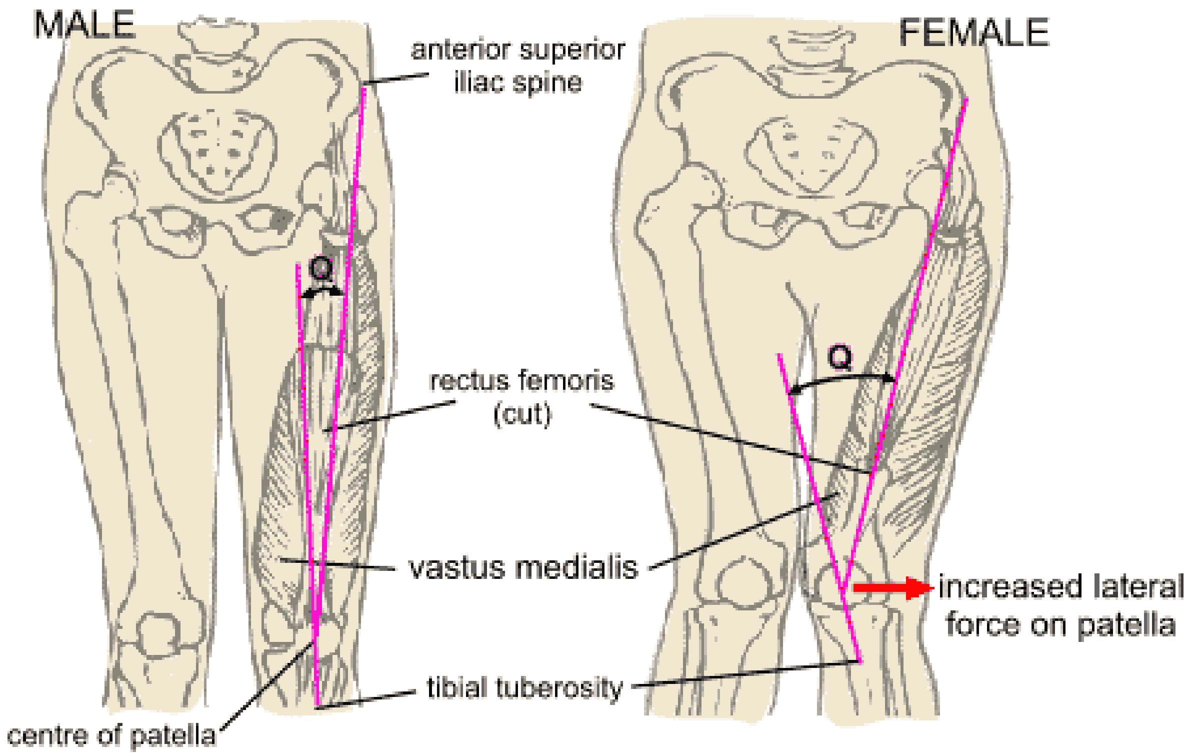
A meta-analysis found a trend that the protein requirement of women is approximately 10% lower than that of men; however, the difference was not statistically significant. A 2023 study on protein requirements for endurance trainees also found no significant sex difference. Since high protein intakes have many potential benefits, it's not advisable to set lower relative protein intakes for women than for men.

Application

As per the course topic on fat intake, women can err on the side of higher fat and lower carbohydrate intakes than men. You could theoretically reduce protein intake by up to 10%, but only do this if there is good cause for it: in practice, this is only if needed to stay in ketosis. It's generally safest to keep protein intake up at the same relative intake as for men.

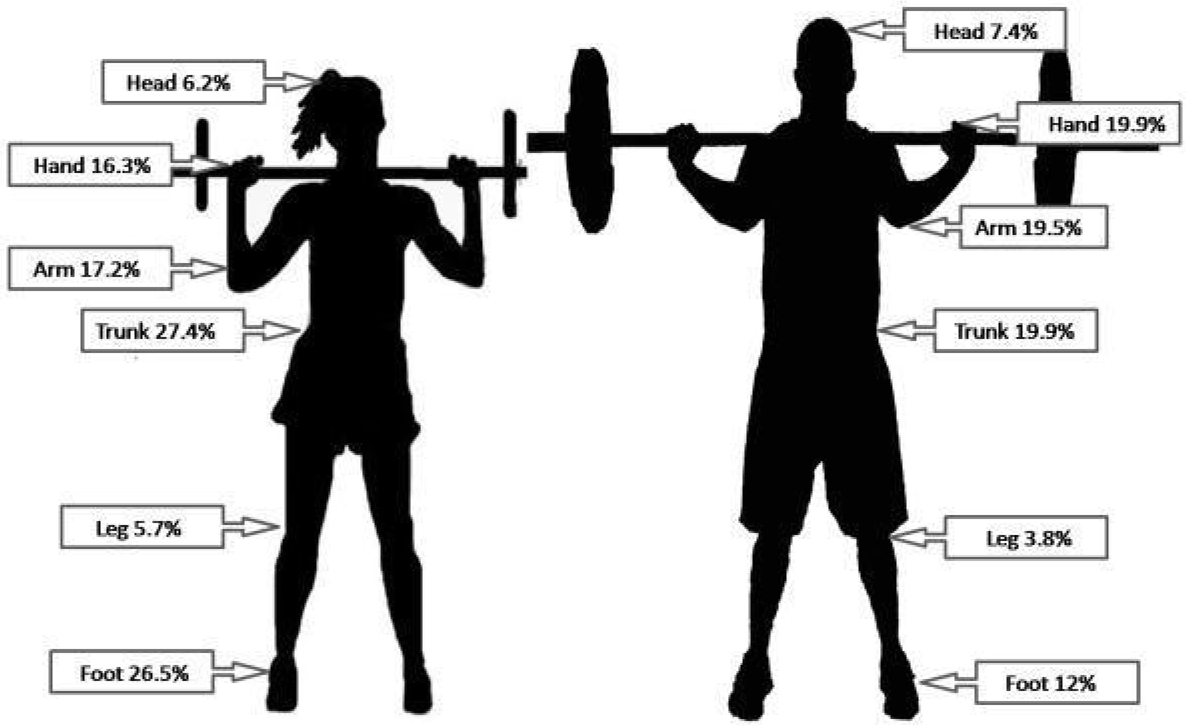
Anatomical differences

Despite seemingly large anatomical differences between men and women, few of these are relevant during resistance training. One notable exception is the Q-angle, the angle between the patellar tendon and the quadriceps muscles. Women have approximately double the Q-angle of men, because they tend to be shorter and have wider hips.



Women's greater Q-angle is generally an athletic disadvantage for 2 reasons. First, a greater Q-angle reduces force transfer from the quadriceps muscles to the knee joint, reducing knee extension torque. Second, a greater Q-angle increases the lateral forces on the patella for a given knee extension torque. As a result, women are more prone to knee injuries and extra care should be taken to avoid these. (Discussed in the course topic on injuries.)

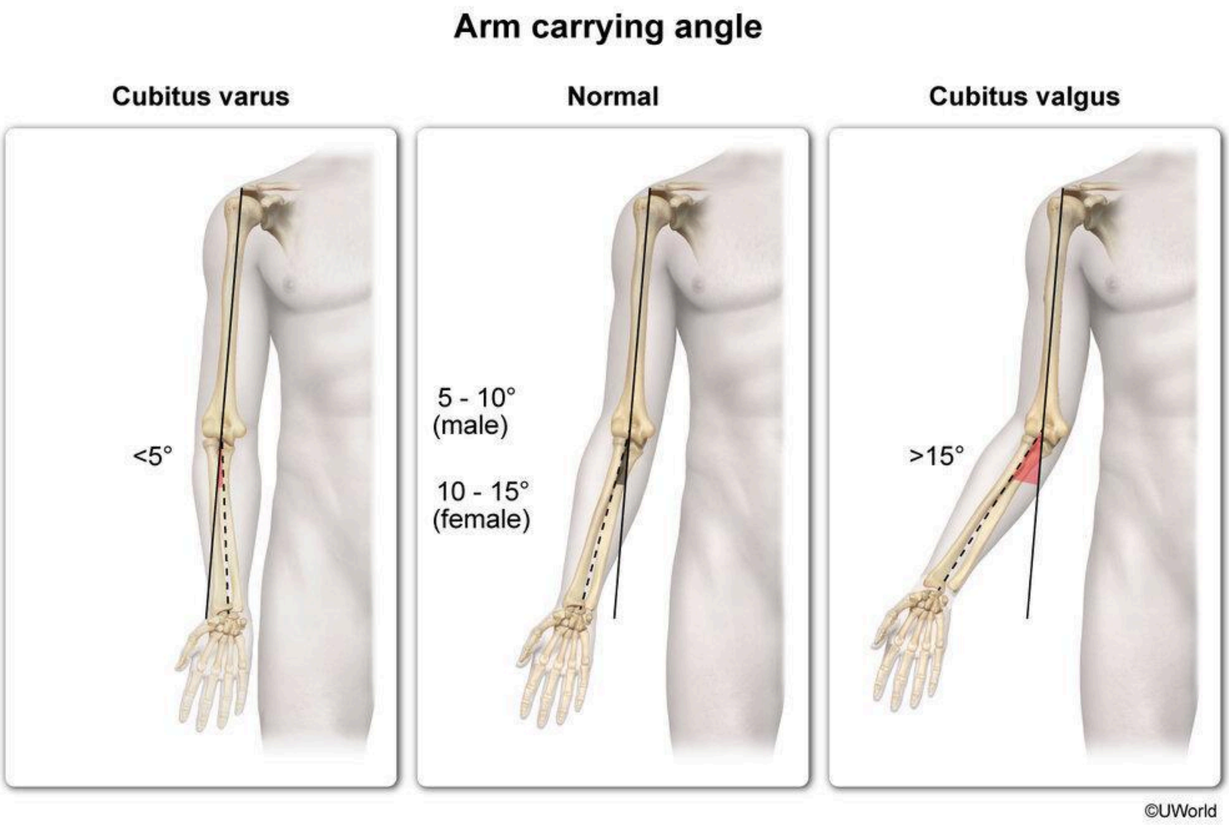
Other than the knee, in general women experience roughly the same types of injuries as men with the same frequency as men. However, some research finds men get injured far more often than women. The different injury rates are mostly the result of men doing more stupid stuff in the gym that causes acute trauma or overuse injuries, while women have more accidents, like dropping weights on their feet.



Frequency of injury locations per sex.

A second anatomical difference is that women have greater hip flexibility than men. Women in general tend to be more flexible than men. To protect the knees and stimulate the hip muscles, women should therefore consider low bar squats over high bar squats as a default training technique.

A third notable anatomical difference between the sexes is that men have a slightly lower carrying angle than women. The carrying angle measures how far the hands are turned out and away from the body in anatomical position (standing relaxed upright), as illustrated below. The carrying angle is negatively correlated with grip strength [2]. Men tend to have broader shoulders and narrower hips and therefore a lower carrying angle and an anatomical advantage over women in grip strength.



[Source]

Pain

While we're on the topic of injuries, common wisdom holds that women have a higher pain threshold than men. The common rationale is that women need to be able to tolerate a lot of pain while giving birth. However, in evolutionary terms, it's plausible that men in most cultures would benefit far more from an increased pain threshold due to their greater propensity to engage in fighting and hunting. In line with our evolution, an abundance of scientific research has concluded that women generally have a similar or lower pain threshold than men. Women tolerate most kinds of pain just as well as men, except pressure pain and thermal (heat/cold) pain, which men seem to bear more easily. That makes evolutionary sense, because these latter pains are exactly the kinds of pain associated with fighting and hunting outside in bad weather.

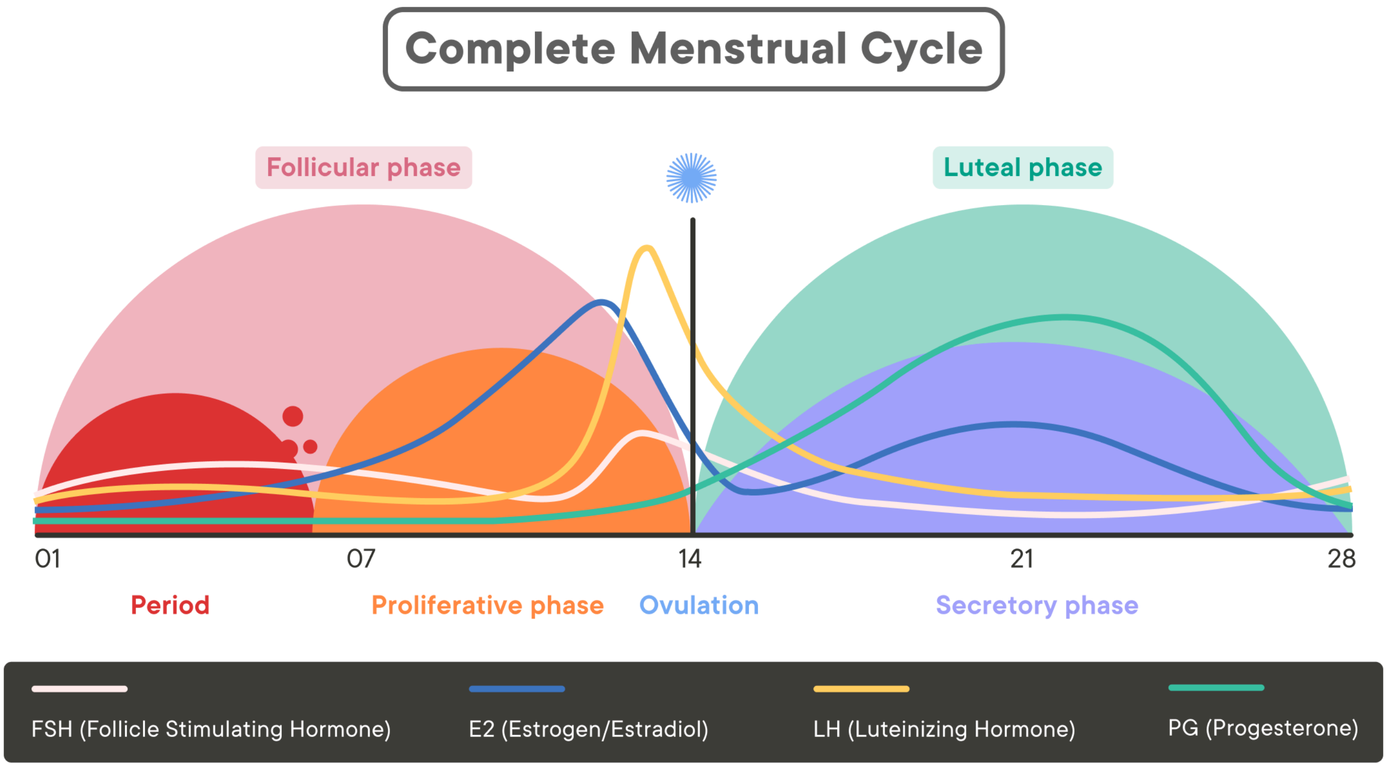
As such, you would expect that women are more sensitive to pain from the bar on their back during squats or the bar on their hips during hip thrusts. However, in Menno's experience there is no notable sex difference in pain reporting between men and women during strength and that's probably because the kind of women that do strength training are not your average women.

Appetite

In contrast to popular belief, there is no meaningful difference between the appetite regulation of men and women.

The menstrual cycle

Many hormone levels fluctuate across the menstrual cycle. Estrogen, specifically estradiol, and progesterone concentrations fluctuate strongly during the menstrual cycle. From the start of menstrual bleeding to ovulation – the follicular phase – estradiol levels tend to be higher than progesterone levels. From ovulation to the start of the next menstruation – the luteal phase – progesterone levels tend to be higher than estradiol levels.



How estradiol and progesterone levels fluctuate across the menstrual cycle. (Source [image](#) and [data](#))

Testosterone levels also peak around the start of the follicular phase, though the variation isn't nearly as large as for estradiol and progesterone.

Estrogen is commonly vilified as the hormone that makes you fat and frail, a reputation based largely on the results of male steroid users. This reputation of estrogen couldn't be more undeserved for women. As you learned, estrogen is anti-catabolic and aids muscle repair.

Progesterone, however, seems to be largely detrimental for fitness purposes, as it has catabolic effects on protein metabolism [2] leading to a reduction in protein balance. Progesterone can also act as a testosterone antagonist, blocking testosterone from exerting its anabolic effects. A study by Riechman & Lee (2022) found a negative correlation between the amount of progestin in strength training women's birth control pills and their rate of muscle growth. Reis et al. (1995) also found a negative correlation between women's gains in maximal strength and changes in their luteal phase progesterone levels, although the relevance of the change is difficult to interpret. Progesterone may also counteract some of estrogen's positive metabolic effects, such as increasing glucose uptake in muscle fibers and reducing protein catabolism. Research on progesterone's muscular effects is scarce though and lower levels are not always better. For example, progesterone treatment in postmenopausal women seems to increase muscle protein synthesis.

If estrogen is generally beneficial and progesterone detrimental for muscular development, the follicular phase should be prime time to build muscle. Estrogen levels peak in the follicular phase, whereas progesterone levels peak in the luteal phase. Based on these differences in hormone levels across the menstrual cycle, we'd expect training to be slightly more effective for our gains during the follicular phase. But do the data support this theory? Let's look at the scientific research.

Menstrual periodization effects

Ok, we admit it. We coined that term, pun intended. Scientists use less catchy phrases like 'menstrual phase-based strength training programming'. Whatever you call it, women can gain more strength and muscle by designing their strength training program in accordance with their menstrual cycle according to multiple studies.

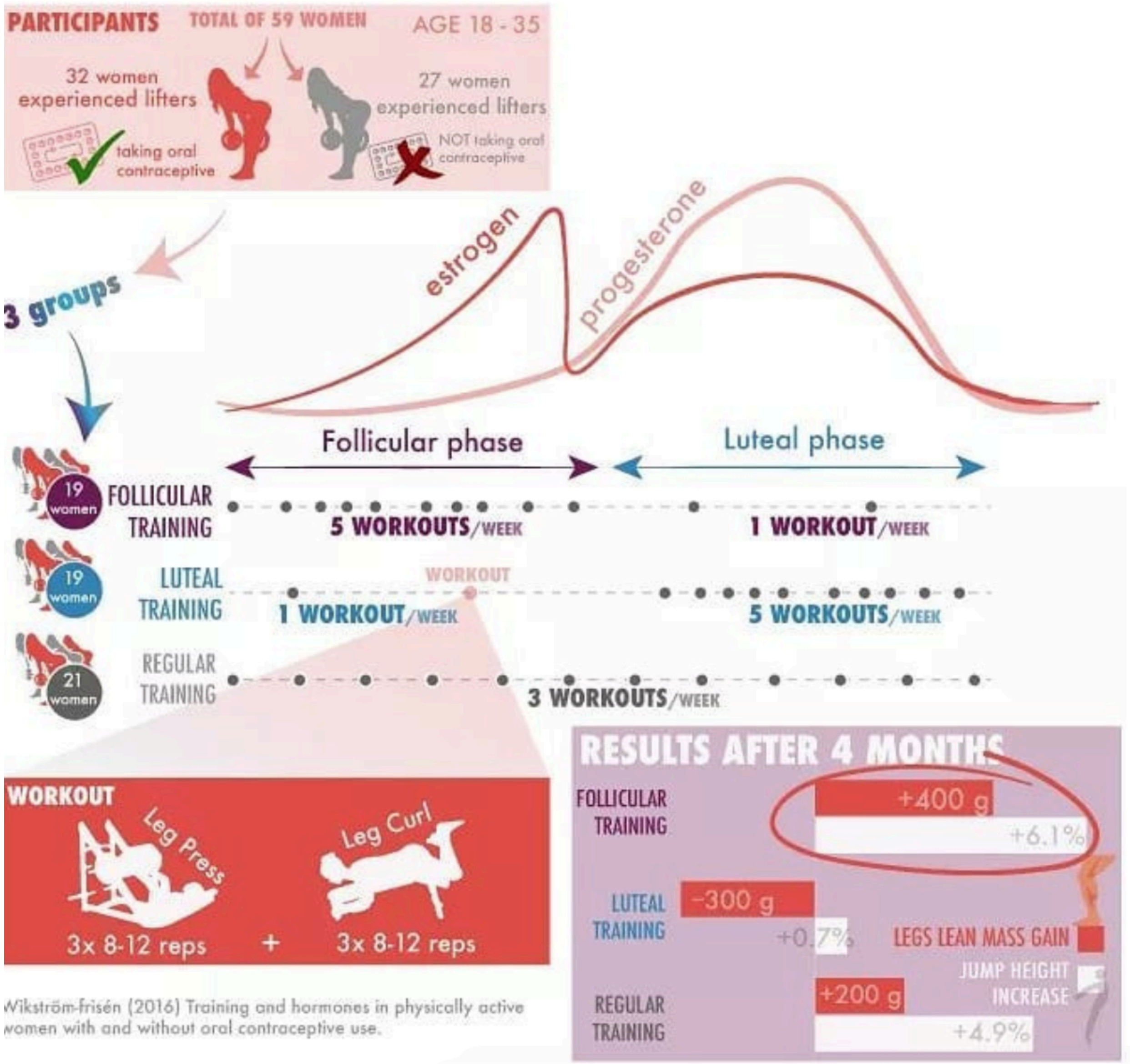
Sung et al. (2014) had 20 women train one leg with 8 workouts in the follicular phase and 2 workouts in the luteal phase for 3 months. The other leg trained with the higher training frequency in the luteal phase. The legs with more workouts in the follicular phase gained 42% more strength (maximum isometric force) and 46% more muscle (sum of 3 diameters) than the legs trained mostly in the luteal phase. Furthermore, the diameter of type II fibers and the nuclei-to-fiber ratio increased significantly in the leg that trained with higher frequency in the follicular phase; these changes were not observed in the leg with a higher training frequency in the luteal phase.

Earlier research by Reis et al. (1995) had compared training one leg with a constant training frequency of one workout every 3 days to a program in the other leg with a higher training frequency (every other day) in the follicular phase and a lower training frequency in the luteal phase. So same total workouts, just performed either regularly across the menstrual cycle, as most people do, or with a higher frequency in the follicular phase. The legs trained with menstrual periodization had a 33% increase in maximal strength compared to just 13% in the regularly trained leg.
In support of hormones as the driving force behind the effectiveness of menstrual periodization, there were positive correlations between the women's gains in maximal strength and estradiol & testosterone but a negative correlation for luteal phase changes in progesterone.

Wikström-Frisén et al. (2017), illustrated below, confirmed that having a higher training frequency in the follicular phase results in the best progress. This study was longer (4 months), had more subjects (59), included only strength trained women and had 3 study groups:

1. A control group training 3x per week across the whole study.
2. A group with a higher training frequency in the follicular phases and lower frequency in the luteal phases (sensible menstrual periodization).
3. A group with a lower training frequency in the follicular phases and higher frequency in the luteal phases (opposite of sensible menstrual periodization).

While not all tests reached statistical significance, the researchers concluded: “Our results indicate that, high frequency periodized leg resistance training during the first 2 weeks of the menstrual cycle is more beneficial to gain power, strength and to increase lean body mass, than the last 2 weeks.” In fact, the menstrual periodization group was the only group with a significant increase in lean body mass in the legs.



A pilot study by [Vargas-Molina et al. (2022)](#) also found tentative support for menstrual periodization. The researchers compared 2 programs with weekly undulating periodization in strength-trained women with a regular menstrual cycle. One group synchronized their strength-focused training week with the follicular phase of their menstrual cycle; the other group started the program regardless of which menstrual phase the women were in. After 8 weeks, the menstrual periodization program led to significantly greater bench press strength development and a trend for greater increases in jump height. Body composition and squat strength improvements did not significantly differ between groups though. One limitation common to periodization research in this study was that the menstrual periodization group ended the program with their strength week, whereas the regular program ended with their deload week. An argument could be made for either to improve strength, but this may have confounded the performance changes.

Only one long-term study failed to find positive effects of menstrual periodization. In Sakamaki-Sunaga et al. (2016) 14 women performed 3 sets of 8-15 reps of arm curls 3 times a week during the follicular phase and once a week during the luteal phase with one arm, and performed the same routine once a week during follicular phase and 3 times a week during luteal phase with the other arm. The lack of positive effects here may have been due to lack of statistical power. Or perhaps hormonal effects are not very relevant when only exercising one small muscle in your body.

Despite the majority of studies finding benefits of menstrual periodization on long-term strength or body composition outcomes, it's mechanistically unclear how. Two studies [1, 2] have investigated the effect of menstrual cycle phase on muscle protein synthesis. Both found no significant differences in MPS after a workout in the luteal vs the follicular phase. It's hard to imagine how muscle growth could be increased in the absence of greater MPS. However, both studies were on untrained women that only exercised their quads for 1 or 2 workouts. This design may not reflect how hormones affect long-term changes in response to higher whole-body training volumes. Alternatively, maybe the menstrual cycle phase does not affect acute anabolic signaling but mediates long-term muscle growth via some other mechanism, such as higher training volumes. Let's look at how the menstrual cycle affects performance.

Performance changes across the menstrual cycle

Many studies have also looked into how strength or performance in general varies across the menstrual cycle. While many studies have found significantly greater performance in one phase than another, the results are all over the place, meaning there is no consistent trend on average in women. A 2024 meta-analysis, two 2020 meta-analyses [2] and a 2023 systematic review found no reliable, significant effect of the menstrual cycle phase on strength. A 2020 review by Pereira et al. also found no consistent difference in fatiguability across the menstrual phases.

The menstrual cycle likely has greater *psychological* effects on performance than physical effects. Many female athletes believe that their performance is affected considerably by their menstrual cycle [2]. A study by Dam et al. (2022) concluded: “No direct correlation was observed between the variations in sex hormones and physical performance parameters. However, positive correlations were observed between physical performance outcomes and self-reported motivation, perception of own physical performance level, pleasure level, and arousal level.” The far greater self-reported psychological than physical effects of the menstrual cycle may be partly cultural. Supposed menstrual cycle symptoms vary greatly across individuals and even within individuals over time. Since sex hormone effects are quite consistent not just within and across individuals but even across sexes and species, it’s plausible that symptoms frequently attributed to the menstrual cycle aren’t caused by it. For example, a trainee may have a bad workout and attribute it to the phase of her menstrual cycle, whereas in reality it was caused by poor sleep quality or stress from a situation at work.

In practice, any difference in physical strength across menstrual cycle phases is typically not large enough to have direct programming implications. The week-to-week increase in strength from training should trump the menstrual phase fluctuations, so women should be able to implement progressive overload just like men over the course of each month.

Nutrition during the menstrual cycle

The menstrual cycle predictably affects appetite and energy intake. During the luteal phase, energy expenditure [2, 3], body temperature [2] and appetite [2] are generally a bit higher than during the follicular phase. The difference amounts to a couple percent or around 40-200 kcal for energy expenditure and ad libitum intake and 0.3-0.7°C for temperature. Women thus naturally tend to eat more during the menstrual phases when their metabolism is faster.

One implication of this is that having a fixed energy intake across the month, as most diets are planned, results in lower energy balance during the luteal phases than the follicular phases. While often done unintentionally, this may actually be advantageous based on the findings that muscular development is faster during the follicular phases. Bulking a bit more during follicular phases and cutting a bit more during luteal phases may take advantage of the metabolic and hormonal effects of each cycle to optimize body recomposition. Menno has even had good success with periodized recomposition diets with a true lean bulking in the follicular phases and cutting in the luteal phases. The regular course recommendations apply for these short cut and bulk phases. However, dietary adherence may suffer. This type of periodization not only requires frequent changes in someone's meal plan but also cutting when someone's appetite is highest. It's thus best reserved for highly motivated trainees that want to squeeze out any potential gains no matter the cost.

Effect of the menstrual cycle on body composition

It's often claimed that the body composition of women and in particular their water retention fluctuates dramatically over the menstrual cycle to the extent that body composition cannot be compared week to week and rather should be compared month to month in each phase of the menstrual cycle. Well controlled research shows that body composition, including often even hydration status, is actually quite constant across the menstrual cycle [2, 3]. Skinfold calipers, DXA scans and ultrasound body fat estimates are consistent across each phase of the menstrual cycle in physically active women. It's normal to have significant variation in your weight and water retention level across days for both men and women. However, this variation does not seem to be systematically higher in any menstrual phase than another. So body composition changes can generally be measured in the same way in men and women: measures like bodyweight and skinfold thicknesses can still be accurately tracked on a week to week basis. BIA readings seem to be more affected but you should normally still see the weekly average BF% go down during a cut, although BIA always has questionable reliability.

Practical applications

If you have a perfectly normal menstrual cycle of 28 days, the follicular phase consists of the first 14 days after the start of menstruation. However, a range of 22 to 36 days is considered a normal duration of the menstrual cycle. It can be useful to measure your body temperature to estimate your menstrual cycle structure. Body temperature tends to spike by at least 0.3° C around ovulation, the midpoint of your cycle between the follicular and luteal phase. There are also many apps that can help you monitor and predict your menstrual cycle.

If you're a woman with fluctuating hormone levels during the menstrual cycle, multiple studies show that planning most of your workouts in the follicular phase of your menstrual cycle can increase strength development and muscle growth. However, this is logistically impractical. It's likely similarly beneficial to keep your training frequency the same but increase training volume during the follicular phases compared to the luteal phase. This is far easier to implement, as you can keep the program the same in all aspects other than the set volume per exercise. The follicular phase is theoretically the ideal time for your muscles to exercise. A ~33% difference in training volume between the phases works well anecdotally, in line with the difference in training volume between a cut and a bulk. If your optimal average training volume for a muscle is 30 sets, you can change this to 30 * 1.17 = 35 sets in the follicular phase and 30 * 0.83 = 25 sets in the luteal phase. This level of finetuning is probably best reserved for the most meticulous female lifters, but as a coach, you can easily program it for your clients without any additional work on their end.

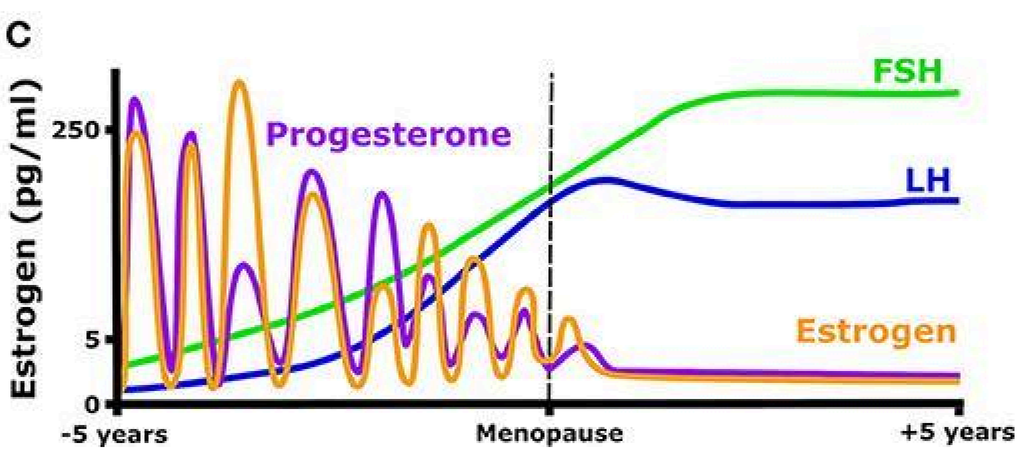
A simpler alternative is to increase the volume in each session by 1 set for each muscle group (or even simpler, adding 1 set per exercise) in the follicular phase and decrease it by 1 each in the luteal phase. This is a practical way to potentially help Aunt Flow help you grow.

It might be beneficial to periodize the diet as well. In fact, this occurs automatically if you maintain a fixed energy intake across the month, because energy expenditure increases during the luteal phases, causing lower relative energy balance. Decreasing energy intake during the luteal phase to cut while lean bulking during the follicular phase may theoretically further optimize body recomposition. However, it requires cutting when women's appetite is highest and requires frequent changes in someone's meal plan, so it's best reserved for the most motivated individuals. Menstrual periodizing of someone's diet is often not worth the disruption of meal planning and habit formation it brings with it.

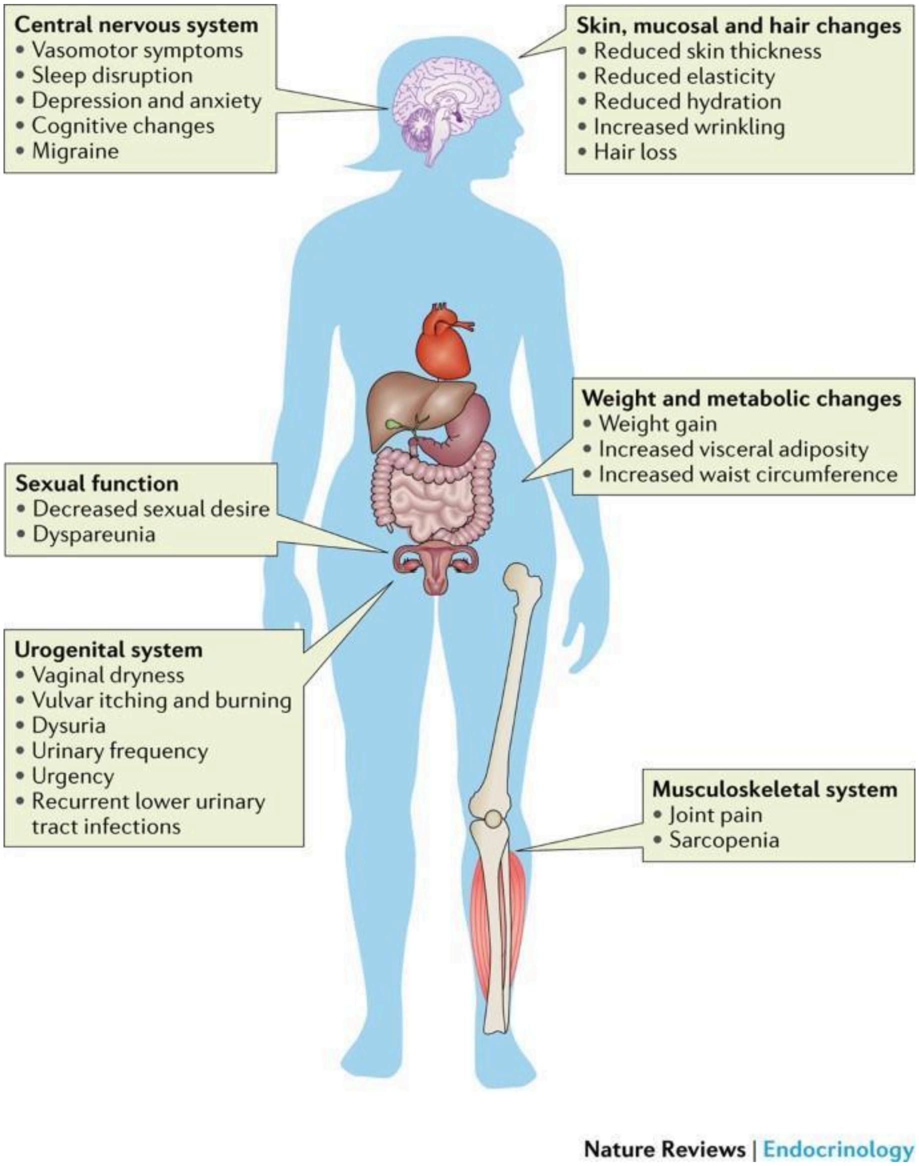
Physical strength and body composition do not vary predictably across the menstrual cycle, so progressive overload and progress monitoring can be implemented as normal.

Menopause

Women in their 40s or 50s go into menopause, a state of ovarian senescence. The process begins around age 35 with full menopause – the complete loss of menstruation – occurring at an average age of 51. As the ovaries stop functioning, sex hormone production and fertility decrease majorly. Most women become completely infertile, testosterone levels drop by roughly half and estrogen levels decrease from 15-350 pg/mL (wide variation across the menstrual cycle) to below 10 pg/mL. Postmenopausal estrogen levels are on average lower than those of adult men (10-40 pg/mL). These dramatic decreases in sex hormone levels result in a wide range of side-effects, including lower mental health and wellbeing, loss of libido, vaginal dryness, poorer connective tissue strength and many more problems, as illustrated below. Postmenopausal women generally lose many of the unique physiological aspects of women, so they no longer need to make many female-specific program adjustments.



Female hormone levels before and after menopause. Source



Symptoms of menopause. Source

HRT

Throughout most of human evolution, women would not live much past the age of menopause, but in modern societies, women spend about a third of their lives post-menopause. Therefore, women undergoing menopause should consider hormone replacement therapy (HRT) to bring their hormone levels back to their previous levels, undoing many of the effects of menopause.

- HRT improves women's body composition and physical performance without exercise and augments muscle growth and some measures of physical performance with exercise.
- HRT likely reduces injury risk during strength training, as menopause causes bone loss and increased susceptibility to muscle damage. Estrogen stimulates collagen synthesis in connective tissues, notably tendons. Estrogen also reduces connective tissue stiffness, which can be good or bad, depending on the context. Reducing estrogen levels with aromatase inhibitors frequently causes joint pain as a side-effect and AAS users with low estrogen levels also frequently experience joint pain, anecdotally.
- HRT significantly improves skin and hair quality.
- Aside from the physical benefits, HRT's main benefit is arguably decreased anxiety, decreased depression and a better overall mood.

HRT does not affect all-cause mortality, although it may increase the risk of some cardiovascular problems (without a net increase in mortality). The risk of cardiovascular complications may primarily result from progestogens, because estrogen-only HRT has been found to improve cardiovascular health [2]. Still, some progesterone is usually incorporated into HRT to reduce the risk of endometrial cancer.

For more information on hormone replacement therapy, see the lecture in the Hormones module.

➢ Recommended reading for postmenopausal women

IMS recommendations on women's midlife health and menopause hormone therapy

Contraceptives

Most people are aware that hormone use by men, notably steroid usage, can significantly affect their body composition. Fewer people realize many women are consuming hormones for contraceptive purposes that can do the same. As per the table below, a variety of contraceptives are available for women to prevent pregnancy and most of them are hormonal in mechanism.

Type	Delivery	Frequency	Example of brand
Contraceptive patch	Thin plastic patch that sticks to the skin & releases oestrogen & progestin through the skin into the bloodstream.	New patch once a week for 3 weeks, no patch on 4th week.	Evra®
Injectable birth control	Injection of a progestin.	Once every 3 months.	Depo-Provera® Noristera®
Implantable rods	Matchstick-sized, flexible, & plastic rod that is inserted under the skin and releases a progestin.	5 years.	Norplant® Implanon® Nexplanon®
Intrauterine devices	Small, T-shaped device, inserted into the vagina, that releases a progestin.	5 years.	Mirena® Skyla®
Oral contraceptives	Consumed in pill form.	Combined OCs are typically ingested for 21 days, followed by 7 non-pill taking days. Progestin-only pills are usually consumed every day.	Microgynon® Yasmin® Marvalon® Cilest® Cerazette®
Vaginal rings	Flexible plastic ring inserted into the vagina that releases oestrogen and progestin.	Worn for 21 days, removed for 7.	NuvaRing®

The most popular contraceptive is 'the pill', but there are different types of oral contraceptive pills (OCs).

1. Progestogen-only pills.

2. Combined oral contraceptive pills, containing an estrogen (typically ethinyl estradiol) and a progestogen (typically progestin, a synthetic progestogen that functions much like the progesterone the female body produces naturally).
    - Monophasic pills contain the same amounts of hormones every day of the menstrual cycle, except for the week of menstrual bleeding when you don't take the pill.
    - Multiphasic pills contain different amounts of hormones for different days to try to mimic the hormonal fluctuations of a natural menstrual cycle.

OCs are usually taken for 21 days followed by a 7-day break, during which menstrual bleeding occurs. The menstrual cycle is thereby set to a 28-day schedule.

All contraceptive pills contain progestins, which are synthetic progestogens, hormones that can bind to the progesterone receptor and thus have similar effects to the natural progestogen, called progesterone, in the body. In other words, progestins are synthetic versions of our natural progesterone. Progestin is the key ingredient of OCs to inhibit follicle growth and ovulation. Progestins reduce the secretion of the follicle stimulating hormone (FSH) and luteinizing hormone (LH). Decreased FSH inhibits follicular development, which in turn inhibits an increase in estrogen levels during the follicular phase. As a result, women who take OC have lower estrogen levels than typically observed in most parts of a regular menstrual cycle. Moreover, most OCs, regardless of type, decrease estrogen, progesterone, free testosterone and insulin-like growth factor 1 (IGF-1) levels. The decrease in free testosterone averages 61% regardless of type of OC. Even worse, the progestins in OCs can bind to the androgen receptor and inhibit the functioning of the testosterone you have left. This is of course a concern for fitness.

Combined oral contraceptive (OC) pills also contain a synthetic estrogen named ethinyl estradiol, which mimics the function of the naturally occurring estradiol. In contrast to progestin, ethinyl estradiol should theoretically be beneficial for female strength trainees, as it should offer similar benefits as naturally produced estrogen.

Some contraceptive pills also contain anti-androgens, such as cyproterone acetate, drospirenone or dienogest. Oral contraceptives with anti-androgens obviously hinder strength training adaptations compared to purely estrogen- and progestin-based oral contraceptives. There is generally no benefit to consuming anti-androgens for the average woman, so women should avoid oral contraceptives containing anti-androgens, unless they have a specific medical reason for their use.

The net effect of any OC on female fitness thus likely depends on the composition of the pill. Theoretically, anti-androgens and progestin are expected to have negative effects, whereas estrogen is expected to have positive effects. If we look at the research on sedentary women, even OCs without direct anti-androgens seem to exert net negative effects. Hormonal contraceptives, both pills and IUDs, have repeatedly been found to induce negative body recomposition in sedentary individuals [2, 3] with weight gain and decreased myofibrillar protein synthesis. Body fat gain resulting from hormonal contraceptive use is likely the result of an increased appetite, as progestins stimulate our appetite [2]. Women on contraceptives tend to be less successful at losing and maintaining weight due to greater difficulty restricting energy intake. In contrast to popular belief though, estrogen normally suppresses appetite.

Oral contraceptives can also impair exercise performance, but the effect may be trivial. A meta-analysis by Elliot-Sale et al. (2020) concluded oral contraceptives likely have a negative effect on exercise performance without differentiating between strength and endurance exercise. They found naturally menstruating women perform better than

OC-taking women, both during menstrual bleeding and during the rest of the menstrual cycle. However, the effect sizes were small, trivial in fact by the authors' classification. 'Trivial' is subjective though: a 2% faster sprint may be meaningless for a recreational trainee, but for a top athlete it may be the difference between coming in 1st or 10th at the Olympics. Moreover, the authors excluded all 14 effect sizes above 2 as 'outliers', which means the analysis was inherently biased against finding large effects. Still, upon reading the studies, it's fair to say the effects of OCs on athletic performance aren't as bad as you would imagine based on the effects in sedentary individuals. A 2022 systematic review also concluded there is generally no significant effect of (monophasic) OCs on muscle strength.

The decidedly negative effects of OCs on the body composition of sedentary women may be because they experience the negative effects of progestin without the positives of estrogen. Estrogen is primarily anti-catabolic and not so much directly anabolic, so it's likely only beneficial for exercising women, in particular for endurance training that stimulates significant catabolic effects. However, in exercising women, there is also no evidence of positive anti-catabolic effects. A 2023 systematic review found that oral monophasic contraceptives even tend to impair muscular recovery after muscle-damaging exercise. A subsequent 2024 well-controlled RCT in strength-trained women also found that women on second-generation oral birth control experienced slower isokinetic strength recovery after a triple leg day workout. However, none of the many other measures of recovery significantly differed between groups, including regular dynamic and isometric strength, power and muscle damage. The researchers thus concluded the detrimental effect of the pills was "marginal". The pills contained 30-35 µg ethinyl estradiol and 10-150 µg levonorgestrel.

Theory aside, what do the data say on the gains of women on hormonal contraceptives vs. no contraception? A 2025 systematic review of 7 studies advised caution for female athletes considering oral contraception due to a small potential negative effect on their body composition. A 2023 meta-analysis of 8 studies found no significant effect of oral hormonal contraceptive pill usage on strength development or muscle hypertrophy. Long-term studies on OC usage in exercising women often find no significant effects, and sometimes even positive effects of high-dose estrogens, although many studies are poorly controlled.

- In Procter-Gray et al. (2008), taking OCs with 30 mcg ethinyl estradiol for up to 2 years had no negative effects on the body composition of competitive distance runners compared to not taking any. Fat mass changes were similar in both groups, as were lean mass changes in women with an irregular menstrual cycle. However, in the subgroup of women with a regular cycle, the pills seemed to result in a 0.8 kg increase in lean body mass (LBM) as measured by DXA scans. This LBM may well have been water, not muscle, as controlling for the presence of strength training significantly reduced the effect. A big limitation of this study was that adherence was poor and there was no standardization of the women's OC usage duration, diet or exercise protocols.
- In a RCT by Riechman & Lee (2022), strength training women on OCs gained less muscle than women not taking OCs; the more progestin was in their pill, the worse their muscle growth. The women on OCs had significantly lower levels of IGF-1 and androgens (DHEA and DHEAS) and higher levels of cortisol. Strength gains and changes in fat mass did not significantly differ between groups.
- In Wikström-Frisén (2017), OC-taking and non-OC-taking women gained similar amounts of lean body mass and strength, but all changes were minimal and this was not the primary study aim. For what it's worth, in the only intervention group gaining muscle (group 1), total lean body mass growth was 0.3 kg in the OC group vs. 0.5 kg in the hormone-free group.
- In Myllyaho et al. (2021) / Ihalainen et al. (2019) (same study), OC usage had no significant effect on strength or endurance performance or body composition in

concurrent trainees. However, the OC users did not achieve any body recomposition, whereas the non-OC users gained a significant amount of lean body mass and lost a significant amount of fat. The OC-users, conversely, experienced a significant improvement in 3km running time, whereas the non-OC users did not.

- In Nichols et al. (2008), there was no difference in performance outcomes between an OC taking and a non-OC taking group of female softball and water polo players. The study wasn't very tightly controlled. Body composition wasn't measured, diets weren't controlled and the OC users were on a variety of different pills with unknown dosages.
- In Dalgaard et al. (2019), there was no statistically significant difference in body composition change or strength development between untrained women taking OCs and those not taking any hormones. However, when specifically comparing OCs containing a higher dose of estrogen (30 mcg ethinyl estradiol vs. 20 mcg), the higher dose estrogen OC users showed a trend for greater muscle growth, specifically in their type I muscle fibers. This supports estrogen has positive effects favoring endurance adaptations, in contrast to the negative effects of progestin. However, a major limitation of this study is that protein intake was significantly higher in the women taking OCs (1.3 vs. 1.1 g/kg/d).
Muscle anabolic signaling, including mTOR expression, did not differ between the groups, but in the OC users the expression of eIF4E and p70S6K decreased, whereas in the hormone-free women it increased. This suggests muscle growth may decrease in the OC-users over time as their training stimulus becomes more strength-specific, possibly because estrogen's anti-catabolic and glucose-sparing effects are more beneficial for endurance training adaptations than strength training adaptations.
- In Romance et al. (2019), trained OC-taking women gained as much muscle and strength as non-OC taking women during an 8-week training program. However, effect sizes were small for all body composition changes, so statistical power was

likely too low to detect any potential negative effects of the birth control pills. The OC usage in this study was ideal for strength athletes, as all women in this study took pills with 30 mcg ethinyl estradiol, none with only progesterone. Macronutrient intakes were measured but not reported. Lack of dietary control is a major limitation of all studies in the literature, because if the oral contraceptives increased appetite, higher protein and energy intakes may bias study results in favor of the OC group.

- In Dalgaard et al. (2020) / Oxfeldt et al. (2020) (same study), high-estrogen OCs did not affect muscle growth or strength development in untrained women compared to not taking anything. The OCs did seem to improve satellite cell accretion and muscle fiber type shifting and they affected multiple growth pathways. The OC-taking women also showed a trend for greater total fat-free mass (FFM) gains, but given the complete lack of greater muscle fiber growth (CSA) or strength, this was likely estrogen-related water retention. Crucially, the OC taking group consumed a significantly higher protein intake, thus biasing the results in favor of the OCs. Unfortunately, the study was also not placebo-controlled, a common limitation of OC research.
- Sung et al. (2022) found no difference in muscle growth or strength development between women taking and not taking OCs of their own choice. The participants were untrained women performing only submaximal leg presses without control of their diets, or measurement of their total body composition.
- Colenso-Semple et al. (2025) found that women taking a second-generation oral contraceptive pill showed no difference in integrated daily muscle protein synthesis or whole body myofibrillar proteolysis in the active or placebo pill phases of the pill cycle. The pill thus did not seem to affect acute muscle growth.

In sum, the effect of birth control pills on exercising women is not nearly as bad as in sedentary women. These results suggest that starting hormonal birth control may initially induce a small negative body composition change, but there's generally no significant effect on long-term gains from exercise.

Conclusion

Hormonal contraceptives can have negative effects on our body composition, though the acute effect is not major, generally only a few percent loss of lean body mass and a similar increase in fat mass. Hormonal contraceptives with relatively high doses of progestin or anti-androgens relative to ethinyl estradiol may also impair strength training performance and adaptations, whereas high doses of ethinyl estradiol may improve endurance training adaptations and possibly even muscle growth. Progestins can also increase your appetite, which makes it more difficult to get and stay lean. Oral contraceptive usage also tends to significantly suppress sex hormone levels. To minimize potential side-effects, female strength trainees should consider non-hormonal means of birth control or oral contraceptives with the lowest amount of progestins and 30+ mcg ethinyl estradiol. These generally don't significantly influence performance or the gains from exercise.

For women that want minimal potential hormonal side-effects, condoms are an obvious birth control option but with obvious practical limitations. An alternative to consider is having an intrauterine device (IUD) inserted. IUDs locally prevent fertilization but not ovulation. IUDs release fewer hormones than OCs with correspondingly fewer effects on systemic hormone levels. After insertion, IUDs often result in an irregular and uncomfortable menstrual cycle for a few months, but afterwards, menstruation can stop completely, which many women consider a benefit. The theoretically best IUD for athletes is the copper one, as it is completely non-hormonal and thus has no negative effects on your body composition. However, the copper IUD tends to aggravate pain and bleeding during menstruation.

Other effects

Birth control pills affect not just our body composition and appetite. While not the primary subject of this course, it's worth noting that oral contraceptives have many psychological effects, some of which can be positive and some of which are decidedly negative. Some research found oral contraceptives significantly increase the risk of depression and reduce general wellbeing. Other studies did not find significant effects on mental health [2] and some research even found positive effects, especially after the first months. There seems to be considerable individual variance with a minority of women being most susceptible to clinical mood disorders from oral contraceptive use.

Similarly, some women experience a reduction in libido and sexual functioning from oral contraceptive use; however, it's unclear what percentage of women are affected with estimates ranging from just 3.5% to 15% to 21% to the majority of studies [2]. A non-trivial minority of women also report increased sexual functioning, but this may be primarily related to having more sex with less fear of unwanted pregnancies rather than biologically increased sex drive.

Just like for our physique, the formulation of the birth control pill can affect the risk of psychological side-effects with progestins generally having negative effects and higher-dose estrogens, especially the newer physiological forms of estrogen, having positive effects.

A major limitation of research on the psychological effects of birth control use is that it's often poorly controlled. It's impractical to determine at random if women are going to use their desired form of birth control or not. Current users may be reluctant to come off, as they're on it for a reason, and non-users likely systematically differ from users in sexual and religious views.

Overall, oral contraceptives are a drug with significant potential hormonal and psychological effects. Prospective users should weigh the pros and cons and try to find a formulation that fits their needs.

Pregnancy

During pregnancy and while breastfeeding, almost all nutritional requirements go up. It becomes extra important to consume a whole-foods based diet with lots of veggies. A healthy pregnancy is good not just for the mother and a successful birth but even for the long-term health of the child. Moreover, what a pregnant mother eats already has lasting effects on the yet-unborn child's taste preferences. The fetus's chemoreceptive system is partly trained by the mother's diet.

Micronutrients

As you learned in the micronutrition module, many micronutritional requirements increase during pregnancy and while breastfeeding. The following are particularly important.

- Folic acid, also known as folate or vitamin B9, is important for the neural development of the child. 600 mcg per day is a healthy intake for pregnant women. Since there's little toxicity risk, supplementing 200+ mcg per day is advisable.
- Iron requirements are extremely high during pregnancy: 27 mg per day. Consuming liver or kidney a few times a week can help greatly to increase iron intake, as well as many other micros. Beware of vitamin A toxicity in excess though. Supplementation can also be considered, but see the micronutrition module for the associated risks.

The following table provides an overview of the commended daily dietary allowances for pregnant and lactating women. See the micronutrition module for more in-depth information with reference to strength training individuals.

Nutrient	Non-Pregnant	Pregnant *	Lactation *
Vitamin A (µg/d)	700	770	1300
Vitamin D (µg/d)	5	15	15
Vitamin E (mg/d)	15	15	19
Vitamin K (µg/d)	90	90	90
Folate (µg/d)	400	600	500
Niacin (mg/d)	14	18	17
Riboflavin (mg/d)	1.1	1.4	1.6
Thiamin (mg/d)	1.1	1.4	1.4
Vitamin B_6 (mg/d)	1.3	1.9	2
Vitamin B_{12} (µg/d)	2.4	2.6	2.8
Vitamin C (mg/d)	75	85	120
Calcium (mg/d)	1,000	1,000	1,000
Iron (mg/d)	18	27	10
Phosphorus (mg/d)	700	700	700
Selenium (µg/d)	55	60	70
Zinc (mg/d)	8	11	12

Data from Otten JJ, Pitzi Hellwig J, Meyers LD, Editors. *Dietary reference intakes. The essential guide to nutrient requirements.* Washington, DC: National Academies Press; 2006.

Protein intake

You should increase protein intake by 0.3 g/kg at the start of pregnancy, rising to an increase of 0.6 g/kg/d after half-term.

Energy intake and weight gain

You should also increase energy intake to meet the energy requirements of the developing fetus. The total cumulative energy cost of the unborn child is ~55k kcal based on research in pregnant mothers, meaning you should increase energy intake by 150-300 kcal per day during pregnancy. These values align well with the theoretically expected energy requirements of 114-322 kcal/d listed in the table below. It's advisable to lean bulk during pregnancy and not spent too much time in severe energy deficit.

	Energy Cost, kcal/day (Mean Daily Increments of Protein and Fat, g/day) by Period of Gestation, wk				Cumulative
Component	0–10	10–20	20–30	30–40	Total, kcal (g)
Protein deposition	3.6 (0.64)[b]	10.3 (1.84)	26.7 (4.76)	34.2 (6.1)	5,186 (925)
Fat deposition	55.6 (5.85)	235.6 (24.80)	207.6 (21.85)	31.3 (3.3)	36,329 (3,825)
Increase in basal metabolism	44.8	99.0	148.2	227.2	35,717
Total net energy	104.0	344.9	382.5	292.7	77,234
Additional energy required from food (total net energy + 10%)	114.0	379.0	421.0	322.0	84,957

a From Hytten (1980), with permission from Blackwell Scientific Publications, Inc.

b Heat of combustion defined as 5.6 kcal/g for protein and 9.5 kcal/g for fat.

Some organizations advise women to gain a specific amount of weight. However, these recommendations are spurious, as macronutrient and micronutrient intake are arguably more important than the mother's weight gain. There is no established mechanism by which weight gain per se benefits the child in any way, provided the mother is not in energy deficit, factoring in extra energy expenditure from the unborn child, and all micronutrient requirements are met. Any benefits of weight gain would also have to be weighed against the risks associated with being overweight. Obesity is associated with almost all pregnancy complications, including miscarriages and stillbirth, as well as reduced fertility in the first place [2, 3]. Many observational studies have looked at weight gain rates in relation to birth complications. The latest (2019) meta-analysis by Voerman et al. of 25 cohort studies concluded the following weight gain rates are *associated* with the lowest risk of pregnancy complications, depending on the pregnant mother's initial weight status.

Mother's weight status pre-pregnancy	Optimal weight gain during pregnancy
Underweight	14-16 kg
Normal weight	10-18 kg
Overweight	2-16 kg
Obese	0-6 kg

The researchers emphasized that these weight gain categories only had 'weak' predictive power to detect adverse maternal and infant outcomes. The weight gain categories from the US National Academy of Medicine (NAM; formerly the Institute of Medicine) performed similarly weakly. Importantly, weight gain rates were significantly less important than the mother's pre-pregnancy weight status. A 2022 meta-analysis on children's cancer risk similarly concluded a mother's pre-pregnancy BMI is significantly associated with the child's risk of getting cancer, whereas weight gain rates during pregnancy are not. It makes sense that weight gain per se is relatively unimportant compared to a nutritious diet and a healthy mother. A primary reason energy intake and proper nutrition correlate in modern populations is because many people's diet quality is so poor that overeating is the only way to avoid nutritional deficiencies. It takes a whole lot of McDonald's to consume enough vitamin C. Assuming vitamin C intake is associated with successful pregnancies, this can show up in research as a positive association between energy intake and successful pregnancies, even though you're arguably much better off having a lower energy intake coming from whole foods than a high energy intake from junk foods.

Associative research is inherently of low scientific quality. Most studies basically just observe what happens in a group of pregnant women living their lives and then try to correlate observed weight gain rates with birth or pregnancy complications. Like all epidemiological research, this approach is very prone to confounding from other factors. For example, Ukah et al. (2019) found that "women with low weight gain were more likely to be African American, more likely to have Medicaid health insurance, and less likely to be married than women with optimal weight gain in each pre-pregnancy BMI category. Except for underweight women, they were also more likely to be young, to have pre-pregnancy diabetes, and to smoke during pregnancy." It's safe to say that energy intake was not the most important factor here, as the diet quality and health of a diabetic, smoking, single mother with poor health insurance is probably not comparable to that of a healthy, exercising mother with a supportive partner and great health insurance.

For obese women in particular, the focus should lie primarily on a healthy diet rather than intentionally gaining weight. Multiple studies have advised that commonly recommended weight gain rates are excessive for obese women [2]. Devlieger et al. (2020) even found that obese women had the healthiest size babies when they lost fat during the pregnancy, ranging from zero weight change for mild obesity to 5 kg weight loss in obesity grade III.

Importantly, weight gain during pregnancy does not necessarily require being in energy surplus, as the placenta and unborn child will logically increase the mother's weight already. Most et al. (2019) measured energy intake and expenditure and body composition rather than merely weight gain. They found obese pregnant mothers generally already gained enough weight even while in energy deficit. Being in energy surplus was associated with excess weight gain. There was no significant relation between energy intake and fetal growth. Matusiak et al. (2020) also found no relation between mothers' attempts to lose weight during pregnancy, regardless of weight status, and their infants' weight, body composition or most body circumferences, except for greater abdominal circumference in mothers that tried to lose weight. The latter could be an indication that intentional weight loss may not be a good idea during pregnancy, but again it may come down more to diet quality rather than weight change. In contrast, there was a clear relationship between the body fat percentage of the mother and the infant: mothers with more fat gave birth to infants with more fat. Evolutionarily speaking, it makes perfect sense that the relationship between energy intake and weight gain during pregnancy and pregnancy outcomes is weak and inconsistent, as the body should prioritize the needs of the child over the preservation of body fat stores, just like the body doesn't break down your vital organs when you're on a weight loss diet.

The dangers of being overweight are clear not just for women but also for men. Overweight male parents are more likely to have children that are born too small or too big (macrosomia), to have children with altered growth curves and to have children with autism.

In conclusion, aspiring mothers and fathers should ideally try to get to a healthy body composition before the mother becomes pregnant. During pregnancy, non-overweight women should probably spend most of their time in moderate energy surplus and avoid considerable weight loss. The provided chart can serve as a rough indication of how much weight to gain, but diet quality is probably more important than energy intake or weight gain per se. Obese women should particularly emphasize diet quality and don't need to be in energy surplus.

Fish

Folk wisdom also says to avoid raw fish during pregnancy, but in modern societies this is typically not needed anymore. While raw fish has a higher prevalence of bacteria and parasites than cooked fish, the resulting infections from those are usually harmless and limited to the gastrointestinal tract. Moreover, freezing is also very effective to kill most pathogens and most 'raw' fish was previously frozen. Even unfrozen raw fish is normally screened for pathogens, so most modern guidelines agree that "Pregnant women need not avoid raw fish if it is obtained from a reputable establishment, stored properly, and consumed soon after purchase."

However, mercury toxicity from fish consumption is a much more serious risk for a fetus than an adult. As you learned in the module on dietary fat, consuming at least 2 grams of daily combined DHA and EPA omega-3s is desirable health wise, so see the health science module on which types of fatty fish to consume with a favorable ratio of omega-3 to mercury. Salmon is generally the most popular choice.

Caffeine

Caffeine is also a potential risk factor for pregnant women above 300 mg per day. Caffeine crosses the placental barrier and a fetus poorly metabolizes the caffeine. Most data indicate caffeine is safe up to relatively high intakes for pregnant mothers, but as you learned in the course module on supplementation, it's prudent not to consume that much anyway to avoid addiction. So for pregnant women in particular, to be safe, don't consume more than 1-2 cups of caffeinated coffee per day.

In terms of supplementation, extra care should be taken not to supplement unnecessary compounds or possibly adulterated supplements in general.

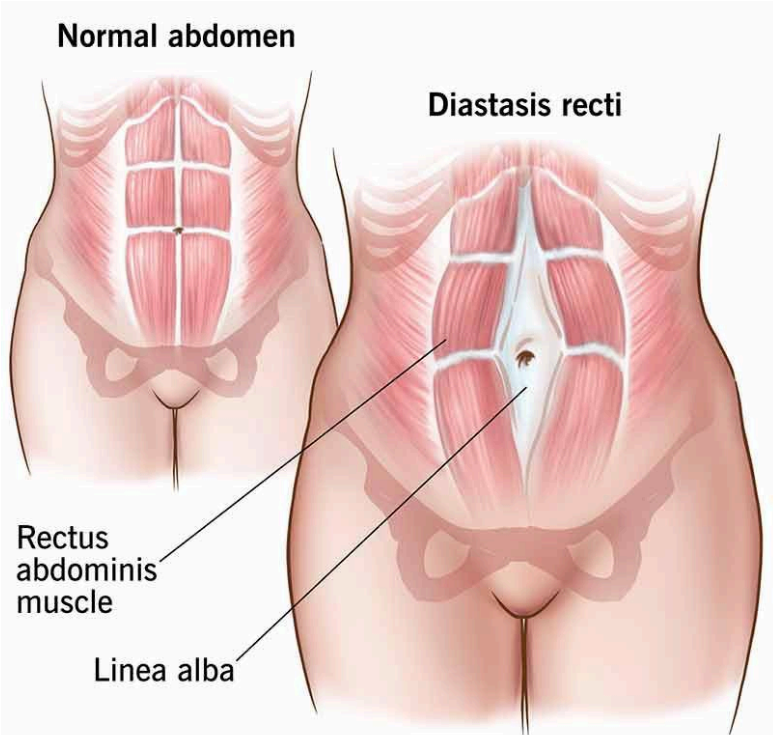
Exercise

As for exercise, the idea to avoid exercise during pregnancy is a case of harmful pseudoscience. Physically activity during pregnancy results in healthier mothers **and** babies. Even the Valsalva maneuver and supine positions are generally safe. Many official health organizations explicitly recommend strength training for pregnant women these days [2, 3]. A 2022 cross-sectional analysis on athletes, primarily CrossFitters and Olympic weightlifters, concluded that "Individuals who engaged in heavy prenatal resistance training had typical perinatal and pelvic floor health outcomes that were not altered whether they engaged in, or avoided Olympic lifting, Valsalva or supine weightlifting." In fact, participants who maintained pre-pregnancy training levels until delivery reported significantly fewer reproductive complications than those who ceased training levels prior to delivery.

Just be reasonable: don't ignore your pain signals and avoid high impacts or pressure on the abdomen. Most women can resume strength training as normal during pregnancy up until the third trimester and generally even during the third trimester. Strength training is a very controlled, low-impact, relatively non-injurious form of exercise, so it's an ideal form of physical activity during pregnancy.

Diastasis recti

Diastasis recti abdominis (DRA) is a separation of the two rectus abdominis muscles – the sixpack muscles – down the middle. It affects over a third of women in the months after giving birth and a common concern is whether abdominal training is safe with a diastasis. It is. Core training during pregnancy helps prevent a diastasis from occurring and may help reduce it after childbirth [2]. There is no solid evidence favoring any specific exercise over another, so most women can keep training as desired based on their aesthetic and functional exercise goals.


Normal abdomen
Diastasis recti
Rectus
abdominis
muscle
Linea alba

Breastfeeding

After pregnancy, there's strong research consensus that children up to 6 months old are exclusively breastfed for optimal health. The children should not consume any other foods or liquids, including water. After 6 months, they can begin consuming whole foods alongside continued breastfeeding up to at least 2 years old.

Most nutritional considerations during pregnancy also apply to lactation, in particular the increase in overall nutritional requirements. Energy expenditure increases by approximately 500 kcal for per day to produce an average of 780 mL breast milk (normal range 450-1200 mL) with an energy content of 67 kcal/100 mL. This also requires an additional 25 g/d of protein. Energy balance and weight changes of the lactating woman do not affect the quality of her breastmilk, as long as micronutritional and protein requirements are met: the breast milk is prioritized so that the woman will catabolize her own tissues if needed to produce the breast milk. Thus, it's not necessary to continue lean bulking throughout lactation and it's safe to start a moderate cut again.

Twin pregnancies

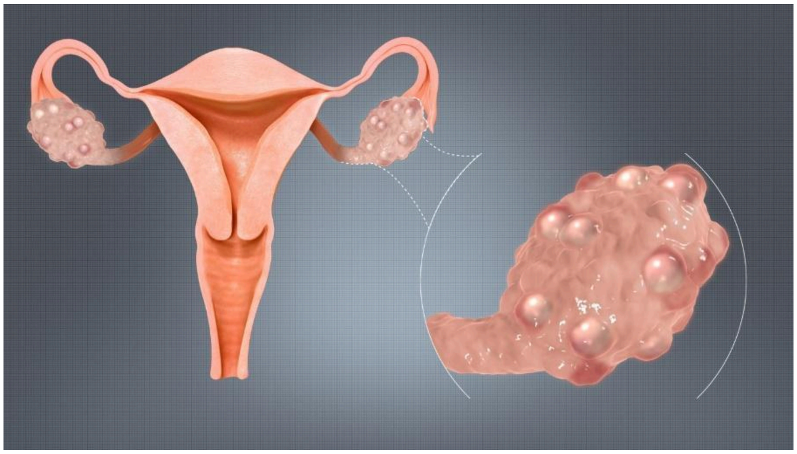
There is little research on twin pregnancies, but the emerging consensus is that nutritional requirements increase more for twin pregnancies than for singleton pregnancies. It's plausible that the increases are linear, so that, for example, a 3 mg increase in zinc requirements for a singleton pregnancy becomes a 6 mg increase for a twin pregnancy. In case you're dealing with a twin pregnancy, we recommend reading this 2022 review on twin pregnancy dietary recommendations.

PCOS

Polycystic ovary syndrome (PCOS) is a relatively common condition in women that can be partially ameliorated with an appropriate diet. PCOS is estimated to affect around 10% of the population, making it the most common endocrine disorder in pre-menopausal women in the world, although estimates vary wildly per population and diagnostic criteria. As the name suggests, PCOS is typically characterized by cysts on the ovaries, but the name is arguably a misnomer, because not all women with cysts on their ovaries have metabolic PCOS. It's not clear what the true cause of PCOS is and there is no permanent cure, only treatment of symptoms. PCOS can be diagnosed based on meeting 2 out of 3 Rotterdam criteria without another known cause:

1. Hyperandrogenism (excess testosterone), causing all its typical symptoms, such as acne and hirsutism (excess male pattern hair growth).
2. Cysts on the ovaries.
3. Oligomenorrhea: irregular menstruation, also called periodic anovulation (lack of ovulation) or periodic amenorrhea (lack of menstrual bleeding). Fertility is thus often compromised in women with PCOS.

Another common diagnostic indicator is the presence of insulin resistance, as it affects the majority of women with PCOS. Consequently, PCOS is a risk factor for type II diabetes and metabolic syndrome.



A polycystic ovary. Source: ScientificAnimations.com

As you may expect based on the presence of insulin resistance, women with PCOS may respond particularly favorably to low-carbohydrate diets. A 2013 systematic review by Moran et al. concluded low-carbohydrate, low-glycemic index diets improve menstrual cycle regularity, insulin resistance and quality of life compared to higher carbohydrate, higher glycemic index diets in women with PCOS. A 2021 meta-analysis of RCTs by Kazemi et al. further supports that low-glycemic diets are more effective than high glycemic index diets in women with PCOS to reduce insulin resistance, waist circumference, LDL-cholesterol, triglycerides and testosterone levels. Theoretically, the decrease in testosterone levels may be disadvantageous for women with PCOS, but basically all effective treatments for PCOS involve a reduction in testosterone and the overall effect may be net beneficial even for muscle growth. Muscle growth is medically desirable for women with PCOS, as it improves insulin sensitivity. Kogure et al. (2016) reported that women with PCOS achieve more favorable improvements in muscularity from strength training than women without PCOS, despite the strength training causing a reduction in androgens in the PCOS group. Goss et al. (2014) found that women with PCOS lose more fat and less muscle on a lower carb diet with the same energy and protein intake as a higher carb diet. However, carbohydrate intake is not as important as overall diet quality, muscle growth and fat loss, so those should be prioritized over carbohydrate restriction per se. For example, a 2020 meta-analysis by Shang et al. found the Dietary Approaches to Stop Hypertension (DASH) diet, which is a generally healthy diet with ~50% carbohydrate, is also very effective for women with PCOS to lose fat and reduce their symptoms. Thus, women with PCOS shouldn't shun healthy carbohydrate sources like vegetables and fibrous fruits.

Other than preferentially following a low-glycemic load diet, women with PCOS can follow all generally advised nutrition and training principles.

Breast implants

Since breasts are largely composed of fat, being very lean for a woman often entails having relatively small breasts. Many lean women therefore consider breast augmentation with synthetic breast implants being most common. Before considering to get implants, there are several considerations you should be aware of.

Safety

Obviously consideration number one, breast augmentation, both via implants or fat grafting, is generally very safe [2, 3]. Aside from the obvious small risks of anesthesia, surgery and infection, the vast majority of women never experience any health problems from their augmented breasts.

Cost

Breast augmentation in a reputable clinic will typically cost at least $2000 USD, ranging up to $8000 USD.

Implant location

The most important consideration for fitness is the location of the implant. You can place it over or under the pectoralis major muscle. For aesthetic reasons, most surgeons recommend placing the implant under the muscle to obscure it and make the breasts retain a natural appearance. However, this requires cutting the lower muscle fibers of the pectoralis major, which results in a permanent loss of pectoralis major size and strength in the range of 10-35%. Some women will never be able to resume chest training with implants under their pecs, as it moves the implants move very uncomfortably and can cause pain. Even exercises like pulldowns may be problematic for life. Implants positioned on top of the chest muscle have little to no effect on performance, although they may move uncomfortably when the pecs contract.

Under-the-muscle implants also prolong post-surgery recovery time from around 4 to around 7 weeks. Most healthy trainees should be able to resume exercise much sooner though. You can often resume exercises that involve no torso movement within a week. Within about 2 weeks you should be able to start doing exercises that don't involve pectoralis major contractions.

Implant shape

Breast implants come in 2 shapes: round and anatomical. While anatomical implants are often marketed as more natural, there is in fact objectively no significant difference in visual appearance between the 2 implant types [2, 3], because both are similarly compressed in shape by the overlying tissue. Only when lying on your back will most people be able to see a difference, with round implants creating rounder breasts with more 'upper pole fullness'. Anatomical implants in this position maintain a more natural appearance.

Anatomical implants have significantly greater risk of rotation. While absolute risk is still low, rotation typically requires re-surgery, so it's highly inconvenient and expensive. Obviously, rotation is not a concern with a round implant.

Implant material

Breast implants are generally made of either silicone or saline. Silicone and saline are equally safe, so the main concern is texture. Most plastic surgeons recommend silicone to mimic the texture of human connective tissue.