

Female Athletes and Hormones

Dr. Melissa MacDonald

I'm going to talk about female athlete and their hormones. A big component of that is RED-S-- formerly known as the Female Athlete Triad-- and how it affects the athlete as a whole.

Disclaimer, I work at Northwestern. I am the Human Performance Center fellow. Other than that, these are my opinions.

I work in the Human Performance Center. I newly work with the Minnesota Vixen. That is my team. And it has been for two years, which is what started me on this path of, why do female athletes have higher rates of ACL?

And when you ask that question, you start down a path of, is it biomechanics? Is it because we have less muscle mass? Is it because of hormones?

And this is where it's taken me. Here are the points of what we're going to go through today. Real quick-- differences between male and female athletes. The four different types-- there is a fifth type that I just didn't include, because it's a very small subset-- affects of the menstrual cycle and then relative energy deficiency.

So let's start off with talking about the sex differences between men and women. And that really starts off with one, their peak height growth. Women start out much, much younger. Maximum height is reached younger.

Then there's also the fact that we have a lower metabolic activity. We have faster skeletal maturity. And then we're generally shorter.


We weigh less. And we have less muscle mass. And when you take those components in, you look at how we perform as athletes, and it kind of matches that flow.

Here are those four types. So when it comes to men and women, men generally you have pre-puberty to post-puberty. And their hormone state is basically the same for their entire lifetime. As they get older, there may be a drop in their testosterone.

But when it comes to women, we have four very, very distinct stages-- and a fifth stage if you include pregnancy and how pregnancy affects our bodies. So pre-puberty matches young boys. We're basically the same before puberty.

The hormones haven't taken over. Our musculature and skeletal systems haven't changed. We are opening growth plates. And that's where Osgood-Schlatter really comes in.

And when it comes to younger females, they may have access issues. There may not be as many sports that they want to participate in. Generally younger, it's soccer, soccer, soccer, which may



be why there is a higher risk of Osgood-Schlatter. Or it's basketball. But if they want to participate, let's say, in football, they may not have access to that-- which a lot of young girls are really getting into football nowadays, which is awesome.

Then you have adolescence. This is where there is that change in the hormones when everything kind of becomes a storm, and your body starts to freak out. And how does your body respond to having all those additional hormones? Your body is trying to get to the point where they have balance, and you're having a controlled cycle.

Then we have body image issues. And how is that affecting your nutritional status? Adult women will decrease in the hormone fluxuations. Because they stabilized. They've reached a point where they have control.

But they have this increased risk of stress fracture, the patellofemoral syndrome, and ACL rupture. And with the number of female athletes on my Vixen, these are the three things that kept coming up. And I'm going, why?

And in postmenopausal, all the hormones go away. And now we're left with a different individual. And how does that affects their ability to build muscle, maintain their bone health, and how our body regenerates a little bit differently. So these are four life stages that have to be taken into account when working with female athletes.

Now let's delve into those hormones. They are such a huge piece of what a female athlete is and how they're affected. The four big ones, estrogen, progesterone, relaxin, and testosterone are the main ones that I have found to have any injury rate affected and related to them.


So estrogen-- this is that first 14 days of the cycle right in the beginning. This is when it spikes and is at its highest point. You have a suppression of fibroblasts. You have increased laxity and load failure.

The ligaments, and tendons, and bones-- everything is affected. When you have excess estrogen, it causes the bones to grow faster at puberty. So if you have someone that's struggling with hormones, they may have reduced growth height.

That's why women initially have huge growth spurts. Their menstrual cycle starts. And they grow as much afterwards. Because this is when the estrogen takes effect.

It also has excitatory affects on your nervous system, meaning, during the first 14 days, this is what female athletes are going to have the most energy. Their workouts are going to go better. Their performance is going to be up.

They're going to be feeling good. Rest is going to go well. So they're going to be happy in their estrogen phase.



Progesterone kicks in for that second half of the cycle, peaks about day 15, and goes throughout the rest. This is where energy it's going to be going down. Bone resorption increases. There is increased degradation of collagen within the joints. And it just negates the effects of estrogen.

This is where an athlete, the week before, crushed the workout, thought they were amazing-- comes in the next week and is like, I can barely lift half the weights I was doing last week. I'm not recovering as fast. I just feel exhausted. What do I do?

And this is a big piece of understanding that. Then how are athletes modifying that? Are they doing a hormonal contraceptive to stabilize where their system is so that they're not fluctuating as much?

The third hormone is relaxin. This is traditionally really thought of as a pregnancy hormone. But during every menstrual cycle, it spikes during the mid phase at ovulation between estrogen and progesterone.

Where this comes in to affect is really the joint ligament laxity. That is a huge piece. So every mid cycle, ligament laxity increases. And study after study has shown that is when ACLs rupture.

A recent study just came out actually comparing levels of relaxin in female athletes. So they took NCAA Division I females across a multitude of different sports and measured their blood levels of relaxin throughout their cycle and then compared it to their injury rates. Who was getting injured?

What they found was that any female athletes that has over 6 picograms per milliliter of blood of relaxin caused her to have a six times increase in ACL rupture. That was the average for the amenorrheic athlete-- so any female athlete that has a cycle that is over 30 days long, which is quite a few. The highest concentration of relaxin was 22 picograms per milliliter of blood. That's huge.

We have something that's showing a huge increase in risk simply based on the concentration of relaxin. Now, an amenorrheic female has the lowest risk to someone who is not cycling at all. But this has its own complications to other parts of the body.

And hormonal contraceptives-- I'm trying to understand hormonal contraceptives and the effects on female performance. But pretty much every study has "and we looked at female athletes, except ones on hormonal contraceptives. We excluded them." Because then it's too big of a variable.

This one actually looked at the concentrations. But there is a huge, huge effect on the overall system. When you're on a hormonal contraceptive, it delays your ability of your body to absorb the nutrients to actually have bone formation. So it reduces bone density.

What's the biggest issue with older females? Osteoporosis. The time in our lives when we're building the most amount of bone is between 18 and 25. Which females are most likely to be on hormonal contraceptive? Females 18 to 25. So are we setting ourselves up to really have issues with osteoporosis in the future-- but slightly protective of the ACL. I'm just kind of playing-- which is best?

Then testosterone-- mainly in a male athletes. It gives the typical muscle building and hormonal effects, a lot of muscle mass production. But in female athletes, there is a higher concentration of testosterone typically. Because we have quite a few Poly-Cystic Ovarian Syndrome athletes and Hyperandrogen Syndrome athletes within the female population that compete at a high level.


All right, so in our follicular phase, which is estrogen, and our luteal phase, which is progesterone-- right in the middle is where that relaxin comes in-- just a little reminder of the menstrual cycle for anyone not having to deal with it on a regular basis. And these are the types of menstrual cycles you can have. We have eumenorrhea, which is just a normal, oligomenorrhea, which is a cycle lasting longer than 35 days, averaging around three to six cycles per year-- which is not overly healthy for a female-- and then amenorrhea, which is just the absence and having fewer than three cycles per year.

When it comes to amenorrheic athletes, it affects 10% to 20% of an athletic population. That is a huge population to have hormones, when, in the regular population, it's less than 10%. When it comes to runners and dancers, when there's an emphasis on being lean-- so in a weight-modified sports-- the effects of having an abnormal cycle is up to 50% of all athletes.

And when you don't have normal hormone cycling, that's when, again, we have the effects on our skeletal system, on our muscular system, and on our energy system to appropriately perform in our activities. This is all the possible causes. I have four highlighted, because those are the ones that I'm going to speak about and emphasize. In particular, this "reduce energy deficiency"-- we're going to get really deep into that one. Because it is such a huge effect on every aspect of the female.

So luteal phase defects-- this is one of the most common problems and the hardest to diagnose. This is where the luteal phase is less than 10 days. So the follicular phase is lasting too long. And they're not having good ovulation.

These individuals are the females that are just having repeated, spontaneous, habitual miscarriages, where they just are not able to maintain a pregnancy. This is where they need to have the blood work to actually check where their hormones are. And that would give you an indication of whether they're having enough progesterone to appropriately carry a fetus. When it comes to spinal bone loss, they average losing bone density 2% to 4% each year. And they have higher issues with infertility.



Next are our key PCOS, which is Poly-Cystic Ovarian Syndrome and our hyperandrogen athletes. And these athletes have testosterone at a higher level than the average female-- sometimes can reach the level of a male athlete, which then they can have male-style distribution of muscles. They can have increased hair and hirsutism on their face, on their chest. They sometimes struggle to compete in the female division for having to go for sex verification testing.

In particular, is actually here, Caster Semenya-- she dominates the 800 meters in the female division. And every time she competes, she has to through sex verification testing. And in 2013, she had her metals stripped and then reinstated the next year. And she pretty much stays out of the eyes of the public because of all the issues she's having.

She recently just competed in the Gold Coast Games, where she won gold. So she's a highly, highly competitive athlete. But she's always facing scrutiny for having excess testosterone.

I have a multitude of Vixen right now that have Poly-Cystic Ovarian Syndrome. They have some hirsutism. And we have teams-- because of how well they're performing-- they have been sent for drug testing-- on our Vixen to be drug tested by independent tester.


They sent our number one this year. They don't like the fact that they're competing at such a high level. And now they're picking out any athlete that is showing any sign of excess testosterone to have testing done.

Birth control-- this is, again, and under-researched area of athletics. But 70% of collegiate athletes are using it. They just get excluded from studies. There are multiple different types, whether it's oral, transdermal, or vaginal. And each one has a different effect.

A oral will have a more systemic effect on the entire body since it has to go through the entire system to be absorbed and utilized-- versus a vaginal ring will just affect those tissues there. But there is some systemic causes. What they're looking at is-- because we're using it during peak mode bone mineral density years, we're showing that decrease. And then when it comes to injuries, performance, and pain, no one has really done an in-depth dive on what that looks like.

Female Athlete Triad-- so this came out in 2005 when the first consensus came out from the International Olympic Committee on what it was And it consisted of just three components. There was a eating disorder. There was low mineral density. And there was irregular menstrual cycles.

And that is what they called the Female Athlete Triad. Then as the years come on, it expanded to be more of a continuum, a sliding scale. So maybe they have had an eating disorder, but they didn't quite have bone mineral density as low as they would like. So they tweaked it and modified it.



But when they actually looked at some of the weight management to marathon runners, whether they were male or female, they were showing symptoms of the Female Athlete Triad. And they realized that this issue may go beyond just females.

So in 2014, they renamed it Relative Energy Deficiency in Sport, RED-S, because of having effects on both males and females. It is still more common in females, because we have higher body image issues and body image pressures. And they really, really focused in on two pieces.

How much are you eating, and how much are training? Because you can have athletes that are eating enough food, necessarily, but then they're over-training themselves beyond what their body can handle. And then the sports that are most effected are those weight sensitive and appearance.

So this is your gymnasts. This is your wrestlers. This is your fit model athletes that are training hours and hours a day to get that perfect physique and then not eating enough.

Really, the prevalence is-- in adult females, it's about 20% of them-- in adolescent females, 8% to 13%. And that's huge. Males, it only affects about 8% of adult athletes and 3% of adolescents.

What it really comes down to is this 30 kilograms a day. This is what's required to start to show RED-S. A normal day is like 36 or 40. So it's not a lot. Once you really start to cut out any calories and any major nutrients, it quickly comes down.

And then distorted body image, decreased performance, or a clinical eating disorder-- when it comes to body image, I find this to be the biggest issue for our females. I had an athlete on a sideline that had a cardiac event, because they hadn't taken their cardiac medication. They had a known issue. And they had opted not to take their medication for three days prior to competing at a high level, because it was prom that weekend. And their medication made them bloated.

They essentially died on a court to look good in a prom dress. Body image is huge for females. And to ignore it is a disservice.

And I know, as a female athlete growing up, I didn't eat enough food. Because any time a female would eat more, they kind of got, hey, so you're going to look fat. You're going to be fat in your prom dress.

So we opted not to eat. And we'd go play, because we wanted to look thin. And then it would affect our hormones.

So here's what RED-S has become. There are performance and health consequences. This itty-bitty area here is what the Female Athlete Triad encompasses. This is the entire effect.

And this does not-- you can tell a female athlete. You can tell the athlete this is going to be the effect. This is what will get their interest, discussing the fact that their performance is going to go down. They're not going to be able to compete at the same level.

They're not going to be able to lift at the same level. They're going to be irritable. They're going to be depressed. And these are the signs that we need to be seeing and picking up on.

Do we have an athlete that's suddenly not performing, has a poor attitude about what's going on? We need to start searching into that. Do they have impaired judgment?

Are they just slipping? Are injuries starting to crop up? Are they just having this chronic shit splint that just won't go away?

So here's what the consensus statement has brought up for early detection. They want you to find this as fast as possible. The closer you can get it to the start to nip it in the bud and get them back to a normal eating status, the less long-term consequences you have. Now, the highest risk ones are those with serious eating disorders and psychological conditions. But it's those moderate risk ones in the middle that are the hardest to detect and get them help.

So we look at what the appearance of the athlete is. Do they have a prolonged body fat percentage that is less than what would be ideal? Are they suddenly just dropping weight unnecessarily? We have an expectation of, hey, you should be reaching these height milestones, and they're not making them.

For females, we always are looking at their menstrual cycle. So have they always been on a regular cycle, and all of the sudden, now their cycles are going a little longer? Maybe they're going shorter-- then just becoming irregular to nonexistent. Or do they have a late start? So are you working with a 16 or 17-year-old female athlete, and they've never had a menstrual cycle?

And for a male athlete, what's their hormones look like? If they aren't eating enough, they will have a lower testosterone. For an athlete that has a chronic history of stress fracture, I'm going to put them through an assessment.

And then when it comes to looking at them, we determine that they might be at risk. We develop a treatment plan. Are they not being compliant with it? Everything revolves around having an athlete be compliant with what you're coming up with to treat them.

When it comes for strategies to help get them out of this RED-S, we either need to increase their intake in nutrients or decrease their activity-- not as easy as it sounds to actually correct. When it comes to an athlete that's training for a marathon and you go, hey, I want you to drop your miles per week by 20, they're going to look at you, laugh, and up it by 40. Because that's what runners do. They want to run. They want to go as far as possible.

We want them to increase their daily kilocalorie by 300 to 600 per day. That's maybe adding an extra meal. But for a female athlete that maybe is focused on, hey, to make this sport, I have to look like this-- when it comes to gymnastics, when it comes to dance-- that can be hard to convince them that eating is the way that they need to go.

When it comes to knowing whether they're coming out of it, for females, we use their menstrual cycle. As they start to re-regulate, we know they're becoming more energy efficient instead of energy deficient. To help bring this around, oral contraceptives are being used in mainstream.

But there's the bone loss issues. And if you were to have someone that's not cycling appropriately, bone loss may already be a problem. And typically, it's the protein and carbohydrate intake. And they have depleted glycogen liver stores. So it's giving them the appropriate nutrients.

With correcting depleted bone loss, weight training is a safer way to help load the bones. So we start getting them to eat, restoring their estrogen-dependent bone mineralization and then giving them a high impact or a resistance training program just to appropriately load their joints. So we use Wolff's Law to increase their bone density.

We also would look at potentially adding calcium supplementation and vitamin D supplementation. You have to have both to properly transport into the bones. And in Minnesota and the Midwest, this is a huge issue. So test your athletes. And know what their vitamin D stores are, because this 1,500 to 2,000 IU may not be enough to actually effect what they need.

With the psychological sequela, you have an athlete that may have a huge mental image piece. They may have a mental performance piece. They could actually have an underlying eating disorder.

This is where we need to bring in a mental health professional. There are sports psychologists to help with the performance issue. But co-managing and using an integrative system for working on the athletes for the psychological piece is huge.

This is their Return to Play from RED-S. If you have an athlete that is non-compliant with treatment, they are not allowed to compete, except for under supervision. And it's only practice. We don't want them going to the highest level of competition when they're energy deficient.

You create a written athlete agreement. The athlete agreement is there to go, this is what I need to do. Here's what I'm going to do with you. And we're going to work together to get you better and back on the field.

A moderate-risk athlete typically will only compete under supervision but can train with the team normally, as long as they follow their training programs set up by the treatment plan. And then a low-risk athlete can have full participation. When it comes to how to make recommendations, always, always emphasize nutrition over weight management. We want to make sure they're getting the appropriate macros, the appropriate nutrients, but we don't want them to have this fixation on their weight.

We're going to set realistic goals. So we're not going to expect, if they're severely, severely energy efficient, that they're going to resolve this in a month. It may take six months to have a full and complete recovery. And we want to set milestones that they can meet so that they feel success as they're progressing through the program.

And then the best way to manage these is through an integrative care team with the use of an overarching sports physician or sports clinician to manage them, a nutritionist, a psychologist, a physiotherapist, and a physiologist-- so those kind of individuals to look at all aspects of the athlete to make sure that they're meeting the needs of their performance.