



#268: You've got male: The wide-ranging effects of testosterone

VOICEOVER

Welcome to Up Close, the research talk show from the University of Melbourne, Australia. Australia.

DYANI LEWIS

I'm Dyani Lewis. Thanks for joining us. Testosterone, it's the very essence of maleness. It evokes images of raw strength and competitiveness, virility and square-jawed male maturity. Testosterone is what makes a man a man, and without it we wouldn't get from one generation to the next. But testosterone and other male hormones, collectively known as androgens, have effects that reach far beyond simply setting in motion sexual maturity for half of our species. So what happens when someone lacks this body morphing hormone? Can you have too little or too much testosterone? What role does it play in the physiology of females? To tease out some of the remarkable effects of this ubiquitous hormone, I'm joined in the Up Close studio by endocrinologist Professor Jeffrey Zajac, who is the Director of Endocrinology at the Austin Hospital and Head of the University of Melbourne Department of Medicine. Welcome to Up Close Jeffrey.

JEFFREY ZAJAC

Good morning. Thank you for having me.

DYANI LEWIS

Jeffrey, some of the most striking effects of testosterone are in how it alters the male body during development. Could you start by telling us a bit about what sort of physical changes testosterone induces in the male body.

JEFFREY ZAJAC

The effects of testosterone are time-dependent, so there are three times in life when testosterone goes up; there's a little burst during intra-uterine development, there's a short time after birth in the neo-natal period, and then the most obvious burst is at puberty in boys. So when boys go through puberty they change from pre-pubertal non sex-driven people to sex-crazed male teenagers and that effect is almost entirely due to the secretion of testosterone from their testes. So as the testosterone goes up, it makes their muscles grow, it makes their body shape change, it makes their

bones grow, it changes the way the brain works and it causes all those effects we recognise in teenage boys. Then over a period of time those effects stabilise and they grow into adult males, and the male body shape, the sexual function and lots of other factors about the way males operate is determined and regulated by testosterone.

DYANI LEWIS

Now puberty is obviously the period where we most noticeably recognise these changes, but what about the other peaks that happen before birth, and then immediately after, do we know what those peaks are for?

JEFFREY ZAJAC

Well, yes and no. The peak during development in the uterus is required to switch on the development of the male sexual organs, the external and the internal sexual organs, so if you don't have that peak of testosterone during development the male organs don't develop and what you might call the default state develops, which is the female body shape and genital pattern. Nobody really knows what the neo-natal spike does. Grandmothers often giggle when their little grandson pees in the air with his penis erect and it turns out, not only is that person peeing, but they're already having an erection and usually if you point that out to Grandma, she gets a bit of a shock. So presumably, the main function of testosterone at that stage is not that, but it may have something to do with activating mechanisms in the brain or other tissues, but it's not really clearly understood.

DYANI LEWIS

Then at each time after these peaks, does the testosterone level fall back down again?

JEFFREY ZAJAC

Yes, so during most of the pre-pubertal life, the levels of testosterone are the same in males and females.

DYANI LEWIS

Then even after puberty the levels fall down again as well?

JEFFREY ZAJAC

It's not crystal clear. Testosterone goes up a lot at puberty and then in cross-sectional studies testosterone gradually drops as people age. There's no rapid drop, as in the menopause in women, but there is a gradual decline. There's a very controversial non-syndrome called the andropause which has got no scientific basis. There's no sudden drop in testosterone, there's a gradual decline. On the other hand, there have been studies in healthy men, longitudinal studies, which show no measureable decline with age. So that controversy needs to be resolved.

DYANI LEWIS

So you call it a non-syndrome because you say there's no clear evidence for it?

JEFFREY ZAJAC

Well it's completely non-existent. It's made up, it's nonsense. It is true that if you take 70 year olds in general and compare them with 40 year olds, the average testosterone will be lower but there is no sudden drop in testosterone over several years that's the equivalent of the menopause in women. So there is no andropause.

DYANI LEWIS

Now you mentioned that the average across a sample of men will be lower in older men, how much does testosterone vary from one man to the next?

JEFFREY ZAJAC

Well unfortunately in our field, our assay, our test is not very good, it's one of the few tests in medicine that's got worse over the last 10-20 years because as the assays have got automated and more rapid and cheaper, the gold standard tests are no longer used. So the test itself can vary from day to day, and the test itself can vary on the same sample if done in different laboratories. So we often measure testosterone several times before we are happy with the result. But if you factor that in and you do multiple measurements, in general testosterone might run between ten and 30 nanomoles per litre; it might be in the 20s in teenage males, and be more likely in the teens, between ten and 20, as people are in their 40s and 50s. But again in my field, we don't have age ranges of testosterone, the studies just haven't been done. I guess a problem in our area is that men have been a lot less studied than women, so we don't have the data.

DYANI LEWIS

That must make it quite difficult as a clinician to diagnose people if you don't have, I guess, a benchmark level of testosterone?

JEFFREY ZAJAC

Well it's quite a common clinical problem. I see a lot of patients who come in and their GP has measured their testosterone because they're having difficulty concentrating and they're having various problems coping with day to day stresses and the one measurement might be slightly low and they tell the patient they're testosterone deficient, and that if they get testosterone everything will be fixed, and they get given testosterone and a few months later nothing is fixed and then they come and see me and want to know why it isn't working. It's not working because it wasn't the problem.

DYANI LEWIS

Now, all hormones are produced in one part of the body and they are a chemical message that's to be received in another part of the body, so whereabouts is testosterone made, and what tissue, or tissues in the body is it communicating with?

JEFFREY ZAJAC

Now, I guess I don't really need to answer this question because everybody knows the answer to this, they think. In males, most of the testosterone comes from the testes, from the testicle. There are small amounts of testosterone made in other

tissues. In women, testosterone is made in the ovaries and there can be local synthesis of testosterone in some places. There's a little gland above the kidney, called the adrenal, which produces testosterone and in some circumstances can produce too much testosterone, but in men the main site of testosterone production is the testis.

DYANI LEWIS

Whereabouts is that message being sent?

JEFFREY ZAJAC

Everywhere.

DYANI LEWIS

Okay, so how do cells in the body see that message?

JEFFREY ZAJAC

So testosterone is a steroid hormone. Estrogen, estradiol, cortisol, they're all steroid hormones, so they circulate in the blood and they act on cells in the body by binding to a target called a receptor. It's a very specific target; it's like a lock and a key, so the testosterone binds very specifically to its receptor, which is called the androgen receptor. All cells in the body have androgen receptors, and men and women have similar numbers of androgen receptors, and when testosterone binds to the androgen receptor it activates it and then modulates the function of the target cell.

DYANI LEWIS

Once the androgen receptor has perceived that testosterone, it modulates effects, what do you mean by modulates? How does that work?

JEFFREY ZAJAC

So, like other steroid hormones, testosterone binds to the receptor which is mostly in the cytoplasm of the cell. The receptor then migrates to the nucleus of the cell and binds to a variety of other proteins which regulate its function. The receptor then binds to specific sequences in the DNA and those sequences switch on a variety of target genes. So if a gene has this particular target sequence, the receptor will bind to it and then the expression of that gene will be changed; it will either switch on or switch off or be regulated in a much more complicated way, and it's the pattern of gene expression within a particular cell that regulates the function of that cell; it turns it into a muscle cell, or if it's a muscle cell, makes it grow more. So when testosterone activates a cell, a suite of genes, which you can measure, are switched on and off in a particular pattern and the expression of those genes then regulates the function of the cell.

DYANI LEWIS

So it's interesting that every single cell in the body would contain an androgen receptor, does this imply then that testosterone really has effects body-wide?

JEFFREY ZAJAC

Yes, now I fibbed a little. It's not every single cell, but most cells, and it's true probably that testosterone does have actions in the entire body. You can live without testosterone. If you take away testosterone, the person doesn't die, it's not required for survival and you, a female, have very low levels of testosterone and you seem to be perfectly fine. So you don't need testosterone to be alive, or to survive, or to be normal. You need testosterone to masculinise and be a male.

DYANI LEWIS

So in your work as an endocrinologist, you must come across a wide range of people for whom this neat sequence of testosterone production and then testosterone perception doesn't exactly work, so what type of conditions do you encounter in your practice?

JEFFREY ZAJAC

It's sort of tricky because most of the people I see don't have anything wrong with their testosterone, they're like the patient I described earlier, where somebody thinks because the assay isn't very good that they might have testosterone causing a whole slew of non-specific problems like weakness, lethargy, difficulty concentrating, problems at work, and most likely those things are non-medical in origin. On the other hand, people with real pathological deficiency in testosterone are often under-diagnosed and they often present as males who either don't fully develop during puberty, they may present in infertility clinics, they may be just diagnosed on physical examination. The commonest illness in this category is called Klinefelter syndrome, it's a genetic disease, and those patients have very small testes and moderately, or severely, low levels of testosterone which causes their bones to be thin, their muscles to be weak, many other problems. It's a very varied condition, some of them have no specific problems at all and some of them have quite a lot of problems. Endocrinologists identifies them because they've got gynaecomastia, slightly large breasts, and they have very small firm testes and you can see people who are in their 20s or 30s who clearly have Klinefelter's syndrome and in their entire lives nobody's actually examined their testes. So that's a bit of a failing of our medical system because it's not part of a routine examination unfortunately.

DYANI LEWIS

Klinefelter's is a condition where they've got an extra X chromosome, is that right, so they've got an X and a Y, but also an extra X chromosome, so does this just throw out the balance of hormones in the body?

JEFFREY ZAJAC

Yes, so they're XXY, and they often have somewhat low levels of testosterone. You're exactly right, it sort of throws out the balance of hormones in the body so they have these problems. Almost always, they're 100 per cent infertile, not absolutely, there are some special sub-categories of Klinefelter's where that might not be the case, but often they respond very nicely to testosterone replacement and, as I've said, as opposed to the first category of patient I talked about, these patients are often under-diagnosed and we should be trying harder to find them and give them testosterone treatment.

DYANI LEWIS

What about when the receptor is defective, what sorts of conditions happen when that's the case?

JEFFREY ZAJAC

Well, endocrinology is full of very interesting genetic conditions and so if the receptor is not working, it's called the Androgen Insensitivity syndrome, and such patients even if they are XY males develop as females. So because the testosterone in utero is not functioning, can't work, the external genitalia don't change to the male pattern, so they are female. They have a vagina that's relatively short and blind ending. They have no uterus, but they do have testes and those testes make testosterone and so you have a woman who is completely female; in some ways you might say super-female because she's got absolutely no testosterone activity as opposed to a normal female, normal female body shape but won't be having periods and won't be fertile. If you measure testosterone in such a person, it may well be in the male range so everybody gets a bit of a shock. There are cases of this problem in which the androgen receptor can be a little bit functional, it's not quite as clear whether they're male or female and they often have the most problems in their lives.

DYANI LEWIS

I'm Dyani Lewis and you're listening to Up Close. I'm speaking with endocrinologist, Professor Jeffrey Zajac, and we're talking about his research into the male hormone, testosterone. Jeffrey, in your research you also look at testosterone in mice. How can mice help you pick apart the different effects that testosterone has on the body?

JEFFREY ZAJAC

Well there's things you can do to mice that you can't do to people. If you want to reduce the amount of testosterone, the easiest way is to remove the testes. It's tricky when you want to do that to humans, they obviously did that to the castrati in the 16th century to make them sing better.

DYANI LEWIS

But I'm sure most people would object quite strongly now.

JEFFREY ZAJAC

I don't think our ethics committee would allow us to do that any more. But we can do it in mice and we study the androgen receptor in mice and we study androgens in mice, and we study this by either taking away the testosterone, by removing the testes, or taking away the androgen receptor by switching it off using interesting, complicated but relatively straightforward genetic technology.

DYANI LEWIS

You have some really nifty techniques of just shutting down the androgen receptor in particular tissues. How can that help you?

JEFFREY ZAJAC

Yes, we have this technology that's termed Cre-Lox, which is a mechanism for

removing or inactivating the function of the androgen receptor in a time- or tissue-specific manner in mice. So we study the androgen receptor in reverse, so we remove it from the whole animal, or from a particular tissue like muscle, and then we compare that with a normal wildtype animal and so the difference must be what the androgen receptor does.

DYANI LEWIS

So what happens in a mouse if you make, for example, a muscle blind to the testosterone, if you shut down the receptor in just the muscle?

JEFFREY ZAJAC

If you remove the androgen receptor from the whole mouse, you have an androgen insensitivity syndrome mouse, like we were talking about in humans. Now, in mice, that mouse is called a male mouse, even though its genitals are female. It's a sort of difference in the way we use the terminology, so in that male mouse the muscles are reduced in bulk by about 20 or 30 per cent. There's a muscle in the pelvis called the Levator Ani which is near the prostate gland, which goes down about 90 per cent. Now nobody quite knows what that muscle does, but it is the most sensitive muscle to removing either testosterone or the androgen receptor. So the muscles go down, they go down in bulk by about 20 per cent, and they get about 20 per cent weaker.

DYANI LEWIS

Now how do these effects compare to what you would see in people who have low testosterone levels, or androgen insensitivity in terms of their muscles?

JEFFREY ZAJAC

Well, in a patient with Androgen Insensitivity syndrome, she has female muscles so they're generally females, in general weaker than males in terms of their muscles, but lower muscle bulk. In terms of what happens if you remove testosterone, so despite what I said about us not being able to do that, there is an interesting medical condition that we study. In patients with prostate cancer, one of the therapies for a particular type of prostate cancer is to remove the testosterone. This used to be done by removing the testes, orchidectomy, and then it used to be done by giving large doses of estrogen, both of which had some negative issues. Nowadays, there are drugs which are given by injection which make the testosterone drop to zero, and so there's a very lowest form of testosterone you can get, and these males have side effects from this therapy; their muscles become thin, their bones become thin, they increase the amount of adipose tissue, the amount of fat tissue, and we have a large number of these males who we study from before they have this treatment over a period of six months or a year, and we can compare what happens to their muscles and their bones and their adipose tissue with what we see in the mice. So we can predict and can modify our theories depending on what happens. Obviously studying mice is easier than studying humans but in the end, you want the information to be of relevance to human illness and human physiology and so we need to check anything we find in the mice, in humans, and this is a very good model of removing testosterone.

DYANI LEWIS

With these men that have their testosterone brought right down to the minimal, minimal level during prostate cancer treatment, when you remove that treatment, obviously that testosterone level will bounce back up but do they regain their muscle?

JEFFREY ZAJAC

Often they have this treatment for many years, and often they're elderly male, so there's not very much information about what happens when you stop the therapy, it's called Androgen Deprivation Therapy, and our studies haven't gone on long enough to find out what happens when the men stop. You would think, in theory, there would be a tendency to regain muscle bulk, but it's not clear that there's good data that that happens.

DYANI LEWIS

Muscles are only one of target of testosterone in the body, so what other complaints do these men have as a side effect of the Androgen Deprivation Therapy?

JEFFREY ZAJAC

Well, their bones get thin, they don't complain about that, but it is osteoporosis and they complain when they break one. So they're much more likely to break their bones. They do have an increase in fat tissue and there's a link between an increase in the fat tissue within the abdomen called visceral fat and the risk of cardiovascular disease. So it's quite possible that reducing testosterone in these men may increase the risk of cardiovascular disease and it might surprise you to hear that the commonest cause of death in both breast cancer and prostate cancer is heart disease.

DYANI LEWIS

Is that right?

JEFFREY ZAJAC

Yes.

DYANI LEWIS

What about things like personality, because I guess in the popular sense, testosterone is very much linked to personality traits; it's often thought of in terms of aggressiveness or competitiveness or that sort of thing. Is there much known about how testosterone affects personality, and I guess the effects of the Androgen Deprivation Therapy on personality?

JEFFREY ZAJAC

Well there's a lot of anecdotal evidence. There's not much actual data, everybody's got a theory. The best evidence comes from, what are termed, transgender individuals. So there is a small percentage of individuals who are female, who are sure that they are male. I, and other endocrinologists, treat these people by giving them testosterone which masculinises them. So if I gave you testosterone you would masculinise nicely. If you have baldness in your family, your hair would fall out, your

body shape would become male, your breasts would atrophy, but not disappear, you would grow a beard and you would grow body hair. Now, would you become an aggressive individual? Not unless your personality was an aggressive personality. So it's doesn't take mild people and make them aggressive. If you are aggressive and you take away testosterone, well people lack initiative, and they lack activity, so in that sense they look as if they're less aggressive and if you give them the testosterone back, they would go back to what they were before. But it's not really clear that testosterone makes individuals who have low levels and then have it replaced, it's not clear that it makes them more aggressive.

DYANI LEWIS

How quickly would testosterone take effect on a female, like those changes you were talking about?

JEFFREY ZAJAC

It's sort of slow, but definite and definitive, so it would take about three months for your beard to start growing, about six months for your body shape to change and if we have an interview in two years time, you would look completely male. Not your genitals, but the rest of you. People wouldn't be able to tell. Your voice would be deep. Now, in this field, this is tricky because a lot of those changes are irreversible so you really want to be sure; you and the patient, and the patient's psychiatrist know what you are doing.

DYANI LEWIS

So how come you can't reverse these effects?

JEFFREY ZAJAC

Well when you give testosterone to a female to masculinise the person, or when a male goes through puberty, a number of the effects of testosterone are irreversible. So the voice is deepened and that doesn't change because the structure of the voice box changes. Testosterone activates hair growth and baldness, hair growth in the beard and body, and baldness on the scalp, and once that happens you can't reverse it by taking the testosterone away. The effects on muscle bulk and body shape can be reversed, and the effects on some other metabolic functions, the effect on the fat tissue might be reversible, but many of the actions of testosterone, if it's used for a period of time, are irreversible. In female to male transgender individuals, we make it clear to them that many of the effects of testosterone are irreversible and they shouldn't assume they can go back to looking like and sounding like what they were before if they change their minds, which they very rarely do I would point out.

DYANI LEWIS

You're listening to Up Close, I'm Dyani Lewis, and my guest today is Jeffrey Zajac, an endocrinologist who's been telling us about the role of testosterone in the body. Jeffrey, testosterone is metabolised from cholesterol, and cholesterol is obviously a component of our diet, so are there environmental or dietary influences on our testosterone levels?

JEFFREY ZAJAC

Yes. In fact, there's lots of ways you can make your testosterone go down. In men who are depressed, who are overweight, who have diabetes, testosterone levels can be quite low. In the same way that when women are under stress, their estrogen level goes down and their periods stop, men have a similar effect where their testosterone goes down but you don't notice very much because they don't have periods to see. So there are a lot of ways in which the environment causes testosterone to go down from its peak to something that's sub-optimal. So there are many ways to get testosterone to go back to what it should be, lifestyle issues, reduction of stress, improvement of depression, decrease in obesity, so all of those things improve the testosterone level and they would be very valuable in a therapeutic sense. Is there a way to take your normal testosterone and make it higher by eating something from the forest? Not that I know of.

DYANI LEWIS

So for someone who's had an unhealthy lifestyle, perhaps they're a bit overweight, they've got this decrease in testosterone, if they were trying to rectify that by exercise, is it the exercise itself that's improving testosterone or is it just that you're removing some of these other things like excess fat tissue and poor diet or stress?

JEFFREY ZAJAC

Now, it might surprise you to hear this, but I don't know the answer to that question. Testosterone is regulated by the brain, by a little gland in the brain called the pituitary which is regulated by part of the brain immediately next to it called the hypothalamus, which is regulated by the rest of the brain. So that regulatory function is very complicated and is both hormonal, neurological and psychological. Is there a study where you take men with a particular level of testosterone and exercise half of them and not the other half, and see if the testosterone goes up? Not in any good sense where you can say, oh yes just exercise makes testosterone go up. It's clear that better health makes testosterone go back up to normal. If you go to the gym and you start exercising, my prediction is it wouldn't change your testosterone level at all. In marathon runners, in female marathon runners, their periods stop because their estradiol level goes down because of too much exercise, so the prediction in men would be exactly the same thing, that if you do too much exercise, not only doesn't it increase your testosterone, it would reduce your testosterone. So the only way to increase your testosterone is to take testosterone or something similar. Testosterone is usually not bio-available in oral formulation, so most of the things that people take orally won't have any effect on testosterone one way or the other. There are a few oral formulations and they're very toxic so I wouldn't take them either.

DYANI LEWIS

Jeffrey, if we come back to the role of testosterone in muscle development, the muscle building effects that you see with anabolic steroids, is that essentially equivalent to taking testosterone supplements?

JEFFREY ZAJAC

Yes, they take testosterone because it works, and it works very well. So if you start

with a very low level of testosterone in a person with testes that aren't working, or in a transgender female to male person, the muscles start growing and they keep growing as long as you give the testosterone. In mice, it's not clear that there's an upper limit to the dose of that effect, that is, the more testosterone you give, the more muscles grow. Now the body builders believe that this is similar in humans, that the more you take, the more muscle you grow. Now obviously this hasn't been studied in a rigorous scientific way because you would never be able to do that in an ethical sense, but certainly the body builders believe this, they have very complicated regimens where they grow their muscles by giving all sorts of complicated variations of testosterone. Sometimes they have trouble getting actual testosterone so they use synthetic versions of these that, as you said at the beginning, these are termed androgens and they use other androgens in order to avoid detection, but many of these things work just as well as testosterone. Unfortunately for the body builders, if you take large doses of testosterone, well I guess the general public won't know this but the body builders know this, testosterone is the immediate substrate for estrogen, for estradiol. So if you have too much testosterone, you end up with too much estradiol as well.

DYANI LEWIS

So testosterone is metabolised into estrogen?

JEFFREY ZAJAC

Yes, in a woman, in the ovary testosterone is the step before estradiol. So obviously in the ovary, most of the testosterone is made into estradiol. In the testis, most of the testosterone stops at testosterone. But if you swamp the body with testosterone, like the body builders do, then you have an increase in the amount of circulating estradiol and that causes the breasts to grow and body builders have a number of colourful names for this phenomenon. It also causes the testes to atrophy because they don't need to make testosterone and the testosterone production and the sperm production switches off, so they get large breasts and small testes, and they take various other medications to combat this issue but in general they're not too worried about the small testes because it doesn't affect the body building, but they can be quite worried about the enlarged breasts because that isn't good for the competition.

DYANI LEWIS

But they're certainly not becoming the hyper-male that they set out to become necessarily with some of these side effects.

JEFFREY ZAJAC

No, with hormones, the right amount is the right amount. More is not better. Usually more is worse, so there's nothing better about taking more of any hormone.

DYANI LEWIS

What about the other clinical applications, not for body builders obviously, but in clinical practice, are there reasons for giving testosterone?

JEFFREY ZAJAC

Well, if you're deficient in testosterone as I suggested before, it's replacement of what you're missing so that's standard endocrinology, if patients have had their testes removed because of tumours or trauma or some other problem, or if they're not functioning because the patient's had mumps or some other problem, or trauma, then the testosterone needs to be replaced. In transgender, female to male transgender individuals, testosterone is enabling them to live in the body that they think they deserve. Now, testosterone could be used for a lot of other things. In illness, when people have chronic illness, heart disease, cancer, AIDS, almost any chronic illness, the muscles waste away and when elderly patients are admitted to hospital, even after a week or so, their muscles are starting to waste away. So in theory, if you gave them testosterone, this should build up their muscles but the problem is if you give too much testosterone to an ageing male, this can have unwanted side effects and even more so in a female. So if we could work out how to harness the muscle growing effects of testosterone without actually using testosterone, that would be a very useful therapeutic agent.

DYANI LEWIS

That's then looking at some of the downstream effects that are happening in the muscles, I guess, is that right?

JEFFREY ZAJAC

Yes, so if you could work out, and this is one of the things my lab studies, if you could work out the pathway from the androgen receptor to the muscle cells growing and activate something further along the pathway, distant to the androgen receptor, you might be able to get muscle growth but without the masculinising effects of testosterone. This would be a potentially very useful therapeutic agent.

DYANI LEWIS

Are there any reasons that you would give it to females, I know testosterone has been used in, say, low libido and that kind of thing.

JEFFREY ZAJAC

Yes, so this is also a very controversial area with people with strong views, and there have been studies on this. Females have very low levels of testosterone. The standard testosterone assays are useless for measuring testosterone in females unless it's elevated, so measuring low levels of testosterone in females with a normal assay is meaningless, so if somebody tells a patient that their testosterone is low and that this is a problem there's no good data for that. There are now much better testosterone assays that are valid in females and there's no suggestion that testosterone deficiency occurs suddenly. If the ovaries are removed for medical reasons, then the testosterone does drop in women and that can perhaps have clinical consequences. There is some data that testosterone may regulate female libido, but there's no good evidence that a slow decline in testosterone in women as they age is controlling or regulating libido in women and there's some data that giving a burst of testosterone may be beneficial in this area, but it's very controversial data and many endocrinologists, like me, don't believe it.

DYANI LEWIS

Sounds like we should keep testosterone as the male hormone then.

JEFFREY ZAJAC

Well my view is that testosterone is for men. That is my view.

DYANI LEWIS

Jeffrey Zajac, thank you very much for being my guest today on Up Close and discussing your work on testosterone.

JEFFREY ZAJAC

Thank you for having me.

DYANI LEWIS

Professor Jeffrey Zajac is the Director of Endocrinology at the Austin Hospital and head of the University of Melbourne Department of Medicine. If you'd like more info on this episode, or a transcript, then head to the Up Close website. Up Close is a production of the University of Melbourne, Australia. This episode was recorded on 3rd October 2013. Producers were Eric Van Bommel, Peter Clarke and myself, Dr Dyani Lewis. Audio engineering by Gavin Nebauer. Up Close is created by Eric Van Bommel and Kelvin Param. Until next time, goodbye.

VOICEOVER

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