

Arctic ground squirrels muscle up to hunker down

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When Arctic ground squirrels are getting ready to hibernate they don't just get fat - they pack on muscle at a rate that would make a bodybuilder jealous. And they do it without suffering the harmful effects that high levels of testosterone and other anabolic steroids usually cause. University of Toronto Scarborough (UTSC) researchers have started to untangle how the squirrels manage it, and their results could someday have implications for human health.

Arctic ground [squirrels](#), it turns out, ramp up their anabolic steroid levels and keep them high not just during the spring mating season, but during the summer and fall. To avoid the damaging effects of these high levels, they seem to suppress androgen receptors in all tissues except muscle, according to Rudy Boonstra, professor of biological sciences at UTSC.

Boonstra's research will appear in an upcoming issue of *Functional Ecology*. It is co-authored by Brendan Delehanty, also of UTSC, and Adrian J. Bradley of the University of Queensland.

Like many other hibernators, Arctic ground squirrels go underground in winter and burn the fat they stored up during the summer and fall. But Arctic ground squirrels have a problem faced by almost no other hibernator. Other animals dig below the frost line and hibernate in a relatively warm 0° C. Because Arctic ground squirrels can't get below the permafrost, they have to spend their eight-month hibernation at temperatures as low as -23° C.

Thus to stay alive their metabolisms have to run at a higher rate than other hibernators. Stored fat provides much of the energy they need, but it can't give them the levels of glucose required by vital tissues such as the brain and heart. Only burning protein stored in muscles will provide the needed glucose.

To see what was going on, Boonstra and colleagues examined the blood of Arctic ground squirrels in Canada's northern Yukon territory over an entire active season, and compared it with blood taken from Columbian ground squirrels from southern Alberta, a species which hibernates at about 0°C.

In most ground squirrels, testosterone levels in males peak during mating season then fall drastically afterwards. In male Arctic ground squirrels, anabolic steroid levels (including testosterone) start out higher than in other species and stay elevated - between 10 and 200 times higher than in any other ground squirrels. Females also had exceptionally high levels of androgens, between 40 and 100 times higher than in other ground squirrels.

These high levels of androgens help both males and females to increase lean body mass (i.e. muscle) by about 25 percent in the months leading up to winter hibernation - mass which is then consumed as they hibernate.

In another portion of the study Boonstra and colleagues showed that in males these anabolic steroids were not being produced at the normal site of production, the testes. Instead, the squirrels produced them in their adrenal glands.

High doses of anabolic steroids also have negative effects, such as suppressing the immune system, and in older human males, causing prostate cancer. Men who take anabolic steroids to increase muscle mass and strength can suffer side effects like baldness, scarring acne, shrinkage of the testicles, behavioral and psychiatric problems, and increased risk of cardiovascular disease.

Arctic ground squirrels are proposed to down-regulate androgen receptors in tissues other than muscle. In other words, the androgens coursing through their bodies are invisible to all tissues

except [muscle](#), which protects them from the ill effects of too much androgen. How they do this still isn't known.

Because of the role of androgen levels on prostate cancer, understanding how Arctic ground squirrels turn off androgen receptors could someday have implications for human health, Boonstra says.

Provided by University of Toronto Scarborough

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