Focus on Muscle Metabolism: Sex Differences in Sport and Obesity

The skeletal muscles of men and women process glucose and fats in different ways. A study conducted by the University Hospital of Tübingen, the Institute for Diabetes Research and Metabolic Diseases of Helmholtz Munich and the German Center for Diabetes Research (DZD) e.V. provides the first comprehensive molecular analysis of these differences. The results possibly give an explanation why metabolic diseases such as diabetes manifest differently in women and men – and why they respond differently to physical activity.

Skeletal muscles are far more than just "movement driving motors." They play a central role in glucose metabolism and therefore also in the development of type 2 diabetes. This is due to the fact that around 85 percent of insulin-dependent glucose uptake takes place in the muscles. This means that if muscle cells react less sensitively to insulin, for example in the case of insulin resistance, glucose is less easily absorbed from the blood. This process is specifically counteracted by physical activity.

Women's and Men's Muscles Work Differently

The degree to which muscles work differently in women and men has long been underestimated. It is precisely this issue which has now been investigated by researchers led by Simon Dreher and Cora Weigert. They examined muscle biopsies from 25 healthy but overweight adults (16 women, 9 men) aged around 30 years. The test subjects had not taken part in regular sporting activities beforehand. Over a period of eight weeks, they completed one hour of endurance training three times a week, consisting of 30 minutes of cycling and 30 minutes of walking on the treadmill.

Muscle samples were taken before they started, after they had the first training session and at the end of the program. Using state-of-the-art molecular biological methods, including epigenome, transcriptome and proteome analyses, the team investigated sex-specific differences at various levels.

Men React with more Stress to Exercise

The result: The first training session triggered a stronger stress response at the molecular level in men, which became manifest in the increased activation of stress genes and the increase in the muscle protein myoglobin in the blood. In addition, male muscles showed a distinct pattern of what are called fast-twitch fibers, which are designed for short-term, intensive exercise and preferably use glucose as an energy source.

Women had significantly higher amounts of proteins that are responsible for the absorption and storage of fatty acids: an indication of more efficient fat utilization. After eight weeks of regular endurance training, the muscles of both sexes matched and the muscle fiber-specific differences decreased. At the same time, women and men produced more proteins that promote the utilization of glucose and fat in the mitochondria, the "power plants of the cells."

"These adjustments indicate an overall improvement in metabolic performance, which can help to reduce the risk of type 2 diabetes," says Weigert. "In future, our new findings might help to better predict individual diabetes risks and tailor recommendations for exercise therapies more specifically to women and men."

What happens next? The scientists now want to investigate the role sex hormones such as estrogen and testosterone play in these differences – and how hormonal changes in old age influence the risk of metabolic diseases.

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Further information

- Deutsches Zentrum für Diabetesforschung e.V.