How muscle fatigue originates in the head

December 5 2011

this is a test on the bicycle ergometer with the measurement of brain activity. Credit: University of Zurich

The extent to which we are able to activate our muscles voluntarily depends on motivation and will power or the physical condition and level of fatigue of the muscles, for instance. The latter particularly leads to noticeable and measurable performance impairments. For a long time, the research on muscle fatigue was largely confined to changes in the muscle itself.

Now, a joint research project between the University of Zurich and ETH Zurich has shifted the focus to brain research. Headed by neuro-psychologist Kai Lutz from the University of Zurich in collaboration

with Urs Boutellier from the Institute of Human Movement Sciences and Sport at ETH Zurich, the researchers discovered neuronal processes for the first time that are responsible for reducing muscle activity during muscle-fatiguing exercise. The third and final part of this series of experiments, which was conducted by Lea Hilty as part of her doctoral thesis, has now been published in the *European Journal of Neuroscience*.

Muscle's nerve impulses inhibit motoric area in the brain

In the initial study, the researchers showed that nerve impulses from the muscle – much like pain information – inhibit the primary motoric area during a tiring, energy-demanding exercise. They were able to prove this using measurements in which study participants repeated thigh contractions until they could no longer attain the force required. If the same exercise was conducted under narcotization of the spinal chord (spinal anesthesia), thus interrupting the response from the muscle to the primary motoric area, the corresponding fatigue-related inhibition processes became significantly weaker than when the muscle information was intact.

In a second step, using functional magnetic resonance imaging, the researchers were able to localize the brain regions that exhibit an increase in activity shortly before the interruption of a tiring, energy-demanding activity and are thus involved in signalizing the interruption: the thalamus and the insular cortex – both areas which analyze information that indicates a threat to the organism, such as pain or hunger.

Neuronal system has regulating effect on muscle performance

The third study has now shown that the inhibitory influences on motoric activity are actually mediated via the insular cortex: In tests using a bicycle ergometer, the researchers determined that the communication between the insular cortex and the primary motoric area became more intensive as the fatigue progressed. "This can be regarded as evidence that the neuronal system found not only informs the brain, but also actually has a regulating effect on motoric activity," says Lea Hilty, summing up the current result. And Kai Lutz points to the new research field that now opens up with these results: "The findings are an important step in discovering the role the brain plays in muscle fatigue. Based on these studies, it won't just be possible to develop strategies to optimize muscular performance, but also specifically investigate reasons for reduced muscular performance in various diseases." Prolonged reduced physical performance is a symptom that is frequently observed in daily clinical practice. It can also appear as a side effect of certain medication. However, so-called chronic fatigue syndrome is often diagnosed without any apparent cause.

More information: Lea Hilty, Lutz Jäncke, Roger Luechinger, Urs Boutellier, and Kai Lutz. Limitation of Physical Performance in a Muscle Fatiguing Handgrip Exercise Is Mediated by Thalamo-Insular Activity. Human Brain Mapping. December 10, 2010. doi: 10.1002/hbm.21177

Lea Hilty, Kai Lutz, Konrad Maurer, Tobias Rodenkirch, Christina M. Spengler, Urs Boutellier, Lutz Jäncke, and Markus Amann. Spinal opioid receptor-sensitive muscle afferents contribute to the fatigue-induced increase in intracortical inhibition in healthy humans. Experimental Physiology. February 11, 2011. doi: 10.1113/expphysiol.2010.056226

Lea Hilty, Nicolas Langer, Roberto Pascual-Marqui, Urs Boutellier, and Kai Lutz. Fatigue-induced increase in intracortical communication between mid⁄anterior insular and motor cortex during cycling exercise.

European Journal of Neuroscience. November 21, 2011. doi: 10.1111/j.1460-9568.2011.07909.x