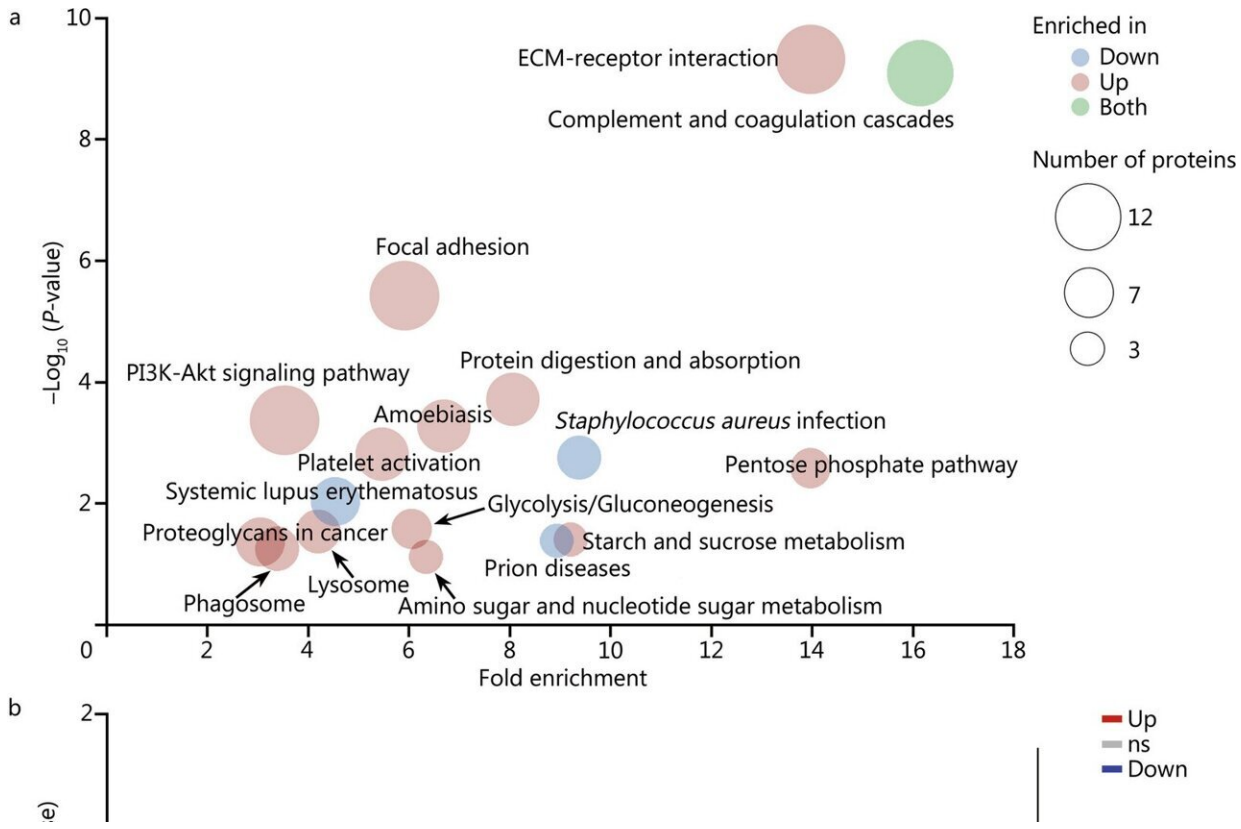
Vigorous exercise, rigorous science: What scientists learned from firefighters in training

November 9 2023



Comparative multi-omics analysis of blood plasma prior and post exercise. a Functional-enrichment analysis of proteins differentially abundant (Student's t-test $P \leq 0.05$) after the exercise session. The enrichment analysis was done with DAVID and the graph is plotted in function of the fold enrichment versus Fisher's exact test P-values. The colors represent if the pathways were overrepresented in up-regulated or down-regulated proteins, while the circle

sizes represent the number of regulated proteins in each pathway. b Boxplot of abundance ratios of extracellular matrix (ECM) proteins comparing pre- and post-exercise sessions. Black diamonds represent outlying data points. c Boxplot of abundance ratios of regeneration factors comparing pre- and post-exercise sessions. d ELISA analysis of plasma dermcidin levels prior and after the exercise session. Credit: *Military Medical Research* (2023). DOI: 10.1186/s40779-023-00477-5

Eleven young firefighters went through a rigorous training exercise, carrying up to 40 pounds of gear over hilly terrain during a 45-minute training exercise in the California sun. Gloves, helmets, flashlights, goggles, and more weighed them down as they sprinted through the countryside wearing fire-resistant clothing to show they were ready to serve as wildland firefighters.

When the training was over, they immediately went to the medical tent—not to rest and recover but to give samples of their blood, saliva, and urine for analysis by a team of scientists equipped with needles, test tubes, cold packs, and the gear of their own trade.

Then, the scientists from the Department of Energy's Pacific Northwest National Laboratory (PNNL) analyzed more than 4,700 molecules—proteins, lipids, and metabolites—from each of the firefighters, seeking to understand what happens when the body undergoes intense physical exercise. Measuring and interpreting the data from thousands of such measurements is a specialty of PNNL scientists who explore issues related to climate science and human health by analyzing millions of sensitive measurements using mass spectrometry each year.

For this study, the intent was to increase safety for first responders and others.

"Heat stress can be life threatening," said Kristin Burnum-Johnson, a corresponding author of the study. "We wanted to take an in-depth look at what's happening in the body and see if we're able to detect danger from exhaustion in its earliest stages. Perhaps we can reduce the risk of strenuous exercise for first responders, athletes, and members of the military."

As expected, the team detected hundreds of molecular changes in the firefighters. The differences before and after exercise underscored the body's efforts at tissue damage and repair, maintenance of fluid balance, efforts to keep up with increased energy and oxygen demand, and the body's attempts to repair and regenerate its proteins and other important substances.

But in the saliva, the team found some unexpected results. There was a change in the microbial mix of the mouth—the oral microbiome—showing that the body was increasingly on the lookout for bacterial invaders. Scientists also saw a decrease in signaling molecules important for inflammation and for fighting off viral infections.

A decrease in inflammation makes sense for people exercising vigorously; less inflammation allows people to breathe in air more quickly, meeting the body's eager demand for more oxygen. Having fewer inflammatory signals in the respiratory system helps the body improve respiration and blood flow.

Less inflammation, better breathing

But less inflammation leaves the body more vulnerable to viral respiratory infection—which is exactly what other scientists have noted in elite athletes and others who exercise vigorously. Some studies have shown that a person is up to twice as likely to come down with a viral respiratory infection in the days after an especially energetic workout.

"People who are very fit might be more prone to viral respiratory infection immediately after vigorous exercise. Having less inflammatory activity to fight off an infection could be one cause," said Ernesto Nakayasu, a corresponding author of the paper published Oct. 18 in *Military Medical Research*. He notes that the work provides a molecular basis for what clinicians have noticed in their patients who do strenuous workouts.

The team hopes that the findings will help explain why some people are more vulnerable to respiratory infection after a workout.

More information: Ernesto S. Nakayasu et al, Elucidating regulatory processes of intense physical activity by multi-omics analysis, *Military Medical Research* (2023). DOI: 10.1186/s40779-023-00477-5

Provided by Pacific Northwest National Laboratory