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Capacity for exercise can be inherited, biologists find

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Biologists at the University of California, Riverside have found that voluntary activity, such as daily exercise, is a highly heritable trait that can be passed down genetically to successive generations.

Working on mice in the lab, they found that activity level can be enhanced with "selective breeding" - the process of breeding plants and animals for particular genetic traits. Their experiments showed that mice that were bred to be high runners produced high-running offspring, indicating that the offspring had inherited the trait for activity.

"Our findings have implications for human health," said Theodore Garland Jr., a professor of biology, whose laboratory conducted the multi-year research. "Down the road people could be treated pharmacologically for low activity levels through drugs that targeted specific genes that promote activity. Pharmacological interventions in the future could make it more pleasurable for people to engage in voluntary exercise. Such interventions could also make it less comfortable for people to sit still for long periods of time."

In humans, activity levels vary widely from couch-potato-style inactivity to highly active athletic endeavors.

"We have a huge epidemic of obesity in Western society, and yet we have little understanding of what determines variation among individuals for voluntary exercise levels," Garland said.

Study results appear online Sept. 1 in the Proceedings of the Royal Society B.

The researchers began their experiments in 1993 with 224 mice whose levels of genetic variation bore similarity to those seen in wild mouse populations. The researchers randomly divided the base population of mice into eight separate lines - four lines bred for high levels of daily running, with the remaining four used as controls - and measured how much distance the mice voluntarily ran per day on wheels attached to their cages.

With a thousand mice born every generation and four generations of mice each year, the researchers were able to breed highly active mice in the four high-runner lines by selecting the highest running males and females from every generation to be the parents of the next generation. In the control lines, breeders were chosen with no selection imposed, meaning that the mice either changed or did not change over time purely as a result of random genetic drift.

By studying the differences among the replicate lines, the researchers found that mice in the four high-runner lines ran 2.5-3-fold more revolutions per day as compared with mice in the four control lines. They also found that female and male mice evolved differently: females increased their daily running distance almost entirely by speed; males, on the other hand, increased speed but they also ran more minutes per day.

The study is an example of an "experimental evolution" approach applied rigorously to a problem of biomedical relevance. Although this approach is common with microbial systems and fruit flies, it has rarely been applied to vertebrates due to their longer generation times and greater costs of maintenance. The results of such studies can inform biologists about fundamental evolutionary processes as well as "how organisms work" in a way that may lead to new therapeutic strategies.

"This study of experimental evolution confirms some previous observations and raises new questions," said Douglas Futuyma, a distinguished professor of ecology and evolution at Stony Brook University, New York, who was not involved in the research. "It shows that 'there are many ways to skin a cat': different ways in which a species may evolve a similar adaptive characteristic - running activity, in this case. Garland and coauthors go further by beginning to explore the detailed ways in which an adaptive feature, such as muscle size or metabolic rate, may be realized and by showing sex differences in the response to selection. It would be fascinating to know, and challenging to find out, if any one of these different responses is adaptively better than others."

Provided by University of California - Riverside

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