Sweating in the Service of Science

A washboard stomach takes discipline – and a good exercise program. **Erich Albert Müller** from the **Max Planck Institute for Occupational Physiology** studied the best way to develop muscle. Today, more than 50 years later, the basic principles Müller described remain valid – as do many of the insights from the research carried out in the field of occupational physiology at the time.

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At the Kaiser Wilhelm Institute for Occupational Physiology, riding a bicycle following the consumption of half a bottle of liquor and two liters of beer – something that would attract hefty penalties in the road traffic context – was a remunerated activity. The scientists at the institute wanted to find out how alcohol affects the performance of manual laborers. To this end, they appointed a test subject and put him to work on the ergometer: in a long-term experiment lasting six months, the test subjects "consumed half a liter of Münsterländer corn schnapps and four (0.5 l) bottles of Dortmunder beer on the alcohol days."

According to the experiment protocol, sometimes the test subject was also allowed to get drunk on the day of the experiment itself, and occasionally even the night before. The scientists comment on the decline in the work performance of the test subject as follows: "Our experiments show that the hangover effect triggers a quantitatively stronger and more dramatic deflection of the performance curve than the direct consumption of alcohol." Indeed, if alcohol was instead consumed shortly before the start of work, the same volume of alcohol had a positive effect on performance. Conclusion: "The less work is perceived 'as a burden', the more intensive and untainted is the test subject's willingness to work." The aim of the experiments was not, however, to recommend alcohol as a means of increasing performance, but to describe the effects of alcohol consumption, which, in the past at least, was very common among not only manual workers.

Body building with visible results: Erich Albert Müller with one of his test subjects at the Kaiser Wilhelm Institute for Occupational Physiology.

Photo: KWI for Occupational Physiology

Far from devoting their efforts exclusively to exploring the effects of intoxicants on performance, the scientists at the Kaiser Wilhelm Institute for Occupational Physiology, founded in 1912, were dedicated to the "scientific research of the physiology, pathology and hygiene of mental and physical work" and thus aimed to illuminate as many aspects of the field of occupational physiology as possible.

In 1929, the institute moved from Berlin to Dortmund in the Ruhr area, the very center of hard physical work in Germany. There, in the mine shafts and the scorching furnaces of the steel works between the rivers Rhine and Ruhr, the physiologists found the precise conditions in which they were so interested and that enabled them to explore a wide range of research questions. For example: How does physical work influence health? What nutrients does the body need in order to withstand enormous physical strain? The scientists at the institute developed a series of unusual experiments to find answers to questions of this nature.

THE ULTIMATE BODY-BUILDING FORMULA

They researched the dust-filtering characteristics of the human nose, for instance. To this end, they blew dust into the noses of test subjects. As a result of this work, they discovered a correlation between dust-binding in the nose and silicosis (black lung): "It turns out that silicotic changes are more likely to occur in miners whose noses do not filter dust well, and that such changes are more severe in these miners than in miners whose noses have good dust-binding capacities (…)."

In another experiment, the researchers placed a test subject in a climate chamber and had him ride a bicycle in the service of science, in this case for several hours at temperatures of up to 46 degrees Celsius, with and without access to liquids. The subject's sweat was meticulously collected to measure the volume of chlorine it contained. The young man was weighed before and after the experiment to enable the researchers to extrapolate the volume of sweat produced. The aim of this experiment was to discover how heavy physical work at high temperatures affects the body's mineral metabolism and performance capacity.

In contrast, the experiments that Erich Albert Müller introduced as department head at the institute in Dortmund centered on muscular activity of a decidedly less sweaty nature. Together with his colleague Theodor Hettinger, Müller discovered the ultimate bodybuilding formula in the 1950s, by which time the Kaiser Wilhelm Institute had been renamed the Max Planck Institute for Occupational Physiology. The two scientists studied the cor-

relations between training stimulus and muscle strength in untrained test subjects of both sexes: "We observed that contractions involving less than about one third of maximum strength do not train the muscle. If the contraction of a muscle exceeds one third of its maximum strength, its mass grows and hence also its strength," wrote Müller.

What was surprising about this was the discovery that strength increases at a maximum rate if the muscle is contracted at only half of its maximum strength. Moreover, it was discovered that contraction of only a second's duration per day was sufficient to achieve the maximum possible increase in strength. Although these values have since been corrected – it is assumed today that, ideally, muscle should be contracted around five times per day for five seconds and each time at 70 percent of maximum strength – the basic principles still apply: to attain maximum effect for minimum effort during strength training, the intensity, duration and frequency of the load should be correctly metered.

But the researchers' interest was not restricted to just industrial work. One research group at the institute focused on energy consumption during the most common of all activities: housework. For this study, the scientists fitted three Dortmund housewives with facemasks and respiratory gas meters and monitored them in the course of their everyday activities. Everything was meticulously recorded, from the darning of socks and buttering of bread to the mangling of laundry and polishing of floors. Based on the women's oxygen consumption, they calculated their energy expenditure and made recommendations as to how the housework could be streamlined – for example through the "general introduction of time- and calorie-saving household appliances."

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» Many specialized departments with first-class expert researchers from the most wide-ranging disciplines [at the Kaiser Wilhelm Institute for Occupational Physiology] all pursue the same aim: to improve the working lot of human beings by organizing the work process in an optimum way for both humans and their work.

Along with the household, agriculture provided another research focus for the institute. In this context, the researchers explored the question of how walking on different kinds of arable soil affects the energy needs of farm workers. The quest for the most favorable form of basket – from an occupational physiology perspective – for potato planting presented another fascinating challenge for the scientists. The findings: a worker burns 70 percent more calories while walking in a stubbly field or in a potato furrow than when walking on smooth soil. Furthermore, kidney-shaped baskets with shoulder straps are more suitable than oval baskets with handles because they align better with the surface of the body and reduce the static work required.

Role reversal: Erich Albert Müller, this time as a test subject himself in an experiment on the "Energetics of the vertical downward-directed pull movement." The photograph is from Müller's postdoctoral thesis of 1930.

Erich Albert Müller retired in 1966 and settled in Freiburg, where he continued to work with undiminished enthusiasm. In his self-built laboratory, he tinkered with improvements to ergometers and continued his research on muscle training. When he died in 1977, he left behind a body of work comprising more than 300 scientific publications, some of which are regarded as seminal contributions to the science of ergonomics.

Müller's reputation was established in particular by his definition of a performance pulse index (*Leistungspulsindex*), which specifies the individual limit of physical endurance. This pulse endurance limit inspired renowned sports medicine specialist Wildor Hollmann to develop a similar principle, the anaerobic threshold, in 1959 and, based on this, lactate measurement, which is now an indispensable tool in both competitive and recreational sports.

Müller did not limit the use of his technical skill to the further development of useful devices such as ergometers, pulse-measuring devices and respiratory gas meters. While still living in Dortmund, he provided an unforgettable reception to his visitors with the help of an original and ingenious technological device: when anyone rang his doorbell, the door opened as if by magic, and a moving step conveyed the astonished guest through the door.

Nevertheless, Müller was, in principle, an ardent supporter of stair-climbing as an activity: "To maintain the body as an energy machine at a standard level of performance, all you need are your own four walls (...). However, to keep the heart and circulation working well, it is also necessary to run up a staircase at top speed for ten seconds every two to three days." ◀

Photo: KWI for Occupational Physiology