Introduction to Exercise Physiology & Sports Performance

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Lecture - 02
Evolution of Exercise physiology

Good morning, ladies and gentlemen. Welcome to lecture 2 of week 1 of the course on Essentials of Exercise Physiology and Sports Training. Today, we will be speaking about Evolution of Exercise Physiology. I will be covering the lecture in the following outline: history, Harvard Fatigue Laboratory, the Scandinavian influence, the contemporary approach, research and its settings, research tools, current tests and conclusion. As early as 1793, there was a paper by Seguin and Lavoisier which described the oxygen consumption of a young man as 24 liters per hour at rest and 63 liters per hour during exercise.

Lavoisier believed that the site of oxygen utilization and carbon dioxide production was in the lungs. Around 1850, several German physiologists demonstrated that combustion of oxygen occurred in tissues throughout the entire body. In 1888, an apparatus was described that enabled scientists to study subjects during mountain climbing and the subjects had to carry a 7 kg gasometer on their backs. The first textbook published on exercise physiology, Physiology of Bodily Exercise, was written in French by Fernand LeGrange in 1889.

Today, we know that this early attempt to explain the responses to exercise was in many ways limited to speculation and theory. Three scientists, A.V. Hill of Britain, August Krogh of Denmark and Otto Meyerhof of Germany, received Nobel Prizes for research on muscle and muscular exercise in 1922. Hill worked on the precise measurements of heat production during muscle contraction and recovery.

Meyerhof discovered the relationship between the oxygen consumption and the measurement of lactic acid in muscles. Hill's studies on humans led to the development of a framework of physiological factors related to distance running performance. Krogs and Johannes Lindhard from Denmark studied carbohydrate and fat metabolism during exercise and control of the cardiovascular and respiratory system responses during exercise.

J.S. Haldane in the UK worked on the role of carbon monoxide in the control of breathing and developed the respiratory gas analyzer that bears his name. C.G. Douglas worked with Haldane

in the role of oxygen and lactic acid in the control of breathing during exercise at various altitudes. The canvas and rubber gas collection bag used for many years in the exercise physiology laboratories was invented by C.G. Douglas.

The Harvard Fatigue Laboratory No laboratory has had more impact on any field or as much as an impact on the field of exercise physiology than the Harvard Fatigue Laboratory. A.V. Hill visited Harvard University in 1926 and his visit prompted the establishment at Harvard to set up the Harvard Fatigue Laboratory in 1927 by the world-famous biochemist L.J. Henderson. A young biochemist from Stanford University, David Bruce Dill, was appointed as the first director of research and he held this position until the HFL closed in 1947. HFL investigations were conducted in the Nevada desert, on the Mississippi Delta and on White Mountain in California at an altitude of 13,000 feet. These laid the foundation for future investigations on the effects of the environment on physical performance and in exercise and sports physiology. The Harvard fatigue laboratory focused primarily on general problems of exercise, nutrition and health.

Until World War II, when HFL scientists helped to form several new laboratories for the US military and published the methodologies for military research which are still used throughout the world. In the 20-year period, HFL scientists published approximately 350 research papers. HFL trained most of the scientists who became world leaders in exercise physiology during the 1950s and 60s. Most contemporary exercise physiologists can trace their roots back to the HFL. These are some of the research areas which the HFL was undertaking.

They were working on looking into metabolism, environmental physiology, clinical physiology, aging, blood and physical fitness. They also were instrumental in inventing the Harvard Step Test. The Scandinavian influence. In 1909, Johannes Lindberg established a laboratory at the University of Copenhagen in Denmark. Lindberg and 1920 Nobel Prize winner August Krogh published papers on topics like metabolic fuels for muscle and gas exchange in the lungs.

Three Danish physiologists, Erik Hohwu Christiensen, Erling Asmussen and Marius Nielsen came to the Harvard fatigue laboratory in the 1930s and studied exercise in hot environments and at high altitudes. They then went back to Denmark and set up three different laboratories and continued to work in different fields. In the late 1930s, Eric Hohwu Christiansen teamed up with Ole Hansen to study carbohydrate and fat metabolism during exercise, and these are amongst the first studies in sports nutrition. Jonas Bergström in the early 1900s reintroduced the muscle biopsy needle He was actually studying muscular dystrophy. But this needle biopsy technique enabled physiologists to conduct histological and biochemical studies in human muscle before, during and after exercise and also to study muscle nutrition.

Per Scholander in Norway introduced a gas analyzer in 1947. Martti Karvonen in Finland published a formula for calculating exercise heart rate that is still widely used today. In the late 1950s, Henry Taylor and Erlsworth Buskirk published papers describing the criteria for

measuring maximal oxygen uptake and thus establishing the gold standard for cardiorespiratory fitness. In the 1960s, development of electronic analyzers to measure respiratory gases made studying energy metabolism much easier. This technology and the development of radio telemetry for monitoring heart rate and body temperature during exercise was a result of the US space program.

In the early 1970s, Dr. Steven and Betty Horvath published a detailed history of the HFL, including the laboratory and the field studies conducted by the key scientists of that era. McArdle Katch and Katch published one of the most comprehensive reviews of the evolution of exercise physiology in 1981.

Research: Exercise and sports scientists regularly conduct research to understand the mechanisms that regulate the body's physiological responses to acute bouts of exercise, as well as its adaptations to training and to detraining. This research is conducted at major research universities, medical centers, and specialized institutes using standardized research approaches and select tools by a team of exercise physiologists.

Research can be undertaken in the laboratory. It has the advantages of a controlled environment, sport-specific equipment, and it simulates the demands of the sport. The laboratory facilities are not always accessible. It has got limited value in assessment of team sports and laboratory tests are not conducted in the sporting environment. Field tests can be conducted in the workplace, on a running track, in a swimming pool or during athletic competitions.

The advantages are they are specific to the sport and they are conducted in the sporting environment. The disadvantages are the environment can alter test results and a lot of administrative support is required. Research tools, ergometers. When physiological responses to exercise are assessed in a laboratory setting, the participant's physical effort must be controlled to provide a measurable exercise intensity.

That means... We have to be able to accurately measure how much, how more, how little and how long the exercise the athlete is performing. Ergo is work, meter is measure. It is an exercise device that allows the intensity of the exercise to be controlled, to be standardized and to be measured. There are different types of ergometers.

There are treadmills, which individuals can adjust to walking on a treadmill within a few minutes. And most people can achieve their peak physiological fitness on a treadmill. The disadvantage is, treadmills are more expensive than simple ergometers. They are bulky, they require electrical power, and they are not portable. Treadmills make accurate measurement of blood pressure difficult.

Cycle ergometers are still used extensively. The subjects can pedal either upright or reclining or

semi-reclining positions. The advantage is exercise intensity on a cycle ergometer does not depend on the subject's body weight. And cycle ergometers can be used for evaluating changes in submaximal physiological function before and after training in people whose weights have changed.

Other ergometers. These allow athletes to compete in specific sports or events to be tested in a manner that approximates their training and competition. Arm ergometer can be used for upper limb athletes or people who are paralyzed below the waist. The rowing ergometer can be used to test competitive rowers. For swimmers, we can use something called tethered swimming and swimming flumes. For swimmers, we can use something called tethered swimming and swimming flumes.

In tethered swimming, the swimmer is attached to a harness which is connected to a rope, pulleys and some weights. And he must swim against the pull of the apparatus to maintain a constant position in the pool. The swimming flume is operated by pumps which circulate water past the swimmer, who attempts to maintain the body position in the flume. The pump circulation can be increased or decreased to vary the speed at which the swimmer must swim. A swimming flume allows the swimmer to more closely simulate their natural swimming strokes.

There are several confounding factors during research measurements. Temperature, humidity, altitude, noise, eating patterns, sleep, diurnal variations and menstrual cycle variation. Each of these factors either singly or in combination can affect your research data. The current tests which we do as our battery of exercise physiology tests are breath by breath analyzer, which is the gold standard for VO2max. It gives substrate and fuel analysis.

It also gives lactate threshold heart rate and it can be used as a tool for estimating aerobic fitness. We also use a test called lactate threshold. Lactate threshold is a good measure of running fitness. It helps to establish training zones and it helps to predict competition performance. We also use tests such as astrand cycle ergometry, Wingate cycle ergometry, isokinetic dynamometry, body composition analysis, heart rate variability, pulse oximetry, serum ammonia analysis.

Over the years, the research has moved from basic exercise physiology to applied exercise physiology. We were basically looking at how the body responds to exercise initially. And now we are looking at the performance of the elite athletes, performance under heat, exercise at altitude, nutritional aspects of exercise, fluid balance during exercise, ergogenic aids and training for physical fitness.

So what is the take home message for us? Exercise physiology research began in 1793. The British, Scandinavian, German and US scientists drove the research.

Harvard fatigue laboratory was pivotal for conduct of research in exercise physiology, environmental physiology and military medicine. The research can be laboratory or field based. Different types of tools and ergometers have been used over the years. Research has moved from basic to applied over the years. These are the references which I have used in preparing this lecture and I strongly urge you to go through them in the interest of deeper and better understanding of the subject.

I have finished my lecture, ladies and gentlemen. Thank you for listening and thank you for your attention. Please do put in your queries or comments. Please do send us your comments and queries if you have any.

And we will do our best to get back to you. Thank you very much for listening, ladies and gentlemen. And Jai Hind.