Olympic Coach, Forbes Carlile, discusses the scientific approach to training modern athletes.

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To my mind training the sportsman for top performance is, nowadays, very largely a matter of successfully applying the science of physiology. Technical and psychological considerations are important in any sport, but the functioning of the organs, the heart and lungs and blood, and the general responses of the body to exercise are basic to all training.

Today the successful athlete trains fantastically hard. Some Australian long-distance runners I have tested and spoken with train for three or four hours a day, seven days a week. Swimmers, cyclists, canoeists and other sportsmen also spend hours a day training. There is no questioning the broad principle that hard and persistent training is essential if an athlete is to become a champion today. But hard work is by no means the whole story. There are many who train tremendously hard, who often show glimpses of outstanding ability, but who either don’t improve much or get steadily worse. They fall by the wayside.

We read a lot about coach’s successes but we do not read of the failures of the “it’s all in the hard work” brigade. Observing and talking with athletes from many sports has led me to the conclusion that very many are being driven or are driving themselves relentlessly but with an almost complete lack of scientific guidance that would help them reach their best.

Natural aptitude for a sport is perhaps the first requirement for success. No coach can “make a silk purse out of a sow’s ear”, when it comes to producing a champion. There must be outstanding athletic ability which is inborn like musical ability. Although the human body can be moulded and changed a great deal by training, it seems wrong to encourage all and sundry to make the great sacrifices of energy and time necessary to reach the top flight.

Time should not be squandered on unattainable athletic success. There is a great deal of difference between exercising for general fitness or school sports meetings and training to be a champion. One of the problems facing the coach is to know the capabilities and to be able to assess the potential of his charges. This appraisal is no easy matter and scientific knowledge is limited because relatively little research has been carried out. We do know that certain body builds are more suited to some sports than others. For instance, it is better that the tall, muscular fellow row than train for long-distance running, whilst the lean greyhound type person would be ill advised to train for sports requiring great muscular strength.

The principle of aptitude is often overlooked. Experience and scientific testing can save much wasted effort and disappointment. One of the most useful methods of predicting aptitude for the power sports, the sports requiring sustained bursts of effort, is that known as ergometry.

The ergometer, for predicting general athletic ability and physical vigour, was pioneered by the late Professor Frank Cotton at the Physiology Department of the University of Sydney. An ergometer is a machine designed for measuring work output in ergs (the physical unit of work).

Thirty years ago Professor Cotton discovered that students who had good scores on the bicycle ergometer, even though some had never trained, invariably did well when they followed his advice and took up running and other sports seriously. A medical student named Broadbent had never worn spikes, but within a season became the University 880 yards record holder. Outstanding sportsmen nearly always had outstanding bicycle ergometer scores.

In 1947 I undertook some experiments with boys at Shore School, Sydney, as subjects. Using this data I was able to draw up tables for normal boys, relating ergometer performance to age, height and weight. It soon became evident that the outstanding boys at games, even including cricket, were usually the boys with the best scores for their age. Latent ability at sports shows up on the bicycle ergometer performance. Athletic ability usually lies not far below the surface although long practice is still necessary to make a champion.

Professor Cotton invented the rowing ergometer. His machine made an early appearance at a Health Week exhibition in the Sydney Town Hall. Members of the public were invited to have themselves tested. A 28-year-old stepped forward and asked for a test. He had never been a successful sportsman and had never rowed before. His score on the ergometer was far in excess of the average student and on the Professor’s advice and under his guidance, the man from the crowd became Australian Sculling champion, a very successful stroke, and an Olympic oarsman. His name was Peter Evatt. Later, Professor Cotton picked out Stewart Mackenzie from a Kings School crew, which came up to the University for tests. He told the schoolboy that he too could have an outstanding sculling career. After the Professor’s untimely death in 1955, Mackenzie defeated the great Mervyn Wood, then became runner-up in the 1956 Olympic sculls, and in 1957 won the Philadelphia Gold Cup, the symbol of world championship.
In my Drummoyne laboratory I test untried youngsters on the bicycle ergometer. The good scorers for their age are destined for success in whatever sports they show aptitude. They have scored high in the first test of general athletic ability and have demonstrated their ability to drive their bodies to release above average physical power.

Prolonged training must be regarded as a severe stressing agent on the body. Exercise stress is necessary to stimulate the adaptive processes of the organism but when exercise becomes excessive, strain and a breakdown in general adaptation occurs. The problem is to know when to ease down the load of training and use the recuperative powers of rest. When a sportsman goes into severe training there is, in variably, a lowering in the haemoglobin concentration of the blood. This is a normal occurrence, but a sustained low level is an unfavourable sign.

Haemoglobin is the red substance in blood with the very important function of carrying oxygen to the muscles and other tissues. I have found that changes in the haemoglobin level are an important and sensitive indication of how the individual is bearing his training load. Every individual has his own limited amount of Adaptation Energy. When the powers of adaptation are strained by overload of all stresses on the body considered together (and mental stress can be as important as exercise), then one must know when to lighten the load before it is too late and before poor performances follow. A lowered adaptation energy apparently affects the red bone marrow and slows the manufacture of haemoglobin so that measuring the blood haemoglobin concentration is a way of checking the athlete’s response to training.

Sometimes a low haemoglobin level indicates inadequate nutrition, but usually it shows that more rest and less intensive training should be prescribed for a while. Warren Barr, at 14, and with a time of 4.45 to win the NSW Junior Championship is one of Australia’s most promising Freestyle swimmers. He started the season on October 1st with a haemoglobin value of 116%. Six weeks later, when he was training about four miles a day, he was 113%, but by the end of November he had dropped to 107%. This was a danger signal although his times were still good.

A week later, his 440 yards time dropped back considerably. He felt tired and jaded. His haemoglobin level was 101%. Rest and large amounts of Vitamin B12 were prescribed. One week later Warren was back in top form with a level of 112%.

Another way of assessing whether a sportsman is bearing well his load of training is to watch his resting blood pressure and the response of his pulse rate and blood pressure to a standard exercise. With excessive training, the body responds with a significantly increased blood pressure during rest. After standard squatting and running-on-the-spot exercises, the pattern of response given by the excessively trained can be distinguished from the normal.

I was given some excellent scientific papers on this subject by sports medicine research workers when I visited Moscow in 1957. The results of their research on “Indications of Chronic Fatigue” have proved very useful. An important limiting factor in athletic performance is the power of the heart action. There is a great deal of difference in people in the capacity of the heart to force oxygen-carrying blood to the active muscles.

The heartometer is an instrument that measures and makes a permanent tracing of the pulse pressure changes caused by the heartbeat. The graph caused by a complete heartbeat is called a pulse wave. The pulse wave is recorded by means of a rubber sac wrapped around the upper arm with a tube leading to the instrument. The height and area of the pulse wave is closely related to the amount of blood being driven from the heart.

Almost without exception I find that sportsmen who show evidence of outstanding endurance such as Olympic long-distance runner Alan Lawrence, have pulse waves that are very large and show other striking differences when compared with the average performer. We find that outstanding sportsmen in training have relatively large secondary waves on the tracings, an indication of powerful heart action. When the sportsman is fatigued or out of training, the secondary wave is often absent.

We put the athlete through a number of text exercises and take the heart record. If the record is poor, despite training, I have found that the individual always shows low endurance capacity. I believe that little can be done for endurance in such cases even though they are sometimes excellent sprinters.

Fatigue shows up in weakened heart action. An excellent example of this I found in two Olympic canoeists, Dennis Green and Barry Stuart. Following a 16-hour marathon race, it was many days before the heart action returned to normal. It was interesting that this great effort reduced the haemoglobin level about 16%, and it was weeks before it was restored to normal. The two kayak paddlers have sworn that they have contested their last marathon race.

The vital capacity is the amount of air that can be expired from the lungs between maximum inspiration and maximum expiration. This volume is related to the size of the individual. The average value for a good male swimmer is around five litres. We found that two barrel-chested swimmers, Jon Konrads and Brian Wilkinson, were six and seven litres respectively. These were tremendous lung capacities. The most important use of knowing the vital capacity, which is measured on a special type of
gas meter, is to look for small changes during training. Excessive training can cause lowered readings due to blood engorging the liver and preventing full downward expansion of the lung cavity.

**Strength** is now thought to be important for all sportsmen. Machines for measuring grip strength, leg strength and back strength enable us to diagnose the need for various strengthening exercises. The state of the involuntary nervous system is an important factor in the proper functioning of the sportsman. Over-tense and highly-strung individuals are picked out by the individual responses on the psycho-galvanometer, a very sensitive instrument that registers exceedingly small electrical changes at the skin surface. Overtraining and nervous symptoms of **staleness** are indicated by changes read off the dial of the psycho-galvanometer.

I have indicated some of the ways in which we can scientifically measure physiological changes occurring in the sportsman during training. As we study the athlete more, we shall learn more, and gradually replace **hit-and-miss** methods with scientific guidance.