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SPORTS NUTRITION

FROM LAB TO KITCHEN

- MAXIMUM PERFORMANCE
- SPEEDY RECOVERY
- UP-TO-DATE NUTRITIONAL ADVICE

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Sports Nutrition – from Lab to Kitchen is written by leaders in the field who discuss the latest science and translate the scientific findings into a practical message. This book bridges the gap between science and practice.

This book is unique in that it is a book written by world experts in a way that can easily be understood by athletes and which can immediately result in changes that can help performance or recovery. The various chapters are written by leaders in the field who discuss the latest science and translate the scientific findings into a practical message. So it is not just theory, every chapter contains clear advice and by doing so this book bridges the gap between science and practice. After reading this book, athletes and coaches will be up to date with the latest developments, will be able to distinguish fact from fiction and will be able to make changes to their nutritional preparation that will have an impact.

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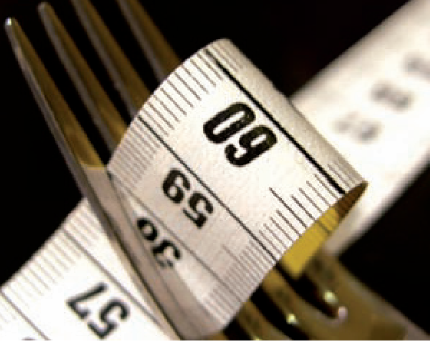




Asker Jeukendrup is a Professor of Exercise Metabolism at the University of Birmingham. Asker has published over 150 papers and book chapters in his career and has published 4 books, including a textbook on Sports Nutrition. His research has contributed enormously to the current understanding of good nutritional practice for athletes and the advice that is generally given to athletes. He received the Otto Wolff von Amerongen prize for his achievements in 2003 and was awarded the Danone Chair at the University of Brussels in 2005. He is also the editor-in-chief of the European Journal of Sport Science. In addition to this Asker has been a training and nutrition consultant to several elite athletes worldwide, including the Rabobank professional cycling team, UK Athletics and some of the world's best marathon runners, swimmers and triathletes. In his spare time Asker competes in Ironman triathlon races. Asker has completed 17 Ironman races, 4 of them at the Ironman World championship in Hawaii.

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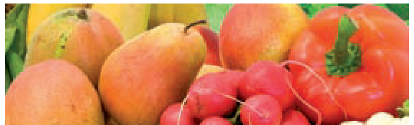
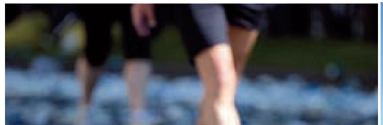

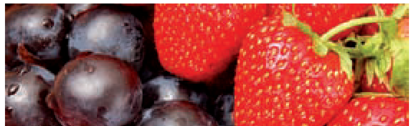
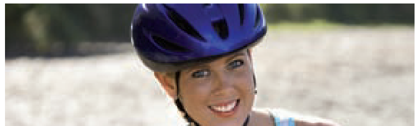

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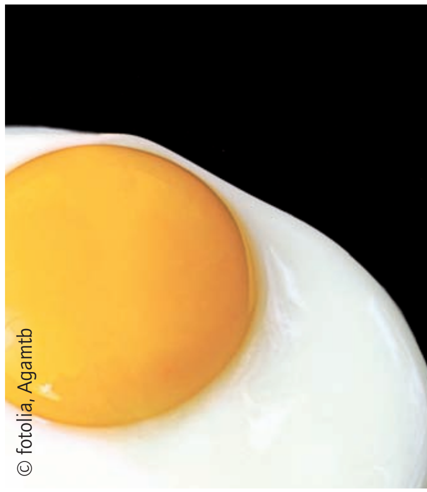

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Chapter 1

The history of sports nutrition: from the early days to the future

Bengt Saltin and Asker Jeukendrup

The Greeks and the Romans

It could be argued that sports nutrition started in paradise when Eve gave the apple to Adam, to make him as strong as God. Nutrition has always intrigued humans. As far back as ancient Greece nutrition has been linked to performance and health. It was Hippocrates (460 BC - ca. 370 BC) who said *"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health"*. The diet of most Greeks and Romans was predominantly vegetarian and consisted of cereals, fruit, vegetables and legumes, and wine diluted with water. When meat was eaten, the most common source was goat for Greeks and pork for Romans.

It is believed that the first documented information about a special diet of a Greek athlete was Charmis of Sparta. He is said to have trained on dried figs. There are other reports of figs being used as sports nutrition. Running was a big part of army training and there were professional runners who were used to send messages sometimes over long distances. The most well known runner was perhaps Pheidipphides, who has been linked to the origin of the marathon. Pheidipphides is said to have run from Athens to Sparta (240km) to ask the Spartans for help when Persians were about to destroy Athens. When the Spartans replied that they were just celebrating an annual ceremony and their laws did not permit them go to Athens to help, Pheidippides had to run back to convey the bad news.

"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health".

Hippocrates (460 BC - ca. 370 BC)

So he ran a total of 480km and he would have used figs as one of his main energy sources. It was estimated that with his 50 kg, he expended 28,000 kcal. (112,000 kJ). He also supposedly ran from Marathon to Athens (40km) which later became the marathon distance at modern Olympic Games). However, whether this run actually took place is still debated.

Olympic Games

According to Galen and other authors, at the end of the third century B.C., athletes believed that drinking herbal teas and eating mushrooms could increase their performance during competition in the ancient Olympic Games (Mottram 1988). There is also a report that states that a meat diet was introduced about the middle of the fifth century by Dromeus of Stymphalos, an ex-long-distance runner. Another account by Diogenes Laertius reports that Eurymenes of Samos consumed a meat diet recommended by his trainer, Pythagoras of Croton. However, by far the best accounts of athletic diet to survive from antiquity are those of Milo of Croton, a wrestler whose feats of strength became legendary and won the wrestling event at five successive Olympics from 532 to 516 B.C. His diet supposedly consisted of 9 kg (20 pounds) of meat, 9 kg (20 pounds) of bread and 8.5 L (18 pints) of wine a day. The validity of these reports from antiquity, however, must be suspect. Although Milo was clearly a large and powerful man, who possessed a prodigious appetite, basic estimations reveal that if he trained on such a volume of food, Milo would have consumed approximately 57,000 kcal (238,500 kJ) per day.

In South America, stimulants like mate tea, coffee and coca were used to increase performance. It has been reported that the Incas chewed coca leaves to cover the distance between Cuzco and Quito, in Ecuador (>1600km).

The first experimental approach

An experimental approach to the field of human muscle energy metabolism had its start in the middle of the 19th century. In 1842 John von Liebig stated that the primary fuel for muscular contraction was protein (Terjung and Horton 1988). However, within two decades this was proven wrong by von Pettenkofer and Voit (1866). Subsequent laboratory experiments focused on whether carbohydrates and fat could be used directly by contracting skeletal muscle. After some initial studies by Chaveux, supporting the view that fat had to be converted to carbohydrates before it could be used by muscle, Zuntz (see Carpenter 1931) claimed that both carbohydrates and fat were oxidized by skeletal muscle, not only at rest but also during exercise. This was confirmed in later studies by Krogh and Lindhard (1920). They also demonstrated that both fuels were used at the same time, in most instances, while protein normally did not play a role as a supplier of energy.

Initially protein was thought to be the only fuel but soon it was discovered that carbohydrate and fat could be used as fuel and that they were used simultaneously in most situations.

An experimental approach to the field of human muscle energy metabolism had its start in the second part of the 19th century. Before 1900 it was generally thought that protein was the fuel for the muscle. In 1842 John Von Liebig stated that the primary fuel for muscular contraction was protein (see Terjung and Horton 1988). Laboratory experiments with humans were performed to unravel whether carbohydrates and fat could be used directly by contracting skeletal muscle. This laboratory approach gave clear cut answers demonstrating that lipids could be used by human skeletal muscle without first being converted to a sugar. It was found not only that both carbohydrate and fat could be used as a fuel, but in most conditions they are used at the same time. It was also concluded that protein did not play an important role as a fuel (see Terjung and Horton 1988).

At the same time other researchers had a more applied approach searching for the optimal diet for Arctic explorers crossing Ice Caps in the world. The Polar expeditions established that with an energy intake of up to 60-70 % coming from fat, subjects could still maintain a relatively high daily high exercise output. The sledge dogs could, however, perform their heavy task with a diet containing up to 90 % fat.

The importance of carbohydrate feeding

Important observations were also made by Levine and colleagues in the 1920s (Levine et al., 1924). They measured blood glucose concentrations in some of the participants of the 1923 Boston Marathon, which at that time was thought of as an almost impossible, unhealthy and grueling challenge, referred to in some papers as "violent exercise" (Larrabee, 1902). They observed that glucose concentrations markedly declined after the race in most runners. These investigators suggested that low blood glucose levels were a cause of fatigue. To test that hypothesis, they encouraged several participants of the same marathon the following year to consume carbohydrates during the race. This practice, in combination with a high-carbohydrate diet before the race, seemed to prevent hypoglycemia (low blood glucose) and significantly improved running performance (i.e., time to complete the race).

The importance of carbohydrate for improving exercise capacity was further demonstrated by Dill, Edwards, and Talbott (Dill et al., 1932). These investigators let their dogs, Joe and Sally, run without feeding them carbohydrates. The dogs became hypoglycemic and fatigued after 4 to 6 hours. When the test was repeated, with the only difference that the dogs were fed carbohydrates during exercise, the dogs ran for 17 to 23 hours.

Substrate utilization

Since these early days there has been continuous progress in our understanding of the importance of intensity, diet and training status for the substrate choice by skeletal muscle when exercising. Most of the knowledge we have today is derived from studies done in the 1930s. Our understanding of why carbohydrate usage is intensity dependent, why muscle training improves fat utilization and reduces lactate accumulation and why carbohydrate loading elongates time to exhaustion, is still limited.

Methodological improvements in the 1950-60s, such as the use of isotopes and the re-introduction of the biopsy needle (by Jonas Bergström) to take muscle biopsies, brought about new tools for more direct measurements of both substrates used and metabolites produced by muscles. In the 1960s the key role of fatty acids (FA) was recognized as was the storage and usage of muscle glycogen.

> **Studies in Scandinavia in the 1960s really improved our understanding of carbohydrate metabolism and have formed the basis of many popular sports nutrition recommendations.**

Since the sixties many exercise studies have investigated the relative importance of carbohydrates and fats for energy turnover, which factors limit the oxidation of these substrates and the regulatory mechanisms handling these substrates. There is consensus that fats play a larger role after training but to what extent serum and muscle triglycerides (TG) contribute is intensely debated. There is also debate about what the exact limitation is for the fat utilization during exercise, especially at higher exercise intensities. It has been suggested that the transport of FA into the muscle is the critical step but there is equally strong evidence of a key role for the mitochondrial respiratory capacity. The regulation of the FA uptake by the mitochondria also plays a role.

Although many questions are still unanswered, despite many years of intensive research, it is clear dietary carbohydrates are essential for optimal performance. Equally clear is that a high capacity for lipid oxidation in the active muscles of an endurance athlete is a requirement for optimal endurance performance. In part this is explained by limited glycogen storage capacity but there is probably a lot more to it than that. In the years to come we will learn more about the interactions between the diet and the training of an athlete.

Hydration

In the 80s there were a number of studies showing that dehydration could reduce performance and extreme dehydration could result in heat stroke and adverse health effects. These studies were soon followed up by work to optimize fluid delivery during exercise. Sports drinks appeared on the shelves of sports shops and supermarkets and were marketed toward a growing number of long distance runners and other athletes.

There was clearly a trend towards drinking more and more during endurance events as evidenced by the IAAF (International Athletics Federation) drinking guidelines and regulations for feed stations during marathon races. In 1953 the IAAF handbook for race organizers indicated that feed stations had to be provided only for marathon aces and only at 15 and 30 km. The 2009 guidelines indicate that water should be available at the start and finish of all events, for events up to 10km drinking should be provided every 2-3 km and for longer events refreshment stations have to be provided every 5km. In addition, water should be supplied midway between these refreshment stations. Effectively the total number of drinking opportunities during a marathon may be 17! Over the years the drinking messages got a bit clouded and many runners interpreted the guidelines as a directive to drink as much as possible. However, it is clear that drinking too much water can result in hyponatremia and more recently the drinking advice has stressed that overdrinking can be dangerous (see Chapter 5).

Micronutrients

Micronutrients have received some attention too. Since their discovery, vitamins have been more or less synonymous with good health because it was clear that a lack of these essential nutrients resulted in illness. Since the 40s and 50s it became common practice for sports people to supplement with vitamins in order to perform better. However, research consistently indicated that as long as there were no deficiencies, vitamin intakes over and above the daily recommended amounts did not enhance performance. Nevertheless, the use of vitamins and minerals, and antioxidants in particular, is still very popular. More recently, however, studies pointed out that large amounts of antioxidants could actually prevent (or at least reduce) normal training adaptations. It has also become clear that large doses of certain vitamins and minerals can have detrimental health effects.

The final note is a tribute to the early researchers in the field and to their accomplishments. Not only is reading their work enjoyable, we have also gained tremendous knowledge from their work. They contributed greatly to both to the applied aspects as well as our more fundamental understanding of possible limiting factors in endurance sports.