2. What it takes to be effective in sports nutrition

2.1 Skills

Why evidence based?

When we started working in professional cycling in the 90s, sport science was non-existent. No pro-team had a nutritionist or sport scientist as part of their staff. Riders were told by their team managers and taught by the older and more successful riders in the team who often had strong views on how training should be conducted and what good nutrition was. There was strong resistance to anyone coming into the sport with a science background and different views than those expressed by the older riders and managers. How could scientific evidence tell them that things should be done differently, if clearly, the old approach had produced world champions? We remember vividly a conversation with one of the riders at the back end of his very lustrous career. He was sceptical and did not want to know about science. Why were we telling him that it was ok to eat salad before the main course and it would not impair his performance? How could we tell him that a large steak before a Tour de France stage wasn't going to give him much energy? This was how he raced his entire career, he had seen the heroes of the previous generation do this (including Eddy Merckx: the greatest cyclist of all time). We told him that throughout his career he had been conducting many experiments on himself to figure out what worked and what didn't. He had tried new things, new foods, new training methods, new bike positions, moving the saddle a millimetre at a time. Essentially, he was a scientist and he figured out over many years and a very long career what worked best for him. In the process though he also made a lot of mistakes and many things that might have worked were never tried. Many, if not most, of the new things he tried did not work and the ideas were abandoned. Some of the things he tried may actually have been detrimental to his performance. It is possible that he tried new things that would have been beneficial but because he had a puncture on that day, it did not result in good performance and all those things were abandoned. Doing experiments in this way has a number of disadvantages. There are so many other factors that are impossible to control in a real life situation. "What about the young riders?" We asked, "Should they go through the same process and make the same mistakes? Or could they avoid making some of these mistakes by understanding a

bit better how the human body works and what experiments in very controlled conditions tell us". In the end he reluctantly admitted that an evidence based approach would allow young riders to make progress faster as it would reduce the chances of making mistakes. In the years to follow he became a big supporter of this approach and he was often the one asking the most questions about evidence of efficacy of nutritional and training practices. He concluded that an evidence approach could not only help the young riders but also the riders at the back end of their careers.

We hope that in this section you get convinced that an evidence-based approach is the most effective way to improve your performance. We also hope that you are aware that pseudoscience is a treat and can result in wasting time, effort and money and can even be detrimental to performance and health. We will provide you with some simple tools that can help you to detect pseudoscience and you should have a better understanding of appropriate scientific methods. We have also seen that it is important to have clear definitions so that when we discuss certain topics we all understand the same thing. We have also clearly defined who this book is for: the athlete who has defined himself/herself as someone who takes his physical exercise, appearance and/or sport seriously and wants to improve. Clearly there are athletes at different levels and with different goals, but what they all have in common is that they want to get better. With this in mind we can start to look at the physiology of the athlete. It is important to understand how the body functions during exercise, how fatigue develops, and to understand what processes are important for performance before we discuss in later chapters how nutrients interact with these processes and how you should adapt your nutrition to optimise them.

2.1.1 Evidence based practice

An evidence based approach to sports nutrition is the conscientious use of current best evidence in making decisions about nutrition to support the performance and health of individual athletes or teams. This is particularly important in today's environment where there are many different opinions, few of which are evidence based. In addition to scientific evidence there is also a lot of pseudoscience and misinformation. Sports nutrition is particularly prone to pseudoscience.

The influence of science in society is ever increasing, also in sport and in sports nutrition. Science sells. As a result, many endeavours that lack the essential characteristics of science have begun to masquerade as one, in order to leverage them for economic or other purposes. Pseudoscience "resembles genuine science on the surface." (Beyerstein, 1996, p. 2). However, a "closer examination of their contents, methods and presentation reveals them to be mere parodies" (Beyerstein, 1996, p. 2). Pseudoscience often uses scientific sounding words, complex words and

sentences, and there is an abundance of scientific-sounding jargon. Many scientific words have been popularized by the media. Examples of such words are "coenzyme", "anti-oxidant," and "free-radical". When such words are used, credibility is automatically granted to what is being claimed, regardless of the validity or context of the claim. Pseudoscience also relies heavily on magnetisms like oxygen, water, vitamin, “energy”, stamina, and toxins. Pseudoscience will direct you to study results and claim that these are scientific findings. However, the results of such studies are non-reproducible, and outcomes are often impossible to measure with conventional scientific methods. Take oxygenated water, which is sold to athletes because it improves their aerobic capacity and VO_2max (note the use of scientific sounding terms). This theory sounds attractive to the naïve person who does not realise that oxygen reaches the body through our lungs and not through our stomachs. The person may also not realise that as soon as a bottle is opened the oxygen will disappear from the water. Even if the oxygen would be taken in and “absorbed” the amount of oxygen that can be trapped in a litre of water would be the equivalent of one or two extra breaths. Inhaling an extra litre of air gives you almost 150mg oxygen whereas you may only find 40-100mg in most products. Inhaling 1 litre of air is much easier than drinking 1 litre of expensive oxygenated water, and it is free. This, however, does not stop producers from referring to the so called “science” that shows that their invention is the best new thing in sports nutrition. Unless you were born with gills, you would not spend too much time and energy on this.

Pseudoscience is spreading rapidly like a plague. It multiplies and spreads much more rapidly than science, because conducting good science takes time. It takes time to collect data, conduct experiments, analyse them, and publish them. You need multiple experiments to show that findings are not “accidental”. In the time it takes to conduct good research, many fake experiments can be conducted, theories can be put forward and sold as science, and even be communicated to the masses as “science”. Social media plays and important role in this and makes it easy for messages to be distributed rapidly. It is impossible to add too much detail in messages that are restricted to 140 characters and messages lose their context easily. It is also difficult to check the credentials of people posting them. So, the views often expressed on the internet and in particular social media are the views of the ones who shout the loudest, not necessarily the ones that have the most knowledge of the subject area. “Pseudoscience often strikes educated, rational people as too nonsensical and preposterous to be dangerous. It is often treated as a source of amusement rather than fear. Unfortunately, this is not a wise attitude. Pseudoscience can be extremely dangerous.” (Coker, May 30, 2001, https://goo.gl/CJb5dj).

Science relies on (and insists on) continuous self-questioning, testing and analytical thinking that make it very difficult to fool yourself or to avoid

facing facts. Pseudoscience, on the other hand, preserves the ancient, natural, inborn, irrational, unobjective modes of thought that have persisted for hundreds of thousands of years. These are the thought processes that have given rise to superstitions and other fanciful and mistaken ideas about man and the world around us. Examples of this are voodoo and racism; from the flat earth to the house-shaped universe with God in the attic, Satan in the cellar and man on the ground floor; from doing rain dances to torturing and brutalizing the mentally ill to drive out the demons that possess them.

> Pseudoscience encourages people to believe anything they want. It supplies specious "arguments" for fooling yourself into thinking that any and all beliefs are equally valid. Science begins by saying, let's forget about what we believe to be so, and try by investigation to find out what actually is so. These roads don't cross; they lead in completely opposite directions. (Coker, May 30, 2001, https://goo.gl/CJb5dj).

For any athlete it is an important skill to be able to distinguish pseudoscience from science. In order to do this, we have to understand what science is and how well science is conducted and presented. If you search the internet for sports nutrition information, it becomes immediately obvious that there is a wide range of information available, often with conflicting information and advice. You will find articles about how slow proteins improve protein synthesis, and you will also find articles about how fast proteins are superior. You will find information about low carbohydrate and high carbohydrate diets. Each of those diets will have proponents and claim that theirs is best. This gives the impression that the field of sports nutrition is complex and confusing, and so scientists cannot make up their minds. This is far from being the truth. The area is not complex, there is consensus about most of the main principles, and the vast majority of the details. So one of the most important purposes of this book is to provide the reader with the tools to distinguish evidence based information from quackery and pseudoscience. In the rest of this book we will focus on evidence and provide you with advice that is based on the currently available evidence.

2.1.2 What is science?

Science may not have a single definition and there may be debate about what science exactly is and how it should be conducted; but fundamentally, there is agreement that science is knowledge (or a system of knowledge) covering general truths obtained and tested through scientific methods.

> Knowing science does not mean simply knowing scientific facts (the energy content of fat, the cooling power of evaporation of sweat etc). It means understanding the nature of science: the criteria of evidence, the design of meaningful experiments, the weighing of possibilities, the testing of hypotheses, the establishment of theories, the many aspects of scientific methods that make it possible to draw reliable conclusions about the physical universe. (Coker, May 30, 2001, https://goo.gl/CJb5dj).

One way to get a better understanding of what science is, is by discussing quackery and pseudoscience. How are these two different and how can you detect these differences?

Pseudoscience is "fake" science dressed up, sometimes quite carefully, to look like the real thing. “Pseudoscience has a strong quasi-religious element: it tries to convert, not to convince. You are to believe in spite of the facts, not because of them. The original idea is never abandoned, whatever the evidence.” (Coker, May 30, 2001, https://goo.gl/CJb5dj). Research is cherry-picked to support the views, and opposing views are ignored and avoided. Ideas are seldom put to the test, certainly not with rigorous scientific methods and sometimes it is claimed that the ideas cannot be tested.

One of the best ways to distinguish science from pseudoscience is to find the origin. If a claim is made on the basis of a research project, where was this research published? If it is not published, that should ring alarm bells immediately. If it is published in a scientific journal that is peer-reviewed and maintains strict standards of honesty and accuracy, this will indicate that it is more rigorous. With a bit more knowledge of the different journals, you could distinguish between highly respected journals and lower ranked scientific journals (although this is not guarantee of scientific rigour or quality). This is the initial assessment.

Next, you could look at the credentials of the individuals involved in the research. Again, this is not guarantee of quality but it helps with the overall assessment. It is possible that young researchers who do not have a huge

publication list on their CV do very high quality work; it is also possible that scientists with a reputation built up over years publish a paper that is lower quality. However, in general it is fair to assume that the chances of a quality paper are greater when it is published by those with a strong reputation in the field of study. Pseudoscience often refers to "experts" who have never published a scientific paper in their lives.

The next criterion that should be applied is the reproducibility of the results. It is extremely important that results of a study are reproducible. It should be possible for anyone to accurately reproduce the study and obtain the same results. This means that when reading about a research study the methods should be very accurately described. If this is not the case, alarm bells should ring again. A good example is a study published in the 70s that showed that eating carbohydrate in the hour before exercise would impair subsequent performance. A study found decreased performance and because there was an attractive theory behind this involving plummeting blood sugar concentrations, sports nutrition advice was to avoid carbohydrate in the hour before exercise. It took almost 100 studies to demonstrate that this study was a false positive and so guidelines had to be be adapted.

Only one of the 100 studies reproduced the findings, most of them demonstrated no effect and some of those studies actually found beneficial effects of carbohydrate feeding in the hour before exercise. This also demonstrates that the weight of the evidence is important, too. One study showing something does not mean much, but if several studies show the same thing, it is more likely that the outcome resembles the truth. So always check how much evidence there is. Was it one study or are there numerous studies supporting the theory?

Such indeed is the respect paid to science, that the most absurd opinions may become current, provided they are expressed in language, the sound of which recalls some well-known scientific phrase. (James Clerk Maxwell, British physicist, 1871).

As mentioned above, pseudoscience can also be recognised by its language. It often uses scientific sounding words and technical terms. Albert Einstein used to say that if you can't explain it simply, you don't understand it well. If quacks feel that they have to toss in a bunch of jargon and science terms to make you think they are the real thing, it is likely that they don't know what they're talking about either. Pseudoscience also frequently uses emotion-raising words and a lot of exclamation marks.

Scientific language strives to use definitions that can only be interpreted in one way. Certain terms that have different meanings in different context

or mean different things to different people will be avoided as much as possible or will be clearly defined. Pseudoscience uses a lot of vague claims that cannot be measured or quantified. An example of such a vague claim in a given treatment is, "removes toxins from your system", never explaining what those toxins are, how they will be removed, or even how you can tell if they will be removed.

2.1.3 Recognising pseudoscience

For those who really understand what science is and how the scientific process works, pseudoscience is relatively easy to recognise. But even without a full academic science education it is possible to recognise pseudoscience. The checklist below can help you distinguish between science and pseudoscience:

At first glance:

- **What language is used?** Red flags are: expressions of emotion, exaggerations, and words like “exclusive”, “magic,” and “secret” are definitely red flags.
- **Use of complex, scientific sounding words** can also be a warning sign.
- **Are the words used measurable and quantifiable or are they vague?** For example, it is possible to measure strength, but how do you measure stamina?
- **Were real scientific processes involved?** As discussed above, evidence-based interventions generally go through many steps of a scientific process before they come into common use. So, if there is no reference to or sign of any of such processes or they are not clearly described, that is a red flag, too.
- **Is there an agenda?** Is a specific product or service being promoted?
- **Is there mention of a conspiracy of any kind?** Claims such as, “Doctors don’t want you to know” or “the government has been hiding this information for years,” are extremely dubious.
- **The use of testimonials.** This is very common in pseudoscience but has very little to no value in helping to understand the truth.
- **Too good to be true?** Some supplements seem to have improve almost every aspect of human life. If something is supposed to improve endurance performance, strength, recovery and other aspects of performance as well as health, this is another red flag. If something sounds too good to be true, chances are that it is too good to be true.
- **Are there claims of exclusivity?**

> Typically, new findings arise out of existing knowledge and involve the contributions of many, many people. It's quite rare… that a new… intervention is something completely novel without a solid existing scientific background to explain how it works, or that only one person figures it out… Watch for words like "proprietary" and "secret." These terms signal that the intervention on offer has likely not been exposed to the light of scientific critique. (Willingham, November 8, 2010, https://goo.gl/pBBJHp).

Scientists would not use these words but someone with an agenda would.

- Are there financial links or passionate beliefs? Are there perhaps financial links or does the person making claims have passionate beliefs? In these situations, one has to be more aware. It does not mean that claims are not true but it should trigger an additional level of awareness.
- Is there expertise? Often names of people who are experts are used. But are they really? Experts should have published extensively. A quick check on Medline would resolve his. Medline is an online search engine of scientific publications (simply type in the name of the "expert" and the topic. If the search does not result in any publications, chances are that the person is not an expert.)
- Belief in authority. Pseudoscience often projects a person with a special ability to determine what is true or false. Others have to accept their judgments. This authority is like "God" in religion.
- Handpicked examples. Handpicked examples and anecdotes are used although they are not representative of the general category that the investigation refers to.

Why are beliefs so strong and so difficult to change?

- Sunk cost fallacy… People who have already wasted money on tickets to a terrible film also waste their evening watching it. It can be the reason that people chomp their way through terrible food [because they paid for it] or get married when the relationship has already soured… [The sunken cost fallacy is] the urge to justify previous decisions using the next one. [Thus] if people have put their weight behind a belief, they are invested in it, and are likely to fight its corner.
- Along with our love of being right, we are hooked on patterns, and make sense of the world by seeking them

out. This leads us to confirmation and selection bias: we look for evidence to support a theory, and ignore evidence to the contrary. Given the several million individually observable things that happen to you every day, it's easy to pick one to prove an idea you've already become attached to, whether superstition or stereotype.

- Everyday life brings a lot of data and sometimes your subconscious summarises it badly, falling victim to the clustering illusion. Any random set of data looks like it has clusters of points in it. If it didn't have clusters, it wouldn't be random scatter, it'd be an evenly spaced pattern. But our addiction to order makes those clusters very seductive, and it's easy to forget that two things that happened at the same time don't have to be related.
- The Dunning–Kruger Effect was brutally summarised by Darwin as "ignorance begets confidence". The less you know, the more likely you are to perceive yourself as an expert. Conversely, the more you know, the more likely you are to doubt your own competence. This means that some people have illusory superiority, and some experts can't explain how they do things because they assume what they do is easy or obvious to all. (Townson, January 26, 2016, https://goo.gl/VjpktD).

People's beliefs become stronger when they concern a health condition.

> "As a health condition degrades and there become fewer and fewer treatment options, the tendency to try anything rises. The confounding part of this equation is the concept of human hope – and that, unfortunately, is what undermines science every time. We hope that something will work, we believe that something will work". (Behrenbruch, as cited in Townson, January 26, 2016, https://goo.gl/VjpktD).

This is the same reason why athletes look to fad diets or to supplements. There is hope that this will give them an edge, accelerate their improvements or their recovery.

2.1.4 Critical evaluation of scientific studies

> Athletes and others must critically examine claims made by the dietary supplements industry, including the "scientific

evidence" that supports the claims. The following are some factors that should be considered when evaluating reports of scientific studies.

- **Does the study have a clear hypothesis?** A well-designed study has a clear hypothesis and a strong theoretical basis for the expected outcome. Some studies, however, are designed with a "shotgun" approach. A supplement is given, and many variables are measured. The more variables that are examined, the greater the chance is that some of them will change. The application of study results should have a sound scientific rationale. For example, sodium bicarbonate may improve buffering capacity, which could result in improved 800 m running performance, but it cannot be expected to improve Ironman triathlon performance (an event that last 8 to 14 hours).

- **Was the study on cells, muscle, animals, or humans?** Results are often extrapolated from findings in cell cultures. These *in vitro* experiments greatly help our understanding of metabolism and molecular interactions. But *in vivo* situations may be quite different. For instance, test tube samples are not exposed to hormonal changes that exist in living organisms. Also, muscle cells in the body may behave differently from isolated muscle cell preparations. Even if living animals are tested, the metabolism of animals may be significantly different from the metabolism of humans. Rats have relatively large stores of muscle glycogen and extremely small stores of intramuscular triacylglycerol compared with humans. High-fat diets in rats clearly improve exercise capacity (see chapter 7), but no evidence indicates that high-fat diets improve performance in humans. Thus, results from different types of studies cannot simply be extrapolated to the human athletes.

- **Was the population for which claims are made comparable to the population in the study?** Coenzyme Q10 supplementation improves VO_2max and exercise capacity in cardiac patients but has no effect on $V.O_2$max or exercise capacity in healthy individuals. Vanadium supplementation increases insulin sensitivity (reduces insulin resistance) in patients with type 2 diabetes but does not seem to be effective in healthy people with normal insulin sensitivity. These examples show how outcomes can differ in a target group that has different

ages, sexes, body compositions, or fitness levels than the study group.

- Were external variables controlled? In an ideal study, all variables and conditions are identical, so that the only difference between the trials is the treatment that each group receives. Then, all observed changes can be attributed with great certainty to the treatment. For example, if in examining the effect of caffeine on exercise performance, the environmental conditions were different in the caffeine and control trials, the observed effects might be related to environmental conditions as much as they are to caffeine.

- Was the study placebo controlled? If subjects have prior knowledge or expectations with respect to a treatment or supplement, their performance could be affected. The proper choice of a placebo avoids this kind of performance bias. With some nutrition interventions, however, matching placebos are difficult to find. For example, branched-chain amino acids (BCAA) have an extremely bitter taste, and finding a placebo with a similar (horrible) taste is difficult. In this case, subjects may be aware of what they receive, possibly influencing the outcome.

- Were adequate techniques used? Endurance capacity (time to exhaustion) has large day-to-day variability (Jeukendrup et al. 1996). Methods used to measure this variability may not detect small differences in performance. Similarly, some measures of body composition have a relatively large error and thus will not be able to detect small changes in fat or fat-free mass. If a treatment (supplement) is said to have no effect, perhaps the particular method used in the study was not sensitive enough to pick up small differences (Currell and Jeukendrup 2008b). A small change in performance (<3%) that is undetectable in a laboratory setting may determine success or failure in a sports event (Currell and Jeukendrup 2008b; Hopkins 2000).

- Were the trials randomized? Randomization reduces the confounding effects of variables that were not controlled or could not be controlled. When a small number of subjects are tested, a so-called counterbalanced design is preferred. If trials are randomized, eight subjects may end up in the treatment group in the first trial and only two in the control group.

A counterbalanced design prevents this imbalance by appointing equal numbers of the control and treatment group to the first trial. Thus, half of the subjects will take the supplement first and the other half will take the placebo first. Failure to randomize treatments in a study may confound the outcome and hence make any conclusions untrustworthy.

- Was a crossover design used? In a crossover study design the same subjects perform both the treatment trial and the placebo trial, allowing comparisons to be made within the same person. Although this type of study design can cause complications, particularly if a test substance that exerts effects in the body for a long time is given before the placebo, it is considered the ideal study design. Failure to use a crossover design may not necessarily affect the trustworthiness of the conclusions, but it is likely that variation between subjects in the measured variables will be greater than that within the same subjects. Hence, if a crossover design is not used, many more subjects will have to be studied to obtain the same degree of confidence that the conclusions are valid.

- Was the assignment random or was self-selection used? If subjects are allowed to self-select their trial group, a significant bias may be introduced. For example, in a study of the effects of chromium on weight loss, subjects most motivated to lose weight would likely choose to be in the chromium group and not the placebo group.

- Do other studies confirm the findings? If one study reports an ergogenic effect of a supplement, the claim may be true. But if several studies come to the same conclusion, the supplement most likely does have an ergogenic effect. The more studies that have been conducted, the larger the variety of subjects tested, and the more varied the dosages of the supplement used, the more generalizable the conclusion is.

- Was the study peer reviewed? Papers sent for publication to peer-reviewed journals undergo a rigorous process whereby usually two or three referees, who are experts in the area, evaluate the paper based on specific criteria. Quality research withstands critical review and evaluation by colleagues. Articles published in popular magazines or on consumer-oriented Web

sites do not undergo this extensive review process and are therefore often filled with errors and untruthful claims. (Jeukendrup & Gleeson, 2018, pp. 296-297).