Dear Editor,

There is a raising interest in the possible role of ketogenic diet (KD) in sport\(^1\) but, although there are some evidence about the usefulness of this nutritional approach in sport\(^2-4\) on the other side many researchers rise some doubts about its efficacy\(^5,6\).

A ketogenic diet (KD) is a nutritional approach where carbohydrate amount is limited to 20-30 grams per day\(^7\) or, in general, less than 5\% of total daily calories\(^8\). When this very low carbohydrate regimen is maintained for more than 4/5 days the body starts to produce the so-called ketone bodies (KBs): acetoacetate (AcAc), \(\beta\)-hydroxybutyric acid (BHB) and acetone. The process of KBs formation, called ketogenesis, occurs principally in the mitochondrial matrix of the liver. The shift from a carbohydrate/fat metabolism to a fat/ketone metabolism is due to the lack of enough oxaloacetate necessary for a full Krebs cycle’s work and to an excess of free fatty acids; as a matter of fact oxaloacetate derives from pyruvate that came from glucose. Oxaloacetate is labile at body temperature and cannot be stored in the mitochondrial matrix.

For this reason it is necessary to refurbish the Krebs cycle with oxaloacetate via the anaplerotic cycle from glucose through ATP dependent carboxylation of pyruvic acid by pyruvate carboxylase. Thus in a condition of low carbohydrate intake the reduction of pyruvate availability and hence oxaloacetate, moves the excess of available fats to a different fate: i.e. the production of KBs in the liver. After be produced, KBs go throughout the body to be re-transformed in acetyl CoA to be utilized in the cells through the normal Krebs cycle.

The importance of this metabolism shift is linked to the impossibility of FFA to pass the blood brain barrier (BBB) whilst the smaller KBs can. Thus the KBs pass the BBB and act as a substitute of glucose for the brain (it is well known that brain could utilize, in normal condition, only glucose). But not only brain utilizes KBs as fuel, also other tissues such heart and skeletal muscle\(^9\). This is an important issue when a KD is applied to athletes.

Regarding the effects of a KD on performance it is necessary to made some "caveat": the first is the type of exercise: endurance or resistance training, the second is the intensity of the exercise. Regarding resistance training (RT) it is clear, even if there are no human data available till now about the molecular effects of a that KD during a RT, that is hard to hypothesize a reasonable mechanism for muscle growth during a very low carbohydrate regimen.

On the other side is well known that KD is widely used in aesthetic disciplines such Body Building. In the latter case KD may be useful during the last days before the competition to lose fat and to prepare to the glycogen load. Obviously, the possible interference between nutrition and training modalities should be taken into account\(^10,11\). No scientific basis seems to have application of a KD in strength/power sports except for those that requires weight control such weight categories sports\(^12\).

In that cases, when a long term weight control fails, a KD could be a useful tool in the sport physician’s hands for a rapid weight loss (RWL) limiting its harmful effects\(^13\). Regarding endurance training (ET) no conclusive data are available, whilst some clinical trials show an effectiveness of a KD on long distance efforts\(^2,4,13,14\) other researchers rises doubts
about its relevance in endurance sports suggesting that the "fat-adaptation strategies reduce rather than enhance metabolic flexibility by reducing carbohydrates availability and the capacity to use them effectively as an exercise substrate"\(^{(15)}\). Unfortunately no conclusive data are available neither for keto-adepts nor for keto-haters but a comprehensive literature analysis suggest that at least for long duration (more than 3 hours) and low-medium intensity performance (i.e. from 50 up to 65% of VO\(_{2\text{max}}\)) a KD diet could be a viable method for increase exercise duration and decrease fatigue perception. For higher intensities and shorter duration race the question remains open to further discussion.

Finally considering the role of a KD in sport with a neutral approach we can suggest that in some sports and in some conditions a KD could be useful for:

- fat reduction and improved efficacy of carbohydrates load during the final phases of a body building preparation\(^{(16)}\)
- fat loss in a weight categories sport in an "emergency" condition (i.e. when a more physiological, gradual weight loss approach failed or was disregarded)\(^{(17)}\)
- long duration, relatively low intensity endurance race like ultra trail or ultra marathons where fat oxidation efficiency play a key role\(^{(18)}\).

More researches are required to elucidate the mechanisms and the role of the KDs in sports.

References


Corresponding author
GERARDO BOSCO
DSB University of Padova
Via Marzolo 3
35131, Padova (Italy)