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Ketosis diet- A gateway to enhance sports performance

Dr. Gurcharan Singh Gill, Dr. Sonia Kanwar
Department of Physical education, S.G.G.S. College Sector 26 Chandigarh, Chandigarh, India

Abstract
Ketogenic diet, known as 'Keto diet' occupying the buzz world for two decades seems to be a relatively new notion for many but its origin laid almost a century back in 1920. Originally ketogenic diet was acknowledged therapeutic diet for treatment of pediatric epilepsy, diabetes etc. But today it is recognized as a rapid weight loss procedure that has shown to be quite effective in short run. Its latent ability in some recent researches attracted numerous investigators to foresee role of 'KD' in sports and for exercise athletes while improving their capacity. With the research it has been revealed that 'Keto' may provide steady and speedy supply of energy and consequently improve athletic performance. Ketogenic diet causes nutritional process called ketosis and body of athlete's habituate ketone bodies in long run. This primary fuel after 'keto-adaptation' result in consistent energy source for body. The deflammatory, anti-oxidative 'Keto' diet helps to improve health by reducing risk of muscle damage or fatigue induced from high-intensity routines. The current article is following narrative approach to sum up various research works done previously. It aimed to draw-up perceived scope of Ketosis Diet as nutritional therapy for resurging after fatigue, muscle damage stimulated from exercise and enhance endurance capacity of athletes at the same time.

Keywords: Keto diet, Ketogenic, ketosis, ketone bodies, aerobic exercises, anaerobic exercises, muscle damage

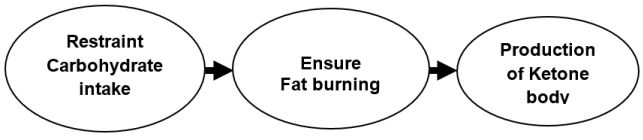
Introduction
Ketosis diet, a dietary regime acknowledged as a therapy primarily by physicians for treatment of epilepsy in 1920s, is attracting the attention of diet planners for its various distinct advantages. Initially in Chicago, Rush Medical Center, Roland T. Woodyatt, observed that Acetone along with beta-hydroxybutyrate (BHB) could be increased in blood by fasting or with consumption of diet rich in proportional fat [41]. Concurrently Dr. Wilder at Mayo Clinic suggested treatment of epilepsy patients by producing ketonemia though ketone-producing diet and subsequently coined the term "ketogenic diet (KD)" that comprised benefits of fasting [39]. Till then many researchers had attempted to pen down the miracles of ketogenic diet (KD) in the treatment of not only epilepsy [20, 28] but Type I Diabetes [23], heart disease [13, 6], some kinds of cancer, certain brain diseases, Obesity [31], Nervous system disorders like: Parkinson's, Alzheimer's disease, sleep disorder [40], Polycystic Ovary Syndrome [22] and even acne [1].

"Ketogenic" is a term usually used for a low-carb diet which means getting more calories from protein and fat additionally less from carbohydrates. Ketosis regarded as a metabolic state is responsible for raised levels of ketone in body that are caused through breakdown of non-carbohydrate sources. The Ketone bodies accelerated by Ketogenic diet stimulate functioning of various organs to its optimal level in human body. Diet concentrating ketosis (through carbohydrate restriction) allow body to switch over from carbohydrate to fat as fuel.

Paoli A (2014) [31] had described Ketosis as natural metabolic state where in lieu of carbohydrates, ingested glucose acts as key energy resource for body. Here body not only reallocate fat as primary source of energy but breaking down of fat into ketone bodies facilitate using it as main fuel by mostly tissues, including muscles and brain [27].

Materials and Methods
Electronic databases were searched for Keywords including PubMed, SPORTDiscus, Sports (Basel), Nutrients, Science Review, healthline and everydayhealth. The search items consisted of related terms like: "Ketogenic", "Ketosis diet", "performance", "keto", "Ketone bodies", "low-carbohydrate", "low-fat", "high-carbohydrate", "high-fat", "Aerobic exercises", "Anaerobic exercises", "Fatty acids", "body-composition", "endurance athlete", "weight loss", "Lactic acid" etc. were used for review. Manual searches were also conducted through references in available sequence of events, meta-analysis re-evaluation on KD and its role in performance enhancement.

Recapitulation of ketosis diet
Researches had proved that ketosis diet work on various mechanisms simultaneously to generate maximum benefits compared to other diet regimes.



- The basic function of Keto diet is curbing Carbohydrates for improving insulin sensitivity and reducing resistance while lowering the risk estimation of some chronic diseases like cancer, cardiovascular diseases, diabetes.
- In the absence of carbohydrates for requirement of energy body use the substitute fuel i.e Fat. This transit helps in comparatively early weight loss than other diet regimes. Ketosis diet have more reliance on using accumulated body fat along with fat intake for healthy diet plan.
- In this breakdown process of fat called 'Ketosis' liver remain active in production of one among three ketone bodies named Beta-hydroxybutyrate (BHB) and the

energy molecules managed on fat instead of carbohydrates. This clean high energy brain fuel not only decrease inflammation in central nervous system but increase mental clarity.

Although like any other phenomenon it also bag some side effects with it in the preliminary stage like: Fatigue, headache, dizziness, sleep disturbances, cramps, heart palpitation, diarrhea/constipation [8, 36] believed that reliance on diet loaded with animal fats and proteins can mar heart health due to increased risk of developing cardiovascular disease with elevated cholesterol level and high blood pressure(hypertension). Marie Spano, RD, a sports performance nutritionist of Atlanta quoted

"Ketogenic diets are often low in vitamin D, calcium, magnesium, and folic acid, which over time can lead to nutrient deficiencies if the diet is not planned carefully,"

Thus, Nutritionist and clinicians advocate vigilant planning for getting optimum benefits of Ketosis diet.

Gateway to enhance sports performance

The tendency towards usage of Ketosis diet changed in last twenty years and it is no longer a therapeutic subject for treating patients. It is a trending weight loss regime now a day. It also got recognition as performance enhancement tool for athletes. Many researchers had tried recently to see the brighter aspects of Ketosis diet for enhancing sports performance while boosting their strength and endurance.

The buzzword 'Keto' is not new in the arena of sports. It had opened a gateway for athletes to enhance their performance and excel in the world of sports. A well-planned personalized Ketosis diet regime can craft wonders in the life of athletes while controlling its bad impacts.

Ketosis and anaerobic athletes

Sports activity that require intense energy for short bursts are recognized as anaerobic exercises. As the name itself symbolizes, *anaerobic* means "without oxygen", The process in these exercises involves breaking down glucose for energy without draining oxygen from athletes. These activities release energy within a small period of time but with high intensity and oxygen demand surpasses oxygen supply. During Anaerobic exercise glycogen present in body disintegrate without using oxygen [3]. In terms of intensity, practically anaerobic exercise out shadow aerobic exercise, however for shorter duration [5]. The biological process of anaerobic exercise involves glycolysis; transformation of surcose contents to adenosine triphosphate (ATP), which is main source of energy during moelcular reactions [12]. Throughout anaerobic exercise quick accumulation of Lactic acid takes place at higher rate. Anaerobic exercise help in building endurance, power and strenthing of muscles [4, 14]. like in weightlifting, cycling, jumping etc. Anaerobic exercise require higher force but for shorter duration as the performance activity takes merely less than 2 minutes. In these exercises energy requirements are satisfied through phosphagen system and lactonic acid generation system, which extremely depend on skeletal muscle glucose. High contracting forces emerged in muscle cause hurting muscle fibres during anaerobic exercise. While repairing and rebuilding muscle protein synthesis require support from essential amino acids along with replacement of carbohydrates. The ketosis diet regime having sufficient protein intake, at least 15% daily intake of calories, help athletes in avoiding amino-acid deficit. Though, low carbohydrate intake, in this process increased dependency of amides on Glucogenesis and debilitation of glucose-store restoration unfavourably influence anaerobic athletes' performance.

Several studies had weighed up the impact of Ketosis diet on anaerobic athletes' performance in various populations. While considering various factors among endurance game players [26], Cross-Fit contestants [19, 38], Gymnastic players [30], and power-lifters [18] ketosis diet intervention for 6 to 12-week duration with normal training regimes, resulted non-significant increase in strength [18, 24, 30, 38] or power [19, 38] compared to control group. A study on endurance athletes showed significantly increased relative power, instead of absolute or total power, resulted from reduced weight among subjects [26]. In another studies, significantly reduced thickness of skeletal muscle [24] or lean body mass (LBM) [19] were noticed.

Ketosis and aerobic athletes

Aerobic exercise popularly known as "cardio." basically provides cardiovascular conditioning. The actual meaning of the term aerobic is "with oxygen". Here amount of oxygen is controlled by breathing while providing help to muscles for burning fuel and movement. Increased respiration and heart rate can be visualized among athletes while performing aerobic activities. Aerobic exercise improves respiratory system of individuals. The aerobic activities such as swimming, running improve lung capacity and keep the heart healthy.

Unlike anaerobic exercises, which are performed with greatest effort for shorter time, aerobic exercises are performed for a comparatively longer period. Exercise intensity and duration [16] decides the role of fatty acids in oxidation process. In exercises needed low or moderate strength, the oxidized of exogenic fatty acids acts as major source of power. But in moderate intensity exercises, the involvement of fatty acid synthesis results in augmented exercise duration. Optimized endurance exercise performance call for regular availability of fatty acids. For aerobic endurance exercise Ketosis diet (KD) may be more advantageous, as it promotes fat usage, in place of carbohydrates, for energy. Fat from 'adipose' tissue provides uninterrupted energy supply, whereas internal carbohydrate storage from glucose within liver and tissues are finite. The resultant raised ketones from ketosis diet may offer alternative source of fuel for maintaining endurance ability of athletes while exercising.

Several studies in past two decades had observed the effect of low carbohydrated diet on performance of athletes [7, 9, 11, 15, 24, 26, 29, 36, 37, 42, 43]. Majorly studies focused on endurance-trained male athletes. The average caloric intake from fat ranged up to 80% with protein ranging between 15–29% and least carbohydrates only 3.5–15. Management times varied from minimum 3 weeks [7, 29] to maximum 20 months [16]. As a result Serum ketone body; βOHB concentrations apparently increased from 0.5-1.2 mM. Mostly studies highlighted significant decreases in body weight [7, 24, 26, 29, 35, 43]. The results advocated 'Keto' diet as efficient dietary plan for reducing weight and balanced physique of sportsperson. Although body and fat mass showed positive changes, yet LC/KD diet failed to effectively and significantly improve

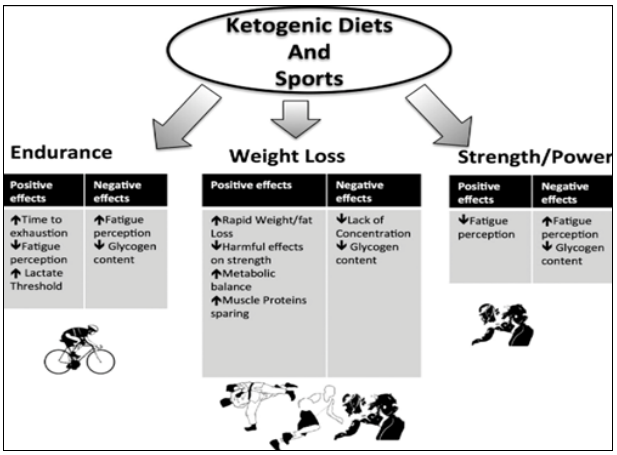
performance of athletes even with considerable decrease in respiratory exchange ratio (RER) and increased fatty acid oxidation (FAO). A study, after examining five separate studies concluded that metabolic state of ketosis improved physical endurance among 39 high-performance athletes due to the ability of body to use fat as substitute source of energy for oxidative respiration [33]. Muscle catabolism and plasma-lactate concentration decreased through Ketosis and provide alternate substrate oxidation procedure. Ketosis enhances intra-muscular triacylglycerol lipase function while doing exercise, in presence of muscle glycogen, carbohydrate and raised glucose level. Another study of 20 endurance athletes had similarly stated improved performance with fat loss compared to HC comparison group by 12 weeks ketogenic diet plan [17].

Nevertheless, clinical assessment and observational experiences from time to time have showed divergent results regarding performance enhancing abilities of ketogenic diet. one review observed that increased levels of ketone bodies due to supplements may speed-up muscle recovery and reduce protein breakdown following endurance exercise [25]. Thus, proposed using ketone esters for obtaining nutritional ketosis without restraining carbohydrate ingestion. Extrinsic ketones correspond to an unconventional anabolism fuel resource and spare carbohydrates. They may possibly amplify post exercise glycogen replacement, decrease hydrolysis of protein, and perform as modulator for metabolism.

Quite a lot of studies have found that the ketogenic diet could help speed up post-workout muscle recovery. One study established self-reported improvement among five athletes with ketogenic diet during revitalization preceded exercise [10]. However, they experienced reductions in some other measures of performance but athletes showed increased ability while utilising fat as energy source, even during high intensity exercise. Mean body weight reduced significantly by 4 ± 3.1 kg, along with computation of eight skinfolds by 25.9 ± 6.9 mm. Average time for exhaustion showed significant drop of 2 ± 0.7 minutes. Rest performance parameters showed average fall, while some raised others showed unchanged results as VO2, peak power. To begin with shortened energy level thereafter the athletes experienced high levels of energy throughout exercise, but reported incapability to undertake highly intense sessions. Athletes informed incidently improved health, enhanced healing ability and improved skin conditions with lesser inflammation.

Another study in off-road cyclists [2] tried to measure long-term effects of polyunsaturated fatty acids rich ketogenic diet on their aerobic performance and exercise metabolism the results showed that ketogenic diet resulted in decreased levels of creatine during kinase function and dehydrogenased lactate, which assess muscular damage during activities. The ketosis diet caused beneficial variation in physique, body mass, and athletes' lipid profile. Significantly increased maximal oxygen consumption (VO2max) and oxygen uptake at lactate adaptation (VO2 LT) were witnessed with ketogenic diet intervention, because of increased adipose tissue oxidation process or improved vasodilatation. The RER (Respiratory Exchange Ratio) notably reduce not only at rest but also during some phases of exercise procedure due to ketogenic diet. The heart rate (HR) and oxygen consumption significantly improved while at rest and through the initial 3 stages of exercise, while reversed during ultimate stage of physical activity carried out with high intensity. Both enzymes Creatine and lactate catalyzation process significantly slowed down at rest as well as at various stages of exercise protocol lasting 105-minute with 'low carb' ketogenic diet.

Studies has shown association of Ketosis with reduced production of ROS through mitochondria and lessen potential tissue damage while ensuring rapid recovery from injury [21]. As a result of ketosis diet, during prolonged exercise while using fatty acids as fuel brain get balanced supply of energy in the form of ketone bodies and bypass the need for high carbohydrate intakes which help for sustained physical and cognitive performances among humans. Besides studied on human, a mouse study showed that muscle recovery following exhaustive exercise increased following a ketogenic diet for 8 weeks [34]. Some parameters indicated that injury resulted from exhaustive exercise improved by KD, after 24-h rest due to sufficient lactate. Improved blood bio-markers and no infuriated damage indicated faster recovery by KD. The results suggested potential use of 'KD' for guarding from fatigue and faster recovery tool after injury among endurance athletes.



Source: PubMed

Both positive and negative impact of Ketogenic diet in sports are well portrayed by a scholar Paoli A, as shown in figure, for endurance, weight -loss and strength/power [32]. The researcher alerted sports trainers, physicians, and dieticians regarding better understanding of both positive and negative impacts of this particular nutritional regime, i.e Ketosis diet, while adopting for endurance and strength sports activities.

Conclusion

Emerging evidence reflect greater prospective benefits of ketogenic diet and its potential use as fuel for better metabolism and consequently improving health and performance. Keto-adaptation help in utilization of ketones and fatty acids as fuelling agent for exercising, with minimized breakage of muscle tissues. Body composition along with power-to-weight ratio could be maintained with lean body mass while burning fat through ketosis. Ketosis also reduce generation of ROS by mitochondria direct to less tissue damage and faster recovery. Steady supply of ketone bodies to brain resulted from using fat as fuel, evade need of more carbohydrate intake and ensures sustained physical as well as cognitive performance of athelets during prolonged exercise. Some scholars are of the view that

Ketosis diet better suits aerobic athletes compared to anaerobic athletes. Studies show that the ketogenic diet may influence numerous aspects of athletic performance. While some state that keto can boost fat burning and enhance endurance, others claim that it could drain energy levels and pose challenge to muscle growth Some studies opposed ketogenic diet considering it not suitable for high intensity bursts of activity, yet others advocated it for enhancing performance for endurance athletes. While some promising results showed increased endurance performance among players, but conflicting evidences found little efficacy of exogenic ketone bodies for enhanced performance thus demands more further research before making any concluding statement. In the light of available literature, it can be concluded that be ketogenic diet may be better suited for low intensity required physical activities and that too in balanced state compared to strength exercise needed burst of energy. More studies are needed to establish whether the ketogenic diet propose any supplementary benefits over other diets for athletes.

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