REVIEW ARTICLE

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The power of ketogenic diet in physical performance – review of the latest research

Moc diety ketogenicznej w sprawności fizycznej – przegląd najnowszych badań

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Abstract

Introduction and Objective. Restrictive diets are growing in popularity as more athletes attempt to improve their physical performance. One such diet that has recently attracted interest is the ketogenic diet, which drastically restricts carbohydrate intake to fewer than 20g per day. The primary objective of this diet is to induce a metabolic state called ketosis, which results in the production of ketone bodies and allows the body to primarily rely on fat as a source of energy. The purpose of this study was to investigate the effects of a ketogenic diet on athletic performance.

Brief description of the state of knowledge. The reported reduction in body weight and body fat remained unaffected by weightlifting performance. Maximal aerobic performance remained unaltered. Running performance over 5 km and endurance during CrossFit training showed no significant differences. During the Wingate test, the ketogenic diet decreased average and peak power by 6% and 7%, respectively. The total distance run in the yo-yo intermittent recovery test was 15% less after the ketogenic diet.

Summary. According to a review of studies, there is no conclusive evidence that a ketogenic diet improves athletic performance. Despite the fact that this diet can aid in weight loss in weight-class sports, it can have a negative impact on performance in activities requiring high levels of sustained effort. There is no conclusive evidence that following a ketogenic diet leads to significant improvements in athletic performance.

Key words

ketogenic diet, athletic performance

Streszczenie

Wprowadzenie i cel pracy. Coraz więcej sportowców decyduje się na stosowanie restrykcyjnych diet w celu poprawy swojej wydolności fizycznej. Zauważa się wzrastające zainteresowanie dietą ketogeniczną, która polega na ograniczeniu spożycia węglowodanów do wartości poniżej 20 g dziennie. Celem diety jest uzyskanie stanu metabolicznego zwanego ketozą, w wyniku którego wytwarzane są ciała ketonowe, co pozwala na zwiększone wykorzystanie tłuszczów jako źródła energii. Celem pracy była ocena wpływu diety ketogenicznej na wydajność sportową.

Opis stanu wiedzy. Dieta ketogeniczna nie wpłynęła na poprawę siły mięśni ani wydajności wytrzymałościowej. Odnotowana redukcja masy ciała i tkanki tłuszczowej pozostała bez wpływu na możliwości w zakresie podnoszenia ciężarów. Również maksymalna wydajność aerobowa nie uległa zmianie. Nie zaobserwowano znaczących różnic w wydajności biegowej na dystansie 5 km ani na sprawność fizyczną podczas treningu CrossFit. Dieta ketogeniczna zmniejszyła moc szczytową o 7% i moc średnią o 6% podczas testu Wingate. Całkowity dystans przebiegnięty w teście przerywanej wytrzymałości Yo-Yo był o 15% mniejszy po zastosowaniu diety ketogenicznej.

Podsumowanie. Analiza badań sugeruje brak jednoznacznych dowodów na korzystny wpływ diety ketogenicznej na wydajność sportową. Choć dieta ta może pomóc w redukcji masy ciała w sportach klasy wagowej, to w sportach wymagających wysokiej intensywności i długotrwałego wysiłku może negatywnie wpływać na wydajność. Nie wykazano, iż zastosowanie diety ketogenicznej prowadzi do istotnej poprawy wyników sportowych.

Słowa kluczowe

dieta ketogeniczna, wydajność sportowa

INTRODUCTION

The concept of 'sports performance' is very broad and ambiguous. In the simplest terms, sports performance can be categorized in terms of intensity, duration and frequency of activity. At one end of the spectrum are events that require

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very high intensity of effort over a short period of time, such as Olympic weightlifting, endurance events, like marathons (26.2 miles), ultramarathons (50+ miles) and multi-stage competitions, such as the Tour de France, which take place over several days or weeks. Each sport is characterized by different dynamics and varying durations. For example, even in 'ordinary' racing sports, an athlete's baseline muscle strength cannot be static, as conditions during competition (whether environmental or related to other athletes) force the use of varying levels of intensity to complete a sprint, chase a fleeing competitor or defend against an attack.

Moreover, field sports, such as soccer and rugby, are not only characterized by alternating periods of low, moderate, and high intensity activity, but also require the athlete's ability to keep his or her mind sharp, quickly analyze a wide range of inputs, and make correct tactical or strategic decisions. Additionally, the complexity of the athlete's decision-making process, strategy, coach's suggestions, etc. must be taken into account. Therefore, caution should be exercised when generalizing any conclusions from studies conducted under laboratory conditions to real-world conditions of sports competitions [1].

Recently, there has been growing interest in alternative diets that allow athletes to achieve an optimal body shape while maintaining or even improving their physical fitness and athletic performance [2]. More and more athletes are opting for energy-reduced or macronutrient-restricted diets to improve their physical performance [3]. Examples of such dietary strategies successfully employed by athletes include restricting energy intake by increasing protein suppl, and introducing intermittent fasting – a time-restricted diet during which food intake is limited to a few hours per day. Another form of dietary restriction that has become popular among athletes is a diet very low in carbohydrates – the ketogenic diet [4–8].

The ketogenic diet is a nutritional approach to drastically reduce carbohydrate intake while increasing fat intake and including an adequate amount of protein, so that the body primarily uses fat as an energy source. Due to the relative glucose deficiency resulting from limiting carbohydrate intake to less than 20 grams or 5% of total daily energy intake, the body begins to produce ketone bodies: acetone, acetoacetate (AcAc) and beta-hydroxybutyrate (βHB). This leads to a metabolic state called ketosis [9, 10]. The ketogenic diet was originally developed to reduce the incidence of seizures in epilepsy. The origins of the ketogenic diet came from reports that excessively high levels of ketone bodies, called ketosis, reduced the incidence of epileptic seizures, and has now also found use in the treatment of obesity, polycystic ovary syndrome, cancer, diabetes, and to increase physical performance in athletes [11, 12].

Restricting carbohydrate intake can contribute to a decrease in muscle glycogen content, resulting in greater fat oxidation [13, 14]. After adapting to a ketogenic diet, the body uses fat as its main source of energy. Since lipids are a macronutrient much more abundant in energy than carbohydrates, they theoretically provide energy for a longer period of time [15]. The ketogenic diet may exert its adaptive effects on the body through a molecular mechanism of regulating cellular signal transduction. Activation of this signalling pathway can lead to increased physical and motor performance through mitochondrial biogenesis, capillary thinning, and regenerative processes, especially efficient utilization of energy substrates from fat [16–18]. Additionally, studies have shown that a ketogenic diet can reduce lactate accumulation after exercise, contributing to better muscle recovery. This evidence suggests that increasing the use of fat as an energy source through a state of ketosis may benefit athletes [19, 20].

The aim of this study was to investigate the effects of a ketogenic diet on athletic performance.

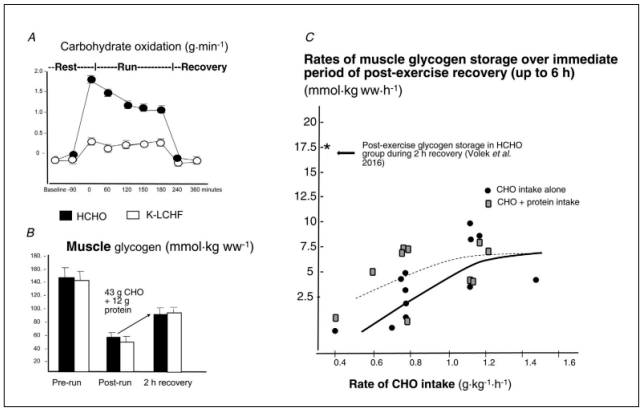

Figure 1. A study of the issues surrounding the effects of long-term adaptation to a low-carbohydrate high-fat ketogenic diet (K-LCHF) on carbohydrate metabolism (CHO) [21].
A – carbohydrate oxidation rates (g min-1) before, during and after 3 h of treadmill running at 65% peak aerobic capacity in ultra-endurance athletes accustomed to a K-LCHF diet > 9 months. B – muscle glycogen content (mmol kg wet weight-1) in ultra-endurance runners following a K-LCHF or high carbohydrate availability (HCHO) diet is measured before and after training. Additionally, HCHO levels are assessed before and after 3 h of treadmill running and after 2 h of post-exercise recovery. C – muscle glycogen storage rates during 2 h of recovery in HCHO-adapted ultra-endurance runners (Volek et al. 2016) are compared with a literature summary of average glycogen storage rates in trained individuals during 2–6 h of post-exercise recovery.

METHOD AND MATERIALS

The PubMed database was analyzed. Articles were searched in English using the following key words: 'ketogenic diet', 'sports performance'. Scientific articles published in the last five years (2018–2022) were included in the search.

RESULTS

Muscle strength parameters. Muscle strength parameters were assessed based on the maximum weight lifted during bench pressing, pulling the bar to the cage with an overhand grip, and bench pressing with both feet on the machine. The cyclic ketogenic diet did not impact any of these parameters [2]. Although the ketogenic diet contributed to weight loss and body fat reduction, it had no effect on weightlifting performance [22].

Spiroergometric parameters. The results of the study showed a reduction in gas exchange ratio in subjects who followed a cyclic ketogenic diet. None of the other spiroergometric parameters changed significantly [2].

Maximum aerobic capacity. The study results revealed no significant differences in peak oxygen uptake (VO2max), time required to reach exhaustion (Texh), or maximum workload (Wmax) when men consuming a ketogenic diet

[23, 24]. In contrast, women showed a significant reduction in VO2max by 10.4 after following a ketogenic diet. Additionally, maximum heart rate (HRmax) was significantly higher in both genders [24]. The ketogenic diet led to a 10% lower peak and mean respiratory exchange ratio (RER) [23].

5 km running performance. No significant differences were observed in running performance over a 5-km distance following the ketogenic diet. Initially, there was a significant average decrease in performance, but subsequent trials showed improvement [23].

Assessment of physical fitness specific to CrossFit training. No significant differences were observed in physical performance during CrossFit training following the ketogenic diet. The results of the Fight Gone Bad test showed no significant differences in individual rounds or overall performance after analyzing three rounds. Notably, the number of repetitions of box jumps was higher after consuming the ketogenic diet in round two. Additionally, in women the ketogenic diet led to increased repetitions in rounds two and three, as well as a higher total number of box jumps across all rounds [24].

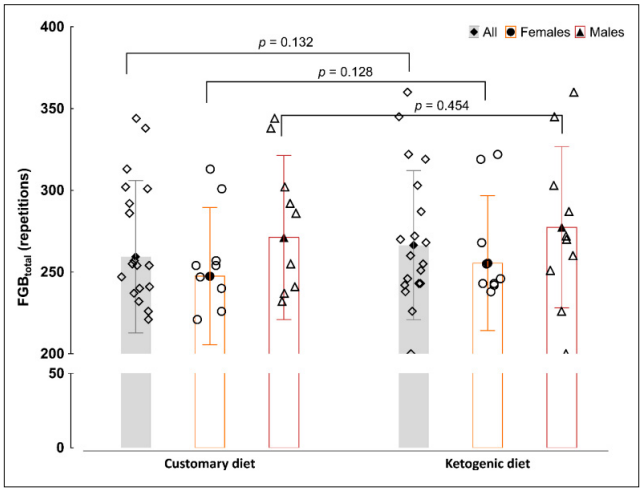

Figure 2. Total scores on the Fight Gone Bad (FGB) test.
Values expressed as mean (black fill) ± standard deviation and raw data (white fill). ♦ – females; O – males; Δ – data were analyzed using one-way analysis of variance (repeated-measures). Statistical significance – $p < 0.05$ [24].

Anaerobic capacity test Wingate. The Wingate test, commonly used to assess high-intensity exercise performance, involves a 30-second ride 'at full speed' on a cycling ergometer. The primary outcomes are peak power and average power. Peak power represents the highest power achieved in any five-second period, typically occurring in the initial five seconds, while average power reflects the mean power recorded throughout the entire test [25]. According to the study, after following ketogenic diet, peak power was 7% lower compared to the power achieved after a high-carbohydrate diet. The average 30-second power was 4% lower during the low-carbohydrate trial, and total work was 6% lower in the ketogenic trial [26].

Intermittent Yo-Yo endurance test. The Yo-Yo intermittent endurance test is a commonly used tool to assess the physical performance of soccer players. It involves acceleration and deceleration phases interspersed with rest. By incorporating progressive speeds and repeated shuttle runs, the test facilitates intermittent exercise, maximizing activation of the aerobic system and evaluating the body's ability to recover from repeated exertion, primarily utilizing the anaerobic system [27]. According to the study, the average total distance run during the Yo-Yo intermittent recovery test was 15% shorter after following a ketogenic diet [26].

SUMMARY

Analysis of the study suggests a lack of conclusive evidence for the beneficial effects of a ketogenic diet on athletic performance. It was noted that there was no effect on improving muscle strength or endurance performance. Instead, weight loss and body fat reduction were observed, with no effect on weightlifting performance. The implication is that athletes should consider using a ketogenic diet to achieve the intended weight reduction in weight class sports.

The results of the study showed a reduction in gas exchange ratio in subjects who followed a cyclic ketogenic diet. There were no significant differences in peak oxygen uptake (VO2max), time required to reach exhaustion (Texh), or maximum workload (Wmax) when consuming a ketogenic diet in men. However, a significant reduction in VO2max of 10.4 was observed in women after consuming the ketogenic diet. Peak and mean respiratory exchange ratio (RER) were 10% lower after the ketogenic diet.

There were no significant differences in 5-km running performance after application of the ketogenic diet. Initially, an average significant decrease in the score was shown; however, this improved in subsequent trials. Use of the ketogenic diet had a rather small effect on aerobic capacity, as determined by measuring cardiorespiratory indices, and had no significant effect on fitness during CrossFit training.

The low-carbohydrate diet reduced exercise performance, as evidenced by 7% lower peak power, 4% lower average power, and 6% lower work performed during the 30-second Wingate cycling test. In addition, performance during the field test designed to mimic intermittent anaerobic exercise loads in team sports such as soccer, was reduced by 15% after the ketogenic diet.

In summary, the ketogenic diet did not show any significant improvements in athletic performance.

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