MLS – HEALTH & NUTRITION RESEARCH (MLSHNR)
http://mlsjournals.com/Health&nutritionrsearch-Journal
ISSN: 2603-5820
(2023) MLS-Health & Nutrition Research, 3(2) 184-199. doi.org/10.60134/mlshn.v3n1.2924

Influence of nutrition on the improvement of sport performance in speed swimming

Influencia de la alimentación en la mejora del rendimiento deportivo en natación de velocidad

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Manuscript information:

Received/Recibido:19/06/24
Reviewed/Revisado: 15/07/24
Accepted/Aceptado:04/11/24

Keywords:
Mediterranean diet, sports nutrition, diet for swimmers, macronutrients, swimmer metabolism, nutritional strategies.

ABSTRACT

The aim of this work is to develop a dietary guide specifically designed for sprint swimmers, to help them select the right nutrition to enhance their performance. Bibliographic review of the scientific literature of the last five years thanks to the use of bibliographic search engines. Consequently, 33 relevant studies were found and analysed for their scientific relevance to the topic. The set of studies indicates that the diets analysed (Mediterranean diet, ketogenic diet, high-carbohydrate diet and intermittent fasting diet) generally improve performance. However, in the case of sprint swimming only the Mediterranean diet and the high carbohydrate diet show favourable data, since the other two show that the improvement in performance occurs at low intensities 65% of VO2max in women and 80% of VO2max in men. Due to the metabolic needs of sprint swimmers, both the Mediterranean diet and the high carbohydrate diet are suitable to improve their performance. However, in the long term the high carbohydrate diet may be detrimental to health compared to a balanced diet.

Palabras clave:
Dieta Mediterránea, nutrición deportiva, dieta para nadadores, metabolismo en nadadores, estrategias nutricionales.

RESUMEN

El objetivo de este trabajo es elaborar una guía alimentaria específicamente diseñada para nadadores de velocidad, para ayudarlos a seleccionar una nutrición adecuada que potencie su rendimiento. Revisión bibliográfica de la literatura científica de los últimos cinco años gracias al empleo de los buscadores bibliográficos. Consecuentemente, se encontraron 33 estudios relevantes, los cuales fueron analizados por su relevancia científica hacia el tema. El conjunto de estudios señala que las dietas analizadas (dieta Mediterránea, dieta Cetogénica, dieta alta en hidratos y dieta de ayuno intermitente) por lo general mejoran el rendimiento. Sin embargo, en el caso de la natación de velocidad solo la dieta Mediterránea y la dieta alta en hidratos muestran unos datos favorables, puesto que las otras dos muestran que la mejora en el rendimiento se da a intensidades bajas 65% del consumo máximo de

	oxígeno (VO2 Máx.) en mujeres y 80% del VO2 Máx. en hombres. Debido a las necesidades metabólicas de los nadadores de velocidad tanto la dieta Mediterránea como la dieta alta en hidratos de carbono son adecuadas para mejorar su rendimiento. No obstante, a largo plazo la dieta alta en hidratos puede ser perjudicial para la salud en comparación con una dieta equilibrada.

Introduction

Nutrition is a key aspect to improve athletes' performance. This is because nutrients are the fuel used by the body both for optimal performance and for recovery after physical exercise (1).

However, nowadays, thanks to the development of new technologies, especially the Internet and social networks, people's eating habits are highly influenced. In particular, children are highly vulnerable to what is transmitted through social networks, especially when it comes to unhealthy habits compared to proper nutrition campaigns, which tend to be less noticed by this segment of the population (2).

Typically, in sports that require high intensity efforts, most athletes tend to opt for a diet rich in carbohydrates to meet their energy needs and increase their performance during the match or event (3). However, in the case of such sports, the intake of a diet rich in carbohydrates can increase the fat in the central area, thus impairing the athlete's performance (4).

In the case of sprint swimming, there has been a tendency to change the characteristics of the diet towards a more balanced diet, not high in carbohydrates (5). In addition, although swimmers do not usually have a high central fat index, due to the high training volume, the Mediterranean diet is recommended as an alternative due to its healthy properties (6).

Throughout this review, an evaluation of the current literature on the different diets most commonly used by athletes will be carried out describing their benefits, diet content, adherence and detrimental effects. Some of the most studied diets are the Mediterranean diet, ketogenic diet (KD), high carbohydrate (HC) and intermittent fasting. The possible adverse effects of the different diets when the swimmer does not follow them properly will also be taken into account.

Method

In order to carry out this Final Degree project, taking into account that it is a literature review, a search for articles was carried out to compare the effect on sports performance and health of the different diets most commonly used today.

This literature search on the subject began on February 8, 2023 and ended on April 29, 2024. The scientific literature was found after searching in different databases, taking into account different inclusion and exclusion criteria.

Continuing along this thread, the inclusion criteria taken into account are as follows: studies that have been published between 2019 and 2024 and that are reviews, meta-analyses, experimental studies, clinical trials, case-control studies, cohort studies or observational studies. Consequently, the exclusion criteria used include studies whose population sample is less than 5 persons, whose age is more than 5 years old and whose language is neither Spanish nor English.

Figure 1 shows the keywords and Boolean markers used in each bibliographic search engine and the results obtained.

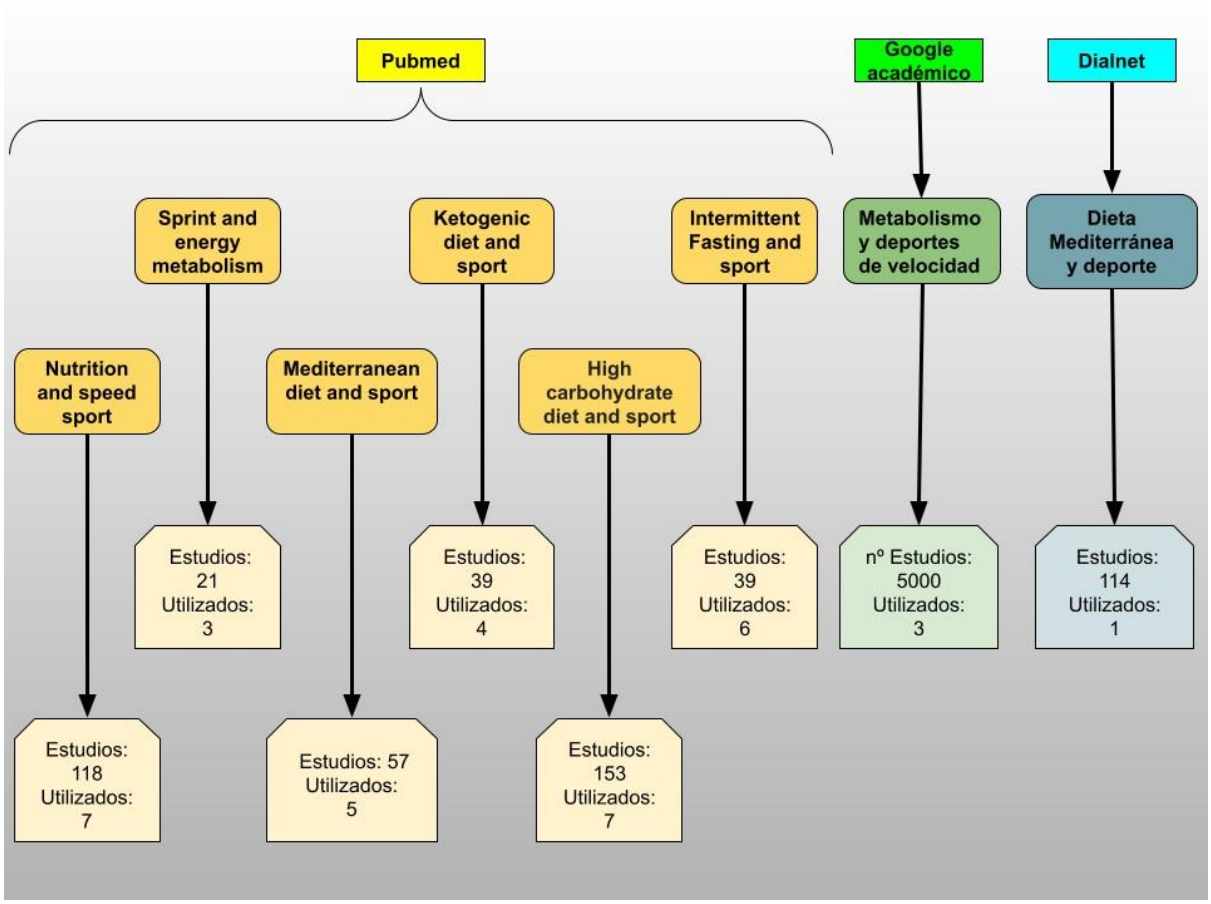

Figure 1. Search methodology used in the article

Results

Speed swimming is that which comprises the distances of 50 and 100 meters. Typical in these competitions are fins with times ranging from 20 seconds to less than one minute, respectively. This distance must be covered by the swimmer in the shortest possible time and at maximum intensity, which means that the anaerobic pathways provide most of the energy compared to the oxidative pathways (7).

As in other sprint sports, the energy pathway that will predominate in the 50 and 100 m races is anaerobic. Therefore, the limiting factor in this sport would be the depletion of ATP-PCr reserves (7). However, other authors relate the appearance of central fatigue, caused by metabolic acidosis, as the main cause of decreased performance (8).

That said, the main energy pathway will vary depending on the distance of the event. Therefore, athletes should work on all energy pathways, prioritizing those shown in Table 1 and ensuring that energy stores are replenished through proper nutrition (9).

Table 1. Relationship between energy systems and swimming speed distances. (7)

Weather (s)	Distance	% ATP-PCr	% Anaerobic glycolysis	aerobic metabolism
10-15	25 m	50	50	0
19-30	50 m	20	60	20
40-60	100 m	10	55	35

Mediterranean Diet

The Mediterranean diet has been used by the countries surrounding the Mediterranean Sea for hundreds of years, and is based on lean protein, such as fish and chicken, fruit and vegetables, berries, nuts and olive oil (10). The great benefit that has been commonly associated with this diet is that it reduces the risk of different diseases, such as cancer, and it is currently being studied for its anti-inflammatory qualities compared to Western diets (11).

Usually, the Kidmed questionnaire is used to assess the adherence to the Mediterranean diet by the child population. This questionnaire takes into account that they eat more than two pieces of fruit a day; they eat at least once a day vegetables, either fresh or cooked; they eat fish 2-3 times a week; they eat at least one serving of legumes a week; they eat pasta or rice 5 times or more a week; they eat some cereal or derivative for breakfast; they eat nuts 2-3 times a week; eating two servings of dairy products a day; using olive oil (12).

If we talk about sports performance, the Mediterranean diet shows that it helps to improve performance on the basis that it performs a body recomposition, reducing the fat index of athletes. It also reduces the inflammatory effect that the body produces in response to high-intensity training (13). This can help swimmers, as a low abdominal fat index is key to improved performance (6).

In addition, in the case of a study conducted on CrossFit athletes, after following a Mediterranean diet for 8 weeks, there was an improvement in the performance of the athletes, since the maximum number of repetitions was improved (13). Another study similar to the previous one in which runners and kickboxers were subjected to a change in their eating habits, redirecting the athletes to a lifestyle in line with the Mediterranean diet. This produced an increase in performance in both groups of athletes, the runners saw their VO2max increase and the kickboxers saw an increase in the squat and counter movement jump (CMJ)(14).

In summary, the Mediterranean diet stands out for its ability to help athletes achieve their goals. This is because, despite providing a moderate caloric intake, it manages to supply individuals with the nutrients necessary to support workouts, while keeping body fat levels low (15,16). This added to the fact that in general it is a diet moderately easy to follow by the population (17) and that it provides foods rich in antioxidants (fruits and vegetables) (11), make this diet a good option for swimmers looking to improve their performance and broaden their nutritional options.

Ketogenic Diet

The impact that this diet has on athletic performance is the fact that several studies show how the subjects after being subjected to a low carbohydrate intake see how the metabolism of carbohydrate oxidation slows down, which means that the glucose reserves can remain high until the end of the test which maximizes the performance of the athletes (18).

An example of a study that supports the above is the one conducted on Cross-fit athletes, 11 men and 11 women, who underwent a DC for four weeks. As a result, it was found that men increased fat utilization, mainly in exercises at an intensity of

80% of VO2max. However, this did not occur in women, who only saw their metabolism vary at intensities lower than 65% of VO2max (19).

Another study conducted the same year on endurance athletes showed that performance was not affected in athletes with DC compared to the control group when exercises were performed at intensities lower than 65% of VO2max. In addition, the time to onset of fatigue did not vary between the two groups of athletes (20).

However, both studies do not clarify what happens when subjects approach submaximal intensities, as is the case in sprint swimming. Therefore, one could take as a reference the study conducted on 25 men practicing endurance sports by subjecting them to a CD and a reintroduction to carbohydrates at week 10. This study shows that there is no change in strength and power between the control group and those subjected to DC when performing squat, bench press and dead weight exercises at intensities greater than 85% or RIR 0 (repetitions in reserve) (21).

Despite all of the above, a study conducted in 2019 in which 16 23-year-old men and women were subjected to 4 days of a DC, indicated that, when performing an anaerobic exercise, in this case stationary cycling and the Yo-Yo test, there was a decrease in the watts and meters achieved in the aforementioned tests. These facts have a very important impact on those athletes whose sport is of high intensity and short duration (22).

Another negative aspect of the CD would be the reduction of muscle mass due to the fact that such a diet may not cover the total nutritional requirements of athletes. This in turn has an impact on bone health as studies have shown how serological markers of bone health are altered by the use of the ketogenic diet for short periods of time. This aspect is of vital importance mainly in endurance sports and in those in which the athlete's triad may appear on a regular basis (23).

To finish with this diet, mention the difficulty that the population usually finds in following such a restrictive diet compared to others such as the Mediterranean diet (24).

High Carbohydrate Diet

The HC diet is characterized by the fact that more than 55% of the total calories obtained from food come from carbohydrates. In addition, due to the wide variety of carbohydrate-rich foods available for consumption, it can be stated that the main function of these foods in the human body is to be used as fuel. This is because this macronutrient can be metabolized quickly to generate energy for high-intensity exercise (25).

In the case of most sports, especially those of long duration, the so-called crossover point occurs. This point can be defined as the physiological state of an athlete in which the energy demands go from being satisfied mainly by fat metabolism to glucose metabolism being essential to continue performing an activity (26).

That said, at first glance it appears that this diet, by providing muscle fuel, is a good choice for improving athletic performance. However, one study showed that

endurance athletes who maintained a high carbohydrate diet (10 g/kg/day) compared to the 6.5 g/kg/day control group for 14 days had no significant difference in increasing running speed. In addition, although both groups saw their fat mass decrease, the athletes who were subjected to the diet suffered less fat loss (26).

On the other hand, another study comparing an HC diet or a DC diet for a short period of time (three weeks) in 24 adults showed that the HC diet had a greater effect on the performance of the athletes, i.e., these subjects achieved a higher VO2max, longer time to onset of fatigue and a better watts/kg ratio. Also, both diets obtained similar data in terms of weight loss (25).

The two previous studies refer to athletes whose sport was endurance. In contrast, this article again compares two groups of amateur athletes, one subjected to a low-carbohydrate diet and the other to a high-carbohydrate diet but this time on submaximal efforts performed on a stationary bike. As a result, it was found that the group that improved its performance to a greater extent throughout the tests was the group that was subjected to the HC diet (27).

Continuing with this type of studies in which the sample performs a sport in which the anaerobic pathway predominates. It was intended to demonstrate that eating a carbohydrate-rich, caffeinated meal prior to intervallic training can improve results. Consequently, it was found that there were no alterations in performance due to either the carbohydrate-rich meal or the caffeine (28).

As for swimming itself, a study was conducted in which swimmers were subjected to a HC diet (69% carbohydrate, 16% fat and 16% protein) and another group of swimmers were subjected to a low-carbohydrate diet (16% carbohydrate, 67% fat and 18% protein). After those three days the swimmers had to swim at intensities of 50, 60 and 70 % of the maximum aerobic capacity. As a result, it was shown that a high-carbohydrate diet did not affect glucose utilization at medium intensities (29).

One of the negative aspects of carbohydrates is that, depending on the time they take to be assimilated, they can have adverse effects on the gastrointestinal system (30). This is because ingesting large amounts of carbohydrates can cause the bacterial communities present in the intestine to suffer great stress as a consequence of their work in digesting the enormous amount of nutrients. This can cause athletes who are not accustomed to these abundant intakes of carbohydrates to suffer from indigestion or constipation, thus decreasing their performance (31).

Finally, for this diet the literature does not show any studies that discuss its adherence in sport. Consequently, a study conducted on obese adults showed that a priori a diet rich in carbohydrates is more palatable and therefore more appetizing. However, it can also decrease satiety and increase heartburn, making it difficult to adhere to this type of diet (32).

Intermittent Fasting Diet

Intermittent fasting is a practice that consists of restricting food for a few hours during the day or even for a whole day. This type of diet has gained prominence among athletes because it is used by "*influencers*" and by some professional athletes (33). The expected effect of this diet is that, after 3-8 hours of

fasting, gluconeogenesis is activated in order to maintain blood glucose levels, which increases fat oxidation to create ATP in the muscles (1,33).

Having said that, it is clear that this type of diet is commonly used for weight loss, however, a study of active women showed how this diet and high-intensity interval training can help improve both body composition and athletic performance (34). This is supported by the study conducted on 40 men performing Ramadan and practicing an endurance sport, who saw an increase in their performance and had no problems with muscle catabolism. However, it was found that men who were fed had better results than those who were not fed (35).

However, in professional athletes, results similar to those described above were obtained, as shown in the study carried out on endurance runners, in which it was seen that the effects of training were not diminished. Also, body composition had similar values following intermittent fasting as the control group (36).

A year later, another analysis conducted on elite cyclists showed similar results to the previous study, with both performance and body composition improved compared to the control group. What follows is that intermittent fasting may be a strategy to consider in sports that rely on body composition and are endurance sports (37).

However, all the articles mentioned above only refer to sports with a highly aerobic component, which is far from the objective of this study. Thus, an analysis conducted on thirteen adolescent handball players aimed to show the effects of caffeine on performance in maximal tests (the SJ test, the Illinois agility test and 5 m *shuttles* test) during the month of Ramadan. It showed that caffeine increased performance, but these tests revealed that during the month of Ramadan the adolescent girls suffered a decrease in performance compared to the same tests performed one week before the start of the diet (38).

In summary and in accordance with the above, intermittent fasting is a strategy that does not negatively affect the aerobic performance, strength and fatigue rate of athletes. However, this type of diet may show a deterioration of the sprinting and Wingate capacity, i.e. the anaerobic capacity of athletes (39).

Discussion and Conclusions

The articles found on the Mediterranean diet explore its effects on sports performance in different sports modalities, such as CrossFit training, endurance exercise, ski racing, kickboxing and swimming, in both an adult and an adolescent population.

The study by Ficarra S, et al. (13) examines the effects of the Mediterranean diet combined with CrossFit training in trained adults. Finding significant improvements in performance and body composition, suggesting that this combination may be beneficial for active individuals.

On the other hand, Soldati et al. (14) and Baker et al. (15) research on the effects of the Mediterranean diet on sports performance. Both studies found improvements in the aerobic capacity of the subjects. However, the first shows how the Mediterranean diet does have positive effects on anaerobic power and the second concludes that anaerobic improvements are negligible. However, it is true that this last study stresses the importance of doing research that lasts longer in order to verify whether the Mediterranean diet is efficient in improving anaerobic exercise performance.

The study by Helvaci et al. (16) focuses specifically on adolescent athletes and finds improvements in performance and lactate clearance with a Mediterranean-style diet after 20-meter sets. This suggests that this type of ditta may be especially beneficial for a youth population when the exercise they perform requires maximal or submaximal efforts.

Finally, Altavilla et al. (6) and Calella et al. (17) analyze adherence to the Mediterranean diet among adolescent and university athletes. It is found that there is good adherence to the Mediterranean diet among these athletes, indicating that it is a viable and popular option among athletes.

Taken together, these studies suggest that the Mediterranean diet may have significant benefits on sports performance and body composition in both adult and adolescent athletes. However, more research is needed to find the best way to implement this diet in different sporting contexts, as it is often a hypocaloric diet which may produce some risk for athletes (15,16).

Selected articles on the ketogenic diet indicate how it affects different aspects of sports performance and health in different populations, from CrossFit athletes to runners and endurance trainers.

Effect on sports performance: while Durkalec-Michalski et al. (19) and Shaw et al. (20) observe certain negative effects on performance, especially in high-intensity and submaximal exercise, Wilson et al. (21) find no significant impact of the ketogenic diet compared to the Western diet on strength and power in a group of men at high intensities. On the other hand, Wroble et al. (22) reported a decrease in anaerobic performance in both women and men, more specifically, at intensities greater than 65% of VO2 max in women and 80% of VO2 max in men.

Effect on body composition: Wilson et al. (21) points out that the ketogenic diet does not adversely affect body composition which, as mentioned above, is key to improved swimming performance.

Bone health: Heikura et al. (23) find that a short-term ketogenic diet can negatively affect bone health markers. Which highlights the importance of considering the long-term effects of this type of diet on the athlete's bone health.

Adherence to the diet: Landry et al. (24) found that the Mediterranean diet and the ketogenic diet have similar adherence in the population. However, the results show a slightly better level of adherence to the Mediterranean diet.

Overall, these studies highlight the complexity of the effects of the ketogenic diet on sports performance and health, and the importance of considering factors such as type of exercise, duration of diet, and adherence to the diet to fully understand its impacts.

The studies sought about the HC diet show the impact it has on the physical performance and body composition of athletes of different sports modalities.

The study by Wachsmuth et al. (25) compared a high-carbohydrate/low-fat diet with a low-carbohydrate diet in physically active adults. They found that the high-carbohydrate diet improved the performance of individuals. However, it was observed that blood triglycerides increased markedly, which in the long run can harm individuals and their performance.

Baart et al. (27) examined the effect of a low-carbohydrate, high-fat diet on exercise efficiency and economy in male amateur athletes compared to a high-carbohydrate diet. They found that the latter diet showed better results than the low-carbohydrate diet, despite the fact that the latter is associated with improved fat metabolism. This suggests the importance of carbohydrates in this sport.

This is in agreement with the study by Bestard et al. (29)in which the effect of low and high carbohydrate diets on swimming economy was compared. They found that low-carbohydrate diets did not improve swimming economy, suggesting that carbohydrate needs may be important for this type of exercise and more so at high intensities.

King et al. (26) investigated the effects of a high-carbohydrate diet and "gut training" in elite endurance athletes. They found that these interventions had minimal effects on gastrointestinal status and performance, suggesting that they may not be effective strategies for improving performance in highly trained athletes.

Hulton et al. (28) investigated the effect of the addition of caffeine and a carbohydrate-rich diet before intermittent exercise. They found that neither caffeine nor carbohydrate feeding improved performance. The authors themselves point out that the small sample size could have negatively affected the result.

Finally, the study by Furber et al. (31) found an association between gut microbial stability and improved endurance performance in athletes following dietary periodization, suggesting that gut health may play a role in athletic performance. In addition, it found that the high-carbohydrate diet can be detrimental to the gut microbiota of athletes.

Taken together, these studies highlight the complexity of the relationship between high-carbohydrate diet and physical performance, and underscore the importance of considering the individual needs of athletes when designing dietary strategies to improve performance and health.

The articles reviewed examine the impact of intermittent fasting (IF) and temporary food restriction (TRF) on body composition and physical performance in various populations and sporting contexts.

The study by Martínez-Rodríguez et al. (34) examines how HIIT and intermittent fasting affect body composition and physical performance in active women. While in the article by Triki et al. (35) investigate the timing of resistance training during Ramadan fasting and its effect on muscle strength and hypertrophy. Both studies show two quite different types of population but show quite similar results in terms of improved sports performance and improved health. The first showed how this nutritional strategy is valid to improve body composition and performance at the same time and the second showed an improvement in performance without a decrease in muscle mass. Despite this, the second study shows how the control group presents better results in terms of performance.

With respect to another population group, such as elite athletes. Tinsley G.M., et al. (36) and Moro T., et al. (37) found that intermittent fasting can be a strategy to be considered by athletes whose sports are endurance sports. Since in both studies it is found that the performance of the athletes was improving without any repercussion on the health of the athlete. Furthermore, in these sports, weight is a key indicator for performance improvement and both studies were successful in ensuring that subjects maintained adequate body composition.

On the other hand, the study by Bougrine H., et al (38) whose main objective was to demonstrate the increase in sports performance during Ramadan thanks to caffeine supplementation. The result was that, despite the improved results due to the use of caffeine, the athletes showed poorer submaximal and maximal effort results compared to the week before they started intermittent fasting due to Ramadan.

In summary, the articles show clear evidence that intermittent fasting may be an appropriate strategy for endurance sports. However, in sports with an anaerobic component or intermittent efforts.

Limitations

After reviewing recent articles on the relationship of different types of diets with the improvement of performance in the sport of swimming, more specifically in the speed modalities. To point out a set of aspects to be taken into account when carrying out new studies on this subject:

The first aspect to mention is the scarcity of studies found that directly relate swimming to a specific type of diet.

The second aspect to be improved is the methodology of the studies themselves, since most of the studies found present a fairly small sample and tend to compare diets with each other, without a control group or without taking it into account.

The third and last aspect to take into account is the duration of the studies. It would be appropriate to conduct a study covering a full season in order to compare how the different diets adapt to the different seasonal loads.

Having performed the analysis of the current literature, it should be noted that there is still a long way to go to find the most suitable diet for sprint swimmers. Since this population group is very heterogeneous and each individual may present very different variables to be taken into account. However, the literature shows how there are different diets that may have a greater effect on performance than others.

Regarding the Mediterranean diet, it is important to highlight its great variability of contexts in which it can be carried out. There is enough evidence to affirm that this diet can be a relevant factor to improve performance in both aerobic and anaerobic sports. In addition, its characteristics make it a very complete and balanced diet. However, this diet is often low in calories, which can negatively affect swimmers.

As for the ketogenic diet, despite being a dietary pattern that shows results in improving the body composition of the subjects, which is related to improved performance. It is not the best choice for sprint swimmers as studies show that performance at maximum intensities is impaired by this type of diet. In addition, although swimming is a low-impact sport, there are studies that link this diet to bone health problems, which can be harmful to elite swimmers because of their strength and plyometric work.

Continuing with the high-carbohydrate diet, evidence suggests that swimmers may consider the high-carbohydrate diet to improve performance in their sport. In spite of the above, the evidence found compares this diet with the low-carbohydrate diet, so more studies would be needed to be able to fully affirm the above. Also note that this diet can alter both blood triglyceride levels and gut microbiota. These aspects can be detrimental to the health of athletes.

Finally, the intermittent fasting diet shows significant evidence in improving performance in endurance sports and in the health of athletes. However, when it comes to improving results in sports dependent on the anaerobic system, such as sprint swimming, studies show a clear worsening of results.

To summarize, it is clear that both the Mediterranean diet and the HC diet are good options for swimmers. Nevertheless, it would be more advisable to follow a Mediterranean diet as it has fewer associated long-term health problems than the HC diet. However, the Mediterranean diet, in order to maximize performance, must be adjusted to the individual needs of the swimmer. Therefore, the nutritionist should work together

with the trainer to make the appropriate adjustments to this type of diet according to the training loads and the time of the season.

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