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Effect of Requisite Nutrition for Athletes of Endurance Training: A Non-Empirical Review

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Abstract

Weakness during endurance exercise is associated with a reduction in muscle glycogen beyond the physiological basal level, the response to compensate for this effect has been through the increase in carbohydrate uptake. Also, other dietary combinations have shown effectiveness in the required carbohydrate supply in improving the performance of athletes before and during endurance workouts. The search was made in Green Science Hub, PubMed, Free Full PDF, and World Wide Web for randomized trials published from 1995 to 2022 with a basic interest in performance in endurance exercise. All citations amounted to 22 which were examined based on the inclusion criteria of randomization or crossover allocation to diet and the basic result was endurance performance. Four full-text articles qualified for inclusion and were added to the current review. In the days to weeks before testing, one trial with an increased fat diet versus carbohydrate enhanced performance, others proved infinitesimal in effect. There was no advantage in changing protein for carbohydrates during this period, but hazelnut consumption improved performance. In the pre-event meal, fat improved performance in combination with carbohydrate intake. During endurance events, interchanging carbohydrates with protein had different results on performance and should be studied more. Conclusively, carbohydrate provides the highest energy before and during activities for all endurance performance compared to other ones needed in high amount, including water.

Key words: Effect, Nutrition, Athlete, Endurance, Training

1. Introduction

Exercise is one of the non-pharmacological means of improving various metabolic conditions and achieving a healthy lifestyle. A recommendation has it that a lesser time frame of about 25-35 minutes at a low to moderate intensity to serve as a periodic weekly routine workout is needed to achieve fitness, some scholars have proposed that two days in a week can unleash fitness goals (O'Donovan, Lee, Hamer & Stamatakis, 2017).

Participation in endurance events has gained popularity both nationwide and globally, with 2.5 million triathlon participants in the US in 2015 (Vitale & Getzin, 2019). Studies revealed interest has been recorded in other distance races such as mud runs, colour runs, and obstacle course races than the conventionally accepted marathon races. Many factors are responsible for an athlete's performance and general fitness which are primarily determined by the physiological and metabolic status; this is a function of the cells to have the required nutrient and use them effectively to generate the energy needed for very high-intensity endurance training (Williamson, 2016). Sequel to the emerging interest in endurance workouts, there is a need to determine and define the nutritional requirement that can compensate for the metabolic deficits that are inherent with endurance activities.

Most studies have contrasted the result of different dietary consumption, yet conviction on their energy supply to meet the demand for endurance events has not been well documented. This may be a sequel to the physiological peculiarities of the different athletes. Also, the science of nutrition is encompassing and requires many scientific procedures that may incorporate other related disciplines to determine the standard effect of a dietary consumption other than relying on physically observed biomarkers Suh as fatigue and poor coordination.

Optimal nutrition is one of the Frontline strategies used by athletes in improving performance, especially in endurance activities, based on what an athlete consumed before exercise, in the course of the exercise, and at the end of the exercise determines to a large extent his performance and ability to maintain healthy living. Different food products have different nutritional values and requirements for improving performance in athletes. Products that release nutrients needed in generating ATP in the metabolic part way, princely the oxidative part way are used to fuel muscular contraction during endurance training (Andrus & Andrus, 2017). Cellular respiration is fuelled by glycogen stores, intermuscular fat, triacylglycerol stores, and protein. According to White, Carol, Johnson, Pamela, Swan, Sherrie, Tjonn and Barry (2007), energy intake and energy expenditure are the key determinants of body weight. As compared to the conventional high-carbohydrate/low-fat diet, low-carbohydrate/high-protein diets are associated with reduced hunger and higher energy expenditure. Carbohydrates (CHO) release more ATP per unit of oxygen, therefore, increasing performance during endurance activities (Spriet & Wat, 2003; Andrus & Andrus, 2017). Low-carbohydrate diets enhance fatigability and can reduce the desire to exercise in free-living individuals (to meet the above need most of the studies have focused on carbohydrate compensation to glycogen store deficits.

There have been efforts to seek an alternative to carbohydrates in recent times. This includes enhancing gluconeogenesis for more use of non-glucose substrates such as protein and fatty acids in the generation of ATP for endurance activities.

2.0 Method

2.1 Search Strategy

Four separate literature searches were conducted in PubMed, Green Science Hub, Free Full PDF, World Wide Web, and SCOPUS. The under-listed terms were adopted in PubMed and Green Science Hub: (endurance or aerobic) and (exercise or workout or training) and (performance or recovery) and (diet or dietary intake/ dietary uptake) and (carbohydrate uptake/ intake or fat intake or protein intake) and (trial or randomized controlled trial or longitudinal or double-blind or single-blind or intervention or comparative or comparison) and (human or humans).

In Free Full PDF, SCOPUS, and World Wide Web, the following terms were adopted (endurance exercise or aerobic or endurance performance) and (performance or recovery) and (diet) and (carbohydrate intake or fat intake or protein intake) and English [Language]. Articles amounted to 13 in number from PubMed and Science Hub; 27 articles from Free Full PDF, SCOPUS, and World Wide Web were used.

3.0 Screening

All titles were reviewed to determine eligibility for abstract review. Full-text PDFs were obtained. Forty full texts were reviewed for primary findings, out of which seventeen similar articles gained consideration in the final review.

3.1 Inclusion Criteria

The inclusion criteria are as follows:

- Consideration was given to articles that have a randomized control trial design and crossover design or crossover design only.
- dietary treatment before to endurance event, in the course of the event, and at the end of the event
- The intensity ranges from moderate-to-high
- The basic expected outcome added in the publication

4.0 Findings

Cholewa, Newmire and Zanchi (2019) reported that reducing CHO or glycogen supply may not have an impact on acute resistance training to achieve success with a training volume <8 sets with a time ≤ 45 minutes (reduced volume and increase intensity) through higher consumption of CHO after restriction time tends to promote acute strength effectiveness, muscular endurance, and increased muscle mass. The study showed that carbohydrate remains the most effective source when energy is needed in a higher amount for higher metabolic activities such as insurance training. It is reported that acutely increasing blood glucose before resistance exercise might improve performance training sessions >50 min (high volume and moderate intensity) (Louis, Marquet, Tiollier, Bermon, Hausswirth & Brisswalter, 2016).

Getzin, Milner and Harkins (2017) affirmed that runners and triathletes who took carbohydrates before training and after training recorded increased blood glucose which aided performance, especially at the finishing phase.

Carey, Staudacher, Cummings, Stepto, Nikolopoulos, Burke and Hawley (2001) conducted a randomized crossover study comparing six days of fat adaptation diet and another diet with an increased percentage of carbohydrates among seven competent cyclists. All participants did not have any training for 24 hours but had a diet with increased carbohydrate content on the seventh day, and later had more carbohydrates as their pre-exercise meal. The report has it that strength increased more by 11% in the fat-adaptation group, but there was a zero difference in the expected performance in the distance covered within the one-hour time trial carried out after four hours of training at 65% capacity of maximum VO2. There was also increased oxidation of fat and reduced carbohydrate oxidation in the fat-adaptation group.

White, Carol, Johnson, Pamela, Swan, Sherrie, Tjonn and Barry (2007) in their general assessment and empirical recommendation on CHO supply and effectiveness revealed that CHO remains the major energy source for moderate to severe range of exercise and glycogen depletion is a major limiting factor of performance.

When the objective is to maximize performance in the course of training or competition, it is beneficial to supply the maximum amount of carbohydrates before exercise and in the course of exercise. It is advisable to consume 1-4 kg of CHO (reduced glycemic index) 1-4 hours before exercise and an optimal quantity of CHO (90 g/h) which represents a 2:1 ratio of glucose and fructose.

In support, to make sure glycogen stores remain at the normal physiological basal levels, it is paramount to consume carbohydrate diets with a high glycemic index of at least 1 g/ kg/ h in the two to four hours at the end of the training session. Sequel to the foregone, increasing daily carbohydrate intake to 10g/kg the day 24-36 hours before training improves performance (White, Johnston, Swan, Tjonn & Sears, 2007).

In a study by Hill (2017), drilled male participants who are cyclists were organized from local cycling clubs and were randomly assigned using a double-blind manner to one of two dietary groups; carbohydrate and whey protein isolates or carbohydrate and calcium caseinates. Participants completed double training periods per week at Victoria University, in summation to their training and these included one sprint interval session and one longer interval session. Participants were provided with all meals, snacks, and supplements for the 8-week duration of the study. Baseline and post-exercise testing followed the dietary and exercise intervention consisting of a DXA scan to assess body composition, a graded exercise test (GXT) for determination of lactate threshold and VO2 peak, and a 2-hour steady-state cycle followed by a 20-km time trial as a measurement of endurance performance. Samples of blood and muscle were analyzed pre and post the exercise training and nutrition intervention.

Findings showed that when comparing two high-quality proteins post-exercise for 8 weeks, carbohydrate and calcium caseinates increased CS activity however, neither supplement altered mitochondrial function or protein expression. Endurance exercise performance and body composition were comparable between proteins. These results indicate that when two high-quality proteins are ingested post-exercise for 8-weeks, time-trial performance, body composition and mitochondrial function are similar for trained cyclists.

Another study examined the effect of increased fat and moderate protein diet in contrast with a control diet in 20 recreationally vibrant men. Results showed that there was a decrease in work output with maximal and mean power in the group with increased fat percent. In line with earlier trials, oxidation of fat was high while RER showed a reduced value in the fat and moderate protein group (Fleming, Sharman, Avery, Love, Gómez, Scheett, Kraemer & Volek, 2003).

Jäger, Kerksick, Campbell et al. (2017) recommended that consumption of whole foods that contain a high-quality and increased amount of protein should be cherished; notwithstanding, dietary protein of high quality is better consumed in form of supplements to facilitate ingestion. Also, timing is a factor for deriving the potential benefits of protein in enhancing recovery and achieving the expected goal of lean body mass.

Very low diets can result in reduced intramyocellular lipid levels and high muscle glycogen levels, although no difference was observed in the time needed to accomplish the assigned distance (Larson-Meyer, Borkhsenious, Gullett, Russell, Devries, Smith &Ravussin, 2008)

The above result was evident when a very low dietary fat consumption for three days was studied against a moderate-fat diet before a day of glycogen normalization on a 10 km run distance next to a 90 minutes preload run in 21 men and women.

A study revealed that a moderate concentration on carbohydrate consumption over time impairs oxidation of fat, though small evidence exists showing improve fat oxidation ability next to pr-exercise carbohydrate consumption for prolonged but not shorter duration exercise, as training influenced performance due to the fact that nutrient plan that regulates carbohydrate availability differs based on the type of nutrition regimen adopted.

On the contrary, some studies have reported that mitochondrial signalling influenced by acute consumption of CHO may correlate to the quantity of CHO taken and the intensity of the training (Rothschild, Kilding&Plews, 2020)

A mild reduction was observed in the duration needed to complete a 20 km time trial at the end of 150 minutes of continuous state cycling at 70% rate of VO2 max, i.e., 29.3 minutes Vs 30.7 minutes in the high-fat group; this was a sequel to the study on the effect of a high carbohydrate diet compared to ten days of a high-fat diet. A diet with an increased percentage of fat was seen to have increased fat oxidation and reduced oxidation of all carbohydrates, muscle glycogen, and lactate (Lambert, Goedecke, Zyle, Murphy, Hawley, Dennis & Noakes, 2001).

A review by Vitale and Getzin (2019) reported that exercising one hour per day requires 5-7g per kilogram of the bodyweight of carbohydrates, whereas moderate to high-intensity training needs 6-10 g /kg/day as obtainable in the joint position stand of the Academy of Nutrition and Dietetics of Canada including American College of Sports Medicine. Ultra-endurance training such as one that requires high dissipation of energy for everyday execution with a duration of 4-5 hours of moderate to high intensity per day should have up to 8-12g/kg/day of carbohydrates to fuel the exercise

Lambertetal (2001), studied ten days of increased fat intake with a high CHO consumption. The period used in accomplishing a 20km time trial at the end of 150minutes of constant cycling at the rate of 70% of VO2max, that is, 29.3 minutes against 30.7minutes in the high-fat group reduced. The diet with a high-fat percentage showed evidence of high oxidation and reduced oxidation of the whole CHO, glycogen in the muscle, and lactate.

In a randomized, double-blinded study by Cramer, Housh, Johnson, Coburn and Stout (2012), a comparison of carbohydrate, protein, and ribose-containing repletion drinks VS carbohydrates in the course of 8 weeks of aerobic drill for thirty-two men (age, mean+- SD = 23+- years) performing test for aerobic capacity (V(02) peak), time to burn out at 90% V(02) peak, and percentage body fat (% fat), and fat- free mass (FFM)

Based on the outcome, a complete and total mean difference was reported ($p > 00.05$) between the TEST and the standard group that took the supplementary diet for the training-induced changes in I BW, fat percent, free fat mass, V(combining Dot Above) O2 peak, or TTE. From the observed result, CHO may likely produce some results as will be obtainable from a carbohydrate-protein mixture if CHO is consumed singly at the end of endurance training. There is the possibility that comparing the high amount of carbohydrates in both groups POST post-exercise drink, that is, (TEST and CON 76 and 939) accordingly brings the potential gains of the added protein, ribose, and other similar ingredients in the TEST drink in eight weeks drill scheduled.

High-quality dairy foods were studied by Haakonssen, Ross, Cato, Nana, Knight, Jenkins, Martin and Burke (2014), with drilled 32 female cyclist experts given servings of dairy foods of about 1350 mg of ca+, two hours before training.

No report stated increment or reduction in the distance covered in the 10 minutes cycle time trial carried out at the end of 80 minutes of constant conditioned cycling at 60% VO2 max.

In a study of carbohydrate versus placebo, high-intensity exercise lasting longer than 1.5-2 hours typically results in depleted glycogen stores. Previous research has led to recommendations of CHO as the primary fuel source for optimal performance during endurance exercises exceeding 60 minutes (Temesi, Johnson, Raymond, Burdon & O'Connor, 2011).

According to McMahon, Leveritt and Pavey (2017) from the result of their studies on supplementary dietary nitrates and their impact on endurance training and analysis of time trial (TT), time of exhaustion (TT), and graded exercise test (GXT) examined said that the moderator characteristics such as training type, duration of dosage, NO3 – type and nature, study quality, fitness integrity and percentage of nitrite change using univariate meta-regression. The pooled analysis reviewed a trivial negligible impact in support of the dietary NO3– supplementation.

Trials of TTE recorded less but insignificant results in support of NO3- dietary supplementation in GXT performance analysis with effect size equal to 0.025, 95% CL equals -0.06 to 0.56, and P> 0.05). Heterogeneity was insignificant in the meta-analysis. No statistical effect was recorded from the meta-regression analysis. It concluded that when endurance training ability was tested, there is a possibility that NO3may produce a good effect, but dietary NO3 supplementation may not have improvement tendencies for time-trial performance.

A study conducted by Osterberg, Zachwieja and Smith (2008) randomized thirteen trained, male cyclists in a double-blind crossover design to three beverages: CHO-only versus CHO-PRO versus placebo (noncaloric, artificially sweetened, identical electrolyte profile). Every subject had a similar one-day diet and 12 hours of overnight fasting before every trial. Before the collection of data, subjects made sure they completed four weeks. The outcome did not show any effect in time-trial performance regarding capacity output, or RPE between carbohydrate singly and carbohydrate-protein diet. But carbohydrates resulted in quicker performance compared to placebo and CHO-PRO by 6% as reported. Interestingly, greater inter-individual variability was observed in CHO-PRO compared to other beverages.

Hansen, Bangsbo, Jensen, Krause-Jensen, Bibby, Sollie, Hall and Madsen(2016) randomized eighteen male cyclists to a CHO-only beverage or a lower CHO-PRO beverage and long-distance or short-distance rides during a one-week trial. Diet was kept consistent throughout the week. Each group had an intake of 18g protein recovery drink daily, but this was not considered in the protein content of the carbohydrate-protein group diet.

There were insignificant differences reported in maximum power output in contrast to the benchmark. The reduction was observed in the average power liberation in the course of the performance test in both carbohydrate and carbohydrate-protein groups compared to the benchmark. Indicators of muscle damage increased in the CHO-PRO group compared to baseline, whereas no significant changes were seen in the CHO group.

5. Discussion

Athletes are becoming familiar with fat in generating ATP during endurance training. Various studies have proposed that enhancing the oxidation of fat may compensate for glucose depletion and therefore performance is increased. Oxidation of fat was regularly seen in persons who underwent a moderate to a high-fat diet as marked by a reduction in muscle glycogen, high fat oxidation, and reduced respiratory exchange rate. Irrespective of this, diets with a high percentage of fat had an insignificant effect on performance relative to a high carbohydrate. The quality and the amount of CHO diet also influence performance.

Precisely, a low carbohydrate with a low glycemic load. In contrast with the glycemic index, a reduced glycemic intake takes into account the quantity of the carbohydrate, which seems to be important in evaluating carbohydrate quality. Comparing a high-protein diet to a high-carbohydrate diet, the high-protein diet had no effect or bad effect on timed trials compared to high-carbohydrate diets. It is worthy of note that athletes who added hazelnut had a longer period of exercise than those who took isocaloric diets, despite the reduced carbohydrate content of hazelnut. Studies should be made on other inherent benefits that are peculiar to hazelnut and similar nuts especially to ascertain their fatty acid profile.

Considering the difference in the time frame of these researches, more control trials are needed to vividly state the effect of an increased protein diet on endurance performance. Fat has effectiveness only when consumed with low carbohydrates before endurance training. It was not known if the additional calories combined with carbohydrate loading had an impact on the total performance. Further studies using other energy substituents before an event are needed to understand this good effect. Good fibre diets in moderate amounts have been demonstrated to enhance performance, apart from calories. There is no trial on protein before the training that was reviewed in this paper, but an investigation of partial replacement of CHO with protein is needed, especially given the decreased carbohydrate, and increased protein diets. While nitrates from beetroots showed prospects for performance improvement, studies with higher sample sizes are required to explain more nitrate beneficial effects due to the increased demand for beetroot juice in the market.

In essence, the demand for dairy foods is on the increase as it has been known to be a recovery diet, but calcium from such did not improve performance when consumed before training. During endurance training lasting longer than 1-2 hours, carbohydrates supplied more energy compared to fat and protein. As carbohydrate is known as the major fuel source during long, moderate-intensity endurance events, various studies have proved there is a limit to exogenous carbohydrate oxidation during training. Partly replacing carbohydrates with protein has been suggested to be additional means of improving performance. Consumption of protein during high-intensity training has been shown to reduce the effect on endurance performance. Due to the time constraint of trials, more studies with extended periods are required to explain if partly replacing protein may aid the preservation of glycogen stores. Protein type does not seem to have an ergogenic effect, but there are few studies in this regard.

6. Conclusion

Carbohydrate is the most effective fuel source both before and during training for different endurance performances. More detailed research is needed to understand more how the quality of carbohydrates may enhance performance, as several studies indicate a high carbohydrate, reduced glycemic concentration diet has inherent ergogenic advantages. While fat-adaptation results in improved metabolic responses, there are little or no ergogenic benefits observed so far. Isoenergicpartial substitution of carbohydrate with protein or fat should be further studied, however, as earlier trials have proposed some inherent advantages. Fat also plays a crucial role in assisting the metabolic function of carbohydrates, particularly during endurance training.

7. Recommendations

1. The percentage of carbohydrates in other diets should be higher in comparison when contemplating nutrition for athletes in endurance training.

2. A professional in dietary planning should always be consulted if optimal performance is the goal of any endurance training undertaken.

3. Finally, the focus of future trials should concentrate more on food-based interventions rather than simply macronutrient-based particularly recommended by the Dietary Guidelines for athletes to focus on foods rather than individual nutrients.

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