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# NUTRITIONAL INTERVENTIONS TO AUGMENT HIGH-THROUPUT INTERVAL TRAINING DURING PHYSIOLOGICAL AND PERFORMANCE ADAPTATIONS

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**ABSTRACT**

High-intensity interval training (HIIT) and other forms of high-throughput interval training are increasingly recognized as efficient exercise strategies for improving cardiovascular fitness, metabolic health, muscular performance, and exercise capacity within relatively short training periods. However, the physiological adaptations induced by repeated high-intensity exercise are strongly influenced by nutritional status, energy availability, substrate utilization, and post-exercise recovery. Nutritional interventions may therefore provide an important complementary approach to maximize the physiological and performance benefits of interval training. The integration of targeted nutritional strategies—including adequate carbohydrate availability, high-quality protein and essential amino acids, hydration and electrolyte replacement, and selected evidence-based nutraceuticals—may enhance exercise tolerance, optimize energy metabolism, support muscle protein synthesis, reduce excessive fatigue, and accelerate recovery between training sessions. Specific interventions such as creatine, dietary nitrate, omega-3 fatty acids, vitamin D in deficient individuals, and selected polyphenol-rich foods may further influence pathways involved in mitochondrial function, muscle adaptation, inflammation, oxidative stress, and neuromuscular performance. However, the response to nutritional supplementation is highly individualized and may depend on training status, exercise intensity, baseline nutritional status, timing, dose, and the type of adaptation being targeted. The rationale for nutritional interventions during interval training is therefore based on the concept that optimal nutrition can augment, rather than replace, the adaptive stimulus provided by exercise. A well-designed nutritional strategy may help maintain training quality, increase the capacity to perform repeated high-intensity bouts, and facilitate recovery, thereby potentially enhancing long-term cardiovascular, metabolic, muscular, and performance adaptations. Nevertheless, excessive or inappropriate supplementation, particularly high-dose antioxidant use, may not necessarily improve adaptation and could potentially interfere with beneficial exercise-induced signalling pathways. This topic highlights the need for an integrated, individualized approach combining exercise prescription, nutritional optimization, recovery, and evidence-based nutraceutical use. Further controlled research is warranted to identify which nutritional interventions, when provided to which individuals and at what stage of training, most effectively enhance physiological adaptations and performance outcomes associated with high-intensity interval training.

***Keywords:*** Muscle repair, Rehabilitation, Sports performance, High-intensity interval training, sports nutrition, carbohydrate availability, protein synthesis, mitochondrial adaptation, recovery, ergogenic aids, physiological adaptation, exercise performance.

## INTRODUCTION

High-intensity interval training (HIIT) is widely used in competitive sports, recreational fitness, rehabilitation under professional supervision, and physical conditioning. It involves alternating periods of relatively intense exercise with recovery periods that may consist of passive rest or lower-intensity activity. Depending on the protocol, an interval session may emphasize repeated sprint performance, aerobic capacity, anaerobic power, metabolic conditioning, or a combination of these outcomes. The physiological demands of interval training can be substantial. During intense work intervals, ATP turnover increases rapidly, carbohydrate oxidation becomes important, and the contribution of anaerobic energy pathways rises as exercise intensity increases. During recovery, the body restores phosphocreatine, resynthesizes ATP, regulates acid–base balance, and gradually restores physiological stability. Repeated training sessions stimulate adaptations in skeletal muscle, the cardiovascular system, and the mechanisms responsible for energy production.

However, training adaptations are influenced by more than the exercise stimulus itself. Inadequate energy intake, insufficient carbohydrate availability, insufficient protein consumption, dehydration, and poor sleep can compromise the quality of training and the recovery process. Conversely, a well-designed nutritional plan can help an athlete complete demanding sessions, maintain training consistency, and adapt to repeated exercise more effectively. The phrase high-throughput interval training can be interpreted as an approach that delivers a substantial amount of high-quality interval work, or a high training workload, within a limited time. It is not a universally standardized exercise-science term. Accordingly, this discussion applies established evidence from HIIT, SIT, and repeated high-intensity exercise research to nutritional strategies that support high-workload interval training.

The objective is not simply to maximize nutrient intake. Rather, it is to match nutritional availability to the physiological demands of training while preserving long-term health and allowing the body to respond appropriately to exercise.

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## PHYSIOLOGICAL BASIS OF HIGH-THROUGHPUT INTERVAL TRAINING

### Energy systems and metabolic demand

The human body relies on three interconnected energy systems during high-intensity exercise: the phosphagen system, anaerobic glycolysis, and oxidative phosphorylation.

The phosphagen system rapidly supplies energy through stored ATP and phosphocreatine. It is particularly important during very short sprints, explosive movements, and the initial seconds of maximal-effort exercise. Anaerobic glycolysis generates ATP through the breakdown of glucose and muscle glycogen, contributing substantially during repeated high-intensity efforts. Oxidative phosphorylation uses oxygen to generate ATP and becomes increasingly important during longer intervals and recovery periods.

Although these systems operate simultaneously, their relative contributions depend on exercise intensity, interval duration, recovery duration, and the athlete's conditioning level.

Nutritional interventions can influence the availability of substrates used by these systems. Carbohydrates support glycolytic and oxidative energy production, while creatine supplementation may increase muscle phosphocreatine availability. Dietary fats support energy needs at lower intensities and contribute to overall energy sufficiency, while protein supplies amino acids for tissue maintenance and remodelling.

### Mitochondrial and cardiovascular adaptations

Repeated interval training stimulates molecular signalling pathways associated with mitochondrial biogenesis and oxidative metabolism. One important regulator is peroxisome proliferator-activated receptor-gamma coactivator 1-alpha (PGC-1α), which participates in the regulation of genes involved in mitochondrial function.

Over time, appropriate interval training can improve maximal oxygen uptake ($VO_2$-max), exercise economy, peripheral oxygen utilization, and the ability to sustain demanding exercise. Cardiovascular adaptations may include improvements in stroke volume, vascular function, and the distribution of blood flow to active muscles.

Nutrition supports these adaptations by ensuring adequate energy availability and supplying essential nutrients for cellular function. Nevertheless, the presence of a nutrient does not automatically enhance an adaptation. The training stimulus, total dietary intake, recovery, and individual characteristics determine the overall response. Research suggests that certain nutritional interventions can improve the quality of acute HIIT performance, but evidence that they consistently produce superior long-term adaptations remains limited for several supplements (1-8).

### Muscle remodelling and recovery

High-intensity exercise creates a physiological stimulus that requires recovery and remodelling. Muscle protein turnover increases, glycogen stores may decline, and temporary changes occur in inflammatory, oxidative, and cellular signalling processes.

The objective of recovery nutrition is to provide the resources needed to restore homeostasis and prepare for the next training session. Adequate carbohydrate supports glycogen restoration, protein supplies amino acids for tissue repair, and fluids and electrolytes replace sweat losses.

These processes are particularly important when training frequency is high. If the interval workload repeatedly exceeds the athlete's capacity to recover, performance may decline despite a well-designed training program.

## NUTRITIONAL ASSESSMENT BEFORE INTERVENTION

Nutritional interventions should begin with an assessment rather than immediate supplementation. The athlete's training schedule, current dietary habits, body mass, health status, exercise goals, and recovery patterns should be evaluated.

### Energy availability

Energy availability refers to the dietary energy remaining for normal physiological functions after accounting for exercise expenditure. Persistently inadequate energy availability can compromise bone health, hormonal function, immunity, reproductive health, mood, and athletic performance in people of all sexes. An athlete attempting to improve body composition may be tempted to combine severe calorie restriction with demanding interval training. This approach can impair training quality and increase the risk of inadequate recovery. A moderate, individualized energy deficit may be appropriate in some circumstances, but aggressive restriction is generally inconsistent with maximizing high-intensity training performance (6-7).

### Macronutrient assessment

The three main macronutrients have complementary roles:

Carbohydrates: support high-intensity exercise and replenish muscle and liver glycogen.

Protein: supplies amino acids for tissue repair, muscle remodeling, and maintenance of lean mass.

Dietary fats: provide concentrated energy and essential fatty acids and support normal hormonal and cellular functions.

Micronutrients, including iron, calcium, vitamin D, magnesium, and B vitamins, also contribute to normal physiological function. Their importance does not mean that routine supplementation is necessary for every athlete. Supplementation is most appropriate when dietary assessment, clinical evaluation, or laboratory findings identify a specific need

### Individual differences

Nutritional planning should account for age, sex, body size, training experience, food preferences, dietary restrictions, climate, and medical history. Menstrual function, gastrointestinal tolerance, sleep, and recovery between sessions can provide useful information when evaluating whether a nutrition plan is appropriate.

For example, a trained cyclist completing two demanding sessions in one day may require a different carbohydrate strategy from a recreational athlete performing one brief interval session three times per week. The same supplement may also produce different effects in different individuals.

## MAJOR NUTRITIONAL INTERVENTIONS

### Carbohydrate availability and periodization

Carbohydrates are among the most important nutritional factors for high-throughput interval training because repeated high-intensity efforts depend substantially on muscle glycogen and blood glucose.

Insufficient carbohydrate availability may reduce the ability to maintain power output, complete prescribed intervals, and preserve training quality across consecutive sessions. Adequate carbohydrate intake can be especially valuable when intervals are long, the total workload is high, or recovery time is short.

Practical carbohydrate strategies include:

Consuming carbohydrate-containing meals before demanding sessions. Using easily digested foods when the pre-exercise meal is close to training. Consuming carbohydrate during prolonged sessions when the workload and duration justify it.

Replenishing glycogen after demanding sessions, particularly when another workout follows within several hours.

For many athletes, approximately 1–4 g of carbohydrate per kilogram of body mass in the 1–4 hours before exercise can be considered according to the time available, the session demands, and individual gastrointestinal tolerance. This is a flexible planning range, not a requirement to consume the maximum amount before every workout.

During prolonged or exceptionally demanding exercise, approximately 30–60 g of carbohydrate per hour may help maintain fuel availability. Short interval sessions generally do not require carbohydrate intake during exercise if the athlete begins adequately fuelled.

The concept of train low, compete high involves deliberately performing selected sessions with reduced carbohydrate availability while maintaining high carbohydrate availability for important performance sessions. Low-carbohydrate training can enhance certain acute molecular signals related to oxidative metabolism, but this does not establish that it produces superior long-term performance. Excessive restriction can compromise training quality and recovery. A periodized strategy should therefore be used selectively rather than applied to every interval session (8).

**Protein and essential amino acids**

Protein supports the repair and remodelling of skeletal muscle following exercise. Although HIIT is not identical to resistance training, repeated sprinting, running, cycling, and other demanding movements can produce substantial muscular stress.

For many exercising adults, a daily protein intake of approximately 1.4–2.0 g/kg of body mass is a useful evidence-based range. The appropriate amount depends on the total workload, energy intake, training objectives, and individual circumstances. Simply consuming more protein does not guarantee greater cardiovascular or mitochondrial adaptation.

Protein intake can be distributed across the day, with meals or snacks providing approximately 0.25–0.40 g/kg per serving as a practical starting point for many athletes. Common sources include milk, yogurt, eggs, fish, poultry, soy foods, beans, lentils, and other legumes. A varied plant-based diet can support training when total protein and essential amino acid requirements are met.

Consuming protein after training is useful when it contributes to adequate daily intake and recovery. However, there is no need to treat the post-exercise period as a narrow window that closes immediately. A balanced meal containing protein and carbohydrate within a reasonable period after exercise is generally practical.

Research supports protein's role in muscle protein synthesis and recovery, but evidence that unusually high protein intake independently increases the long-term benefits of HIIT remains insufficient (3-8).

**Creatine monohydrate**

Creatine is stored in skeletal muscle, where it contributes to rapid ATP regeneration through the phosphocreatine system. Supplementation may improve repeated high-intensity exercise capacity, particularly when performance involves short, intense bouts separated by recovery periods.

Creatine monohydrate is the most extensively studied supplemental form. A common maintenance protocol is 3–5 g daily. An optional loading protocol uses approximately 20 g daily, divided into smaller doses, for 5–7 days, followed by maintenance intake. Loading is not essential; smaller daily doses gradually increase muscle creatine stores.

Potential benefits include improved repeated-effort capacity and support for training adaptations when combined with appropriate exercise. Creatine may also increase body mass because of increased water retention within muscle.

Its ability to improve HIIT performance is better established than the claim that it consistently amplifies every long-term cardiovascular adaptation to HIIT. People with kidney disease, relevant medical conditions, or medications that affect kidney function should consult a qualified healthcare professional before using it. Athletes should select independently tested products to reduce contamination risks (3-8).

**Caffeine**

Caffeine acts primarily through adenosine receptor antagonism and can reduce perceived effort, increase alertness, and improve selected aspects of exercise performance. Depending on the individual and exercise protocol, these effects may help an athlete maintain effort during demanding intervals.

Research commonly examines doses of approximately 3–6 mg/kg taken around 30–60 minutes before exercise. However, lower doses may be sufficient for some individuals, and higher doses can increase adverse effects without providing additional benefit.

Potential problems include anxiety, tremors, palpitations, gastrointestinal discomfort, and disturbed sleep. Sleep disruption is particularly relevant because it may undermine recovery and adaptation even when the immediate workout feels easier. Caffeine should be tested during training rather than introduced for the first time during competition. People who are sensitive to caffeine, have relevant medical conditions, are pregnant, or use interacting medications should seek appropriate professional guidance. Caffeine is an optional performance aid, not a substitute for carbohydrate availability, adequate hydration, or sleep.

**Beta-alanine**

Beta-alanine is a precursor to carnosine, a compound found in skeletal muscle that contributes to intracellular buffering. Increasing muscle carnosine may help manage the acid–base disturbance associated with certain forms of intense exercise. Research suggests that beta-alanine is most relevant to high-intensity efforts that last approximately one to several minutes, although benefits vary according to exercise type and protocol. Common research protocols use approximately 3.2–6.4 g daily for several weeks. The supplement works through gradual increases in muscle carnosine rather than an immediate stimulant effect. Dividing the daily dose or using a sustained-release product may reduce paraesthesia, a temporary tingling sensation that can occur after ingestion.

Beta-alanine may help some athletes tolerate demanding work intervals, but its effects on long-term $VO_2$-max or general endurance is not consistently established. It should be considered only after basic dietary and recovery requirements have been addressed.

**Dietary nitrate**

Dietary nitrate, available in foods such as beetroot, can contribute to nitric oxide production through the nitrate–nitrite–nitric oxide pathway. Nitric oxide participates in vascular regulation and may influence blood flow and the oxygen cost of exercise. Some studies suggest that nitrate supplementation can improve exercise efficiency or performance under particular conditions. Responses vary with training status, exercise modality, dose, and the characteristics of the individual.

Research protocols often examine nitrate intake approximately 2–3 hours before exercise, while other approaches use repeated intake over several days. Products vary considerably in nitrate content, so the quantity of beetroot juice alone does not reliably indicate the delivered dose. Nitrate is a potentially useful intervention, but it should not be presented as a guaranteed means of increasing $VO_2$-max or producing superior adaptations. Individuals taking blood-pressure medications or other relevant drugs should seek medical advice before using concentrated nitrate products (7, 8).

**Sodium bicarbonate**

Sodium bicarbonate is an extracellular buffering agent that can influence the movement of hydrogen ions between muscle and blood during intense exercise. Under appropriate conditions, it may improve performance in repeated high-intensity efforts, particularly when the exercise involves substantial glycolytic demand. Research commonly examines doses around 0.2–0.3 g/kg, taken sufficiently early before exercise to allow the athlete to assess tolerance and achieve the intended physiological effect. However, gastrointestinal symptoms such as bloating, nausea, and diarrhoea are common limitations. The substantial sodium load also makes it inappropriate for some individuals.

Sodium bicarbonate may be relevant to selected competitive athletes undertaking repeated sprints or demanding intervals, but it is not necessary for routine exercise. Its use should be individualized and tested under professional guidance. The evidence for acute performance benefits is stronger than the evidence that supplementation consistently increases long-term training adaptations.

## HYDRATION AND ELECTROLYTE MANAGEMENT

Hydration is essential for maintaining cardiovascular function, thermoregulation, and exercise performance. During interval training, metabolic heat production rises rapidly, and sweating helps regulate body temperature. In hot or humid environments, fluid losses may be substantial.

Dehydration can increase cardiovascular strain, reduce the ability to dissipate heat, and impair exercise performance, particularly when fluid losses are large. Conversely, excessive consumption of plain water can dilute blood sodium concentrations and contribute to exercise-associated hyponatremia.

**A practical hydration strategy involves three stages.**

Before exercise: Begin training in a reasonably hydrated state. Drink fluids with meals and according to thirst, adjusting intake for environmental conditions and expected sweat loss.

During exercise: Drink according to thirst, individual sweat rate, exercise duration, and access to fluids. For short sessions, water is usually sufficient. Longer sessions, repeated workouts in the heat, and sessions involving heavy sweating may justify a beverage containing sodium and carbohydrate.

After exercise: Replace fluid losses gradually, alongside normal meals. Body mass measured before and after training can help estimate fluid loss when measurements are made under consistent conditions. When rapid rehydration is necessary, replacing approximately 125–150% of the measured fluid deficit over the subsequent hours can be useful, with sodium-containing foods or beverages helping retain fluid.

There is no single fluid volume appropriate for all athletes. Sweat rates vary considerably, so drinking plans should avoid both substantial dehydration and forced overconsumption.

## VITAMINS, MINERALS, AND ANTIOXIDANT NUTRITION

Micronutrients support oxygen transport, energy metabolism, muscle contraction, bone health, and immune function. Their importance becomes especially apparent when an athlete has a dietary deficiency or inadequate energy intake.

Iron is necessary for haemoglobin formation and oxygen transport. Low iron status can impair exercise tolerance and contribute to fatigue. Athletes experiencing unexplained performance declines, persistent tiredness, or other possible signs of deficiency should seek clinical assessment rather than automatically taking iron supplements.

Calcium and vitamin D support bone health and normal muscle function. Magnesium participates in numerous enzymatic reactions, including those involved in energy metabolism and muscle function. B vitamins help the body metabolize energy-yielding nutrients.

A varied diet containing vegetables, fruits, whole grains, legumes, dairy or fortified alternatives, nuts, seeds, and appropriate protein sources can provide many of these nutrients. Supplementation may be justified where deficiency, restricted food intake, or increased physiological requirements are identified.

Antioxidant nutrients are also important for normal cellular function. However, routinely taking large doses of isolated antioxidant supplements is not necessarily beneficial. Exercise produces reactive oxygen species that participate in signalling pathways involved in adaptation. High-dose antioxidant supplementation may interfere with some training-related responses under certain conditions, although the magnitude and consistency of these effects vary.

The preferred strategy is to obtain antioxidants primarily through a diverse diet rather than assuming that more supplementation produces better recovery.

## NUTRIENT TIMING AROUND INTERVAL TRAINING

The timing of food intake can influence training quality and recovery, but it should be considered alongside total daily energy and nutrient intake.

*A practical nutrition timeline*

| | | |
|---|---|---|
| 1–4 hours | Before Pre-training nutrition | Consume a carbohydrate-rich meal or snack, with moderate protein if appropriate. Select foods that digest comfortably and avoid excessive fat or fibre immediately before exercise if these cause gastrointestinal problems. |
| During Exercise | Fuel and fluid availability | For short sessions, water may be sufficient. For prolonged or repeated demanding sessions, consider carbohydrate and electrolytes according to exercise duration, sweat losses, and the timing of the next workout. |
| 0–2 hours | After Recovery nutrition | Eat a meal or snack containing protein and carbohydrate. Prioritize rapid carbohydrate replacement when another demanding session is scheduled soon; otherwise, normal balanced meals can generally restore glycogen over time. |
| All day Recovery | Daily nutritional consistency | Meet total energy and protein needs, consume sufficient carbohydrate for the training workload, replace fluids, and maintain a regular sleep schedule. |

When recovery time between demanding sessions is less than approximately four hours, rapid glycogen restoration becomes particularly important. Sports nutrition guidance commonly recommends around 1.0–1.2 g of carbohydrate/kg/hour during the early recovery period provided this is tolerated and rapid replenishment is genuinely necessary. Athletes with longer recovery periods can generally distribute carbohydrate intake across ordinary meals and snacks (9-10).

## FLOWCHART: INTEGRATING NUTRITION WITH HIGH-THROUGHPUT INTERVAL TRAINING

The following flowchart illustrates a systematic framework for designing, implementing, and evaluating nutritional interventions. It emphasizes that supplement selection occurs only after basic nutritional requirements have been assessed.

**Step 1:** Define the objective. Establish whether the program targets $VO_2$ max, repeated sprint ability, endurance, power, or general conditioning. Different objectives place different demands on energy systems.



**Step 2:** Assess nutritional adequacy. Evaluate energy intake, carbohydrate and protein consumption, hydration, dietary variety, sleep, and recovery. This step helps identify limitations that might otherwise be incorrectly attributed to insufficient supplements.



**Step 3:** Correct basic deficiencies. When energy or nutrient intake is inadequate, prioritize correction before introducing cryogenic aids. A supplement cannot compensate reliably for chronic under-fueling or insufficient recovery.



Step 4: Match the intervention to the limitation. Carbohydrates may be most relevant when glycogen availability limits training. Protein is important when total intake is inadequate. Creatine may be useful for repeated high-intensity work, while caffeine may assist selected athletes with perceived effort. Buffering agents and nitrate have more protocol-specific applications.



**Step 5:** Integrate nutrition and training. The nutritional plan must match the exercise program, rather than being implemented independently of it. A demanding training session requires appropriate fuelling and recovery, whereas a lighter session may not require specialized sports products.



**Step 6:** Monitor outcomes. Record interval completion, power or pace, perceived exertion, recovery between sessions, body mass trends, sleep quality, and adverse effects. Where appropriate, assess objective indicators such as $VO_2$-max, time-trial performance, or repeated-sprint output.



**Step 7:** Adjust the plan. If performance fails to improve, review training progression, dietary sufficiency, illness, sleep, and recovery before adding more supplements. This feedback process supports individualization and reduces unnecessary expenditure.

The flowchart is a conceptual decision framework rather than a clinically validated algorithm. It provides a practical way to translate the available research into a repeatable process.

## MECHANISMS THROUGH WHICH NUTRITION MAY ENHANCE PHYSIOLOGICAL ADAPTATION

Nutritional interventions can influence training adaptations through several interconnected mechanisms. Understanding these mechanisms helps distinguish between an intervention that improves performance during a single session and one that may enhance the long-term response to training.

### Improved training quality

The first mechanism is an increase in the quality or quantity of work completed. Adequate carbohydrate availability may enable an athlete to maintain a target pace, power output, or interval duration. Creatine may support repeated high-intensity efforts, while caffeine may reduce perceived exertion in some individuals. If these interventions allow an athlete to complete more high-quality training without compromising recovery, they may indirectly support greater adaptation. However, increasing workload beyond the athlete's recovery capacity can produce the opposite result.

### Enhanced recovery between sessions

Nutritional recovery involves restoring energy reserves, replacing fluid losses, and supplying amino acids for tissue maintenance and remodeling. Adequate carbohydrate supports glycogen replenishment, while protein supports muscle protein synthesis. Sufficient energy intake and sleep help maintain the physiological conditions necessary for adaptation.

Recovery is not merely the absence of fatigue. It is an active process through which the body restores function and becomes better prepared for subsequent exercise.

**Cellular signalling and mitochondrial remodelling**

HIIT stimulates signalling pathways involved in mitochondrial biogenesis, substrate utilization, and cellular stress responses. Manipulating carbohydrate availability may influence some of these signals. Nevertheless, stronger acute signalling does not necessarily produce superior long-term performance.

For example, training with low glycogen availability may increase selected molecular responses, but repeated low-fuel sessions may reduce exercise quality. The most effective approach depends on the interaction between the training stimulus, nutritional status, and the athlete's recovery capacity.

**Improved physiological efficiency**

Certain interventions may influence the efficiency of energy production or the regulation of muscle contraction. Dietary nitrate may affect nitric oxide availability, while creatine supports rapid ATP regeneration. Beta-alanine increases muscle carnosine over time, contributing to intracellular buffering.

These mechanisms are physiologically plausible and supported to varying degrees by experimental evidence. Their practical significance depends on the exercise protocol and the athlete's individual response. No single supplement can be expected to improve every component of performance (9-10).

## PRACTICAL APPLICATION: AN ILLUSTRATIVE DAILY NUTRITION PLAN

The following example illustrates how a recreational athlete or trained individual might organize nutrition around an afternoon interval session. Actual quantities should be adjusted to body mass, training intensity, appetite, dietary preferences, and total daily requirements.

**Breakfast (balanced):**

BALANCED BREAKFAST

[CARBOHYDRATES] [PROTEIN& FAT] [MICRONUTRIENTS]

Rolled/Old- Fashioned Oats | Milk | Banana | Nuts (Almonds, Walnuts, etc.) | Yogurt (Greek or Soy)

Oats with milk or fortified soy milk, banana, nuts, and yogurt which provides carbohydrate, protein, fats, and micronutrients.

**Lunch:**

Healthy Indian veg meal rice, dal, vegetables and salad served in a plate. Rice or roti, dal or another protein-rich food, vegetables, and curd if tolerated. Supports daily energy intake and provides a mixture of macronutrients.



**Figure-1:** Ideal menu of lunch

**Pre-training snack:**

Banana with toast or other familiar carbohydrate-rich snacks which provides readily available fuel before demanding intervals.



**Figure - 2:** Ideal menu of Pre-training snacks.

**Post-training recovery:**

Milk or fortified soy milk with a meal containing eggs, tofu, lentils, or another protein source, alongside rice, potatoes, bread, or fruit. This supplies protein and carbohydrate to support recovery.



**Figure - 3:** Ideal menu of Pre-training recovery.

**Dinner: Fish with vegetables Nutrition**

Fish, chicken, tofu or legumes with vegetables and a suitable carbohydrate source.contributes to total daily nutrient requirements and ongoing recovery.



**Figure - 4:** Ideal menu for dinner

This example does not prescribe exact calorie or macronutrient quantities because those depend on the individual. It also illustrates that sports nutrition does not require expensive products: ordinary foods can provide most of the nutrients needed to support interval training.Supplements should be considered only when they offer a clear, evidence-based advantage for the specific training objective.

## LIMITATIONS, SAFETY, AND FUTURE RESEARCH

Despite growing interest in nutritional interventions for HIIT, important evidence gaps remain.

First, many studies examine acute performance outcomes rather than long-term training adaptations. An intervention that improves performance in one session does not necessarily produce a larger increase in $VO_2$-max, mitochondrial content or competitive performance after several months.

Second, research protocols vary substantially in interval duration, exercise intensity, participant training status, nutritional intake, and supplementation procedures. This variation makes direct comparisons difficult.

Third, individual responses can differ according to genetics, sex, age, habitual diet, medication use, training experience, and gastrointestinal tolerance. More research is needed to determine which interventions are most useful for different athlete populations.

Fourth, supplements may carry safety risks. Products can contain undeclared ingredients, contaminants, or substances prohibited in competitive sport. Independent certification can reduce, but not eliminate, these risks. Athletes should check applicable anti-doping guidance and consult qualified professionals when necessary.

Finally, supplementation should never displace fundamental aspects of performance development. Training progression, adequate energy intake, consistent sleep, psychological well-being, and appropriate recovery remain central to successful adaptation.

Future research should investigate combined nutritional and training strategies over longer periods, using standardized protocols and meaningful performance outcomes. Studies should also examine how energy availability, carbohydrate periodization, protein distribution, and selected ergogenic aids interact rather than evaluating each factor in isolation.

## CONCLUSION

Nutritional interventions can play an important role in supporting high-throughput interval training and the physiological adaptations associated with repeated high-intensity exercise. Adequate energy availability, carbohydrate intake, protein consumption, and hydration form the foundation of an effective nutritional strategy. These factors help maintain training quality, replenish glycogen, support muscle remodelling, regulate body temperature, and prepare the athlete for subsequent sessions.

Creatine, caffeine, beta-alanine, dietary nitrate, and sodium bicarbonate may offer additional benefits in specific circumstances. However, their effectiveness depends on the exercise protocol, individual characteristics, dosage, timing, and tolerance. Their ability to improve acute performance should not automatically be interpreted as proof of superior long-term physiological adaptation.

Carbohydrate periodization illustrates the need for balance. Selected sessions with reduced carbohydrate availability may stimulate certain metabolic signals, but high-quality interval work often benefits from adequate fuel availability. Similarly, protein supports recovery and tissue remodelling, but excessive intake does not necessarily enhance every training outcome.

The most effective strategy is therefore an individualized, evidence-based approach that integrates nutritional assessment, targeted intervention, structured interval training, adequate recovery, and continuous performance monitoring. The accompanying flowchart provides a framework for this process, emphasizing that nutritional deficiencies should be corrected before supplements are introduced and that interventions should be retained only when they are safe, practical, and beneficial.

Ultimately, the objective is not to maximize supplement consumption but to optimize the interaction between training stimulus, nutritional availability, and recovery. When these elements are coordinated effectively, athletes are better positioned to sustain demanding interval workloads, support physiological adaptation, and improve performance over time.

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