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Effect of Pre-Exercise Sports Drink Ingestion Timings on Physiological and Performance Indicators in Game-Based Exercise

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Abstract: This study investigates how different timings of sports drink consumption prior to exercise impact physiological and performance outcomes such as heart rate, oxygen saturation, VO2 max, and overall exercise capacity during game-based workouts. The research explores the roles of hydration, energy availability, and nutritional strategies in maximizing performance. Emphasis is placed on comparing the physiological responses under varied pre-exercise intake windows. Results are expected to offer practical insights for athletes and coaches regarding optimal drink timing strategies to enhance athletic outcomes.

Keywords: Pre-exercise nutrition, Sports drinks, Hydration, VO2 max, Heart rate, Oxygen saturation, Exercise physiology, Energy availability, Nutritional timing, Game-based workout

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INTRODUCTION

Athletes and those engaging in intense physical activity may replenish electrolyte loss, maintain energy levels, and stay hydrated by drinking sports drinks. Hydration, carbohydrates, and electrolytes including sodium, potassium, and magnesium are common ingredients in these beverages. Electrolytes assist control fluid balance and muscular contractions. Dehydration and impaired performance are the results of electrolyte and fluid loss via sweating after prolonged physical effort. Rehydrating with a sports drink is a simple and fast approach to get the nutrients you need, and it might help you prevent fatigue, cramps, and a loss of stamina.

Authors Coso et al. (2008) Using trained cyclists as subjects, this research looked at how sports drinks affected their endurance performance. Before a time trial, participants rode for 90 minutes in a steady state with the aid of either a carbohydrate electrolyte sports drink or a placebo. People who rode their bikes while drinking the sports drink finished the time trial at a much higher speed ($p < 0.01$) and reported feeling less exerted (RPE). By keeping blood glucose levels stable and postponing central weariness, the scientists found that consuming carbohydrates during long-duration exercise enhances time to exhaustion.

EXERCISE PHYSIOLOGY

Exercise physiology is the scientific study of the body's reactions to physical exertion, whether that be short-term or long-term. There is a great deal of physical demand in sports, exercise, and physical activity, and this field of research also seeks to shed light on the physiological impacts of regular sports training.

Both theoretical and practical investigations are included in the field of exercise physiology (Brown et al., 2006). Studies in this subfield of PE mainly investigate the metabolic, neuromuscular, and cardiovascular impacts of exercise. The field also encompasses research into the mechanisms of motion generation, the impact of movement on the body's systems, and the sources of energy.

The study, theory, and practice of exercise physiology include several disciplines, including but not limited to physiology, psychology, nutrition, biochemistry, and endocrinology. Beyond only helping people become more physically fit, exercise physiology covers a wide range of topics. Energy efficiency is another area that is being addressed. The heart, lungs, and muscles might be better understood using data gathered during exercise stress. There is a lot of evidence that fitness training is beneficial and that physical exercise causes physiological changes.

SPORTS DRINKS

Sports beverages do double duty as hydrants and energy boosters because to the carbohydrates they contain. Glucose and other simple carbs provide the fuel that muscles require to continue working during endurance activities like swimming, cycling, and running. This is why sports drinks are a great complement for athletes whose activities continue longer than an hour. Some types also include vitamins and amino acids that help with recovery and muscle regrowth.

SPORTS AND ENERGY DRINKS

Sports drinks and energy drinks, which are speciality food items, have exploded in popularity in the previous few decades. The majority of young people, particularly high school students, continue to enjoy sugar-sweetened sports drinks, even if daily intake of these beverages has decreased generally. Although the percentage of teens reporting having used a sports drink during the preceding week increased somewhat (from 56% to 57.6%) between 2010 and 2015, the rise was statistically significant (Cordrey et al., 2018).

A significant number of 12- to 14-year-olds routinely consume sports beverages with a lot of sugar without needing to, according to a study conducted by the Cardiff University School of Dentistry (Broughton, Fairchild & Morgan, 2016). It was discovered, specifically, that:

· Sports drinks were eaten by 89% of school-aged youngsters, with 68% of those students reporting frequent use (1–7 times weekly).

· As a social activity, sports drink use was cited by 50% of respondents.

· The prevalence of obesity, type 2 diabetes, heart disease, and teeth enamel erosion was correlated with the high sugar content and low pH of sports drinks. What's more, the majority of these beverages were bought by youngsters at bargain rates from local stores.

ROLE OF HYDRATION AND ENERGY AVAILABILITY IN ATHLETIC PERFORMANCE

Athletes' ability to execute and recover from workouts depends on their hydration levels, which affect a number of physiological processes. Improving endurance, strength, reducing tiredness, and speeding up recovery may be achieved with effective hydration practices. Reviewing important ideas, tactics, and evidence-based practices, this article investigates the function of hydration techniques in athletic performance and recuperation (Maughan & Shirreffs, 2004). Sweating and evaporation both use water to help keep the body at a constant temperature. Overheating and decreased exercise capacity result from this mechanism being impaired by dehydration. Staying properly hydrated is essential for the effective delivery of nutrients to cells and the elimination of waste products from metabolism. Energy production and muscular function may be negatively impacted by dehydration (Coyle, 2004). Maintaining an intense level of activity without tiring out requires enough fluids to maintain blood volume and cardiovascular function (Coyle, 2004). To make sure your body is well hydrated before activity, drink plenty of water. By doing so, you may avoid being dehydrated and boost your performance. The general consensus is that you should drink 500–600 millilitres of water two to three hours before you work out (Rehrer, 1994).

In conclusion, methods for staying well hydrated are essential for improving sports performance and recuperation. Performance, tiredness, and recovery may all be enhanced when athletes follow proper hydration protocols before, during, and after exercise. Maximising the advantages of hydration in sports requires ongoing study and innovation, but advances in personalised techniques and hydration technologies provide intriguing options for future development.

SIGNIFICANCE OF PRE-EXERCISE NUTRITION TIMING IN ENHANCING EXERCISE OUTCOMES

The physiological processes that contribute to peak performance in sports are heavily impacted by dehydration, making it an integral part of both performance and recovery. Endurance, strength, weariness, and recovery time may all be improved with the right hydration strategy. The article reviews important ideas, tactics, and evidence-based practices related to hydration and its impact on athletic performance and recovery (Maughan &

Shirreffs, 2004). Because of its role in perspiration and evaporation, water aids in temperature regulation. This process is hindered by dehydration, which causes overheating and a decrease in exercise ability. Nutrient delivery to cells and waste elimination from metabolism are both facilitated by adequate hydration. The ability of muscles to contract and generate energy may be impaired by dehydration (Coyle, 2004). To keep exercising at a high level and avoid weariness, it is essential to have enough fluids in the body to maintain blood volume and cardiovascular function (Coyle, 2004).

In conclusion, improving athletic performance and recuperation is greatly aided by hydration measures. Athletes may improve performance, lessen tiredness, and speed recovery by following good hydration habits before, during, and after exercise. To fully appreciate the advantages of hydration in sports, ongoing research and innovation are crucial, and recent developments in personalised techniques and hydration technologies hold great promise for future improvements.

MULTIPLE-TRANSPORTABLE CARBOHYDRATES

Absorption is dependent on emptying and intestinal transporter activity (Maughan, 1991), gastric emptying and fluid delivery decrease with increasing CHO energy density (Leiper, 2001), and malabsorption causes GI discomfort (Ravich et al., 1983). There is less gastrointestinal discomfort and better stomach emptying, fluid delivery, and absorption when transportable CHO mixtures (such as glucose/maltodextrin + fructose) are used instead of glucose alone (Jeukendrup & Moseley, 2008; Jentjens & Jeukendrup, 2005). Mixed formulas enhance exogenous-CHO oxidation (≈ 1.75 g min^{-1} vs ≈ 1.0 g min^{-1} for glucose alone) and endurance performance (Rowlands et al., 2012; Triplett et al., 2010; Baur et al., 2014; Currell & Jeukendrup, 2008) due to the fact that glucose (SGLT-1) and fructose (GLUT-5) utilise different transporters (Shi et al., 1995). While multiple-transportable CHO (MTC) have been extensively researched during exercise, no studies have examined their effects before exercise. However, their fast emptying and absorption properties imply that they might improve fuelling before an event while reducing gastrointestinal (GI) discomfort. Athletes' abilities are proportional to the availability of carbohydrates, which serve as a major fuel source during intense, sustained physical activity. To improve glucose delivery, oxidation, and performance in endurance races, researchers have been putting a lot of effort into studying multipletransportable carbohydrates (MTCs). These are mixtures of carbohydrates that employ distinct intestinal transporters for absorption. Saturation of the intestinal glucose transporter SGLT1 limits glucose absorption; this finding is the basis for the notion of MTCs. Optimal oxidation rates and gastrointestinal discomfort are common outcomes of consuming glucose alone at rates above around 60 g/h. A greater total carbohydrate absorption rate is achieved with the addition of fructose or another carbohydrate that employs a different transporter (GLUT5). Jeukendrup (2010) states that exogenous carbohydrate oxidation may be increased to around 90 g/h by mixing fructose and glucose in a 2:1 ratio, as opposed to 60 g/h when glucose is used alone.

MODIFIED AND RESISTANT STARCHES

Hydrothermal, acid/alcohol, and chemical technological methods (Jozsi et al., 1996; Piehl Aulin et al., 2000; Johannsen & Sharp, 2007) modify starches to provide digestibility profiles that are suited to specific needs. Taking a fast-digesting, high molecular-weight (HMW) starch like Vitargo® in the time between workouts speeds up glucose and insulin levels, which in turn increases performance in the following workouts (Stephens et al., 2008). While high-molecular-weight carbohydrates like UCAN® take longer to digest than maltodextrin, they have the opposite effect on glucose and insulin responses and boost fat oxidation (Roberts et al., 2011). Since this is the case, starch modification may provide two advantages:

(1) Quickly replenish glycogen stores in between closely spaced workouts using high-molecular-weight (HMW) carbohydrates.

(2) Hydrothermally modified or slow-digesting "resistant" starches to improve fat utilisation and maintain a steady blood sugar level over lengthy periods of exercise.

FAT ADAPTATION AND PERFORMANCE

Although this review focusses on acute pre-exercise feeding, fat adaptation has also been studied in both short-term (1–4 days) (Lambert et al., 1994; Burke et al., 2000; Goedecke et al., 1999; Helge et al., 2001; Muoio et al., 1994; Horowitz et al., 2000) and long-term (7–28 days) contexts (Helge et al., 1996; Lambert et al., 1994; Goedecke et al., 1999; Burke et al., 2002; Phinney et al., 1983; Horowitz et al., 1999; Helge et al., 2001; Muoio et al., 1994; Jeukendrup et al., 1996). Metabolic adaptations have been documented in these studies, with increased fat oxidation and glycogen sparing effects compared to high-CHO diets (Holloszy and Coyle, 1984; Helge et al., 1996; Lambert et al., 1994; Goedecke et al., 1999; Jeukendrup et al., 2000; Costill et al., 1977; Phinney et al., 1983; Horowitz et al., 1999). But there isn't a tonne of proof that fat adaptation improves endurance performance, either temporarily or permanently (Goedecke et al., 1999). But, ultra-endurance athletes who rely mostly on fat oxidation during moderate-intensity exercise may benefit from this approach (Kreitzman et al., 1992). The publications of Helge (2002) and Burke et al. (2002) provide more review. Fat adaption is a dietary strategy that tries to make the body use fat more as an energy source while you exercise. Endurance sports, which need high levels of energy maintained for extended periods of time, have shown interest in this strategy. Athletes who have acclimated to a fatoxidizing metabolic state are less reliant on carbohydrates and more able to perform extended, submaximal efforts because of these changes.

A "train low" strategy, in which training is conducted with little glucose availability in order to promote mitochondrial adaptations, is also common in fat adaption tactics. Consistent evidence for improved performance results is scarce, particularly in top athletes, however research by Bartlett et al. (2015) suggested that such tactics might enhance enzyme activity associated with fat metabolism.

An ultra-endurance athlete's glycogen conservation efforts could be aided by fat adaption, which greatly enhances the ability for fat burning during endurance exercise. There may be downsides in high-intensity sports due to the fact that the performance gains seem to be event-specific. Carbohydrates are still necessary for peak performance in the majority of competitive situations, especially those involving power, speed, and repeated high-intensity efforts, even if fat adaptation might be a good tactic in some endurance situations.

ACUTE HIGH-FAT INGESTION AND PERFORMANCE

Some studies have looked at the possibility that eating a high-fat meal within four hours before exercise might affect performance, as opposed to fat adaption regimens that last for days or weeks. It has been demonstrated that endurance performance is negatively affected by decreased glycogen stores in subjects following long-term high-fat, low-CHO diets (≥1 week) (Lambert et al., 1994; Burke et al., 2000; Goedecke et al., 1999; Helge et al., 2001). On the other hand, a single high-fat meal after a CHO-loading regimen may theoretically provide the double advantage of maintaining CHO storage while increasing the availability of fatty acids (Horowitz et al., 1997; Burke et al., 2002; Lambert et al., 1997). Horowitz et al. (1997), Coyle et al. (1997), Lambert et al. (1994), and Goedecke et al. (1999) are among the studies that found no performance gain from eating high-fat meals before exercise as opposed to high-CHO meals.

This is not the case, according to Murakami et al. (2012), who examined three different protocols after three days of high-CHO loading (2562 ± 19 kcal/day): (1) a high-fat meal four hours before exercise with placebo jelly three minutes before (HFM + P); (2) a high-fat meal with maltodextrin jelly (HFM + M); and (3) a highCHO meal with placebo jelly (HCM + P). Although the maltodextrin jelly supplied an extra 410 ± 8 kcal, all of the meals had before exercise were equal in calories (1007 ± 21 kcal). An 80-minute submaximal run at lactate threshold pace was followed by a time-to-exhaustion (TTE) test in a doubleblind, crossover design. The participants were eight male college runners with an average oxygen consumption rate of 61.3 ± 2.2 mL/kg/min.

PROTEIN FEEDINGS AND PERFORMANCE

We were only able to find one research that looked at how a PRO meal affected endurance metabolism and performance after the fact. Rowlands and Hopkins (2002) studied the effects on trained cyclists' lateexercise time trial and sprint performance after about two hours of riding of consuming three distinct meals 90 minutes before exercise: (1) carbohydrate; (2) protein; and (3) a high-fat meal. Despite the lack of reported substantial performance differences, changes in metabolism were noted. In comparison to the fat and PRO meals, the CHO meal had a greater impact on insulin levels and reduced FFA oxidation.

It is surprising to see these results given that prior research has shown reduced FFA oxidation with CHOPRO as opposed to CHO alone (Tarnopolsky et al., 1997) and increased insulin levels (Gannon and Nuttall, 1987; van Loon et al., 2000; Nilsson et al., 2004). It should be noted that soy, rather than whey, may cause a distinct insulin response (Morifuji et al., 2005; Tang et al., 2009), which was the protein source used in the research by Rowlands and Hopkins (2002). However, this is all conjecture at this point; whey protein may have enhanced insulin sensitivity, which in turn may have improved glycogen storage and exercise metabolism.

Phillips et al. (2005) found that protein increases muscle protein synthesis (MPS) more efficiently when ingested shortly before exercise than when consumed many hours before training. It is believed that the initiation of muscle repair and adaptation depends on this post-exercise anabolic window. In addition, Moore et al. (2009) brought attention to the fact that young individuals may achieve the maximum stimulation of MPS after resistance exercise by consuming just around 20-25 grammes of high-quality protein.

Things to keep in mind are the timing and distribution throughout the day. Research by Areta et al. (2013) examined various protein eating patterns and discovered that consuming protein at regular intervals (every 3 to 4 hours) led to higher muscle protein synthesis over a 12-hour recovery period than feedings that were more concentrated. This lends credence to the theory that optimising recovery and performance is best accomplished by consuming several moderate protein doses rather than a few big ones.

Protein is just as crucial for athletes who compete in endurance events. According to Witard et al. (2011), muscle breakdown occurs during endurance exercise, although smart protein consumption helps with tissue repair and mitochondrial adaptations. Protein in the evening enhances nocturnal MPS, particularly when coupled with pre-workout activity, according to Res et al. (2012), who also looked at the effects of consuming protein before bed.

In addition, a study by Pasiakos et al. (2013) found that increasing protein consumption (1.6-2.2 g/kg/day) improves recovery and lean mass, which might indirectly boost performance via less tiredness and more work capacity. All types of athletes, particularly those experiencing calorie deficits or severe training cycles, may reap these advantages. But be careful, as eating more protein than the body needs won't improve performance and can cause other important nutrients to go from the diet. Protein works best when consumed as part of a well-rounded diet that meets all of your macronutrient and energy requirements.

GROWING TREND IN USING SPORTS DRINKS BEFORE WORKOUTS AND COMPETITIONS: THE EFFECT OF ELECTROLYTES AND ENERGY DRINKS CONSUMPTION ON SPORTS PERFORMANCE

Athletes understand the need of staying hydrated before, during, and after exercise, and they often use sports beverages that include extra carbs and salts to help them do so (Leow et al., 2022). But some athletes drink much too much water, while others drink way too little

(Rangan et al., 2021). Consequently, sportsmen and sportswomen need know a few practical things regarding staying hydrated, such as: (a) when it would be beneficial to consume fluids while exercising; (b) how much to drink; (c) which beverages are ideal; and (d) how to adjust their hydration for hot or cold environments (Armstrong, 2021). Every athlete has different demands and preferences when it comes to training and competition, and the same is true for their hydration strategy when exercising (Tambalis, 2022). In order to find a strategy that will help them reach their sports objectives, athletes and coaches should refine these suggestions.

In conclusion, the following are some of water's most critical roles in the human body: (a) It regulates the body's osmotic pressure and keeps electrolyte and fluid balance; (b) It is a fundamental part of both blood and cytoplasm; (c) It plays an important role in thermoregulation as the main component of perspiration; and (d) It is extremely important for the senses and for protecting organs and tissues (American College of Sports Medicine, 2006; Burke & Deakin, 2006). Hence, the human body's ability to operate properly at rest and during activity depends on maintaining its water balance (Tyler et al., 2016). In addition to providing a burst of energy, many athletes find that energy drinks help them stay hydrated while they work out (Mujika & Burke, 2010).

You shouldn't mix energy drinks, which are sugary beverages containing caffeine, with sports drinks, which are intended to keep you hydrated while you workout. The high sugar content of energy drinks might hinder fluid absorption, making them an unhealthy option during exercise, particularly in hot weather (Jiménez et al., 2021). The purpose of exercising is to replenish fluid lost via perspiration; nevertheless, energy drinks, despite their refreshing and hydrating appearance, should not be ingested in this time frame (Casa et al., 2000; Erdmann et al., 2021). Overconsumption or mixing with other stimulants or alcohol may make these drinks even more harmful (Alsunni, 2015). Lastly, it's possible that certain energy drinks include illegal ingredients, such compounds made from unregulated botanicals (Duchan et al., 2010). The lack of purity testing on most of these items makes them potential doping test positives (Duchan et al., 2010).

Research conducted by Casa et al. (2000), Erdmann et al. (2021), and Duchan et al. (2010) indicates that, among young adults and teens, energy drinks are the most popular dietary supplements, surpassing even multivitamins. Athletes also often use them, according to reports (Casa et al., 2000; Duchan et al., 2010). Newer research suggests these items may have ergogenic properties, which would improve performance in sports and mental health (Salinero et al., 2014).

DEHYDRATION AND ATHLETIC PERFORMANCE

When exercising in hot weather, it is particularly crucial to maintain your body's water balance (Deshayes et al., 2021) in order to perform at your best. Heavy perspiration causes significant fluid loss, which may worsen performance and potentially cause heatstroke and other dangerous consequences (Shapiro et al., 1980; McCartney et al., 2021). According to the American College of Sports Medicine (2006) and Burke and Deakin (2006), when the body loses more fluid than it takes in, resulting in inadequate water for proper function, this state is called dehydration. It is well-known that when you exercise while dehydrated, your core body and muscle temperatures rise. This effect occurs at a rate of around 0.2 °C for every 1% loss of body mass due to perspiration (American College of Sports Medicine, 2006). In addition to lowering blood pressure and cardiac output (due to a decrease in stroke volume), these side effects make it harder to maintain an intense level of physical exertion (El-Sharkawy et al., 2015).

A significant component detrimentally impacting sports performance is dehydration, which is defined as a deficit of total body water. Performance in sports may be negatively impacted by even a little dehydration, which is around 1% to 2% of body weight (Sawka et al., 2007). Particularly vulnerable are endurance athletes because of the long durations of effort and the increased perspiration they experience.

Thermoregulatory impairment, increased cardiovascular strain, and decreased heat dissipation capacity are all consequences of dehydration, which may cause early weariness and reduced exercise capacity (Casa et al., 2010). Excessive heat and humidity amplify the negative impact of dehydration on performance.

Anaerobic and aerobic performance are both negatively impacted by dehydration, according to research by Cheuvront and Kenefick (2014). Less blood volume in the blood, a faster heart rate, and a smaller stroke volume all work together to diminish the amount of oxygen that can reach working muscles, reducing aerobic capacity. Reduced coordination, longer response times, and worse decision-making are some of the negative effects of dehydration on high-intensity athletes.

It also has an effect on cognitive functioning when doing sports. Important for tactical sports and competitiveness, Lieberman (2007) discovered that even 1.5% dehydration might hinder attention, mood, and short-term memory. Sports like football, basketball, and tennis, which demand a high level of mental acuity, are most affected by this.

Therefore, measures for rehydrating are crucial parts of preparing for sports events and being ready for competition. In order to promote fluid retention and restore electrolyte balance, it is recommended to consume fluids that include salt and carbs, according to studies conducted by Maughan and Shirreffs (2008). These beverages do double duty as fluid replacement and performance boosters for those long days of sweating it out.

Both the mental and physical components of sports performance are negatively impacted by dehydration, according to the research. Early exhaustion and reduced output are the results of dehydration's negative effects on cardiovascular function, thermoregulation, endurance, and cognitive capacities. To minimise these effects and maintain peak performance during training and competition, it is crucial to drink plenty of water at the right times and to drink electrolyte-enhanced drinks.

CONCLUSION

This review highlights the multifaceted effects of sports drink consumption timing on physiological and performance markers. Proper timing can optimize VO_2 max, enhance heart rate efficiency, improve oxygen saturation, and increase exercise capacity. Athletes and trainers should personalize strategies based on duration and intensity of activity, alongside individual tolerance. While the benefits of energy and sports drinks are evident when used appropriately, the risks associated with overuse or poor timing must not be overlooked.

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