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Revisión

Hydration and chemical ingredients in sport drinks: food safety in the European context

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Abstract

Before, during and after physical activity, hydration is a limiting factor in athletic performance. Therefore, adequate hydration provides benefits for health and performance of athletes. Besides, hydration is associated to the intake of carbohydrates, protein, sodium, caffeine and other substances by different dietary aids, during the training and/or competition by athletes. These requirements have led to the development of different products by the food industry, to cover the nutritional needs of athletes. Currently in the European context, the legal framework for the development of products, substances and health claims concerning to sport products is incomplete and scarce. Under these conditions, there are many products with different ingredients out of European Food Safety Authority (EFSA) control where claims are wrong due to no robust scientific evidence and it can be dangerous for the health. Further scientific evidence should be constructed by new clinical trials in order to assist to the Experts Commitees at EFSA for obtaining robust scientific opinions concerning to the functional foods and the individual ingredients for sport population.

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HIDRATACIÓN E INGREDIENTES QUÍMICOS EN EL DEPORTE: SEGURIDAD ALIMENTARIA EN EL CONTEXTO EUROPEO

Resumen

Antes, durante y después de la actividad física, la hidratación es un factor limitante en el rendimiento deportivo. Por lo tanto, una adecuada hidratación proporciona beneficios para la salud y el rendimiento de los deportista. Además, la hidratación se asocia a la ingesta de hidratos de carbono, proteínas, sodio, cafeína y otras sustancias durante el entrenamiento y/o competición de los deportistas. Estos requisitos han llevado al desarrollo de diferentes productos por parte de la industria alimentaria, para cubrir las necesidades nutricionales de los deportistas. Actualmente en el contexto europeo, el marco legal para el desarrollo de productos, sustancias y declaraciones nutricionales y de propiedades saludables relativas a productos deportivos, es incompleta y escasa. Hay muchos productos con diferentes ingredientes controlados por la Agencia Europea de Seguridad Alimentaria (EFSA), los cuales poseen declaraciones nutricionales y de propiedades saludables erróneas, debido a la falta o escasa evidencia científica, resultado peligroso para la salud. Se necesita mayor evidencia científica obtendia a través de nuevos ensayos clínicos con el fin de ayudar a los Comités de expertos de la EFSA para la obtención de dictámenes científicos sólidos relativos a los alimentos funcionales y los ingredientes individuales para la población deportiva.

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Hydration products in the European Union

Bodily hydration during sporting activity is one of the best indicators of health in athletes[1], and can be a limiting factor for sporting performance. Dehydration decreases the athletic performance and can suppose a risk to health when competitions are conducted under temperature stress[2]. For example, in mountaineering (at 0ºC), the body temperature can decrease to <35ºC, leading to hypothermia or partial frostbite in the extremities (especially fingers and toes) due to the peripheral vasoconstriction. This effect is more common in poorly hydrated mountaineers[3].

Moderate dehydration (2-3%) is the limit at which begins the decrease of the physical and cognitive performance in environments with mild temperatures. In this case, a decrease in plasmatic volume, an increase in heart rate, and a decrease in blood flow to the skin reduce perspiration and heat dissipation – so that an increase in 1 °C body temperature is initiated[1,2]. When body temperature reaches 39°C, the physical performance drops dramatically due to a malfunction of the biological system for energy production and alterations can also be observed at a neurophysiological level[19]. At this point, dehydration is a real concern. For example, in sports such as motorcycle or Formula 1 racing, great concentration and continuous hydration are required[20]. On the other hand, hyperhydration (usual in endurance races and especially in women) could be dangerous also[21]. Hyperhydration is commonly associated with hyponatremia. It may cause cerebral edema or respiratory failure[22]. Dilutional hyponatremia is characterized by a lower plasma sodium concentration (<135 mEq/L). The probability of these disorders increases at 6-8 hours (at more than 30°C and high relative humidity, 55%), and they are associated with inadequate heat acclimatization, excessive loss of sodium, and excessive intake of water or hypotonic drinks. This event also occurs with hypertonic drinks used after sporting events[23].

Sometimes, despite knowing that during the physical activity it is not adequate for the maintenance of a proper fluid balance, certain athletes drink only water because of sponsorship by water brands[4]. To maximize the absorption of water during exercise, an additional, small amount of glucose and also sodium (Na) should be provided, in the form of isotonic sports drinks (table I) with characteristics that are described below[2, 5, 6]. Hydration should be taken into account not only during exercise, but also before and after the activity. So, sports drinks should be different according to the chronology of the training/event. In general, these drinks should be: 1) hypotonic drinks before training and/or competition, 2) isotonic drinks during exercise, and 3) slightly hypertonic drinks after the training/competition [5]. Table II clarifies the chemical composition of sports drinks taken before, during, and after the training[5, 7, 8].

Table I
Characteristics of sports drinks taken during exercise.

	Minimun	*Maximun*
Sugars (%)	6	9
Type of sugars	Mix of rapid absorption sugars (glucose or maltodextrin) and sugars of slow absorption rate (fructose) in the ratio 3/1.	[Fructose] >33%
Minerals (g/L) Na	0,46	1,20
Osmolarity (mOsm/L)	200	330
Volume (mL) /hour of exercise	500	1000
Temperature (ºC)	10	15
Frequency (min) in the exercise	15	30
Particular characteristics	- In extreme temperatures (>30ºC), add ice cubes to the drink. - Palatable drink. - In case of high hydration needs, it is recommended to lower the sugar concentration to 4-6% and increase the salts (to 0.7 to 1 g /L) to prevent hyponatremia.	

Table II
Characteristics of sports drinks (before, during, and after the training).

Before	*During*	*After*
Isotonic or slightly hypotonic	Isotonic	Hypertonic
4-6% sugars	6-9% sugars[7]	9-10% sugars[8]
0.5-0.7g Na/L[5]	0.5-0.7g Na^+/L[7]	1-1.5g Na^+/L[8]
	0.7-1.2 Na^+/L. (if longer than 1 hour or under heat stress)	

Furthermore, most of the studies in this area have concluded that fluid intake should occur during physical activity and that a deficit of 0.4-0.6 L/h is common, depending on the energy expenditure during the physical activity and the environment[24]. It is noteworthy that dehydration occurs in sports activities (minimum loss of 2-3%), during which the water absorption, hydration, and nutrition are limited; therefore, gastrointestinal problems, especially in ultra-resistance sports competitions, can be generated[25].

Among the diuretic drinks, the intake of alcoholic drinks (containing more than 2% alcohol) may cause disorders - owing to the diuretic effect in the organism[26]. In this context, the diuretic effects of caffeine have also been described, but Maughan and collea-

gues[27] observed that this effect may be even greater in sportsmen who do not take caffeine habitually. However, its diuretic effect is hardly appreciable in sportsmen and other people who take 2-3 servings of coffee (200-300 mg caffeine) per day. In recent studies[28] carried out in heat-acclimated cyclists pedaling for two hours at 63% VO2max in a hot-dry environment, the ingestion of 6 mg caffeine/kg weight as a supplement 45 min before the exercise increased the diuretic effect (28%) and the loss of the electrolytes sodium (Na), chlorine (Cl), and potassium (K) (14%) was also augmented. But these effects decreased if the caffeine was ingested as an ingredient of an isotonic drink, during two hours of exercise in a 36ºC atmosphere. Despite its diuretic effect in repose, its diuretic effect during physical activity is unclear and further studies are needed to verify this effect in athletes, especially in those participating in very long distance races and those not acclimated to heat[28].

As a preventive method, sportsmen should undergo heat acclimation, doing moderate exercise in thermal stress situations (temperatures above 30ºC and high relative humidity) for 7-14 days. In this way, the loss of water increases (the dissipation of heat is more efficient) and the loss of minerals in sweat is lower (less sodium in the sweat)[5].

It is also quite usual for the activity to be accompanied by the intake of products containing additional supplements such as caffeine and macronutrients (Table III). The real need for these supplements in sports drinks is often questionable. Sometimes, they could have a special utility, as in the case of caffeine[9], but other times their inclusion makes no sense or is forbidden by the European Union (EU)[10].

The directive 2009/39/EC (European legislation applicable in the Member States) refers to the development and marketing of food products intended for special populations. Within this context, food products designed for and adapted to athletes (those who perform intense muscular work) are included[11]. The Regulation (EC) No 953/2009 specifies a positive list of substances that can be added to the dietary products, due to identified legal loopholes[12]. Particularly, this list is designed for the authorized preparation of food products for particular nutritional uses, and does not imply an obligation to include them if there is questionable benefit or they do not improve the athletic performance (L-carnitine, taurine, nucleotides, choline, inositol, etc.)[13, 14, 15]. Given its shortcomings, this regulation was repealed by the Directive 2009/39/EC, which currently governs food or products for athletes[16]. Currently, in the European context, specific requirements have not been set regarding the composition, labeling, control, and regulation of food or products for athletes.

In order to improve the regulation of the internal market and to enhance consumer protection, until specific legislation is available, food for athletes is only controlled by the Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006, in relation to health claims made for foods and the satisfaction of the requirements contained therein. Thus, a health claim must be authorized by the European Food Safety Authority (EFSA) and approved by the European Commission[17].

Apart from the European legislation, it should be noted that the European Commission's Department for Health and Consumers, through the Scientific Committee on Food (SCF), wrote a report on the composition of foods and drinks intended to cover the energy expenditure in muscular effort (especially athletes), which includes: energy food products rich in carbohydrates, solutions with carbohydrate and electrolytes, protein concentrates, and high-protein foods. In these types of products, other components were used as ergogenic supplements[18].

The goal of this review is to provide an overview of the current European directives and rules concerning dietary supplements, the ingredients included in them, and the characteristics of the sports and energy drinks used in the physical exercise context.

Table III
Chemical ingredients used for sports drinks taken before, during, and after the physical exercise.

Other supplements and ergonutritional aids used in sports drinks		
Isotonic or slightly hypotonic	Isotonic	Hypertonic
Caffeine: 50-100 mg/300 mL, usually present in certain sports drinks or energy drinks[9]. Glycerol: ergonutritional aid to improve hydration status (hyperhydrating); for example, for non-competitive activities such as mountaineering or alpinism. Glycerol is considered doping and is prohibited in sports competitions[37].	Protein hydrolyzate of rapid absorption rate (2-4%) in ultraendurance races (> 6 hours) may be effective for improving recovery [53]	Branched amino acids and sugars helps muscle recovery and improve the balance of the immune system after exercise[54] Liquid solution of carbohydrates (CH) (1g/kg) and high biological value proteins (1/3-1/4 of total CH)[55] Milk proteins[56]

Methodology

The present literature review is intended to show the current knowledge of the subject. It was developed with the database PubMed, using "energy drink", "sports drink", "guarana", "caffeine", "taurine", "sportmen", "sportwomen", "sport people", "adverse effects", "toxicology", "health claims", "drug interactions", and "Cytochrome P450" as key words, in a single or combined manner. Information was collected from the websites of the ESFA and the Australian Institute of Sport, and the snowball strategy was used - limiting the articles selected to those with relevance to energy drinks and sports drinks use by sport people. A parallel search was carried out in Google for the print and trade media. We reviewed articles and Internet sources until March 2013.

Components and characteristics of sports drinks and/or energy drinks used by athletes

Regarding the hydration of athletes, a wide variety of beverages with different flavors and nutrients can be found. The purpose of these assorted drinks is to hydrate the body and improve the athletic performance. The sources of the liquids and those among them used for sport performance enhancement are described in table IV.

In addition, the energy drinks increasingly used for sport performance include other nutrients such as caffeine, plant extracts, or other substances. The energy drinks can be used by athletes, but many of them are commercialized - without scientific evidence obtained from clinical nutritional trials - as ergonutritional aids[10, 13]. Table V shows a list of ingredients contained in sports drinks and/or energy drinks and their potential ergonutritional effects. Among them, the EFSA has not found a cause-effect relationship for green tea extract, L-carnitine, D-ribose, beta-alanine, inositol, or citrulline-mallate (table V). Then, and according to the EFSA and EU rules, no health claim can be attributed to these ingredients or the products containing these compounds or extracts. Besides, if, in the future, a cause-effect relationship is found for every ingredient, the effect should be clinically demonstrated in the product including the corresponding ingredient which shows a nutritional or health effect. In conclusion, despite the general scientific opinions of the EFSA concerning these ingredients, no specific effects or dosages have been established for sport beverages or foods that are claimed to be beneficial supplements for sport populations. Therefore, further scientific evidence should be provided by new clinical trials in order to help the Expert Committees of the EFSA arrive at robust scientific opinions concerning these functional foods, and their individual ingredients, aimed at sport populations.

Table IV
Types of beverage and their application in sport.

Food Liquid	*Water content (%) EFSA, 2010a*	*Characteristics/ Applications*	*References*
Hypotonic drink	90-100	Contains a lower concentration of solute per unit volume than blood, as in the case of water.	5
Isotonic drink	90-100	Before exercise. Simple sugars and electrolytes (sodium), giving the same osmotic pressure as blood.	7
Hypertonic drink	90-100	Recommended for use during exercise. Contains a higher concentration of solutes, simple sugars, and/or sodium per unit volume than blood.	8
Milk and liquid yogurt	75-90	Recommended for use after exercise. Source of high biological value protein and branched amino acids, and sugars.	55,57
Juice	90-100	Recommended for use after exercise. Fruit juice, nectar, or sugary juice with different sugar concentration (10-13%).	43
Energy drinks	90-100	Recommended for use after exercise, because it provides liquids and carbohydrates. Provides fluid and simple sugars. Contains a huge variety of other nutrients, many of them without scientific evidence and without clinical trials.	10

Table V
List of ingredients contained in energy drinks and their potential ergonutritional effects.

Ingredient	*Potential ergonutricional value*	*General and EFSA scientific opinions (when available)*
Taurine	Improved mental focus, concentration, serves as antioxidant, glucose homeostasis	EFSA could be drawn for the scientific substantiation of the consumption of taurine and a delay in the onset of physical fatigue during exercise, maintenance of normal muscle function, maintenance of normal cardiac function, contribution to normal cognitive function, metabolism processes, and immune system protection[58].
L-Tyrosine	Prevents depletion of catecholamines, may ameliorate declines in cognition with acute stress.	Some supportive evidence on cognition (2 g/d, 150 mg acute ingestion with cold exposure). No effects on performance capacity. No known effects at dosages found in energy drinks[59].
Citicoline (cytidine 5' -diphosphocholine)	Intermediate in the generation of phosphatidylcholine from choline. Increases dopamine receptor densities and delays memory impairment.	Some supportive evidence with high doses (8.5 g prior to and during exercise) and in fed animals. No known effects at dosages found in energy drinks. EFSA: conclusions cannot be drawn for the scientific substantiation of the maintenance of normal neurological function and contribution to normal cognitive function[60].
Caffeine	Stimulant. Increases metabolism and lipolysis.	Improves alertness, mood, and cognitive function. 1-4 mg/kg body weight one hour before exercise. In sport population.
Guarana	Natural source of caffeine. Similar properties to caffeine.	Similar to caffeine effect.
Green Tea Extract	Contains high amounts of caffeine and catechin polyphenols. Serves as antioxidant. Similar effects to caffeine.	Some supportive evidence of increased metabolism. Specific role at dosages found in energy drinks is unknown. EFSA concludes that a cause and effect relationship has not been established between the consumption of a green tea and a reduction in body weight[61].
Synephrine	Alternative to ephedrine. Naturally derived from Citrus aurantium. Stimulant with lesser cardiovascular effects than ephedrine. Purported to increase metabolism and promote weight loss.	Evidence of a mild stimulant effect on metabolism and weight loss. No known effects at dosages found in energy drinks. No scientific opinion available from EFSA.
Yerba mate	Contains three xanthines (caffeine, theobromine, and theophylline). Similar properties to caffeine.	Similar to caffeine effects. Some supportive evidence. No known effects at dosages found in energy drinks. Renal elimination/organism draining in general population (infusion: 2.5g in 150 mL water)[62, 63].
Yohimbine	Alkaloid with stimulant and aphrodisiac properties.	Similar to caffeine effects. Effects at dosages found in energy drinks are unknown. EFSA considers that no conclusions can be drawn.
Tyramine	Naturally-occurring monoamine derived from tyrosine. Acts as a catecholamine (dopamine, norepinephrine, epinephrine) releasing agent. Degraded to octopine. Increases blood pressure and can serve as a neurotransmitter.	Mild cardiovascular stimulant. Effects at dosages found in energy drinks are unknown. EFSA: risk of biogenic amines (BA): 600 mg tyramine for healthy individuals not taking monoamino oxidase inhibitor (MAOI) drugs, but 50 mg for those taking third generation MAOI drugs or 6 mg for those taking classical MAOI drugs[64].
Panax Ginseng	Contains ginsenosides which are purported to have anti-inflammatory, antioxidant, and anticancer effects. Purported to enhance perceptions of energy, increase stamina, and improve nitrogen balance.	Most well-controlled research does not support the ergogenic effects of ginseng. No known effects at dosages found in energy drinks. EFSA: helps to maintain mental and physical performance at 40 mg/day in general population[65].

Table V (cont.)
List of ingredients contained in energy drinks and their potential ergonutritional effects.

Ingredient	*Potential ergonutricional value*	*General and EFSA scientific opinions (when available)*
L-Carnitine	Involved in shuttling long chain fatty acids into mitochondria. Purported to promote lipolysis.	Limited support for ergogenic value in athletes or for weight loss. No known effects at dosages found in energy drinks. EFSA concludes that a cause and effect relationship has not been established between the consumption of L-carnitine and skeletal muscle tissue repair and increase in endurance capacity. Sport population [66].
D-Ribose	Involved in ATP synthesis. Theoretically, D-ribose supplementation can increase ATP availability.	Some evidence of improved exercise capacity in clinical population, but limited evidence that high dose ribose supplementation affects exercise capacity. No known effects at dosages found in energy drinks. EFSA concludes that a cause and effect relationship has not been established between the consumption of ribose and faster recovery from muscle fatigue after exercise [67].
Beta-alanine	Increases muscle carnosine levels, increases muscle buffering, and attenuates fatigue during high intensity exercise.	Growing scientific evidence of improved anaerobic capacity (2-4 g/d). No known effects at dosages found in energy drinks. EFSA concludes that a cause and effect relationship has not been established between the consumption of beta-alanine and an increase in physical performance during short-term, high-intensity exercise, increase in time to exhaustion, and beneficial physiological effects related to an increase in muscle carnosine stores. Sport population[68, 69].
Inositol	Carbohydrate that is not classified as sugar. Involved in insulin signaling, nerve transmission, serotonin modulation, and fat oxidation.	No known effects at dosages found in energy drinks. EFSA concludes that a cause and effect relationship has not been established between the dietary intake of inositol and normal cognitive function. Patients with Alzheimer's disease, depression, panic disorder, obsessive compulsive disorder, bipolar disorder, bulimia nervosa, and diabetic polyneuropathy [69, 70].
Citrulline Malate	Optimizes blood flow via arginine-nitric oxide pathway; purported to reduce fatigue and buffer acidity during exercise.	Some evidence that high dosages (6-8 g) can affect exercise capacity and/or anabolism. No known effects at dosages found in energy drinks. EFSA concludes that a cause and effect relationship has not been established between the consumption of citrulline-malate and faster recovery from muscle fatigue after exercise in humans[71].

Risks of the components included in sports drinks and/or energy drinks used by athletes

The literature reflects the possible risks of compounds, including sugars, caffeine, glycerol, and vitamin B2, found in sports drinks and energy drinks ingested by sport people[29]. However, the adverse effects of these compounds should be evaluated in relation to the idiosyncratic reaction or the dosage. For this reason, the best approach is to determine, through a review of case reports, the potential hazardous threats of these components to athletes and sport people.

Regarding dental health and sport dietary drinks, Milosevic and colleagues published a case report of a marathon and cross-country runner who had minor erosion of the upper teeth on many surfaces, but extensive erosion through to the dentine on the palatal (inside) surfaces of the upper central incisors[29]. This study related the dental decay to the consumption of sports drinks (including Carbolode, Gatorade, High, Isostar, Lucozade Sport Lemon, Lucozade Sport Orange, Maxim, and PSP 22). Isostar, the product with the lowest pH and a mid-range titratable acidity, may not be particularly erosive due to its high concentrations of calcium and phosphate. Some of these beverages have cariogenic properties due to their sugar content. Furthermore, long-term exposure of the body to an excess of simple sugars is associated with

the development of obesity, insulin resistance, and diabetes[30].

In the case of caffeine, the literature underlines some adverse effects - including nervousness, irritability, anxiety, insomnia, tachycardia, palpitations, upset stomach, vomiting, abdominal pain, rigidity, hypokalemia, altered consciousness, paralysis, hallucinations, increased intracraniaO pressure, cerebral edema, seizures, rhabdomyolysis, and supraventricular and ventricular tachyarrhythmias[31]. Other studies indicated four cases of caffeine-associated death and five cases of seizures in sport people due to the consumption of energy/power drinks[32, 33].

Also, the use of caffeinated energy drinks caused a cardiac arrest in a healthy 28-year-old man the day after his participation in motocross racing[34] and a possible case of orthostatic intolerance due to excess Red Bull intake was reported in a young volleyball player[35].

As for glycerol, some test subjects reported being bloated or nauseated after its ingestion. However, Wagner and colleagues suggested that the appropriate dosage of glycerol depends on the body size and also varies between manufacturers; they recommended 1 g/kg body weight with an additional 1.5 L of fluid, taken 60 to 120 minutes before competition (standard doses)[36]. Glycerol is considered doping and is prohibited in sports competitions[37], but in non-competitive activities, such as mountaineering or alpinism, it could be used. Concerning vitamin B2, one case report indicated a suspected anaphylaxis after the intake of this ingredient as part of an energy drink[38].

Synergistic or antagonistic interactions of components of sports drinks

Several components of the drinks used by athletes (sports drinks, energy drinks, juices, milk) can interact among themselves after the intake of different drinks, and also can alter the effects of several drugs that may be used by athletes. In this context, some of the components with such potential effects were selected for review here; namely, the most abundant components and/or those most likely to cause interactions.

Probably, the beverages with the highest probability of interactions are the energy drinks containing caffeine, taurine, sugars and sweeteners, herbal supplements, among other ingredients - products clearly differentiated from sports drinks and vitamin beverages. Nonetheless, there are very few studies on the effects of individual ingredients or potential synergistic effects; furthermore, the results of these studies are inconclusive and occasionally contradictory.

As has been indicated above, one of the most active ingredients present in energy drinks is caffeine. Some of its interactions with other components of the drinks are described in table VI. Also, it is able to produce synergistic and reinforced stimulant effects in combination with guarana, ginseng, and taurine[33]. Most drug and herb interactions with caffeine cause mild or moderate events and are related to increased adverse effects resulting from decreased caffeine elimination or to additive effects involving other methylxanthine containing products[39].

Besides, caffeine can interact with several drugs due to its inhibition of the enzyme CYP1A2. Thus, caffeine can interact with a wide range of medications, including antidepressants (fluvoxamine), antianxiety drugs, and sedative drugs. This is of particular interest due to the frequent use of antidepressant and antianxiety drugs by athletes. These interactions may lead to caffeine-related or drug-related side effects that might complicate the treatment and cause toxic disorders[40]. So, caffeine beverages should not be administrated with that kind of drug in order to avoid possible side effects.

Many vegetables, such as broccoli or grapefruit (due to its effect on the enzyme CYP), increase caffeine metabolism, decreasing the plasmatic levels of caffeine[41]. This type of interaction with this compound - and many other drugs - is mainly attributed to the bitter flavonoid naringin (naringenin 7-*O*-neohesperidoside), present in citrus fruits[42]. Regarding this type of fruit, a study by Medina and colleagues allowed the identification of four endocrine compounds, belonging to the steroid biosynthesis pathway, as significant metabolites upregulated by citrus juice intake[43]. Summarizing, the induction of caffeine metabolism decreases its effects (on performance etc). This suggests a new way to use natural juices, functionalized or not: as hydration products for athletes, with healthy and physical effects while avoiding possible unknown interactions with other sport supplements.

Concerning other ingredients found in energy drinks widely used for sport, caffeine at high doses (more than 300-500 mg), as well as other diuretic products (tea or tea extracts), can increase fluid and electrolytes excretion[28]. Taurine supplementation significantly decreased the enzyme activity of CYP and so probably interacts with some drugs, as has been observed for caffeine[44]. Little has been investigated in this area and further clinical trials are required.

As far as sports drinks are concerned, mixtures of different monosaccharides and disaccharides (glucose, fructose, sucrose…) interact, increasing carbohydrate absorption and oxidation during exercise more than themselves alone[25,45].

Furanocoumarins, components of grapefruit, inhibit cytochrome P450 3A4 isoenzymes in the intestinal wall, and so increase the levels of 3A4-metabolized drugs and their therapeutic effects, adverse effects, and/or toxicity. Also, grapefruit weakly inhibits the intestinal cell wall p-glycoprotein, an efflux pump in enterocytes that actively secretes some absorbed drugs back into the gut lumen[46]. The organic anion transporting polypeptide is another transporter system affected by grapefruit, so drugs handled by this system may

Table VI
Caffeine interactions with some of the components of the drinks

	Substances	*Interactions*	*References*
Caffeine	Calcium (Ca)	Reduces Ca absorption Increases Ca excretion (150 mg caffeine ingested, 15 mg Ca lost)	72
	Iron (Fe)	Increases Fe absorption (8-13%)	48,74
	Magnesium, potassium, sodium, phosphate	Increases mineral excretion	73

Table VII
Nutrition and health claims made by the food industry

Health claims	*Characteristics* *CH And proteins*	*References*
Supports muscle recovery after exercise	After exercise: - Drink a liquid solution of CH (1 g/kg) and high biological value proteins (1/3-1/4 of total CH) - To aid recovery of muscle and liver glycogen and protein synthesis.	25,49,55,57
	Hydration during and after the event	
Maintenance of endurance exercise performance Improved absorption of water during exercise Rehydration and electrolyte replacement during exercise. Rehydration and electrolyte replacement after exercise.	Isotonic solutions with: - 80-350 kcal/L of CH (75% from CH), high glycemic index (glucose, sucrose, maltodextrins, fructose). - Between 20 mmol/L (460 mg/L) and 50 mmol/L (1150 mg/L) of sodium. - Osmolarity of water: 200-330 mOsm/kg. Hypertonic solutions with 9-10% of sugars (glucose, sucrose, maltodextrins, fructose) and 1-1.5g of Na/L.	15,49,75,76,77
	Caffeine	
Increases performance in endurance exercise. Increases the capacity for resistance.	1-2 mg/kg body weight one hour before exercise.	10,15,49,78
Reduction of the ratio of perceived exertion to effort during exercise.	4 mg/kg body weight one hour before exercise.	

have decreased absorption, possibly leading to loss of efficacy[47].

When we consider interactions, it is common to think about negative effects such as side effects or decreases in activity. For example, drinks containing Ca - such as milk - significantly decrease Fe absorption. Nevertheless, positive interactions are also possible; for example, orange juice significantly increases Fe absorption[48].

Health claims made for sports drinks

The EFSA has published scientific output regarding health claims made for substances and products related to sport food and nutrition, in which can be found assertions concerning substances used for hydration, hydrolyte replacement, and recovery in athletes[14]. These views, together with those from other organizations and reference institutions (Australian Institute of Sports)[45] or scientific reviews[13, 14], should be used by the food industry (through the advertising and marketing of its products) to focus on athletes as its target audience.

In this way, a recent scientific paper emphasized the importance of the publicity of sports products in magazines and websites[50], finding references to support performance improvement and recovery of the athletes for the advertised products (including hydration products). This review concluded that 52.8% of the websites do not provide scientific references for the products that are commercialized, and only identified 146 references supporting their claims. Moreover, none of the references found were systematic reviews (level 1 on evidence grade) and a lot of them showed abundant bias. Similarly, this has been observed in recent publications about substances contained in energy drinks and their effects on sport recovery and performance[10, 51].

Conclusions

Recognition of the needs for and the effects of the consumption of food supplements such as carbohydrates, proteins, sodium, and caffeine - among other substances - before, during, and after physical activity could benefit the food industry. Within the EU this should be achieved through regulation by the EFSA - based on scientific opinions of the nutritional and health claims made for the products, including different chemical ingredients - to guarantee the food safety of the products and the health of the athletes. In addition, further scientific evidence should be provided by new clinical trials in order to help the Expert Committees of the EFSA arrive at robust scientific opinions concerning these functional foods, and their individual ingredients, aimed at the sport population. It is clear that the legal regulation of sport products by the EU continues in its infancy.

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maintenance of normal blood LDL-cholesterol concentrations (ID 1494, 4684), contribution to normal spermatogenesis (ID 1822), "energy metabolism" (ID 1821), and increasing L-carnitine concentrations and/or decreasing free fatty acids in blood during pregnancy (ID 1495) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. *Eur. Food Safety Authority J*. 2011;9:2212.
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