Research Review about Sports Beverage's Functions on Improving Athletic Ability

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Abstract

Sports beverage is a kind of functional beverage developed according to the changes of body functions during sports on the basis of scientific research. The nutritional ingredients in sports drink are essential elements for human body, which can improve the fatigued body, promote the recovery of body and improve the athletic abilities. The selection of sports beverage is also important, for we shall consider the characteristics of different sport events. Sports beverage shall be used at suitable time and in proper amount. The functions of sports beverage's taste on athletic ability shall also be considered. This paper is to discuss the influence and functions of all nutrients in sports beverage on human body's athletic ability and the functions of scientific selection of sports beverage on the athletic ability so as to further provide scientific basis for reasonable selection and use of sports beverages.

Keywords

Sports beverage, Athletic Ability, Research Review.

1. Introduction

Human will sweat a lot under motion state, and the loss of sweat will cause a lager loss of water and electrolyte in human body. So drinking of sports beverage before, during and after sports can supplement water rapidly for athletes so as to maintain the physical electrolyte balance during sports, lower the body temperature, improve the activity of metabolic enzymes during sports, delay the feeling of fatigue, accelerate the elimination of fatigue feeling, promote the recovery of athletic ability and improve the sport performance.

The national standard on sport beverage in China (2009 version)[1] defines the sport beverage as a kind of drink in which the nutrients and the contents can suit the physiological characteristics of athletes or people who need a lot of physical activities, and which can supply water, electrolytes and energies that can be rapidly absorbed for human body. With the development of sports causes and improvement of competitive sports regulations, Schneider et al [2] made more specific explanation on sport beverage: Sport beverage always contains carbohydrates, mineral substances, electrolytes, vitamin and other nutrients, but beverage drink is different from functional beverage, for functional beverage may also contain caffeine, etc. Sport beverage is also called the fifth generation beverage, for it's the new generation of drink following sodas, packaged drinking water, tea drink, fruit juice and fruit juice beverage.

2. Main Functions of All Nutrients in Sport Beverage

2.1 Functions of water, electrolytes and carbohydrates in sport beverage to improve athletic ability

Water is the most important body fluid whose content is the largest - accounting for 2/3 of human body weight. The plasma contains a lot of water, which accounts for 91% - 92% of gross plasma. As the stored blood is mobilized during sports, causing the increase of circulating blood volume, so the circulating blood volume of athletes increases much more than that of people who have no exercise, especially for the athletes who take the endurance events. The increment for ordinary people is 10%, while for athletes is 25% or above. Long time of durance movement and sweating a lot will reduce the plasma volume. Higher temperature, heavier exercise intensity and longer exercise time will cause

larger loss of water in plasma. After vigorous exercises, the chemical components in human's plasma will have obvious changes. Due to the water transfer in plasma and profuse sweating, water and inorganic salt in plasma will reduce obviously, the concentration of other substances in plasma will increase relatively, and the blood will be concentrated. The longer the exercise time is and the higher the exercise intensity is, the above changes will be more obvious. For instance, long time outdoor sport, off-road mountain games and long-distance natural rock climbing may cause dehydration. Dehydration is sure to influence the athletic ability or even threaten the lives. Long-time outdoor sport with high intensity may increase the water demand by human body of 2-2.5L every day up to 12-15L, or even up to 25% to 30% of the body's water content. During vigorous exercise or military training, profuse sweating may cause serious loss of water and inorganic salt from human body. If the lost water and inorganic salt can't be recovered within 24h, it may cause heat-related illness. Some research indicated that if the water loss reached 20% of the body weight, the human life may be threatened, the load of cardiovascular system may become heavier, the heart rate may be increased, blood pressure may be lowered, metabolism may be in disorder, and in severe cases, people may have circulatory failure, collapse, obnubilation and even coma[3].Supplementation of sport beverage before and during exercise can provide energy for muscles, brain and other tissues and organs and provide water resources for maintenance of body fluid equilibrium and dehydration prevention [4].

Different sweat rates during sport may cause different compositions of sweat. But the main compositions are water and electrolytes. Electrolytes are the compounds that conductive under molten condition in aqueous solution, such as sodium, calcium, magnesium, etc. Some researches indicated that intake of water without necessary supplementation of sodium could cause syndrome of inappropriate antidiuretic hormone secretion, restrain the secretion of aldosterone, increase the extracellular water and glomerular filtration rate, restrain the renal tubular reabsorption and cause hyponatremia[5]. The muscle spasm after vigorous exercise may be related to dehydration and a large loss of salt. Supplementation of sport beverage containing electrolytes after sweating a lot for athletes can reduce the chances of muscle spasm. If the lost salt can't be supplemented, the electrolyte balance will not be achieved after sport even supplemented with a large amount of fluid. A study[6] indicated that a proper supplementation of sport beverage containing 18~59mmol/L sodium would not only supplement with the lost water and electrolytes, but also contribute to prevention or delay of exercise induced fatigue, which had obvious effect on improving the sport performance. Some scholars suggested that intake of liquid equal to 125%-150% of the sweat loss containing 50-60 mmol/L sodium will help to eliminate the dehydration caused by exercises and fully recover the body as soon as possible[3].Reasonable supplementation of water and electrolytes in sport beverage can improve the athletic ability of human body. Such supplementation shall be arranged scientifically according to the loss situations of body, for unreasonable supplementation of electrolytes is adverse to the balance of internal environment. The national standards of sport beverage specify that: The index of sodium in sport beverage is 50-1200mg/L, and the index of kalium is 50-250mg/L[7].

Carbohydrate is an important energy supply method, which are in three main forms: blood glucose, muscle glycogen and hepatic glycogen, existing in human body. Glycogen can break up into glucose for ATP synthesis of cells when the energy needed by cells increases. Sport beverage is an important and effective way for carbohydrate supplementation. It’s important to supplement carbohydrates during extra-long time sport. In 1967, Hultmon had put forward the glycogen filling method before competition, which helped the athletes for extra-long distance sport improve their competition performance[8].Campbell et al. [9] indicated that supplementation of carbohydrate-electrolyte beverage could help to improve the performance of rowers' upper limb movement and increase the total work. Later, Li Xiangyang[10] et al indicated that supplementation of carbohydrate-electrolyte beverage with 6% sugar content 15min before exercise could maintain a high blood glucose concentration for rower during long-time sport, prolong the exercise time, increase the total work and have obvious effect on the rowers' athletic ability. The results of this research are the same as those

by Campbell et al. Some foreign researches[11] indicated that supplementation of carbohydrate-electrolyte beverage 45-60min before exercise during long-time endurance sport could prevent athletes from suffering hypoglycemia and improve their sport performance obviously. Supplementation of oligose beverage during long-time endurance sport can save the use of muscle glycogen and hepatic glycogen, maintain a high level of blood glucose and stabilize the levels of blood volume, serum insulin and blood lactic acid[12].Professor Chen Jidi had also indicated in his research that supplementation of oligose beverage during long-time endurance sport could maintain a high level of blood glucose, stabilize the levels of blood volume, serum insulin and blood lactic acid, increase the total work of sport and prolong the exercise time[13].Some researches indicated that the carbohydrate-electrolyte beverage could effectively improve the physical power of football players, delay the declination of tactical sport ability, improve the brain power, maintain normal moods and increase the attentions. In recent years, some scholars had some discovers: Guo Zhebin [14] carried on low-oxygen training for 7 students of Health Sports School. Carbohydrate-electrolyte beverage is given to the students when having dehydration, which obviously improved the symptom of trainees and recover the water balance of their bodies. Wei Bing [15] et al observed the

Functions of sport beverage on human body's athletic ability, fatigue elimination and function state regulation, etc. Some researches showed that the sport beverage could keep the subjects a high blood glucose level during long-time high intensity exercise, stabilize the potassium ion and magnesium ion in serum after exercise, lower the lactate level during limited quantity exercises, speed up the recovery of blood lactic acid after exercises and obviously relieve the fatigue of subjects. Other researches showed that supplementing carbohydrates during exercise had active effect on relatively short-time and high-intensity sport [16,17].

In addition, the amount of supplementation shall be scientific. Some researches showed that the increase of carbohydrate concentration would increase the beverage's osmotic concentration, while the water absorption by human body decreased. So, the carbohydrate concentration in sport beverage should not be too high[18].Some researches indicated that the carbohydrate concentration in sport beverage might affect the rate of beverage passing the stomach. The passing rate of low osmosis beverage through stomach is very high, so increased the rate of beverage entering the blood, which is good for body's absorption[19].

2.2 Amino acid/protein in sport beverage

Protein is mainly consisted of amino acids, which are important physiological regulation substances for human body. The amino acids available in human body come from not only the food proteins, but also the proteins in tissues and cells. These two kinds of amino acids are mainly used for not only the synthesis of cell components so as to realize self-renewal, but also the synthesis of bioactive substances such as enzyme and hormone.1g protein can release about 4.3kcal energy by complete oxidation in human body, so protein is an important source of body energy. The protein metabolism in human body can be judged from the nitrogen balance test. The nitrogen substances in food are mainly proteins. Extra-long-time exercise, long-time hunger, exercise-induced injuries and wasting diseases will all cause negative nitrogen balance of human body. As the energy metabolic substrate, amino acids can turn into carbohydrates through heteroplasia in the liver, and then transfer into glycogen. Hepatic glycogen breaks up into glucose, which is transferred to the movement skeletal muscle through blood circulation. Moreover, the alanine, leucine and isoleucine in skeletal muscle can be turned into intermediate substances of energy metabolism to participate in the energy metabolism. Some researches showed that vigorous durance exercise training may intensify the protein metabolism, and muscle tissues shall be increased for strength training. So appropriate increase of protein supplementation will improve the athletes' athletic ability obviously. If there is no sufficient supply of exogenous amino acids, the concentration of amino acids in blood and muscles will decrease due to the release of endogenous amino acids[20].The researches by Dreyer[21] et al suggested that supplementation of necessary amino acids or proteins rich of leucine could maintain the protein metabolism balance and improve the synthesis of muscle proteins. During medium-

endurance sport events, the limbs of athletes will intake the branched chain amino acids selectively, as the movement can improve the ability of muscles to oxidize the branched chain amino acids. Some researches showed that the baseline level of glucose in blood might change slightly, and some amino acids could cause the secretion of insulin. Supplementation of proteins and amino acids for body may have some functions on athletes' athletic ability. During the circulation of alanine-glucose and glutamine-glucose, some glucose generated during transformation of alanine and glutamine in liver can enter the muscle cells again and be oxidized to generate energies. In the cycling events, the metabolic level of glutamine can be well used to predict the generation of pyruvic acids and the metabolic capability of body [22,23].The polymer of ammonia and glucose can improve the storage of muscle glycogen, however, they can also be used to improve the contents of exoskeleton muscle glycogen[24,25].In endurance sport events, after the muscle glycogens are exhausted, the energy supply of amino acids will increase proportionally. Some researches indicated that if the intake rate of branched chain amino acids by muscles during exercise increased during long-time and high-intensity sport, the exudation quantity could increase in multiplies. However, no research has verified till now that this method can improve the athletic ability of human body.

2.3 Functions of vitamins in sport beverage to improve athletic ability

Vitamin is a trace organic substance to keep normal physiological functions of human and animals which must be taken from food. It plays an important role in human's growth, metabolism and development. As such substances can't be generated in human body or the synthetic amount is insufficient, they are absolutely necessary although the demand is low, and must be supplied by food. Vitamin is a necessary organic compound for human body metabolism. Human body is just like a complex chemical plant, carrying on kinds of biochemical reactions continuously. Such reactions have close relations with the catalytic action of enzymes. Vitamin is different from the three substances like carbohydrate, fat and protein, accounting little content in natural food but necessary for human body. Some vitamin like B6.k can be compounded by the germs in animal intestinal, and the synthetic amount can meet the demands by animals. The animal cells can turn tryptophan into nicotinic acid (belongs to b-vitamins), but the synthetic amount can't meet the demands. Now most sport beverages on the market contain b-vitamins. B-vitamins are water soluble vitamin, including thiamine, riboflavin, nicotinic acid, pantothenic acid, biotin, cobalt amino acid, etc. As coenzyme components, they play important roles on the functions and energies of cells, especially the mitochondria[26].In practice, the confirmation of demands of a vitamin to be increased during exercise for different sport events and intensities shall be based on a lot of scientific researches. The most convictive data are from the researches of vitamin metabolism in athletes. Moreover, the group survey data with rigorous design also has some reference values. For instance, it's recommended that 0.19mg vitamin B6 shall be supplied for each gram of protein intake. Manore[27] has reported that the supplementation of vitamin B6 by athletes for long period could improve the vitality of glutamic oxalacetic transaminase in erythrocytes and the concentration of pyridoxal phosphate in plasma and content of vitamin B6 in muscle, improve the maximum oxygen absorbed by athletes and shooting ability, and improve the excitation of muscle of male athletes. When the protein content increase in food, the demands of vitamin B6 shall also increase correspondingly. The carbohydrate generation function by decomposition of muscle glycogen, lactic acids and amino acids are all related to vitamin B6.A certain amount of vitamin B6 can help to decompose the protein, fat and carbohydrate. It has the functions of vomiting inhibition and development promotion, and its lack will cause emesis or cramp. Excess intake may also cause so-called neuropathy, a kind of neurologic disease about feeling dull, of which the best situation is anesthesia of skin. Vitamin B12: movement can speed up the metabolism of erythrocytes and also induce oxidative stress. The increase of muscle tissues is always accompanied by the reinforcement of metabolism of nucleic acids. All these processes need the participation of vitamin B12. However, no reports have indicated whether the movement could increase the demands of vitamin B12 while increasing the metabolic rate. Its lack may cause

pernicious anemia. Vitamin C is also called L- ascorbic acid, a water soluble vitamin, which can deal with the scurvy and is of acidity, so called ascorbic acid. Its contents in lemon juice, green plants and tomatoes are very high. Ascorbic acid is monoclinic lamella or needle crystal, easily being oxidized and generating dehydrogenation ascorbic acid, which still have the function of vitamin C. In alkaline solution, the lactonic ring in dehydrogenation ascorbic acid molecule is easily broken up by water into diketone glunic acids. Such compounds can't turn into lactone structure in animal body. The sulphates finally compounded by sulfuric acid and oxalic acid generated in human body will be expelled by urine. Thus, diketone glunic acid will have no physiological activity any longer. Plants and most animals can compound vitamin C in their own bodies. However, as the lack of enzymes to transfer L-glunic acid into vitamin C in human body, primates and guinea pigs, vitamin C can't be compounded, which must be taken from food. If the food is short of vitamin C, it will cause scurvy. Now the dyspoiesis of intercellular substances may cause symptoms like bleeding, gomphiasis, difficulty in injury healing and fracture-likely. As the half-life period of vitamin in human body is long (about 16 days), so the scurvy may occurs about 3 to 4 months after eating food without vitamin C.As vitamin C is easily to be oxidized or reduced, it's generally considered that its natural functions are related to this property. Vitamin C is directly related to the normal synthesis of collagen, metabolism of tyrosine and absorption of iron. Its main function is to help the body to complete redox reactions so as to improve the brain power and intelligence. Vitamin C can capture the free radicals, preventing the diseases such as cancers, atherosclerosis, rheumatism, etc. In addition, it can also improve the immunity, and is good for skin, gingiva and nerves. Supplementation of vitamin C can prevent cataract. And taking vitamin C can protect liver and prevent stomach cancers. Until now, vitamin C is deemed as harmless, as the kidney can excrete surplus vitamin C. The newly published research reports in America indicated that the circulation of a large amount of vitamin C goes against the healing of injuries. If the intake of vitamin C exceeds 1000mg, it will cause diarrhea, kidney stone or infertility, and even gene deficiency. Vitamin E and D also play important roles in human bodies. Maybe the immunity function and influence on athletic ability of vitamins are the same as other nutrients, and their functions are small and potential, but they can't be ignored.

3. Scientific selection of sport beverage

3.1 Characteristics of different sport events

Athletes of different sport events are different in explosive power, endurance, harmony, etc. So their demands on nutrition are different. After the same quantitative load exercise, different kinds of sport beverages may have active functions in improving the athletes' functions. Li Shicheng et al[28] had taken the students of Martial Arts Major of Sports University as subjects. The research showed that after quantitative load exercise, the subject supplemented two kinds of sport beverage, which both improved the glucose response and heart rate recovery after exercise, while no notable difference showed between the two kinds except the concentration functions. For different specialized trainings, as the mechanisms causing fatigue are different, targeted selection of different sport beverages may be better for the recovery of athlete's body functions. Deng Yunlong et al [29] had carried out researches on the athletes of triathlon training team from Bayi Military PE Training Unit. Different sport beverages are given to the athletes in different specialized trainings to see the influences on endurance. The results showed that different sport beverages had different effects on the aerobic exercise ability and anaerobic exercise ability.

The energy required for sport under ultimate strength, sprint, middle-distance running, etc. are mainly supplied by ATP, CP and anaerobic glycolysis of carbohydrates. A lot of acid metabolites are generated in short time. These athletes shall be supplied by the beverages containing carbohydrates, vitamins, phosphor, iron and magnesium which can promote the rapid resynthesis of ATP and CP and reduce the acidification trend of body fluid. In endurance events managed by physical ability such as middle-long-distance swimming, marathon and long-distance cycling, the total energy consumption of energies by athletes is large. In the later stage, the stable state of metabolism is destroyed, and the movement recovery is slow, so the athletes shall supplement some beverages

containing carbohydrates, proteins, vitamins and fats. Davis et al[30] found in their researches that the supplementation of sport beverage could improve the cycler's best performance by 75% 30min after 2h exercise. In the skill-leading events like football and basketball, the movement intensity of athletes is high, and profuse sweating may cause dehydration. Intake of carbohydrate-electrolyte beverage before and during exercise can notably improve the athletic ability. Some reports indicated that supplementation of sport beverage containing carbohydrates before and during competition for football players could save the muscle glycogen and delay the fatigue[31].In the physical ability-leading events like throwing and weight lifting, muscular coordination is required, and the metabolism of nitrogen substances is intensified, so beverages containing protein, potassium, sodium, magnesium, etc. shall be provided to the athletes. Han Jili et al[3] reported that the athletes of strength events could supplement creatines to increase the storage of phosphocreatine and improve the athletic ability.

3.2 Proper supplementation of sport beverage

The demands of any substance by human body have a limitation. Too little intake will have no effect, while too much may have adverse effects. For instance, the water intake by athletes shall be moderate. If there is water loss during exercise, small amount each time by multi times of water supplementation is required to gradually reach the water balance in human body. Too much or too fast supplementation may increase the sweating, cause further loss of water or dilute the gastric juice, affecting the digestion, diaphragmatic muscle movement and breathing. Large increase of water may also increase the blood volume and the heart load. It may have adverse effect on improvement of athletic ability and the recovery of physical ability. So attentions shall be paid to the amount of water intake during training.

Different beverages may play different roles in different time. So the intake time is also important. Proper water intake before exercise can increase the water storage of body but the water should not be too sweet. Intake of 400-600ml sport beverage 2-3h before exercise will ensure the body fluid balance at the beginning, and it enable the body to discharge surplus water before exercise[32].Intake of water containing too many carbohydrates before exercise can cause insulin reaction, reduce the blood glucose, drain the muscle glycogen too early, quicken the fatigue, and cause the stomach cramps, which are not good for exercise. Athletes continuing exercise more than 1h are suggested to supplement carbohydrates and electrolytes, such as intake of 30-60g carbohydrates each hour to maintain the oxidation of carbohydrates and delay the fatigue. Loss of 1kg weight during exercise requires 1000mL supplementation of fluid, which can speed up the recovery of water, carbohydrates, inorganic salts and microelements, improve the rapid recovery of muscle glycogen and realize the function of elimination of fatigue feeling. For instance, one of the functions of beverage "Snow Lotus" is to improve the blood circulation, improve shell temperature, open the surrounding blood vessels and make people warm, like the effect of warm-up. So it can be taken before competition to pre-warm the body, save energies consumed by preparation movement. Some researches showed that 10min after taking this beverage, the shell temperature began to rise, keeping a peak value for about 60min. So it's better to intake 15 to 30min before competition. If taking too early, the athletes can't begin the competition when it has the best effect.

3.3 Selection of beverage flavors

The unique flavor of sport beverage may also affect the athletes' choice. In America, from 1989 to 1008, the proportion of sport beverages for children had increased from 2% to 12%[33].Mango flavor has been widely applied in beverage industry, while orange flavor has also been applied in sport and function beverages. The choice trends of other flavors like cherry, grape and pineapple are declining. So the flavors of products are important, and the related changes are like revolution. The athletes will also choose beverages according to their favors, so the flavor may also affect their improvement of athletic abilities. Further exploration and researches on sport beverage are required.

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