Urgent Need of Nutritional Strategy and Innovated Functional Foods for Athletes Health and Fitness

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ABSTRACT

The present review discussed the biochemical and physiological changes as well as the different sorts of nutritional deficiencies and health hazards to which the athletes may be exposed in addition to the importance of production and evaluation of innovated functional foods for athletes. Ergogenic substances and phytochemicals of possible impacts on athletes are also discussed. Athletes need special nutrients and bioactive constituents before, during and after exercise to keep on their fitness and performance and to achieve successful results during their games. They also need to be healthy without any sort of nutrients' deficiency. So, it is important to study the necessary nutrients and functional food ingredients for athletes and incorporate them into ideal functional foods to achieve their performance and to keep them in a healthy state. Such functional foods must be evaluated in athletes through following up biochemical, physiological and anthropometric parameters reflecting nutritional status, oxidative stress, antioxidant state, immunity, fitness and performance. Functional foods for athletes differ according to the practiced games. These functional foods must correct any nutrient deficiency in athletes that may occur due to practicing sports. Proper athlete's nutrition is essential for continuity of his/her sports with a good health and without loosing fitness.

Key words: Athletes, health hazards, ergogenic substances, functional foods, performance, nutrition.

INTRODUCTION

It is generally accepted that sports lead to both healthy bodies and minds, but what to eat is a problematic. The majority of young men and college students like to practice gymnastic and related sports for building their bodies. However they do not aware about the proper nutrition required to increase muscle mass without inducing negative health effect. In addition, athletes practicing different types of sports need special nutrition before, during and after training to be in a healthy state together with complete fitness and performance. Supplementation of special food products formulated by nutritionists may be the solution.

Different health hazards for athletes have been reported that may be mainly related to oxidative stress, dehydration and gastro intestinal tract (GIT) effect during strenuous exercises (1, 2). Also, previous studies showed that the nutritional status of athletes is affected; the change in nutritional status differs according to the type of sport (3, 4).

Nutritional strategy aims to compensate for the higher metabolic rates during training and the game itself is required. Nutritional supplements are important to increase energy production and, consequently, to compensate for the metabolic needs of athletes. On the other hand, athletes in long-duration types of sports (e.g., runners, triathletes and cyclists) are in need of carbohydrate together with certain amino acids. Without proper nutrition, athletes may suffer different forms of nutrient deficiency due to high energy expenditure during training and game practicing. In addition in order to acquire fitness and performance, athletes must take all the required

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nutrients and calories needed according to the practiced game. Incorrect or improper nutrition of athletes may result in low performance and fitness during games and may result in nutrients' deficiency or some physiological disorders. So consumption of special food or functional food may guard against the occurrence of such problems (5-8).

Production of innovative functional food is crucial for athletes and this required first studying nutritional status, physiological and biochemical changes occur due to practicing different sports and training. Also, suitable functional foods must be designed to be suitable before, during and after training. Follow up study must be carried out for assessment of the efficiency of a proposed food formula in athletes. Screening of phytochemicals and nutrients constituents of the prepared food products is very important to assign the suitable quantity of food for each athlete.

Nutritional status of athletes

Athletes are faced with the challenge of meeting nutrition requirements for growth and development, as well as sport performance. Proper nutrition is similar for athletes and non-athletes. The only difference related to the amount of energy needed by athletes for the intense physical activity and for affording greater performance (5). Major dietary problems of college athletes reported by coaches were consumption of junk food, poor eating habits, and consumption of an unbalanced diet (9). In some athletes dietary intake was relatively well-balanced according to the recommended dietary allowances (RDAs). However others have low energy intake or imbalance of protein and fat and insufficient minerals and vitamins. Nonetheless, practicing a sport may allow young adults to have a nutritional status closer to recommended values. So, practicing a sport may allow athletes to balance their energy intake and expenditure and could be a good way to have a nutritional status closer to RDAs (10). However some sorts of nutrients deficiency were reported in athletes as can be noticed in the subsequent section.

Fatty acids' status of athletes differs according to the practiced game. In spite of similar dietary patterns, as assessed by a food frequency questionnaire, plasma fatty acids (FA) profile in the football women players showed significantly higher proportions of stearic, oleic, and monounsaturated FA (MUFA), and significantly lower proportions of total and n-6 polyunsaturated FA (PUFA) than in the water polo women and control group. The water polo players had higher percentages of palmitoleic and arachidonic acid than the control. Erythrocyte FA profile demonstrated significant higher proportion of oleic acid and MUFA in the football group than in the controls, and decreased stearic acid and elevated palmitic and palmitoleic acid in the water polo players than in the other 2 groups. Both groups of athletes had significantly lower percentages of n-6 dihomo--linolenic acid, n-6 PUFA, and total PUFA compared with the controls (4).

In detrained swimmers; body weight, fat mass and waist circumference increased, whereas resting metabolism decreased (3).

A high proportion of elite female soccer athletes were not in energy balance and failed to meet carbohydrate and micronutrient recommendations, with depleted iron and vitamin D status. Such suboptimal nutritional status may affect soccer performance and physiological growth and development (6). Also, professional basketball male Spanish players are at higher risk of hypovitaminosis D after wintertime. Adequate intake of dietary calcium and vitamin D is required if athletes are to avoid low serum 25(OH) D levels when exposure to sunlight is limited (7).

A nutritional study carried out on 203 male rugby players age 15-18 yr competing at Senior School's Cup level in Leinster, Ireland showed most players (68%) had a healthy percentage body fat, 22% were classified as underweight, and 9.7% were overweight. Despite a positive attitude toward nutrition, poor nutritional knowledge and dietary practices were observed in many players (11).

Studying the effect of high-intensity physical activity during training on the biochemical status of thiamin and riboflavin in athletes was carried out by Sato et al. (12). Thiamin and riboflavin concentrations in blood of men and women athletes were measured during a low-intensity preparatory period and compared with measurements taken during a high-intensity training period. Additional variables measured included anthropometric characteristics, estimated energy expenditure during swim training, distance covered, resting energy expenditure obtained by indirect calorimetry, estimated energy requirement per day, and dietary intake of energy, thiamin, and riboflavin estimated from 3-day food records. For both male and female subjects, no major changes were observed in anthropometric characteristics or dietary intake, but energy expenditure during swim training per day significantly increased in the intensive-training

period. Blood thiamin concentration decreased significantly during the intensive-training period compared with the preparation period; however, the concentration of riboflavin was unchanged. These results suggest that intense training affects thiamin concentration, but not riboflavin, in blood of college swimmers.

Nutritional Strategies for athletes

It was reported by Maughan and Burke (13) that the objective of training is to have optimum performance on the day of competition through three processes; hard training to obtain the needed training stimulus, smart training to maximize adaptations to the training stimulus,and training specifically to fine- turn the physiology required for competition strategies. Dietary strategies for competition must target the factors that might cause fatigue during the event, improving performance by reducing the onset of these factors. So, the required nutritional strategies to achieve these various processes are different, and even opposite to each other.

Nutritional Strategies for athletes can be divided into nutritional strategies before, during and after exercise. The strategies in nutrition are mainly focusing on increasing muscle glycogen stores before exercise. The most acceptable and effective way is to lower the training frequency and strengthen three to four days before the competition. Besides, the consumption of foods of high carbohydrates content must be increased. These two ways are useful in carbohydrate-loading. An intake of nine to ten gram per kilogram of the body weight per day is sufficient to increase the storage of glycogen in liver and muscle. Three to four hours before the competition, a high carbohydrate meal is also very efficient in boosting up the glycogen stores. Depletion of muscle glycogen and dehydration are from the major factors leading to fatigue. Therefore it is important to drink well some kinds of sports drinks during exercise, especially the prolonged types. A well formulated carbohydrate-electrolytes solution may help in preventing severe dehydration and also help stimulate and regulate carbohydrate metabolism in the working muscles and thereby the onset of fatigue can be delayed (14). Sports drinks which are able to provide 30 to 50 grams of carbohydrate per hour are reported to be efficient in optimizing endurance performance. The National Research Council (15) suggests an intake of one milliliter of extra fluid per kilocalories (1ml/kcal) and it is a generally accepted recommendation. For instance, finishing a marathon requires about 3000 kcal of energy (16) and so it requires an intake of 3 liters extra fluid. Rate of recovery from exercise is depending on the rate of fluid balance restoration and the rate of muscle glycogen replacement. Muscle glycogen re-synthesis is the most immediate process after exercise, so in order to achieve the optimum rate of glycogen re-synthesis, a carbohydrate-electrolyte solution is useful. The optimum amounts of sports drinks are about one liter with 6 to 7% of carbohydrates, which is about one gram per kilogram of the body weight. A better recommendation is to consume 50 grams of carbohydrate every hour until the next meal. In theory, the overall intake of carbohydrates ought to be about ten grams per kilogram of the body weight during the recovery period of 24 hours. The delay of carbohydrate consumption for two to three hours after the exercise reduces the rate of glycogen. After an intense bout of exercise, whether aerobic (i.e. marathon) or anaerobic (weight lifting), sufficient rest and recovery is required for muscle. It is that period of recovery that may have the greatest influence on subsequent bouts of exercise. For the exercised muscle to sufficiently recover, a 48-72 hour rest period is recommended. On the other hand, athletes such as football players and cyclists, who perform subsequent bouts of intense physical exercise, train a particular muscle two to three times a week in order to achieve and enhance training goals (i.e. muscular strength and endurance and muscle mass). With these athletes, it is not unusual for them to turn to dietary supplements. It was reported by Spaccarotella and Andzel (8) that to maximize glycogen resynthesis, athletes should consume about 1.2 g carbohydrate per kilogram body weight as glucose and sucrose immediately after exercise and each hour thereafter for 4-6 hours postexercise. Alternatively, they may consume 0.8 gkg(-1)h(-1) in combination with 0.4 gkg(-1)h(-1) amino acids or protein. Liquids provide valuable fluids for rehydration, and an ideal recovery beverage should not only contain carbohydrate and protein but also contain electrolytes, including about 0.3-0.7 g sodiumper liter fluid to help restore sodium lost through sweat. Chocolate milk may be as effective as or superior to these beverages in promoting recovery. Research regarding the effects of specific types of amino acids and antioxidants on recovery is mixed. Further investigation is needed before specific recommendations about consumption of mixture of amino acids and antioxidant for recovery can be made. Future

studies that include women and athletes representing a variety of sports, ages, and training levels and that use consistent methodology will lead to a better understanding of the effects of postexercise intake on recovery (8).

The effect of carbohydrate type as short term supplement on self-paced endurance cycling performance was studied by Macdermid et al. (17). A 6% galactose drink does not enhance performance time during a self-paced cycling performance trial in highly trained endurance cyclists compared with a formula typically used by endurance athletes (50:50 glucose-maltodextrin) but may improve the ability to produce intermediate self-paced efforts.

A case study demonstrated by Moran et al. (18) showed the race nutrition practices of a female runner who completed her first 100-km off-road ultra-endurance running event in 12 hr 48 min 55 s. Food and fluid intake during the race provided 10,890 kJ (736 kJ/hr) and 6,150 ml (415 ml/hr) of fluid. Hourly reported carbohydrate intake was 44 g, with 34% provided by sports drink. Hourly carbohydrate intake increased in the second half (53 g/hr) compared with the first half (34 g/h) of the race, as the athlete did not have access to individualized food and fluid choices at the early checkpoints and felt satiated in the early stages of the race after consuming a pre-race breakfast. Mean sodium intake was 500 mg/hr (52 mmol/L), with a homemade savory broth and sports drink (Gatorade Endurance) being the major contributors. The athlete consumed a variety of foods of varying textures and tastes with no complaints of gastrointestinal discomfort. Despite thinking she would consume sweet foods exclusively, as she had done in training, the athlete preferred savory foods and fluids at checkpoints during the latter stages of the race. This case study highlights race-day nutrition strategies to manipulate race-day food and fluid intake to meet the nutritional goals.

A study carried out by Carvalho et al. (1) showed that fluid restriction during exercise was accompanied by a greater level of dehydration and increased perceived exertion but had no effect on basketball performance compared with ad libitum drinking of water or a carbohydrate-electrolyte sports beverage. Athletes with more knowledge about hydration and better self-reported hydration behaviors ingested more fluids during training sessions.

Lowering the glycaemic index of the pre-exercise meal can enhance lipid utilization by up to 100 % through reduced insulin concentrations, although its application may be restricted to specific training sessions rather than competition. Chronic effects of dietary glycaemic index have not yet been confirmed and need future study before any recommendations (19).

Impacts of nutrients, phytochemicals, ergogenic substances, synthetic steroids and probiotic intake on athletes

Ergogenic substances and synthetic steroids have a wide spread use, particularly among non-professional athletes. However the key of success is a proper athletic nutrition which is a balanced intake of essential nutrients. Modulation of dietary composition and/or supplementation with specific nutrients to improve human physical performance is a working definition of nutritional ergogenic aids. Ergogenic aids are taken to enhance energy utilization by producing more, controlling its use, or increasing mechanical efficiency. Most athletes are looking toward enhancing performance by proper training modalities and methods; however, some look to the biochemical route for a "quick fix." Thus, the use of chemical agents is on the rise. Androstenedione, dehydroepiandrosterone, and the "parent" compound, testosterone are anabolic-androgenic agents. The former two have equivocal activity, but testosterone is both anabolic and androgenic in doses that adolescents might receive. Growth hormone and insulin-like growth factor-1 are anabolic, nonandrogenic compounds with undoubted effects on the lean body mass compartment. (20). Growth hormone is used by athletes to produce physical performance. The safety profile of GH developed over the past 25 years has shown few adverse events. The challenge is to determine whether GH therapy poses any long-term risks (21).

Psychologic or pharmacologic procedure may be an aid to improve physical work capacity or athletic performance (22). Amphetamines, carbohydrates, hormones, proteins, amino acids, steroids, caffeine, additional red blood cells, and phosphates are just a few of the aids that have been examined in the literature to determine if a possible ergogenic benefit occurs. Athletes use a few of these aids routinely, and only a few cause real controversies. Many male and female athletes use a variety of dietary supplements in the belief that they may have a positive influence on skill,strength,power,or endurance. At some point during an exercise program, whether training to increase muscular strength, cardiovascular performance, or improve recovery from an intense bout of exercise, an individual may reach a performance plateau. With the increasing placed on elite and often on young athletes to achieve high levels of exercise performance, manipulation of

diet through nutritional supplementation has increased. For several years, nutritional strategies such as overfeeding and ingesting carbohydrate/protein before and after exercise have been the foundation for enhancing exercise performance and muscular strength. On the other hand, dietary supplements may be the cornerstone for improving performance. Some dietitians and exercise scientists believe an adequate diet, which meets the recommended dietary allowance (RDA) for macronutrients, vitamins and minerals, is sufficient to achieve top performance. However, other experts believe that supplementation is necessary to restore specific nutrient,vitamin, or mineral levels that may be suppressed during prolonged or intense exercise. For example, Vitamin E supplementation before exercise has shown to maintain normal values that usually decrease during prolonged endurance exercise,prevent free radical damage during intensive exercise, and decrease serum creatine kinase levels, a measure of muscle damage (23). In addition, theres an abundance of evidence that plasma values of the amino acid glutamine fall substantially during and/or after very prolonged exercise (24-26). The emergence of creatine and nutritional formulations containing creatine, have been the most popular nutritional strategies employed by resistance-trained athletes to promote gains in strength and fat-free mass. Creatine is an ergogenic aid that improve muscle mass, strength and endurance. The rationale is that creatine supplementation has been reported to increase total body mass (27-31), fat-free mass (31- 33) single-effort and/or repetitive sprint capacity (27, 28, 31, 34), strength and/or power, (35), and work performed during sets of maximal effort muscle contraction. Cottrell et al. (36) has reported that creatine supplementation was sufficient to increase mean power when the between bout recovery interval was 3 minutes or less. Creatine supplementation decreases oxidative DNA damage and lipid peroxidation induced by a single bout of resistance exercise (37).

Potential side effects caused by oral creatine supplementation on gastrointestinal, cardiovascular, musculoskeletal, renal and liver functions showed no strong evidence. Reported side effects, like muscle cramping, gastrointestinal symptoms, changes in renal and hepatic laboratory values, needs further investigation since the studies do not represent well-controlled trials. The only documented side effect is an increase in body mass. The amount of contaminants present in creatine monohydrate due to industrial production may be an extra unwanted outcome. Recently, controlled studies showed that in healthy subjects, oral supplementation with creatine, even with long-term dosage, may be considered an effective and safe ergogenic aid. It is preferred that athletes should consult medical supervision on administration of creatine (38). Glutamine is another dietary supplement for athletes due to its effect in increasing muscular strength and improving recovery. However there is a lack of research examining the effects of glutamine supplementation on muscular strength, exercise performance, and recovery from exercise. During exercise, increases and decreases in plasma glutamine levels have been demonstrated and these variations are reflected upon the type, duration, and intensity of exercise. A number of studies have shown an increase in plasma glutamine level following brief (< 1 hour) high intensity exercise in humans (39, 40). On the other hand, after prolonged exhaustive exercise,such as a marathon,a significant decrease in plasma glutamine has been observed during and post exercise (25, 41). This decrease is relatively transient,lasting approximately 6-9 hours after a marathon. Other study has demonstrated similar effects to plasma glutamine with levels returning to baseline within 2-3 hours post-exercise in some cases and others showed plasma glutamine levels below normal at 24 hours post-exercise (42). It has not yet to be determined whether plasma glutamine levels decrease during repeated bouts of anaerobic (Sprinting) or aerobic (Tour de France) exercise, possibly decreasing recovery time to exercise leading an athlete or individual into an over-trained state (24). Consequently, glutamine levels can be significantly reduced or remained low for several weeks (25). In such athletes increased susceptibility to infection may result from impaired immune function caused by prolonged low levels of plasma glutamine due to intense or prolonged exercise training. Furthermore, the reduction in plasma glutamine levels following very prolonged exercise may result from an increased demand and uptake of glutamine by the tissues of the body that require it (skeletal muscle, adipose tissue, liver, kidney,and immune cells). The fall in plasma glutamine could be due to a combination of increased uptake and decreased production/alerted transport kinetics (24). The links between a decrease in plasma glutamine during exercise and an increased risk of infection (24, 43- 46) could pose a need for exogenous glutamine supplementation to stimulate faster recovery time, prevent overtraining syndrome, and allow an individual to participate in multiple bouts of exercise more frequently and prolonging time to fatigue.

Carnitine is administered as a supplement to improve the bodys ability to use stored fat as fuel. Carnitine enhances lipid oxidation, increases VO2 max, and decreases plasma lactate accumulation during exercise. Therefore, L-carnitine supplementation might benefit athletes. Giving 2 grams/ day of L-carnitine for six weeks to male marathon athletes improved running speed of 5.68% and decreased average oxygen consumption and heart rate in the treadmill test following supplementation. For carnitine to be effective as an ergogenic aid an adequate supply of lipids available as fuel, shifting metabolism toward utilization of fats as an energy source, and having a relative shortage of available endogenous carnitine must be present (47). Supplementation of L-carnitine induced a significant post-exercise decrease of plasma lactate and pyruvate and a concurrent increase of acetylcarnitine (48). However Colombi et al. (49) reported that although administration of L-carnitine was associated with a significant increase in the plasma concentration of all analyzed carnitine fractions, significant changes in running time, plasma concentrations of carbohydrate metabolites (glucose, lactate, and pyruvate), of fat metabolites (free fatty acids, glycerol, and beta-hydroxybutyrate), of hormones (insulin, glucagon, and cortisol), and of enzyme activities (creatine kinase and lactate dehydrogenase) were not observed. It is suggested that L-carnitine may induce subtle changes in substrate handling in metabolically active tissues when fatty-acid availability is increased, but it does not affect whole-body substrate utilization during short-duration exercise (50). L-carnitine might only exert a beneficial effect when there are actual deficiencies. Use of non-carbohydrate nutrients to stimulate muscle l-carnitine uptake may prove more beneficial for optimizing lipid utilization, but this requires more research (19).

Branched chain amino acids supplementation might be recommended in sport activities that change in intensity and require quick responses to external signals (e.g., soccer and other team games) (51).

Citrulline supplementation was reported to induce beneficial effect to athletes. In animal experiment, citrulline supplementation significantly increased the swimming time until exhaustion. Exercise-induced blood ammonia elevation was repressed by citrulline supplementation, and exercise-induced blood lactate increment in the citrulline-supplemented group was significantly lower than that in the non-supplemented group. Citrulline supplementation may facilitate the detoxification of ammonia via the urea cycle and inhibit additional glycolysis. Thereby, citrulline supplementation may be useful for improving the exercise performance of athletes (52).

The total individuals that attend a gym and use protein powder supplements far exceed the recommended dietary allowance of protein for general population and/or athletes, are able to cause health problems (53). Thereby, previously separate dietary protein recommendations for strength and endurance in athletes are no longer supported, and the daily intake for adult athletes suggested by most of the entities is about 1.5 g kg(-1) body mass with a range of perhaps 1.0 to 2.0 g kg(-1) body mass. This recommendation is a broad landmark that needs to be adapted to the individual circumstances of the athlete. Research of the past decade indicates a beneficial effect with respect to a positive net muscular protein balance if athletes ingest some protein before an exercise bout. The amount of protein to be ingested to elicit the highest benefit is about 10 to 20 g h(-1), but due to the insufficient amount of available data, it is not possible yet to rank different protein types or sources according to their anabolic potential. A simple way to translate the nutrient-based recommendations is the Swiss Food Pyramid for Athletes, which ensures a sufficient intake of energy, and all macro- and micronutrients in relation to the volume and intensity of the daily exercise (54).

High-dose serotonin-"depleting" large neutral amino acids supplementation given 3 h prior to intermittent high-intensity exercise improved reactive motor skill and agility performance in Australian Rules football players (55).

The antioxidative effect of whey protein against hydrogen peroxide toxicity using C2C12 myoblasts was studied by Xu et al. (56). Whey protein pre-incubation prevented the decrease in cell viability after hydrogen peroxide treatment. The production of 8-hydroxydeoxyguanosine associated with DNA oxidative damage was also inhibited by the whey protein pre-incubation. Endogenous antioxidant defense, such as glutathione, catalase, and superoxide dismutase activity, was also modulated by the antioxidant. At the same time, enhanced mRNA expression levels of heme oxygenase-1 and NADPH quinone oxidoreductase-1 were observed in cells pre-incubated with whey protein before H2O2 abuse. This suggests that whey protein improved the antioxidant capacity against acute oxidative stress through multiple pathways and this protein may serve as an alternative source of antioxidants for prevention of athletic injuries caused by Reactive oxygen species (56).

Functional food components and phytochemicals such as lycopene, carotenoids, tocopherols, phenolic compounds and phytosterols which are strong antioxidant (57, 58) may have beneficial effect in athletes by protection from health hazards. Different plant food extracts rich in the previously mentioned bioactive constituents that have been shown to possess antioxidant and anti-inflammatory activities could possess health benefits in athletes. These are mixture of, crude methanol extract of green tea, wheat germ oil and acetone extract of tomato, mixture of crude methanol extract of rosemary, walnut oil and acetone extract of sweet potato and mixture of crude methanol extract of broccoli, hazelnut oil and acetone extract of carrot (59, 60). Also, alcohol date extract rich in phenolic compounds was shown to possess anti-inflammatory and antioxidant effect (61,62),so may afford protection for athletes during extraneous exercise. A study tested the acute anti-inflammatory and immune-modulating influence of a quercetin-based supplement consumed by endurance athletes 15 min before a 2-hr treadmill runs at 70% VO (2max). The quercetin supplement provided 1,000 mg quercetin, 120 mg epigallocatechin 3-gallate, 400 mg isoquercetin, 400 mg each eicosapentaenoic acid and docosahexaenoic acid, 1,000 mg vitamin C, and 40 mg niacinamide. The quercetin supplement caused a strong increase in plasma quercetin levels but did not counter postexercise inflammation or immune changes relative to placebo (63).

Flavanol-rich fruit extract supplementation may suppress inflammation or tissue damage caused by high-intensity exercise training in long distance runners. The change in the serum interleukin-6 level between pre- and mid-training were significantly lower in the supplemented group, while the change in the transforming growth factor- level between pre- and post-training was significantly greater in the supplemented group (64). This effect may be explained on the basis of the antioxidant activity of flavonol compared with the placebo.

Consumption of plant flavonoids, antioxidants, and n-3 fatty acids is proposed to have many potential health benefits due to their antioxidant and anti-inflammatory activities. A study carried out by McAnulty et al. (65) examined the effects of daily supplementation of 1,000 mg quercetin + 1,000 mg vitamin C (QC); 1,000 mg quercetin, 1,000 mg vitamin C, 400 mg isoquercetin, 30 mg epigallocatechin gallate, and 400 mg n-3 fatty acids (QFO); or placebo (P) for 2 weeks to athletes. Plasma quercetin was significantly elevated in QC and QFO compared with P. Plasma F(2)-isoprostanes, Plasma antioxidant capacity represented by ferric reducing ability of plasma (FRAP), and vitamin C were significantly elevated and oxygen-radical absorbance capacity [ORAC] significantly decreased immediately postexercise, but no difference was noted in the overall pattern of change. Post hoc analyses revealed that the QC and QFO groups did not exhibit a significant increase in F(2)-isoprostanes from baseline to immediately postexercise compared with P. This study indicates that combining flavonoids and antioxidants with n-3 fatty acids is effective in reducing the immediate postexercise increase in F(2)-isoprostanes. Moreover, this effect occurs independently of changes in plasma antioxidant capacity (65).

Performance in many team sports is partially dependent on the ability to perform repeatedly at high intensity. Previous research demonstrates that capsaicin (CAP) has physiological and metabolic effects that could influence exercise performance and inflammation. A study was conducted to investigate the influence of CAP on performance and the interleukin-6 (IL-6) response to repeated sprints. Relative to the placebo control, CAP significantly increased the sum of ratings of gastrointestinal distress (GD) symptoms by 6.3-fold. There was no difference between treatments in fastest or mean sprint time, fatigue, IL-6 response, rate of perceived exertion (RPE), or muscle soreness but CAP did not influence repeated sprint performance or the IL-6 response and caused substantial GD. Therefore, CAP is not recommended for athletes involved in repeated sprinting (66).

Blueberries are rich in antioxidants known as anthocyanins, which may exhibit significant health benefits. Strenous exercise is known to acutely generate oxidative stress and an inflammatory state, and serves as an on-demand model to test antioxidant and anti-inflammatory compounds. A study was conducted by McAnulty et al. (67) to examine whether 250 g of blueberries given per day for 6 weeks and 375 g given 1 h prior to 2.5 h of running at 72% maximal oxygen consumption counters oxidative stress, inflammation, and immune changes in well-trained subjects. Blood, and urine samples were obtained pre-exercise and immediately postexercise,and blood and urine 1h postexercise. Increases in blood F-isoprostanes and urine RNA (5-OHMU) were significantly less in blueberry and plasma IL-10 and natural

killer (NK) cell counts were significantly greater in blueberry vs. control. So, daily blueberry consumption for 6 weeks increases NK cell count,and acute ingestion reduces oxidative stress and increases anti-inflammatory cytokines (67).

Boron supplement, a trace element nutrient, has been shown to increase the concentration of plasma steroid hormones and suggested as an ergogenic safe substance for athletes, however it should be further investigated (68). Chromium apparently has a role in maintaining proper carbohydrate and lipid metabolism in mammals. As this role probably involves potentiation of insulin signaling, chromium dietary supplementation has been postulated to potentially have effects on body composition, including reducing fat mass and increasing lean body mass. Chromium may have beneficial effects in athletes who may have exercise-induced increased urinary chromium loss; however, its effectiveness in manifesting body composition changes has been an area of intense debate in the last decade (69). Ca may increase non esterified fatty acids availability although it is not clear whether this effect occur. Ca and caffeine can increase non esterified fatty acids availability under certain circumstances which could theoretically enhance fat oxidation, yet strong experimental evidence for this effect during exercise is lacking. Co-administration of nutrients to maximize their effectiveness needs further investigation (19).

Spaccarotella and Andzel (70) reported that low fat chocolate milk may be as good as a carbohydrate electrolyte beverage at promoting recovery between training sessions during preseason in soccer players. While the effect of fish oil supplementation on fat oxidation during exercise are conflicting. In spite of some strong putative mechanisms, the only crossover trial showed no significant effect on lipid during exercise (19). On the other hand fish oil showed previously to possess anti-inflammatory activity (71) so, may afford potential benefits in athletes in this respect.

The impact of the pharmaceutical preparations Ripronat and Rotavit Royal on the physical working capacity and psychomotor performance of the young football players during their basic preparatory period of physical conditioning was studied in male football players. The medicament was given for 4 weeks. Results showed that ripronat increase the aerobic capacity and psychomotor performance of football players, and it would be recommended for administration during early stages of training, when main emphasis is made on aerobic performance (72).

Studies in endurance athletes have shown strain-specific probiotic benefit in terms of maintenance of immune function and, for certain strains, reduction of episodes of respiratory and/or gastrointestinal tract infections (73) . Also, certain strain of probiotic was shown to possess anti-inflammatory activity (60) thereby potential health benefit of such strain is expected in athletes.

Necessity of special nutrition and functional food for athletes and prospective studies

Nutrition is very important for athletes. Athletes for each sport game needs special nutrition for the training time and for playing the game itself. Different nutrients' deficiency and physiological disorders may appear if athletes do not receive the proper nutrition. A need for some type of planned action is necessary to combat this problem. This planned action includes studying the nutritional status of athletes practicing different games with consequent formulation of suitable functional foods for each case along with prescription of the proper dietary regimen. A follow up study must be required to prove the efficiency of the studied formula. Safe and efficient special food products are required to have healthy athletes enjoying fitness and performance.

Prospective studies are required to prepare innovated functional foods for athletes to be given before, during and after training. Also a long term special foods must be prepared to prevent nutrient deficiency in athletes. More studies are needed to examine the influence of consumption of new innovated special formulas on the fitness and performance in athletes. It is also important to follow up different biochemical and anthropometric measures in athletes after supplementation of such innovated functional foods. First of all studying basal line of nutritional status, physiological and biochemical changes occur due to practicing different sports and training is very necessary before any dietary intervention. Formulation and preparation of different functional foods that suit each case utilizing the aforementioned nutrients and phytochemicals must be studied well. Analysis of nutrients and phytochemical contents of such proposed special food formulas must be carried out to know the exact percentage of all constituents after food processing. Different strains of probiotic incorporated as functional foods and their impact on athletes health are worthy to be studied. Intervention and evaluation of the functional foods in athletes during follow up study of the different anthropometric (body mass index; skin

fold thickness, mid arm circumference and muscle mass... etc to determine % body fat and protein) and biochemical parameters must be carried out. Biochemical parameters of blood and urine will help to detect any changes in the metabolism or any nutrient deficiency. The biochemical parameters differ according to the applied functional food whether before, during or after exercise or game. Also the biochemical parameters to be determined differ according to the type of sport. Generally, haemoglobin, haematocrit and other parameters reflecting anaemic state are important to be determined. Plasma lipid profile, free fatty acids, total protein, albumin and globulin are necessary to be assessed. Blood urea nitrogen, creatinin, uric acid, lactate and plasma activity of transaminases (ALT, AST) and lactate dehydrogenase are among the essential parameters to be estimated. Beta-hydroxy butyrate, glutamine, creatine phosphokinase and minerals are necessary to be determined. White blood cell count must be followed. Interleukin-6,tumor necrosis factor-α, biomarkers of oxidative stress, biomarkers of antioxidant state are necessary to be assessed to follow up any improvement in the inflammatory biomarkers and oxidative stress of athletes. Certain hormones such as cortisol, testosterone, growth hormone and insulin must be followed. Assessment of physiological parameters such as vital capacity, maximal oxygen consumption (VO2 peak), breath reserve and breath frequency, fitness and performance are doubtless essential to be studied. Full clinical investigation including heart rate, blood pressure, electrocardiogram etc must be continuously recorded during the follow up study.

In addition to the proposed functional foods, a dietary regimen should be designed to better enhance athletic performance and minimize any health risks associated with practicing games. The outcomes of the present study are expected to have a direct impact on the athletes health and therefore their skills and performance.

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