Nutrition Considerations for Athletes with Physical Disabilities

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Abstract
Nutrition, which is an important factor that improves physical performance, has a major place in the lives of both disabled and nondisabled athletes. The main purpose of nutritional assessment of disabled athletes is to assess the individual's consumption to determine the insufficiencies and to suggest the necessary changes to design the most appropriate nutrition plan. Nutrition strategies play a key role in confirming the performance of disabled athletes. Considering the nature of the disability and the specific sports branch, it is important to determine the necessary nutrition solutions to ensure the best protection for the athletes concerned. The literature on the specific nutritional needs for the best sports performance of disabled athletes is insufficient and should be considered in light of current information on specific disability physiology.

Introduction

Although there are many comprehensive studies about the effects of nutrition on the performance of athletes, studies on disabled athletes are limited (1). Little is known about the nutritional needs and problems of disabled athletes. There is a need for more nutritional information and proper nutrition practices for disabled athletes than regular athletes participating in competitions and those who exercise for health (2).

Nutrition, which is an important factor in the physical performance of athletes, has an important place in the lives of both disabled and nondisabled athletes (3). Adequate nutrition guarantees the recovery of energy and the need for energy generation for the activity. Besides, inadequate energy intake causes the energy balance to shift significantly to the negative side (4). An inadequate diet in terms of quality and quantity plays a role in the development of diseases that can lead to nutritional deficiencies and disabilities (5).

Performance of athletes is about genetics, ability, power, type of sport, training as well as nutrition. Current studies are mainly a comparison of disabled athletes versus nondisabled athletes, and a few studies on athletes participating in Paralympic Olympics (2). In Paralympic sports, there is not enough knowledge about their nutritional needs and also about this population's food intake. It may be because of the heterogeneity of their disabilities (6). Every type of disability may require a specific nutrition plan. The main purpose of nutritional assessment of disabled athletes is to define the individual's consumption, to know the mistakes, and to suggest the necessary changes to design the most appropriate nutrition plan. Hydration status, muscle fuel, energy utilization, and ergogenic support should be taken into account when creating a nutrition strategy for disabled athletes (7). The energy requirement and nutritional needs of the athlete differ according to the region and type of physical disability. Although there are no standard values for the athletes' daily recommended energy and nutrient intake levels (DRI), athletes are similar to the general population and have a variety of nutrient requirements and composition (1). The important thing is to create an appropriate diet program by calculating the requirements specific to the athlete. This article reviews the nutritional status and needs of athletes with physical disabilities in terms of energy, macronutrient, and micronutrient requirements.

Ideal Body Weight

Amputation adjustment

For people with amputations, adjustments need to be done by using the following equation via the factors in the Table for the estimation of ideal body weight (IBW) (8).

$$[(100\text{-}\%\text{amputation})/100] \times \text{IBW for original height}$$

Spinal cord injury adjustment

For people with spinal cord injuries, IBW estimation should be adjusted as:

–For paraplegia, subtraction 5% to 10% from IBW.
–For quadriplegia, substraction 10% to 15% from IBW.

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Table.
Amputation adjustments for estimating IBW.

Percentage Body Weight Contributed by Body Part	
Hand	0.7%
Forearm and hand (below elbow)	2.3%
Entire arm	5.0%
Foot	1.5%
Lower leg and foot (below knee)	5.9%
Entire leg	16.0%

In the Paralympic games, 1749 volunteer-disabled athletes' heights and body weights were measured to calculate body mass indices. The prevalence of obesity was found to be higher (at least 3.1 times more) in the athletes of the United Nations (UN) and at higher risk.

In addition, the prevalence of obesity is high in the general population of the UN. It is foreseen to eliminate the situations that contribute to the development of obesity and create health risks (9). In a study of Latin American Special Olympic athletes, >40% of disabled athletes were found to be overweight and obese. These results suggest that efforts need to be made to prevent and reduce the rates of overweight and obesity among Latin American Special Olympics participants (10). In another study, nutritional status and anthropometric measurements of 15 athletes (mean age, 32.3 years) of a Brazilian amputee football team were evaluated before the world championship. Although there is no parameter to compare amputee athletes with nondisabled athletes, it is noticed that the presence of fat tissues of amputee athletes are much higher when compared with nondisabled athletes. According to their positions on the football field, the subcutaneous fat tissue and body weight of the midfield players are found to be more than others (11).

Resting energy expenditure and metabolic rate

The resting energy expenditure (REE) is the amount of energy the body uses to maintain normal functions and homeostasis. REE is affected by factors such as age, body composition, gender, climate, hormonal status, and body temperature (12). It is stated that the resting metabolic rate (RMR) of disabled athletes is 12% to 27% lower than nondisabled athletes. The level of disability of the athlete affects the metabolic rate (13). It is thought that the low muscle mass of the disabled athletes causes lower RMR compared with healthy athletes. However, in a study conducted on athletes with spinal cord injury, it was found that RMRs were not significantly different when compared with the control group (14). In another study, paraplegic individuals were found to be low in RMR due to low lean tissue mass (15). Furthermore, the RMR of paraplegic tennis and basketball players was found to be 9% to 12% lower than the values predicted by the Harris-Benedict equation (7).

RMR is an important component of total energy requirement, and it is very important to ensure energy balance in increasing the performance of disabled athletes (13). The limited number of studies conducted in this area has led to the inability to develop specific equations for disabled athletes. Therefore, it is recommended to calculate the RMR of disabled athletes by indirect calorimetry.

In a study of 25 healthy individuals with a mean age of 33.5 years, and 37 disabled individuals with a mean age of 31 years, 40% of the disabled were overweight, and 14% were obese. Also, in individuals with disabilities, REE, lean body mass, and bone mineral density were found to be less, and fat mass was found to be higher than the individuals without any disabilities (16).

Energy expenditure and requirements

There is a wide range of energy requirements for disabled athletes according to the physiology of the sport and the functional abilities of the individual athlete. Most studies on energy expenditure were performed with athletes with spinal cord injury. When a spinal cord lesion occurs, the athlete's maximum heart rate decreases. Studies have shown that athletes with spinal cord injury have lower RMR. Visually impaired athletes generally have similar energy requirements compared with healthy athletes. However, factors, such as access to shopping, cooking opportunities, dietary difficulties, and social activity, can affect the daily diet types and the amount of energy consumed on a daily basis. Determining the food consumption of these athletes is important (6).

Collins et al. (17) and Ainsworth et al. (18) developed a reference range using the metabolic equivalent of task (MET) score to calculate the amount of the energy consumption for the wheelchair users. For adult athletes with spinal cord injuries, the accepted 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ METs score was reduced to 2.7 $mL \cdot kg^{-1} \cdot min^{-1}$ METs score. Acceptable scores should be developed for elite athletes and young athletes with spinal cord injuries.

Daily energy expenditure is calculated as the sum of four different energy outputs: RMR, thermal effect of nutrition, adaptive thermogenesis, and thermal effect of activity. These indices deviate from the estimated calculations for the general population in Paralympic athletes (19).

The energy requirements of disabled athletes are lower than those of healthy athletes. It has been determined that this requirement is between 1500 and 2300 kcal on average (20,21). According to Mountjoy et al. (22), a negative energy balance in athletes can cause Syndrome's Relative Energy Deficiency in Sport. In this syndrome, various systems can be affected in the human body. These systems may include, gastrointestinal system, metabolism, immune system, hematology and endocrine systems, cardiovascular and skeletal systems, and psychology. This leads to negative changes in glycogen stores, muscle strength, performance, increased risk of injury, and reduced response to training.

The distribution of energy intakes for healthy individuals should be 55% to 60% from carbohydrates, 12% to 15% from protein, and <30% from fat. Due to the trauma to the body, high protein and due to the inactivity caused by disability, reduced fat intake (<25% of total energy intake) is needed (1).

Carbohydrate

Although the energy expenditure of athletes in wheelchairs is lower, the contents of the carbohydrate portions are similar when compared with healthy athletes (23,24). Optimal carbohydrate intake with diet is important to maintain body weight and regenerate glycogen stores

(25). Inadequate intake of carbohydrate causes negative effects, such as reducing oxygen concentration and supply, increasing muscle cramps and injuries, causing weakness, and eventually lowering the performance of the athlete (26). In a study of Ferro and colleagues (27), in which nutritional habits and performance status of elite wheelchair athletes were evaluated, it was stated that the carbohydrate consumption of the athletes was lower than the recommended values and the fat consumption was found to be higher than requirements. Wheelchair athletes, regardless of the cause of the disability, use the upper muscles and arms of the body more. Wheelchair athletes have similar glycogen use as healthy athletes but glycogen stores were found to be low at the beginning of the exercise. Therefore, a high rate of carbohydrate before exercise will increase the performance of athletes (21).

Recommendations of carbohydrate-rich foods and fluid consumption for the recovery process to healthy athletes also are recommended for athletes with disabilities. Although the intake of carbohydrates to increase the durability of the athlete is not known, there is very limited literature on this issue for disabled athletes (28). In a study by Spendiff and Campbell, before the 20-min arm crank ergometer training, 8% carbohydrate solution is given to a group and placebo is given to the other group. After all, the performance of the group consuming 8% of the solution is increased by 1 km (11.5 km vs. 12.5 km) (29). In another study, it was found that 1 $g\cdot kg^{-1}$ of maltodextrin supplementation with whey protein before exercise increased the exercise performance (30). In a study in which the nutritional status and supplementary use of Paralympic athletes were investigated, it was found that the average carbohydrate consumption of the participants was 3.5 $g\cdot kg^{-1}\cdot d^{-1}$ (31). In the current literature, although the recommended daily intake of carbohydrates was 5 to 10 $g\cdot kg^{-1}\cdot d^{-1}$ for athletes with disabilities (25), it was found that athletes consumed lower amounts of carbohydrates (27,32).

Protein

During exercise, there is a negative balance between protein synthesis and disintegration rates throughout the body and an increase in the oxidation rate of amino acids, which causes a transient catabolic state. Protein catabolism increases, depending on the type of exercise. If sufficient dietary protein is not consumed in the recovery process for muscle protein synthesis, protein catabolism will overcome protein synthesis and result in loss of muscle mass and negative nitrogen balance. When the amino acid and energy intake is sufficient for a long period of recovery after exercise, a positive protein balance is formed throughout the body (33). It is argued that the use and requirement of protein after exercise is similar to that of nondisabled athletes. If the individual has a pressure injury, the need may increase a little more (34). Arginine is recommended because of its vasodilating, collagen synthesizing and cytokine response enhancing properties in wound healing (35,36), but the medical history of the athletes should be examined and evaluated (6). In one study, nutritional profiles of elite disabled long distance racing athletes were examined. Ten male athletes (174 cm in height, 62.2 kg in weight) with a mean age of 30.7 (18-46 years) participated voluntarily. The average daily energy intake of disabled athletes was found to be 2138 kcal (34.5 $kcal\cdot kg^{-1}$), below the recommended value for active men (3500 $kcal\cdot d^{-1}$, 52 $kcal\cdot kg^{-1}$) and protein consumption (104 $g\cdot kg^{-1}$) was found to be more than female athletes with similar energy intake (37). In another study, as a result of nutritional assessments of athletes; energy intakes were found to be sufficient, but the energy distributions were incorrect and protein intakes were inadequate. It is suggested that a good nutrition plan is needed for the athletes who want to increase their performances (11).

Disabled athletes do not have a customized protein intake recommendation. In studies performed in disabled athletes, daily protein intake was determined as 1.4 to 1.6 $g\cdot kg^{-1}\cdot d^{-1}$ (27,31). For healthy athletes, the suggestion of daily protein intake is 1.2 to 2.0 $g\cdot kg^{-1}\cdot d^{-1}$ (38), and in the studies, it is stated that athletes with disabilities get enough protein (27,31), but more studies are needed about this issue.

Fat

Fats which are basic elements of cell membranes are one of the main components of a healthy diet that facilitates the absorption of fat-soluble vitamins. Fats are used as the substrate for energy in the form of plasma free fatty acids, intramuscular triglycerides, and adipose tissue, especially in endurance training (38). The number of the studies on the dietary fat requirements as well as the protein requirements of disabled athletes are quite limited. In a study that investigated the nutritional status and nutritional knowledge of amputee wheelchair basketball players, it was determined that athletes provided 44% of their daily energy requirement from fats (39). In another study conducted with spinal cord injury athletes, it was determined that athletes obtained 29% of their daily energy from fats (20). These differences may be due to local reasons as well as the lack of knowledge of athletes. In Potvin and collegues' (37) study with disabled athletes, it was determined that vitamin and mineral consumption were sufficient and the energy distribution of macronutrients was found to be 19.5% for protein, 47.9% for carbohydrate, and 32.1% for fat, respectively (37). For healthy athletes, the recommendations in the literature indicate that the dietary fat distribution should be 20% to 35% (38), but there is no specific recommendation for the athletes with disabilities.

Micronutrients

The distribution of macronutrients needs to be planned to ensure the presence of substrates to regulate metabolic pathways and to modulate physical training-induced musculoskeletal adaptations (40). It is considered to be appropriate for disabled athletes that micronutrients other than vitamin D are at the recommended level for nondisabled athletes (41). The effects of vitamin D supplementation of 6000 $IU\cdot d^{-1}$ for 12 wk in athletes with spinal cord injury with inadequate vitamin D levels were investigated. At the end of the study, an increase of 11% in the zometric elbow flexion force of the athletes was observed and no significant change was observed in peak strength or average strength during arm crank ergometer (42). According to some sources, calcium, iron, vitamin C, beta carotene, thiamin, folic acid, and copper are recommended to the athletes with spinal cord injuries; calcium, iron, and niacin supplements also are recommended for athletes with cerebral palsy (43).

In a study with 33 disabled Olympic athletes (19 with cerebral palsy, 14 with visually impared), according to their food consumption records, 64% of visually impaired athletes and 53% of athletes with cerebral palsy consumed <800 $mg \cdot d^{-1}$ of calcium. Calcium consumption of athletes with cerebral palsy was found to be in the range of 446 to 638 $mg \cdot d^{-1}$. It was determined that the athletes consume milk less than two cups per day and do not receive calcium supplements (16). In another study with wheelchair athletes, it was found that they consumed insufficient amount of micronutrients other than vitamin A, vitamin E, niacin, riboflavin, thiamine, vitamin B_6, vitamin B_{12}, iron, phosphorus, and selenium. It is suggested that nutritional supplements may be a possible solution if only adequate nutrient intake cannot be achieved by regular diets. In addition, it is suggested that it will be beneficial to develop nutrition education for the athletes and to make dietary records and analysis to ensure adequate vitamin and mineral intake (44).

Fiber and fluid

Water is an essential nutrient for both intracellular and extracellular biochemical and physiological functions. About 50% to 70% of the human body consists of water. Body water content is directly related to body composition; as the muscle mass increases, the body's water mass increases. Physiological loss of 1% to 2% water from the body affects both aerobic and anaerobic performance (45). In the study performed with disabled athletes, the level of knowledge about the hydration status of athletes was found to be low (3). Athletes should be trained in self-determination of hydration status. In determining the hydration status, urine color is considered a method that can be used in athletes (46). The recommended fluid intake levels for athletes have not been determined due to the low number of studies specific to disabled athletes. Therefore, it is more appropriate for athletes to be trained to determine their own situation.

Dietary fiber intake—whether an athlete or not—may be insufficient in the majority of disabled people (20,21). In physically disabled individuals, intestinal transition can last up to 80 h and cause serious gastrointestinal problems (47). Such problems like constipation will decrease the performance of the exercise (48). In a study that examined nutritional status of paralympic athletes, dietary fiber intake levels were found to be low (31). It is recommended that the athletes should be educated about the importance and sources of dietary fiber; furthermore, a diet rich in fiber and combined with adequate fluid intake is recommended to regulate bowel movements (49).

CONCLUSIONS

Nutrition strategies play a key role in determining sports performance in athletes with physical disablilities. Considering the nature of the disability and the specific sports branch, it is necessary to determine the needed nutrition solutions to ensure the best protection of the athletes concerned. The literature on the specific nutritional needs for the best sports performance of disabled athletes is insufficient. Care should be taken in the application of nutrition strategies applied to nondisabled athletes in disabled athletes. The specific needs of such athletes should be considered in the light of current information on specific disability physiology. Active disabled athletes who participate in sports should be provided with adequate and balanced nutrition, educated about the effect of nutrition on the performance, the importance of fluid consumption, and supplementation by the dietician.

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