

ROLE OF NUTRITION FOR INJURY REHABILITATION IN ATHLETES AND FOR BETTER PERFORMANCE AFTER RECOVERY: A REVIEW

Abstract

The process of restoring to normal life after injury, by proper training and therapy is known as rehabilitation. There is no sports participation without the risk of injuries and fear of injury affects the performance of athletes. There are various types of sports injuries that are categorized under muscle, joint, and bone injuries. These injuries occur because of inadequate nutrition, improper techniques, use of improper equipment, and because of not wearing protective equipment. After having an injury, it is important to recover quickly and to enter the game as soon as possible. The role of nutrition during rehabilitation is very important and providing an adequate amount of nutrition is mandatory as micro and macro nutrients which are present in an athlete's diet can speed up the recovery time if consumed in proper amounts. Strain, sprain, dislocation, fractures, knockout, punch syndrome, wrestler ear weightlifter blackout, etc are some common sports injuries. In this review, we have focused on the role of various micro and macronutrients and certain supplements which are required for injury recovery. Intake of a diet that is rich in protein, carbohydrates, fats, antioxidants, fiber, omega-3 fatty acids, phytochemicals, and vitamins C and D is very beneficial as it increases the recovery rate. Probiotics, dietary fiber, and prebiotics decrease the side effects caused by antibiotics and are also responsible for increasing the absorption of protein. Phytochemicals are found in fruits and its consumption through whole food is considered beneficial as compared to supplements. Phytochemicals

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reduce muscle soreness and inflammation and increase the recovery time. During rehabilitation, maintaining energy balance is very important as a negative energy balance can reduce muscle mass. Intake of collagen, with gelatin and vitamin C, helps in joint and tendon injury recovery. It also reduces knee pain and increases the thickness of the cartilage. Vitamin D can be received from sunlight and can also be consumed through supplements. Intake of vitamin D and calcium supplements increases bone density.

Keywords: Rehabilitation; Athletes; Micronutrients; Macronutrients; Muscle Injury; Bone Injury; Joints Injury; Nutrition; Postsurgical

I. INTRODUCTION

Rehabilitation means recovery or coming back from any kind of injury, which might occur because of accidents or other possible reasons. If we talk about athletic performance, injuries are an inevitable consequence, sustained once or more by them during their athletic career (Close *et al.*, 2019). Despite the health benefits of sports and sports activities (such as physical, physiological, and cognitive aspects), injury, or fear of sports injury acts like a barrier and restrict players from participation (Papadopoulou, 2020). There is no sports participation without the risk of injuries and about one-third of these injuries require up to 7 days of absence from training or competition (Turnagöl *et al.*, 2021). Over 5 million injuries are recorded every year worldwide out of which the maximum cases are reported during the period of competition (Vallejo *et al.*, 2023). Out of overall injuries, skeletal muscle injuries account for 40%, with the lower leg being the predominant site. However, the head and neck followed by lower and upper limbs are commonly injured regions, whereas superficial tissue and skin injury are quite common tissue-type injuries followed by joint capsules and ligament injuries (Turnagöl *et al.*, 2021). Other common injuries include stress fractures, tendons, and ligament injuries, which might occur because of high-impact sports in athletes having low nutrition availability (Close *et al.*, 2019). Injury although vary from male to female as well as between age groups (Ozturk & Kilic 2013). According to the data from “Sports injuries and illnesses in the Tokyo 2020 Summer Olympics”, it is estimated that, out of 11315 players, 206 players were reported injured or ill because of sports activity. Tokyo 2020 medical staff reported 3.9 illnesses and 9.1 injuries per 100 athletes over the period of 17 days (Ozturk & Kilic 2013).

Some common types of sports injuries are sprain, strain, dislocation, fractures, knockout, punch syndrome, wrestler ear, wrestler ear, weightlifter blackout, stitch at the side, low back pain, shoulder impingement, tennis elbow, javelin throwers elbow, boxer elbow, mallet finger, runner’s knee, jumper’s knee, shin splint, and turf toe. (Elmagd, 2016). **Sprain** is a lower limb injury that accounts for 16%-40% of overall sports injuries (Halabchi & Hassabi, 2020). It is a kind of injury that affects the anterior talofibular ligament and is most common in basketball, American football, and soccer players (Halabchi & Hassabi, 2020). **Strain** injury mechanisms generally involve high muscle-tendon units, high-velocity movements, and extensive muscle-tendon units (Hickey *et al.*, 2022). **Dislocation** is a bone injury in which the end of the bones is shifted from their normal positions, the most common type of dislocation in sports are shoulder, knee, and elbow (Elmagd, 2016). **Fractures** account for 10%- 15% of all sports injuries. According to the data, 23.7% of fractures are caused by playing basketball, and, 24.9% is radius fracture (Wang *et al.*, 2019). **Knockout** refers to the traumatic loss of consciousness because of powerful blows which cause a cerebral concussion (Elmagd, 2016). **Punch syndrome** is commonly seen in boxers because of knockout blows, indicated by lower limb weakness, gait unsteadiness, slow muscular movement, speech hesitancy, hand tremors, and mental dullness. **Wrestler’s ear** refers to the injury which is commonly seen in boxing, rugby, and wrestling players, caused because of injury or blunt trauma to the external ear (Haik *et al.*, 2018). **Weightlifter blackout** is caused because of the reduced cardiac output and blood flow as the very high thoracic pressure is released (Compton *et al.*, 1973). **A stitch at the side** is a performance-limiting pain that often occurs during swimming or running (Eichner, 2006). **Low back pain** is an injury that affects the bony lumbar spine, discs between the vertebrates, ligaments around the spine and discs, spinal cord and nerves, muscles of the low back, integral organs of the pelvis and abdomen,

and the skin covering the lumbar spine (Elmagd, 2016). **Shoulder impingement** appear because of repetitive overhead activities is sports like swimming, volleyball or handball where the subacromial soft tissues are inflamed (Castaldo *et al.*, 2023). **Tennis elbow** is a lateral elbow injury where the upper limb function is limited (Ikonen *et al.*, 2022). **Javelins throwers elbow** is restriction and inflammation and pain around the elbow joint and forearm due to the damage to tendons, bones, ligaments, and forearms (Elmagd, 2016).

According to the various types of injuries, the most common type of tissue injuries are superficial tissue and skin (42.9%), and joint capsule (31.4%) (Wang *et al.*, 2014). Joint sprains account for (31.4%), contusions (19.7%) which is common in sports like boxing, judo, taekwondo, and wrestling, concussions account for (3.2%) and muscle injury accounts for 9.5% (Wang *et al.*, 2014).

There are various risk factors for injury, such as, not wearing protective equipment, training status, weight categories, and low nutrition availability (Turnagöl *et al.*, 2021). Nutrition plays a vital role in the prevention of injury and in avoiding lean mass loss, by preventing oxidation of amino acids during immobilization (Close *et al.*, 2019; Rodriguez *et al.* 2007). Balancing energy requirements during the time of rehabilitation is important as it may foster recovery, (Close *et al.*, 2019). Usually, as there is a decrease in physical activities of athletes, therefore the energy requirements are reduced, but to prevent a decline in muscle mass, elevating protein intake to 2.0g/kg/day is recommended, as it also prevents the accumulation of fat in athletes (Papadopoulou, 2020). Supplements such as collagen, gelatin, and vitamin C are generally recommended for recovery during joint, tendon, and connective tissue injury (Turnagöl *et al.*, 2021). Gelatin provides both, prophylactic and therapeutic treatment for ligament, tendon, and for bone health, as it improves the thickness of cartilage (Peeling *et al.*, 2018). Fish and fatty acids have anti-inflammatory properties as they are rich in antioxidants, therefore they are beneficial to injured athletes (Papadopoulou, 2020). Some injuries require rest and nutrition to recover while others require surgery.

II. POSTOPERATIVE NUTRITIONAL REQUIREMENTS

It is recommended that before surgery, the diet should contain high carbohydrates and protein, for the night which is before surgery there should be a decrease in the amount of carbohydrates and protein in the diet and before few hours before surgery a clear liquid diet should be consumed containing essential amino acids and starch (Ryan *et al.*, 2020). After surgery, the body enters a hypermetabolic state which requires the support of micro and macro-nutrients (Ryan *et al.*, 2020). The main goal after surgery is to maintain muscle mass, control blood glucose levels, maintain the energy demand of the body, and enhance the recovery rate. There is an increase in energy demand during the recovery phase therefore it is important to focus on calorie, protein, and micronutrients requirement during this period (Tipton, 2015). As there is a decrease in the physical activities of athletes after surgery, therefore energy requirements also decrease. Proper energy balance is the priority during rehabilitation as there can be a loss in muscle mass because of a negative balance of energy. In order to prevent sarcopenia, there should be a higher energy intake of around 25-30kcal/kg of body weight. As higher energy can lead to the deposition of fat in the body, therefore resistance training is also important, and, also increasing protein intake by up to 2.0g/kg/day can be beneficial (Turnagöl *et al.*, 2021).

III. NUTRITION FOR MUSCLE INJURY REHABILITATION

The primary goal during rehabilitation is to heal the injured area and to return to competition, which can be done with the help of proper nutrition, as it improves the healing process and helps in enhancing the performance of the athlete (Papadopoulou, 2020). The most common type of sports injury which can also lead to immobilization and decrease in physical activity is muscle injury (Turnagöl *et al.*, 2021). Amino acids and protein, antioxidants, creatine, and omega-3 are given special attention as they prevent muscle loss and promote injury healing (Turnagöl *et al.*, 2021).

- 1. Amino Acids and Protein Intake:** There is a loss of up to 0.5-0.6% of muscle mass per day during immobilization, which results in loss of strength, and neuromuscular degeneration followed by muscle atrophy (Vallejo *et al.*, 2023). According to the research, athletes and other individuals who are indulged in physical activities require a protein intake more than that of the normal recommendation (0.8 g/kg/day), at the time of health disturbances like inflammation and sickness higher dose of protein is recommended to maximize muscle protein synthesis, the protein recommended is up to 2.2 g/kg/day (Evans *et al.*, 2023; Papadopoulou, 2020). It is suggested that no health issues are observed because of a higher intake of protein in a healthy person (Evans *et al.*, 2023). During recovery, key importance should be given to the type, amount, timing, and frequency of protein intake. It is observed that extracts of whey protein have proximate amino acid content and are found in skeletal muscles in approximate proportions. Quality of protein plays a vital role as compared to quantity of protein for example, the result after giving 2g of leucine and 20-30g of high-quality protein is the same in muscle mass and strength (Papadopoulou, 2020). An increase in protein intake during recovery prevents muscle loss but it is also observed that if combined with aerobic and resistance exercise it provides a positive effect, as seen in the case of a woman who was provided with 1.6g/kg protein per day when she was on bed rest for 60 days where aerobic and resistance exercise enhanced the recovery effect (Turnagöl *et al.*, 2021). It is suggested that instead of taking supplements, consuming protein from whole food like eggs, dairy products, fish, legumes, and cereals support the gut microbiota and this should be highlighted in the diet plans of athletes (Kårlund *et al.*, 2019). It is important to balance the daily protein distribution, i.e., consumption of protein in breakfast meal should be between 31.5±1.3g, for lunch it should be 29.9±1.6g and for dinner it should be 32.7±1.6g as it enhances the muscle synthesis by 25% more (Turnagöl *et al.*, 2021).
- 2. Creatine:** Creatine in the form of creatine monohydrate (CrM) is the safest and most widely studied nutritional supplement (Kreider *et al.*, 2022). According to the research, there is an increase in myogenic regulating factor 4 (MRF4) which is responsible for greater muscle fiber area and peak strength after taking creatine supplementation up to 15g/day for 3 weeks during rehabilitation (Kreider *et al.*, 2021). Creatine intake benefits the athlete's recovery time and performance by increasing the total musculoskeletal creatine pool by up to 25% (Vallejo *et al.*, 2023). During the period of supplementation, CRM supplementation helps in maintaining muscle mass, strength and endurance, muscle creatine concentration, GLUT-4 concentration, muscle glycogen, IGF-1, and myogenic regulatory factors (Vallejo *et al.*, 2023).

3. Omega 3 Fatty Acids: At the time of muscle recovery, inflammation, pain, and swelling takes place and it is considered as a part of the natural tissue recovery process (Turnagöl *et al.*, 2021). It is considered that prostaglandin which is produced from omega-3 has an anti-inflammatory function and it is also responsible for improving blood flow and reducing swelling and pain (Jouris *et al.*, 2011). These unsaturated fatty acids improve lipid oxidation by acting as antioxidants, found highest in virgin olive oil (Papadopoulou, 2020). According to the research, the consumption of fish oil reduces muscle loss during injuries, and 10 consecutive days of consumption of fish oil pills alleviated muscle atrophy in immobilized rats, however, no studies have investigated the same effects on immobilized human (Turnagöl *et al.*, 2021). Consumption of fish oil is considered beneficial for muscle loss but is not effective for gaining muscle mass hence intake should be in appropriate doses (Papadopoulou, 2020).

IV. NUTRITION FOR JOINT INJURY REHABILITATION

As the maximum movement of an athlete's body depends on joints, therefore joint injuries are the most common type of injuries in sports. Sprain, strain, dislocation, and wrestler ear, etc. are some usual joint injuries in sports. Such injuries can cause immobilization and can also affect the performance of the athlete (Turnagöl *et al.*, 2021). Supplements like collagen, gelatin, and vitamin C are helpful in improving the recovery period of such injuries.

In bones, tendons, ligaments, and cartilage, the primary structural protein is collagen. Tendons are composed of water (around 55-70%) and dry mass around (30-40%) (consisting of extracellular matrix), out of which 60-80% of dry mass contains collagen (mainly collagen type 1) (Taye *et al.*, 2020). It is considered that oral intake of type 1 collagen improves the collagen fibrils composition in tendons and hydrolyzed collagen stimulates the collagen cycle regulation (Turnagöl *et al.*, 2021). According to the research, intake of about 10g of hydrolyzed collagen supplementation per day helps in increasing the thickness of cartilage in patients and it also reduces knee pain (Vallejo *et al.*, 2023).

Table 1: Tabular Representation of Collagen Benefits on Joint Injuries

Injury	Supplement	Duration
Joint pain	25ml liquid collagen + 10g hydrolysed collagen	24 weeks per day
Chronic ankle injuries	5g collagen peptide	6 months per day
Tendon and ligament injuries	10-15g hydrolysed collagen	3 months Per day

(Turnagöl *et al.*, 2021)

Gelatin is used as an ideal supplement for repairing cartilage defects (Maihemuti *et al.*, 2023). While using an in-vitro model, it has been proved that gelatin with vitamin C can improve collagen production as after treating ligaments with vitamin C and pro-collagen amino acids, collagen production increased three times (Paxton *et al.*, 2010). During an injury and after returning to the field, it has been proved that gelatin is beneficial in collagen production following the cases when 15g gelatin was consumed before 1 hour for a 6-min rope test which was conducted to stimulate collagen production, it was recorded that the rate was increased by two times (Shaw *et al.*, 2017). According to research which was conducted on rats by using vitamin C to study oxidative stress it was observed that the number of chondrocytes, fibrocartilage, and collagen after 6 weeks were comparatively increased and the intensity of dihydroethidium and protein carbonyls after 6 weeks were decreased no difference was observed in biochemical strength. This shows that vitamin C decreases oxidative stress and accelerates healing (Uehara *et al.*, 2023). Citrus fruits like kiwi, strawberries, lemon, orange etc, and other food items like broccoli, and pepper should be consumed during rehabilitation.

V. NUTRITION FOR BONE INJURY REHABILITATION

Bone stress injuries generally affect the return to sport timeline, and it is noted that bone injuries of some regions like the femoral neck, anterior tibial shaft, and tarsal navicular are generally related to high rates of obstacles (Hoenig *et al.*, 2023). About 27% of fractures take place in mixed martial arts sports which accounts for the maximum percentage out of the total sports followed by wrestling which is 21.3% and then kickboxing which accounts for 20% (Turnagöl *et al.*, 2021). Fractures generally occur due to insufficient nutrient intake and in those areas of the bones where there is overuse of injuries as repeated force is applied over that region (Moran *et al.*, 2012). Bone stress injuries can be treated with simple activity modification, non-weight-bearing immobilization, medications, and surgery (Hoenig *et al.*, 2022).

Role of Vitamin D in Bone Injury: Vitamin D and calcium play a vital role in bone recovery which is necessary for athlete's rehabilitation. There are positive impacts seen on muscle growth and cell differentiation and an increase in sarcoplasmic calcium uptake which leads to higher contractions in muscles (Cashman *et al.*, 2016). Vitamin D is obtained from sun exposure and from diet. In diet, vitamin D is found in ergocalciferol and calciferol (which is much more effective than ergocalciferol) (Fogleman *et al.*, 2022). It is documented that the consumption of 800IU/day of vitamin D with 2000mg of calcium decreases the risk of fractures in female navy employees (Lappe *et al.*, 2008). Some micro and macro minerals like protein, phosphorus, magnesium, fluoride, and potassium play a major role in bone health followed by iron, silicon, zinc, vitamin A, vitamin C, and vitamin K (Maughan *et al.*, 2018).

VI. SOME OTHER DIETARY RECOMMENDATIONS

1. Carbohydrates: During rehabilitation, it is recommended that the intake of adequate amounts of carbohydrates, fats, protein, and antioxidants is beneficial. But according to an investigation, it is concluded that carbohydrate intake does not affect inflammation and muscle soreness during recovery (Miles *et al.*, 2007). It is recorded that there is an increase in muscle protein breakdown and a decrease in total protein balance because of

the lower concentration of carbohydrates (Papadopoulou, 2020). During the period of intense exercise carbohydrates plays a vital role in restoring muscle, reducing fatigue, and improving physical performance (Clark et al., 2016). But the role of carbohydrates during recovery requires more study.

- 2. Role of Dietary Fiber, Probiotics and Prebiotics:** It is estimated that the gastrointestinal microbiome can affect nutritional outcomes. Because of the stress is caused due to extreme exercise and insufficient recovery, 20-60% of athletes are suffering (Hsu et al., 2015). It is estimated that about 30-60% of athletes are suffering from gastrointestinal problems because of certain exercises and their intensity factors. Endurance exercises might affect the permeability of the intestine, immune response, and inflammation (Lamprecht et al., 2012). Studies are required to understand the effect of dietary fiber during recovery. 16 studies were conducted to understand the role of probiotic supplementation for athletes out of which 2 studies demonstrated that probiotic supplementation is responsible for increasing performance (Coqueiro et al., 2017). Microbiome decreases the side effects caused by antibiotics as it enhances mucosal immunity (Gleeson et al., 2012). It is observed that *Lactobacillus acidophilus* and *Bifidobacterium* have positive immune effects followed by *Bacillus coagulans* which improves absorption of protein. Consuming refrigerated probiotics empty stomach is considered more beneficial during rehabilitation. (Jäger et al., 2018). According to research, with the help of gut microbial modulation, which helps in muscle recovery, beneficial effects in vertical jumps have been observed (Jäger et al., 2018).
- 3. Phytochemicals:** Phytochemicals have different types of plant ingredients which have several structures which help in promoting positive health effects. Fruit-derived polyphenol improves vascular functions which results in improving muscle perfusion and it also improves oxygen extraction. It is considered that polyphenols play a major role in enhancing sports activity of athletes. After the intake of blackcurrant supplement, there is an increase in sprint running has been recorded in research (Keane et al., 2018). It is recommended that one should consume food items that are rich in polyphenols and chocolate as it helps in reducing oxidative stress and inflammation (Angelo & S 2020). Phytochemicals reduce muscle soreness and increase recovery time. Consumption of polyphenol-rich fresh food such as red fruits, tea, and natural juices has much more beneficial effects as compared to the consumption of concentrated supplements (Angelo, 2020).

VII. CONCLUSION

Balance diet plays an important role during recovery period of athletes. Adequate amount of good quality protein and amino acids plays a vital role followed by omega 3 fatty acids and creatine. Consuming good quality protein from whole food is much more beneficial than consuming protein through supplements. Protein intake during the recovery period should be high to avoid a decrease in muscle mass. Creatine and omega-3 fatty acids reduce muscle soreness and decrease the recovery period. Intake of collagen, with gelatin and vitamin C, helps in joint and tendon injury recovery. It also reduces knee pain and increases the thickness of the cartilage. Vitamin D can be received from sunlight and can also be consumed through supplements. Intake of vitamin D and calcium supplements increases bone density. There is no such therapeutic role of carbohydrates in the recovery phase but

according to some studies it is considered that low level of carbohydrates is responsible for the decrease in muscle mass. Probiotics, dietary fiber, and prebiotics decrease the side effects caused by antibiotics and are also responsible for increasing the absorption of protein. Phytochemicals are found in fruits and their consumption through whole food is considered beneficial as compared to supplements. Phytochemicals reduce muscle soreness and inflammation and increase the recovery time. During rehabilitation, maintaining energy balance is very important as a negative energy balance can reduce muscle mass. Due to a decrease in physical activity, there is less requirement of energy and to avoid muscle protein breakdown, more protein should be consumed.

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