Study on injury characteristics and prevention measures of elite diving athletes

Kim Jun-woo[1, a], Son Byul[1, b, *],

[1]Korea Institute of Science and Technology Information (KISTI), 245 Daehak- ro, Yuseong- gu, Daejeon, 305-806, Korea
a.kim_jun_woo_895558@icloud.com ,b.sonbyul_2026@gmail.com
***Corresponding Author**

Abstract: Diving, as a source of pride and representative event in China's competitive sports, has achieved remarkable accomplishments for the country on the international competitive stage and stands as a glory of Chinese sports. While these brilliant achievements have been attained, they have been accompanied by a reality where athletes are plagued with numerous injuries. Therefore, how to scientifically understand and prevent injuries in diving based on the actual conditions of diving training has become an important guarantee for extending the athletic lifespan of China's elite athletes. To this end, drawing from the author's many years of practical experience in diving, this paper reviews and organizes the high-risk injury sites and traumas in diving, with the aim of prolonging the competitive capacity of China's elite athletes and providing a data foundation and valuable experience for the standardized and scientific training of competitive diving in China.

Keywords: diving, injury sites, specific characteristics, prevention measures

1. Introduction

Diving has been an important force in leading China's competitive sports to glory. Chinese competitive diving has won countless honors for the country at international competitions of all levels. However, behind these brilliant achievements, one cannot overlook the frequent turnover of diving athletes, the generally young competitive age, the high training costs, and the short duration of maintaining high-level competitive ability. Diving is classified as a high-risk competitive sport, as athletes jump from high altitudes performing various difficult somersaulting and twisting movements before entering the water, a process that harbors various injury risks. Furthermore, the strong repetitive nature of diving movements is also an important cause of frequent injuries [1]. Based on scientific induction and organization of various diving injuries, and drawing from the author's many years of practical experience in diving work, this study proposes corresponding injury prevention and treatment measures and methods, aiming to provide a data foundation and valuable experience for the standardized and scientific training of competitive diving in China.

2. Research objects and methods

2.1. Research objects

The research objects of this paper were 42 currently active athletes from the national training team, including 24 male athletes and 18 female athletes, with an average age of 17.6 years and an average training duration of 8.4 years. Their athletic levels were: 36 International Masters of Sports and 6 Masters of Sports.

2.2. Research methods

2.2.1. Literature review method

Relevant literature on diving athlete injuries and prevention measures was reviewed to establish the theoretical foundation for this paper.

2.2.2. Interview method

https://doi.org/10.62852/css/2026/200

The author utilized the opportunity of coaching the national diving team to conduct in-depth interviews with each athlete, understanding their current injury conditions and past injury histories, thereby providing reliable data for this research.

2.2.3. Mathematical statistics method

Data processing tools such as Excel 2010 were used to organize and summarize the data obtained from interviews, making the practical and theoretical aspects of this research more prominent.

3. Results and analysis

The distribution of injury sites among diving athletes is extremely extensive, with key injury locations including the lower back, knee joint, wrist joint, eye, elbow joint, and cervical spine. For platform diving events, upper limb injuries—particularly wrist injuries—are especially common, while springboard events show higher incidence rates of lower back and lower limb injuries. Additionally, lower back, wrist, and eye injuries are common susceptible sites for both springboard and platform events. Table 1 presents common injury types in diving, and Table 2 shows the characteristics of injury occurrence sites.

As shown in Table 1, the distribution of injury sites among diving athletes is very broad. The most common types of injuries are muscle injuries and joint injuries, accounting for 32.8% and 26.6% respectively, with ligament injuries at 16.4% also representing a significant proportion. According to Table 2, among diving athletes, the incidence of lower back muscle strain is the highest, with 31 cases accounting for 16.68%; cervical spine injuries occurred in 11 cases (5.95%), and rotator cuff injuries in 9 cases (4.78%). Furthermore, the injury rate of fundus damage among diving athletes is also relatively high, with retinal degeneration in 16 cases (8.61%) and retinal holes or detachment in 3 cases (1.59%). The following sections will focus on analyzing the injuries that occur most frequently among athletes.

Table 1 Common Injury Types and Percentages of Diving Athletes

	Muscle Injury	Joint Injury	Ligament Injury	Cartilage Wear	Enthesopathy	Stress Fracture	Others	Total
Cases	42	34	21	9	7	6	9	128
Percentage (%)	32.8	26.6	16.4	7.0	5.5	4.7	7.0	100

Table 2 Statistics of Susceptible Injury Sites and Types of Diving Athletes

Site	Injury Diagnosis	Cases	Percentage (%)
Lower Back	Lower back muscle strain	31	16.68
	Lumbar muscle fasciitis	28	14.97
	Lumbar spondylolysis	6	3.19
	Lumbar disc herniation	6	3.19
Knee Joint	Patellar injury	15	8.08
	Medial collateral ligament injury	12	6.48
	Meniscus injury	8	4.25
	Knee bursitis	4	2.13
Eye	Retinal degeneration	16	8.61
	Retinal hole/detachment	3	1.59
Shoulder Joint	Rotator cuff injury	9	4.78
	Subacromial bursitis	5	2.66
	Glenoid labrum injury	3	1.59

https://doi.org/10.62852/css/2026/200

	Shoulder dislocation	1	0.53
Cervical Spine	Cervical spine injury	11	5.95
Elbow Joint	Medial collateral ligament injury	6	3.19
	Elbow epiphysitis	3	1.59
	Elbow dislocation	1	0.53
Wrist Joint	Wrist epiphysitis	4	2.13
	Wrist synovitis	3	1.59
	Scaphoid fracture	2	1.06
Lower Leg	Tibial stress fracture	6	3.19
	Tibial periostitis	1	0.53
Others	Finger contusion	2	1.06
	Achilles paratenonitis	1	0.53

3.1. Lower back muscle injury

3.1.1. Injury site

Strain occurs in the sacrospinalis and lower erector spinae muscles, accompanied by related ligament injuries and adhesions, resulting in chronic damage to the deep fascia around the third lumbar vertebra.

3.1.2. Clinical manifestations

This condition is commonly seen in diving athletes. Clinical manifestations include soreness, heaviness, and dull pain in the lower back muscles, particularly noticeable in the bilateral lumbar muscles, lower erector spinae, and above the iliac crest. Local numbness, pain, muscle spasms, and cold sensations are present, with pain intensifying after training; severe cases may even affect training participation.

3.1.3. Injury mechanism

This is primarily due to the nature of diving as a sport where athletes rely on abdominal and back muscle groups for power generation in the air without fixed support points and with specific movement trajectories [2]. Throughout the execution of complete movements, the lower back muscles remain in a state of high tension, completing several rotations and somersaults within an extremely short time (approximately 1.4 seconds), with daily training reaching 100–200 repetitions. The long-term accumulation of fatigue makes this injury the most prevalent among diving athletes.

3.1.4. Prevention measures

3.1.4.1. Fatigue relief

Emphasis should be placed on regular massage, relaxation, recovery and regeneration of this area, and DMS (Deep Muscle Stimulator) relaxation. For mild injuries, acupuncture and other methods can be employed to prevent deterioration of the condition.

3.1.4.2. Strength enhancement

Four-Direction Static Support (increasing instability and reducing contact area): Key points—includes four exercises: plank support, supine static V-up, prone static V-up, and lateral support.

Prone Contralateral Back Extension: Key points—athlete lies prone on a mat with one hand behind the head; the athlete is required to rotate the trunk on the side with the hand behind the head toward the same side while lifting the opposite leg upward, keeping the leg straight; switch to the other side after completing one side.

Four-Direction Wooden Doll Push Exercise: Key points—athlete lies supine on a mat with legs clamped together and hands crossed over the chest; the athlete is required to keep the entire body straight and tense;

https://doi.org/10.62852/css/2026/200

the coach lifts the athlete's legs upward with both hands while the athlete uses waist strength to maintain the "tense" body position; repeat multiple times.

3.2. Cervical spine injury

3.2.1. Injury site

Injuries mainly occur at the axis (C2) and atlas (C1), specifically manifested as: possible transient subluxation of the axis and atlas, accompanied by injuries to the upper trapezius, levator scapulae, and sternocleidomastoid muscles.

3.2.2. Clinical manifestations

Needle-like pain at the axis and atlas positions of the neck, reduced neck range of motion, and inability to easily complete rotational movements.

3.2.3. Injury mechanism

The risk of cervical spine injury in diving athletes is higher than in other sports, which is due to the specific characteristics of diving. Athletes enter the water in a "reverse streamline" body posture, at which point the impact force between the water and the head-neck region is substantial. If the entry angle is too large or too small, the probability of injury increases by 4–6 times. Secondly, the occurrence of injuries is also related to the young age of athletes and weak neck muscle strength. Additionally, young athletes are in a developmental period where bones and muscles are growing, with relatively lax ligaments and joint capsules; improper behaviors in daily life and training can also cause cervical spine injuries. Therefore, special attention should be paid to this issue.

3.2.4. Prevention measures

Prevention measures primarily focus on neck strength training, as detailed below.

3.2.4.1. Neck resistance protraction and retraction exercise

Key points—Use a mini resistance band to secure the athlete's head; the athlete is required to complete protraction and retraction exercises while the coach holds the other end of the band, performing opposite movements to create resistance.

3.2.4.2. Neck resistance left rotation and depression exercise

Key points—Use a mini resistance band to secure the athlete's head; the athlete is required to first rotate the head to the left, then perform a depression movement while the coach holds the other end of the band, performing opposite movements to create resistance.

3.2.4.3. Neck resistance right rotation and depression exercise

Key points—Opposite of (2).

3.2.5. Injury site

Shoulder injuries in diving athletes are mostly complex injuries, but the most common types include rotator cuff injuries caused by long-term accumulation of fatigue, glenoid impingement injuries caused by improper entry angle during "hands-together" water entry, and long head of biceps tendon injuries caused by knee-tucking during multi-revolution somersaulting movements.

3.2.6. Clinical manifestations

Limited shoulder joint range of motion prevents upper limb elevation, making the "hands-together" action impossible to complete. Pain is concentrated in the deep anterior deltoid, soft tissues around the glenoid, and deep middle deltoid.

3.2.7. Injury mechanism

In diving competitions, the platform height is 10m. When athletes jump from the platform, their final entry velocity is generally around 14 m/s. According to the law of conservation of momentum, this means the impact force borne by the athlete themselves will exceed 400 kg. When technical errors occur and the entry angle changes significantly, the force on the upper limbs will also change accordingly. Particularly during the entry process, the angle between the athlete's trunk and upper limbs, under the dual action of

https://doi.org/10.62852/css/2026/200

water surface impact force and the athlete's own muscle contraction force, causes the shoulder joint to endure violent impact. This impact generally occurs below the acromioclavicular joint, at the anterior 1/3 of the acromion, or below the coracoacromial arch. Over time, this leads to glenohumeral joint instability, resulting in impingement injuries to the muscle groups and ligaments surrounding the shoulder joint.

3.2.8. Prevention measures

3.2.8.1. Prone fly

The athlete lies flat on an elevated platform with both feet naturally placed on the ground to support the body, holding dumbbells of appropriate weight in both hands, repeatedly performing abduction and adduction movements with straight arms.

3.2.8.2. Bent-Over reverse fly

Key points—Opposite of (1).

3.2.8.3. Shoulder "Y" exercise

Key points—Starting from a half-squat position with a straight back and hands placed at the sides of the body, then retract both scapulae downward and inward, followed by raising both hands overhead to form a "Y" shape with the trunk; repeat.

3.3. Tibial stress fracture

3.3.1. Injury site

At the 1/2 position of the tibia.

3.3.2. Clinical manifestations

Fractures at the 1/2 position of the tibia appear in a "beak-like" form.

3.3.3. Injury mechanism

This injury generally occurs when platform divers perform high-difficulty movements such as 109C and 5156B. For example, when athletes run on the platform to complete 109C, they require substantial pushing force to obtain the reactive force from the platform surface. At this time, the athlete's tibia bears longitudinal pressure, while the anterior tibia first generates tensile stress and the posterior generates compressive stress under the action of the anterior tibial muscle. Simultaneously, the tibial periosteum is continuously pulled by muscle tension during plantar flexion, causing the tibial periosteum to gradually separate. This leads to inflammation beneath the periosteum, thereby obstructing local blood circulation and causing insufficient blood supply, resulting in stress fracture.

3.3.4. Prevention measures

Currently, in addition to surgical treatment, this condition can also be addressed through walking in shallow pools and leg strength pushing exercises to reduce gravitational load on the limbs, achieving the purpose of rehabilitation training. Additionally, during regular training, the training of Group 1 and Group 4 optional movements should be appropriately reduced to minimize unnecessary acute running, jumping, and pushing movements.

3.4. Fundus injury

3.4.1. Injury site

Fundus injuries are primarily retinal degeneration.

3.4.2. Clinical manifestations

In the early stages of injury, the athlete's vision gradually declines accompanied by a certain degree of eye soreness; in the later stages of injury, retinal detachment may occur, leading to blindness.

3.4.3. Injury mechanism

This injury is a common condition among diving athletes and poses significant harm. Particularly when platform divers jump head-first from the 10m platform, the eye undergoes impact deformation due to the enormous impact force of water at the moment of entry. The vitreous base tissue, compressed by the impact

https://doi.org/10.62852/css/2026/200

force, cannot extend synchronously with the eyeball wall; over time, retinal holes or detachment may occur. More seriously, if the athlete opens late during entry or has excessive body inclination, the water surface may directly strike the eyes, causing acute retinal detachment. Most fundus lesions belong to chronic injuries, gradually accumulating from micro-injuries during long-term training and competition; the longer the training duration, the greater the possibility of fundus injury [3].

3.4.4. Prevention and treatment measures

There are relatively few prevention and treatment measures for this injury. Currently, eye protection can only be achieved through raising athletes' awareness of protection and correcting erroneous movements.

4. Suggestions

The distribution of injury sites among diving athletes is extremely extensive, with key injury locations including the lower back, knee joint, wrist joint, eye, elbow joint, and cervical spine. For platform diving events, upper limb injuries—particularly wrist injuries—are especially common, while springboard events show higher incidence rates of lower back and lower limb injuries. According to the survey and analysis of this study, five types of sports injuries—lower back muscle injury, cervical spine injury, shoulder joint injury, tibial stress fracture, and fundus injury—are considered the most prevalent among diving athletes, accounting for 39.21% of the total injuries surveyed, representing a significant proportion. It is recommended to: enhance athletes' self-protection awareness; strengthen special training for vulnerable areas; reinforce medical supervision and functional assessment of athletes' susceptible injury sites; and emphasize psychological counseling for diving athletes to alleviate psychological pressure caused by competition or training.

5. Conclusion

As a landmark event in China's competitive sports, diving has achieved world-renowned accomplishments on the international stage. However, the long-term high-intensity training load borne by athletes and the high-risk nature of the sport itself have made sports injuries an important factor constraining the continuation of athletes' competitive careers and the maintenance of their competitive levels. Through systematic investigation and analysis of injury conditions among 42 currently active elite diving athletes from the national training team, this study comprehensively reviewed the distribution characteristics, occurrence mechanisms, and prevention measures of injuries in diving, clearly identifying five high-incidence injury types: lower back muscle injury, cervical spine injury, shoulder joint injury, tibial stress fracture, and fundus injury. Corresponding comprehensive prevention strategies were proposed, including specific strength training, fatigue recovery management, technical movement standardization, and strengthened medical supervision.

Extending the athletic lifespan of elite athletes and maintaining their high-level competitive capacity requires not only scientific training methods and advanced medical support, but also the establishment of systematic injury prevention awareness and comprehensive athlete protection mechanisms. This study aims to provide practical references for the standardized and scientific training of competitive diving in China, assisting the Chinese diving "Dream Team" in better safeguarding athletes' physical and mental health while pursuing outstanding achievements, thereby realizing the sustainable development of competitive sports.

6. References

[1] Ren Yuheng, Tian De Xiang, Shi Hefu, et al. Epidemiological Survey of Sports Injuries in Elite Athletes [J]. Chinese Journal of Sports Medicine, 2000, 19(4): 377-386.

[2] He Jian long, Nian Wenjing, Zhao Huanbin, et al. Study on Core Strength Training for Improving Competitive Ability of Diving Athletes [J]. Journal of Hebei Normal University: Natural Science Edition, 2014, 23(3): 98-100.

[3] Zhou Linzhi, Li Fenglian, Guo Jinlong, et al. Investigation and Analysis of Sports Injuries in Diving Athletes [J]. Chinese Journal of Sports Medicine, 2009, 28(2): 181-186.

https://doi.org/10.62852/css/2026/200