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# *Physical Rehabilitation of Ankle Injuries in Basketball Players*

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***Abstract.*** Ankle-related injuries are common musculoskeletal injuries in basketball, with lateral ankle ligament strains and tears being the most prevalent. Athletes' repeated jumping-landing, rapid direction-changes, single-foot rotation, acceleration and deceleration place heavy loads on feet and ankles, increasing risks of first-time and recurrent injuries. Although many athletes recover from acute ankle ligament injuries, some experience persistent pain, repeated sprains or ankle instability.Ankle rehabilitation has shifted from rest-based passive treatment to active, phased and standardised interventions, including external protective gear, exercise plans, neuromuscular training, sport-specific rehabilitation and psychological-readiness assessment. This paper reviews acute-phase management, staged physical rehabilitation, novel auxiliary rehabilitation equipment, functional assessments, return-to-sport criteria and long-term injury prevention for basketball players.Evidence suggests functional rehabilitation, ankle supports, progressive exercise, balance and neuromuscular training, plus sport-specific practice produce good results. Aquatic and virtual-reality training may act as supplements but lack sufficient supporting evidence. Clinicians should not decide return-to-sport timelines solely by injury duration or single test outcomes; instead, should consider pain, ankle mobility restrictions, subjective feelings, physical control and sport-specific performance. Individualised staged rehabilitation helps restore function, reduce re-injury risk and support safe competitive return.

***Keywords:*** Ankle Injuries, basketball, physical rehabilitation

## 1. Introduction

Basketball is a high intensity intermittent sport, which imposes great burdens on the lower limbs of participants. On the court, athletes need to complete movements such as jumping, landing, acceleration, deceleration, torso rotation with force and sudden route changes, and they also have to respond to unpredictable behaviours of teammates and opponents.

Physical stress brought by these sport movements makes feet and ankles more vulnerable to injuries. Ankle injuries trouble amateur basketball lovers, high school teams, university teams and professional athletes. Once injured, athletes have to suspend training and competitions, their sport performance will decline, and risks of subsequent injuries will also rise.

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In basketball matches, landing acts are major triggers for ankle injuries. McKay's research team conducted surveys with a large number of non professional basketball participants as subjects. Statistical data show that 3.85 cases of ankle ligament sprain can be found per 1 000 sport participations; roughly 45.9 % of injured athletes need to miss competitions for at least seven days, and nearly 45 % of documented injuries are caused by landing movements. Previous ankle injuries are strongly correlated with subsequent re sprains, and negative impacts caused by one acute sprain will not disappear completely with the relief of acute phase pain [1]. This research result has practical reference significance for basketball players. In confrontational scenarios such as rebounding, lay ups and jump shots, athletes often land in crowded areas, they are likely to step on other players' feet and further suffer rapid ankle inversion injuries.

Troubles brought by ankle sprains go beyond short term pain and swelling. Most injured people can achieve obvious physical improvements within several weeks after injury, while some individuals still endure long lasting pain and joint instability. A systematic review finished by van Rijn's team mentions that symptoms of patients subside fast in the early post injury stage; however, for some patients, physical discomfort and limited limb movements will persist even months after sprains [2]. According to the latest clinical guidelines, nearly 40 % of patients with lateral ankle sprains develop chronic ankle instability [3]. For basketball players, such joint instability will create practical sport related problems. Insufficient muscle strength, poor balance, declined proprioception and unsatisfactory physical control during movements will interfere with athletes' completion of fundamental actions including jumping, landing, sharp cutting and rapid direction shifts.

In recent years, ideas for ankle injury management have changed obviously. Previously clinical staff mostly required injured individuals to stop all activities so as to relieve pain and prevent further damages to wounded parts. Modern rehabilitation work attaches greater importance to the restoration of normal physical functions, and it helps athletes adapt to sport related requirements of their own events.

Apart from above mentioned conventional measures, new technologies such as virtual reality systems and wearable motion acquisition devices also bring more possibilities for individualised rehabilitation. Nevertheless researchers in relevant fields still need to complete more clinical trials to verify actual effects of these devices under real clinical scenarios.

This article sorts out latest research progress on physical rehabilitation for basketball players with ankle injuries. It mainly introduces treatments in acute injury phase, progressive training schemes, implementation modes of neuromuscular training, applications of modern technology assisted rehabilitation devices, detection and evaluation of physical functions, judgment bases for athletes returning to competitive matches, and implementation measures for long term prevention of similar injuries.

## 2. Acute ankle injuries and current clinical treatments

Sudden ankle twisting injuries are common sport related reasons for hospital outpatient visits. In the field of sports medicine, multiple different approaches are adopted to treat injuries and facilitate healing of wounded parts. First, medical staff will carry out detailed physical examinations on injured sites, and doctors will arrange image examinations to clarify actual injury conditions. Second, rest plays an important role; patients need to apply ice compressions on painful sites to reduce local swelling. Third, therapists will use fixing bandages for patients, bandages will limit joint mobility ranges and prevent injuries from worsening.

External manifestations of ankle sprains change along with injury severity and damaged anatomical structures. Injured people will feel painful, wounded areas will swell with skin

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ecchymosis, pressing affected sites will generate soreness, ankle movements will be restricted, the injured side can hardly bear full body weight, and physical stability will decline while standing. Under extremely serious injury conditions, joints will show obvious laxity, and motor functions of limbs will drop sharply.

Clinicians traditionally divide lateral ankle sprains into Grade 1, Grade2 and Grade3 according to ligament damage degrees and function losses. Medical workers can only regard these three grades as simple references instead of precise standards for judging patients' healing time.

Grade 1injuries bring slight ligament damages with only minor restrictions on joint movements. Grade 2 and Grade 3 injuries cause more serious tissue destructions and greater losses of motor functions. Even if athletes share identical ligament injury grades, their individual rehabilitation processes will differ greatly [4].

Based on above mentioned facts, medical staff need to complete comprehensive evaluations. Medical examinations should figure out how injuries happen, locate tender points, observe swelling severity, judge patients' weight bearing capacity, check joint mobility ranges and ligament tightness, and understand restrictions in daily activities. Medical workers can refer to Ottawa Ankle Rules to determine whether patients need X ray radiography [3, 5]. People should also realise that physical examination results will change after swelling and pain are relieved. When acute phase symptoms are too severe for complete examinations, clinical staff can re conduct inspections several days later to obtain more reliable information about ligament conditions and joint movement limitations [5].

Modern clinical practice no longer advocates traditional treatments such as long term immobilisation and absolute bed rest. Updated treatment programmes actively promote restoration of physical functions. The sports medicine field still recognises the RICE principle, namely rest, ice, compression and elevation. Yet modern rehabilitation specialists recommend avoiding unnecessary long term immobilisation while protecting damaged tissues. Dubois and Esculier put forward the PEACE & LOVE framework for soft tissue injury treatments [6]. This framework states that in acute phases, staff should protect wounded parts, elevate affected limbs, carry out moderate anti inflammation measures, apply compression bandages and complete patient health education work. After acute phases, therapists should arrange progressive weight bearing exercises, popularise health knowledge, conduct blood circulation promoting activities and schedule regular physical exercises.

This treatment framework has practical values in real world work. Its core advantage lies in helping staff strike a balance between protecting damaged tissues and permitting appropriate movements. Excessive physical loads right after injuries will aggravate various symptoms, while prolonged immobilisation will lead to declined muscle strength, reduced overall physical fitness and slower functional recovery.

After patients start doing activities, ankle braces or sport tapes can provide mechanical stability for joints. Evidence based guidelines propose that medical staff shall combine such external auxiliary tools with training programmes rather than merely depend on passive treatments [5, 7].

Besides, athletes and therapists shall select proper ways to reduce local effusion and relieve pain feelings. Compression bandage dressing and elevation of wounded limbs can mitigate acute phase discomforts. When clinical assessments meet requirements, doctors can permit patients to take analgesic drugs. Literature indicates that non steroidal anti inflammatory drugs in acute phases can ease pain and reduce swelling. Medical workers need to consider patients' original physical conditions, control drug dosages and medication durations, and pay attention to potential influences of medicines on soft tissue repair [8]. Meanwhile such drugs can only reduce pains during rehabilitation exercises; they cannot replace complete sets of rehabilitation training procedures.

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In acute phase treatments, popularising health related knowledge for patients is also a key link. People with sport related injuries shall not equate pain disappearance with full recovery of physical functions. Athletes need to understand that training loads should be increased gradually, rehabilitation exercises shall be persisted in, and returning to basketball in phases is of great importance. Injured athletes, physiotherapists, physical fitness coaches, doctors and head coaches shall maintain smooth communications, so as to prevent athletes from taking part in high risk sports too early.

## 3. Progressive physical rehabilitation

Rehabilitation workers adopt step by step physical recovery modes to carry out progressive physical rehabilitation work. Restoration of motor abilities is critical for injured patients. Treatment teams will make dynamic rehabilitation programmes combined with individual healing conditions. Guided training forms the core of rehabilitation work, and training helps patients recover muscle strength gradually. Relevant studies suggest that when evaluating effects of this set of programmes, people shall pay attention to its step by step implementation

At present, physical exercise has become the core part of ankle sprain treatment schemes. After acute phase pains are reasonably controlled, rehabilitation programmes shall improve multiple physical dimensions step by step, including ankle mobility ranges, strength of surrounding muscles, muscle endurance, balance capacity, joint proprioception and whole limb neuromuscular control levels.

In early rehabilitation stages, clinical staff often adopt these intervention measures: active ankle movement exercises, restricted weight bearing, muscle isometric contractions and low intensity strength training. After patients' symptoms get relieved to a certain degree, therapists can raise difficulty levels of resistance exercises. Training movements shall cover muscles corresponding to ankle dorsiflexion, plantarflexion, inversion and eversion.

Training for calf muscles deserves key attention. Calf muscles provide power for body propulsion, stable landing and repeated high intensity movements. In later rehabilitation stages, therapists can add single leg strength exercises and lower limb function training to simulate physical loads brought by basketball matches.

Published clinical programmes support exercise centred rehabilitation ideas. In 2021, the Journal of Orthopaedic & Sports Physical Therapy released clinical practice guidelines. The guidelines suggest that patients with lateral ankle sprains or chronic ankle instability shall take joint range of motion exercises, standing weight bearing training, neuromuscular coordination practice and balance related training [3]. These guidelines emphasise that healing of ankle connective tissues does not mean restoration of athletes' sport performance. Even when swelling and pains of many athletes mostly subside, they still suffer declined muscle strength, poor balance, weakened limb position perception and unstable motor control.

For basketball players, neuromuscular training and proprioception training carry great significance. In matches, athletes have to cope with unpredictable changes of body postures and external confrontational thrusts. Stability of ankles does not only rely on passive restraint functions of ligaments. The neuromuscular system perceives changes of joint positions and outputs response signals rapidly, which also constitutes an important part of joint stability.

During rehabilitation, proprioception training can start with simple movements, such as single leg standing balance maintenance and multi directional reaching out movements. Afterwards therapists can let patients train on unstable surfaces, apply slight external force interferences, arrange jumping practice, controlled landing practice and rapid direction change practice. When athletes' physical

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capacities improve, rehabilitation movements shall get closer and closer to real game basketball actions. Step by step training modes help athletes gain stable ankle control under environments similar to real competitions.

Data from randomised controlled trials prove that proprioception training can lower sprain recurrence probabilities. Hupperets and his research colleagues enrolled 522 athletes with recent ankle injuries in total. Their study compared conventional therapies with an eight week home based balance training programme [9]. 22 % of subjects in the training group suffered new sprains, while re injury proportion reached 33 % in the group receiving ordinary care. Relative risk of this training was 0.63; every nine people finishing the whole training could avoid one case of recurrent sprain. This research outcome provides important references for basketball players. Previous ankle sprains will greatly raise re injury possibilities, hence balance and proprioception training shall not be terminated right after athletes recover daily activity abilities.

According to 2021 clinical guidelines from the Journal of Orthopaedic & Sports Physical Therapy, when facing patients with chronic ankle instability, rehabilitation staff shall evaluate complete kinetic chains. They shall not simply attribute ankle problems to insufficient strength of a certain muscle [3]. Therapists need to observe movement patterns of whole legs and find specific weak points of each individual that influence sport participation.

Strength training shall not only focus on injured ankles. Completion of basketball actions depends on coordinated movements of the whole lower limbs. When athletes jump and land, run forward with force, change directions rapidly and keep physical balance, feet, ankles, knees and hips cooperate with one another to finish movements.

After athletes' overall physical conditions improve, rehabilitation training can gradually move away from basic clinical exercises and turn to sport specific practice. Straight line running exercises can transit to acceleration and deceleration practice, then lateral movements, sharp cutting, single leg jumps, two leg jumps and speed variation training will be added. In later training periods, basketball exclusive actions will be introduced, including defensive sliding, defensive close out movements, rebounding practice, lay ups, lay up in motion shooting and controlled direction change exercises. Such progressive training modes allow athletes to adapt to dual physical and psychological tests brought by basketball before they get unrestricted match permissions.

## 4. Auxiliary rehabilitation measures and emerging rehabilitation equipment

In ankle rehabilitation work, conventional exercises remain the foundation for patients' recovery. Scientific researchers keep studying various auxiliary tools. When athletes cannot safely bear full body weight, aquatic rehabilitation training serves as a good alternative option. Buoyancy generated by water can share body weights; athletes can finish movements such as displacement, balance maintenance and strength training under reduced joint stress conditions.

In the field of musculoskeletal injury rehabilitation, virtual reality related devices draw growing attentions. Virtual reality systems can build interactive scenarios. These scenarios can test people's balance capacity and movement completion conditions; they can also raise subjects' training interests and improve completion rates of training tasks. A 2023 systematic review and meta analysis incorporated ten randomised controlled trials, whose theme was virtual reality training for orthopaedic ankle injuries [10]. Compared with common physiotherapy, subjects receiving virtual reality based training obtained obvious balance improvements with a standardised mean difference of 0.359. Partial outcome indicators reflect improved gaits, enhanced muscle strength and better subjectively perceived ankle stability. However qualities of included literatures are uneven; only a small number of trials meet judging standards for high quality researches.

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## 5. Functional evaluation and return to sport

Even if basketball athletes walk without pains, they may still suffer insufficient muscle strength, poor physical stability, low self confidence, or defects in motor control under variable real game environments. Disappearance of symptoms does not equal ideal rehabilitation outcomes. Athletes' re participation in sports is a multi stage progressive process rather than a single time point.

The 2016 Bern Consensus Document puts forward that permission for returning to competitions forms a continuous developmental process [11]. This process starts with finishing rehabilitation tasks, then transits to complete training sessions, and finally moves to official matches. This idea fits basketball well, for unrestricted competitive matches impose far higher physical requirements than daily activities.

Literature introduces the PAASS evaluation framework [12]. This practical assessment tool faces athletes in rehabilitation after acute lateral ankle injuries, and it is jointly established by experts from multiple countries and different fields. The PAASS model contains five major evaluation sections: pain perception, physical limitations of ankles, athletes' subject. Medical staff need to evaluate pain conditions under simulated competition tasks and within a full day cycle around assessments. Inspections for physical limitations of ankles cover joint mobility amplitudes, muscle strength, endurance and explosive power. Athletes' subjective states include self confidence, feelings of non joint collapse and psychological readiness. Movement control inspections contain limb position perception and dynamic balance. Sport specific tests include small single leg jumps, leaps, rapid direction changes, cone weave running and uninterrupted completion of one full team training session.

This model suits basketball very well, since basketball games require athletes to repeatedly finish multi directional fast movements. When conducting functional detections, evaluators can adopt tasks such as single leg hops, triple hops, cross line hops, timed hops, lateral hops, dynamic balance detections and direction change speed tests. Evaluators shall not simply regard test results as pass or fail judgments. Rehabilitation workers also need to observe movement completion qualities, changes of symptoms, fatigue tolerance levels and gaps between sport performances and pre injury levels.

Psychological readiness constitutes another key inspection point for returning to sports. Though some athletes pass all physical examination items, they still fear re injuries, lack self confidence and worry about landing and rapid direction change movements. The Ankle Ligament Reconstruction Reinjury Sensitivity Index (ALR RSI) is developed to assess psychological readiness of athletes after ankle ligament reconstruction surgeries. This scale evaluates emotional responses, confidence levels in sport related tasks and subjectively perceived re injury risks [13]. Still more researches are needed to verify effectiveness of this scale when it is applied to other ankle injury types and other sport crowds. Ankle oriented psychological assessments can obtain information unavailable merely through physical examinations.

Based on above mentioned conditions, athletes shall return to basketball in phases instead of taking part in high intensity official matches directly. Athletes first complete individual skill exercises, then join group training, afterwards take low contact training, finish full team training sessions and finally participate in official matches. In each phase, coaching teams shall observe changes of pains, physical function levels, movement completion patterns and self confidence degrees. Athletes must go through a complete training cycle without obvious symptom aggravation before obtaining unrestricted competition permissions.

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## 6. Injury prevention strategies and long term management

Even if basketball players finish complete sets of standard rehabilitation procedures, risks of re injuries cannot be totally eliminated [1, 6]. Previous ankle sprain experiences form important risk factors for subsequent ankle injuries. Hence long term continuous protective work is quite critical for basketball players. Injury prevention exercises shall become fixed components of daily training instead of being terminated right after athletes get permissions to return to matches.

Besides, long term injury prevention work also requires evaluations of whole lower limb movement patterns. Ankles cannot independently fulfil motor functions. When athletes jump, land and change directions rapidly, movements of feet, ankles, knees and hips are closely connected. Rehabilitation assessments shall not only measure ankle muscle strength; staff shall also pay attention to whole leg control modes and find individual weak links that cause low movement efficiency and insufficient dynamic stability.

Complete injury prevention schemes also include warm up and preparation activities. Dynamic stretching, progressive speed increasing running, muscle activation exercises and controlled jumping movements help athletes adapt to physical loads brought by high level basketball matches. Warm ups can assist the development of rehabilitation, strength and balance training, yet warm ups cannot replace these core training contents.

During match seasons, long term tracking of athletes' conditions is of great importance. Indicators such as pain feelings, obvious joint swelling, subjective joint instability perceptions, joint mobility ranges, muscle strength, balance capacities and athletes' self-confidence can hint whether training loads exceed bearing limits. Rehabilitation staff and coaches can adjust training plans at early stages to avoid small scale problems evolving into severe injuries.

## 7. Discussion

Progress achieved in ankle rehabilitation for basketball athletes in the sports medicine field also reflects changes of overall industrial ideas. Clinical intervention modes gradually transit from passive patterns to individualised, evidence based and active intervention patterns. Published studies prove that physical exercise centred programmes shall be selected as core treatment options. Progressive joint range of motion exercises, strength training, balance practice, proprioception practice and neuromuscular retraining can solve various functional defects that still exist after acute phase swelling and pains subside.

Existing research evidence supports functions of balance training after acute phase symptoms subside. Hupperets' experiment confirms that balance training can reduce injury recurrence rates, which reminds us that rehabilitation work shall not end when athletes subjectively feel physical improvements [8]. This point is critical for basketball, for athletes repeatedly face landing and rapid direction change movements every week, and stability of ankles will be constantly tested.

New technologies emerging in rehabilitation fields add more usable tools for clinical work. When athletes can hardly finish full weight bearing, aquatic training helps initiate sport exercises at earlier stages. Virtual reality can improve interestingness of balance training. However current researches cannot verify that effects of new technologies are superior to traditional rehabilitation means. Many published studies have limitations such as small sample sizes, complex subject compositions and short follow up durations. Wearable devices, motion capture techniques and artificial intelligence have promising development prospects. Whether such technologies can enter daily clinical work shall rely on solid clinical trial evidence rather than mere technical novelty.

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Judgment criteria for athletes returning to sports represent another important progress. Past rehabilitation programmes mainly referred to time elapsed after injuries or pain disappearance. Modern evaluation modes believe that these two indexes alone are far from enough. Even without subjective pains, athletes may still suffer insufficient balance, poor muscle strength, lack of self confidence and unsatisfactory completion of sport specific movements. The PAASS framework takes both physical and psychological states into consideration, and it provides more comprehensive evaluation tools [12].

This multi dimensional evaluation mode fits basketball sports well. Basketball contains plenty of unpredictable repeated movements, large landing impact forces and fast direction changes. Before returning to official competitions, rehabilitation programmes shall simulate match scenarios as much as possible. Some athletes can pass slow speed single leg balance tests, but they still have difficulties finishing many high speed cutting and jumping combined training drills. Such athletes have not reached competition participation conditions.

Psychological dimensions in rehabilitation processes deserve more attentions. Fears of re injuries and obvious lack of self confidence will change athletes' movement patterns and stop them from trying high risk basketball movements. When clinical staff add psychological assessments into each phase of return to sport processes, some problems hard to observe directly can be detected.

## 8. Research limitations and future prospects

This paper has several limitations. First of all, sample sizes adopted in relevant researches are relatively small, which restricts generalisation of research conclusions to other crowds. Secondly, most research data are obtained through subjects' self reports, and self reporting will bring certain response biases. Besides, cross sectional designs adopted in researches cannot observe changes over time, so causal relationships among variables cannot be confirmed.

At present, plenty of researches provide reliable bases for formulating ankle rehabilitation programmes, yet obvious deficiencies still exist. A large number of rehabilitation trials recruit athletes in a broad sense instead of targeting basketball crowds specially. Hence research outcomes can hardly fully reflect special requirements of basketball events, such as repeated jumping, high frequency confrontational direction changes and large weekly training volumes.

Great differences exist among various researches in rehabilitation programmes, evaluation indicators, definitions of rehabilitation outcomes and judgment standards for returning to sports. Direct horizontal comparisons of results from different researches face difficulties. Therefore follow up scientific researchers shall carry out basketball specific randomised controlled trials and adopt evaluation tools reached consensus within academic circles.

More in depth researches are needed for applications of rehabilitation related technologies. Virtual reality, wearable sensing devices, camera based motion capture systems and artificial intelligence may help therapists observe movement patterns and training loads more accurately in the future. Apart from observing short term balance improvements, follow up researches shall also study outcome indicators with practical significances, including time consumption for returning to sports, injury recurrence rates, competitive sport levels and long term ankle stability.

## 9. Conclusion

Ankle injuries, especially lateral ankle sprains, are clinical problems requiring key attentions in basketball sports. Frequent jumping, landing, sharp cutting and high speed direction changes on courts are inducements for injuries. Many athletes can recover after acute sprains. Nevertheless

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persistent symptoms and repeated injuries demand systematic rehabilitation work and implementation of long term prevention measures.

Modern rehabilitation programmes shall carry out function oriented interventions right in acute phases. Afterwards joint mobility ranges shall be enlarged step by step, muscle strength shall be developed, proprioception shall be improved, neuromuscular control shall be optimised, balance ability shall be enhanced and sport specific motor capacities shall be rebuilt. External ankle braces can provide extra protections. Standardised balance and neuromuscular training can lower injury recurrence probabilities.

Aquatic training and virtual reality based training can serve as supplementary options for partial athletes. Existing research evidence does not support complete replacements of traditional exercise centred rehabilitation by new technologies. Wearable devices and artificial intelligence driven rehabilitation modes have good prospects, yet sufficient clinical trial evidence is needed before they can become routine clinical standards.

Successful rehabilitation after basketball players' ankle injuries cannot be simply interpreted as letting athletes return to courts for matches. Real goals lie in rebuilding every competitor's capacities to bear dual physical and psychological loads brought by basketball competitions, as well as lowering re injury possibilities. According to rehabilitation related researches, individualised, step by step and evidence based training programmes form optimal foundations for safe, effective and long term returns to sports.

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