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ANKLE

Management of acute lateral ankle ligament injury in the athlete

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Abstract
Purpose Inversion injuries involve about 25 % of all injuries of the musculoskeletal system and about 50 % of these injuries are sport-related. This article reviews the acute lateral ankle injuries with special emphasis on a rationale for treatment of these injuries in athletes.
Methods A narrative review was performed using Pubmed/Medline, Ovid and Embase using key words: ankle ligaments, injury, lateral ligament, ankle sprain and athlete. Articles related to the topic were included and reviewed.
Results It is estimated that one inversion injury of the ankle occurs for every 10,000 people each day. Ankle sprains constitute 7–10 % of all admissions to hospital emergency departments. Inversion injuries involve about 25 % of all injuries of the musculoskeletal system, and about 50 % of these injuries are sport-related. The lateral ankle ligament complex consists of three ligaments: the anterior talofibular ligament, the calcaneofibular ligament and the posterior talofibular ligament. The most common trauma mechanism is supination and adduction (inversion) of the plantar-flexed foot.
Conclusion Delayed physical examination provides a more accurate diagnosis. Ultrasound and MRI can be useful in diagnosing associated injury and are routine investigations in professional athletes. Successful treatment of grade II and III acute lateral ankle ligament injuries can be achieved with individualized aggressive, non-operative measures. RICE therapy is the treatment of choice for the first 4–5 days to reduce pain and swelling. Initially, 10–14 days of immobilization in a below the knee cast/brace is beneficial followed by a period in a lace-up brace or functional taping reduces the risk of recurrent injury. Acute repair of the lateral ankle ligaments in grade III injuries in professional athletes may give better results.
Level of evidence IV.

Keywords Ankle · Ligament · Injury · Lateral · Sports · Athletes · Treatment

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Introduction

It is estimated that one inversion injury of the ankle occurs for every 10,000 people each day [9, 33]. Ankle sprains constitute 7–10 % of all admissions to hospital emergency departments [45]. Inversion injuries involve about 25 % of all injuries of the musculoskeletal system, and about 50 % of these injuries are sport-related [7, 10, 16, 18, 20]. In the systematic review of Fong et al., the ankle was the most commonly injured area of the body in 24 of 70 sports included [14]. The majority of ankle sprains occur in individuals under 35 years of age, most commonly in those aged 15–19 years [32]. They account for up to 40 % of all athletic injuries and are most commonly seen in athletes participating in basketball, soccer, running and ballet or dancing [5, 11, 31]. Up to 53 % of basketball injuries and

29 % of soccer injuries can be attributed to ankle injuries, and 12 % of time lost in football is due to ankle injuries [13, 17]. The injury rate in volleyball players was 0.9 per 1,000 player hours with 0.7 % during practice and 2.6 % during games [4]. Three-quarters of ankle injuries involve the lateral ligamentous complex; there is conflicting evidence as to whether females are more prone to these injuries when compared to males [16, 20].

Without adequate diagnosis and treatment, ankle injuries may lead to chronic instability, osteoarthritis and other permanent sequelae [7, 15, 21]. For high-level commercial sports teams, absence of key players due to injury may result in defeat and economic loss. Athletes have significantly greater load and demand on their ankle joints than the average population and sports performed at the highest level are possibly an unfavourable prognostic factor for the development of residual complaints [30]. Therefore, treatment of acute ankle ligament injuries in the athlete provides an extra challenge. Some guidelines for diagnosis, treatment and prevention of acute lateral ankle ligament injury in general population were formulated previously [27]. This article reviews the acute lateral ankle injuries with special emphasis on a rationale for treatment of these injuries in professional athletes. A professional athlete is defined as a person who trains and plays a sport for a living.

Anatomy

The tibiotalar joint is considered a simple hinge joint but it is much more complex due to its articular, ligamentous and tendinous anatomy. The lateral ankle ligament complex consists of three ligaments: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) [36]. The ATFL blends with the ankle capsule and runs from the antero-inferior margin of the fibula to the lateral margin of the talus inserting near the junction of the talar body and neck. The CFL originates on the inferior margin of the fibula distal to the ATFL and runs underneath the peroneal tendons to insert on the lateral tubercle of the calcaneus. The PTFL is a thickening of the capsule from the posterior fibula to the lateral tubercle of the posterior process of the talus.

The ATFL is the first or only ligament to be damaged in two-thirds of all injuries [10]. It is important to understand that these ligaments all contribute to the stability of the ankle joint. This is because the talus rotates in the ankle mortise when ankle motion occurs and therefore one ligament cannot provide stability at all joint positions. Broström [10] found that combined ruptures of the ATFL and the CFL occurred in 20 % of cases and that isolated rupture of the CFL was very rare. The PTFL is usually not injured in an inversion injury of the ankle because its maximal load to failure is 3 times that of the ATFL and this ligament is lax when the ankle is plantar flexed.

Classification

Most authors use the term “ankle sprain” to describe a morphologic condition representing a diversity of pathology, ranging from overstretching of the ligament to complete rupture with instability of the joint. There are several grading and staging systems for lateral ankle ligament injuries based on anatomical injury, clinical symptoms, trauma mechanism, stability and “severity” of the injury. A classification is only relevant when it has consequences for treatment of prognosis. We propose the system introduced by Hamilton and Kaikkonen in 1982. This system incorporates anatomical damage with patient’s symptoms. To classify the severity of the ankle sprains, this system grades the injuries from I to III [22, 40]. In clinical practice, only the difference between a simple sprain (grade I) and real instability (grade II or III) is relevant because the only grades II and III require an additional treatment. This classification system is only reliable when made with delayed physical examination as discussed further on [40–42].

Mechanism of injury

Understanding the injury mechanism is important for optimizing treatment, injury prevention and for the research goals. A twisting injury or “going over on the ankle” usually results in an inversion of the foot and ankle. The most common trauma mechanism is supination and adduction (inversion) of the plantar-flexed foot. Sometimes, there is also an external rotation of the lower leg with respect to the ankle joint [19]. Inversion injuries of the plantar-flexed foot result in ATFL injury because the ligament is tight in this position.

The majority of ankle sprains during soccer were sustained during player contact (59 %) except for goalkeepers in whom 79 % occurred during non-contact situations [46]. Andersen et al. analysed the ankle supination sprain injury with video and reported that there were two major mechanisms: (1) impact by opponent on the medial aspect of the leg just before or at foot strike, resulting in a laterally directed force causing the player to land with the ankle in a vulnerable inverted position; (2) forced plantar flexion when the injured player hits the opponent’s foot when attempting to shoot or clear the ball [2].

History

Inversion injuries of the ankle, if not diagnosed and treated properly, may lead to late symptoms in 30–40 % of the patients [7, 15]. A correct diagnosis is important but there is no information correlating the history of injury mechanism with the precise diagnosis or grade of a lateral ligament injury. A cracking sound at the time of injury does not discriminate between a rupture or not. Patients with a rupture report more immediate swelling while in those without a rupture, the swelling appears later. Patients who sustain a rupture are more frequently compelled to stop their activities while patients without a rupture report more frequently that they can continue their activities. The ability to bear weight is relevant for the Ottawa ankle rules [3].

Examination

The initial assessment is not accurate enough to diagnose the grade of injury but is important as a triage mechanism to provide initial first care to protect the athlete from further injury, or advise the athlete to discontinue the game or match. The gold standard in the diagnosis of acute lateral ligament injury remains the delayed physical examination [40–42]. The most important features of physical examination are swelling, haematoma, localized pain on palpation and positive anterior drawer test. The site of the pain on palpation is important. If there is no pain on palpation on the anterior talofibular ligament, there is no acute lateral ankle ligament rupture [40–42]. Delayed physical examination (4–5 days post-trauma) provides a diagnostic modality of high quality and is more reliable than physical examination within 48 h after trauma. Because of the diffuse location of the pain and swelling, the examiner cannot differentiate haematoma from oedema, and the anterior drawer test is unreliable [40–42]. Localized pain on palpation in combination with haematoma discoloration gives a 90 % chance that there is an acute lateral ligament rupture [40–42]. A positive anterior drawer test by itself has a sensitivity of 73 % and a specificity of 97 % [40–42]. A positive anterior drawer test in combination with pain on palpation at the ATFL and haematoma discoloration has a sensitivity of 98 % and specificity of 84 % for having an ATFL injury.

About 60 % of the patients with an acute lateral ankle ligament injury have pain on palpation at the level of the medial malleolus. Forty percentage of the patients with an acute lateral ankle ligament injury have pain on palpation over the anterior syndesmotic ligament without a rupture of this ligament being present probably due to an anterior capsule tear.

Imaging

In acute lateral ankle ligament injury, the existence of a fracture must be excluded. The ability to walk again within 48 h after trauma indicates a good prognosis [12]. The Ottawa ankle rules have been developed to rule out fractures after acute ankle injuries [3]. Most athletes who visit the emergency room are examined using radiographs to rule out fractures despite the fact that the prevalence of ankle fractures is less than 15 % [3].

Stress radiography has no role in the routine diagnosis of lateral ankle ligament injury.

Ultrasound and MRI can be useful in diagnosing associated injury (bone, chondral or tendon) and are routine investigations in professional athletes.

Ultrasound has been demonstrated to be an accurate investigation that leads to little discomfort in patients but requires technical expertise and the data may be difficult to interpret on retrospective review by other physicians. The sensitivity and specificity of ultrasound investigation for a ligament rupture are 92 and 64 %, respectively. The predictive value of a positive ultrasound investigation is 85 % and of a negative ultrasound investigation 77 % [40, 42]. Ultrasound is accurate in demonstrating the presence of joint effusion. MRI is reliable in the diagnosis of acute ligamentous ankle injuries, evaluation of tendon disorders, occult fractures and osteochondral lesions, although the last can be diagnosed more reliable with a CT scan [8]. Imaging the ankle at 20° of plantar flexion and the use of superficial coils improve ligament visibility. Early arthroscopy provides an evaluation and treatment tool for intra-articular (chondral) injuries, but we do not routinely perform this operation in professional athletes, only in patients with MRI diagnosed intra-articular pathology that requires surgery.

Management

Treatment of grade II and III acute lateral ankle ligament injuries can be treated with individualized aggressive, non-operative measures. The treatment is based upon the stages of biological ligament healing. These phases are the following: inflammatory phase, the proliferation phase (6 weeks to 3 months after trauma) and the remodelling or maturation phase (until 1 year after trauma) [1].

The initial treatment during the inflammatory phase is directed towards avoiding or diminishing excess swelling and ongoing injury, thus optimizing the healing process [1]. RICE (Rest, Ice, Compression and Elevation) therapy is the treatment of choice for the first 4–5 days to reduce pain and swelling [38]. Although some authors concluded that early mobilization is beneficial [6], we prefer a short

initial period of 5–7 days (max 10 days) of immobilization in a below the knee cast or removable boot. This is supported by the CAST study of 584 patients with acute lateral ligamentous injury who had a faster recovery with a short period of immobilization when compared to treatment in a compression bandage [29]. There were flaws in this study including no description of additional interventions, this was a postal questionnaire, and there was a 17 % drop-out rate, but overall, the results suggest initial immobilization is beneficial. Prolonged immobilization has a detrimental effect on muscles, ligaments and joint surfaces and will result in inferior outcome [26].

During the second proliferation phase, the tissue responds with vascular ingrowth, fibroblast proliferation and new collagen formation. Protection of inversion is important during this phase of healing to prevent excess formation of weaker type III collagen formation that can contribute to chronic elongation of the ligament. Controlled stress on the ligament will promote proper collagen fibre orientation so that full return to activities will be possible between 4 and 8 weeks after the injury. In addition, motion, stretching and strengthening will avoid the harmful effects of immobilization on the muscle, joint cartilage and bone.

Functional treatment with a tape, semi-rigid or lace-up brace appears to be superior with regard to symptom relief, return to work, return to sport, and joint stability for treating acute lateral ankle ligament injury when compared with a period of more than 4 weeks of immobilization [26]. The use of an elastic bandage has fewer complications than taping but is associated with a slower return to work and sport and more reported instability than a semi-rigid ankle support [28]. A lace-up ankle support is effective in reducing swelling in the short term compared with a semi-rigid ankle support, elastic bandage or tape [28].

The use of therapeutic ultrasound and electrical muscle stimulation in the treatment of acute lateral ankle ligament injury is not advised [39]. The efficacy of non-steroidal anti-inflammatory drugs in the treatment of acutely sprained ankles has been studied in prospective randomised double-blind trials, and it seems that this is beneficial in the short term with regard to pain, swelling and return to sport. A meta-analysis of all available studies is currently being performed [37]. During the first six weeks of treatment, physiotherapist-supervised peroneal muscle strengthening and proprioceptive training with a multidirectional balance board should be continued. Activities in this phase should progressively simulate the professional athlete's required activities during practice and competition. An appropriate progression should be devised by the physical therapist, athletic trainer, coach or physician overseeing the athlete's rehabilitation programme. After the first six weeks, the lace-up brace or tape may be continued during higher-risk activities.

Surgical repair can be performed in patients with chronic lateral ankle ligament injury, but today, most patients with acute lateral ankle ligament injury are treated non-operatively. The Cochrane review of Kerkhoffs et al. [24] regarding the comparison of surgery versus conservative treatment for acute lateral ankle ligament injuries fails to demonstrate a clearly superior treatment approach. There was limited evidence for longer recovery times, higher incidences of ankle stiffness, impaired ankle mobility and more complications in the surgical treatment group [24]. Less objective instability (anterior drawer test and talar tilt test) was observed following operative treatment. The time of the season, athletes' expectations, sports specific ankle load, individual history, stage of his or her career, time from trauma to diagnosis, collateral ankle joint damage and access to an expert orthopaedic surgeon are all features to take into account when considering an operative treatment of lateral ankle ligament injuries in the high-level athlete [25].

The advantage of a repair is that objective instability, as defined by a positive talar tilt on stress radiographs or positive anterior drawer sign, was significantly less common when compared to non-operative treatment. Because increased objective instability is a predictor for future ankle sprains [43], an acute reconstruction is preferred in professional athletes. As for several other operations, it is known that when a repair is performed by an experienced surgeon in a high-volume centre, the outcome will improve [25]. When considering an acute repair in a professional athlete, the patient should be referred to high-volume centre to improve outcome.

When performing repair in an acute injury, we prefer a direct anatomical reconstruction of the ruptured lateral ligaments. Postoperatively, a cast is applied for 2 weeks and then a removable boot for a further 4 weeks with physiotherapy supervised range of motion and muscle strengthening/proprioceptive training commenced following the 2 weeks of immobilization. The athlete remains non-weight-bearing during the first 2 weeks, partial weight-bearing from 2 to 4 weeks and then full weight-bearing form 4 weeks postoperatively. A graduated functional return to training programme is set on an individual basis aiming for return to training/play within 12 weeks of injury.

Injury prevention

The most important risk factor for an ankle sprain is a previous ankle sprain. This is due to reduced proprioceptive function and reduced mechanical stability [23]. There is a significant decrease in recurrent injuries in previously injured ankles using balance board training [44]. Therefore, athletes should be advised to complete a supervised

rehabilitation programme of balance training exercises. It is controversial if this training is beneficial in normal healthy ankles in preventing sprains. A semi-rigid or lace-up brace has been shown to lead to a significant reduction in recurrent ankle sprains in previously injured ankles [34, 35]. There is some controversy as to whether taping is also beneficial in preventing recurrent sprains. There is no evidence to demonstrate that a high ankle shoe prevents future injury in athletes. In many sports, the ankle sprains are caused through unpredictable player on player contacts, and it will be impossible to prevent many of these injuries by instigating avoidance training techniques.

Conclusion

Delayed physical examination (4–5 days post-trauma) provides a diagnostic modality of high quality. Ultrasound and MRI can be useful in diagnosing associated injury (bone, chondral or tendon) and are routine investigations in professional athletes. Treatment of grade II and III acute lateral ankle ligament injuries can proceed with individualized aggressive, non-operative measures. RICE (Rest, Ice, Compression and Elevation) therapy for the first 4–5 days to reduce pain and swelling is beneficial. We prefer a short period (5–10 days) of immobilization in a below the knee cast or removable boot followed by a structured functional rehabilitation programme usually supplemented with a period using a lace-up brace or taping. Acute repair of the lateral ankle ligaments in professional athletes with grade II or III lateral ankle ligament injury gives better results with a similar (possibly earlier) time to recovery and reduces the risks of longer-term instability.

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References

1. Akeson WH, Woo SLY, Amiel D, Frank CB (1984) The chemical basis for tissue repair. In: Hunter LH, Funk FJ (eds) Rehabilitation of the injured knee. C. V. Mosby, St. Louis, pp 93–147
2. Andersen TE, Floerenes TW, Arnason A, Bahr R (2004) Video analysis of the mechanisms for ankle injuries in football. Am J Sports Med 32(1 Suppl):69–79
3. Bachmann LM, Kolb E, Koller MT, Steurer J, Ter Riet G (2003) Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. BMJ 326:417–423
4. Bahr R, Karlsen R, Lian O, Ovrebø RV (1994) Incidence and mechanisms of acute ankle inversion injuries in volleyball. A retrospective cohort study. Am J Sports Med 22(5):595–600
5. Balduini FC, Vegso JJ, Torg JS et al (1987) Management and rehabilitation of ligamentous injuries to the ankle. Sports Med 4(5):364–380
6. Bleakley CM, O'Connor SR, Tully MA, Rocke LG, Macauley DC, Bradbury I, Keegan S, McDonough SM (2010) Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. BMJ 10(340):c1964
7. Bosien WR, Staples OS, Russell SW (1955) Residual disability following acute ankle sprains. J Bone Joint Surg Am 37: 1237–1243
8. Breitenseher MJ, Trattnig S, Kukla C, Gaebler C, Kaider A, Baldt MM et al (1997) MRI versus lateral stress radiography in acute lateral ankle ligament injuries. J Comput Assist Tomogr 21: 280–285
9. Brooks SC, Potter BT, Rainey JB (1981) Inversion injuries of the ankle: clinical assessment and radiographic review. BMJ 282: 607–608
10. Broström L (1966) Sprained ankles. V. Treatment and prognosis in recent ligament ruptures. Acta Chir Scand 132:537–550
11. Colville MR (1998) Surgical treatment of the unstable ankle. J Am Acad Orthop Surg 6(6):368–377
12. De Bie RA, de Vet HC, van den Wildenberg FA, Lenssen T, Knipschild PG (1997) The prognosis of ankle sprains. Int J Sports Med 18(4):285–289
13. Ekstrand J, Gillquist J (1983) Soccer injuries and their mechanisms: a prospective study. Med Sci Sports Exerc 15(3):267–270
14. Fong DTP, Hong Y, Chan LK, Yung PSH, Chan KM (2007) A systematic review on ankle injury and ankle sprain in sports. Sports Med 37(1):73–94
15. Freeman MAR (1965) Instability of the foot after injuries to the lateral ligament of the ankle. J Bone Joint Surg Br 47:669–677
16. Garrick JM (1977) The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. Am J Sports Med 5:241–242
17. Garrick JG, Requa RK (1973) Role of external support in the prevention of ankle sprains. Med Sci Sports 5(3):200–203
18. Glick JM, Gordon RB, Nashimoto D (1976) The prevention and treatment of ankle injuries. Am J Sports Med 4:136–141
19. Hertel J (2002) Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. J Athl Train 37(4): 364–375
20. Hosea TM, Carey CC, Harrer MF (2000) The gender issue: epidemiology of ankle injuries in athletes who participate in basketball. Clin Orthop Relat Res 372:45–49
21. Jackson DW, Ashley RD, Powell JW (1974) Ankle sprains in young athletes: relation of severity and disability. Clin Orthop Relat Res 101:201–215
22. Kannus P, Renstrom P (1991) Current concept review. Treatment for acute tears of the lateral ligaments of the ankle. J Bone Joint Surg Am 73:305–312
23. Karlsson J, Peterson L, Andréasson G, Högfors C (1992) The unstable ankle: a combined EMG and biomechanical modeling study. Int J Sport Biomech 8:145–151
24. Kerkhoffs GM, Handoll HH, de Bie R, Rowe BH, Struijs PA (2007) Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. Cochrane Database Syst Rev CD000380
25. Kerkhoffs GM, Tol JL (2012) A twist on the athlete's ankle twist: some ankles are more equal than others. Br J Sports Med 46(12): 835–836
26. Kerkhoffs GM, van den Bekerom MPJ, Assendelft WJ, Blankevoort L, Struijs PA, van Dijk CN, Smidt N (2012) Immobilisation and functional treatment for acute lateral ankle ligament

injuries in adults. Cochrane Database Syst Rev (personal communication)
27. Kerkhoffs GM, van den Bekerom M, Elders LA, van Beek PA, Hullegie WA, Bloemers GM, de Heus EM, Loogman MC, Rosenbrand KC, Kuipers T, Hoogstraten JW, Dekker R, Ten Duis HJ, van Dijk CN, van Tulder MW, van der Wees PJ, de Bie RA (2012) Diagnosis, treatment and prevention of ankle sprains: an evidence-based clinical guideline. Br J Sports Med 46(12): 854–860
28. Kerkhoffs GM, van den Bekerom MPJ, Struijs PA, Assendelft WJ, Blankevoort L, van Dijk CN (2012) Different functional treatment strategies for acute lateral ankle ligament injuries in adults. Cochrane Database Syst Rev (personal communication)
29. Lamb SE, Marsh JL, Hutton JL, Nakash R, Cooke MW; Collaborative Ankle Support Trial (CAST Group) (2009) Mechanical supports for acute, severe ankle sprain: a pragmatic, multicentre, randomised controlled trial. Lancet 373(9663):575–581
30. Linde F, Hvass I, Jurgensen U, Madsen F (1986) Early mobilizing treatment in lateral ankle sprains. Course and risk factors for chronic painful or function-limiting ankle. Scand J Rehabil Med 18:17–21
31. Lindenfeld TN, Schmitt DJ, Hendy MP et al (1994) Incidence of injury in indoor soccer. Am J Sports Med 22:364–371
32. Nilsson S (1983) Sprains of the lateral ankle ligaments II. Epidemiological and clinical study with special reference to different forms of conservative treatment. J Oslo City Hosp 33:13–36
33. Ruth C (1961) The surgical treatment of injuries of the fibular collateral ligaments of the ankle. J Bone Joint Surg Am 43:229–239
34. Sitler M, Ryan J, Wheeler B, McBride J, Arciero R, Anderson J, Horodyski M (1994) The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball. A randomized clinical study at West Point. Am J Sports Med 22(4):454–461
35. Surve I, Schwellnus MP, Noakes T, Lombard C (1994) A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. Am J Sports Med 22(5):601–606
36. Van den Bekerom MPJ, Oostra RJ, Golano Alvarez P, van Dijk CN (2008) The anatomy in relation to injury of the lateral collateral ligaments of the ankle: a current concepts review. Clin Anat 21(7):619–626
37. Van den Bekerom MPJ, Sjer AEB, Struijs PAA, Blankevoort L, van Dijk CN, Kerkhoffs GMMJ (2010) Non steroidal anti-inflammatory drugs for treating acute ankle sprains. Cochrane Database Syst Rev 11:CD008810
38. Van den Bekerom MPJ, Struijs PAA, Welling L, Blankevoort L, van Dijk CN, Kerkhoffs GMMJ (2012) What is the evidence for RICE therapy in the treatment of ankle sprains? Systematic review of literature. J Athl Train 47(4):435–443
39. Van den Bekerom MPJ, van der Windt DAWM, van der Heijden GJ, Van den Berg S, ter Riet G, De Winter AF, Bouter LM (2011) Therapeutic ultrasound for acute ankle sprains. Cochrane Database Syst Rev 15;6:CD001250
40. Van Dijk CN (1994) On diagnostic strategies in patients with severe ankle sprain. Thesis, University of Amsterdam, The Netherlands (ISBN 10: 9090068805/ISBN 13: 9789090068800)
41. Van Dijk CN, Lim LS, Bossuyt PM, Marti RK (1996) Physical examination is sufficient for the diagnosis of sprained ankles. J Bone Joint Surg Br 78(6):958–962
42. Van Dijk CN, Mol BW, Lim LS, Marti RK, Bossuyt PM (1996) Diagnosis of ligament rupture of the ankle joint. Physical examination, arthrography, stress radiography and sonography compared in 160 patients after inversion trauma. Acta Orthop Scand 67(6):566–570
43. Verhagen EA, Van der Beek AJ, Bouter LM, Bahr RM (2004) Van Mechelen W (2004) A one season prospective cohort study of volleyball injuries. Br J Sports Med 38(4):477–481
44. Verhagen EA, van der Beek AJ, Twisk J, Bouter LM, Bahr RM, van Mechelen W (2004) The effect of a proprioceptive balance board training program for the prevention of ankle sprains: a prospective controlled trial. Am J Sports Med 32(6):1385–1393
45. Viljakka T, Rokkanen P (1983) The treatment of ankle sprain by bandaging and antiphlogistic drugs. Ann Chir Gynaecol 72:66–70
46. Woods C, Hawkins R, Hulse M, Hodson A (2003) The Football Association Medical Research Programme: an audit of injuries in professional football: an analysis of ankle sprains. Br J Sports Med 37(3):233–238