

Review

# Anterior cruciate ligament injuries in soccer: Loading mechanisms, risk factors, and prevention programs

Boyi Dai <sup>a</sup>, Dewei Mao <sup>b</sup>, William E. Garrett <sup>c</sup>, Bing Yu <sup>d,\*</sup>

<sup>a</sup> Division of Kinesiology and Health, University of Wyoming, Laramie, WY 82071, USA

<sup>b</sup> Shandong Sports Science Research Center, Jinan 250102, China

<sup>c</sup> Duke Sports Medicine Center, Duke University, Durham, NC 27710, USA

<sup>d</sup> Division of Physical Therapy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA

Received 19 April 2014; revised 3 June 2014; accepted 7 June 2014

Available online 30 July 2014

## Abstract

Anterior cruciate ligament (ACL) injuries are common in soccer. Understanding ACL loading mechanisms and risk factors for ACL injury is critical for designing effective prevention programs. The purpose of this review is to summarize the relevant literature on ACL loading mechanisms, ACL injury risk factors, and current ACL injury prevention programs for soccer players. Literature has shown that tibial anterior translation due to shear force at the proximal end of tibia is the primary ACL loading mechanism. No evidence has been found showing that knee valgus moment is the primary ACL loading mechanism. ACL loading mechanisms are largely ignored in previous studies on risk factors for ACL injury. Identified risk factors have little connections to ACL loading mechanisms. The results of studies on ACL injury prevention programs for soccer players are inconsistent. Current ACL injury prevention programs for soccer players are clinically ineffective due to low compliance. Future studies are urgently needed to identify risk factors for ACL injury in soccer that are connected to ACL loading mechanisms and have cause-and-effect relationships with injury rate, and to develop new prevention programs to improve compliance.

Copyright © 2014, Shanghai University of Sport. Production and hosting by Elsevier B.V. Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).

**Keywords:** ACL injuries; Biomechanics; Injury prevention; Soccer

## 1. Introduction

Soccer is the most popular sport in the world.<sup>1</sup> Playing soccer can improve musculoskeletal, metabolic, and cardiovascular functions.<sup>2</sup> However, soccer is one of the sports that have the highest risk of anterior cruciate ligament (ACL) injury.<sup>3,4</sup> The incidence rates of ACL injury in soccer range 0.15%–3.67% per person per year and 0.07–1.08 per 1000 sports exposures across various age and competition levels.<sup>5,6</sup> Female soccer players are 2–3 times more likely to suffer ACL injuries compared to male soccer players.<sup>5,7</sup> The majority of ACL injuries occur without external contact to the knee joint.<sup>4,8–15</sup>

ACL injuries have brought financial burden to society, and caused devastating consequences to patients' quality of life. Based on an estimated 200,000 cases of ACL tears in US each year, annual cost of ACL injury is estimated to be US\$4 billion for surgical treatment alone.<sup>16</sup> The lifetime financial burden of these injuries to society is estimated to be US\$7.6 billion annually when treated with ACL reconstruction and US\$17.7 billion when treated with rehabilitation.<sup>17</sup> Even with ACL reconstructions, individuals after reconstructed ACLs usually have abnormal strength, proprioception, balance, and neuromuscular control patterns<sup>18</sup> as well as increased risks for re-injury.<sup>19–21</sup> Many of these individuals are not able to return to their pre-injury level of activity.<sup>22</sup> Fifty-nine percent to 70% of these individuals would develop radiographically diagnosed knee osteoarthritis; 16%–19% would have symptomatic knee osteoarthritis over their lifetime, and 13%–15% would need total knee arthroplasty.<sup>17</sup> Tremendous research and clinical

\* Corresponding author.

E-mail address: [bing\\_yu@med.unc.edu](mailto:bing_yu@med.unc.edu) (B. Yu)

Peer review under responsibility of Shanghai University of Sport.

efforts have been made in the last 2 decades to prevent ACL injuries and improve the rehabilitation after ACL reconstruction surgeries,<sup>23–25</sup> however ACL injury rates have not been reduced.<sup>10,26,27</sup>

van Mechelen et al.<sup>28</sup> proposed a sequence for preventing sports injuries. In this sequence, prevention of sports injury should follow four steps: (1) descriptions of the extent of injuries, (2) understanding of injury mechanisms and identification of risk factors, (3) development of injury prevention strategies, and (4) evaluation injury prevention strategy. The problem of ACL injury has been well described, however, the injury mechanisms and risk factors for ACL injury are still not well understood and identified. Consequently current ACL injury prevention programs have limitations that prevent them from being effective. Therefore, the purpose of this review is to summarize the relevant literature on ACL loading mechanisms, ACL injury risk factors, and current ACL injury prevention programs for soccer players. We hope this review will contribute to the development of future ACL injury prevention programs in soccer as well as in other sports.

## 2. Loading mechanisms

The ACL is a primary restraint to anterior translation of the tibia relative to the femur.<sup>29</sup> *In vitro* studies demonstrated that an anterior shear force applied on the tibia was the primary ACL loading mechanism.<sup>30,31</sup> The magnitude of anterior shear force applied on the tibia and its effect on ACL loading are largely affected by the posterior ground reaction force and knee flexion angle during a movement. The posterior ground reaction force on the foot during a movement creates a flexion moment at the knee that needs to be balanced by an extension moment at the knee. The quadriceps is the primary generator of knee extension moments. While generating knee moments, the quadriceps applies an anterior shear force at the proximal end of the tibia that is a primary cause of anterior tibial translation and ACL loading mechanism.<sup>30,31</sup> A previous study demonstrated that the peak impact posterior ground reaction force was significantly correlated to the peak impact knee extension moment and proximal tibial anterior shear force during the landing of a stop-jump task.<sup>32</sup>

Knee flexion angle affects ACL loading through its relationships with patella tendon-tibia shaft angle and ACL elevation angle.<sup>33–35</sup> Studies showed that ACL loading decreased when knee flexion angles increased.<sup>30,36</sup> Taylor et al.<sup>37</sup> recently quantified *in vivo* ACL length during a landing task using a combined fluoroscopic, magnetic resonance imaging (MRI), and videographic technique. They found that knee flexion angle and ACL length were negatively correlated, and that the peak ACL length actually occurred prior to landing when the knee flexion angle was minimal. Taylor et al.<sup>38</sup> also found that knee flexion angles explained 61% of the variance in ACL length, and that peak ACL length occurred in mid-stance during walking when the knee was close to full extension. Using the same technique, Brown et al.<sup>39</sup> found that landing with an increased initial knee flexion angle decreased peak ACL length during both pre-

landing and landing phases of a drop vertical jump task. Kim et al.<sup>40</sup> recently estimated knee kinematics at the time of ACL injury for eight patients following ACL injuries through reconstruction of the relative positions of the femur and tibia at the time of ACL injury by maximizing the contact of bone bruise areas between the femur and tibia in MRI. Their results showed a mean tibial anterior translation of 22 mm, a mean knee flexion angle of 12°, and a mean knee valgus angle of 5° at the time of ACL injury. These findings clearly demonstrate that anterior translation of the tibia relative to the femur is the primary mechanism of ACL injury, and that a small knee flexion angle is responsible for an increased anterior shear force at the knee and thus anterior translation of the tibia relative to the femur.

The ACL can also be loaded by a compressive force along the longitudinal axis of the tibia through a posterior tilted tibial plateau.<sup>41,42</sup> With the presence of a posterior tibial plateau slope, a compressive force can generate an anterior shear force to cause the tibia to translate anteriorly and load the ACL.<sup>41,42</sup> An *in vitro* study showed that anterior translation of the tibia relative to the femur increased when the posterior tilted tibial plateau slope increased from 8.8° to 13.2° under a 200 N compressive force loading.<sup>43</sup> An *in vivo* study showed that female patients with ACL injuries had significantly greater posterior tibia plateau slopes than the uninjured individuals.<sup>44</sup> These results provided a plausible explanation of the mechanism of ACL injury occurring in vertical landing tasks in which the external forces on the lower extremity are mainly in the vertical direction.

Knee “valgus collapse” was repeatedly proposed to be the major ACL injury mechanism especially in women based on the observation of ACL injury video records.<sup>9,45</sup> Quatman and Hewett<sup>45</sup> proposed sex-specific mechanism of ACL injuries. The investigators indicated that a primarily “sagittal plane” ACL injury mechanism might be correct for male athletes, but female athletes sustained ACL injuries by a predominantly “valgus collapse” mechanism. However, evidences from quantitative studies did not support “valgus collapse” as the injury mechanism for either males or females. *In vitro* studies demonstrated that, although knee valgus, varus, and internal rotation moments affected ACL loading, their effects were significant only when an anterior shear force was present at the knee.<sup>30,31</sup> A recent *in vivo* study demonstrated that the knee valgus collapse did not increase ACL length when the knee was in a flexion position.<sup>46</sup> Also, studies demonstrated that medial collateral ligament was the primary structure resisting knee valgus moment in an intact knee, and that a pure valgus moment could not rupture ACL until the medial collateral ligament was completely ruptured.<sup>47–49</sup> Only 6% patients who had ACL injuries completely ruptured their medial collateral ligaments.<sup>50</sup> Further, an *in vitro* study found that the knee valgus motion significantly increased only after the ACL had been injured,<sup>42</sup> which indicated that the increased knee valgus motion observed in injury video records was likely a consequence instead of a cause of ACL injuries.

Current literature suggests that anterior translation of the tibia relative to the femur is the primary mechanism of ACL

Download English Version:

<https://daneshyari.com/en/article/1084153>

Download Persian Version:

<https://daneshyari.com/article/1084153>

[Daneshyari.com](https://daneshyari.com)