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Magnetic Resonance Imaging Findings of Bone Marrow Edema in a Division I NCAA Women's Soccer Team During a Competitive Season

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ABSTRACT

The purpose of this study was to evaluate the prevalence of knee bone marrow edema (BME) in female NCAA Division I soccer players, over a competitive season, and the effect of recovery on the prevalence. Thirty percent of knees demonstrated BME at baseline, 53% postseason, and 39% postrecovery. Measured by the Knee Osteoarthritis Scoring System (KOSS), BME changed significantly across the 3 time periods ($P = .033$). There was a significant increase from preseason to postseason ($P = .034$) and a significant decrease from postseason to recovery ($P = .018$). BME is considered a continuation of stress injury, and the clinician should be able to identify and provide early intervention.

Keywords: athletes, bone marrow edema, soccer, sports, stress-related injury

INTRODUCTION

The use of magnetic resonance imagining (MRI) has provided researchers and clinicians with a powerful tool to evaluate various bone soft tissue maladies, such as meniscus tears, articular cartilage injuries, ligamentous structures, and bone marrow edema (BME). First described by Wilson et al in 1988, BME is characterized as increased signal intensity on T2-weighted MRI images and decreased signal intensity on T1-weighted images.[1,2] The suggested pathogenesis of these marrow changes contends that increased blood pooling, edema, reactive hyperemia, and possible microfracture of the trabecular subchondral bone alter the marrow signal intensity.[3] A positive correlation between BME and clinical complaints has been noted in previous studies involving both athletic and nonathletic populations.[4-6] BME has been hypothesized to be part of a continuum of physiologic reactions to biomechanical load and potentially a precursor of stress-related injury.[2] Furthermore, the literature has consistently shown that the severity of edema on MRI may be predictive of recovery time.[4]

Interestingly, numerous studies have assessed BME in athletic populations and identified a large number of asymptomatic cases.[2,7-10] The clinical significance of BME in these asymptomatic athletes remains poorly understood: Is it a normal physiologic reaction to stress (training loads) without significant consequences? Or is it a pathologic overuse injury that may lead to long-term joint deformation and degeneration? It is imperative to identify and closely monitor these athletes to assess risk of further injury on a case-by-case, sport-by-sport basis, as it has been suggested that sport-specific biomechanics may be responsible for these edematous changes.[2]

Soccer, in particular, is a high-intensity sport that places considerable stresses on the lower extremities and can lead to potential overuse injuries.[11,12] Numerous studies have documented that female soccer players are more likely to experience and report overuse injuries, specifically of the knee joint, during the course of a competitive season, when compared with their male counterparts.[12-15] Regular monitoring of joint integrity and the development of future interventions to reduce joint inflammation could play a significant role in decreasing these injuries. However, to our knowledge, no studies to date have used MRI to monitor changes in bone marrow integrity of the knee joint during the course of a season in female soccer players.

The purpose of the present study was to evaluate the prevalence of BME at the knee joint of a cohort of female National Collegiate Athletic Association (NCAA) Division I soccer players, over the course of a competitive season, and the effect of a recovery period on the prevalence of BME. We hypothesized that the incidence of BME would increase from baseline to postseason measurements due to the increase physical demands placed on the athletes. Furthermore, we hypothesized that the incidence of BME would decrease from postseason after a period of recovery.

METHODS

Experimental Approach to the Problem

For this prospective study, data were collected at 3 time-points (preseason, postseason, and post-recovery). The initial data collection session was performed 1 week before the start of the team's official preseason training camp. After obtaining informed consent, each subject completed a brief questionnaire to obtain information with regard to injury history, treatment for these injuries, date of birth, presence of claustrophobia, and presence of any type of metal present in their body. Upon completion of the questionnaire, subjects' height and weight were obtained; anterior drawer, Lachman, and pivot shift tests were performed; and the girth of the knee at the level of the inferior pole of the patella was measured using a cloth tape measure.

MRI

Before undergoing the imaging procedure, all subjects completed an MRI Procedure Screening Form. Subjects then underwent an MRI examination of their right and left knees. Each subject was thoroughly screened for safety by a qualified radiologic technologist trained in the use of the MRI unit (Toshiba Vantage 1.5-Tesla MRI, Toshiba America Medical Systems, Irvine, CA). Each subject was positioned supine, feet directed first into the magnet; the knee to be imaged was supported to ensure no movement, and then placed in a fully extended position with the lower extremity at 15°-20° of external rotation. A quadrature imaging coil specific for knee imaging was used. The knee joint being imaged was placed at the isocenter (0.5 inch inferior to the patella) of the knee. Table 1 lists the sequences, imaging techniques, and timing parameters used to obtain the images.

Table 1. Sequences and Corresponding Imaging Techniques and Parameters Used to Obtain Knee Images

Protocol	Time (min:sec)	Pulse Sequence	Time of Repetition (ms)	Time of Echo (ms)
Coronal locator	0:21	Fast spin echo (8) 2D	1,112	15
3-plane locator	0:30	Field echo 2D	72	9
Shimming	0:13	Field echo 2D	200	4.8/9
Sagittal proton density	4:30	Fast spin echo (4) 2D	2,750	18
Sagittal T2-weighted fat saturation	3:46	Fast spin echo (7) 2D	4,092	60
Coronal T2-weighted	3:46	Fast spin echo (7) 2D	4,092	60
Coronal proton density	4:23	Fast spin echo (4) 2D	2,300	18
Coronal STIR	3:27	Fast spin echo (7) 2D	3,750	48
Coronal T2-weighted 2.5 mm	3:18	Fast spin echo (7) 2D	3,596	60
Sagittal T2-weighted 2.5 mm	3:18	Fast spin echo (7) 2D	3,596	60

STIR = short tau inversion recovery.