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# Silent meniscal abnormalities in athletes: magnetic resonance imaging of asymptomatic competitive gymnasts

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**Abstract**

***Background*—Magnetic resonance imaging (MRI) produces exceptionally detailed images of the intra-articular structures of the knee. Recognising the range of MRI appearances within a normal population is therefore necessary in order to avoid attributing a greater significance to these than is clinically justified.**

***Objective*—To compare MRI appearances in asymptomatic gymnasts with those in a less active population in order to identify findings that may be seen in the absence of significant pathology and thereby aid the clinical management of this athletic group.**

***Methods*—MR images were obtained from 24 knees of asymptomatic competitive American collegiate gymnasts aged 18–22. The menisci were evaluated according to established grading criteria, and compared with a group of controls matched for age and sex.**

***Results*—Grade 3 intrameniscal signal abnormalities are considered to be highly correlated with meniscal tears. When compared with control group, the experimental group of gymnasts had a significantly different distribution (p<0.001) of grade 3 intrameniscal signal changes, preferentially involving the lateral meniscus. The overall incidence of grade 3 changes (13%) in gymnasts was not, however, significantly different from the incidence in the controls.**

***Conclusions*—A knowledge of these MRI appearances is important when evaluating the lateral menisci within this group of athletes to prevent unnecessary treatment or intervention. This is particularly pertinent when the imaging findings do not closely correlate with the site of symptoms.**

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Magnetic resonance imaging (MRI) is a highly sensitive diagnostic tool for studying intra-articular structures of the knee[1 2] and provides exquisite anatomical detail. A knowledge of imaging abnormalities that may occur without associated clinically significant symptoms is important for appropriate patient management.

For athletes, unnecessary treatment or intervention may be as damaging to a competitive future as failure to diagnose a clinically significant injury. Rapid, accurate evaluation of possible injuries in this group is, therefore, crucial. Meniscal signal abnormalities in the knee in certain athletic groups, and the appearance of frank meniscal tears in asymptomatic non-athletes have been described in a number of MRI studies.[3–8]

Gymnastics involves major repetitive impulse loading and twisting stresses to the knees. Training generally starts in early childhood and competitive training is consistent throughout the year. The gymnasts in our study were aged between 18 and 22, which represents a tightly defined study cohort. They were older than subjects likely to have MRI pitfalls typically described for the knees of children[9] and younger than those exhibiting age related degenerative changes.[10]

## Methods

The project was approved by the university committee on research involving human subjects (principal investigator EJ Potchen). Two groups were studied: an experimental group recruited from the current Michigan State University gymnastics teams, and a control group with a similar age and sex distribution recruited from the local population.

All subjects participated as volunteers, and gave informed, written consent. They all completed a questionnaire confirming no prior history of meniscal injury or surgery, and a full clinical examination of the knee was performed by a sports medicine physician (DOH). The experimental group comprised 14 asymptomatic gymnasts (four female, 10 male) with an average age of 20 (range 18–22), and an average period of gymnastics training of 13 years (range 8–20).Three subjects had a history of injury in one knee—a past meniscal injury, previous arthrography, and a history of patella tendinitis and chondromalacia patella—and in these subjects only the single asymptomatic knee was examined. In one asymptomatic subject, only a single knee was scanned. In all other subjects both knees were studied—a total of 24 knees.

The control group comprised 14 subjects (five female, nine male) with an average age of 20 (range 18–23). None of the subjects in the control group had engaged in gymnastics at any level, and none was involved in collegiate level competitive athletics. Two subjects had a history of prior intervention in one knee, and in these subjects only the single asymptomatic knee was examined. In all other subjects both knees were studied—a total of 26 knees.

Magnetic resonance imaging was performed on a 1.5 T Signa (GE Medical Systems, Milwaukee, Wisconsin) using a quadrature transmit/receive extremity coil. The scanning

*Table 1 Classification of meniscal signals showing distribution among the meniscal horns*

| *Group—meniscus* | *Meniscal horn* | *Intrameniscal signal < grade 3 No tear* | *Intrameniscal signal = grade 3 Indicative of a tear* |
|---|---|---|---|
| Experimental—gymnasts | | | |
| Medial | Anterior | 24 | 0 |
| | Posterior | 24 | 0 |
| Lateral | Anterior | 21 | 3 |
| | Posterior | 21 | 3 |
| Control | | | |
| Medial | Anterior | 26 | 0 |
| | Posterior | 23 | 3 |
| Lateral | Anterior | 26 | 0 |
| | Posterior | 26 | 0 |

protocol comprised T1 weighted spin echo axial images (TR 600, TE 20, 5 mm slices, 1 mm interslice gap, 256 × 256 matrix, 16 cm FOV, 1 NEX) followed by proton density and T2 weighted spin echo sagittal (TR 2000, TE 20 and 80, 5 mm slices, 1 mm interslice gap, 256 × 192 matrix, 16 cm FOV, 1 NEX, SI sat pulse). Proton density and T2 weighted fast spin echo coronal images were then acquired (TR 3000, TE 17 and 102, ETL 8, 5 mm slices, 1 mm interslice gap, 256 × 128 matrix, 16 cm FOV, 2 NEX, SI sat pulse), followed, finally, by axial gradient echo volume T2* weighted images (TR 65, TE 13, flip angle 25°, 0.7 mm slices, 128 × 128 matrix, 16 cm FOV, 2 NEX, SI sat pulse).

Images were evaluated by a radiologist experienced in musculoskeletal MR imaging (AG), who was blinded to the cohort to which the images related. Each meniscal horn was graded in accordance with a system based on that described by Lotysch[11] and validated by Crues and Stoller.[12 13] Grades 1 and 2 reflect patterns of intrameniscal signal that are not in contact with an articular margin, and these appearances are not considered to represent tears. An intrameniscal signal contiguous with an articular surface is generally found to have a high correlation with meniscal tears and is classified as grade 3. In our study the diagnosis of a meniscal tear was further restricted to cases in which a signal abutting an articular surface was identified on at least two consecutive slices. This refinement increases the diagnostic accuracy for arthroscopically confirmed meniscal tears to greater than 90%.[14]

## Results

Within the group of gymnasts we identified six grade 3 intrameniscal signal changes in 48 menisci examined (13%). These were all seen within the lateral meniscus (table 1). Figure 1 illustrates a grade 3 signal abnormality within the anterolateral meniscus of an asymptomatic gymnast. Within the control group, grade 3 signal changes were identified in three of 52 menisci studied (6%) and, in contrast, these were restricted to the posterior horn of the medial meniscus (table 1).

If we assume that the probability of grade 3 intrameniscal signal abnormalities in either the lateral or medial meniscus conforms to a binomial distribution then the greater incidence of lateral meniscal tears in the gymnasts compared with that in the matched control group is significant ($p<0.001$). However, the greater incidence of medial meniscal tears in the control group than in the group of gymnasts was not statistically significant.

## Discussion

Our study has shown that the incidence of asymptomatic grade 3 signal abnormalities in our group of gymnasts is comparable with that of a matched population group. However there is a significant difference in the location of these changes, with a greater proportion found within the lateral meniscus. The 13% incidence of lateral meniscal abnormalities in our experimental group of gymnasts compares with none seen within the lateral menisci and 6% seen in the medial menisci of our control group. Incidences of 3–7% of predominantly medial meniscal tears have been reported.[3–5] The lateral meniscal grade 3 changes in the gymnasts were evenly divided between the anterior and posterior horns, whereas the medial meniscal changes in the controls were seen only in the posterior horn (table 1).

Some studies have suggested that athletic groups, including American football players at collegiate level and marathon runners, show an increased incidence of meniscal abnormalities.[6–8] Medial meniscal abnormalities affecting the posterior horn have been shown to be more common than those of the lateral meniscus in both symptomatic and asymptomatic populations.[1 3 12 13] This is in keeping with the pattern of abnormalities we identified in our control group. A combination of the size, shape, and relative immobility of the medial meniscus, combined with the greater shear stress transmitted to the posterior horn, may account for these

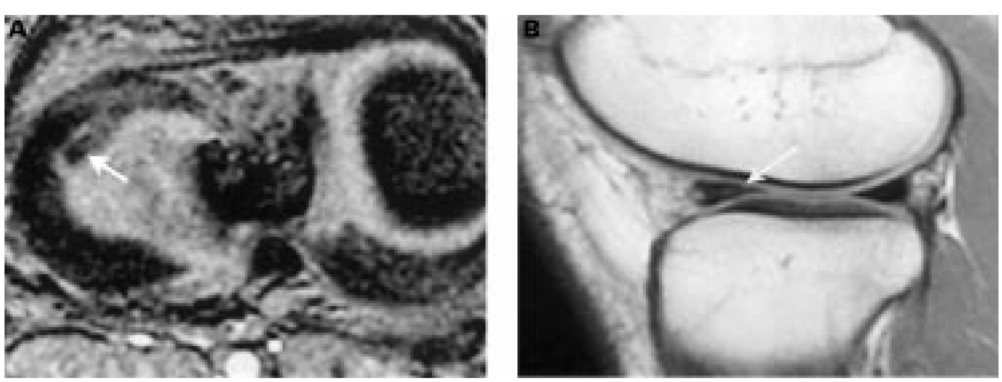


*Figure 1 18 year old asymptomatic female gymnast. (A) Axial T2* weighted gradient echo; (B) sagittal proton density spin echo images show grade 3 intrameniscal signal abnormality in the anterior portion of the lateral meniscus (arrows).*

findings. The reason why the lateral meniscus of gymnasts is preferentially affected is unclear. Physical factors, such as an increase in the patellofemoral (Q) angle, were excluded during the clinical examination. Interestingly, no medial meniscal tears were identified within the group of gymnasts despite an expectation of medial abnormalities. This finding was not, however, of statistical significance. We were sensitive to the need to reduce the risk of false positive evaluations. The age range of our athletes excludes the linear horizontal bands of perforating vessels seen in children.[9] We were conscious also of artefacts resulting from anatomical structures, such as the transverse meniscal ligament, lateral inferior geniculate artery, and popliteus tendon,[15] as well as imaging artefacts due to volume averaging from the normal concavity of the outer meniscal edge,[4] truncation artefact,[16] and the magic angle effect.[17] Diagnostic accuracy was further enhanced by restricting classification as grade 3 to abnormalities shown on at least two consecutive slices,[14] and we required signal abnormalities to be confirmed in more than one imaging plane.

Despite the fact that a meniscal signal classified as grade 3 is generally accepted as representing tears, in the subjects we examined they did not represent clinically detectable lesions. We postulate that the abnormalities result from subclinical or repeated minor trauma, the pattern of which may be influenced by the young age at which training begins. Studies of asymptomatic subjects in whom signal abnormalities persist after surgical repair have attributed the signal to granulation tissue,[18] which characteristically shows increased signal owing to its high water content. We suggest that a comparable mechanism of repair may be operating here.

The distinctive pattern of abnormalities within this specific group of athletes is significant. In gymnasts a grade 3 signal shown within the lateral meniscus, in the absence of clinical symptoms that closely correlate with the site of the abnormality, should be interpreted with caution when considering treatment. This study also highlights the importance of establishing and understanding the range of normal baseline MRI appearances within other tightly defined athletic groups.

## Contributors

CN Ludman coordinated and helped initiate the study. She recruited the participants, performed the MR imaging and data collection, wrote the paper, and will act as guarantor. DO Hough participated in the design of the study and performed the medical examinations of the athletes. TG Cooper participated in the design of the study and data collection. He advised on the technical aspects, performed the statistical analysis of the data, and helped to edit the paper. A Gottschalk initiated and participated in the design of the study, performed the radiological interpretation of the images, and helped in editing the paper.

We would like to acknowledge the help of Holly Kasavana from the department of intercollegiate athletics, Michigan State University, for assisting in the recruitment of the athletes and for facilitating the study. We would also like to thank the collegiate gymnasts who volunteered their time.

## Obituary

Regretfully, David O Hough, one of the coauthors on this paper, died unexpectedly on 26 September 1996 at the age of 50. Originally from San Diego, David Hough attended the University of California-Davis. In 1975 he assisted in establishing the Michigan State University (MSU) Department of Family Practice and in 1976 he helped to start the MSU sports medicine programme, which he directed until his death.

Dr Hough was a highly respected researcher and practitioner in the fields of family practice and sports medicine. He authored over 100 publications and coauthored the textbook, *Primary Care Sports Medicine*. He was responsible for developing drug education and testing programmes and provided counselling for students and coaches. After his death a memorial scholarship was established in his name, to be awarded for excellence in family practice.

He was a caring, compassionate, highly principled, and extremely likeable man who contributed widely to the local community. He was devoted to his family, and leaves a wife, Jill, and two children, Jeffrey and Kristin. He will be greatly missed (TGC/CNL).


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### Take home message

In competitive gymnasts, grade 3 signal changes may be seen within the lateral menisci without representing significant pathology. This has important implications for the clinical management of this group of athletes, and these appearance should be interpreted with caution in the absence of close symptomatic correlation.