J oint position appreciation at the knee is influenced by a number of sensory modalities, including visual and cutaneous cues, but the most important proprioceptive afferents appear to be from the mechanoreceptors in the muscles, ligaments, and capsule of the knee.  

It has been shown that rupture of the anterior cruciate ligament is associated with a poorer sense of joint position. This indicates that the vulnerability to injury of knees deficient in anterior cruciate ligament may be due to the loss of proprioceptive input as well as decreased mechanical stability. In addition to this, evidence from animal studies indicates that stretching of the anterior cruciate ligament may be due to the loss of proprioceptive input as well as mechanical restraints but also have a neurophysiological role in joint function and protection. A report that knee joint laxity increases with exercise raised the question as to whether there is any compensatory change in joint position appreciation.

**Background:** It is now generally accepted that the ligamentous structures of the knee not only act as mechanical restraints but also have a neurophysiological role in joint function and protection. A report that knee joint laxity increases with exercise raised the question as to whether there is any compensatory change in joint position appreciation. 

**Objective:** To test whether there is a compensatory mechanism for increased ligamentous laxity during normal levels of activity.

**Methods:** Joint position appreciation was measured, using a previously reported technique, in the knees of sportsmen at rest and after warm up.

**Results:** Joint position appreciation was found to be significantly more sensitive after warm up ($p = 0.003$).

**Conclusions:** These findings indicate that joint position appreciation within the knee accommodates physiological changes within the ligaments and muscles after exercise.

**Subjects and Method**

**Subjects**

Adult male volunteers (mean age 25; range 18–33) were recruited from a local rugby football club. All subjects were questioned about past knee injuries and were also clinically examined before inclusion in the study. Excluded from the study were those with a history of previous knee operations or a recent history of significant injury to the knee, femur, or tibia.

**Apparatus**

A purpose built padded frame permitted the leg under examination to rest in a totally relaxed manner (fig 1). An electrogoniometer (Penny & Giles Blackwood Ltd, Blackwood, Gwent, Wales, UK), tested to be accurate to 0.5°, was attached to the thigh and shin using padded strapping. The subject lay with one leg supported on the frame, with a screen preventing any visual clues as to the position of the leg.

The test, as previously described, involved the passive movement of the leg to a predetermined sequence of ten positions of knee flexion between 0 and 60°. The subject indicated what he perceived the position of his knee to be using a hand held model of a leg, incorporating another electrogoniometer (fig 2).
The output from the electrogoniometers was fed into a preamplifier before numeric representation on a liquid crystal display. The data were put in a Macintosh microcomputer and processed using a macro written to calculate the mean difference (Ω) between successive changes in the knee flexion angle and successive changes in perceived angle—that is, the mean error in estimating the changes. The reproducibility of this measurement has been previously reported.15

### Method

Before undertaking any physical activity, 12 subjects (23 knees) were tested to assess their sense of knee joint position, and the data recorded. Each subject then performed a standardised warm up, consisting of jogging and stretching exercises, of four minutes duration. The sense of knee joint position was then re-evaluated using a technique identical with that of the initial assessment.

A previous study using a similar method showed that, if the test is repeated on the same day, the results are highly reproducible—that is, there is no significant experimental learning—obviating the need for a separate experiment to control for this.

### Statistical analysis

The data were compared using the Wilcoxon signed rank test, with values of probability of less than 0.05 accepted as being statistically significant. Correlation was assessed by the method of least squares from which Pearson's coefficient of correlation was derived.

### RESULTS

Using this modified apparatus, with its more accurate measurement, a wide variability in measured joint position sense was found between individuals (table 1); this has been reported in a previous study.15

### Effect of age on joint position appreciation in the resting knee

A trend was found for joint position appreciation to deteriorate with increasing age; the correlation was, however, weak (Pearson's coefficient of correlation = 0.44).

### Effect of warming up on joint position appreciation in the knee

After warm up, the mean value of Ω fell from 10.59 to 8.21 (table 2); this represents an improvement in accuracy of joint position appreciation. When subjected to statistical analysis, the difference was found to be highly significant (p = 0.005: Wilcoxon signed rank test).

### DISCUSSION

In this study, the mean values of joint position appreciation were similar to those reported in the resting knees of normal subjects.15 This would support the view that the method used not only has intrasubject reproducibility but also that reproducibility exists between comparable subject groups. Previous studies have shown a decreased accuracy of joint position appreciation with increasing age.16–18 We did not observe any strong correlation to support these previous observations; the small age range within our subject group best explains this.

The most important finding in this study is that, after warm up exercise, there is an improvement in measured joint position appreciation. This may be explained by an increase in the sensitivity of the mechanoreceptors around the knee or a more central mechanism. The method used is passive and minimises the rate of change of muscle length, and will therefore primarily measure ligament rather than muscle based proprioception. It is our hypothesis that the ligaments of the knee act not only as static neural transducers but are also capable of accommodating physiological changes in ligamentous laxity; the results appear to support this. Teleologically, this would be expected, as it is difficult to envisage a biological system protecting the ligaments and joint structures that decompensates in response to the physiological changes occurring after exercise, within the ligament itself.
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REFERENCES
1 Johansson H, Spjander P, Sjoka P. A sensory role for the cruciate
2 Schultz RA, Miller DC, Kerin CS, et al. Mechanoreceptors in human
4 Barrack RL, Skinner HB, Buckley SL. Proprioception in the anterior
5 Barrett DS. Proprioception and functional result following anterior
6 Corrigan JP, Cashman FP, Brady MP. Proprioception in the cruciate
of the antagonist musculature in maintaining knee stability. Am J Sports
8 Solomonov M, Baratta R, Zhou BH, et al. The synergistic action of the
anterior cruciate ligament and thigh muscles in maintaining joint stability.
9 Lattanzio P-J, Petrella, RJ. Knee proprioception a review of mechanisms
measurements and implications of muscular fatigue. Orthopedics
10 Marks R, Quinnery HA. Effect of fatiguing maximal isokinetic quadriceps
contractions on ability to estimate knee position. Percept Mot Skills
13 Rovick JS, Reuben JD, Schrager RJ, et al. Relationships between knee
14 Wong C-J, Walker PS. The effects of flexion and rotation on the length
arthroplasty: the influence of prosthetic design. Clin Orthop
16 Barrett DS, Cobb AG, Bentley G. Joint proprioception in normal,
17 Kaplan FS, Nixon JE, Reitz M, et al. Age related changes in
proprioception and sensation of joint position. Acta Orthop Scand
18 Skinner HB, Barrack RL, Cook SD. Age-related decline in