ORIGINAL ARTICLE

Effect of warming up on knee proprioception before sporting activity

M J Bartlett, P J Warren

Br J Sports Med 2002;36:132-134

See end of article for authors' affiliations

Correspondence to:
Mr Bartlett, Northwick Park
Hospital, Watford Road,
Harrow, Middlesex
HA1 3UJ, UK;
mjbartle@freenetname.co.uk

Accepted
3 December 2001

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 ($p = 0.005$).

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

Joint 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.¹⁻³ It has been shown that rupture of the anterior cruciate ligament is associated with a poorer sense of joint position.⁴⁻⁶ 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 triggers a neural feedback mechanism leading to contraction of the hamstrings and thus limitation of the forward excursion of the tibia on the femur.⁷⁻⁸ It is reasonable to postulate that there are a number of such protective mechanisms supplementing the static ligamentous restraints of the knee with active muscular control, thus reducing the risk of injury to the joint.

Exercise to fatigue levels appears to decrease joint position appreciation in the knee,⁹⁻¹¹ and Skinner *et al*¹¹ have postulated that this is due primarily to the loss of efficiency of muscle mechanoreceptors. Exercise has been shown to produce a temporary increase in A-P laxity of the knee,¹² and it has also been shown that the lengths of the cruciate ligaments vary with knee flexion angle and also with tibial rotation.¹³⁻¹⁴ These factors would seem to leave the knee more vulnerable to injury during and after exercise than at rest, which would be a considerable disadvantage to continued effective knee function. Although this unfortunate state of affairs may exist after severe exercise with muscle fatigue, we postulate that there may be a compensatory mechanism for increased ligamentous laxity during normal (subfatigue) levels of activity. An increase in the sensitivity of mechanoreceptors in response to mild exercise would provide the necessary enhancement of reflex neuromuscular protective mechanisms, and knee proprioception would be expected to improve. An experiment was designed to test this hypothesis.

SUBJECTS AND METHOD

Subjects

Adult male volunteers (mean age 25; range 18-33) were recruited from a local rugby football club. All subjects were

Figure 1 The apparatus incorporates a screen that eliminates visual cues to the subject while the knee is supported on a padded frame; knee flexion is measured using an electrogoniometer attached to the leg.

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,¹⁵ 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).

Figure 2 Hand held knee model incorporating an electrogoniometer permitting perceived knee flexion to be assessed.

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.¹⁵

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).

Table 1 Individual subjects' joint position sense in knees at rest and following 'warm up'

Subject & side	Pre-exercise	Post-exercise	Age
1 R	15.7	7.5	30
1 L	10.2	7.3	30
2 R	15.2	8.1	19
2 L	13.5	12.6	19
4 R	9.7	11.4	24
4 L	10.1	8.5	24
5 R	8.6	5.1	19
5 L	4	6.1	19
6 R	20.7	12.1	33
7 R	5.6	6.2	18
7 L	4.2	5.2	18
8 R	8.1	5.6	22
8 L	7.3	7.4	22
10 R	13.8	14.1	23
10 L	13.9	12	23
11 R	7.6	6.6	27
11 L	12.1	7.4	27
12 R	13.6	8.3	26
12 L	7.4	8.2	26
13 R	4.5	7.3	28
13 L	13	10.4	28
14 R	17.8	6.6	31
14 L	6.9	4.9	31

Table 2 Mean measured joint position sense in knees at rest and following 'warm up'

	Mean value of Ω	Range of Ω
Resting knees	10.59	4.0–20.7
Knees after 'warm up'	8.21	4.9–14.1

When values obtained after warm up were plotted against the resting values of Ω , a weakly positive correlation was observed (Pearson's coefficient of correlation = 0.58).

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.

Take home message

After a period of stretching and gentle exercise, knee proprioception measured passively improves, indicating an increase in sensitivity of proprioceptive mechanisms associated with the ligaments around the knee.

ACKNOWLEDGEMENTS

We are grateful for the support offered to this project by The Wishbone Trust. We are also grateful for the advice of Professor G. Bentley

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Authors' affiliations

M J Bartlett, P J Warren, Northwick Park Hospital, Watford Road, Harrow, Middlesex HA1 3UJ, UK

Note: PJ Warren died in December 2001.

REFERENCES

- 1 **Johansson H**, Sjolander P, Sojka P. A sensory role for the cruciate ligaments. *Clin Orthop* 1991;**268**:161–78.
- 2 **Schultz RA**, Miller DC, Kerr CS, *et al*. Mechanoreceptors in human cruciate ligaments. *J. Bone Joint Surg [Am]* 1984;**66**:1072–6.
- 3 **Schutte MJ**, Dabezies EJ, Zimny ML, *et al*. Neural anatomy of the human anterior cruciate ligament. *J Bone Joint Surg [Am]* 1987;**69**:243–7.
- 4 **Barrack RL**, Skinner HB, Buckley SL. Proprioception in the anterior cruciate deficient knee. *Am J Sports Med* 1989;**17**:1–6.
- 5 **Barrett DS**. Proprioception and functional result following anterior cruciate reconstruction. *J Bone Joint Surg [Br]* 1991;**73**:833–7.
- 6 **Corrigan JP**, Cashman WF, Brady MP. Proprioception in the cruciate deficient knee. *J Bone Joint Surg [Br]* 1992;**74**:247–50.
- 7 **Barratta R**, Solomonov M, Zhou BH, *et al*. Muscular coactivation: the role of the antagonist musculature in maintaining knee stability. *Am J Sports Med* 1988;**16**:113–12.
- 8 **Solomonov M**, Barratta R, Zhou BH, *et al*. The synergistic action of the anterior cruciate ligament and thigh muscles in maintaining joint stability. *Am J Sports Med* 1987;**15**:207–13.
- 9 **Lattanzio P-J**, Petrella, RJ. Knee proprioception a review of mechanisms measurements and implications of muscular fatigue. *Orthopedics* 1998;**21**:463–71.
- 10 **Marks R**, Quinney HA. Effect of fatiguing maximal isokinetic quadriceps contractions on ability to estimate knee-position. *Percept Mot Skills* 1993;**77**:1195–202.
- 11 **Skinner HB**, Wyatt MP, Hogdon JA, *et al*. Effect of fatigue on joint position sense of the knee. *J Orthop Res* 1986;**4**:112–18.
- 12 **Skinner HB**, Wyatt MP, Stone ML, *et al*. Exercise-related knee joint laxity. *Am J Sports Med* 1986;**14**:30–4.
- 13 **Rovick JS**, Reuben JD, Schrage RJ, *et al*. Relationships between knee motion and ligament length patterns. *Clin Biomech* 1991;**6**:213–20.
- 14 **Wang C-J**, Walker PS. The effects of flexion and rotation on the length patterns of the ligaments of the knee. *J Biomech* 1973;**6**:587–96.
- 15 **Warren PJ**, Olanakuhn TK, Cobb AG, *et al*. Proprioception after knee arthroplasty: the influence of prosthetic design. *Clin Orthop* 1993;**297**:182–7.
- 16 **Barrett DS**, Cobb AG, Bentley G. Joint proprioception in normal, osteoarthritic and replaced knees. *J Bone Joint Surg [Br]* 1991;**73**:53–6.
- 17 **Kaplan FS**, Nixon JE, Reitz M, *et al*. Age related changes in proprioception and sensation of joint position. *Acta Orthop Scand* 1985;**56**:72–4.
- 18 **Skinner HB**, Barrack RL, Cook SD. Age-related decline in proprioception. *Clin Orthop* 1984;**184**:208–11.

BASEM Merchandise 2002

BASEM stock

Ties	Multi motif	£6 + £1.50 p&p
------	-------------	----------------

New stock to order

Sweaters	Lambswool fine knit, V-neck or round neck with small motif. Machine washable. State colour and chest size required.	£32 + £3 p&p
Sweatshirts	With small motif. State colour and chest size required.	£25 + £3 p&p
Polo shirts	With small motif. State colour and chest size required.	£23 + £3 p&p

Send orders to John H Clegg JP BSc (Hons) DipEcon (Open) LDS RCS Eng, Hon Secretary, Birch Lea, 67 Springfield Lane, Eccleston, St Helens, Merseyside WA10 5HB, UK. (Tel and Fax: 01744 28198)