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APPLIED CLINICAL PHYSIOLOGY

# Inter-tester reliability of a self-monitored active knee extension test

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**KEYWORDS**
Knee extension test;
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Self-monitored test;
Hamstring

**Summary**
*Purpose:* The purpose of this study was to assess inter-tester reliability of two testers using a novel self-monitored active knee extension (AKE) test in the clinic setting.
*Method:* Twenty normal (asymptomatic) subjects (20–24 years) volunteered after informed consent. Before testing the knee joint axis and long axis of the femur and fibula of the right leg were marked, and later used to align the goniometer. The subject lay supine on a bench and flexed their right knee and hip to 90°. The subject monitored the position of their right femur manually, and kept it at 90° flexion throughout the test. The subject straightened their right leg maximally, keeping the foot relaxed, and held this position for 5 s. Each participant performed two repetitions of this movement with a 3 s rest between each. At the end of the second repetition a standard Perspex goniometer was positioned over the previously marked lateral joint axis and the goniometer arms aligned along the femur and fibula. The knee joint angle was recorded in degrees. Testing was carried out at the same time on two consecutive days. Tester 1 examined all subjects on day one, tester 2 examined all subjects on day two.
*Results:* Mean values for the AKE test for the two testers was 145.45° (SD 8.4) and 147.2° (SD 9.04). Tests for inter-tester reliability revealed an intra-class correlation coefficient (ICC) of 0.761 (0.395–0.905, 95% confidence interval; $P < 0.05$).
*Conclusion:* The AKE test when used in conjunction with goniometry, accurate surface marking, and manual monitoring of the test leg is a reliable measure of hamstring muscle length.


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# Introduction

## Relevance of hamstring length

Evaluation of posture can be an intrical part of physical assessment before both physical therapy and exercise prescription (Kendall et al., 1993). Whole body assessment has been shown to reveal distinct posture types (Norris and Berry, 1998), but local muscle tests are required to highlight specific muscle length changes (Jull and Janda, 1987; Norris, 1995). Hamstring muscle tightness has been described as intrical to the lordotic posture type (Jull and Janda, 1987).

Hamstring stretching is often used prophylactically in sport. Research to support this action is varied however, with some authors reporting that lower limb injuries are decreased as a result of regular hamstring stretching (Hartig and Hendeerson, 1999) while others have found no correlation between injury and muscle length (Meeuwisse and Fowler, 1988).

## Hamstring length measures

Tightness of the hamstring muscles has traditionally been measured using the straight leg raise (SLR) test. However, movement of the pelvis in this test (Bohannon, 1982) make the test less specific to the hamstrings and therefore raises questions of the appropriateness and reliability of the SLR test. It has been argued that differences in the movement of the sciatic nerve exist between the two tests (Urban, 1981). In addition the SLR has been described as the 'key tension test' of the lower limb and trunk (Butler, 1991) making it potentially more useful as a neurological test rather than a muscle length test in the clinical setting.

The active knee extension (AKE) test involves movement at the knee joint but not the hip, while the SLR test involves movement of both the hip and knee joints, making it more difficult to control. Moreover, the SLR test is a passive test, the end point of which is dependent on the force administered by the tester. The AKE test is an active test, the final position being dependent on the tension developed by the subject's quadriceps muscles and the end point of the available joint motion. The test is therefore arguably safer as the end point is dictated by the users themselves.

The AKE test is often used to measure hamstring tightness as part of orthopaedic physical assessment, with normal values of knee motion to within 20° of full extension being quoted (Magee, 2002). The test has been recommended as an alternative to the SLR test for providing an indication of hamstring muscle length (Cameron and Bohannon, 1993).

Some testers have found intra-tester reliability of the AKE test to be high using a metal rig to assist in measurement and straps to limit pelvic and leg motion (Gajdosik and Lusin, 1983). However, others have questioned the reliability of this procedure (Worrell et al., 1991). These types of apparatus are rarely available in the clinic however, especially in the sports club setting where muscle imbalance measures are of particular relevance. Here, the clinician must rely instead on manual techniques and basic goniometry. A self-monitored AKE stretching exercise has been described (Norris, 2004). This exercise has been adopted for this study as a modification of the standard AKE test.

**Table 1** Means (M) and standard deviations (SD) for physical characteristics of participants.

| | *M* | Standard deviation |
|---|---|---|
| Age (years) | 21.1 | 2.7 |
| Height (cm) | 174.3 | 11.9 |
| Mass (kg) | 71.8 | 14.4 |

## Purpose of this study

The purpose of this study was to assess inter-tester reliability of a novel self-monitored AKE test using asymptomatic subjects.

# Method

## Subjects

Twenty (7 male and 13 female) full-time students on a sports rehabilitation course at the University of Salford were recruited for this study (see Table 1 for their physical characteristics). No participant had any history of low back or hip pathology, and each gave their informed consent before testing commenced. The testing procedure was explained to the subjects and each signed an informed consent form.

## Design

This was an inter-tester reliability study between two testers conducted over 2 days. Tester-one was a qualified physiotherapist, familiar with the use of the AKE test. Tester-two was a strength and conditioning specialist who had undergone one half-hour instruction session on the AKE test.

## Procedures

Testing occurred on two consecutive days. On day one, Tester-one examined all participants using the AKE test described below. On day two, Tester-two examined all participants. Both testing sessions took place at the same time of day (11 a.m.). Before testing each tester marked the centre of the knee joint axis over the lateral joint line of the right leg. Two lines were drawn from this point, one joining this axis point to the centre of the greater trochanter of the femur, and a second joining the axis point to the apex of the lateral malleolus. The lines were removed with alcohol after testing and redrawn at the commencement of each testing session.

The subject lay supine on a bench and flexed their right knee and hip to $90^\circ$. They monitored the position of the femur with their right hand, and were instructed not to allow the femur to move away from the hand at any point during the test (Fig. 1). The participant was instructed to extend their right leg as far as possible, keeping their foot relaxed, and hold the position for 5 s. Each participant performed a single repetition of the movement to familiarize themselves with the action. A second repetition was performed and at the end of the 5 s holding period the angle of knee extension was measured using a standard Perspex goniometer (Physiomed, Manchester, UK). The centre of the goniometer was positioned over the axis point previously marked on the lateral joint line, and the goniometer arms were positioned along the lines marked on the femur and fibula. The goniometer measurement was taken within 2 s of the end range of knee extension being reached to ensure the same length of static stretch for each subject.

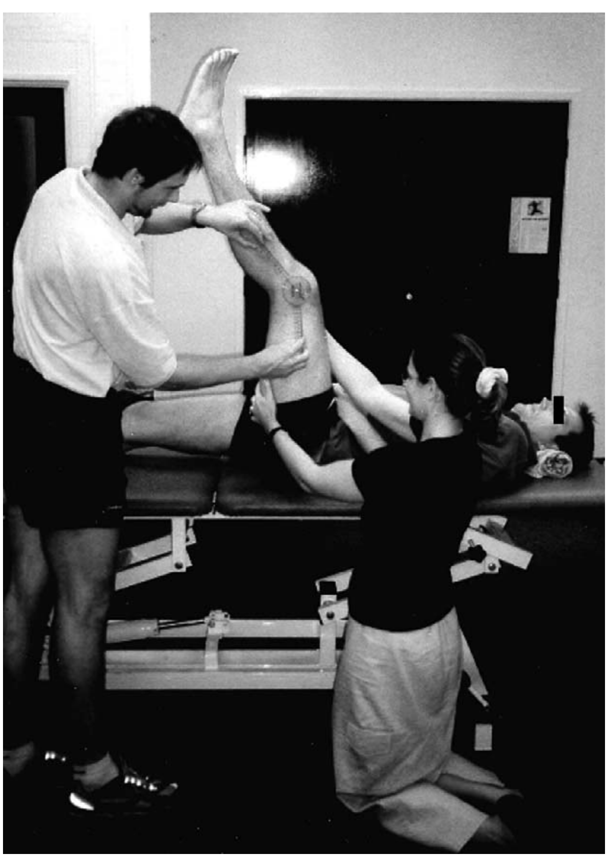

**Figure 1** Positioning the leg for self-monitoring and measurement.

## Data analysis

Repeated measures ANOVA was used to test for systematic bias. The measure of reliability used was an intra-class correlation coefficient (ICC) with limits of agreement defined as per Bland and Altman (1986). Mean difference of $\pm 2$SD.

## Results

Results for each tester are displayed in Table 2.

The mean difference between testers was $3.6^\circ$ ($\pm 2.3$) with a range of differences from $0^\circ$ to $8^\circ$. Repeated measures ANOVA revealed no systematic bias ($F = 0.02$; $P = 0.598$). Tests for inter-tester reliability revealed an ICC of 0.761 (0.395–0.905, 95% confidence interval; $P < 0.05$). The limits of agreement (mean difference $\pm 2$SD) were $-15^\circ$ to $+17^\circ$.

## Discussion

Several measures are used to test muscle lengths around the pelvis (Norris, 2000). Both the SLR and AKE tests are used to test the length of the hamstrings. The AKE test involves less motion in the lumbar spine and pelvis and so was chosen for this test. It should be noted that the AKE test relies on the subjects perception of exertion at full range and this is a limitation of the test. However, the control which this gives the subject is an advantage clinically if both tests are used by relatively inexperienced testers in the gymnasium setting, or by athletes themselves when working in pairs as part of a general exercise screening programme. As this study was designed to assess the AKE test for

**Table 2** Mean AKE results for the 20 participants as assessed by each tester.

| Tester | Mean AKE (degrees) | Standard deviation |
|---|---|---|
| 1 | 145.45 | 8.4 |
| 2 | 147.2 | 9.04 |

field usage as well as clinical usage, the inherently safe nature of the test was deemed advantageous.

Although the AKE test is used clinically to measure length of the hamstrings, changes to the sciatic nerve are also likely to occur (Butler, 1991). General anesthesia has been shown to increase the range of motion at the knee increasing popliteal angle by a mean value of 8.1° (Krabak et al., 2001). The test result will also differ depending on the indicator used for end range motion, the onset of resistance occuring before full anatomical end range. For this reason the passive knee extension (PKE) test has been shown to give greater range of motion than the AKE. The suggestion being that the PKE represents initial length and the AKE maximum length of the hamstrings (Gajdosik et al., 1993).

The subjects for this study were young, healthy and asymptomatic. Changes in muscle recruitment may occur following joint pathology, a feature termed arthrogenic inhibition (Janda, 1993). Alteration in hamstring activity has been shown following both ankle (Bullock-Saxton et al., 1994) and knee (Lephart et al., 1998) pathology. Such a change could have a greater implication for the reliability of an active test such as the AKE than for a passive test such as the SLR, and may therefore alter the criteria for test selection in clinical practice.

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