The Effect of Pelvic Position on Popliteal Angle Achieved During 90:90 Hamstring-Length Test

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Context: Hamstring muscle length is commonly measured because of its perceived relationship to injury of both the hamstrings themselves and the pelvis and lumbar spine. The popliteal (knee-extension) angle measured from the starting position hip and knee at 90° is a commonly used indirect measure of hamstring muscle length. When this measure has been undertaken in the literature previously, little attention was paid to the position of the pelvis, which may significantly influence measurements taken. Design: Repeated-measures. Setting: University human performance laboratory. Participants: 60 healthy physically active males (mean age 20.1 ± 1.8 y, range 18–24 y). Intervention: The 2 extremes of pelvic position (anterior and posterior). Main Outcome Measure: Popliteal angle (with maximal knee extension) was measured in 2 positions, 1 of full anterior and 1 of full posterior pelvic tilt. Results: The mean difference in popliteal angle between anterior to posterior pelvic positions was 13.4° ± 9° (range 0–26°); this was statistically significant (P = .0001). Conclusion: The findings of the study indicate that pelvic position has a significant effect on popliteal angle and therefore should be taken into account when measuring hamstring muscle length.

Keywords: measurement, pelvis position, validity

Hamstring muscle length (HML) is routinely measured because of its perceived relationship to performance,1 injury prevention,2 postural alignment and lumbopelvic motion,3 low back pain,4 and hamstring muscle injury.5 Clinically, HML is commonly measured indirectly by angular measurements of unilateral active or passive knee extension with the hip flexed to 90° (popliteal angle [PA]).6 Those undertaking this measurement have rarely taken the position of the pelvis into consideration in the literature. The position of the pelvis has been shown to have a significant effect on HML7; therefore, if this is not taken into account during the measurement of HML it is likely to affect the construct validity of the resulting knee angle measured, along with the repeatability of the measurement. In their systematic review of hamstring muscle-stretching methods Decoster et al8 commented on the generally poor standard of the research undertaken and the lack of consistent findings for any given technique. Of the 28 studies included in their review,9 none standardized the pelvic position during testing, which may have had an effect on the reliability and repeatability of their outcome measures and, so, the results.

Apart from the potential effect on measurement error in not taking pelvic position into account, which could influence the findings of, for example, stretching studies and athlete screening, failure to control pelvic position may have a significant impact on rehabilitation outcome. As mentioned, hamstring length would appear to significantly influence pelvic position.7 Congdon et al7 found that extending the knee in a position of hip flexion significantly increased pelvic posterior rotation, and this relationship occurred to a greater degree and at greater ranges of knee flexion in subjects with short hamstrings on straight-leg-raise testing. This would appear to indicate that individuals with short hamstrings compensate for the lack of extensibility by posteriorly pelvic tilting to allow extremes of knee extension to occur. The use of posterior pelvic tilt to compensate for short hamstrings could then increase load on the sacroiliac joints and the lumbar spine, possibly leading to pathology. It may prove useful in these individuals to assess flexibility in the uncompensated anterior pelvic-tilt position to assess how much uncontrolled pelvic tilting is being used to mask hamstring inflexibility.

Davis-Hammonds et al9 found that males demonstrated significantly greater anterior pelvic tilt than females at maximum knee extension during running. Taking into account the work of Congdon et al,7 this would then mean that males would require greater relative flexibility of the hamstring muscles to achieve this. As it is believed that the majority of high-speed-sprinting hamstring injuries occur during terminal swing phase,10 it might be that these individuals lack the necessary flexibility (range) in an anterior tilted position and so place greater internal stress on their hamstring muscles.

The aim of this study was to assess the effect of the 2 extremes of pelvic position (maximally anterior and posterior tilt) on popliteal angle during the standard clinical test of HML passive knee extension from the 90° hip-flexed position.

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Pelvic Position and Popliteal Angle

Method

Participants

Sixty male subjects (mean age 20.1 ± 1.8 y, range 18–24 y) participated in the study. All were free from any low-back, pelvic, or leg pain for a minimum of 3 months before the study. They all give written informed consent, and the study was approved by the host institution’s research ethics committee.

Procedures

The lateral knee-joint line (distal to the lateral femoral epicondyle) and lateral malleolus of the left leg were marked on all subjects by the same examiner. The subject then lay supine on a standard treatment table; the leg to be tested was flexed at the hip to 90° with the knee in 90° flexion and the thigh actively held against a barrier to maintain the 90° position. An examiner then passively extended the knee to the point of firm resistance to further movement and a change in pressure in the pressure biofeedback unit (PBU). A digital photograph of the subject was then taken using a Fuji Finepix S304 digital camera (with a picture resolution of 3 megapixels). The camera was positioned on a tripod 3 m away from the subject, with camera height set to the individual’s knee height. The subject’s leg was framed in the picture to maximize the limb within the frame, and the settings of the camera remained constant for all pictures taken. The photograph was then loaded onto a PC and the angles were calculated using ImageJ computer software (http://rsb.info.nih.gov/ij/download.html). The PA was calculated by measuring the angle of the intersection of the vertical line of the barrier and a line passing through the lateral knee and lateral malleolus marks.

This procedure was undertaken 3 times for each of the 2 pelvic positions, with the mean score then used for further analysis. The order of testing, that is, posterior or anterior pelvic tilt, was carried out in block fashion with even-numbered subjects starting with anterior-tilt position and odd-number subjects the posterior-tilt position. The anterior pelvic position was achieved in the 90° hip position by instructing the subject to maximally anterior tilt the pelvis using the standard cue, “Hollow the lumbar spine off the couch as much as possible and hold it there.” A PBU placed under the lumbar spine (S1–L1) was then inflated until it completely filled the available lordotic space. The knee was extended as described while the PBU pressure gauge was monitored for any increase in pressure indicating posterior pelvic tilting (pushing down onto the PBU); if the pressure increased (by more than 2 mmHg), the test was undertaken again. For the posterior pelvic position, once in the 90° hip position the subject was instructed to maximally posteriorly tilt the pelvis: “Flatten the lumbar spine against the couch and hold it there.” A PBU placed under the lumbar spine (S1–L1) was then inflated slightly. The knee was extended as described while the PBU pressure gauge was monitored for any decrease (by more than 2 mmHg) in pressure indicating anterior pelvic tilting (lifting of the PBU).

Analysis

The difference in PA between the 2 pelvic positions was assessed using a paired t test. Before the study commenced, intratester reliability of the method was examined. Ten subjects undertook the measurement procedure on 2 separate occasions. The intraclass correlation was calculated, with ICC31 for the anterior pelvic position being r = .98 and for the posterior pelvic position r = .95. The smallest detectable differences were 3.2° and 3.9° for the anterior and posterior pelvic positions, respectively. In all cases 180° was taken to equal full knee extension.

Results

The mean knee angle for the anterior pelvic position was 113.2° (± 37.7°), and for the posterior pelvic position, 126.6° (± 42.3°; 180° equals full extension); both are shown in Figure 1. The mean difference between anterior and posterior positions was 13.4° ± 9° (range 0–26°). Changing the pelvic position had no effect (or 1 below the smallest detectable difference and so likely to be due to measurement error) on PA in 5 of the 60 subjects. The difference in PA between the 2 pelvic positions was statistically significant (P = .0001). There was a significant correlation between the subjects’ popliteal angle in the anterior and posterior pelvic-tilt positions (r = .98).

Discussion

The findings of this study indicate that when PA is measured using the 90:90 knee-extension test for HML, the position of the pelvis has a significant bearing on the degree of PA achieved. If the pelvis is held in an anteriorly rotated position, this significantly decreases PA compared

![Figure 1](image) — Mean (standard deviation) of popliteal angle achieved in both pelvic positions.
with a posteriorly rotated position. It would appear that no previous study has investigated this question, making comparison of these findings difficult. Fredriksen et al. found that pelvic rotation contributed 4.1° to the PA during an active knee-extension test, when measuring the degree of pelvic motion as the knee was extended. This value was considerably less than the difference in angle found between the 2 pelvic positions in this study. However, Fredriksen et al. did not monitor the starting pelvic position, and as the test was conducted with a hip-flexion angle of 120°, the subjects may already have been in a significant degree of posterior pelvic tilt, as indicated by the study of Congdon et al.

The PA reported in this study was lower than the values previously reported in the literature, with values ranging from 139° to 152°. Only the study of Krabak et al. reported similar values (129° ± 9°). The current study used only male subjects in larger numbers than any previously reported; this may have influenced the range of the results influencing the average score, but when the standard deviations of the results are taken into account the ranges of population scores are not dissimilar to those previously reported for males.

The study indicates that care must be taken to control for starting pelvic position when undertaking investigations into hamstring muscle flexibility. The strong correlation between the PA measurements between the 2 positions would indicate that the position chosen is not as important as consistency of that position to minimize measurement error. However, the position chosen for measurement might have more significance where the influence of hamstring length on functional performance is of interest. For instance, males have demonstrated significantly greater anterior pelvic tilt than females at maximum knee extension during running. Failure to achieve sufficient knee extension (PA) in a hip-flexed and anteriorly tilted position could increase load on the hamstring muscles or cause the pelvis to posteriorly rotate to compensate for the lack of hamstring flexibility, potentially stressing the sacroiliac joints or lumbar spine. By testing these individuals in an anteriorly rotated position, functional range could be assessed, whereas when being tested in a posteriorly rotated position they may appear to have sufficient range to perform the task.

**Conclusion**

Previous studies measuring PA have not taken into account or controlled for pelvic position. As illustrated by this study, the position of the pelvis has significant bearing on the subsequent measurement, so not accounting for starting pelvic position is likely to affect the validity and reliability of results. To maintain construct validity of the measurement, it is recommended that, when measuring PA using the 90:90 knee-extension test for HML, starting pelvic position and motion be considered and controlled for.

**References**