Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students

G Baltaci, N Un, V Tunay, A Besler, S Gerçekler

The sit and reach (SR) test is a field test used to measure hamstring and low back flexibility. This test is present in most health related fitness test batteries because it is believed that maintaining hamstring and low back flexibility may prevent acute and chronic musculoskeletal injuries and low back problems, postural deviations, gait limitations, and risk of falling.

Many studies on the validity and reliability of SR test protocols have been reported, and a number have been proposed. The assumed validity of the SR test is based on a logical analysis of its requirements. However, Jackson and Baker reported a study that examined the relations between the SR test and criterion measures of hamstring and low back flexibility in 102 female students.

A Pearson correlation coefficient analysis was significant (p<0.01) for the traditional sit and reach test with back saver sit and reach test and flexibility of hamstrings (r = 0.45 and 0.65 for left and right legs, and 0.63 and 0.53 for left and right legs respectively). Also, the back saver sit and reach test for the left (p<0.01) and right (p<0.05) leg was significantly associated with hamstring flexibility (r = 0.37 and 0.25 for the left leg and 0.50 and 0.44 for the right leg respectively).

Conclusion: The results indicate that the back saver sit and reach test produces reasonably accurate and stable measures of hamstring flexibility. Moreover, it appears that this test is a safe and acceptable alternative to the traditional and chair sit and reach tests as a measure of hamstring flexibility in young women.
the ACSM manual. The SR test was performed using the procedures outlined in the manual. Reaches short of the toes were recorded as minus scores, the middle of the toe at the end of the shoe represented a “zero” score. Reaches beyond the toes were recorded as plus scores. Participants were in-structed to reach down the extended leg in an attempt to touch the toes. A static position was held for two seconds while the physiotherapist (SG) recorded the “reached score” using a 40 cm ruler positioned parallel to the lower leg. The heel on the floor and foot dorsiflexed, and bent the other leg so that the sole of the foot was flat against the floor about 15–30 cm to the side of the body’s midline. With the extended leg as straight as possible and hands on top of each other with palms down, participants were to “slowly bend forward at the hip joint, keeping the spine as straight as possible and the head in normal alignment with the spine”. Participants were in-structed to reach down the extended leg in an attempt to touch the toes. A static position was held for two seconds while the physiotherapist (SG) recorded the “reached score” using a 40 cm ruler positioned parallel to the lower leg. The middle of the toe at the end of the shoe represented a “zero” score. Reaches short of the toes were recorded as minus scores, and reaches beyond the toes were recorded as plus scores.

SR test
The SR test was performed using the procedures outlined in the ACSM manual. A standard SR box was placed on the floor, by placing tape at a right angle to the 38 cm mark. The participant sat on the floor with shoes on, and fully extended one leg so that the sole of the foot was flat against the end of the box. She then extended her arms forward, placing one hand on top of the other. With palms down, she reached forward sliding the hands along the box scale as far as possible. The physiotherapist (AB) recorded the average of the three trials on each leg.

Goniometric measurement
The goniometric measurement of hamstring flexibility was administered by one experienced physiotherapist (VT) after the other three tests had been completed. Following procedures outlined by the American Academy of Orthopaedic Surgeons' and Kendall et al., she used a goniometer to measure hamstring flexibility during a passive straight leg raise. This test was selected because of its prevalent acceptance as a criterion measure for hamstring flexibility and its high reliability (0.95<0.99). The axis of the goniometer was aligned with the axis of the hip joint. The tester positioned the stationary arm in line with the trunk and placed the moveable arm in line with the femur. With the knee held straight, the participant's leg was moved passively into hip flexion until tightness was felt. At that point, the physiotherapist (VT) read the goniometer in degrees of motion. Three trials were performed on each leg, and the average was used for analysis. Scores were recorded to the nearest degree for both legs.

Data analysis
Pearson correlation coefficient analysis was used to determine the relation between the CSR, SR and BSSR tests and the criterion goniometer measurement. Ninety five percent confidence intervals were computed for all correlation coefficients. Statistical Package for Social Sciences (SPSS) MS Windows Release 8.0 (SPSS Inc) was used for the statistical analysis.

RESULTS
The 102 female subjects had a mean (SD) age of 22 (1.46) years, height of 168.3 (8.9) cm, and weight of 59.7 (11) kg. Table 1 gives their flexibility characteristics. Correlation coefficients were calculated for the three different SR tests to provide reliability estimates (table 2). The correlation between the hamstring flexibility values for the right

Table 1  Flexibility scores for participants

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair sit and reach (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>-8.3</td>
<td>9.9</td>
</tr>
<tr>
<td>Left</td>
<td>-8.2</td>
<td>9.9</td>
</tr>
<tr>
<td>Sit and reach (cm)</td>
<td>5.9</td>
<td>7.8</td>
</tr>
<tr>
<td>Back saver (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>-6.2</td>
<td>5.4</td>
</tr>
<tr>
<td>Left</td>
<td>-5.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Goniometer (°)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>76.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Left</td>
<td>75.3</td>
<td>9.8</td>
</tr>
</tbody>
</table>

Table 2  Intercorrelations of chair sit and reach, sit and reach, and back saver sit and reach tests with goniometer measured flexibility in all participants (n = 102)

<table>
<thead>
<tr>
<th></th>
<th>CSRL</th>
<th>CSRRI</th>
<th>SR</th>
<th>BSSRL</th>
<th>BSSRR</th>
<th>GML</th>
<th>GMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSRL</td>
<td>0.98**</td>
<td>0.22*</td>
<td>-0.03</td>
<td>0.14</td>
<td>0.22*</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>CSRRI</td>
<td>0.23*</td>
<td></td>
<td>-0.02</td>
<td>0.17</td>
<td>0.21*</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>SR</td>
<td>0.45**</td>
<td>0.65**</td>
<td>0.63**</td>
<td>0.53**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSSRL</td>
<td>0.66**</td>
<td>0.37**</td>
<td>0.25*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSSRR</td>
<td>0.50**</td>
<td></td>
<td>0.44**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GML</td>
<td>0.80**</td>
<td></td>
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</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (two tailed).
*Correlation is significant at the 0.05 level (two tailed).

and left leg was 0.80, therefore the degree of range of motion for each leg was averaged for each subject to provide one value for hamstring flexibility.

**DISCUSSION**

Although the CSR, SR, and BSSR tests are the most commonly used field measures of hamstring flexibility in current fitness test batteries, the SR and BSSR tests have inherent limitations for adults with low back problems or who have difficulty sitting on a level surface with legs extended. Therefore, the CSR test was proposed as an alternative for assessing hamstring flexibility in elderly people.

The purpose of this study was to determine the relations between the three SR tests and hamstring flexibility because the test is used as a measure of hamstring flexibility in young females. The test protocols for the criterion measures were taken from a study in which their reliability and validity were demonstrated.

Our analyses indicated that the traditional SR and BSSR tests were highly related to hamstring flexibility. In contrast, the CSR test was not related to hamstring flexibility for either the right or left leg (r = 0.22 and 0.21 respectively). These findings show that both SR and BSSR tests are valid for measuring hamstring flexibility. The CSR test detected individual differences in the flexibility of hamstrings of these female university students.

These results support the findings of Jackson and Baker and Chung and Yuen. However, they concluded that hamstring flexibility can only be measured by the traditional SR test, but we have provided evidence that the BSSR test can be used instead of the traditional SR test in young female subjects. From multiple regression analysis, Jackson and Langford suggested that the combination of flexibility in both hamstrings and lower back contributed to the reported variation in test scores. However, testing subjects of a wide age range, as was done by Jackson and Langford, is questionable. Jackson and Baker and Jackson and Langford reported validity coefficients for the SR test ranging from 0.64 to 0.88 in studies involving teenage and middle aged participants respectively. Also, Patterson et al., in a study involving 11–15 year olds, reported fairly comparable BSSR coefficients for male participants (left leg r = 0.68; right leg r = 0.72), but somewhat lower values for female participants (left leg r = 0.51; right leg r = 0.52). The low CSR reliability values for the young women in this study were not similar to the SR and BSSR values reported in other studies, with r coefficients for left and right leg in all cases consistently being 0.23 and 0.16 respectively. No participants were eliminated because of their inability to perform the CSR test. Also, because of our emphasis on careful checking of the participants in this study, none fell backwards during the test or were in an incorrect position. No injuries occurred during CSR testing. Careful monitoring is recommended when assessing frail participants or those with balance problems.

Although the SR tests do not satisfactorily measure lower back flexibility and are only moderately valid measures of hamstring flexibility, they are still the only field tests that are practical and easy to administer. Moreover, Jackson et al. reported that the SR test was not related to reported lower back pain in either a cross sectional or prospective sample of adults. Evidence of the relation between hamstring flexibility or lower back flexibility and lower back health is not documented. Future studies are needed to explore the influence of hamstring flexibility on lower back health. The need to develop a more practical field test with improved validity for hamstring and lower back flexibility is apparent.

**REFERENCES**

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