Comparing the Sit and Reach With the Modified Sit and Reach in Measuring Flexibility in Adolescents

Werner W.K. Hoeger, David R. Hopkins, Sherman Button, and Troy A. Palmer

This study compared the proposed modified sit and reach test (MSR) and the commonly administered sit and reach test (SR) to determine if the MSR can administratively control possible limb-length biases. Subjects (N=258) were administered two trials of each test. The MSR test incorporates a finger-to-box distance (FBD) to account for proportional differences between legs and arms. Individuals with high FBD measurements demonstrated a poorer performance on the SR test. An analysis of the subjects failing to meet the Physical Best standard (25 cm) indicated a higher probability of failure for those with larger FBD scores. The subjects were subsequently separated into three groups: high, medium, and low FBD. There were no significant difference among the groups on MSR performance but a significant difference was found on SR performance. The MSR test appears to eliminate the concern of disproportionate limb-length bias expressed by many practitioners.

The sit and reach test is a common measure of flexibility used in many fitness test batteries. Physical Best and Fitnessgram (1, 5), two nationally recognized testing and educational programs for youth, include the sit and reach item. Inclusion of this test item is based on the importance of trunk and hip flexibility in the prevention and alleviation of low back pain and tension during adulthood. Wilmore and Costill (10), nevertheless, indicated that the sit and reach test as it is commonly administered has inherent limitations in that it does not allow for differences in limb lengths or proportional differences between the legs and arms.

The most common assumption when interpreting sit and reach flexibility test results is that individuals with better scores possess a higher degree of trunk and hip flexibility. The question must be raised, however: Does a better score really indicate greater flexibility, or could it be that for some subjects the relationship between leg length and arm length significantly affects the final sit and reach score?

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Initial studies found no significant relationship between hip flexibility as measured by the sit and reach test and leg length, standing reach, and standing height for college women (7), nor for the relationship between lower limb length and sit and reach performance for elementary school boys (8).

Broer and Galles (2) investigated the relationship of trunk-plus-arm-length to leg length as well as weight to height in the ability to perform the toe-touch test. They concluded that the relationship of reach length to leg length was not important in the performance of this test for individuals of average body build. After examining extreme body types (reach length to leg length), they concluded that the relationship was significant for extreme body types. Wear (9) investigated the relationship between leg length and trunk length to sit and reach performance in college men. No significant relationship was reported between leg length and sit and reach performance, but a significant relationship was found between the excess of trunk-plus-arm-length over leg length and sit and reach performance.

Hopkins (3) observed a difference in individual scapular abduction during sit and reach test administration. It was estimated that scapular abduction may account for 3 to 5 cm of variation in the final sit and reach score. Because the test is designed to measure hip and trunk flexibility, Hopkins recommended that shoulder girdle mobility be controlled during the test. Jackson and Baker (6) investigated the relationship between leg length and trunk length to sit and reach performance in college men. No significant relationship was reported between leg length and sit and reach performance, but a significant relationship was found between the excess of trunk-plus-arm-length over leg length and sit and reach performance.

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Could the problem of validity relate to bias in proportional limb lengths? Because the question of bias for some individual extreme proportional arm/leg length differences persisted, Hopkins (3) and Hopkins and Hoeger (4) proposed the modified sit and reach test to administratively negate the effects of shoulder girdle mobility and proportional differences between arms and legs.

The purpose of this study was to investigate possible bias of disproportionate limb lengths for school-age children in performing the sit and reach test and to determine whether the modified sit and reach test can administratively control for this possible bias.

**Method**

As regularly administered, the starting position for the sit and reach test places the individual’s feet against the box relative to the 23-cm point (see Figure 1). Following the reach portion of the test, the criterion score would be 23 cm plus or minus the distance reached during the test (Distance A in Figure 2, assuming that the individual reaches beyond the feet).

In the modified sit and reach protocol, the performer assumes a sitting position with the head, back, and hips against the wall (90° angle at the hip joint—see Figure 3) and the feet against the sit and reach box. A sliding measurement scale or yardstick with a range of 0 to 90 cm is placed on the box. The performer is instructed to place hand over hand and reach out level with the measurement scale. During the initial reach, the head and back must remain in contact with the wall; only scapular abduction should be performed. The sliding measurement scale is then slid along the top of the box until the zero point of the scale is even with the tip of the fingers. This administrative technique establishes the finger-to-box distance (FBD). The FBD establishes a relative zero point for each individual based on proportional differences in limb lengths. After the relative zero
Figure 1 — Starting position for the sit and reach test.

Figure 2 — The sit and reach test.
point is established, the sliding measurement scale is held firmly in place and the performer can then complete the reach test. The score would be the total distance reached (Distance B in Figure 3).

**Subjects**

Of the 258 volunteers, 125 were male and 133 were female; all ranged in age from 14 to 19 years. They were administered two multiple trials of the modified sit and reach test (MSR). Informed consent was obtained from all participants and their parents. The Accuflex I (modified sit and reach box, manufactured by Novel Products Figure Finder Collection, Addison, IL) was used for all tests. Prior to testing, all subjects were administered a 5-minute low back and hamstring stretching routine. Two practice trials were allowed before recording the reach score for the two trials. For each recorded trial, the FBD and Distances A and B were recorded as previously discussed. The score for the sit and reach test (SR) was 23 cm plus or minus Distance A. The B distance constituted the score for the MSR. The score to be analyzed was the average of the two trials for each test.

Pearson product-moment correlation estimates were calculated to estimate the relationship among SR, MSR, and FBD. Since the standard for the SR for
Physical Best is 25 cm for both sexes and all ages, an analysis of the FBD for those failing to meet the standard was conducted to determine whether those with large FBD scores were more likely not to achieve the standard.

Internal consistency estimates of reliability for the FBD and MSR (Distance B) score were established through the use of intraclass correlation. Based on individual FBD measurements, the subjects were trichotomized into groups identified as high FBD (FBD >28 cm), medium FBD (FBD >23 cm and <28 cm), or low FBD (FBD ≤23 cm). The high FBD group represented individuals with proportionally longer legs than arms. The medium FBD group represented average proportioned limb-length individuals, and the low FBD group represented individuals with longer arms relative to legs. A one-way MANOVA with the three levels of FBD grouping as the independent variable and SR and MSR performance as the dependent variables was used to compare group differences. Follow-up univariate F's and the Scheffé procedure for multiple comparisons were also used.

**Results**

Table 1 presents the mean age and flexibility performance data for the entire sample (n=258) and by groups according to FBD. Internal consistency reliability estimates for FBD and MSR were .98 and .94, respectively. The FBD distance ranged from 15 cm to 37 cm, with a mean of 26 cm (S=±4.3 cm). Thus, maximally the FBD could account for a 22-cm difference in performance. The zero-order correlation between FBD and MSR was found to be .08 (p>.05). However, the correlation between FBD and SR was found to be -.36 (p<.05), indicating that individuals with high FBD measurements—longer legs relative to arms—demonstrated a poorer performance on the SR test. The FBD accounted for 13% of the shared variance in SR performance. The zero-order correlation between SR and MSR was .84 for all subjects. Sixty of the 258 subjects failed to meet

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<thead>
<tr>
<th>Table 1</th>
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<tr>
<td><strong>Age and Flexibility Performance for All Subjects and by Groups According to Finger-to-Box Distances (FBD)</strong></td>
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<tr>
<th>Variable</th>
<th>All subjects (N=258)</th>
<th>Low FBD (FBD ≤23 cm) (n=95)</th>
<th>Medium FBD (FBD &gt;23 cm and ≤28 cm) (n=85)</th>
<th>High FBD (FBD &gt;28 cm) (n=78)</th>
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<tbody>
<tr>
<td>Age (yrs)</td>
<td>15.8 .8</td>
<td>15.7 .8</td>
<td>15.8 .8</td>
<td>15.7 .8</td>
</tr>
<tr>
<td>Modified sit and reach (MSR) (cm)</td>
<td>35.8 7.9</td>
<td>34.5 7.4</td>
<td>35.3 7.9</td>
<td>37.3 8.4</td>
</tr>
<tr>
<td>Sit and reach (SR) (cm)</td>
<td>32.3 8.3</td>
<td>35.3 7.4</td>
<td>31.8 8.2</td>
<td>28.5 8.1</td>
</tr>
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the 25-cm standard of Physical Best, while 45 of the 60 subjects (75%) were found to have FBD scores greater than the median (26.4 cm) of all subjects.

In order to examine more closely the relationship between FBD and reach performance, individuals were grouped according to FBD. Table 1 presents the age and reach performance for the derived high, medium, and low FBD groups. A one-way MANOVA indicated a significant difference (Wilks’ $\lambda$ = .18, $p<.01$) among the groups on at least one of the dependent variables (MSR and SR). The follow-up ANOVA indicated no significant difference among the groups on MSR performance ($F=2.87, p>.05$), but a significant difference was found among the groups on SR performance ($F=16.5, p<.01$). The Scheffé procedure for multiple comparisons indicated that the low FBD group performed significantly better on the SR test than the medium and high FBD groups, and the medium FBD group performed significantly better than the high FBD group.

**Discussion**

Broer and Galles (2) indicated that the sit and reach performance of subjects with extreme differences in arm length to leg length or a combination of trunk and arm length are affected with predictable results. The results of this study agree with the finding of Broer and Galles (2). Those individuals with larger FBD scores, or initial reach distances farther from the sit and reach box, demonstrated a higher probability of failing to achieve the recommended Physical Best standard of 25 cm. The results of the MANOVA analysis indicates that the MSR technique administratively negates the bias introduced by disproportionate arm and leg length relationships.

Jackson and Baker (6) indicated that since findings of limb length bias can only be related to comparatively small numbers of subjects, the test has not been challenged. Within the age range of this study, it appears that the bias of the FBD may be applicable to a greater percentage of subjects than previously thought. Regardless of the number of subjects affected by the bias, the most accurate field measurement procedure for all subjects should be used.

Since the MSR protocol requires only a few additional seconds to administer, it appears feasible and would eliminate the concern expressed by Wilmore and Costill (10) and many practitioners concerning disproportionate limb length bias.

**References**


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