Effects of Measurement Method and Subject Characteristics on the Functional Reach Test in Typically Developing Children

K Volkman, MS, PT1, N Stergiou, PhD2, W Stuberg, PhD, PT1, D Blanke, PhD2 and J Stoner, PhD1
Munroe-Meyer Institute at the University of Nebraska Medical Center1, and University of Nebraska at Omaha2

Purpose
To examine the effects of four measurement techniques on the Functional Reach Test (FRT) in children using two methods of reach and two methods of measurement: 1 Arm Finger-to-Finger (1AFF), 1 Arm Toe-to-Finger (1ATF), 2 Arm Finger-to-Finger (2AFF), and 2 Arm Toe-to-Finger (2ATF). Effects of gender, age, height, lower extremity strategy (heels up or down) and size of base of support (BOS) area were also studied.

Hypotheses
1. Scores obtained from the four methods would significantly differ from each other.
2. One-arm scores would be significantly greater than two-arm scores due to biomechanical factors such as increased trunk rotation and shoulder protraction.
3. Toe-to-finger scores would be significantly greater than finger-to-finger scores.
4. Scores would increase with age and height, but effects of gender, strategy and BOS area were not predicted.

Subjects
80 typically developing children, half male and half female, were tested. They were divided into three age groups: 7-8 years, 11-12 years, and 15-16 years. Subjects were selected as a population of convenience from a local day camp and through personal contacts. This study was IRB approved, and informed parental consent was obtained prior to testing. Subjects were screened for inclusion by use of a questionnaire for current or past history of orthopedic or neuromuscular symptoms treated by a physician or physical therapist. Ankle active range of motion was also observed for plantarflexion (up on toes position) and dorsiflexion (metatarsal heads off the floor) in standing.

Methods
• Height was measured to the nearest 0.1 cm using a metric tape fixed to a wall.
• Subjects stood on paper on a hard surface next to a measuring stick positioned at shoulder height. The feet were traced on paper for calculation of the BOS area (length of feet times width of stance).
• Each subject used the same self-selected lower extremity strategy during all tests (either heels up or heels down).
• Subjects were instructed to reach as far as they could without taking a step or falling.
• Reach scores were obtained by measuring the reach held for three seconds and taken to the nearest 0.2 cm. Three trials were measured with the greatest distance score used.
• One-arm and two-arm reach methods were reversed in order for approximately half the subjects.
• Finger-to-finger scores were calculated as the difference in distance from the end of the index finger at initial position to end of finger in reach position. The subject’s dominant hand was used for the reach test.
• Toe-to-finger scores were calculated as the difference from the location of the toes at the zero point of the measuring stick to the end of the finger in reach position.
• A repeated measures ANOVA with post hoc multiple pair-wise comparisons (Tukey’s method) was used to compare mean reach measurements among method and among groups defined by subject characteristics (age, height, gender, strategy and BOS area). The effect of subject characteristics on the reach measurement was investigated within each of the four methods to control for the interaction between subject characteristics and measurement method using least squares means analyses.

Results
• Initially, no significant difference was found between 1AFF and 2AFF scores, although 1ATF and 2ATF methods did significantly differ (1ATF exceeded 2ATF scores by approximately 6-7 cm, p<.001). However, further analysis showed the start position of the finger moved backward when the arms were raised for the two-arm reach which was not evident when using with the traditional finger-to-finger method. The difference between the 1AFF and 2AFF scores also was significant (t = 13.15, p<.001) and the magnitude was approximately the same as the difference between 1ATF and 2ATF scores.3

Subgroup analyses showed the effects of age, height and BOS area were significant (p<0.05). No method by gender (p=0.5) or method by strategy (p=0.8) interactions were found. Selection of strategy was fairly balanced across age groups, with 45/80 subjects choosing the heels-down strategy.

• Mean reach scores increased with age (p<0.05). The effect of age on reach measurement was investigated within each method separately. Mean reach scores differed significantly between 7-8 year olds and 11-12 year olds in 1ATF and 2ATF methods after adjusting for confounding effects of subject characteristics such as height (p<0.05, and p=0.02, respectively). Data on age groups has been reported in a previous presentation.2

• Mean reach scores increased with height (p<0.05). The effect of height on reach measurement was investigated within each group separately. Table 1 shows mean reach scores differed significantly among the height quartiles of the distribution for each measurement method (p<0.02 for each overall test within each method). After adjustment for multiple tests, mean reach scores under the 1ATF and 2ATF methods differed significantly (p<0.05) between all pairs of quartiles except the two shortest. The means, standard deviations, least squares means and standard errors for each of the four methods are shown in Table 2. Least squares means and the standard error were estimated in order to adjust for confounding effects of gender, height, age, BOS and strategy. These descriptive statistics differ because the height groups were not balanced across all confounding factors.

• Mean reach scores increased with BOS area in 1ATF only (p=0.01). The effect of BOS area on reach measurement showed the mean reach scores differed significantly across two BOS groups for the 1ATF method only (p<0.02).

Conclusions
FRT scores were affected by reach method and subject characteristics of age, height and BOS, especially for toe-to-finger methods. Scores were not significantly affected by gender or strategy. The three tallest height quartiles significantly differed from each other in the toe-to-finger methods. 1AFF scores for the age groups were comparable to those found in the literature.1 Reliability data from this study showed the toe-to-finger methods to be more reliable than the traditional finger-to-finger methods in the subjects of this study.2

Clinical Relevance
1. Lower extremity strategy during testing may not be important as long as the strategy remains consistent between testing sessions.
2. In the literature, age groups have been used for normative data in children.1 These results show height groups may be preferred when using the toe-to-finger methods to compare FRT scores across children.

References

Table 1: ANOVA results for height category under each method

<table>
<thead>
<tr>
<th>Method</th>
<th>df</th>
<th>F value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1AFF</td>
<td>3</td>
<td>3.58</td>
<td>0.0183*</td>
</tr>
<tr>
<td>1ATF</td>
<td>3</td>
<td>11.33</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>2AFF</td>
<td>3</td>
<td>3.45</td>
<td>0.0211*</td>
</tr>
<tr>
<td>2ATF</td>
<td>3</td>
<td>10.53</td>
<td>&lt;0.0001*</td>
</tr>
</tbody>
</table>

*p<0.05

Table 2: Descriptive statistics of FRT (cm) by height group

<table>
<thead>
<tr>
<th>Height (cm)</th>
<th>1AFF LSM (SE)**</th>
<th>1ATF LSM (SE)**</th>
<th>2AFF LSM (SE)**</th>
<th>2ATF LSM (SE)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;130.2</td>
<td>130.2-148</td>
<td>148.1-168.5</td>
<td>&gt;168.5</td>
<td></td>
</tr>
<tr>
<td>&lt;130.2</td>
<td>24.80 (2.01)</td>
<td>28.64 (1.38)</td>
<td>31.81 (1.31)</td>
<td>38.36 (2.13)</td>
</tr>
<tr>
<td>130.2-148</td>
<td>28.64 (1.38)</td>
<td>31.81 (1.31)</td>
<td>38.36 (2.13)</td>
<td></td>
</tr>
<tr>
<td>148.1-168.5</td>
<td>31.81 (1.31)</td>
<td>38.36 (2.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;168.5</td>
<td>38.36 (2.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*M (SD) = mean (standard deviation)
**LSM (SE) = least squares means (standard error)