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Test Items and Standards Related to Flexibility/Range of Motion on the Brockport Physical Fitness Test

Francis X. Short and Joseph P. Winnick
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This manuscript provides information on the test items and standards used to assess flexibility and range of motion in the Brockport Physical Fitness Test. Validity, attainability, and reliability of the back saver sit and reach, the shoulder stretch, the modified Apley test, the modified Thomas test, and the Target Stretch Test are discussed. Particular attention is paid to the utility of these tests for youngsters with mental retardation and mild limitations in fitness, visual impairments (blindness), cerebral palsy, spinal cord injury, or congenital anomalies or amputations. Suggestions for future research are provided.

Flexibility and range of motion are subcomponents of musculoskeletal functioning in the Brockport Physical Fitness Test (Winnick & Short, 1999). For the purposes of the BPFT, range of motion (ROM) was defined as the extent of movement possible in a single joint, where traditional tests might include goniometry techniques typically measured in angular units. Flexibility was conceptualized as the extent of movement possible in multiple joints represented by one’s ability to perform a functional movement. Traditional tests of flexibility might include field tests that typically measure how far one can reach. Relationships among the relevant subcomponents of musculoskeletal functioning, profile statements that may represent appropriate fitness goals for particular youngsters, test items, and standards are shown in Figure 1.

The BPFT flexibility items include the back saver sit and reach (BSSR), the Apley test (modified), the shoulder stretch, and the Thomas test (modified). The only test of ROM is the Target Stretch Test (TST). In the BPFT, certain flexibility/ROM tests are recommended (R) or optional (O) for specific groups of youngsters. Both recommended and optional items generally are deemed appropriate for youngsters with particular disabilities, but recommended items are preferred. Readers are referred to the test manual (Winnick & Short, 1999) for test item selection guides and for specific test protocols.

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Acquire/maintain at least functional range of motion in various joints in the body

Target Stretch Test

Shoulder Stretch Test (modified)

Shoulder

Hip

Hamstring

General

Specific

Minimal

Preferred

(Standards appropriate for youngsters whose functional ROM is not significantly restricted by impairment; includes youngsters with cerebral palsy in classes C3-C8)

(Standards appropriate for ambulatory youngsters whose hip flexibility is not significantly restricted by cerebral palsy, including class C5 and C7)

(Standards appropriate for youngsters whose hip flexibility is not significantly restricted by cerebral palsy, including class C3 and the affected side of class C7)

(Standards appropriate for youngsters whose hamstrings flexibility is not restricted by impairments and for whom test item is recommended)


Validity

Tests of flexibility have been used in physical fitness test batteries for many years. Fleishman (1964), for example, included measures of dynamic and extent (static) flexibility in his Basic Fitness Tests, and Johnson and Londeree (1976) incorporated a bob and reach test in the Motor Fitness Test Manual for the Moderately Mentally Retarded. No attempt was made by the authors of these earlier tests to justify the inclusion of a flexibility item on a health-related basis. In fact, most of the fitness tests published prior to 1980 now are considered more appropriately to be tests of skill-related fitness rather than measures of health-related fitness.

When flexibility tests are used as measures of health-related physical fitness, the rationale is usually based on a presumed relationship between flexibility and low back pain or upon functional independence. One of the components of the Health Related Physical Fitness Test (American Alliance of Health, Physical Education, Recreation, and Dance, AAHPERD, 1992, 1980), for instance, was abdominal and low back-hamstring musculoskeletal function measured by modified sit-ups and sit and reach tests. The FITNESSGRAM (Cooper Institute, 1992, 1999), a health-related criterion-referenced fitness test currently endorsed by AAHPERD, includes the BSSR and shoulder stretch tests as measures of musculoskeletal functioning because the upper body and abdominal/trunk regions were deemed important for “maintaining functional health and correct posture, thereby reducing possibilities of future low back pain and restrictions in independent living” (p. 21). More recently,
Warburton, Gledhill, and Quinney (2001) conducted a literature review on the relationship between musculoskeletal fitness and health status. One of their conclusions was that flexibility is positively associated with mobility and independence.

The rationale for the inclusion of flexibility or range of motion test items in a fitness battery for youngsters with disabilities is linked to the health-related needs typically associated with a specific impairment. While the health-related flexibility needs of individuals with either MR or VI might not differ significantly from those of the general population (i.e., neither MR or VI is associated inherently with restrictions in flexibility), they often do for those with physical disabilities. (It should be noted, however, that among youngsters with MR, those with Down syndrome often exhibit excessive flexibility, and teachers should be aware of the health-related implications of this characteristic as well.) People with physical disabilities are at greater risk for restrictions in functional health, posture, and independent living due to reduced flexibility than are members of the general population. According to Surburg (1995), flexibility is important to people with physical disabilities for a number of health-related reasons, including enhanced performance of activities of daily living, improved mobility and independence, improved posture and muscle balance, prevention of injury, and reduction in postexercise muscle soreness. Restrictions in flexibility are commonly associated with CP, especially when spasticity is prevalent. Hypertonicity of the muscles restricts range of motion in the joints. The flexors, adductors, and internal rotators tend to dominate their antagonists, resulting in many of the health-related problems noted by Surburg (1995). Furthermore, when these muscle imbalances are severe, contractures can result. For these reasons, Sherrill (2004) writes that improved flexibility has long been considered the most important fitness goal for youngsters with CP.

Maintenance of flexibility also is critical for youngsters with SCI. It is especially important to maintain appropriate levels of flexibility in those joints surrounded by active muscle because the mobility of those joints is critical to the youngster’s independence. The ability to transfer, propel a wheelchair, or perform other activities of daily living is influenced by flexibility. Youngsters with SCI also are susceptible to muscle imbalance resulting from heavy reliance on specific muscle groups required in wheelchair use, including the anterior shoulder muscles (DiRocco, 1995). Muscle imbalances around a joint will serve to limit the range of motion for certain joint actions, reduce the functional ability of the joint, and increase the likelihood of muscular injury. As with CP, contractures are also possible in persons with SCI.

Clearly certain amounts of flexibility and range of motion are necessary for good health, but how much? As with muscular strength and endurance, there is no universally acceptable criterion for health-related flexibility/range of motion. Although criterion levels of maximum oxygen intake and percent body fat have provided references for aerobic capacity and body composition, no such index currently is available for any measure of musculoskeletal functioning (including measures of flexibility). Criterion levels of flexibility/ROM, therefore, generally are established through expert opinion. In the development of the BPFT, expert opinion was provided by the Project Target Advisory Committee. Depending upon the test item, expert opinion often was informed by reviewing norm-referenced data sets, by considering values used in clinical settings, and/or by consulting recommendations or research results found in the literature. The specific approach utilized is discussed in the following sections for each of the five test items.
Back Saver Sit and Reach

The BSSR is included in the BPFT battery in response to the health-related concern of low back pain (or the risk of developing low back pain in the future). The BSSR has been shown to validly measure hamstring flexibility, but research has failed to confirm a relationship between the test and indices of low back pain even though the anatomical logic for such a relationship is strong (Plowman & Corbin, 1994). The BSSR is a recommended test item for the general population, as well as for youngsters with MR, VI, and CA/A (for use with unaffected limbs only).

**Standards** The general CR standards for the BSSR, as well as the other measures of flexibility, are provided in Table 1. These are the same standards associated with the FITNESSGRAM. The FITNESSGRAM standards were based on expert opinion formed as a result of an analysis of existing norm-referenced data

Table 1  General CR Standards for Flexibility/ROM Tests

<table>
<thead>
<tr>
<th></th>
<th>BSSR (in.)</th>
<th>Shoulder Stretch (P/F)</th>
<th>Apley (mod.)</th>
<th>Thomas (mod.)</th>
<th>TST Min.</th>
<th>TST Pref.</th>
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<tbody>
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*Note.* Min. = minimal; BSSR = back saver sit and reach; P/F = pass/fail; Pref. = preferred; TST = Target Stretch Test.


Values for BSSR and shoulder stretch are adapted, with permission, from the Cooper Institute, 2004, *FITNESSGRAM/ACTIVITYGRAM test administration manual*, 3rd edition (Champaign, IL: Human Kinetics) 61, 62.
sets (Plowman & Corbin, 1994). No specific CR standards are recommended for the BSSR in the BPFT for youngsters with CA/A (unaffected limbs only), VI, or MR. Youngsters with these disabilities are expected to attain the same standards as youngsters without disabilities (i.e., general standards). For youngsters with CA/A, it is assumed that unaffected areas should demonstrate the same level of flexibility as is expected in the corresponding areas of youngsters without disabilities; hence, no specific standards are required.

In the case of youngsters with VI, Winnick and Short (1982) reported significant differences on sit and reach performance between girls with and without visual impairments (the difference between the boys was nonsignificant). Although statistically different, the difference in the means between the girls with and without visual impairments was not very large in a practical sense. The mean difference was 4 cm, which was approximately .5 standard deviations below the mean score for the girls without visual impairments. Winnick and Short (1982) reported that one-third of their sample of visually impaired girls was able to reach or surpass the median score obtained by their sample of girls without visual impairments. Consequently, it was decided that youngsters with VI should be expected to attain the BSSR standards recommended for the general population.

Previous research has reported hamstring flexibility differences between youngsters with and without MR. Rarick, Dobbins, and Broadhead (1976), for instance, reported differences ranging from approximately 4 cm for boys to approximately 7 cm for girls in the 6-9 age range. Furthermore, they reported that the means for participants with educable MR ranged from between .65 (boys) to 1.19 (girls) standard deviations below the means obtained for participants without MR and that although one-third of the boys with MR could achieve or surpass the median performance of the boys without MR, only 8% of the girls with MR could reach the same level of achievement when compared to the girls without MR. Pizzaro (1990) reported sit and reach performance differences of approximately 8 cm between participants with and without an educable form of MR.

While these statistics might suggest the need to offer specific CR standards for youngsters with MR on the BSSR, two other considerations argued against it. First, the general CR standards for the BSSR are at or below the 25th percentile for youngsters without disabilities, when compared to the Health Related Test sit and reach norms (AAHPERD, 1980). Over one-half of the Rarick et al. (1976) sample of boys with MR and 27% of the girls with MR were able to achieve the 25th percentile of their counterparts without MR.

The second consideration deals with the fitness level of the youngsters tested. It is generally agreed that youngsters with MR tend to be less active and less fit than youngsters without disability of similar age. Standards should be adjusted as necessary for youngsters with disabilities, but those adjustments should be based on the influence of impairment not on the influence of a sedentary lifestyle or poor fitness. If it can be assumed that Special Olympians can be considered more active and more fit than other youngsters with MR, data provided by Roswal, Roswal, and Dunleavy (1984) are instructive in this regard. They provided sit and reach norms for Special Olympians with mild and moderate levels of retardation. Median values for male participants (aged 8-19) with MR ranged from 5 cm below to 9 cm above the median values for boys without MR on the sit and reach test associated with the Health Related Test. Females with MR had median values ranging from 3 to 8
cm below the median values for females without MR. In only one of eight gender by age (8-15 and 16-19) by level of retardation (mild and moderate) categories presented by Roswal et al. did the median value obtained by Special Olympians with mild and moderate levels of retardation fall below the general CR standard in the BPFT. These data were interpreted to suggest that with training, the general CR standards associated with the BSSR are within reach of, and appropriate for, youngsters with MR.

**Attainability** As part of Project Target (Winnick & Short, 1998), the BSSR was administered to 135 boys and girls with MR aged 10-17. The test was administered twice to each subject, once with the right leg forward and once with the left, for a total of 270 measures. Participants were designated as individuals with mental retardation and mild limitations in physical fitness. In regard to traditional classifications, the participants would be identified primarily as youngsters with moderate mental retardation. Fifty percent (60 of 120) of the scores obtained by the girls and 63% (94 of 150) of those made by the boys met or exceeded the general CR standard for the BSSR.

Similarly, 96 participants with VI took the BSSR. Both right and left legs were tested, bringing the total number of scores to 192. The large majority of participants were classified as at least legally blind although 21 of the participants were partially sighted. Seventy-one percent (57 of 80) of the scores attained by the girls and 70% (78 of 112) of the scores made by the boys reached or surpassed the general CR standard. Similarly, Lieberman and McHugh (2001) reported pass rates of 71-76%, depending on the leg tested, for youngsters who were blind.

**Shoulder Stretch and Apley Test (Modified)**

The shoulder stretch test and a modified version of the Apley test are included in the BPFT battery as measures of shoulder flexibility. The shoulder stretch is an item that also is associated with the FITNESSGRAM. "The shoulder stretch has been added as an option [for the FITNESSGRAM] to try and illustrate that flexibility is important throughout the body—not just the hamstrings, and that flexibility is very specific to each joint" (Plowman & Corbin, 1994, p. 87). The shoulder stretch is simply scored pass/fail; a "pass" requires the ability to touch the fingers of the opposite hands behind the back in a particular way.

The Apley test was included as an alternative measure of shoulder flexibility in the BPFT for two reasons. First, it was more easily administered to youngsters in wheelchairs than the shoulder stretch, and second, it lent itself to the development of a modified scoring system that would reduce the number of zero scores made by youngsters known to have restrictions in flexibility (i.e., those with CP) and, instead, increase the chances that those youngsters would score somewhere on an achievement continuum. In addition to retaining the traditional object of the Apley test (touching the superior medial angle of the opposite scapula) and assigning it a “3,” the modified scoring system also includes intermediate scores logically associated with certain activities of daily living. The ability to touch the top of the head provides the requisite shoulder flexibility for certain grooming functions (e.g., shampooing or combing the hair) and scores a “2,” while the ability to touch the mouth is indicative of the flexibility necessary to perform other
important tasks (e.g., eating, drinking, brushing teeth) and scores a "1." Inability to touch the mouth scores a "0." The shoulder stretch or the Apley test is either a recommended or optional test item for every group covered by the BPFT. The shoulder stretch is optional for youngsters with MR or VI and for youngsters in the general population. The Apley is recommended for most youngsters with CP or SCI. Both tests are recommended for youngsters with CA/A depending on the nature of impairment.

Both the shoulder stretch and Apley tests require shoulder flexion in combination with external rotation and shoulder abduction, an action believed to be critical for many activities of daily living and, therefore, functional health (Advisory Committee, 1995). A preliminary study of the relationship between the Apley test and subjective measures of functional independence on selected activities of daily living (ADLs) was conducted as part of Project Target (Winnick & Short, 1998). Thirty-eight participants with CP took a battery of tests, including the modified Apley test, and completed a modification of the Functional Independence Measure (Keith, Granger, Hamilton, & Sherwin, 1987). Data analysis included the construction of $2 \times 2$ contingency tables between the Apley (pass vs. fail) and the measure of functional independence (independent vs. dependent) for eight ADLs. Significant and moderate phi coefficients between the Apley and functional independence were found for two of the ADLs, eating (.52) and toileting (.60). The coefficients for three of the other ADLs were lower and nonsignificant. (Coefficients for the remaining ADLs could not be determined due to empty cells in the contingency tables.) The moderate coefficients obtained for two of the ADLs indicates that some relationship exists between the modified Apley and functional independence, but the magnitude of the coefficients is insufficient to claim acceptable evidence of statistical validity. Still, the logic for such a relationship remains strong.

**Standards**  
As shown in Table 1, the general CR standards for the shoulder stretch and the modified Apley tests are the same for all gender and age combinations, a "pass" for the shoulder stretch and a "3" for the modified Apley. The standards for both of these items were determined solely by expert opinion (Advisory Committee, 1995; Plowman & Corbin, 1994) and are believed to reflect optimal levels of shoulder flexibility (Advisory Committee, 1995). Most youngsters taking the BPFT, regardless of disability classification, are expected to be able to meet the general standards for the item that is recommended for them.

Specific standards are recommended for the modified Apley test only for youngsters with more severe forms of CP. Youngsters in CP classes C1 and C2L are expected to score at least a "2" on the Apley. A "2" requires youngsters to touch the top of their heads (rather than the opposite scapula). Again, this standard was determined through expert opinion (Advisory Committee, 1997). No specific standards are available for the shoulder stretch; however, the shoulder stretch generally is not an item that is recommended for youngsters with physical disabilities.

**Attainability**  
Participants ($n = 124$) with MR were tested on the shoulder stretch in conjunction with Project Target (Winnick & Short, 1998). Participants were tested on both right and left shoulders bringing the total number of scores to 248. Of the 114 attempts made by the girls with MR, 40, or 35%, were successful. The boys were successful 46% (61 of 134) of the time.
Participants (n = 103) with VI were also tested on the shoulder stretch. Again, both shoulders were tested bringing to 206 the total number of scores. Attempts made by the girls with VI were successful 63% (57 of 90) of the time. Boys passed the test 51% (59 of 116) of the time. More recently, Lieberman and McHugh (2001) tested youngsters who were blind on the shoulder stretch and, depending on the side tested, reported pass rates of between 47-53%.

Although participants with CP (n = 18) had difficulty with the shoulder stretch (6% passing rate for 36 tests), they were more successful on the modified Apley test, the recommended item for this group. Forty-three youngsters in CP classes C2U-C8 were tested on two different occasions during Project Target. Two slightly different protocols were used with the Apley. In the first, youngsters (n = 13) attempted the Apley once with each shoulder. Of the 26 attempts made, 18, or 69%, were successful. In the second protocol, youngsters (n = 30) were asked to attempt the Apley with their preferred arm only. (The preferred-arm protocol was field-tested to account for differences in how the condition might affect different sides of the body, such as in hemiplegia.) Twenty-one of the 30 youngsters, 70%, met the criterion (a score of “3”) using their preferred arm.

**Thomas Test (Modified)**

The modified Thomas Test is included in the BPFT battery only for selected ambulatory youngsters with physical disabilities. Specifically, it is recommended for CP classes C5-C8, ambulatory youngsters with SCI, and, depending upon the site of an anomaly/amputation, certain youngsters with CA/A. The Thomas test traditionally has been used in clinical settings to test for length of the hip flexor muscles (Kendall, Kendall, & Wadsworth, 1971). It is included in the BPFT as a test of hip extension in response to the observation that many youngsters with physical disabilities experience shortening of the hip flexors (Advisory Committee, 1995). Although some youngsters experience this shortening as the result of the immobilization and/or inactivity of the hip joint associated with habitual sitting (Kottke, 1990), the rationale for the inclusion of this item in the battery is based on its relationship to posture and ambulation. When a hip flexion contracture is present, additional strain is placed on the back and hip extensor muscles (Perry, 1992). Furthermore, a hip flexion contracture frequently requires postural compensation to maintain the center of gravity over the feet. Common compensatory mechanisms include lumbar lordosis or knee flexion resulting in a crouched posture (Perry, 1992). Youngsters with CP often are unable to fully extend the hips and knees and this posture requires “considerable muscular effort by the antigravity muscles to prevent collapse” when walking even at slow speeds (Waters, 1992, p. 487).

The traditional Thomas test requires participants to lie supine on a table and to bring one leg toward their chest until the lower back is flat, while the tested leg (i.e., the opposite leg) stays in contact with the table (0 degrees of hip flexion). As with the Apley test, however, a modified scoring system was developed for use with the BPFT modified version of the Thomas test. In this modification, youngsters are positioned on the table so that the greater trochanters are on a line 11 inches from the edge of the table. Youngsters who are able to successfully execute the Thomas in the traditional way score a “3” on the test. Other scores are derived by using simple trigonometry to calculate leg elevations for 15 and 30 degrees of hip
Flexibility/Range of Motion

Fifteen degrees of hip flexion results in approximately three inches of leg elevation measured 11 inches from the greater trochanter (i.e., at the edge of the table). Similarly, 30 degrees of hip flexion results in approximately six inches of leg elevation measured at the edge of the table.

The selection of 15 and 30 degrees of hip flexion as important points in the modified scoring system was linked to the notion that contractures could be described as mild, moderate, or severe. In the BPFT version of the Thomas test, a hip flexion contracture of 15 degrees or less is considered mild and scores a “2” on the test. Perry (1992) indicated that increased lumbar lordosis is the least stressful way of reducing hip flexion leverage and that a hip flexion contracture of 15 degrees, however, is easily compensated by lumbar lordosis. Hip flexion contractures greater than 15 degrees are more serious, especially when knee flexion of equal degree is used as compensation. “The biomechanical requirements of flexed-knee stance are greater than normal and are associated with increased quadriiceps, tibio-femoral, and patello-femoral forces. The most significant increases occur at angles of knee flexion beyond 15 degrees” (Waters, 1992, p. 483). Hip flexion contractures ranging from 15 to 30 degrees are considered moderate in the modified Thomas test and score a “1.” In the BPFT, contractures greater than 30 degrees are considered severe, a characterization consistent with the description used by the American Medical Association (1993). Severe contractures score a “0” on the modified Thomas.

Standards

General standards for the Thomas test are given in Table 1. As with the shoulder stretch and Apley tests, the general standard is the same regardless of age or gender, a “3.” The ability to score a “3” on the modified Thomas is indicative of a hip flexor muscle that has “normal length” (Kendall et al., 1971).

Specific standards are provided for CP classes C5-C7 (affected limbs only). The youngster classified as C5 has moderate to severe diplegia or hemiplegia (Peacock, 1988). Youngsters with spastic diplegia typically have a flexed hip and knee posture (Waters, 1992). The Project Target Advisory Committee (Advisory Committee, 1997) agreed that it was unrealistic to expect youngsters classified as C5 to score a “3” on the modified Thomas test given the nature of the condition. Instead the Committee approved a score of “2” as the specific standard, which represents a realistic goal of minimizing the effects of shortened hip flexor muscles among youngsters with spastic diplegia. Similarly, the participant classified as C6 has “functional involvement” in all four limbs (Peacock, 1988) that may limit the potential for hip extension, hence a score of “2” is the recommended CR standard. Class C7 is appropriate for persons with hemiplegia (Peacock, 1988). Consequently it is anticipated that youngsters should be able to achieve the general standard “3” for the unaffected leg, but the specific standard “2” would be appropriate for the affected leg.

Attainability

A total of 23 ambulatory participants with CP (aged 10-47) were tested on the modified Thomas test as part of Project Target (Winnick & Short, 1998). Each participant was tested on both legs bringing the total number of tests to 46. Participant performance was compared to established standards to determine success rates (a score of “2” for C5, C6, and the affected side for C7; a score of “3” for the unaffected side for C7 and C8). A total of 31 of the 46 (67%) tests had passing scores. Classes C6-C8 had passing rates ranging from 67-93%, but C5 had
a passing rate of just 44% (8 of 18). It appears that the standards for C5 might be the most difficult to attain.

Target Stretch Test

The TST is an original test of range of motion associated with the BPFT. The intent of the test is to provide testers with easily administered alternatives when more traditional tests of flexibility/range of motion prove inappropriate for youngsters with physical disabilities. The TST provides subtests to measure wrist extension, elbow extension, shoulder extension, shoulder abduction, shoulder external rotation, forearm supination, forearm pronation, and knee extension. With the exception of forearm pronation, which was included specifically for use with youngsters with SCI quadriplegia, the subtests of the TST were selected with youngsters with CP in mind. As noted earlier, the flexors, adductors, and internal rotators tend to dominate, especially when spasticity is prevalent. The TST subtests, therefore, were selected to address some of the stereotypical postural and movement patterns associated with spastic CP. In the BPFT, the TST is a recommended or optional test item for all CP classes and, under certain circumstances, for youngsters with SCI and CA/A.

The TST scoring system requires that testers estimate the extent of movement in a particular joint by superimposing a theoretical clock around the joint and using the tested limb to “read” the clock to the nearest half-hour. The estimated time on the clock is then translated to a test score ranging from 0-2 based upon visual criteria provided by a series of sketches. Due to the subjective nature of the TST, some preliminary criterion-related validity work was conducted during Project Target (Winnick & Short, 1998). Twenty (20) TST subtests were administered to three participants and videotaped from a tester’s perspective. Three graduate students were given a five-min training session on scoring the TST, were shown the videos of the 20 TST subtests, and scored them. The project coordinator served as a fourth tester. Criterion scores were established later by taking goniometry readings of the 20 joint actions from the videotape. TST scores ranging from 0-2 were given for each of the 20 subtests based on the obtained goniometry values. The scores assigned by the four testers were then compared to the criterion scores determined from goniometry (a total of 80 comparisons). The testers correctly scored the tests 85% of the time. Individual accuracy scores ranged from 75% to 95% among the four testers. When the goniometry determined values were rounded to the “nearest half-hour” (the protocol required of the tester on the TST), the testers’ accuracy improved to 90%. Safrit (1990) indicated that validity coefficients determined in this manner should exceed 80%.

Standards

The TST is the only test of flexibility or range of motion in the BPFT battery that has both minimal and preferred CR standards. Most youngsters, regardless of disability, are expected to meet at least the minimal general standards; no specific CR standards are associated with the test. (Due to the variable nature of range of motion for those with more severe forms of CP, however, testers are encouraged to develop individualized standards for youngsters in C1 and C2.) The minimal and preferred general standards are constant for all gender and age combinations. For each subtest, a test score of “2” is meant to convey that the youngster is able to
approximate optimal range of motion for a particular joint action. A score of “1” is indicative of a somewhat reduced but, nevertheless, functional range of motion.

The preferred standards approximate the optimal range of motion typically found in the human body for a particular joint. Values reported in the literature for “normal” ranges of motion in various joints vary somewhat from source to source. The preferred standards for the TST are based primarily on the “normal limits” reported by Cole (1990). In some cases, Cole’s values were adjusted down “to the nearest half-hour” on the theoretical clock used in TST scoring in an effort to improve objectivity. In the case of shoulder external rotation, the preferred standards are based on values reported by the American Academy of Orthopaedic Surgeons (1965) since the TST protocol for this subtest differs from that used by Cole (1990). Table 2 provides goniometry values for the normal limits for each joint action as well as for preferred and minimal standards.

Table 2  Goniometry Values Associated With TST Score

<table>
<thead>
<tr>
<th>Joint</th>
<th>Normal Limits</th>
<th>Preferred/ Optimal</th>
<th>Minimal/ Functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist Extension</td>
<td>70°</td>
<td>60°</td>
<td>30°</td>
</tr>
<tr>
<td>Elbow Extension</td>
<td>0°</td>
<td>0°</td>
<td>-15°</td>
</tr>
<tr>
<td>Shoulder Extension</td>
<td>60°</td>
<td>60°</td>
<td>30°</td>
</tr>
<tr>
<td>Shoulder Abduction</td>
<td>170°</td>
<td>165°</td>
<td>120°</td>
</tr>
<tr>
<td>Shoulder External Rotation</td>
<td>40-90°</td>
<td>75°</td>
<td>30°</td>
</tr>
<tr>
<td>Supination/Pronation</td>
<td>90°</td>
<td>90°</td>
<td>45°</td>
</tr>
<tr>
<td>Knee Extension</td>
<td>0°</td>
<td>0°</td>
<td>-15°</td>
</tr>
</tbody>
</table>

1Values come from Cole (1990) except for shoulder external rotation which came from the American Academy of Orthopedic Surgeons (1965).

While the preferred general standards approximate optimal range of motion, the minimal general standards purport to reflect functional range of motion. Surburg (1995) distinguished optimal and functional range of motion. He considered optimal to be full range of motion, but acknowledged that for some people with disabilities, the pursuit of functional range of motion might be more appropriate. “The limits of the disabling condition and the ROM needed to permit adequate functioning, mobility, and independence define the functional range of motion” (Surburg, 1995, p.102). Other researchers (e.g., Cunningham, Paterson, Himann, & Rechnitzer, 1993; Ryu, Cooney, Askew, An, & Chao, 1991; Vasen, Lacey, Keith, & Shaffer, 1995) have attempted to more precisely define functional range of motion by determining the ROM necessary to perform specific activities of daily living.

Since range of motion requirements will vary from task to task, the selection of a single CR standard to reflect functional ROM in a generic sense can provide only an estimate of the demands of function. Still, the establishment of functional ROM standards has merit in conveying the notion that some health-related benefits can be derived from the pursuit of greater range of motion even when the limits of range of motion are restricted by impairment. The minimal standards associated with each
of the subtests of the TST were adopted by the Advisory Committee (1997) for use with the BPFT. These values have been used as “functional” standards in hospital settings in the state of Michigan for many years, lending some practical credence to their adoption. Unfortunately, there is little documentation on the derivation of these values and, instead, they seem to be part of an “oral tradition” among those who use them (K.J. Richter, personal communication, March 18, 1997). The Advisory Committee (1997) preferred the Michigan standards to other sets of values that were considered, including versions related to the AMA’s system for the evaluation of permanent impairment (American Medical Association, 1993).

Research that has attempted to establish functional ROM values for activities of daily living has identified values similar or identical to the TST minimal general CR standards. Ryu et al. (1991) found that the majority of their hand placement and range of motion tasks could be accomplished with 40 degrees of wrist extension. The TST minimal standard for wrist extension by comparison is 30 degrees. Cunningham et al. (1993) found that 120 degrees of shoulder abduction is an acceptable threshold for adequate function and were able to use this criterion to distinguish between independent and dependent elderly participants. The TST functional standard for shoulder abduction also is 120 degrees. Functional ROM of the elbow joint was studied by Vasen et al. (1995). They concluded that all 12 ADLs investigated in their study could be accomplished with a 15 degree loss from optimal elbow extension. This is the same value used as a functional standard in the TST. Again, the required ROM will vary from task to task, but some of the functional ROM values found in the research literature being close to, or identical to, those adopted for use with the TST provides a modicum of support for these functional standards.

**Attainability**

The TST was field-tested and modified a number of times over the life of Project Target. Protocols and standards changed during the evolution of the test. When the final version of the TST, including standards, was adopted by the Advisory Committee (1997), consideration was given to data generated as the result of previous field tests. In the most recent of the previous versions, the protocol was the same, but the minimal standards were different. Compared to the current minimal standards, the previous standards were more difficult for four of the eight subtests and the difference between the standards ranged from 8-18 degrees, depending on the subtest. Using the previous version, 130 of the TST subtests were administered to participants from CP classes C3-C8. Participants met at least the minimal standard on 122 of the subtests for a 94% pass rate.

Limited attainability data exist for the current version of the test. Fifteen participants with CP (C3 and higher) took a total of 45 of the various TST subtests. A score of “2,” the preferred standard, was obtained on 32 (71%) of the subtests. The minimal standard, a score of “1,” was given for 12 (27%) of the subtests. A total of 98% of the tests, therefore, were passed using the minimal CR standards.

**Reliability**

Although the Apley and Thomas tests have been used in clinical settings (Advisory Committee, 1995) and have been recommended for use in adapted physical education programs (Lasko-McCarthey & Knopf, 1992), and although the shoulder
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stretch is a recommended item in the FITNESSGRAM (Cooper Institute, 1992), a review of literature failed to uncover any research on the reliability of these items. No reliability data on the Apley and Thomas tests were collected as part of Project Target, in part because it proved difficult to identify a large enough sample of participants with physical disabilities from a particular subclassification to obtain any meaningful results. Shoulder stretch reliability was estimated during one Project Target study using youngsters with MR as participants (n = 35). Depending on the side of the body tested, both alpha coefficients and P values ranged from .83—.94 where participants were tested twice, 14 days apart (Winnick & Short, 1998).

Only one study was found that investigated the reliability of the BSSR. Patterson, Wiksten, Ray, Flanders, and Sanphy (1996) tested 84 boys and girls aged 11-15 and reported intraclass reliability coefficients of .99 for both genders using the mean of four trials as the criterion score. They also found Rs ranging from .95—.97 when reliability was determined for a single reach (the fourth), as required in the BPFT protocol. Project Target staff tested 33 youngsters with MR on the BSSR on two occasions spaced 14 days apart. Depending on the leg tested, alpha coefficients ranged from .95—.96 and proportions of agreement (P) ranged from .89—.92 (Winnick & Short, 1998).

The reliability of other forms of the sit and reach test is fairly well-established. Plowman and Corbin (1994) summarized some of the reliability research conducted on two versions of the sit and reach and concluded that scores obtained by participants on these tests are highly consistent. Both interclass and intraclass reliability coefficients typically associated with versions of the sit and reach test are very high (often above .95). The reliability of the sit and reach and related tests also has been investigated using participants with disabilities. Results of these investigations are summarized in Table 3. As with those studies conducted with participants without disabilities, the reliability coefficients for tests related to the BSSR conducted with participants with disabilities tend to be high.

Data supporting the reliability of the Target Stretch Test is yet to be collected. Some preliminary work on objectivity, however, was conducted as part of Project

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants</th>
<th>N</th>
<th>Age</th>
<th>Field Test</th>
<th>Reliability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson &amp; Londeree (1976)</td>
<td>mod. MR</td>
<td>1105</td>
<td>6-21</td>
<td>bob &amp; reach</td>
<td>r = .80—.99</td>
</tr>
<tr>
<td>Daquila (1982)</td>
<td>visually imp.</td>
<td>50</td>
<td>10-17</td>
<td>sit &amp; reach</td>
<td>a = .98</td>
</tr>
<tr>
<td></td>
<td>auditory imp.</td>
<td>50</td>
<td>10-17</td>
<td>sit &amp; reach</td>
<td>a = .99</td>
</tr>
<tr>
<td></td>
<td>ortho. imp.</td>
<td>50</td>
<td>10-17</td>
<td>sit &amp; reach</td>
<td>a = .80</td>
</tr>
<tr>
<td>Reid, Montgomery, &amp; Seidl (1985)</td>
<td>trainable/educable MR</td>
<td>20</td>
<td>20-39</td>
<td>trunk forward flexion</td>
<td>R = .94</td>
</tr>
<tr>
<td>Pizzaro (1980)</td>
<td>educable MR</td>
<td>44</td>
<td>12-15</td>
<td>sit &amp; reach</td>
<td>R = .90</td>
</tr>
<tr>
<td></td>
<td>trainable MR</td>
<td>37</td>
<td>12-15</td>
<td>sit &amp; reach</td>
<td>R = .97</td>
</tr>
</tbody>
</table>

r = interclass coefficient; a = alpha coefficient; R = intraclass coefficient
Target (Winnick & Short, 1998). While working from an earlier version of the TST, two testers independently scored 175 of the various TST subtests taken by 38 participants with CP. The alpha coefficient calculated for the combined 175 paired observations was .92, which represents an acceptable level of interrater reliability (Safrit, 1990). Although the scoring of the TST has been modified from this earlier version and additional objectivity work is required, the results of this preliminary study suggest the probability that testers can score performance on a fairly consistent basis using the criteria associated with the TST protocol.

**Discussion**

A future goal in the ongoing validation of the BPFT is to determine decision validity (Safrit, 1990) for all test items. Decision validity refers to the accuracy of classification into some health-related category provided by the CR standard (e.g., healthy vs. diseased, high risk vs. low risk, independent vs. dependent, etc.). It should be noted that as with the youngsters with disabilities included in the BPFT, decision validity has yet to be determined for youngsters without disabilities on measures of flexibility. Standards for the BSSR and shoulder stretch tests included in the FITNESSGRAM battery were determined through expert opinion and have not yet been statistically related to health status. Some preliminary work attempting to determine decision validity on the TST, Apley, and Thomas tests was conducted as part of Project Target, but these efforts did not link specific test scores to the ability to independently perform certain ADLs. Additional work is required.

The attainability data reported here are encouraging. The passing rates for youngsters with disabilities generally ranged between 35-70% for most items recommended for specific groups (and higher for the TST). These passing rates seem to suggest that the standards will be within reach for many youngsters with the disabilities covered by the BPFT (although some training may be necessary). Practitioners, in fact, may experience higher passing rates among youngsters with CP than reported in this manuscript for the Apley and the TST. Although these tests are designed to be administered to limbs on both sides of the body, youngsters with CP need to attain the CR standard only on one side of the body in order to “pass” the test. The attainability data reported in this chapter considered tests administered to both sides of the body for all groups (including those with CP). That the standards appear attainable by many youngsters from a particular category provides an indication that the protocols associated with the tests also are appropriate.

Reliability data currently available for the flexibility and range of motion tests is insufficient. In addition to the need to conduct more test-retest studies on each of these items it also is necessary to determine the consistency of classification (i.e., fit vs. unfit) provided by the standards (Safrit, 1990). Do participants who pass the test on day 1 also pass it on day 2?

The validation of the flexibility and range of motion tests associated with the BPFT is a significant and on-going endeavor. The area of criterion-referenced health-related physical fitness is fertile ground for research by interested professionals and graduate students. Based on the information presented in this paper, the following suggestions are made for future research:
• Determine the degree of statistical relationships between measures of flexibility and range of motion and indices of physiological and functional health;
• Determine the decision validity of the CR standards for all items and for all disability groups;
• Correlate TST scores with goniometry values to determine criterion-related validity;
• Use goniometry values to determine if scores obtained on the Thomas test accurately reflect the degree of contracture implied in the scoring system (Is accuracy a function of body composition or type?);
• Determine or confirm the attainability of the Apley standards for youngsters in CP classes C1 and C2L;
• Confirm the attainability of the Thomas test for youngsters with CP, especially those in class C5;
• Confirm the attainability of both the minimal (functional) and preferred (optimal) standards of the TST for youngsters with CP;
• Determine or confirm the consistency of classification for all test items and all disability groups; and
• Confirm the objectivity of the TST.

Although some significant work remains to be done on the validation of the BPFT, currently available information on the flexibility and range of motion items suggests that these tests and their standards are sufficiently valid and reliable for use with youngsters with selected disabilities. Future research may result in alterations to some of the items or standards, but this is considered a natural part of the evolution of the test.

References


