Concurrent Validity of Equilibrium Tests in Boys With Learning Disabilities With and Without Vestibular Dysfunction

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Key Words: equilibrium • posture • sensory integration

Six equilibrium measures were administered to 50 boys with learning disabilities, 25 with and 25 without suspected vestibular system dysfunction. Pearson product moment correlations were computed between test scores for the total sample and for each subgroup to establish concurrent validity between tests. Four correlations for the total sample and three for each of the subgroups were statistically significant. However, only 3 of the 10 correlation coefficients mentioned were greater than r = 0.5. The relatively low magnitude of many of the correlations obtained demonstrates that different tests of equilibrium measure different balance-related competencies, and that competence in one area does not indicate competence in another. Therapists evaluating equilibrium should administer more than one test. The tilt test used in this investigation did not correlate significantly with any other test. This suggests that tilt tests should routinely be included in the evaluation of equilibrium.

The link between postural background movements, especially movements to maintain equilibrium, and skilled or learned movement has been established through the application of physical laws to human movements. As Broer (1966) stated, "whenever one body part moves away from the line of gravity in one direction (as occurs with skilled or learned movement), the center of gravity shifts in that direction. If this shift puts the center of gravity beyond the base of support, another body part must move in the opposite direction to bring the center of gravity back over the base or balance will be lost" (p. 43). These compensatory movements, which maintain or regain the center of gravity over the base of support for the purpose of maintaining equilibrium, should be finely tuned, automatic, and not consciously controlled. When equilibrium is impaired, the task of maintaining a position becomes a willed movement, executed at a great expense of energy, and more skilled and purposeful activity cannot be efficiently accomplished (Bobath, 1971).

The relative importance of equilibrium reactions to human function has encouraged therapists to find a means for evaluating them. However, no matter how theoretically accurate the above law or principle of human equilibrium, it offers little insight to therapists faced with the task of evaluating equilibrium reactions in children with central nervous system (CNS) damage or dysfunction. When this law is applied to the infinite number of potential combinations of human movements, the task becomes overwhelming. Therefore, most therapists resort to objective assessments of equilibrium based not on the above functional principle of equilibrium but on another physical prin-
valid, reliable, and also sensitive to development have
principle. This second principle states that the wider the
base of support and the nearer the center of gravity
to the center of the base, the more stable is the
individual (Broer, 1966). Clinicians attempting to em-
ploy standardized measures of equilibrium that are
valid, reliable, and also sensitive to development have
turned primarily to tests of one-legged standing, beam
walking, and tandem walking. The logic behind this
choice appears to be that if disturbances in equili-
rium exist, these disturbances will be most easily
detected by drastically narrowing the base of support
and objectively measuring the length of time an in-
dividual can maintain balance.

While based on an important physical law, such
objective evaluations fail to consider the more func-
tional but often qualitative or subjective aspects of an
equilibrium response that provide the postural back-
ground for skilled activity. In everyday life, children
rarely are required to stand on one leg, walk on a
beam, or tandem walk, except in the context of a
skilled activity (e.g., play, dressing). Yet commonly
used objective evaluations require that the child con-
sciously control equilibrium rather than use it auto-
matically as part of a functional task. Therefore, ther-
apists concerned with bridging the gap between pos-
tural responses and skilled activity often augment
their objective evaluation of equilibrium with subjec-
tive observations of functional equilibrium.

Weisz (1938) has indicated that equilibrium re-
actions are elicited under the following three condi-
tions: (a) through changes in the position of the body
in space—as when a person is moving from place
to place or position to position, (b) through changes
in the body’s supporting surface—as when a person is
tilted, or (c) through changes in the position of the
extremities in relation to the body—as when a person
is reaching.

Therapists evaluating equilibrium by (a) placing
the child on unstable surfaces, (b) gently displacing
the child as he or she attempts to maintain a position,
or (c) asking the child to obtain objects slightly
beyond reach appear to be making the evaluation
more functional in a manner supported by the litera-
ture. However, research has offered little help to the
therapist in terms of how much tilt or active displace-
ment a normal child of a given age should be able to
withstand before losing balance. To make this kind
of judgment, therapists must rely on their own clinical
skill and knowledge of normal development.

In response to this need, Fisher and Bundy
(1982) developed four functional tests of equilibrium
by selecting and modifying commonly used clinical
assessments of equilibrium in accordance with
Weisz’s (1938) description of the conditions under
which equilibrium reactions are elicited. The tests
were designed to evaluate equilibrium reactions in
both a quantitative and qualitative manner and in-
cluded a tilt board test, two reaching tests (from a
stable and an unstable base), and a test of manual
displacement where the child was gently pushed
while standing on a stable surface. In a pilot study,
Fisher and Bundy found that certain tests and com-
binations of tests correlated with age and discrimi-
nated between normal boys and boys with sensory
integrative (vestibular) dysfunction. Furthermore, the
quantitative aspects of the tests (maximum angle of
rotation or of displacement from vertical position during
reaching, angle scores) could be reliably scored (in-
ter- and intrarater reliabilities, r = .98). However,
Fisher and Bundy, like other researchers (Drowatzky
& Zuccato, 1967; Sanborn & Wyrick, 1969) found low
correlations between equilibrium test scores; al-
though each test was a measure of equilibrium, chil-
dren who obtained high angle scores on one test did
not necessarily obtain high angle scores on others.
The result was poor correlations between test scores:
Fisher and Bundy concluded that the tests measured
different age-related aspects of equilibrium, and they
therefore recommended that several types of assess-
ments be used to adequately evaluate balance.

Two standardized evaluations of balance com-
monly used by therapists are drawn from the Southern
California Sensory Integration Tests (SCSIT) (Ayres,
1980) and the Bruininks-Oseretsky Test of Motor
Proficiency (Bruininks, 1978). The SCSIT includes
two tests of balance, Standing Balance: Eyes Open
(SBO) and Standing Balance: Eyes Closed (SBC);
both are tests of one-legged standing. The Bruininks-
Oseretsky Balance subtest (BOBS) includes eight
items; seven of these are of one-legged standing on
the floor or on a balance beam or of walking a line or
beam. The final item is more functional and requires
that the child walk across the beam while stepping
over a stick placed at knee height.

BOBS, SBO, and SBC evaluate very different as-
pects of balance from those tests developed by Fisher
and Bundy (Fisher & Bundy, 1983; Fisher 1984); yet
all three groups of tests have face validity, and all
together groups of tests have been shown to discrimin-
ate between normal children and children with CNS dys-
fuction (Ayres, 1976; Bruininks, 1978; Fisher &
Bundy, 1982). Subsequent studies modified, stan-
dardized, and collected preliminary normative data on
two of the four original tests on approximately
300 normal children 3 to 13 years old (Fisher, 1984;
Izraeleviz, Fisher, & Bundy, 1985). The three tests
include Tilt Board Tip (TBT), Flat Board Reach
(FBR), and Tilt Board Reach (TBR). The fourth test,
Flat Board Push, was discarded because it was difficult
to administer in a reliable manner. The validity of the
modified TBT, FBR, and TBR was demonstrated by
the ability of the three angle scores to predict age (R²
all of these tests, although considered to be measures of developmental or diagnostic evaluation. Low correlations would also be of theoretical interest since it would suggest that the administration of all six tests may not be necessary for the evaluation of equilibrium. If, however, as is hypothesized, the tests do not significantly correlate, those low correlations would support the need for the use of multiple valid tests for the thorough evaluation of equilibrium as part of a developmental or diagnostic evaluation. Low correlations would also be of theoretical interest since all of these tests, although considered to be measures of equilibrium, appear to measure different aspects of equilibrium.

Since equilibrium reactions are often depressed in children with learning disabilities (LD) and since equilibrium measures are frequently included in the evaluation of children with LD, the subjects for this investigation were all boys with documented LD. Furthermore, since equilibrium has been considered, at least in part, to be a vestibular function (Weisz, 1984), it would seem that the relationship between test scores might differ between LD children with no evidence of vestibular dysfunction and LD children with suspected vestibular dysfunction. Therefore, correlations were computed both for the total sample and for two subgroups of LD boys with and without suspected vestibular dysfunction.

Method

Subjects

The subjects were 50 boys who were enrolled in a private Midwestern school for children with LD. They ranged in age from 6 to 13 years (see Table 1). All were of at least average intelligence and all had known LD, which had been documented by psychological evaluation at the time of school placement. They were free from hearing loss, orthopedic disorder, and severe visual or neurological disorders.

Twenty-five of the boys demonstrated impaired vestibular system functioning as determined by (a) the prior results of the SCSIT, the Southern California Postrotary Nystagmus Test (SCPNT), clinical observations of neuromotor behavior administered by two occupational therapists certified in the administration and interpretation of the SCSIT and (b) the concurrent results of the SCPNT and clinical assessment of the ability to assume and maintain the prone extension posture.

More specifically, after completion of all testing, the subjects with suspected vestibular dysfunction were selected from the total sample by means of a two-stage screening process. In the first stage, boys who demonstrated depressed scores on concurrent prone extension and/or concurrent SCPNT were identified. Because means and standard deviations for SCPNT can vary significantly between experienced examiners, the subjects were only considered to have depressed concurrent SCPNT scores if their scores were more than one standard deviation lower than the mean established for approximately 150 normal boys tested by the principal investigators (Fisher, 1984).

In the second stage, the prior test results associated with vestibular dysfunction were reviewed. If, in the first stage of screening, the boys demonstrated depressed scores on both concurrent prone extension and the concurrent SCPNT, they were selected for inclusion in the group with suspected vestibular dysfunction. More specifically, after completion of all testing, the subjects with suspected vestibular dysfunction were selected from the total sample by means of a two-stage screening process. In the first stage, boys who demonstrated depressed scores on concurrent prone extension and/or concurrent SCPNT were identified. Because means and standard deviations for SCPNT can vary significantly between experienced examiners, the subjects were only considered to have depressed concurrent SCPNT scores if their scores were more than one standard deviation lower than the mean established for approximately 150 normal boys tested by the principal investigators (Fisher, 1984).

Table 1: Means and Standard Deviations of Age (in Months) for the Two Groups and the Total Sample

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Age (SD)</th>
<th>F (1,46 )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD with vestibular dysfunction (n = 25)</td>
<td>121.3 (25.0)</td>
<td>5.656</td>
<td>.02</td>
</tr>
<tr>
<td>LD without vestibular dysfunction (n = 25)</td>
<td>137.7 (22.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Sample ( N = 50 )</td>
<td>129.5 (24.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: LD = learning disabled.
tongue, cocontraction, and gravitational security. The remaining 25 subjects did not demonstrate a meaningful cluster of scores and observations suggesting vestibular dysfunction.

**Procedure**

Testing was carried out in two phases. During the first phase, the BOBS was administered according to the standardized instructions by the same therapists who had administered the prior SCSIT, SCPNT, and clinical observations.

During the second phase, five tests of equilibrium were administered to each child. Three of these tests (TBT, FBR, and TBR) were based on those developed by Fisher and Bundy (1982). The remaining two equilibrium tests were based on the SBO and SBC tests (Ayres, 1980). In addition, all children had an assessment of the ability to assume and maintain the prone extension posture (Fisher, 1984), and the SCPNT (Ayres, 1975) was administered. The principal investigators administered all tests in the second phase. The results of Phase 1 testing were unknown to the Phase 2 examiners at the onset of Phase 2 testing. The two phases of testing were separated by approximately 3 months.

All Phase 2 testing was carried out in a large well-lit, distraction-free room. The order of testing was systematically varied to control for the effects of order and fatigue. The SCPNT was always administered last, and Fisher and Bundy’s three tests were administered as a unit. Prone extension, SBO, and SBC were tested prior to or following Fisher and Bundy’s tests; the SBO always immediately preceded the SBC. Descriptions of the tests and precise administration procedures are described elsewhere (Fisher, 1984; Izraelevitz et al., 1985).

**Results**

Because performance on equilibrium measures is known to change with age (Ayres, 1980; Bruininks, 1978; Fisher, 1984; Fisher & Bundy, 1982; Izraelevitz et al., 1985) and because the two groups of subjects differed significantly in age (see Table 1), z scores were computed for each of the equilibrium measures for each child. In addition, a z score for a composite total angle score (TOT) was also computed, which was derived from the sum of the raw angle scores for TBT, FBR, and TBR. The z scores for the BOBS were based on standardized information from the Bruininks (1978) test manual. All other z scores were based on the preliminary normative data obtained for normal boys 6 to 13 years of age (Fisher, 1984).

Means and standard deviations for the z scores for each test by the LD group and for the total LD sample are shown in Table 2. Overall, the means for both LD groups and for the total LD sample were lower than the means for the normal sample against which the LD groups were compared (Fisher, 1984), and the group with vestibular dysfunction demonstrated slightly lower mean scores than did the group with no suspected vestibular dysfunction. Only the BOBS differed significantly between the two groups (p < .05).

Pearson product moment correlation coefficients between test scores were computed for the total sample. Correlations between TOT and TBT, FBR and TBR were not computed since each of the latter contributed to TOT; therefore, significant correlations would be meaningless. The resulting correlation matrix is shown in Table 3.

Only 4 of the 18 correlations for the total sample reached statistical significance (p < .05). One of those four was a negative correlation, indicating that children who scored relatively higher on one test scored relatively lower on the other test and vice versa (see Table 3).

To determine whether the presence or absence of vestibular dysfunction resulted in a different pattern of significant correlations between test scores than was found for the total sample, Pearson product moment correlation coefficients were computed, by group, for each pair of tests. The results of these correlations are also shown in Table 3.

As can be seen in Table 3, different pairs of tests significantly correlated for the two LD groups. Because it frequently was noted that the direction of the correlations between the same tests differed between the groups, Fisher z transformations were used to compute statistical comparisons of the correlation coefficients for each test between groups to determine whether the correlations were significantly different. The results of the comparisons are shown in Table 4. Only two of the comparisons (FBR with SBC and TBR with FBR) reached statistical significance (p < .05).
Table 3
Correlations \((r)\) Between Tests for Total Sample and by Group

<table>
<thead>
<tr>
<th></th>
<th>BOBS</th>
<th>SBO</th>
<th>SBC</th>
<th>TBT</th>
<th>FBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.17</td>
<td>0.14</td>
<td>0.34</td>
<td>0.11</td>
<td>0.34</td>
</tr>
<tr>
<td>Vestibular</td>
<td>-0.11</td>
<td>-0.14</td>
<td>-0.34</td>
<td>-0.11</td>
<td>-0.34</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>SBC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.46**</td>
<td>0.33*</td>
<td>0.54**</td>
<td>0.40*</td>
<td>0.40*</td>
</tr>
<tr>
<td>Vestibular</td>
<td>0.38*</td>
<td>0.22</td>
<td>0.40*</td>
<td>0.40*</td>
<td>0.40*</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>0.54**</td>
<td>0.40*</td>
<td>0.40*</td>
<td>0.40*</td>
<td>0.40*</td>
</tr>
<tr>
<td>TBT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.11</td>
<td>0.09</td>
<td>0.13</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Vestibular</td>
<td>-0.06</td>
<td>-0.01</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>FBR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.13</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Vestibular</td>
<td>-0.05</td>
<td>-0.22</td>
<td>-0.35</td>
<td>-0.35</td>
<td>-0.35</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>TBR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.16</td>
<td>-0.27*</td>
<td>-0.17</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Vestibular</td>
<td>0.28</td>
<td>-0.32</td>
<td>0.0009</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>-0.08</td>
<td>-0.27</td>
<td>-0.43**</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>TOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Vestibular</td>
<td>-0.19</td>
<td>0.07</td>
<td>-0.38</td>
<td>-0.38</td>
<td>-0.38</td>
</tr>
<tr>
<td>Nonvestibular</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Note. BOBS = Bruininks-Oseretsky Balance subtest; SBO = Standing Balance: Eyes Open (part of the Southern California Sensory Integration Tests [SCSIT]). SBC = Standing Balance: Eyes Closed (part of SCSIT). TBT = Tilt Board Tip. FBR = Flat Board Reach. TBR = Flat Board Reach. TOT = total angle score. NA = not applicable.

Discussion
The primary purpose of this investigation was to examine concurrent validity between tests of equilibrium. Whether or not concurrent validity could be established, the attempt to do so was deemed important. If concurrent validity could be established, therapists could be assured that certain tests would provide equivalent measurements of equilibrium and that objective, quantitative standardized tests of one-legged standing beam or tandem walking would provide the same information as do clinical, qualitative observations of tilting reactions or functional equilibrium tests. If concurrent validity could not be established, therapists would receive objective support for the expenditure of additional time required to administer several tests, allowing for the careful evaluation of equilibrium.

Given previously reported evidence to suggest the presence of multiple aspects of equilibrium (Drowatzki & Zuccato, 1967; Fisher & Bundy, 1982; Sanborn & Wyrick, 1969), it was felt that observations of balance that resulted in a composite score, such as the BOBS or TOT, might reflect a broader picture of equilibrium than would any one test alone. Furthermore, the BOBS alone was found to discriminate between the two LD groups (unpublished observation), and the TOT was found to contribute significantly to the discrimination between normal and LD boys (Fisher, 1984). However, the correlations between the BOBS and the TOT were all very low \((r = 0.09\) for the total sample, \(r = -0.19\) for the group with vestibular dysfunction, and \(r = 0.30\) for the group without vestibular dysfunction), suggesting that even these two composite scores do not measure overlapping aspects of equilibrium.

While statistically significant correlations were found between pairs of tests for both the total sample and the individual groups, the question which seems most important is less one of statistical significance than one of clinical meaningfulness: Is the amount of shared variance between any of the pairs great enough so that it can be said that the two tests measure the same aspect(s) of equilibrium? Although no strict rules exist that determine practical or clinical significance, it would seem that tests having correlations of
less than \( r = .50 \) (25% shared variance) are certainly not measuring the same traits. Of the correlations computed for the total sample, only the correlation between the FBR and the TBR met this arbitrary criterion. Correlations computed for each of the pairs of tests by group revealed one correlation for the group with vestibular dysfunction (TBR with FBR) and one correlation for the group without vestibular dysfunction (BOBS with SBC) that met this criterion (see Table 3). These results support the previous finding of Fisher and Bundy (1982) that multiple measurements of equilibrium are necessary to adequately evaluate balance abilities.

The results of this investigation suggest that boys with impaired vestibular function tend to score slightly, but not significantly, lower on equilibrium tests than do boys with no suspected vestibular dysfunction. This investigation also suggests that LD boys as a group may be impaired in their performance of equilibrium tasks when compared with normal boys. The pattern of significant correlations between tests differed between the two groups, suggesting that the equilibrium deficits of LD boys with vestibular dysfunction are in some way different from the equilibrium deficits of LD boys with no apparent vestibular dysfunction. It should be noted that many of the boys in the latter group demonstrated gross motor coordination deficits, including dyspraxia, which may account for their low mean balance scores.

The relatively low magnitude of many of the correlations obtained in this investigation clearly demonstrates that different tests of equilibrium measure different balance-related competencies, and that competence in one area does not indicate competence in another. Therefore, multiple tests of equilibrium are required for a comprehensive evaluation.

Poor equilibrium is both a diagnostic indicator and a cause of functional impairment. The primary purpose for evaluating equilibrium is to determine treatment strategies for its improvement. Therefore, therapists administering multiple tests of equilibrium must attempt to determine the particular aspect(s) of those tests that result in a relatively better or worse performance for a specific child. While therapists recognize the effects of eyes open versus eyes closed on a child's performance, the results of this investigation suggest that the use of vision is only one aspect of the requirements of various equilibrium tests which should be considered. The following discussion is not comprehensive; however, four additional aspects of equilibrium tests which appear to affect children's performance are included.

Therapists should consider the placement of the child's non-weight-bearing extremities (e.g., arms and raised leg in one-legged standing or reaching tasks). Some tests dictate the position of these extremities and some allow the child to place them in the position the child finds most comfortable (i.e., arm position differs, but is fixed for both BOBS one-legged standing tests and the SBO and SBC, whereas the raised-leg position is fixed in the BOBS but “free” in the SBO and SBC). The question that seems most relevant for therapists to ask is this: Is the child allowed to move the non-weight-bearing extremities to assist in maintaining the center of gravity over the base of support? The idea that extremity placement may make a difference in equilibrium testing is supported by Fisher (1984) who found that the extent of abduction (angle) of the uphill non-weight-bearing limbs correlated significantly with the angle score on the TBR and FBR.

Secondly, therapists should consider whether the child has a visual target on which he or she must fixate to successfully complete the task. Reaching tasks, such as FBR and TBR, and some tilt type tests, such as the TBT, require that the child fixate on a target; many tests of one-legged standing do not specify a visual target. Visual fixation as a relevant aspect of equilibrium has also been supported by Fisher (1984), who found that very young normal children and boys with vestibular dysfunction often preferred to look down at the floor or their feet during TBT; they appeared unable to fixate on a visual target (camera), even with repeated instructions to do so. Perhaps even fixation on a target is less relevant than the fact that the child, given a choice, prefers a posture of neck flexion.

A third aspect of equilibrium testing that therapists should consider is the required workload of the weight-bearing extremities. Reaching tasks, accomplished most effectively by abducting the uphill leg, require that the child impose mobility on a very stable, weight-bearing leg; tilt tests require relatively less stability in the weight-bearing extremities. Furthermore, even one-legged standing tests, which would seem to place a reasonably large demand on the weight-bearing extremity, can be accomplished by the child's fixating at the pelvis and “hanging” on ligaments. Fisher (1984) found that very young children and boys with vestibular dysfunction were often reluctant to lift the uphill foot off the board during FBR and TBR. Failure to lift the foot prevented their attaining as great an angle score as was obtained by older normal children.

A final consideration might be whether it is the child or the therapist who is controlling the movements required by the task. Reaching and one-legged standing tests allow the child to determine when and how much movement will occur; tilt tests require that the therapist impose movement on the child. This idea is supported by the low correlations between the TBT and any of the other equilibrium measures. This
finding is interesting since Fisher (1984) and Fisher and Bundy (1982) found that the TBT contributed significantly to a discriminant analysis between boys with vestibular dysfunction and normal boys. Traditionally, tilt tests have been used to identify vestibular dysfunction. Fisher has provided a comprehensive review of that research. The present investigation suggests that tilt tests should be routinely used in the evaluation of equilibrium and that these tests may evaluate an aspect of equilibrium that is very different from one-legged standing tests. Further research is indicated.

Summary
The evaluation and treatment of equilibrium deficits is of concern to occupational therapists treating children with learning disabilities. However, an individual’s relative competence with regard to equilibrium is affected by the manner in which the reactions are elicited. Six equilibrium tests were administered to 50 LD boys. The resulting low correlations between test scores suggest that multiple measurements of equilibrium are essential for an adequate evaluation. Several relevant, but not always considered, aspects of commonly used equilibrium tests were discussed.

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References