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Validity and Reliability of Limits-of-Stability Testing: A Comparison of 2 Postural Stability Evaluation Devices

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Context: A lack of published comparisons between measures from commercially available computerized posturography devices and the outcome measures used to define the limits of stability (LOS) makes meaningful interpretation of dynamic postural stability measures difficult.
Objectives: To compare postural stability measures between and within devices to establish concurrent and construct validity and to determine test-retest reliability for LOS measures generated by the NeuroCom Smart Balance Master and the Biodex Balance System.
Design: Cross-sectional study.
Setting: Controlled research laboratory.
Patients or Other Participants: A total of 23 healthy participants with no vestibular or visual disabilities or lower limb impairments.
Intervention(s): The LOS were assessed during 2 laboratory test sessions 1 week apart.
Main Outcome Measure(s): Three NeuroCom LOS variables (directional control, endpoint excursion, and movement velocity) and 2 Biodex LOS variables (directional control, test duration).
Results: Test-retest reliability ranged from high to low across the 5 LOS measures (intraclass correlation coefficient [2,k] = 0.82 to 0.48). Pearson correlations revealed 4 significant relationships ($P < .05$) between and within the 2 computerized posturography devices ($r = 0.42$ to -0.65).
Conclusions: Based on the wide range of intraclass correlation values we observed for the NeuroCom measures, clinicians and researchers alike should establish the reliability of LOS testing for their own clinics and laboratories. The low to moderate reliability outcomes observed for the Biodex measures were not of sufficient magnitude for us to recommend using the LOS measures from this system as the gold standard. The moderate Pearson interclass correlations we observed suggest that the Biodex and NeuroCom postural stability systems provided unique information. In this study of healthy participants, the concurrent and construct validity of the Biodex and NeuroCom LOS tests were not definitively established. We recommend that this study be repeated with a clinical population to further explore the matter.

Key Points

- The NeuroCom Smart Balance Master provided high test-retest reliability, supporting its use in assessing stability in healthy participants.
- The NeuroCom Smart Balance Master offered more information on dynamic postural stability than did the Biodex Stability System, but each system offered unique information toward an overall postural stability assessment.
- Until a standardized definition of dynamic postural stability is agreed on by researchers and clinicians, neither the NeuroCom nor the Biodex can be considered the criterion standard for assessment.

Postural stability has been defined as the ability to control the body's center of gravity (COG) within a given base of support1,2 and has been extensively researched.3–12 To date, postural stability researchers1,13 have defined the continuum of postural stability from static stability to functional stability. However, the understanding of postural stability control (ie, balance) that is essential for performing activities of daily living and achieving success in sports remains complicated by vague terminology and numerous outcome measures. Postural stability measures used to evaluate postinjury and postsurgical musculoskeletal somatosensation have gained support

from the sports medicine community,4,5,7,8 and the effects of prophylactic ankle bracing, foot orthotics, balance training, and skill training on postural control and athletic performance have all been investigated.6,12,14,15 Yet despite the recent advances in postural stability measurement and the increased applicability of research findings to clinical practice, 3 key problems remain: nomenclature, criterion standards, and technology. The first challenge is the lack of a standardized postural stability nomenclature. The interchangeability of the terms balance and postural stability contributes to this concern; however, for the focus of this study, the construct of dynamic balance is our primary interest. Clinicians need to be familiar with the current nomenclature in order to properly assess patient outcomes and recognize differences in dynamic postural stability testing protocols to make appropriate testing and treatment decisions. We selected the operational definition supported by Nashner and McCollum2 to review 2 criterion tests developed to evaluate this construct. In limits-of-stability (LOS) testing, the person's foot position does not change relative to the platform; however, the platform may move relative to the horizontal surface in one testing design. Tests designed to measure the same construct should show convergent validity, given that the test designs were based on similar definitions. A second concern is the lack of a criterion standard or gold standard for dynamic postural stability (ie, a single evaluative construct that defines good or normal dynamic balance). The Berg Balance Scale formalized the assessment of dynamic and functional postural stability16 and established the criteria for dynamic balance. The Berg Scale is a subjective assessment validated only for evaluating older adults.16 As more advanced computerized tests of dynamic balance are developed, it is important to evaluate both the construct and concurrent validity of these tests in order to improve our clinical capacity to accurately evaluate human movement. The manner in which the numerous variables derived from advanced postural stability kinetic and kinematic technology relate to postural stability has given rise to questions about the validity, reliability, and objectivity of test measures.4,14,17–20 Additionally, questions of clinical applicability and meaningfulness of test measures to aid in the evaluation and rehabilitation of clinic clientele must be addressed.3 The foci here are the LOS tests and the quantification of dynamic stability, calculated using ground reaction force data to locate the center of pressure. Conversion of these data to COG sway angles suggests that regardless of height, the ultimate LOS for adults range from 6.25° to 8° forward, 4° to 4.45° backward, and 8° laterally.2 In order to accurately assess a criterion for dynamic postural stability, the outcome measures obtained with computerized posturography instrumentation must be both valid and reliable. To date, the reliability of many of the outcome measures used to assess postural stability has not been established.8,17,19–24 Reports of postural stability studies14,25 often include several significant outcome measures, with each variable analyzed individually and without mention of the multifaceted nature of dynamic balance. Published evidence of validity for the numerous manual and computerized assessment devices currently in clinical use for measuring postural stability is also lacking. Even when measures are reliable, no clear indication is provided as to which component of stability is affected (eg, visual, vestibular, somatosensory), nor is the location of the deficit or improvement in the somatosensory-neuromuscular system identified.26 The lack of reliability and validity data is problematic for clinicians and researchers interested in postural stability assessment. Reliability, the consistency of scores and the lack of measurement error, is a component of validity. Validity is a more complex concept involving multiple components that all provide evidence that the applied measures truly assess and offer information about the stated attribute.27 Construct and concurrent validity are 2 components of dynamic postural stability that can be investigated through interclass correlation analysis. Construct validity evidence is provided when similar variables are correlated with and predictive of the given construct,27 in this instance dynamic postural stability. We use concurrent validity, a submeasure of criterion-related evidence for validity, when trying to demonstrate that similar tests measure the same thing, or what researchers often call the gold standard, by demonstrating the highest predictive validity of the theoretical construct.27 A gold standard is not required, but at minimum, a theoretical construct must be established.27 Given that no current gold standard exists for dynamic postural stability, outcomes from these tests are used as criteria to compare one test against another. Using the operational definition of dynamic stability, researchers also compare these tests with the definition to assess their construct validities. Dynamic postural stability outcome measures produced by various commercial testing devices should be compared to provide much-needed information about the quantification of LOS and the construct of dynamic postural stability. To date, we are aware of no authors who have reported comparisons of commercially available computerized posturography devices and the testing outcome measures used to determine dynamic LOS, leaving both the construct validity and concurrent validity of these dynamic postural stability tests in question. Our intention was to evaluate whether 2 patented computerized posturography testing devices that quantify LOS assessed similar or different components of postural stability. Therefore, the purposes of this study were to determine the magnitude of the relationships between clinical measures from 2 commercially available postural stability testing devices used to assess dynamic LOS to establish concurrent and construct validity and to identify the test-retest reliability of outcomes from both devices.

Key Words: postural control, balance, measurements

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