Narrowing Beam-Walking Test (NBWT)

Introduction

The Narrowing Beam-Walking Test (NBWT) is a performance-based clinical test designed to assess balance ability in ambulatory individuals with lower-limb impairments who may be at risk for falls (e.g. lower-limb prosthesis users). Its design facilitates an assessment of balance ability with minimal subjective interpretation (i.e. participants are either on or off the beam), while the increasing level of difficulty (i.e. decreasing beam width), renders it suitable for a broad range of ability levels and possible applications. The test requires participants to walk along a set of four beams, each narrower than the last. Further distances walked on the NBWT indicate greater balance ability and reduced fall risk.[1-3]

Establishing Author: *Sawers & Hafner, 2018*[1] **Data Type**: *Ratio*

Measurement Type: *Performance-based test* **Assessment Type**: *Observed performance*

Patient Population

The Narrowing Beam Walking Test (NBWT) was developed and assessed for validity and reliability with lower-limb prosthesis users:

- With a unilateral transtibial or transfemoral amputation
- With at least one year of experience using a lower-limb prosthesis
- With or without a history of falls
- Who are able to walk a short distance (about 3m) without an assistive device

Resources

Time: 10 minutes

Personnel: Patient, test administrator, and spotter

Equipment: The Narrowing Beam Walking Test (NBWT) apparatus should be built to the establishing authors' specifications.[1] The NBWT consists of four, fixed-width beams:

- Beam 1: 6.0 ft (183 cm) long by 7.3 in (18.6 cm) wide
- Beam 2: 6.0 ft (183 cm) long by 3.4 in (8.6 cm) wide
- Beam 3: 6.0 ft (183 cm) long by 1.6 in (4.0 cm) wide
- Beam 4: 6.0 ft (183 cm) long by 0.8 in (2.0 cm) wide

Each board is approximately ¾-inches (1.5 cm) high. The NBWT beams can be made from common construction materials (i.e., high quality 2x8, 2x4, 2x2, and 2x1 boards), but be sure to replace any boards that warp over time. The beams should be connected in sequence from widest to narrowest. The narrowest two beams should have lateral braces to prevent rotation and movement. The beam should be scored with calibrated marks (i.e., lines), starting at 2 feet along the widest beam until the end of the narrowest beam.

Space: The fully constructed beam is 24 feet long. Therefore, you will require a space that is at least 30 feet long by 8 feet wide (to allow adequate room for the evaluator and spotter to stay near the patient). The NBWT should be placed at least 0.91m (3.0 ft) away from the wall or other structures so that participants cannot rely on them for support.

Cost: approx. $300

Administration

The Narrowing Beam Walking Test (NBWT) is administered by asking the patient to walk along the length of the connected beams with their arms crossed across their chest. The patient begins each trial with one foot on the wide end of the beam, and one foot on the ground next to the beam. The patient may use their assistive device to get into position, but should not use it when attempting the test. With their arms across their chest, patients are instructed to walk along the beam at any speed they choose. Five trials should be administered, though only the final three trials are used in scoring the measure. Begin the test by explaining the test to the patient:

- *The goal of this test is to walk as far as possible along the beam. Speed is not being evaluated. Begin the test by standing with one foot on the wide end of the beam and the other foot on the ground to the side. You may choose which foot to put on the beam and which to put on the ground. Please cross both your arms across your chest.*

Once you have provided an overview, provide a demonstration of how to walk the beam with arms crossed across your chest. Illustrate when the test will stop, both by stepping off the beam and by uncrossing your arms. After demonstrating, provide test instructions:

- *When I say 'begin,' please walk along the beam as far as you can. Please walk at a comfortable speed. Remember to keep your arms crossed over your chest as you walk. Once you move your arms away from your body or step off the beam, I will ask you to stop. Are you ready? 'Begin.'*

Provide the test instructions above before the patient begins each trial. Spot or guard the patient, using a gait belt as appropriate, as they walk along the beam. Allow the participant to rest (at least 15 seconds) between each trial. Provide the test instructions before each trial and at least 15 seconds of rest after each trial.

Scoring

The test administrator should pay close attention to the patient as they walk along the beam, noting the location of the patient's feet when they either step off the beam or uncross their arms, whichever occurs first. Record the distance walked for each trial as the last 6-inch mark that the patient's forward foot crossed before they stepped off the beam or uncrossed their arms to regain their balance.

- For example, if the patient's right foot was between the 10-foot mark and 10-foot-6-inch mark when their left foot stepped off of the beam, the distance for that trial would be 10 feet.
- If the patient's forward-most foot was between the 11-foot-6-inch mark and the 12-foot mark when the patient/participant uncrossed their arms the distance for that trial would be 11.5 feet.
- If the patient's back foot is at the 13-foot-6-inch mark, and forward-most foot steps on the beam at the 14-foot-6-inch mark, but slides off to the side or the patient's foot then touches the ground, the distance for that trial would be 13.5 feet (the distance of the final foot to successfully accept body weight).
- Record the distance for the trial as '0' if the participant cannot begin to walk along the beam, or if they do not pass the '0' mark (which is located at a point 2 feet along the widest section of the beam). Once the patient's forward-foot crosses the '0' mark, record the distance as noted above.

Normalized distance, the overall score for the Narrowing Beam Walking Test, is calculated by dividing the distance walked in each of the three scored trials (the third, fourth, and fifth trials) by the calibrated length of the beam (i.e., 22.0ft (6.71m)). After dividing the distance of each trial by 22.0, find the average of the normalized distance for the three scored trials. This is the overall normalized distance for the NBWT.

$$\frac{(Trial\ 3 + Trial\ 4 + Trial\ 5)}{66.0} = overall\ normalized\ distance\ for\ the\ NBWT$$

Interpretation

The overall normalized distance for the NBWT will be a value between 0.0 and 1.0, where higher values (i.e., those closer to 1.0) represent better balance ability, and lower values (i.e., those closer to 0.0) represent poorer balance ability.

Psychometric Properties

The NBWT has undergone initial testing with unilateral lower limb prosthesis users to assess key psychometric properties, including validity, reliability, and responsiveness.

Validity:

- Face Validity
  - Distance walked along the narrowing beam indicates differences in balance control and ability.
- Normality of Distribution
  - Scores of the NBWT exhibit normal distribution (W= .964, *P*= .240)[2]

- Content Validity
  - Fewer than 15% of participants scored near the minimum or maximum possible normalized score (i.e., within the first or last bin of the normally distributed histogram)[2]
- Construct Validity
  - Known-Groups Construct Validity
    - Significantly lower normalized scores for fallers (≥1 falls in the previous 12 months) than for non-fallers (0 falls in the previous 12 months)[2]
    - Faller mean normalized score = 0.33 vs. non-faller mean normalized score = 0.51 (*P* = .003)
    - Significantly lower normalized scores for repeat fallers (≥2 falls in the previous 12 months) than for single instance or non-fallers (0-1 falls in the previous 12 months)[3]
      - Repeat faller mean normalized score = 0.25 vs. non-faller mean normalized score = 0.51 (*P*≤ .001)
    - Significantly lower normalized scores for participants with transfemoral amputations than for participants with transtibial amputations[2]
      - TF mean normalized score = 0.30 vs. TT mean normalized score = 0.46 (*P*= .011)
    - Significantly lower normalized scores for participants classified as K1 and K2 ambulators than for participants classified as K3 and K4 ambulators[2]
      - K1 and K2 mean normalized score = 0.26 vs. K3 and K4 mean normalized score = 0.51 (*P*< .0001)
  - Convergent Construct Validity
    - Strong negative correlation between NBWT scores and Four Square Step Test times (ρ=-.80, *P*<.0001)[2]
    - Strong negative correlation between NBWT scores and Timed up and Go test times (ρ=-.70, *P*<.0001)[2]
    - Strong positive correlation between NBWT scores and Berg Balance Scale scores (ρ=.85, *P*<.0001)[2]
    - Moderate positive correlation between NBWT scores and Activities-Specific Balance scale scores (ρ=.49, *P*<.001)[2]

- Discriminant Validity
  - Discriminant validity of the NBWT was evaluated by analyzing the area under curve of the test's receiver operating characteristic (ROC) curve. The NBWT displayed an area under the curve of 0.81[2], greater than the

threshold of 0.80 as the recommended limit of clinical acceptability at a 95% CI.[4]

- Concurrent and Predictive Validity
  - Concurrent Validity
    - The NBWT exhibits a greater area under the ROC curve than for other common clinical measures of balance control and ability[2]

Clinical Measure	Area under ROC curve
NBWT	0.81
Timed Up and Go (TUG)	0.71
Four-Square Step Test (FSST)	0.70
Berg Balance Scale (BBS)	0.66
Activities-Specific Balance Confidence Scale (ABC)	0.65

*recommended limit of clinical acceptability of area under ROC curve = 0.80[4]

  - Predictive Validity
    - Pending
    - The NBWT was found to have a likelihood ratio of 3.0 (LR+= 3.0) for predicting fallers vs. non-fallers in an ambulatory lower-limb prosthesis user population.[3] Lower limb prosthesis users are 3 times as likely to be classified as "fallers" if the overall normalized score on the NBWT is calculated to be ≤0.43.[3] While the likelihood ratio for the NBWT was not sufficient to indicate large and conclusive changes in the probability of a fall event, a likelihood ratio of 3.0 indicates a small, but important shift in the probability of a fall.[3]

Reliability:

- Test-retest Reliability
  - No statistically significant differences in test scores were observed between test sessions for the NBWT (t=-1.821, *P*=.066).[5]
- Inter-rater Reliability
  - Two-sided paired t-tests revealed no statistically significant differences in mean test scores between raters for the NBWT (t=1.276, *P*=.207).

Responsiveness:

- Minimal Detectable Change (MDC)
  - The MDC_{90} (minimal detectable change on a 90% confidence interval) for the Narrowing Beam Walking Test is 0.16.[5]
- Floor and Ceiling Effects

- The NBWT exhibits neither ceiling nor floor effects
  - Of the 40 participants that participated in the validation study, none scored at the minimum (0.0) or maximum (1.0) scores for the measure, suggesting the measure's ability to measure a broad patient population as well as quantify changes in balance without reaching the scale limits.[3]

Documentation in Clinical Notes

When documenting the results of the test in clinical notes, first start with stating the name of test and the day the test was performed. Depending on what type of test was performed, describe the results (patient scored this normalized score). Compare these results to the results of the same test taken at an earlier time. Describe what these results mean in terms of patient health (improvement/deterioration, increase/decrease of patient's balance abilities, etc...)

Example: When assessed with the Narrowing Beam Walking Test on (99/99/9999) the patient recorded a normalized score of (X.X). This score was [greater/less] than previously recorded. This represents an (X.X) point [decrease/increase] in the normalized score since last recorded on (99/99/9999), and therefore represents an [improvement/deterioration] in the patient's balance abilities.

Limitations

The Narrowing Beam Walking Test may be susceptible to floor effects for lower-limb prosthesis users with significant mobility restrictions.[1] Additionally, while the results of the study suggest that most participants' performance will plateau within 5 trials (i.e., 2 practice trials and 3 scored trials), but this may not be accurate for every participant.[1] Research using the NBWT has thus far only included unilateral lower-limb prosthesis users; additional research is required to understand how performance may vary for bilateral lower-limb prosthesis users or participants of different populations.[2] Data regarding falls in these studies was collected retrospectively via self-report and may have been affected by recall bias; additional prospective research is required to collect accurate falls data and evaluate the NBWT's ability to prospectively predict falls.[2] Other known risk factors for falls among lower-limb prosthesis users (such as strength, protective stepping, number of medications, and sense of vibration) were not considered in these studies, but may improve model performance in future studies using the NBWT.[3]

Acknowledgement/Disclaimer

The Authors, the Outcomes Research Committee, and the American Academy of Orthotists and Prosthetists do not endorse the use of any single outcome measure over any other single outcome measure and declares no conflict of interest in the presentation of the measure. There may be multiple versions of the instructions published in the research literature. This reference guide has attempted to remain consistent with the instructions from the original developers of the outcome measure whenever possible, however, in some instances specific versions of the instructions are chosen for ease of use in the clinic.

References

1. Sawers A, Hafner B. Narrowing beam-walking is a clinically feasible approach for assessing balance ability in lower-limb prosthesis users*. Journal of Rehabilitation Medicine*. 2018;50(5):457-464. doi:10.2340/16501977-2329.
2. Sawers A, Hafner BJ. Using clinical balance tests to assess fall risk among established unilateral lower limb prosthesis users: cutoff scores and associated validity indices. *PM&R.* 2019;12(1):16-25. doi:10.1002/pmrj.12160.
3. Haynes RB. Clinical epidemiology: how we do clinical practice research. 3rd ed. Lippincott, Williams, and Wilkins.
4. Sawers A, Kim J, Balkman G, Hafner B. Inter-rater and test-retest reliability of performance-based clinical tests administered to established unilateral lower limb prosthesis users. *Physical Therapy.*