

Original Article

Optimizing Testing for BPPV – The Loaded Dix-Hallpike

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OBJECTIVES: Although the Dix-Hallpike testing is generally considered as the gold standard for the identification of the posterior canal benign paroxysmal positional vertigo (BPPV), we investigated a modification of the maneuver termed the “loaded Dix-Hallpike.” Study Design: Prospective randomized controlled trial.

MATERIALS and METHODS: Twenty-eight patients participated in this prospective study comparing the standard Dix-Hallpike (S-DH) to the loaded Dix-Hallpike (L-DH) test. Each patient underwent repeated testing with the S-DH and the L-DH. The patients were placed into two groups. Fourteen patients underwent 3 rounds of S-DH testing followed by 3 rounds of L-DH testing. The other fourteen patients underwent 3 rounds of L-DH testing followed by 3 rounds of S-DH testing. The duration of nystagmus and the latency prior to the onset of nystagmus were measured for each test. Additionally, the patients were asked to rate the severity of their symptoms following each test.

RESULTS: The duration of nystagmus of the L-DH was significantly longer than that of the S-DH ($p < 0.0001$). The patients reported a higher severity score with L-DH as compared to with S-DH ($p < 0.001$). The L-DH was found to be more sensitive than the S-DH ($p = 0.0131$).

CONCLUSION: The L-DH produces significantly longer duration of nystagmus, stronger symptoms, and improved sensitivity when compared to the S-DH.

KEYWORDS: Vestibule, labyrinth, peripheral vertigo, benign paroxysmal positional vertigo

INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is the most common otologic cause of dizziness. The condition is often self-limiting but can become chronic or relapsing and have considerable negative impact on the quality of life and daily activities. BPPV is a disorder caused by dislodged free floating particles (otoconia) from the utricular macula that migrate into the semicircular canals. The otoconia then migrate in the canal following changes in the head position with relation to gravity. The movement of these particles causes pressure differentials within the capillary sized membranous canal, causing displacement of the cupula and its associated cilia, resulting in the perception of motion. Patients often report discrete, positional dizziness lasting seconds. Common provocative activities include bed mobility (e.g. lying down or rolling over in bed), overhead activities (e.g. look up to a shelf higher than the head), or bending forward to pick up an object or tie shoes.

Health care costs associated with BPPV are often significant. It is estimated that it costs approximately \$2000 to arrive at the diagnosis of BPPV and that >65% of patients with this condition will undergo potentially unnecessary diagnostic testing or therapeutic interventions ^[1-9].

A recent theory offered by Boselli et al. ^[10] suggested a mechanism for reduced responses with repeated Dix-Hallpike testing. Otoconia may reside at various locations along the inferior aspect of the posterior canal at varying distances from the cupula resulting in differing particle trajectories during Dix-Hallpike testing. This would theoretically cause fluctuant cupular displacements depending on the location of the debris prior to the Dix-Hallpike testing ^[10].

This study was presented as a poster at the Combined Otolaryngology Spring Meeting, April 18-22, 2018 National Harbor, Maryland, USA.

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The purpose of this study was to compare the sensitivity of the standard Dix-Hallpike (S-DH) testing with the loaded Dix-Hallpike (L-DH) test in patients with known posterior canal BPPV. We hypothesized that by "loading" the otoconia adjacent to the cupula prior to Dix-Hallpike testing, there would be an enhanced likelihood of evoking a positive response.

MATERIALS AND METHODS

Twenty-eight patients presenting to the Geisinger Otolaryngology Vestibular and Balance Center between March 2017 and August 2017 with symptoms and clinical test findings consistent with unilateral posterior canal BPPV were enrolled in the study. All patients were found to have unilateral, posterior canal, canalithiasis type BPPV with up beating, geo-torsional nystagmus lasting <30 seconds during testing. The study protocol was approved by the Geisinger IRB committee. A full medical and vestibular history was taken from each patient. All patients were examined and data were collected by a single clinician, Jeffrey Walter, DPT, NCS.

Each patient in the study underwent 3 rounds of testing with the standard Dix-Hallpike (S-DH) maneuver. The head was turned 45 degrees towards the affected side. Patients were reclined on their back with the head extended to 20 degrees below earth-horizontal. They also underwent 3 rounds of the loaded Dix-Hallpike (L-DH) maneuver (head rotated 45 degrees to the affected side and flexed forward 30 degrees in the plane of the posterior canal for 30 seconds) as shown in Figure 1. Subsequently, the patients were reclined to their back with head extended to 20 degrees (same as the S-DH maneuver). The patients were placed from the upright position to the dependent position within 2 seconds in all study trials. Our protocol included one minute between each trial to allow the otoconia to settle to the most dependent portion of the canal and for symptoms to resolve.

The patients were placed into one of two groups in an alternating order based on presentation to the Balance Center (initial subject assigned to group 1, 2nd subject to group 2, 3rd subject to group 1, etc.). Fourteen patients in group 1 underwent S-DH testing x 3 trials followed by L-DH testing x 3 trials. Fourteen patients in group 2 underwent L-DH testing x 3 trials followed by S-DH testing x 3 trials.

Eye movements during each trial were video recorded with the use of Micromedical monocular "Real Eyes" infrared goggles. To minimize saccadic eye movements during the testing, patients were cued to attempt to maintain their gaze on a stationary visual target, placed in primary gaze, in all study trials.

MAIN POINTS

- The Loaded Dix-Hallpike produces longer duration and more intense symptoms for the patient.
- The Loaded Dix-Hallpike results in fewer false negative trials when compared to the Standard Dix-Hallpike.
- Increased duration and fewer false negatives will allow clinicians to more accurately diagnose BPPV. This will result in more timely treatment and fewer unnecessary tests for the patients.

Study exclusion criteria included the use of vestibular sedatives within 24 hours of the appointment, history of emesis production in tandem with symptom provocation, inability to tolerate full testing protocol, refusal to participate in the study protocol, severe spinal mobility limitations, presence of spontaneous, gaze-evoked or static positional nystagmus, and patients with variant forms of BPPV (multi-canal BPPV, horizontal canal involvement, bilateral BPPV, or cupulolithiasis). Subjects did not complete positioning tests during their clinic encounter prior to the initiation of the study protocol. The patients rated the perceived severity of the symptoms evoked with each test using a Likert scale ("0" no dizziness to "10" extreme dizziness) immediately following each testing trial. Latency was measured from the time the patient was placed supine with head extended 20 degrees until nystagmus was noted. Duration was measured from the onset of nystagmus until complete cessation.

All video recordings were jointly analyzed by two reviewers (Luke Andera MD and Jeff Walter PT, DPT, NCS). Dr. Andera has experience with vestibular disorders as a resident ENT physician and Dr. Walter as an experienced vestibular physical therapist within the Geisinger Otolaryngology Vestibular and Balance Center. Videos were randomly selected by a study assistant. The study reviewers were blinded to the type of the positioning test being employed in each video review. Each test video was reviewed until a consensus was reached regarding the latency and the duration of nystagmus between the investigators.

Statistical Analysis

Chi-squared test was used to test nystagmus observed rate. A paired t-test was performed on the data to compare the results of the S-DH and the L-DH for variables of duration of nystagmus, latency, and patient reported symptom severity score. For all analyses, a $p < 0.05$ was considered statistically significant. Statistical analysis was performed using the SAS system (version 9.4, SAS Inst. Cary, NC).

RESULTS

The participants included in this study were 16 females and 12 males with a mean age of 59.64 years (SD 12.73).

Nystagmus was observed in 80 of the 84 L-DH trials vs only 69 of the 84 trials with the S-DH. This resulted in a 17.86% (15/84) "false" negative rate with the S-DH testing versus only 4.76% (4/84) in the L-DH testing ($p = 0.01$). Two of the 28 patients did not have nystagmus during any of the three S-DH trials. None of the 28 patients had more than one "false"-negative trial with the L-DH testing.

The average duration of nystagmus with the S-DH testing was 8.10 sec (range 0-24 sec) (95% CI, 6.85-9.35) and for the L-DH testing, it was 12.68 seconds (range 0-28 sec) (95% CI, 11.33-14.03). The 4.58 seconds difference in duration of the nystagmus between the testing maneuvers was significant ($p < 0.0001$) (Table 1).

The mean symptom severity rating for the S-DH testing was 3.82 (range 0-10) (95% CI, 3.19-4.45) as compared to 5.58 (range 0-10) (95% CI, 4.96-6.20) for the L-DH testing (difference of 1.76, $p < 0.001$). Multiple patients reported severity scores of 1 or greater when no nystagmus was observed. When patients reported symptoms in the absence of nystagmus, the severity score was never higher than in trials where nystagmus was evoked (Table 1).

Table 1. Duration of observed nystagmus, patient symptom severity scores, and latency of nystagmus with each testing maneuver

Test Type	Mean	Standard Deviation	Minimum	Maximum
Duration of Nystagmus				
Standard Dix - Hallpike	8.10 sec	4.55 sec	0	24
Loaded Dix - Hallpike	12.68 sec	5.12 sec	0	28
Patient Severity Score				
Standard Dix - Hallpike	3.82	2.49	0	10
Loaded Dix - Hallpike	5.58	2.46	0	10
Latency of Nystagmus				
Standard Dix - Hallpike	2.63	1.67	0	8
Loaded Dix - Hallpike	3.64	3.14	0	25

Caption - Duration of evoked nystagmus was significantly longer with the L-DH testing when compared to the S-DH testing ($p < 0.0001$). Loaded Dix-Hallpike maneuvers produced significantly stronger subjective symptoms in patients when compared to the standard Dix-Hallpike ($p < 0.001$). The latency of the L-DH testing was 1.09 seconds longer; however, this was not statistically significant ($p = 0.1783$).

The average latency for S-DH testing was 2.46 seconds (range 0-8 sec) (95% CI, 2.06-2.86) with a standard deviation of 1.67 seconds. The average latency for L-DH testing was 3.55 seconds (range 0-25 sec) (95% CI, 2.61-4.49) with a standard deviation of 4.24 seconds. The latency difference of 1.09 seconds between the two testing methods was not statistically significant ($p = 0.1783$) (Table 1).

The concept of fatigue of BPPV with repeated testing was measured with both maneuvers. Patients who had nystagmus in the first and third trial with each method were included. Twenty of the twenty-eight patients had nystagmus in the first and third trial with the S-DH. Twenty-four of the twenty-eight patients had nystagmus with the L-DH in the first and third trials. The difference between the trials was calculated by subtracting the duration of the third trial from the duration of the first trial. The average duration difference for the S-DH was 3.95 seconds (SD 2.58). The average duration difference for the L-DH was 2.83 seconds (SD 3.23). Although, the S-DH and L-DH maneuvers had reduced duration with repeated testing, the differences were not statistically significant ($p = 0.3813$).

Although responsiveness to canalith repositioning maneuvers was not the focus of this investigation, all patients in this study reported resolution of positional vertigo following the initial treatment session. All patients in this study appeared to have a successful response to treatment despite undergoing six positioning tests at their initial encounter. This suggests that repeated testing does not appear to limit efficacy of subsequent treatment maneuvers. No patients experienced any adverse outcomes as a result of participation in this study.

DISCUSSION

The findings from this study suggest that the use of the L-DH appears to improve the likelihood of evoking a response, increase the duration of nystagmus, and worsen the severity of the symptoms related to testing when compared to S-DH testing. An explanation of our results likely relates to several anatomical considerations. The base of the posterior canal has been shown to be relatively flat compared to the rest of the canal using 3D modeling of temporal

bone^[11]. The cupula resides in the ampullated end of the canal. The cupula of the posterior canal sits at an approximate angle of 30 degrees off the vertical plane. The position approximates the angle of the common crus of the anterior and posterior canals. The location of the displaced otoconia in the posterior canal determines how far it will migrate during positioning testing using the Dix-Hallpike. If the otoconia is located at the posterior aspect of the relatively flat base of the posterior canal, the otoconia does not have as large a distance to traverse through the canal as it would if the otoconia were located closer to the cupula. When a patient is upright, the otoconia could be resting anywhere along the base of the canal. Flexing the head forward 30 degrees (L-DH) prior to performing Dix-Hallpike testing facilitates otoconial migration towards the ampullated portion of the posterior canal adjacent to the cupula. The increased duration of nystagmus found in the L-DH is likely the result of the otoconia moving a greater distance through the canal compared to in the S-DH. The debris would also migrate near its maximal velocity for a longer duration of time. These factors would potentially account for the longer duration of nystagmus, increased perceived severity of symptoms, and improved sensitivity demonstrated with the L-DH testing in this study (Figure 2).

Improving test parameters with BPPV-related testing will enhance diagnostic efficiency. When performing positioning tests, patients often generate saccadic eye movements and often close their eyes when they begin to experience symptoms. This contributes to the difficulty in identifying the presence of nystagmus, particularly for a novice clinician. The examiner may be more likely to correctly diagnose BPPV with L-DH testing given that it likely increases the duration of evoked nystagmus. Earlier diagnosis will lead to quicker treatment resulting in improved quality of life for the patients and a reduction in the use of unnecessary and costly testing.

The findings of this study support the value of repeated positioning tests. Evren et al.^[7] found similar results when testing 207 patients with BPPV. They found that 135 patients showed nystagmus with initial Dix Hallpike and an additional 28 out of 68 were positive with a second Dix-Hallpike. These findings support the use of repeated testing when examining patients for BPPV.

Increased symptom severity scores with L-DH testing likely relates to increased duration of nystagmus. Our findings support the concept of “subjective” BPPV. There were many instances during our testing protocol where patients with no nystagmus gave severity scores of greater than zero. This suggests that patients with BPPV may experience symptoms from migrating otoconia in the absence of nystagmus. Another possibility is that patients had a “conditioned” response to positioning tests based on prior experience. Patient severity score did not directly coincide with the degree of nystagmus. Some patients with very intense nystagmus lasting a long duration consistently gave lower severity scores than other patients with a brief and light nystagmus. In all likelihood, many factors contribute to a patient’s sensitivity to BPPV-related symptoms, including age, proclivity towards motion sickness, and anxiety which were not investigated formally in this study.

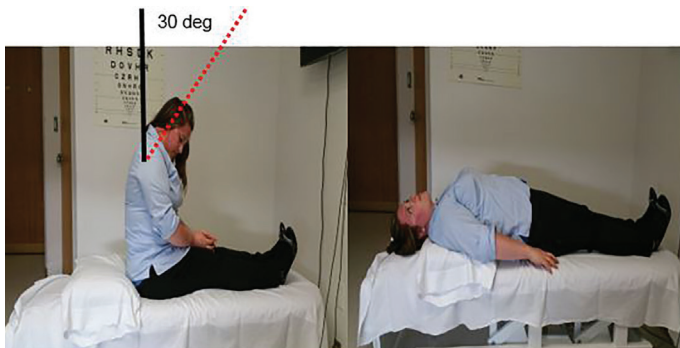


Figure 1. “Loaded” Dix-Hallpike (L-DH), head is flexed to 30 degrees in the plane of the right posterior canal and maintained for 30 seconds prior to placing the subject supine.

We did not find any statistically significant difference in the latency between the two testing methods. The latency was variable between both each individual trial in each patient and between different patients. We found that a significant number of trials did not have any measurable latency. The nystagmus started immediately when the head was placed dependent for testing. Latency never exceeded 25 seconds in any testing trial. This would suggest that maintaining the dependent position of the Dix-Hallpike for 30 seconds is sufficient to conclude a “negative” test result.

With repeated testing, there was no statistically significant fatigue in the duration of the nystagmus with either maneuver. When patients return to an upright position with untreated BPPV, the otoconia migrate back toward the cupula. This causes inhibition from the posterior canal which induces the illusion in the patient that he/she is falling forward. Patients frequently react to the illusion by extending their head and torso back in the plane of the involved posterior canal. If the clinician does not get the patient to a fully upright position (long sitting) and does not wait a sufficient amount of time for the otoconia to settle prior to performing another Dix-Hallpike maneuver, the otoconia will likely be positioned further away from the cupula than it was with the initial testing. Repeated testing would likely demonstrate a diminished response since the otoconia will not have as large of a distance to migrate through the canal. In our study, we were diligent about ensuring that the patient returned to a fully erect position and waited one minute between trials. This likely explains why there was no significant fatigue demonstrated in our study. The two subjects in our study who failed to demonstrate nystagmus with all S-DH testing trials were tested with L-DH testing prior to S-DH

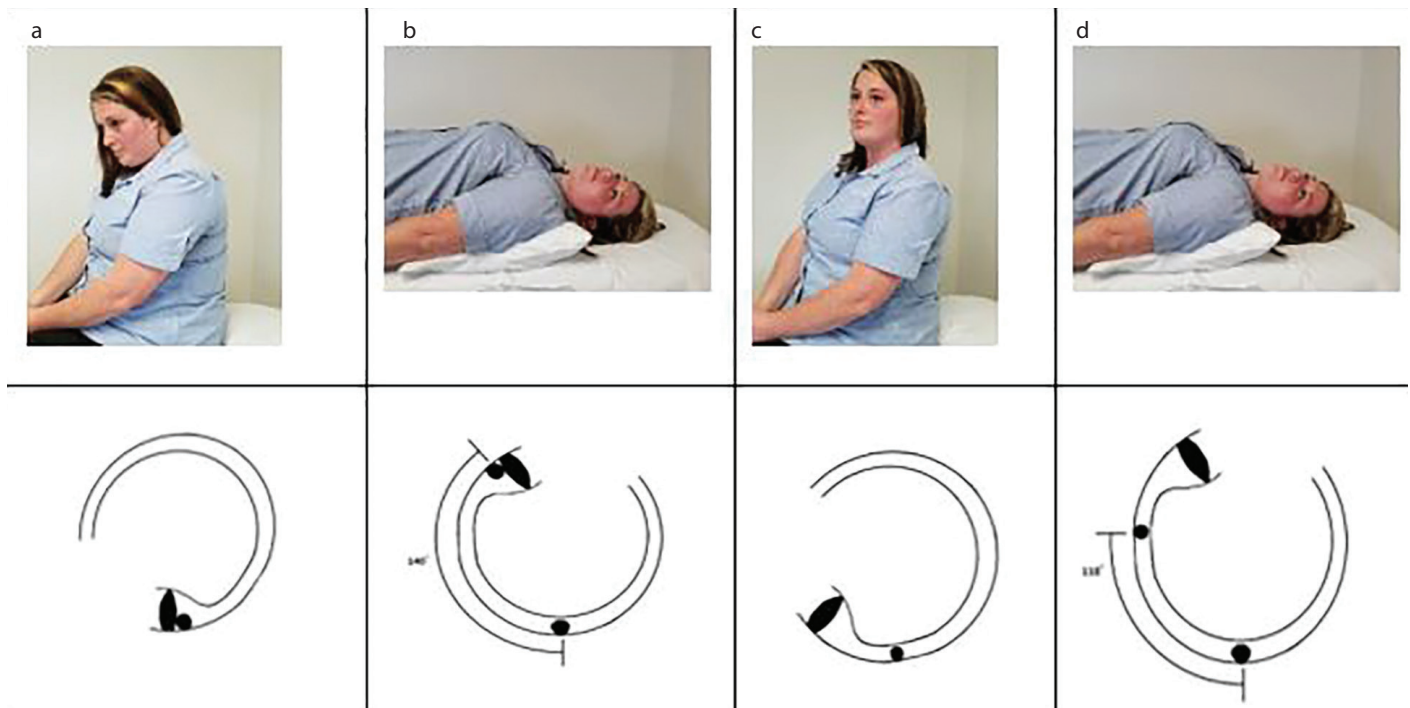


Figure 2. a-d. a) Shows the patient in loaded Dix-Hallpike. Posterior canal drawn below shows otoconia adjacent to the cupula, b) shows the patient supine with neck extended 20 degrees. The canal illustration below shows the distance the otoconia travels through the canal to most dependent position, approximately 140 degrees, c) shows the patient in starting position for standard Dix-Hallpike. Canal illustration below shows otoconia in the base of the canal in the most dependent position, d) shows the patient supine with neck extended 20 degrees. The canal illustration below shows the distance the otoconia travels through the canal to the most dependent position, approximately 110 degrees. The increased distance the otoconia travels within the canal between picture B and picture D, i.e., 30 degrees is what we believe results in the increased duration of nystagmus and enhanced sensitivity of the loaded Dix-Hallpike.

testing. This may be attributable to “fatigue” with repeated testing; however, we had no instances of negative repeated L-DH following S-DH testing. Therefore, fatigue would seem less likely to be responsible for this finding.

One of the limitations of our study was that only patients willing or able to undergo multiple rounds of testing were included. We feel this may have biased our study population towards patients with mild to moderate BPPV, which implies that our results are possibly more valuable since diagnosis of BPPV in this patient group may be more challenging. Patients who report a history of severe symptoms or nausea/vomiting with changes in position may be more likely to find L-DH testing intolerable. Clinicians should use judgment and weigh the risks and benefits when choosing which positioning test to perform in these patients.

Another limitation of this study is that we did not measure the nystagmus velocity. Measurement of torsional nystagmus currently relies on use of scleral coils which is not practical in a large-scale clinical study. Because of the increased sensitivity and longer duration of nystagmus with L-DH testing during this study and in daily practice, all patients with suspected BPPV at our institution are now routinely tested using this method.

Further randomized control studies are needed to support the results of increased sensitivity and increased duration of nystagmus with L-DH testing in patients with posterior canal BPPV. Suggestions for future studies include utilizing a mechanical chair to eliminate testing variability during positioning tests. Improved identification of BPPV will likely lead to prompt treatment, less unnecessary imaging studies, decreased office visits, reduced falls, and improved quality of life for patients.

CONCLUSION

Optimizing tests to identify BPPV is important since it is a very common condition, which is amenable to treatment. This study demonstrated that L-DH appears to improve test sensitivity, increase the duration of nystagmus, and worsen the severity of the symptoms related to testing when compared to S-DH testing. Performing the L-DH in patients with positional vertigo may enhance a clinician's ability to identify BPPV.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Geisinger Medical Center.

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – J.W., L.A.; Design – J.W., L.A.; Supervision – W.J.A., J.S.G.; Resource – J.W.; Materials – J.W.; Data Collection and/or Processing – J.W., L.A.; Analysis and/or Interpretation – H.S., J.W., L.A.; Literature Search – L.A.; Writing – L.A., J.W.; Critical Reviews – W.J.A., J.S.G.

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Conflict of Interest: The authors have no conflict of interest to declare.

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