Original Article

Dizziness Handicap Inventory Scores in Aiding the Diagnosis between Horizontal and Posterior Canal Benign Paroxysmal Positional Vertigo

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Objective: To identify the Dizziness Handicap Inventory [DHI] scores and items that can be differentiated in benign paroxysmal positional vertigo [BPPV] patients between posterior canal BPPV [PCB] and horizontal canal BPPV [HCB].

Materials and Methods: A prospective cross-sectional study, the study subjects were patients presented at the otolaryngological clinic at HRH Princess Maha Chakri Sirindhorn Medical Center, Srinakharinwirot University, Thailand. The setting was a tertiary otolaryngology practice. The subjects were patients diagnosed with PCB or HCB using the Dix-Hallpike test and the supine roll test. All the patients completed DHI forms at their first visit prior to consultation and at the last visit. All cases were treated with proper maneuver and followed-up until satisfactory clinical improvements and absence of positional induced nystagmus.

Results: Sixty-four patients had PCB, 50 had HCB during the study period between April 2015 and March 2017. The average DHI scores for PCB and HCB were 38.91±22.21 and 48.12±19.55 (*p*-value 0.022), respectively. The *p*-values of the differences in the average functional items, emotional items, and physical items between both groups were 0.028, 0.061, and 0.026, respectively. Significant difference in the items with *p*-value <0.01 were item 7 (function, difficulty reading) and 23 (emotion, depression). Significant difference with *p*-value <0.001 was the combination of item 7 and 23.

Conclusion: The DHI scores of BPPV were higher for HCB than PCB. Moreover, the patients with BPPV who had the positive values of items 7 and 23 may provide physicians with clue to look for HCB.

Keywords: Dizziness handicap inventory, Posterior canal, Horizontal canal, Benign paroxysmal positional vertigo

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Vertigo, especially benign paroxysmal positional vertigo [BPPV], is one of the most common health problems encountered in otolaryngological, emergency, and neurological clinics. Over the past two decades, accumulated evidence and clinical knowledge of BPPV has disclosed a variety of diseases based mainly on pathology in each semicircular canal. There are many cases in the literature that explain the details of the disease and report on the clinical features of the two most common types. These are known as posterior canal BPPV [PCB] and horizontal canal BPPV [HCB]. PCB is diagnosed by the presence of rotary nystagmus after performing the Dix-Hallpike test [DH] and is resolved by the Canalith repositioning procedure [CRP]. Contrarily, HCB is diagnosed by the presence of a horizontal nystagmus after performing the supine roll test (the Pagnini-McClure test) and can be resolved using the Lempert maneuver. The symptoms of both are very similar. The selection of improper test and treatment may aggravate vertigo and disturb pathology[1], which may be lead to the diagnosis of wrong canal. However, recent studies describing the clinical history differences between both types of BPPV are rare. The present study aimed to explore the clinical score differences between PCB and HCB using a popular and reliable questionnaire known as the Dizziness Handicap Inventory [DHI][2], which is a self-perceived handicap scoring of the effects of vestibular disorders.

Materials and Methods

The study design was a prospective data collection from the otolaryngological clinic at the HRH Princess Maha Chakri Sirindhorn Medical Center, Srinakharinwirot University, Thailand. The setting was a tertiary otolaryngology clinic, between April 1, 2015 and March 31, 2017. The present study

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was approved by the University's Ethical Review Committee.

The author was selected all the cases (n = 114) who were diagnosed with BPPV in accordance with the American Academy of Otolaryngology-Head and Neck Surgery [AAOO] clinical practice guidelines [CPG] (2008) in the present study. The classical appearances of all diagnostic maneuvers inducing nystagmus were confirmed using Frenzel goggles or video nystagmography. The inclusion criteria were patients presented with an episode of positional vertigo positively diagnosed as PCB (n = 64) or HCB (n = 50), had completed the DHI questionnaires at the first visit, and had symptoms that were successfully resolved with specific canal maneuvers. Exclusion criteria were patients with multiple canal BPPVs, anterior canal BPPVs, a history of other peripheral vertigo, a history of treatment with maneuvers, took vertigo control drugs the previous day, and a history of active central nervous system diseases. The Thai language DHI was translated from the original English and validated by the author and colleagues from the inter-faculty of Srinakharinwirot University. The DHI has 25 items that are separated into 3 groups: functional (9 items), emotional (9 items), and physical (7 items). Each question provides responses: yes (4 points), sometime (2 points), and no (0 point). The internal consistency reliability (Cronbach's alpha coefficients) of the DHI questionnaires: 0.835 for functional, 0.867 for emotional, 0.755 for physical, and 0.925 for total scores.

Clinical data collection

The chief complaints and symptoms were obtained from the patients included auditory symptoms, first-time dizzy spells, frequency, related position, duration, onset in regard to clinic visit, previous episodes of dizziness, history of head injury, concurrent medical problems, completion of the DHI form's 25 items (the DHI questionnaire translated into and validated in the Thai language), and the score on the visual analog scale. Vestibular physical examination included the characteristics of the nystagmus, results of the head impulse and head shaking tests, Romberg and the revised sharpened Romberg tests, and positional testing using Frenzel goggles or Videonystagmography (Otometrics, Taastrup, Denmark). Diagnostic maneuver criteria were based on clinical practice guidelines from 2008 (AAOO). All cases were treated with specific maneuver and were followed-up until satisfactory clinical improvements and absence of positional induced nystagmus were noted.

Statistical analysis

Descriptive analysis was presented as mean ± SD and frequency to describe the demographic data of the patients with HCB and PCB. To compare continuous variables among BPPV groups (HCB and PCB) used independent t-test as well as paired t-test for normal distribution; whereas Mann-Whitney test and Wilcoxon matched pairs signed ranks test for non-normal distribution. The categorical variables were analyzed using Chi-squared test. To compare the cumulative resolution after treatment distributions of BPPV groups was used Log-rank test. Quantifying the accuracy of a diagnosis HCB were reported accuracy parameters such as sensitivity and specificity. The *p*-values less than 0.05 were considered as statistically significant. Effect sizes were calculated using Cohen's d index. Effect sizes of 0.2 were considered small, while effect sizes of 0.5 and 0.8 were considered medium and large, respectively. All the statistical analyses were performed using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA).

Results

The author assessed 114 cases of BPPV. Diagnoses were based on the AAOO CPG in 64 cases of PCB and 50 cases of HCB. The HCB group was composed of 47 geotropic cases and 3 ageotropic cases. The demographic data were presented in Table 1. In the present study, there was no statistical difference between the two groups as regards to age, gender, side of lesion, and onset. The patients' average age was 52.64 years and the male to female gender ratio was 1:2.8. The diagnostic ratio by side of ear of left: right was 1:1.04, and the average onset was 12.31 days. In Table 2, the differences in the total DHI and item scores between the two groups revealed that patients with HCB had higher total DHI scores than those with PCB

Table 1. Demographic data of the patients with HCB and PCB

Demographic data	HCB (n = 50)	PCB (n = 64)	*p*-value*
No. of sex (male:female)	12:38	18:46	0.620
No. of side (left:right)	26:24	32:32	0.832
Age (year), mean ± SD	53.80±14.43	51.73±15.91	0.475
Onset (day), median (min-max)	7.00 (1.00 to 40.00)	7.00 (1.00 to 365.00)	0.375

HCB = horizontal canal benign paroxysmal positional vertigo; PCB = posterior canal benign paroxysmal positional vertigo

* Independent t-test was used for age, Mann-Whitney test for onset and the Chi-square for categorical variables

(48.12±19.55 versus 38.91±22.21, *p*-value 0.022). The scores for functional, emotional, and physical impacts of HCB were higher than those of PCB: functional (19.32±8.34 versus 15.66±9.03, *p*-value 0.028); emotional (13.36±8.00 versus 10.41±8.44, *p*-value 0.061); and physical (15.44±5.48 versus 12.84±6.80, p-value 0.026). The differences between HCB and PCB regarding total DHI, function, and physical scores were statically significant. The individual 25 item scores revealed that HCB was higher than PCB for every item. For both groups of BPPV, the greatest statistically significant scores were item 7 and 23, *p*-value 0.007 each. Their Cohen's d values were 0.5236 and 0.5129, respectively. The effect sizes of items 7 and 23 were medium values. Item 7 exhibited a sensitivity of 86.00% and a specificity of 42.12%, while item 23 had a sensitivity of 66.00% and a specificity of 56.25% (shown in Table 3). The combined scores of items 7 and 23 had a sensitivity of 96.00% and a specificity of 28.13%.

All the PCB cases (64) were treated with the CRP and followed-up until symptoms improved and negative result of repeated DH test (45 cases improved 1 hour after CRP, 6 cases in 1 day, 9 cases in 3 days, and 4 cases in 7 days). The median time from diagnosis to application of the select maneuver up to the resolution of vertigo was 1 hour (Table 4). All the HCB cases (50) were controlled with the Lempert maneuver and followed-up in the same manner (37 cases improved 1 hour after the Lempert maneuver, 1 case in 1 day, 6 cases in 3 days, 3 cases in 7 days, and 2 cases in 14 days). The median time from diagnosis and performing

Table 2. Average HCB and PCB scores in each item between HCB and PCB group

Items	HCB (n = 50), mean ± SD	PCB (n = 64), mean ± SD	95% CI	*p*-value*	Cohen's d
1	2.40±1.21	2.13±1.42	-0.224 to 0.774	0.277	0.2083
2	2.24±1.49	2.16±1.48	-0.472 to 0.640	0.766	0.0563
3	2.32±1.42	1.88±1.37	-0.766 to 0.967	0.094	0.3184
4	1.08±1.47	0.78±1.36	-0.229 to 0.826	0.264	0.2109
5	3.20±0.99	2.81±1.37	-0.067 to 0.842	0.082	0.3247
6	1.84±1.45	1.50±1.47	-0.206 to 0.886	0.220	0.2331
7	2.48±1.37	1.69±1.64	0.220 to 1.365	0.007	0.5236
8	2.12±1.53	1.50±1.47	0.060 to 1.180	0.030	0.4128
9	2.08±1.45	1.78±1.52	-0.258 to 0.856	0.290	0.2011
10	1.08±1.47	0.78±1.31	-0.219 to 0.816	0.255	0.2143
11	2.92±1.23	2.41±1.43	0.010 to 1.017	0.046	0.3851
12	2.20±1.63	1.91±1.57	-0.303 to 0.891	0.332	0.1836
13	2.96±1.35	2.63±1.33	-0.166 to 0.836	0.188	0.2498
14	2.28±1.28	1.84±1.44	-0.076 to 0.949	0.095	0.3205
15	0.72±1.33	0.31±0.81	-0.017 to 0.832	0.060	0.3705
16	1.44±1.57	1.09±1.42	-0.210 to 0.902	0.220	0.2314
17	1.04±1.09	1.03±1.23	-0.430 to 0.447	0.969	0.0075
18	1.88±1.30	1.41±1.50	-0.056 to 1.003	0.074	0.3373
19	1.36±1.59	1.28±1.65	-0.528 to 0.685	0.797	0.0486
20	1.68±1.63	1.38±1.59	-0.230 to 0.910	0.317	0.1892
21	0.88±1.29	0.75±1.36	-0.366 to 0.626	0.605	0.0983
22	1.24±1.45	0.91±1.38	-0.193 to 0.861	0.212	0.2360
23	1.56±1.30	0.94±1.13	0.173 to 1.072	0.007	0.5129
24	2.20±1.47	1.65±1.41	0.007 to 1.080	0.047	0.3780
25	2.92±1.16	2.38±1.46	0.044 to 1.046	0.033	0.4130
Functional	19.32±8.34	15.66±9.03	0.397 to 6.930	0.028	0.4215
Emotional	15.66±9.03	10.41±8.44	-0.133 to 6.040	0.061	0.3591
Physical	15.44±5.48	12.84±6.80	0.317 to 4.875	0.026	0.4205
Total DHI	48.12±19.55	38.91±22.21	1.326 to 17.101	0.022	0.4403
Item 7 + 23	4.04±2.16	2.63±2.25	0.590 to 2.241	0.001	0.6420

HCB = horizontal canal benign paroxysmal positional vertigo; PCB = posterior canal benign paroxysmal positional vertigo; DHI = dizziness handicap inventory

* *p*-value was compared between HCB and PCB group by Independent t-test

Table 3. Sensitivity and specificity of item 7, item 23, and item 7 + 23 in diagnosis HCB

Parameters	Item 7, difficulty reading		Item 23, depressed		Item 7 + 23	
	Values	95% CI	Values	95%CI	Values	95% CI
Sensitivity	86.00	78.21 to 91.76	66.00	56.31 to 74.42	96.00	90.06 to 98.56
Specificity	42.19	32.92 to 51.71	56.25	46.54 to 65.42	28.13	20.06 to 37.26
Accuracy	0.614	0.518 to 0.704	0.605	0.509 to 0.696	0.579	0.483 to 0.671
PPV	0.538	0.439 to 0.629	0.541	0.448 to 0.637	0.511	0.413 to 0.604
NPV	0.794	0.713 to 0.868	0.679	0.581 to 0.760	0.900	0.834 to 0.951
LR+	1.488	0.893 to 2.280	1.509	0.893 to 2.280	1.336	0.756 to 2.077
LR-	3.013	2.162 to 3.911	1.654	1.034 to 2.480	7.033	6.089 to 7.838
OR	4.483	3.542 to 5.433	2.496	1.698 to 3.350	9.391	8.776 to 9.750
RR	2.611	1.851 to 3.539	1.687	1.034 to 2.480	5.106	4.135 to 6.036

HCB = horizontal canal benign paroxysmal positional vertigo; PPV = positive predicative value; NPV = negative predicative value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; OR = odds ratio; RR = risk ratio

Table 4. Results of treatment with maneuvers (resolution time after maneuvers)

BPPV	1 hour	1 day	3 days	7 days	14 days	Resolution time (hour)		*p*-value*
						Mean ± SD	Median (min-max)	
HCB (%)	74.00	2.00	12.00	8.00	4.00	36.74±78.62	1.00 (1.00 to 336.00)	0.939
PCB (%)	70.31	9.38	14.06	6.25	0.00	23.58±44.98	1.00 (1.00 to 168.00)	

BPPV = benign paroxysmal positional vertigo; HCB = horizontal canal BPPV; PCB = posterior canal BPPV

* *p*-value was compared between HCB and PCB group by Mann-Whitney test

Table 5. Average total DHI scores before and after treatment

BPPV	DHI scores				*p*-value*
	Before		After		
	Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)	
HCB (n = 50)	48.12±19.55	44.00 (14.00 to 96.00)	8.04±7.47	5.00 (0 to 28.00)	<0.001
PCB (n = 64)	38.91±22.21	37.00 (4.00 to 94.00)	4.22±6.15	0.00 (0 to 20.00)	<0.001

BPPV = benign paroxysmal positional vertigo; HCB = horizontal canal BPPV; PCB = posterior canal BPPV; DHI = dizziness handicap inventory

* *p*-value was compared among HCB and PCB group by Wilcoxon matched pairs signed ranks test

the Lampert maneuver up to the resolution of vertigo was 1 hour (Table 4, Figure 1). The average total DHI scores at the time of resolution after performing maneuver were 8.04±7.47 in HCB group and 4.22±6.15 in PCB group (Table 5).

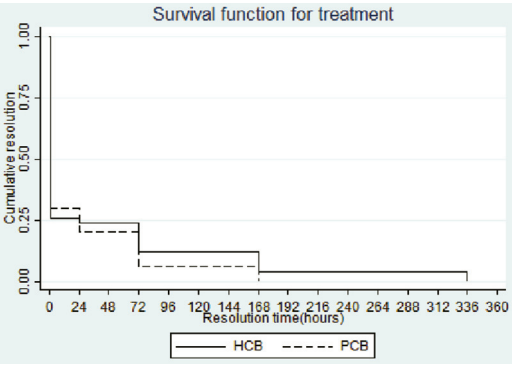


Figure 1. Cumulative resolution after treatment (maneuvers).

Discussion

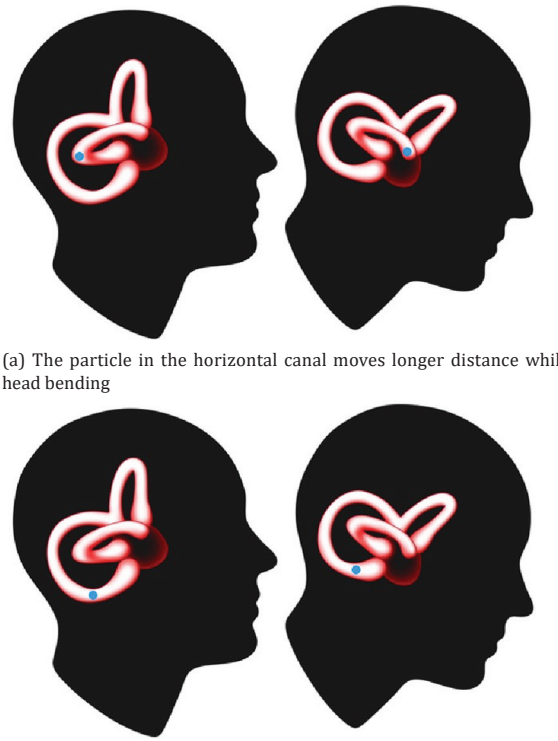
The DHI is the most widely used tool to assess self-perceived handicap effects imposed by a vestibular system disorder. This scoring system strongly correlates with other vestibular function tests such as posturography, the dynamic gait index, and the head impulse test[3]. The preliminary study data demonstrated DHI scores with a high correlation with the visual analog scale, and the Pearson product moment correlation was 0.820. Whitney et al[4] reported that the DHI has some specific characteristics concomitant with BPPV and found that DHI scores were useful for differentiating BPPV from non-BPPV. The mean DHI scores (42.95±21.49) in the present study closely approximated Whitney et al's findings (41.6±22.8)[4] and Chen et al's findings[5].

With recent knowledge, BPPV is classified by the location of displaced otolith particles in the semicircular canals[6]. The most common types of BPPV are posterior and horizontal canal BPPV, which are differentiated notionally by history[7], the plane of the head movement that triggers the symptoms, the side of the head rotation in the supine position that triggers more vertigo, and the lasting duration. The physical examination with specific canal tests induce nystagmus can be used to definitively differentiate diagnoses with greater accuracy than history[8]. However, the limitations of these maneuvers are that they can lead to cervical injuries, spinal cord injuries in obesity and anxiety patient with the positional-induced vertigo[4]. Sometimes, these maneuvers cannot provoke nystagmus ingenuously. According to Inagaki et al[9], this has been demonstrated by Epley's canalithjam hypothesis. Further, in multiple canal involvement, unclassified pattern nystagmus can make diagnosis difficult in differentiating the canals[10].

In the present study, the author evaluated and compared the DHI scores between HCB and PCB. First, the average items and total scores of HCB were higher than those of PCB. Second, the differences in total scores, physical item scores, and functional item scores were significant. Third, regarding the level of items, 2 items showed significant differences, items 7 (difficulty reading) and 23 (depressed) had significant differences. The combination value of items 7 and 23 were also significant.

The average age of the patients in the present study was 52.6 years (±15.2). The HCB group was an average of 53.8 years of age and the PCB group was an average of 51.7 years of age. Regarding patient gender, there was higher prevalence of females than males (2.8:1). The affected side was nearly equal for both ears (left side to right side, 1.03:1). The onset of disease before diagnosis was higher in the PCB (14.10±16.74) than the HCB populations (10.02±9.21). However, the aforementioned differences in the demographic data were not statistically significant.

The difficulty reading effect is influenced by a visual-vestibular integration mismatch that results from the function of the semicircular canal cupula to stabilize the gaze as a vestibulo-ocular reflex. This reflex holds images on the retina during transient head movement. Lying down can induce horizontal nystagmus in HCB[11,12]. Therefore in case of HCB, this effect produces a fine nystagmus (pseudo-spontaneous nystagmus)[13] while moving the head in a pitch plane (bow and lean)[14]. Bending the head to read in a pitch



(a) The particle in the horizontal canal moves longer distance while head bending

(b) The particle in the posterior canal moves shorter distance while head bending

Figure 2. Demonstration that (a) the particle in the horizontal canal can move for longer distance than those in (b) the posterior canal while moving head in the pitch plane.

plane can produce more movement of the particle in the horizontal canal compared to the posterior canal (Figure 2). The greater movement of the particle aggravates and results in increased vibration of the cupula hair cells.

The reason for significant difference in item 23 (depressed) may be related to the high scores of several of the physical items of HCB such as 25 (bending the head), 8 (strenuous activity), 11 (quick head movement), 13 (rolling in the bed), and 1 (looking up). This physical disturbance influences patients' emotions, conforming to a study by Probst et al[15] found that patients with vertigo symptoms who have anxiety were highly correlated with somatization.

In the present study, the differences in both items 7 and 23 between HCB and PCB were statistically significant. Therefore, in patients with BPPV symptoms, the presentation of high DHI scores together with positive values of 7 and 23 items may lead clinicians to the differential diagnosis of HCB as the more likely pathology. Therefore, supine roll test should be performed together with Dix-Hallpike test.

This may lead to the effective selection of the correct particle repositioning method.

Conclusion

Although the overall DHI scores for PCB and HCB were quite similar for cases of BPPV. However, the total DHI scores for HCB were significantly greater than those of PCB. Meanwhile, item 7 (difficulty reading) and item 23 (depressed) had the greatest significant differences in values between each type. Thus, this information may provide physicians to consider the diagnosis of HCB. Also, this suggests physicians to perform supine roll test in combination with Dix-Hallpike test in diagnosing BPPV.

What is already known on this topic?

According to their commendation of practice guideline in diagnosing BPPV[6], physicians should use Dix-Hallpike test for provoked nystagmus first, if the test exhibited horizontal or no nystagmus, the supine roll test should perform to assess horizontal canal BPPV.

What this study adds?

The results from this study suggested that patients who responded with high total DHI scores and positive value of item 7 and item 23 may provide physicians with clue to always look for horizontal canal BPPV.

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Potential conflicts of interest

The authors declare no conflict of interest.

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