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Correlations Between The Thai Version of Dizziness Handicap Inventory (DHI-T) and Vestibular Function Tests

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Abstract

Background: The Thai version of Dizziness Handicap Inventory (DHI-T) may be useful for primary care units to make decisions regarding the referral of patients with dizziness to balance specialists.

Objective: To evaluate the correlations between DHI-T scores and Cervical Vestibular Evoked Myogenic Potential (cVEMP) and caloric test results; and to compare DHI-T scores.

Methods: Subjects were 165 patients with dizziness: 144 patients in the experimental group showed an abnormal cVEMP test and/or caloric test results, 21 patients who had normal tests results were in a control group. The experimental group was divided into three subgroups: Ex-1 (abnormal cVEMP response only), Ex-2 (abnormal caloric response only), and Ex-3 (abnormal cVEMP and caloric response).

Results: The participants had a weak but statistically significant correlation between DHI-T scores and caloric test, and cVEMP test. Additionally, DHI-T score of the experimental group was significantly higher than the control group. The Ex-3 subgroup showed a higher DHI-T score than the other two subgroups, although it was statistically non-significant.

Conclusion: A higher DHI-T score is more likely to be associated with abnormal vestibular test results. Additionally, patients with dizziness who reported more than 25 points on their DHI-T scores were also more likely to have an abnormal caloric and/or cVEMP test results. Therefore, the DHI-T may be used to predict the vestibular test results of patients with dizziness and used as one of the referral criteria.

Keywords: Thai version of dizziness handicap inventory; Cervical vestibular evoked myogenic potential test; Bithermal caloric test

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Introduction

The diagnosis of vestibular disorders includes not only a neuro-otological examination, but also an audiovestibular evaluation. These examinations have to be conducted by a doctor or an audiologist, primarily in tertiary medical care. Some patients are referred for further examinations or consultations. They may be inconvenienced by travelling and paying additional referral expenses. However, screening of appropriate patients with dizziness is important. A self-perception questionnaire is one instrument used in the vestibular screening process.

The Dizziness Handicap Inventory (DHI) was developed by Jacobson and Newman in 1990 from case-history reports of patients with dizziness [1]. The final version consisted of 25 items separated into emotional (9 items), functional (9 items), and physical (7 items) subscales. The DHI has gained in popularity in both clinical and research practice and was translated into 18 languages worldwide, including the Thai version [2-6]. The Thai version of DHI (DHI-T) has good internal consistency. The Cronbach's alphas were 0.921, 0.821, 0.840 and 0.745 for the total score, functional, emotional, and physical subscales, respectively [6].

The correlations between DHI scores and caloric and/or cVEMP test results were evaluated by Jacobson and Calder [7]. They reported that the total DHI scores of patients with bilateral weakness (mean=49.71 pts.) were significantly higher than those of the control group (mean=30.27 pts.) and statistically significant (p=0.03). Patients in both unilateral and bilateral vestibular disorder groups produced higher self-perceived physical subscale scores on the DHI than the control group. Similarly, Jacobson and McCaslin DL and Jacobson GP reported that the total DHI scores and three subscales scores of patients with an uncompensated unilateral vestibular disorder were significantly different from those of patients with normal test results [8]. Accordingly, it was necessary to determine and analyze the correlation between the DHI scores and vestibular test abnormalities. If valid correlations were found, the DHI may be used in the initial screening of patients with dizziness. This supplementary information may help primary care units to make decisions regarding the referral of patients with dizziness to the appropriate specialists.

The purposes of this study were: (1) to analyze the correlations between the DHI-T scores (%) with the unilateral weakness (%) and the asymmetry ratio (%) results from the total participants, the experimental group, and the control group; (2) to compare and analyze the mean DHI-T scores for the experimental and the control groups, and; (3) to compare and analyze the mean DHI-T scores between the three subgroups and between each of the three subgroups and the control group.

Materials and Methods

Participants

The research study was conducted between June, 2016 and March, 2017 at Ramathibodi Hospital, Mahidol University. Patients with dizziness symptoms within the last 6 months, and between 18 to 65 years of age, were selected. Patients who had any external and/or middle ear problems, a moderately severe cervical spine disorders, a previous history of ear surgery, or severe visual impairment were excluded. Patients who could not complete the tests, or absent cVEMP response in either any ear, were also excluded.

A total of 165 patients with dizziness were divided into two main groups: the Experimental (Ex) and the control group. The experimental group was divided into 3 subgroups based on their vestibular test results. The patients in the Ex-1 subgroup had abnormal cVEMP but normal caloric test results (VMP+/CAL-), those in the Ex-2 subgroup had abnormal caloric but normal cVEMP test results (VMP-/CAL+), and those in the Ex-3 subgroup had both abnormal cVEMP and caloric test results (VMP+/CAL+). The control group consisted of patients with dizziness but who produced normal vestibular test results (Table 1).

This research study was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, Mahidol University. All of the patients signed informed consent forms prior to their participation.

Patient examinations

All patients underwent a complete neuro-otological examination at the first clinical consultation. The responses on the DHI-T items were completed either by themselves or during an interview before taking the vestibular function tests. Both the cVEMP and caloric tests were conducted on the same day.

Table 1: Descriptive statistics pertaining to the Experimental (3 subgroups) and control groups.

Groups	Male (n)	Female (n)	Age (Mean ± SD) (years)
Experimental	39	105	57.42 ± 9.93
- Ex-1	14	34	59.25 ± 7.66
- Ex-2	14	40	54.35 ± 11.89
- Ex-3	11	31	59.29 ± 8.59
Control	5	16	51.57 ± 11.06

cVEMP: The cVEMP test was conducted using a model ICS Chartr 200, GN Otometrics. All patients sat in an upright position. The ground electrode was placed over the center of their forehead. The active electrodes were placed over the middle third of the SCM muscle on each side. The reference electrodes were placed on both sternoclavical junctions. A short tone-burst at 500 Hz, 95 dBnHL was transmitted into the ear canal by means of an insert earphone. Patients were asked to turn their heads in the opposite direction from the tested ear.

Positive (P13) and Negative (N23) peaks were identified to determine the presence or absence of a cVEMP response. The Asymmetry Ratio (AR) of the amplitude of the (P13/N23) between the left and right ears were calculated using the following formula:

$$AR\ (\%) = 100 \times \frac{(\text{larger amplitude} - \text{smaller amplitude})}{(\text{larger amplitude} + \text{smaller amplitude})}$$

The AR equal to or higher than 35% was considered to be an abnormal cVEMP result [9].

Bithermal caloric test: The bithermal caloric test was conducted using an AirFx from Micromedical Technologies Inc. The patients wore goggles and were seated in a supine position on a chair with their heads elevated at about a 30 degree angle. For each ear, irrigation with air at 24°C and 48°Ccontinued for 60 seconds. Patients were asked to fixate on the target at 100 second after starting the irrigation and then close their eyes for visual recovery. The Unilateral Weakness (UW) was calculated based on the following formula:

$$UW\ (\%) = \frac{((LC+LW) - (RC+RW))}{((LC+LW+RC+RW))} \times 100$$

where LC, LW, RC, RW were the results of left ear cool, left ear warm, right ear cool, and right ear warm irrigation, respectively.

The UW level equal to or higher than 25% was identified as abnormal caloric result [10].

Statistical analysis

The Kolmogorov-Smirnov or Shapiro-Wilk method was used for distribution testing. The results of the cVEMP test, caloric test and DHI-T scores produced non-normal distributions. For this reason, nonparametric statistical tests were used to analyze the collected data. First, the Mann-Whitney test was used to determine the statistical significance of differences between the means of ranked DHI-T scores for the experimental and control groups, and between the means of ranked DHI-T scores for each of three subgroups and the control group. Second, the Kruskal-Wallis test was used to determine the statistical significance of the differences between the means of ranked DHI-T scores for the three subgroups of the experimental group. Third, Spearman rho correlation coefficients were computed between the ranked DHI-T scores with the ranked UW and the ranked ARof all participants and participants in the experimental and control groups.

Results

Table 2 contains the correlations between the DHI-T scores (%) with the unilateral weakness (%) and the asymmetry ratio (%) results from the total participants, the experimental group, and the control group. For total subjects, there were weak but statistically significant positive correlations between the DHI-T scores and the AR results (rho=0.18, $p<0.05$) and between the DHI-T scores and the UW results (rho=0.2, $p<0.05$). There were non-significant correlations for

Table 2: The Spearman rho correlation coefficients for the means of ranked DHI-T scores, the UW and AR results from the total subjects, the experimental and control groups.

Parameters	Means of ranked DHI-T scores	
	rho	p
Total subjects		
- AR	0.179*	0.022
- UW	0.200*	0.01
Experimental group		
- AR	0.082	0.327
- UW	0.095	0.255
Control group		
- AR	-0.241	0.293
- UW	0.037	0.874

*p< 0.05

Table 3: The Kruskal-Wallis test results for comparison of the mean of ranked DHI-T scores between the three subgroups of the experimental group.

Subgroup	Mean of ranked DHI-T score		
	%	χ^2	p
Ex-1	68.86	3.602	0.165
Ex-2	67.76		
Ex-3	82.75		

Table 4: The Mann-Whitney U test for comparison of the mean of ranked DHI-T scores between each of the three subgroups and the control group.

Group	Mean of ranked DHI-T score		
	%	Z	p
Ex-1	40.83	-3.654*	0
Control	21.67		
Ex-2	43.84	-3.726*	0
Control	22.98		
Ex-3	39.73	-4.734*	0
Control	16.55		

*p<0.05

the experimental and control groups.

The means of ranked DHI-T scores of the experimental group were significantly higher than those of the control group (89.39 *vs.* 39.19). Additionally, a comparison of the means of ranked DHI-T scores for the three subgroups of the experimental group showed that Ex-3 had a higher mean of ranked DHI-T scores than the other subgroups but were statistically non significant (Table 3).

The Mann-Whitney U test showed significant differences in the means of ranked DHI-T scores for each of the three subgroups when compared to that of the control group at p=0.000 (Table 4). The means of ranked DHI-T scores of each sub group were significantly higher than that of the control group.

Discussion

The results of the correlation analysis between DHI-T scores with UW and AR results of the total participants and experimental group seemed to be similar to those in the study of Yip and Strupp [11]. An explanation of these results may be because modulating factors such as compensation, sensory re-balancing, and patients' coping skills might affect the correlations between their DHI scores and

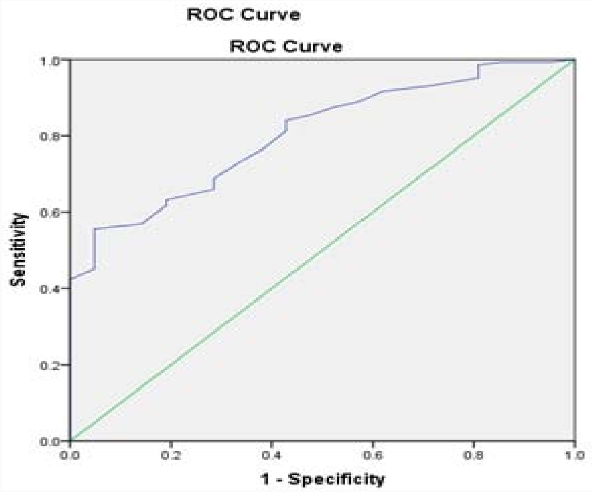

Figure 1: Receiver operating characteristic curve analysis of the DHI-T score to screen the abnormal vestibular function tests.
Note: Positive if greater than or equal to 25 point (sensitivity=0.84, specificity=0.57).

vestibular function test results. Additionally, the frequencies used in the vestibular system tests were between 0 Hz to 16 Hz, mostly in the range of 0.1 Hz to 10 Hz [12,13]. However, the frequencies of 0.5 Hz to 5 Hz represent movements in daily life [14]. Patients with abnormal caloric results were not aware of this deficiency during their natural movements in daily life because the caloric test responses to very low frequency head movements at 0.003 Hz, although this frequency does not correspond with natural movements in daily life [15,16]. Control of movement at low frequency can be compensated easier and earlier than other frequencies using other balance strategies such as information from the visual and proprioceptive systems. Thus, patients with abnormal caloric results presented the DHI scores not substantially different from normal group.

There was non-significant correlation for the control group which might be because this study did not include other vestibular function tests such as vHIT, posturography, rotational test, and ocular VEMP. There was a possibility that patient complaints were more on balance, gait and standing which occur as an abnormal vestibulospinal reflex function rather than eye movement for perception of visual image by VOR. This possibility is supported by three studies which reported on the correlation between the results of posturography and DHI scores [17-19]. Thus, patients with abnormal posturography results but having normal caloric test results may occur. Accordingly, the test results in the present study showed higher DHI scores whereas the percentages of asymmetry ratio on cVEMP and unilateral weakness on the caloric test did not exceed the normal limits.

The significant differences between the means of ranked DHI-T score of the experimental and control groups (Table 3) and between the three subgroups and the control group (Table 4) were consistent with the results of Jacobson and Calder and Jacobson and McCaslin [7,8]. Patients with UW were limited on their balance function which was the inability to stand or walk in darkness, cross the street speedily, or stand still and focus on a moving vehicle [20]. Moreover, patients with otolith disorders showed a greater trunk sway in their linear movements, and sway velocities in tilting motions, than those in the control group [21]. Interestingly, patients with unilateral peripheral vestibular disorder who had a high self-perception handicap also showed concomitant disabilities in supporting senses such as the visual and proprioceptive systems [8]. Additionally, the DHI-T was conducted to evaluate self-perceptions of handicap effects. Thus, patients who had more severe vestibular disorders also had self-perceptions of more severe handicaps. In fact, there is a tendency in patients with abnormal cVEMP and/or caloric test results to feel that they have less balancing stability than patients with normal vestibular test results, perhaps resulting in higher DHI scores.

The differences in the means of ranked DHI-T scores between the three subgroups in the present study were similar to the results of Jacobson and Mc Caslin and Jacobson GP and McCaslin et al. [8,22]. McCaslin et al. [22] reported a trend for patients with abnormal results on both the caloric and cVEMP tests that showed higher total DHI scores than those of patients with abnormal cVEMP or caloric test results, but the differences in DHI scores were non-significant. Jacobson and McCaslin and Jacobson GP concluded that patients with an uncompensated unilateral vestibular disorder had higher DHI scores than those of other groups [8]. All of these researchers were in agreement regarding behavioral measurements of dizziness handicaps and physiological measurements of unilateral vestibular disorder. Uncompensated patients produced abnormal vestibular test results from which they perceived more handicaps than compensated patients. However, there were non-significant differences between groups of patients with abnormal results. According to their reasoning, the objective vestibular test results disagreed with DHI scores which were the patient's subjective perceptions of handicaps because the DHI scores were affected by various factors, e.g. the time period of recurrent dizziness or vertigo, duration of the disease, gender [7,8,23-25]. Furthermore, some factors were not controllable such as lifestyle, an individual's general health, degree of family support, ability to cope with a physical disorder, and psychological distress [8,26].

Additionally, the upper limit (Mean+2SD) of the normal range of the DHI-T scores in the present study for the control group was 50.85%, which was similar to the cut-off score in the study of Saxena and Prabhakar [27]. Their results had shown that the best cut-off point of DHI scores in diagnosing BPPV was 50%. However, the receiver operating characteristic curve determined by setting the cut-off point at 51,showed low sensitivity (38.2%) but very high specificity (100%) which is not the purpose of a screening tool. The chosen cut-off point recommended in the present study is 25%, which shows high sensitivity (84%) and fairly good specificity (57%) (Figure1).

Limitation and Recommendation

There are some limitations of this study. First, the study did not include other vestibular tests. In the control group, there was a possibility that patients might have had a physical abnormality which could not be detected by cVEMP and caloric tests. Thus, their DHI-T scores were inconsistent with the vestibular results of this study. Second, in future studies the number of participants should be increased in order that the distributions of their test results approximate a normal distribution. Third, the various durations of dizziness may affect the results of the correlations between the DHI-T scores with cVEMP and caloric tests results. In addition, future studies should include analyses of the DHI-T subscales.

Conclusion

1. For total participants, there was a weak but statistically significant positive correlation between the means of ranked DHI-T scores and UW (rho=0.200, p=0.010), and the means of ranked DHI-T scores and AR (rho=0.179, p=0.022). For the experimental and control groups, the correlation coefficients were statistically non-significant.

2. The means of ranked DHI-T scores of the experimental group (89.39%) was significantly different from the means of ranked DHI-T scores for the control group (39.19%) at p=0.000 and was much higher as well.

3. The Ex-3 subgroup had a higher mean of ranked DHI-T scores than the other subgroups but was statistically non-significant (Ex-1=68.86%, Ex-2=67.76%, and Ex-3=82.75%).

4. There were significant differences in the mean of ranked DHI-T scores for each of the three subgroups when compared to that of the control group at p=0.000 (Ex-1=40.83% *vs.* control group=21.67%, Ex-2=43.84% *vs.* control group=22.98%, and Ex-3=39.73% *vs.* control group=16.55%).

5. A recommendation that the upper limit of normal range of DHI-T scores should be 25%. This upper limit corresponds to a sensitivity of 84% and a specificity of 57%, which are appropriate for referral purposes.

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