Definition of Balance and Cognition Related to Disability Levels in Vestibular Migraine Patients

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ABSTRACT

Objective: To compare the balance and cognition of vestibular migraine (VM) patients with migraineurs without vertigo history and healthy subjects, and to examine the effects of disability level on these functions.

Material-method: The study consisted of 32 VM patients, 32 migraineurs and 31 healthy subjects with similar sex and age. Balance functions were assessed with Balance Evaluation Systems Test (BEST), dizziness and headache severity with Visual Analogue Scale (VAS), disability related to dizziness with Dizziness Handicap Inventory (DHI), cognition with Stroop test.

Results: There was no statistical significant difference among the three groups in terms of age, gender, height, weight, marital status and education levels ($p>0.05$). Headache severity was higher in migraineurs than vestibular migraineurs and healthy subjects, also dizziness severity was higher in vestibular migraineurs than migraineurs and healthy subjects ($p<0.0167$). The outcomes of BEST 4, 5, 6 and BEST-total were significantly impaired in VM patients than migraineurs and healthy subjects, and worse in migraineurs rather than healthy subjects

($p<0.0167$). Stroop effect of cognitive examination was worse in VM and migraine patients rather than healthy subjects ($p<0.0167$). There was no significant difference between VM and migraineurs ($p>0.0167$). There was a negative correlation between Stroop effect and BEST-total in VM patients significantly ($r=-0.509$, $p=0.003$), and no significant correlation in migraineurs ($p>0.05$). Disability levels of VM patients were low in 38.7%, mild in 51.6% and severe in 9.7% related to DHI. There was no significant difference between balance and cognition function in terms of disability levels ($p>0.05$).

Conclusion: The balance and cognition in VM patients and migraineurs were impaired rather than healthy subjects. The patient groups differed from each other in terms of vertiginous complaints rather than cognition. Solving the functional limitations with further longitudinal examinations can facilitate the treatment. The appropriate physiotherapy programs and patient education methods can be planned for these various issues.

Keywords: Vestibular migraine, disability, balance, cognition

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INTRODUCTION

Migraine is an episodic disease that manifests itself with nausea, vomiting, photophobia, and phonophobia that accompany severe headache. Many patients complain of symptoms such as spontaneous or positional vertigo that is either during migraine attacks or free from the attacks, intolerance of head movements, and imbalance. These recurrent vertigo attacks and migraine association have been known for a long time, and in this clinical table called vestibular migraine (VM); vertiginous symptoms are heterogeneous feature, and are findings that indicate a vestibular problem (1-3).

In the literature, in migraine patients who does not have vertigo history, when changes in balance performance have examined longitudinally,

there may be deterioration compared to healthy, and it is stated that this may originate from migraine's deteriorating effect on the vestibular system (4-8). In patients with vestibular complaints, there is a tendency to choose a sedentary lifestyle, and decrease in the quality of life. The symptoms which came out especially in crowded and rich by visual stimulus environments negatively affect the daily life activities of the patient. When the severity of the disease increases, the severity of the symptoms increases too; and comorbid complaints also occur, and concentration and memory difficulties are seen.

It has been shown that vestibular system has a negative effect on cognitive processes (such as memory, spatial navigation, perception

capacity of the body, concentration difficulties, and learning difficulties) (10, 11). It has been stated that vestibular sensory loss may lead to functional changes on the brain parts that are responsible for processing information which are spatial or non-spatial (12). In migraine patients, the change of cognitive processes is also a subject of curiosity, and there are different opinions on this subject. Like studies that show that there is no effect of migraine on cognitive process, there are also studies showing that cognitive malfunction is more prevalent in migraine patients (13, 14). In addition to this information, according to the results of magnetic resonance imaging of migraine patients there is pathological thickening in somatosensory cortex (15), and there are opinions defending that these structural changes can lead changes in cognitive processes (16, 17). According to some neurophysiological studies in the literature, it is stated that there can be cognitive changes, psychomotor disorders, and memory disorders in migraine patients. At the same time, during short-term migraine attacks; it is stated that there can occur some deteriorations on concentration, comprehension, and communication as well as visual-spatial and numerical memory (18).

The Stroop Test is accepted as the gold standard in the evaluation of attention and cognitive functions, and is particularly prominent in the evaluation of the prefrontal cortex, anterior cingulate cortex, supplement motor cortex, and basal ganglia that have been responsible on anterior attention system. The Stroop task sets out the ease of change a person's perceptual setup in the direction of changing demands and in particular under a "deteriorating effect", and the ability to suppress a conventional behavior pattern and to perform an unusual behavior. When in a condition that this ability is weakened, perseverative, stereotypic, nonconforming behaviors arise; the difficulty of regulating and controlling motor movements may be the subject (19).

According to our information, there are no published studies that comparing balance and cognitive processes on VM patients with migraine patients, who do not have dizziness, and healthy individuals. For this reason, it is aimed to examine balance and cognitive functions in VM patients by comparing them with migraine patients and healthy individuals.

METHODS

The study has descriptive and cross-sectional features, and was performed as a case-control comparison. Target population of the study are the patients who have complaints of imbalance, and those who consult on Outpatient Balance Clinic. After the neuro-otological examinations that were performed, according to the Neuhauser criteria (3) the patients who diagnosed with definitive vestibular migraine, and according to the IHS criteria (20) hospital's health personnel who do not have dizziness complaint and diagnosed with migraine without aura, and the volunteer patients who wanted to involve in the study, and healthy volunteer who do not have headache complaint formed the sample of the study. Inclusion criteria for the study are, for the study group (VM and migraine patients); diagnosed with VM and migraine after neuro-otological evaluation, want to participate the study voluntarily, there should be no medical history of communication and neuromusculoskeletal disease which are in a way that will not allow to apply evaluation methods. Individuals with chronic middle ear disease, peripheral or central vestibular system disease, head trauma, and Benign Paroxysmal Positional Vertigo (BPPV) history were not included in the study. All participants were matched by age and gender. After the detailed medical history was obtained from the patients, neuro-otological evaluation was performed. All balance and cognitive measurements were performed during the absence of the patient's headache and/or dizziness complaint. The study was approved by the Ethics Committee of the relevant institution. All participants were informed about the study, and their informed consent was obtained.

Evaluation Methods

Headache and dizziness severity: Patients are asked to mark headache and dizziness severity that they perceive to the visual analogue scale (VAS), which is a scale rated between 0-10. This scale begins with the absence of pain or dizziness [0] and reaches up to unbearable pain [10] (21).

Balance evaluation: All cases' static and dynamic balance abilities evaluated with Balance Evaluation - Systems Test (BEST). In the test which subclassified to 6 categories, where the subparameters are specified as follows, patients evaluated on a total of 108 points (22).

BEST (1) Biomechanical Constraints: Base of support, center of mass alignment, ankle strength and range, hip/trunk lateral strength, sit on floor and stand up time

BEST (2) Stability limits: Sitting verticality and lateral lean, forward and lateral functional reaching

BEST (3) Transitions-anticipatory postural adjustments: Sit to stand, rises on toes, standing on one leg, alternate stair touching, standing arm raise

BEST (4) Reactive-postural responses: Forward and backward response, compensatory corrective step-forward/backward/lateral

BEST (5) Sensory Orientation: Sensory integration for balance, standing on inclined surface with eyes closed

BEST (&) Stability in gait: gait time, change gait speed, walking with horizontal head movements, pivot turn on walk, step over obstacles, timed get up & go, timed get up & go test with dual task

Cognitive level evaluation: Stroop Test, which have standardized for Turkish people, performed in five different sections (23):

Stroop 1 (Task 1): Duration to read the color names on the writings that are black in white background

Stroop 2 (Task 2): Duration to say squares' colors that are painted with different colors

Stroop 3 (Task 3): Duration to read color names that are written in different colors

Stroop 4 (Task 4): Duration to say color names' color that are written in different colors

Stroop 5 (Task 5): Number of errors when saying color names that are written in different colors

Stroop deteriorating effect: 4. Duration of task completion - 3. Duration of task completion

The completion times of the individuals are recorded. It is found that the most valid feature that Stroop Test measures is aliasing (5th segment that colors have been said) because of the individual who focuses on speaking in a strong sense tends to read the color name at the same time, the resulting delay is called the Stroop effect (23, 24).

Determination of disease disability level: With the Dizziness Handicap Inventory (DHI), it is questioned that how the patient's quality of life affected by the complaints on dizziness and imbalance, and the disabilities caused by complaints. This inventory evaluates the emotional, functional,

and physical effects of the disease in three parts, 25 questions. According to the total score the patient received from the scale, the patients were divided into three disability groups; 0-30 points (mild disability), 31-60 points (medium disability), 61-100 points (severe disability) (25, 26).

Evaluation of the Data

Statistical analysis of the data obtained in the study was made with the statistical package "Statistical Package for Social Science for Windows, Version 15.0". In this study, non-parametric tests were used in interpreting the obtained results due to the reason of failure to meet the requirements for the usage of parametric tests. The results of the tests were interpreted according to the significance level of p value of 0.05. Kruskal-Wallis variance analysis was used to determine the differences between the three groups' measurement methods. In the case of finding a significant difference between the groups, the groups compared in two with the Mann-Whitney U test, for determining the source of the difference. Because the large number of groups lead to an increase in the margin of error in the comparison, Bonferroni correction was used for the aim of determine the source of statistical difference. Bonferroni correction is determined with the formula (level of significance/number of groups). In this study, level of significance was determined as $0.05/3 = 0.0167$ (because of the group number is 3). Therefore, in the analysis to determine the difference between groups, level of significance was taken as 0.0167. According to the Spearman correlation analysis that used to determine the relationship between evaluation parameters ≤ 0.4 weak; 0.41-0.69 moderate and ≥ 0.7 strong were recorded as correlation.

RESULTS

To our study, that we aimed comparison of VM patients' balance and cognitive level, migraine patients without dizziness and healthy control group and examining the disease's disability level's effect on these

functions, a total of 95 patients (32 VM patients, 32 migraine patients, 31 healthy people) were accepted. There was no significant difference between only among the three groups of women in terms of age, gender, height, body weight, marital status and education level ($p > 0.05$) (Table 1).

The severity of headache was found significantly higher in migraine patients (mean 6.75 ± 1.72) than VM patients (mean 4.10 ± 3.68) ($p = 0.004$). The severity of dizziness was found significantly higher in VM patients (mean 5.52 ± 2.54) than migraine patients (mean 1.37 ± 1.93) ($p = 0.000$).

According to the BEST results that evaluates static and dynamic balance abilities; while there is not found significant difference between three groups in BEST 1, BEST 2, BEST 3 results ($p > 0.05$), there is found significant result between three groups in BEST 4, BEST 5, BEST 6 and total results ($p < 0.05$) (Table 2).

In BEST 4, the results of the VM group is significantly lower than migraine group ($p = 0.010$) and healthy group ($p = 0.010$) and the results of the migraine group is also significantly lower than control group ($p = 0.001$) (Table 2). Similarly, in BEST 5 and 6, VM groups' results is significantly lower than migraine patients ($p = 0.000$) and healthy individuals ($p = 0.000$) and migraine patients' results is significantly lower than healthy individuals ($p = 0.000$).

In terms of BEST-total score, it is determined that VM patients is significantly worse than migraine patients ($p = 0.003$) and healthy ones ($p = 0.000$) and migraine patients is significantly worse than healthy ones ($p = 0.000$).

In terms of cognitive function test results, it is found that the Stroop effect value is significantly lower in the VM group than healthy control group

Table 1. Examination of the demographic characteristics of the cases

	VM Group	Migraine Group	Healthy Control Group	P *
Age (years) (mean $\pm$ Sd)	41.32 $\pm$ 9.53	40.56 $\pm$ 8.04	37.63 $\pm$ 7.18	.175
Height (cm) (mean $\pm$ Sd)	162.71 $\pm$ 5.27	162.75 $\pm$ 7.53	160.94 $\pm$ 4.82	.770
Body Weight (kg) (mean $\pm$ Sd)	65.32 $\pm$ 10.11	65.97 $\pm$ 8.30	64.03 $\pm$ 9.15	.546
Education Level n (%)				
Primary School	4 (12.9)	0	0	
Middle School	2 (6.5)	2 (6.3)	2 (6.3)	
High School	5 (16.1)	12 (37.5)	8 (25.0)	
University	20 (64.5)	18 (56.3)	22 (68.8)	

VM: Vestibular Migraine, * P < 0.05 Kruskal-Variance Analysis.

Table 2. Evaluation of cases in terms of balance and cognitive performance

	VM Group (mean $\pm$ Sd)	Migraine Group (mean $\pm$ Sd)	Healthy Control Group (mean $\pm$ Sd)	P *
BEST 1	97.10 $\pm$ 6.33	99.16 $\pm$ 3.71	97.47 $\pm$ 8.19	0.151
BEST 2	94.84 $\pm$ 9.24	97.25 $\pm$ 6.27	96.37 $\pm$ 7.41	0.578
BEST 3	95.74 $\pm$ 9.09	98.22 $\pm$ 5.69	96.28 $\pm$ 8.30	0.392
BEST 4	87.87 $\pm$ 14.18	94.00 $\pm$ 8.09	97.03 $\pm$ 7.61	0.001
BEST 5	73.45 $\pm$ 12.83	84.12 $\pm$ 13.22	93.75 $\pm$ 7.62	0.000
BEST 6	84.07 $\pm$ 12.59	89.37 $\pm$ 9.63	96.12 $\pm$ 4.80	0.000
BEST-T	88.74 $\pm$ 8.43	93.87 $\pm$ 5.50	96.47 $\pm$ 5.84	0.000
Stroop Effect	20.83 $\pm$ 14.44	14.93 $\pm$ 11.62	7.90 $\pm$ 6.06	0.000

BEST TEST: Balance Evaluation - Systems Test, VM: Vestibular Migraine, * p < 0.05 Kruskal-Variance Analysis.

Table 3. Examination of VM patients in terms of disability according to DHI

	Mild	Medium	Severe	P
BEST-T	92.17 (4.04)	86.81 (9.81)	85.33 (11.59)	.398
Stroop effect	20.50 (8.21)	21.62 (18.44)	18.00 (13.75)	.831

* p<0.05 Kruskal-Variance Analysis, VM: Vestibular Migraine, DHI-Dizziness Handicap Inventory, BEST: Balance Evaluation - Systems Test

($p=0.000$), and likewise it is significantly lower in the migraine group than healthy control group ($p=0.000$). Besides, there was not found a significant difference between VM and migraine groups ($p>0.05$) (Table 2).

When the results of the Dizziness Handicap Inventory (DHI), which reflects the level of subjective inhibition and disease disability of patients due to dizziness complaint, are examined; VM patients' 38.7% (12 patients) are in mild disability, 51.6% (16 patients) are in medium disability, and 9.7% (3 patients) are in severe disability group. There was not seen a significant difference between in terms of VM patients' balance and cognitive functions and disability groups ($p>0.05$) (Table 3).

When relation between groups' balance and cognitive functions examined, in VM patients with Stroop effect it is determined that there is negative relation with BAST-T ($r=-0.509$, $p=0.003$) and in migraine patients there is no significant relation between balance and cognitive functions.

DISCUSSION

At the end of the study that have been examined that the VM patients' balance and cognitive performance level's comparison to migraine patients without dizziness and healthy control group and the effect of disease's disability level on these functions, the result was found that VM patients are worse than migraine patients and healthy individuals in terms of balance and cognitive functions.

In our study, it is determined that headache severity is higher in migraine patients than VM patients, as expected in accordance with the literature, in VM group vertiginous complaints are higher than pain.

It is determined that in migraine patients, who do not have complaints on dizziness, increased postural oscillation disorders compared to healthy subjects show subclinic vestibular exposure (7, 8), and especially in patients who have migraine with aura there is higher vestibular exposure than healthy individuals and patients who have tension type headache (4, 5, 27). Boldingh has stated that VM and migraine patients show vestibular malfunction in interictal period and vestibular malfunction is two times more in VM patients than migraine patients (28). It has been seen that in VM patients Romberg test, VOR fixation suppression capacity and static positional nystagmus tests are worse than migraine patients and in accordance with these results it is stated that subclinic vestibular exposure has an absolute role on migraine pathology (28). Similarly, in his retrospective study, Jung has obtained findings that reflect vestibulospinal abnormalities in the VM patient group in dynamic posturography (29). In the studies, between attacks, oculomotor malfunction in VM patients is occurred as peripheral vestibular structures' malfunction and increased body oscillation on posturography due to the negatively affected vestibular pathways (30-36).

When our study evaluated in terms of balance, it has come to our front as similar to literature, that VM group is worse than migraine patients in BEST 4, 5, 6 and total scores, in terms of BEST results which evaluates static and dynamic balance abilities. Also, it is determined that migraine

patients are worse than healthy individuals in the BEST 5 and 6 scores which require stand in balance with eyes closed and various walking activities. Similar to our results, in literature it is foreseen that there are deteriorations of balance abilities in migraine patients who do not have dizziness and this deterioration's can proceed as longitudinally (7, 8).

In his study, Harno has showed that migraine patients have more oscillation in the posturography than in the control group. It has been shown that there are abnormal results in the position eyes open stand in approximately half of the migraine patients and patients who have migraine with aura have higher oscillation speed than the patients who have migraine without aura. After these findings, it has been said that the cause of interictal neuro-otological insufficiency in migraine patients is impaired oculomotor function due to vestibulocerebellar. Parallel to these results, Salhofer has stated that there can be various balance disorders from imbalance to vertigo in migraine patients, and in VM patients it has been defined that the frequent feeling of fall because of the intensified vertigo (32).

In our study that consistent with the study findings on literature and defined pathological explanations, it has been thinking that indicating the vestibular system is affected, VM patients are worse than migraine patients in terms of balance performance and indicating the subclinic vestibular explosion affected, migraine patients are worse than healthy individuals in terms of balance performance.

When the "Stroop deterioration effect" of the Stroop Test was examined in terms of cognitive function in our study, it was observed that VM patients and migraine patients did not differ in terms of test results, meaning VM and migraine group showed similar results, whereas VM and migraine groups were worse than healthy individuals. The Stroop Test, which we use in our study, is a neuropsychological test reflecting the activity of the frontal region and is accepted as the "gold standard" of attention measurements in the literature (24). This test enables cognitive functions, planning and targeted complicated activities to be performed (37). For this reason, cognitive deterioration leads to reductions in physical performance and activities of daily living (38). The relation between cognitive functions and balance functions has been noted in the literature in recent years, and it is emphasized that the effect of consciousness process on posture regulation is important (39). It is stated that the postural corrections are automatic to some extent, and that in some cases the attention process is actively working to maintain balance. This possible relation between postural and cognitive functions was examined using the dual-task method, while changes in performance were tested when cognitive and postural tasks were performed. At this point, it has been shown that cognitive tasks may have a deteriorating effect on balance tasks (40, 41). Andersson et al., in the study that they performed with healthy subjects, found that cognitive functions provide additional support to postural control, in that they do not have independent systems of control of body oscillations and cognitive functions (42).

During migraine attacks, patients become susceptible to all sensory stimuli and identify various cognitive symptoms. There can be seen

increased anxiety, concentration disorders, difficulties in mental tasks, inability to remember the names. This condition affects patient's quality of life negatively (17). Studies in the literature have often been conducted as a comparison between migraine patients and healthy controls, and comparative cognitive functions have not been examined in the VM group as in our study. Calandre et al. has found that deterioration in memory, attention, visuomotor speed processes in migraine patients compared to healthy individuals (43). Mulder stated that migraine patients were slower during neuropsychological tests than healthy individuals, and that because of also the functional deterioration in the prefrontal areas (18).

There are many publications in the literature that saying migraine does not affect cognitive functions. Martins et al. have determined inhibitory control with verbal fluency and Stroop test in patients with migraine and non-migraine headaches, found slowing in tests associated with prefrontal cortex integration and activation, but this result is interpreted as the deterioration of cognitive functions by negatively affecting frontal lobe activation due to chronic pain. In this direction, it is thought that this disorder is not migraine-specific (16, 44).

In two longitudinal studies that performed, there was not determined that the relation between migraine patients and cognitive abilities. Baars et al. have stated that there was no significant change in cognitive performance of migraine patients compared to healthy controls in 1823 participants after a six-year follow-up (45). As for Rist, in the two-year follow-up study, has shown that there was no correlation between migraine and cognitive decline in 6349 women migraine patients (46).

As a result of the study, there is no relation between balance function and cognitive functions, but it has been occurred that as the disability levels of the patients increased, balance performance also deteriorated. Consistent with the literature, it has been seen that vertiginous complaints lead to disability in VM patients, whereas cognitive functions have no effect on disability. This result, which emerges between cognitive functions and balance functions, is thought to be caused by the patients are in a not-attack period. Patients, during clinical interviews, talk about complaints such as concentration difficulties and memory problems in attack period. In this respect, it is thought that there is a need for larger studies involving cognitive functions in VM and migraine patients, including longitudinal and attack period's assessment. The reasons for the differences in the literature results are defined as differences in patient selection criteria, the effects of migraine medications and different testing procedures. Similar to published literature and parallel to the clinical complaints of patients, when the results of our study are examined, VM and migraine diagnosis have negative effects on cognitive function, different from healthy individuals in terms of deterioration, and two groups of patients do not differ from each other.

Limitations of the Study

In the study, patients were evaluated during the not-attack period which is without complaints, and it is recommended that also evaluation of functional differences on the attack period of the patients for the further studies. In addition, there may need additional assessment of the patients' on the disorders of memory and concentration that patients have mentioned frequently, with other vigilance, anxiety, and other neuropsychological tests that measure anxiety.

Conclusions and Recommendations

It is determined that in VM patients, as against healthy individuals, there are deteriorations on balance and cognitive functions level, and compared to migraine patients balance performance is worse; the migraine patients have deteriorations on balance and cognitive functions level compared to healthy individuals.

The two group of patients differ from one another in terms of vertiginous complaints, but there is no difference seen in between them in terms of cognitive processes. But in line of the result that the two group of patients are worse on balance and cognitive functions than healthy individuals, it can be planned that appropriate physiotherapy programs and patient educations aimed at the problems that occur in the patients. Solving functional limitations by performing longitudinal evaluations in patients may facilitate the treatment.

Ethics Committee Approval: Dokuz Eylül University Medical Faculty, Ethics Committee for Non-interventional Research (2013/19-05 decision no, 1024-GOA protocol no.)

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