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# BALANCE AND GAIT PERFORMANCE AFTER PARTICLE REPOSITIONING MANEUVER IN BENIGN PAROXYSMAL POSITIONAL VERTIGO PATIENTS

## ORIGINAL ARTICLE

### ABSTRACT

**Purpose:** The purpose of this study was to examine subjective complaints, recurrence of benign paroxysmal positional vertigo (BPPV), balance and gait with a particle repositioning maneuver (PRM), and to investigate the effects of Brandt Daroff (BD) exercises and comorbid factors as migraine on recovery in BPPV patients.

**Methods:** Fifty-seven patients were treated with a PRM for posterior canal BPPV. The perception of vertigo was estimated with Visual Analogue Scale (VAS), gait with Dynamic Gait Index (DGI), balance with the modified Clinical Test of Sensory Integration and Balance (mCTSIB). If the Dix-Hallpike test was still positive one week after the PRM, the maneuver was repeated. When remission was confirmed, patients were called back after one month to repeat all tests. If the patient suffered only from residual dizziness after one week, BD exercises were recommended for one month.

**Results:** The VAS scores for all patients improved significantly one month after a PRM ( $p < 0.001$ ). The abnormal balance on foam stance before a PRM improved significantly ( $p < 0.05$ ). The DGI scores improved without a statistical difference ( $p > 0.05$ ). It was found that patients with migraine had complaints of more severe imbalance.

**Conclusion:** Subjective complaints, balance and gait abilities improved in all patients after PRM. BPPV patients with migraine have a greater risk of recurrence and lower improvement in balance and gait ability after PRM. BD exercises did not prevent recurrence and residual dizziness.

**Key Words:** Benign Paroxysmal Positional Vertigo; Particle Repositioning Maneuver; Balance; Gait; Recurrence.

# BENİGN PAROKSİSMAL POZİSYONEL VERTİGO HASTALARINDA PARTİKÜL YERLEŞTİRME MANEVRASI SONRASINDA DENGE VE YÜRÜME PERFORMANSI

## ARAŞTIRMA MAKALESİ

### ÖZ

**Amaç:** Benign paroksizmal pozisyonel vertigo (BBPV) hastalarında partikül yerleştirme manevrasından (PYM) önce ve sonra subjektif yakınmalar, rekürrens, denge ve yürüme yeteneklerini incelemek; Brandt Daroff (BD) egzersizleri ile migren gibi komorbid faktörlerin tekrarlama üzerine etkisini belirlemektir.

**Yöntem:** Posterior kanal BPPV'si sebebiyle 57 hastaya PYM uygulandı. Vertigo algısı, Vizüel Analog Skalası (VAS) ile; yürüme, Dinamik Yürüme İndeksi (DYI) ile; denge, duyuşal integrasyon ve denge kliniğe uyarlanmış testi (DIDKT) ile değerlendirildi. Eğer hastada Dix-Hallpike testi manevradan bir hafta sonra pozitif ise manevra tekrarlandı. Remisyon onaylandığında manevra tekrar edilmedi ve hasta bir ay sonra testlerin tekrarı için kontrole çağrıldı. Hastanın bir hafta sonraki kontrolünde sadece baş dönmesi yakınması varsa bir ay boyunca BD egzersizleri yapması önerildi.

**Sonuçlar:** VAS değerleri tüm hastalarda manevradan bir ay sonra anlamlı olarak iyileşti ( $p < 0.001$ ). Manevra öncesinde kötü olan sünger zeminde duruş dengesi anlamlı olarak iyileşti ( $p < 0.05$ ). DYI skorları iyileşti fakat anlamlı fark bulunmadı ( $p > 0.05$ ). Migrenli hastalarda daha şiddetli denge bozukluğu yakınmaları tespit edildi.

**Tartışma:** Subjektif yakınmalar, denge ve yürüme yetenekleri tüm hastalarda iyileşme gösterdi. Migrenli BPPV hastalarının tekrarlama riskinin daha fazla olduğu ve yürüme ve denge yeteneklerinde daha az iyileşme olduğu görüldü. BD egzersizlerinin tekrarlama ve baş dönmesi yakınmalarını önlemediği tespit edildi.

**Anahtar Kelimeler:** Benign Paroksizmal Pozisyonel Vertigo; Partikül Yerleştirme Manevrası; Denge; Yürüme; Tekrarlama.

## INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is a common cause of recurrent vertigo with a high recurrence and prevalence rate (1). The mainstay of therapy is to perform a particle-repositioning maneuver (PRM), and one of the most commonly used PRM is the Epley Maneuver, with a success rate of 75-89% (2). During bouts of BPPV, most patients complain of disequilibrium and unstable gait (3).

The BPPV is a common vestibular symptom in migraine patients who visit neurology clinics. It is discussed that genetic factors and vascular damage of the labyrinth may be responsible for the underlying pathogenetic mechanism of these two conditions (4). Patients with migraine had increased risk of developing BPPV (5).

There is a higher incidence of vertigo attacks between BPPV episodes in migraineurs, but no direct physiological link between migraine and BPPV has yet been established (6).

In this study, we aimed to determine the change of balance and gait functions and to explore the effects of comorbidities as migraine on recovery after a PRM. We also intended to research the efficacy of Brandt-Daroff (BD) exercises in reducing dizziness and preventing the recurrence of BPPV.

## METHODS

The study was approved by the local ethics committee (Institutional Ethical Board of Dokuz Eylül University, (2013/01-12), and each subject gave written informed consent to participate in the study. Additionally, required permissions for all tests.

A total of 57 patients (41 females and 16 males) with the unilateral posterior canal (PC) BPPV were examined before, one week after, and one month after a PRM (Epley Maneuver) in this cross-sectional study.

Patients who had just suffered their first attack of BPPV involving unilateral PC and had been diagnosed by a neurologist were recruited from the Dokuz Eylül University, Faculty of Medicine, Balance Clinic. The diagnosis of BPPV was based on standard clinical criteria: paroxysmal attacks of

vertigo and torsional-upbeat nystagmus provoked by Dix-Hallpike Test (DHT) (1). Additionally, the third edition of the International Classification of Headache Disorders (ICHD-3) (7) was used for the migraine diagnosis to make further subgroup analyze by neurologists, who were volunteers recruited for the study from the staff of the hospital.

Patients with central nervous system involvement defined by magnetic resonance imaging (MRI) or neurologic examination were excluded, or patients with Meniere's disease or other inner ear disease were diagnosed with secondary BPPV (8). Patients who had with the involvement of lateral or anterior canals or bilateral BPPV and also previously BPPV history were excluded.

All patients had full neurological and neuro-otological examinations including tests for spontaneous, gaze-evoked, head-shaking and positioning nystagmus. The examination was done using Visual Eyes 4 Channel Videonystagmography (VNG) (Micromedical Technologies, Chatham, USA).

### Pre-and Post-treatment Assessments:

The subjective intensity of vertigo was evaluated using Visual Analogue Scale (VAS) on a continuum from 0 (no symptom) to 100 mm (the worst symptom) (9).

The Dynamic Gait Index (DGI) was used to assess gait performance during the observation of the patient with varying walking demands (ordinary walking, walking at different speeds, walking with vertical and horizontal head turns, walking over and around objects, making a 180° turn, and stair climbing). The total scores range from the 0 (severe impairment) to 24 points (normal performance) (10). The reliability of DGI was examined and found to have good intra-rater reliability in patients with BPPV (11).

The modified Clinical Test of Sensory Integration and Balance (mCTSIB) which consists of four conditions; stance on firm eyes and foam surface (40x40x15 cm, medium density foam), each stance condition was also performed with eyes open and then closed. Postural stability was clinically observed and assigned a Sway Index. The Sway Index is assessed by observing the postural stability to complete the mCTSIB stance in 30 seconds without falling and is assigned to

characterize sway. It was assigned a value of 1 to 4 to characterize this sway (1=minimal sway, 2=mild sway, 3=moderate sway, 4=a fall) (12). Patients were also evaluated while standing on foam with their head in an extended position and their eyes open and then closed. These positions were added to challenge neck proprioception in the study design (13). Regarding the mCTSIB performance, the patients were divided to subgroups as “fall” when the Sway Index was 4 and “no-fall” when it was 1, 2 or 3. The number of patients who had fallen during the test was recorded.

### Treatment Methods

All patients underwent the DHT before the PRM through videonystagmography (VNG) testing. The first and the second authors initially evaluated each patient with the DHT (#1) and the first author treated each patient with PRM after the DHT (2). The second author was diagnosed with a migraine according to the ICHD-3.

The patients were reviewed one week after the PRM, and the DHT (#2) was repeated.

The absence of both nystagmus and vertigo during the DHT (#2) was considered to indicate procedural success. If the DHT (#2) was still positive for vertigo, asymmetrical dizziness or nausea with or without nystagmus, the PRM was repeated. If the DHT (#2) was negative for nystagmus and vertigo, but the patient described of residual dizziness in daily activities, the BD exercises were recommended until the next visit one month later (14).

The third DHT (#3) was administered one month after the second DHT in all patients. If the DHT (#3) was still positive for nystagmus and vertigo, then a third PRM was given (Figure 1) and defined as “recurrence of BPPV” (15).

Subjective complaints measured using VAS, with “residual daily dizziness” defined as the sensation of unsteadiness or lightheadedness without rotational and/or positional vertigo. All balance and gait tests were performed before the DHT (#1) and after the DHT (#3) (Figure 1).

### Statistical Analysis

Data are shown as the mean and standard deviation, and categorical variables are expressed in percentages. The Wilcoxon signed-ranks test was used to compare the results for DGI and VAS before and after the maneuver. The Mann-Whitney U and Fisher exact tests were applied to test the postural sway differences between groups related to historically characteristics after the maneuver. SPSS for Windows Release 22.0 (Statistical Package for Social Sciences Inc. Chicago, IL, USA) was used in the calculations, and a 5% significance level was adopted. Prior to the study, the power analysis was performed using G Power 3.0.10 program for Windows (G\*Power 3 Heinrich Heine University Düsseldorf, Düsseldorf, Germany) based on the results of the study of Celebisoy et al. (3) and 37 subjects were found adequate considering 95% (5% Type I error level) confidence interval and 80% power.

### RESULTS

The study sample consisted of 57 patients diagnosed with unilateral PC BPPV. The mean age was  $51.45 \pm 13.29$  years, between 23 and 78 years. Twenty of 57 patients had migraine history. Forty-one patients were female, and all of them had a migraine history.

Initially, 62 patients underwent the DHT and PRM. One week after the PRM, five patients still had a positive DHT (#2), underwent a PRM again and

**Table 1:** Subjective Complaints and Gait Outcomes of Patients Related to Migraine History.

Variables	Migraineurs (n=20) Mean±SD	Non-Migraineurs (n=37) Mean±SD	p
VAS Pre- PRM Post-PRM	92.45±9.20 32.52±24.89	89.71±13.92 15.42±20.13	0.756 <b>0.007*</b>
DGI Pre- PRM Post-PRM	18.60±4.52 20.11±3.30	17.43±4.70 20.60±3.31	0.300 0.460

\*p<0.05. Wilcoxon-Signed Rank test. VAS: Visual Analogue Scale, PRM: particle repositioning maneuver, DGI: Dynamic Gait Index.

**Table 2:** Subjective Complaints and Gait Outcomes of Patients Related to Recurrence of Benign Paroxysmal Positional Vertigo.

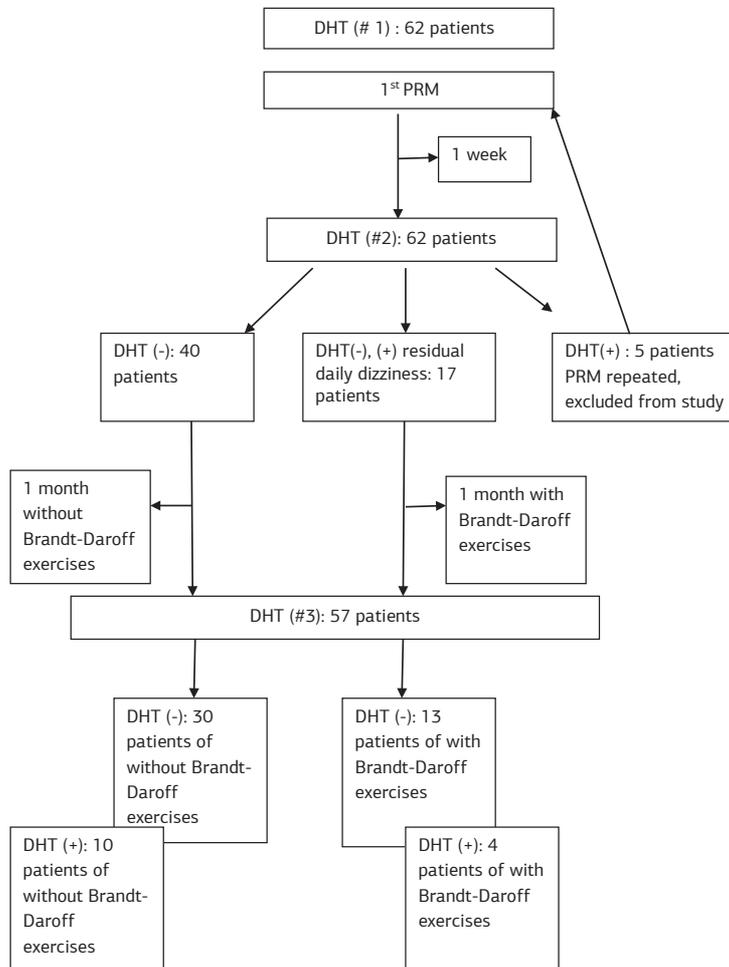
Variables	BPPV-Recurrence (n=14) Mean±SD	BPPV-No recurrence (n=43) Mean±SD	p
VAS	92.38±11.40	90.03±12.89	0.497
Pre- PRM	43.12±20.50	11.92±17.21	<b>&lt;0.001*</b>
Post-PRM			
DGI	17.44±3.62	18.03±5.12	0.249
Pre- PRM	19.34±3.27	20.91±3.18	<b>0.026*</b>
Post-PRM			

\*p<0.05. Wilcoxon-Signed Rank test. VAS: Visual Analogue Scale, PRM: particle repositioning maneuver, DGI: Dynamic Gait Index.

excluded from the study. Forty patients had a negative DHT (#2) and were asked to come back in a month; 17 patients had a negative DHT (#2) but had residual daily dizziness, and they were given daily BD exercises.

One month later the 57 patients were reviewed: in four of the 17 patients, who performed the BD exercises, DHT was positive for nystagmus and

vertigo. They were accepted as recurrence, and a PRM was repeated. Thirteen of the 17 patients were accepted as recovery because DHT was negative for nystagmus and vertigo. During the examination of 40 patients, who were not performing BD exercises, the DHT was positive for nystagmus and vertigo in 10 patients, and a PRM was repeated. Thirty of the 40 patients were accepted as recovery because DHT was negative for nystagmus and vertigo. The

**Figure 1:** Flow chart of the study design. DHT: Dix-Hallpike Test, PRM: Particle-repositioning manoeuvre.

**Table 3:** Number of Patients Falling in the Modified Clinical Test of Sensory Integration and Balance Test Pre and Post Particle Repositioning Maneuver.

Variables		Non-migraineur n (%)	Migraineur n (%)	p
FIEO	Pre-PRM	0 (0)	0 (0)	NT
	Post-PRM	0 (0)	0 (0)	NT
FIEC	Pre-PRM	0 (0)	1 (5)	NT
	Post-PRM	0 (0)	0 (0)	NT
FOEO	Pre- PRM	0 (0)	1 (5)	NT
	Post- PRM	0 (0)	0 (0)	NT
FOEC	Pre- PRM <sup>φ</sup>	6 (16.2)	10 (50)	0.091
	Post- PRM	1 (2.7)	0 (0)	NT
FOHEEO	Pre-PRM <sup>φ</sup>	5 (13.5)	8 (40)	<b>0.039*</b>
	Post-PRM	0 (0)	1 (5.0)	NT
FOHEEC	Pre-PRM <sup>φ</sup>	21 (56.7)	13 (65.0)	0.356
	Post-PRM	0 (0)	1 (5.0)	NT

\*p<0.05. <sup>φ</sup>Chi-square test, NT: Not tested. FIEO: Stance on Firm, Eyes Open, FIEC: Stance on Firm, Eyes Closed, FOEO: Stance on Foam, Eyes Open, FOEC: Stance on Foam, Eyes Closed, FOHEEO: Stance on Foam, Head Extended, Eyes Open, FOHEEC: Stance on Foam, Head Extended, Eyes Closed. PRM: Particle Repositioning Maneuver, MCTSIB: Modified Clinical Test of Sensory Integration and Balance.

total number of recurred patients was 14 out of 57 patients.

Subjective complaints of all patients, estimated by mean scores of VAS improved significantly from  $90.67 \pm 12.41$  to  $21.45 \pm 22.73$  after PRM ( $p < 0.001$ ). The DGI score were increased from  $17.78 \pm 4.61$  to  $20.43 \pm 3.20$  ( $p > 0.05$ ).

According to migraine history, there was no statistical difference between migraineurs and non-migraineurs in pre-PRM VAS scores (Table 1). The post-PRM VAS scores of migraineurs were significantly higher than that of non-migraineurs (mean scores of VAS 32.52 vs 15.42). The residual dizziness rate was 50% (10 of 20 patients) of migraineurs after one month.

Patients with recurrence of BPPV after one month from the PRM had significantly higher VAS scores and lower DGI than patients without recurrence of BPPV (Table 2).

Regarding the mCTSIB performance, more than half of the patients had difficulty on foam with eyes closed and head extended before the first PRM. The number of patients who had fallen during the test decreased after one month during the last examination (Table 3). The mCTSIB performance

before and after the maneuver was not statistically different between migraineurs and non-migraineurs ( $p > 0.05$ ). Even in the most challenging position, foam stance-eyes closed with head extended, there was no significant difference between the patients ( $\chi^2 = 0.854$ ,  $p = 0.544$ ) (Table 3).

There was no significant difference regarding recurrence of BPPV in patients who were given BD exercises and who were not ( $\chi^2 = 0.014$ ,  $p = 0.595$ ).

## DISCUSSION

Our results showed that subjective complaints, balance and gait performance of PC BPPV patients improved one month after PRM. The recurrence rate was 24.5% after a month. Nearly 35% of our patients had a migraine.

Recovery after maneuvers has been discussed in different studies without an exact conclusion. The recurrence of BPPV and residual dizziness indicate poor recovery and is shown with VAS outcomes (16). Recurrence rate and residual dizziness percentages in our study were consistent with previous studies (16,17). Residual dizziness after a successful PRM varies from 37 to 75% (16,18). The current relationship between a migraine and vertigo (19) was also demonstrated in our data: 35.1% of

our patients had a migraine. Residual dizziness was prominent in the migraineurs who made up more than 1/3 of our patients. Migraineurs had worse balance and gait performance than non-migraineurs in our study. Since there are not enough data regarding the impact of having a migraine on the recovery of BPPV, Teixido et al. pointed out that patients with a migraine seem more likely to have BPPV (20). Similarly, our results might show this essential underlying relationship (19). On the other hand, there is a correlation between residual dizziness and anxiety (16,18). The recurrence of BPPV caused higher VAS scores and lower DGI scores after a month in our study, which resulted in balance and gait impairments. The DGI values improved more in patients who did not experience residual dizziness.

Our results confirmed the recovery of balance dysfunction after a PRM (3). The patients' balance performance was normal mainly in conditions measured by mCTSIB after a PRM. Patients had trouble in the foam stance with eyes closed and the foam stance with eyes open/closed in head extended position before the maneuver. Besides the balance difficulties, the performance of these positions improved after the maneuver.

The recognized association between a migraine and BPPV is poorly understood (4,16). It has been speculated that a migraine could cause vasospasm of the labyrinthine arteries, leading to the detachment of the otoconia from the utricular macula (4). In our study, migraineurs suffered more from residual dizziness than non-migraineurs, and the recurrence rate was higher in migraineurs. Subjective complaints after a month, measured by VAS, significantly improved in migraineurs but the post-treatment VAS scores were still higher in migraineurs. Poor subjective recovery in migraineurs might be the result of high VAS scores. Our study also confirmed a female preponderance among BPPV patients. All migraineur patients were female in our sample (19).

The balance performance of non-migraineurs was better than of migraineurs on foam with eyes closed and head extended before a PRM, but all patients improved after a PRM in this condition. The foam stance with eyes closed and the head extended position was used to provoke unsteadiness in

migraineurs in our previous studies, investigating balance in migraineurs without a history of a migraine. It showed that migraineurs performance were worse in this condition than controls (21,22). The stance ability was disturbed because of the modification of the cervical proprioception and vestibular-otolithic inputs with the head extended position. Migraineurs in our study also had more trouble in this position. On the other hand, the migraine history did not affect the change of DGI values after a month; DGI values of all patients improved markedly.

We have also investigated the effect of the BD exercises on the recurrence of BPPV and residual dizziness. These had little to no effect on the recurrence rate or symptom resolution (2,17,23). The recurrence rate was lower in patients followed with BD exercises without a statistical difference, but there was no significant protective effect of the exercises on residual dizziness and recurrence. The recurrence rate was insignificantly higher in patients who were not followed with BD exercises.

In this study, we did not use specific assessment methods for perception dizziness and anxiety. In further studies, the main focus should be the residual dizziness, which could be shown more objectively and treated with specific exercises or behavioral perspectives in the long term with a larger sample size.

In conclusion, the effects of comorbid factors on recovery after PRM in BPPV patients were consistent with the literature. The BPPV patients with a migraine still experience more difficulties in balance and gait functions. The persistent problem of migraineurs mainly was residual dizziness. The BD exercises given for residual dizziness did not have a protective effect on residual dizziness or BPPV recurrence.

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**Conflict of Interest:** None.

**Ethical Approval:** This study was approved by the Institutional Ethical Board of Dokuz Eylul University (2013/01-12).

**Informed Consent:** Written informed consent was obtained from all participants.

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