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# Investigation of Subjective Balance Assessment and Quality of Life of İndividuals with Motion Sickness

# Hareket Hastalığı Olan Bireylerde Sübjektif Denge Değerlendirmesi ve Yaşam Kalitesinin İncelenmesi

## ABSTRACT

### Objective:
The aim of this study was to assess the quality of life of individuals with motion sickness (MS) and to perform a balance examination with subjective vestibular tests.

### Material and Method:
The study group included 24 individuals (2M, 22F) with a mean age of 30.75 ±7 years (range, 18-50 years) with a history of MS, normal hearing and no chronic balance disorder other than MS. A control group was formed of 23 age-matched individuals (3M, 20F) with no history of MS and who met the same other conditions. The Graybiel scale was applied to all the participants and they were asked to rate the symptoms that may occur during a journey on a scale of one to ten. The Romberg, Fukuda, Tandem stance tests, Mini Balance Evaluation Systems Test (BESTest) and SF-36 scale were then applied. Differences between the study group and the control group were determined and correlation analysis was applied to the test results.

### Results:
A significant difference was determined between the groups in respect of the Graybiel scale scores and all symptom scores ($p<0.05$). No pathological findings were observed in any of the participants in the Romberg, Fukuda and Tandem stance tests. A significant difference was observed between the two groups in the Mini BESTest ($p<0.05$). In the SF-36, there were significant differences only in the physical functioning subscale ($p<0.05$). A significant negative correlation was determined between the scores of symptoms seen during a journey and the Graybiel scale and Mini BESTest results.

### Conclusion:
The results of the subjective balance evaluations demonstrated that the performance of individuals with motion sickness was worse and their quality of life was affected more than healthy individuals.

### Key Words:
Motion Sickness, Mini BESTest, Vestibular Disorder

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## ÖZ

### Amaç:

Bu çalışmanın amacı, hareket hastalığı olan bireyleri subjektif denge testleri ile değerlendirmek ve yaşam kalitelerini araştırmaktır.

### Gereç ve Yöntem:

Çalışma grubuna 18-50 yaş aralığında hareket hastalığı öyküsü olan, işitmesi normal ve hareket hastalığı dışında kronik denge bozukluğu olmayan 24 birey (2E, 22K yaş ortalaması 30,75 ±7), kontrol grubuna ise aynı şartları sağlayan ve hareket hastalığı öyküsü olmayan 23 birey (3E, 20K yaş ortalaması 31,34 ± 7) dâhil edildi. Katılımcılara Graybiel ölçeği uygulandı ve yolculuk esnasında oluşabilecek semptomları bir ila on arasında puanlamaları istendi. Sübjektif denge değerlendirmesi için Romberg, Fukuda, Tandem duruş testleri ile Mini BESTesti uygulandı ve hayat kalitelerini değerlendirmek için SF-36 ölçeği uygulandı. Çalışma grubu ile kontrol grubu arasında fark analizinden sonra, test sonuçları arasında korelasyon analizi uygulandı.

### Bulgular:

Graybiel ölçek puanlarında, yolculuk esnasındaki semptomlardan "bulanık görme" dışında tüm semptom puanlarında, Mini Balance Evaluation Systems Test (BESTest) sonuçlarında ve SF-36 ölçeğin fiziksel fonksiyon alt alanında gruplar arasında anlamlı fark elde edildi ($p<0,05$). Romberg, fukuda ve tandem duruş testlerinde her iki grupta da patolojik bulgu gözlenmedi. Ayrıca yolculuk esnasında görülen semptom puanları ve Graybiel ölçeği ile Mini BESTest sonuçları arasında negatif yönlü anlamlı korelasyon olduğu görüldü.

### Sonuç:

Sübjektif denge değerlendirmelerinin sonuçlarında hareket hastalığı olan bireylerin performansının sağlıklı bireylere göre daha kötü olduğu ve bu bireylerin yaşam kalitelerinin daha fazla etkilendiğini göstermiştir.



### Anahtar Sözcükler:

Hareket Hastalığı, Mini BESTest, Vestibüler Hastalık


## INTRODUCTION

Motion sickness (MS) is a common syndrome that emerges after exposure to certain types of movement. MS affects the balance functions of an individual on land, at sea, or in the air, and causes the symptoms such as nausea, vomiting, cold sweats, headache, dizziness, fatigue, and loss of appetite (1). MS is in the same category as car sickness, sea sickness, flying sickness, and space sickness. Sea sickness is the most common type of MS, and previous research has reported that 60% of experienced ship crews are affected (2). Although the pathophysiology of MS has not been completely clarified, in recent years the main reason for MS has been accepted as sensory input conflict causing the development of symptoms. According to this hypothesis, the information coming from the eyes, the semicircular canals, otolithic organs and/or proprioceptive senses during some movements creates confusion in the central nervous system. The symptoms of MS are formed as instinctive defense by the body trying to maintain balance during these movements (3). This disease is usually seen between the ages of two and twelve years, reaching a peak between four and 10-12 years, and is very uncommon under than two years and older than 50 years. It is seen 1.7 fold more in females than males (4).

Although MS is associated with some diseases such as migraine, it can also be seen in healthy individuals with normal vestibular function (5). Various studies have been conducted to investigate the complex pathophysiology of MS, such as examination of changes in salivation, questionnaires and scales, examination of changes in heart rhythm, examination of plasma hormone levels, and examination of changes in gastric motility (6-10). In addition, electronystagmography (ENG), vestibular evoked myogenic potentials (VEMP), dynamic posturography, vestibular autorotation test, and rotation test have been used to evaluate the vestibular system to determine the predisposition to MS (11, 12). Fowler et al., obtained higher amplitude results in the VEMP test evaluating the functions of otolith organs in a group predisposed to MS, whereas Buyuklu et al., found no significant difference between two groups (11, 13). Similar conflicting results have been obtained in studies as there is no definitive protocol for the evaluation of patients. There are not many studies in literature which have used subjective tests for the evaluation of balance in MS, and as there is no definitive evaluation protocol, subjective tests were used in this study.

In addition to dizziness, nausea, and other symptoms, MS can lead to disorders, generally with weak effects, such as a tendency to syncope, deteriorations in sleep quality and personal factors such as trait anxiety or neuroticism (14-16). All of these can have a negative effect on the quality of life of an individual. Even though there are studies in literature that have examined the balance functions of individuals with MS using different tests, very few studies have examined the quality of life of these individuals (11-13).

The aim of this study was to evaluate individuals with motion sickness using subjective balance tests and to examine the quality of life of these individuals. The hypothesis of this study is "Balance test results of individuals with motion sickness symptoms during travel are different from individuals without symptoms, and their quality of life is lower."

## MATERIAL and METHODS

### *Study Design*

The study included a total of 47 subjects, comprising 42 females and five males with a mean age of 31.04±7 years (range, 18-50 years). The participants were separated into two groups as those with a history of MS (study group) and those with no history of MS (control group). The study group included 24 subjects, comprising 22 females and two males with a mean age of 30.75±7 years, and the control group included 23 subjects, comprising 20 females and three males with a mean age of 31.34±7 years. The study exclusion criteria were defined as a history of hearing loss, or the presence of any acute or chronic balance problem.

Participants were asked whether they had ever suffered from vestibular disease or any other illness that could lead to loss of balance. After taking a detailed anamnesis, a hearing test in the 125-8000 Hz range was performed on all the participants to investigate the normal hearing condition of those who met the inclusion criteria. Then the Graybiel scale was applied to determine the predisposition to MS.

**Graybiel scale:**
This scale was designed to investigate the multiple dimensions of MS, characterized by the six important symptoms of nausea-vomiting, skin color, salivation changes, cold sweats, headache, and dizziness (8).

To confirm the scale, the patients were requested to score all the symptoms that could occur during a journey (dizziness, nausea, vomiting, lack of balance, sleepiness, lack of concentration, blurred vision, lethargy, restlessness, loss of appetite, cold sweats, and sensitivity to smell) from one to ten, where one represents the lowest and ten the highest intensity of symptoms.

The study participants who fully completed the Graybiel and symptom scales, were then subjected to the Romberg test, the Tandem Stance test, the Fukuda test, and the MiniBESTest to subjectively evaluate balance.

In the Romberg test, the patient is asked to maintain balance in a position with her eyes open or closed, feet shoulder-width apart, and arms relaxed at the sides (17).

In Tandem test the subject is instructed to maintain balance by placing one foot in front of the other with the eyes open and closed (17).

**Fukuda (Unterberger test):**
The subject is instructed to walk forward with eyes closed and the arms extended forward. A deviation of >45° to the left or right suggests a pathological condition (17).

**Mini-BESTest:**
This clinical balance assessment tool is a shortened version of the Balance Evaluation Systems Test (BESTest). This test can determine potential balance disorders and can explain the reasons. It is also accepted as one of the most comprehensive balance evaluation scales to determine the underlying postural control systems of poor functional balance (18). The test includes sections such as anticipatory postural regulation, reactive postural control, sensory orientation, dynamic walking. The Short- Form (SF)-36 was used to evaluate the quality of life of the study participants.

**SF-36:**
This scale evaluates the perceived physical and mental health of the subjects. The SF-36 contains 36 specific items in eight subscales of physical function, physical role function, body weight, general health, vitality, social function, emotional role function, and mental health (19).

### *Statistical Analysis*

Data obtained in the study were analyzed statistically using SPSS version. 22.0 software. Conformity of the data to normal distribution was assessed with the Shapiro-Wilk test. In the statistical analyses between the groups, the Independent Samples t-test was applied to variables with normal distribution, and the Mann Whitney U-test to variables not showing normal distribution. The level of statistical significance was set as $p<0.05$. Relationships between numerical variables were examined with Spearman rho correlation analysis.

## RESULTS

The demographic information of all the study participants was analyzed. No significant difference was observed between the study group and the control group with respect to age and gender ($p>0.05$).
The pure tone average of all the subjects in both groups was < 25 dB.
The MiniBESTest scores were determined to be significantly different between the study group and control group ($p<0.05$) (Table I).

**Table I.** Mini BESTest Results

| | Study Group | | Control Group | | P value |
|---|---|---|---|---|---|
| Mini BEST | Mean | SD | Mean | SD | |
| | 26.75 | 1.0 | 27.78 | 1.03 | 0.001 |

SD: Standard deviation

The Graybiel scale points were determined to be statistically significantly higher in the study group than in the control group, as expected ($p<0.05$). With the exception of the blurred vision symptom, the points of symptoms

during a journey of the study group were significantly higher than those of the control group (p<0.05) (Table II).

**Table II.** Symptoms During a Journey

| | Study Group | | Control Group | | P value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Graybiel Scale | 27.41 | 9.96 | 4.04 | 2.91 | 0.001* |
| Blurred vision | 1.04 | 1.6 | 0.34 | 1.1 | 0.10 |
| Loss of concentration | 2.12 | 2.6 | 0.26 | 1.0 | 0.03* |
| Sleepiness | 4.91 | 3.2 | 2.0 | 2.2 | 0.01* |
| Loss of appetite | 4.7 | 3.4 | 0.43 | 1.3 | 0.001* |
| Restlessness | 4.29 | 2.8 | 0.39 | 1.4 | 0.001* |
| Lethargy | 4.62 | 2.8 | 0.82 | 1.7 | 0.001* |
| Cold sweats | 3.12 | 2.5 | 0.40 | 1.2 | 0.001* |
| Loss of balance | 2.87 | 2.5 | 0.08 | 0.2 | 0.001* |
| Dizziness | 4.58 | 3.2 | 0.47 | 1.2 | 0.001* |
| Sensitivity to smell | 5.08 | 3.7 | 1.30 | 2.6 | 0.001* |
| Vomiting | 4.66 | 3.7 | 0.17 | 0.6 | 0.001* |
| Nausea | 6.50 | 2.6 | 0.43 | 0.8 | 0.001* |

SD: Standard deviation, *:p<0.05

When the Graybiel scale points were compared according to gender, the scores of females (16.7 ±14.2) were statistically significantly higher than the points of males (7.5±3.1) (p<0.05).

In the Romberg test, Tandem Stance and the Fukuda test, no pathological findings were determined such as falling or direction deviation in any subject.

A statistically significant difference was determined between the two groups only with respect to the physical function score of the SF-36, (p<0.05) (Table III).

**Table III.** Short- Form (SF)-36 Results

| | Study Group | | Control Group | | P value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Physical Functioning | 76.87 | 18.22 | 90.43 | 18.33 | 0.015* |
| Role limitations due to physical health | 67.70 | 35.72 | 75.00 | 32.85 | 0.47 |
| Restrictions due to emotional problems | 63.96 | 37.97 | 59.70 | 45.85 | 0.73 |
| Energy-Fatigue | 52.70 | 21.00 | 53.26 | 19.51 | 0.92 |
| Emotional well-being | 56.83 | 22.68 | 59.30 | 15.80 | 0.66 |
| Pain | 60.41 | 21.93 | 68.58 | 23.76 | 0.22 |
| General health | 59.79 | 18.73 | 58.91 | 15.37 | 0.86 |
| Social function | 63.54 | 18.76 | 70.10 | 20.55 | 0.25 |
| Health change | 51.04 | 21.46 | 54.34 | 19.44 | 0.58 |

SD: Standard deviation, *:p<0.05

The relationships between the MiniBESTest scores, the Graybiel scale and the symptoms during a journey were examined. With the exception of sensitivity to smell, blurred vision, sleepiness, and loss of appetite, a significant correlation was determined between all the other symptom points and the MiniBESTest balance points (p<0.05). The Graybiel scale and the symptom score results were found to be consistent with each other. The results are summarized in Table IV.

**Table IV.** Correlation Analysis Results

| | | r | p | | | r | p |
|---|---|---|---|---|---|---|---|
| Mini BEST | Graybiel Scale | -0.39 | 0.006* | Graybiel scale | Blurred vision | 0.24 | 0.1 |
| | Blurred vision | -0.22 | 0.13 | | Loss of concentration | 0.35 | 0.01* |
| | Loss of concentration | -0.33 | 0.023* | | Sleepiness | 0.46 | 0.001* |
| | Sleepiness | -0.23 | 0.13 | | Loss of appetite | 0.56 | 0.001* |
| | Loss of appetite | -0.26 | 0.067 | | Restlessness | 0.78 | 0.001* |
| | Restlessness | -0.29 | 0.04* | | Lethargy | 0.67 | 0.001* |
| | Lethargy | -0.33 | 0.02* | | Cold sweats | 0.54 | 0.001* |
| | Cold sweats | -0.38 | 0.009* | | Loss of balance | 0.65 | 0.001* |
| | Loss of balance | -0.3 | 0.03* | | Dizziness | 0.62 | 0.001* |
| | Dizziness | -0.33 | 0.02* | | Sensitivity to smell | 0.53 | 0.001* |
| | Sensitivity to smell | -0.27 | 0.06 | | Nausea | 0.83 | 0.001* |
| | Nausea | -0.33 | 0.02* | | Vomiting | 0.8 | 0.001* |
| | Vomiting | -0.43 | 0.002* | | | | |

*: p < 0.05

## DISCUSSION

The aim of this study was to evaluate the balance function of individuals with motion sickness (MS) using subjective tests and to investigate quality of life. Although the diagnosis of MS is difficult, it is possible to determine a predisposition to this disease with investigative scales. In this study, the Graybiel scale was used and the mean scale points of the study group were determined to be significantly higher than those of the control group. The study group were requested to score the symptoms which could be seen during a journey from one to ten points, and with the exception of blurred vision, the mean points for all the other symptoms were determined to be significantly high. A significant positive correlation was determined between the Graybiel scale and the self-scored symptoms of lack of concentration, restlessness, lethargy, cold sweats, loss of balance, dizziness, nausea and vomiting. This may be evidence of the efficacy of the Graybiel scale in the determination of MS.

Conflicting or inconsistent information coming from the vestibular, visual or proprioceptive organs causes MS symptoms to emerge (20). Especially in automated vehicles (train, ship, plane, etc.), symptoms may be more apparent as individuals wish to engage in different activities which do not require observation of the road during the journey (21). The anamnesis and symptoms during travel of the subjects in the study group support the "sensory input confusion" hypothesis of MS, the pathophysiology of which is not clearly defined (3). One of the hypotheses for the occurrence of symptoms during travel is nystagmus, which is related to the optokinetic reflex (OKR) and partly to the vestibulo ocular reflex (VOR). With different visual inputs, input from the oculomotor nerves to the brainstem increases and nystagmus occurs with intraocular pressure. This confusion results in MS symptoms. However, when the gaze is stabilized, the symptoms are less pronounced (22).

While no pathological findings were determined in either group in the subjective balance evaluation of the Fukuda, Tandem Stance, and Romberg tests, significantly lower scores were obtained in the study group for the MiniBESTest, which provides a practical evaluation of postural control and balance disorders. Just as in other diseases, individuals with MS adapt in daily life when the process is not complex in a way that supports the sensory input confusion hypothesis. When individuals are occupied with things such as reading a book or looking at a phone screen, especially in public transportation and large vehicles where the oscillation is greater, vestibular-visual discrepancy increases. This increases the likelihood of symptoms occurring.

The severity and duration of MS depends on the incompatibility of the sensory input signals to the movement and the ability of the individual to adapt to an abnormal environment (23). Incompatibilities in the perception of the body position by peripheral receptors perceiving movement of the internal organs in the abdominal region and visual or vestibular clues are the probable cause of many cases of MS. Postural adaptation can minimize this incompatibility or can allow neuro-sensory compensation. This theory explains why experienced sailors adapt to sea conditions more quickly than those who are inexperienced and why many people feel seasick for the first few days on a ship but this feeling subsides over time (24).

The MiniBESTest allows the multi-directional evaluation of balance with tests such as standing from a sitting position, compensatory stepping, and standing with eyes open and closed on a spongy surface and on a sloping ramp. The reason that patients obtain low points in this test could be the challenging movements in the test other than the movements providing adaptation in daily life. In a previous study, it was reported that the mean postural oscillation rate on both hard and soft surfaces with eyes open and closed, was higher in individuals with MS compared to healthy individuals (25). The results of current study are consistent with the literature. In addition, a significant negative correlation was determined in the current study between the symptom points and the Graybiel scale and MiniBESTest results. This result indicates that individuals with severe symptoms seen during a journey experience difficulty in adaptation and obtained lower points in the balance evaluation.

The SF-36 was used in the current study to evaluate general health and quality of life of the participants. From the sub-sections, only physical function showed a significant difference between the two groups. Other than general health, the control group subjects obtained higher points in all the other areas, but not at a level of statistical significance. In a study conducted on individuals who frequently travel by sea and have MS symptoms, it was reported that individuals with nausea and vomiting experienced had lower quality of life, more concentration impairment, more physical fatigue, loss of appetite and decreased spontaneous movements compared to other individuals (26). In another study, the subjects watched a 360° city panorama, which was reflected visually to create MS symptoms, and the effect was examined on sleep quality and dizziness in daily life, and no significant difference or correlation was observed (26). It is thought that difference obtained in the physical function sub-section in the current study was due to the questions about challenging activities such as moving a table, lifting a heavy object, going up stairs, and swimming. The adaptations developed by the individuals with MS may not have severely restricted daily life in other areas.

### *Limitations*

A limitation of this study in respect of the reliability of the analyses could be said to be the predominance of females who volunteered to participate in the study and met the criteria.

## CONCLUSION

In several studies of MS, the etiology of which has not yet been clarified, it can be understood from the MiniBESTest results that it leads to severe problems, including balance. It was observed that the quality of life decreased according to the SF-36 scores. There is a clear need for further studies to clarify the etiology of this disease and to establish an evaluation protocol.

**Ethics Committee Approval:**
This research complies with all the relevant national regulations, institutional policies and is in accordance the tenets of the Helsinki Declaration, and has been approved by the Karamanoglu Mehmetbey University Faculty of Medicine (Non-Interventional) Ethics Committee (approval number: 08-2021/07).

**Informed Consent:**
All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

**Author Contributions:**
Concept – M.C, F.Y.; Design - M.C.; Supervision – F.Y.; Resources - M.C, F.Y.; Materials - M.C.; Data Collection and/or Processing - M.C., F.Y.; Analysis and/ or Interpretation - M.C., F.Y.; Literature Search – M.C.; Writing Manuscript – M.C..; Critical Review – F.Y.

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

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