Turkish Journal of Clinical Research

Turk J Clin Res. 2025;1(2):108-115
https://doi.org/10.63909/1453019

RESEARCH ARTICLE

Evaluation of utricular and cognitive vestibular functions in community-dwelling elderly individuals

Toplumda yaşayan yaşlılarda utriküler ve bilişsel vestibüler fonksiyonların değerlendirilmesi

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Abstract

Aim: Balance and gait disorders, which are common in the elderly, are also the leading causes of falls. Vestibular disorders in geriatric individuals are often accompanied by impairments in spatial functions. This study aimed to investigate the relationship between utricular function, assessed by the bucket test, and cognitive vestibular functions, evaluated through a questionnaire, in individuals aged 60 and over living in the community.

Methods: Thirty individuals aged 60 and above were included in the study. The Mini-Mental State Examination, Snellen Chart, Bucket Test, and Cognitive Vestibular Function Scale were administered. The relationship between the subscale scores and total score of the Cognitive Vestibular Function Scale and the findings of the Bucket Test was examined.

Results: The study included 15 men and 15 women. The median age of men was 63 (62-67), and the median age of women was 66 (60-67). The median total clockwise Bucket Test score for all participants was 1.2 (0.4–2.8), while the median counterclockwise score was 1.4 (0.5–2.2). A statistically significant difference was observed between genders in Spatial Memory (SM) scores. However, no significant relationship was found between the cognitive vestibular function and utricular function (p>0.05).

Conclusion: In our study, no significant relationship was found between utricular function and self-reported cognitive vestibular function. Additionally, the Bucket Test findings obtained from geriatric individuals may serve as normative data in older adults. Future studies using similar designs in elderly patients presenting with vestibular disorders may help clarify the relationship between utricular function and cognitive vestibular function.

Keywords: Geriatrics, cognitive dysfunction, vestibular diseases, postural balance, elderly.

Özet

Amaç: Yaşlılarda sık görülen denge bozukluğu ve yürüme bozuklukları düşmelerin de en sık nedenidir. Geriatrik bireylerde meydana gelen vestibüler bozukluklar ile beraber uzamsal işlevlerde de bozulmalar görülmektedir. Bu araştırmada, toplumda yaşayan 60 yaş ve üzeri yaşlı bireylerde kova testi ile değerlendirilen utriküler fonksiyon ile anket ile değerlendirilen bilişsel vestibüler fonksiyonlar arasındaki ilişkiyi araştırmak amaçlandı.

Yöntemler: Çalışmaya 60 yaş ve üzeri otuz birey dahil edildi. Katılımcılara Mini Mental Durum Testi, Snellen Kartı, Kova Testi ve Bilişsel Vestibüler Fonksiyon Ölçeği uygulandı. Bilişsel Vestibüler Fonksiyon Ölçeği'nin alt ölçek ve toplam puanları ile Kova Testi bulguları arasındaki ilişki incelendi.

Bulgular: Çalışmaya 15 erkek ve 15 kadın dahil edildi. Erkeklerin ortanca yaşı 63 (62-67), kadınların ortanca yaşı ise 66 (60-67) idi. Tüm katılımcılar için saat yönünde Kova Testi toplam ortanca puanı 1,2 (0,4–2,8), saat yönünün tersine puanı ise 1,4 (0,5–2,2) olarak bulundu. Uzamsal Bellek (SM) puanlarında cinsiyetler arasında istatistiksel olarak anlamlı bir fark gözlendi. Ancak, bilişsel vestibüler fonksiyon ile utriküler fonksiyon arasında anlamlı bir ilişki saptanmadı (p>0,05).

Sonuç: Utriküler fonksiyon ile hastanın kendi bildirdiği bilişsel vestibüler fonksiyon arasında anlamlı ilişki saptamamış olduğumuz çalışmamızda, geriatrik bireylerden elde ettiğimiz Kova Testi bulguları yaşlılarda normatif veri olarak kullanılabilir. Vestibüler bozukluklar ile başvuran yaşlılarda benzer çalışma dizaynının kullanıldığı araştırmalar, utriküler fonksiyon ve vestibüler bilişsel fonksiyon arasındaki ilişkinin değerlendirilmesinde belirleyici olabilir.

Anahtar Kelimeler: Geriatri, bilişsel disfonksiyon, vestibüler hastalıklar, postural denge.

INTRODUCTION

Aging is defined as a period in which an individual's physical and cognitive conditions deteriorate and losses occur in many functions and relationships throughout life. According to the World Health Organization, the age range of 45–59 is considered middle-aged, 60–74 is elderly, 75–89 is advanced elderly, and 90 and above is

Corresponding Author: Banu MUJDECI banumujdeci@gmail.com
Cite as: Mujdeci B, Gulmez IC, Yalcin B, Sahin P, Acar SN. Evaluation of utricular and cognitive vestibular functions in community-dwelling elderly individuals. Turk J Clin Res. 2025;1(2):108-115

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Received: 27 June 2025 | **Accepted:** 16 September 2025 | **Published:** 30 September 2025

Turk J Clin Res. 2025;1(2):108-115
https://doi.org/10.63909/1453019

old age (1). Nearly one-third of elderly individuals over the age of 65 in the community experience falls, and the risk of falling increases with age (2). The presence of conditions such as dementia, which affect cognitive functions, further increases this risk in old age (3).

Balance and gait disorders, commonly seen in the elderly, are the leading causes of falls (4). Approximately 30% of individuals aged 75 and above experience falls each year, and recent data show that the mortality rate due to falls has more than doubled from 2000 to 2016, rising from 51.6% to 122.2% (5). Vestibular disorders seen in geriatric individuals are accompanied by impairments in spatial functions. In particular, there is evidence of spatial perception and cognitive dysfunction in individuals with bilateral vestibulopathy (6–8). With aging, spatial perception, orientation, and posture deteriorate, and falls increase. Falls result in injuries and reduce the quality of life of elderly individuals, adversely affecting their social life (9). The vestibular system plays an important role in maintaining spatial orientation and postural control (10).

A utricular disorder prevalence of 20% has been observed in geriatric individuals (11). With aging, evaluating and intervening in falls becomes even more challenging (12). Among the clinical tests used to evaluate otolith function is the Subjective Visual Vertical (SVV) test. The purpose of the SVV test is to detect abnormal subjective tilting and to evaluate utricular function, which is responsible for vertical perception. The ability to perceive verticality depends on inputs from visual, vestibular, and somatosensory systems (13). SVV is affected by degeneration and lesions in central or peripheral vestibular pathways. Deviations in SVV indicate impaired spatial orientation in patients with central or peripheral vestibular disorders (14–17). Although symptoms and findings associated with otolith dysfunction have not been clearly defined in the literature, sensations such as vertigo, translation, tilting, floating, or inversion are thought to originate from otolith dysfunctions (18–20).

This study aimed to investigate the relationship between utricular function, which enables spatial perception, and cognitive vestibular functions in individuals aged 60 and above living in the community, using the Cognitive Vestibular Function Scale and Subjective Visual Vertical test.

METHODS

This study, aimed at evaluating cognitive vestibular functions and utricular function in the geriatric population, was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University (approval date: 23.11.2023, decision no: 09-412). All participants were informed in detail about the tests, and their verbal and written consents were obtained.

Population and Sample of the Study

The population of the study consisted of geriatric individuals living in the community in Ankara. The sample included 30 voluntary individuals aged 60 years and older who met the inclusion criteria. Participants included were those without a history of balance disorder or hearing loss, no history of ear surgery, no uncontrolled systemic diseases, normal vision or corrected vision with a Snellen Chart score of 0.7, a Mini-Mental State Examination score of 24 or above, and no orthopedic or musculoskeletal problems. Each participant was assessed under equal conditions, in the same setting, and within a single session.

The Cognitive Vestibular Function Scale and the bucket test were used as data collection tools. The Mini-Mental State Examination was used to assess cognitive status, and the Snellen Chart was used to evaluate vision in determining eligible participants. All assessments in this observational cross-sectional study were conducted face-to-face.

Snellen Chart

The Snellen Chart was applied to participants, and individuals with a visual acuity score of 0.7 or higher were included in the study (21).

Mini-Mental State Examination

Participants were administered the Mini-Mental State Examination, a simplified and scored form of cognitive status assessment, whose Turkish validity and reliability have been confirmed (22,23). Individuals with a score of 24 or above were included in the study.

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İstanbul Aydın University (IAU) Cognitive Vestibular Function Scale

IAU Cognitive Vestibular Function Scale, validated and made reliable by Ozkul and Konukseven, was applied to all participants. This scale consists of 20 items with a 5-point Likert scale corresponding to each item. The Likert scale is scored as follows: "Always (5 points)," "Frequently (4 points)," "Sometimes (3 points)," "Rarely (2 points)," and "Never (1 point)." The scale evaluates four subscales: 7 items (items 1–7) assess Vestibular (V) function (max 35 points), 5 items (items 8–12) assess Spatial Memory (SM) (max 25 points), 4 items (items 13–16) assess Spatial Visual Memory (SVM) (max 20 points), and 4 items (items 17–20) assess Temporal Memory (TM) (max 20 points). Items 7, 8, and 19 are reverse scored. The total score across these four subscales (V, SM, SVM, and TM) indicates the participant's overall score. The maximum total score a participant can achieve is 100. A higher score indicates greater dysfunction. Different groupings can be made based on the subscale and total scores (24).

Bucket Test

To assess utricular function, all participants were administered the bucket test. The test uses a bucket with a bright yellow straight line on its inner base and an angle scale on the outer base. During the test, participants were instructed to keep their heads upright and steady, and both eyes open. The participants' faces were aligned with the bucket so that their entire field of vision was inside the bucket. They were asked to look at the yellow line inside the bucket. Participants were informed that the bucket would be rotated five times clockwise and five times counterclockwise. They were told to signal the researcher when they perceived the yellow line as vertically aligned with the ground. The test was performed with 10 repetitions—5 in each direction. The bucket was rotated between 0–45 degrees, and deviations from vertical were measured using the scale on the outer base and recorded. Average deviations greater than 4.0° were considered pathological (25). The bucket used in the study is shown in Figure 1.

Statistical Analysis

IBM SPSS Statistics (Version 21, Armonk NY, USA) software package was used for statistical analysis. For independent group comparisons of quantitative variables, Student's t-test was used when parametric test assumptions were met, and the Mann-Whitney U test was used when these assumptions were not met. For correlation analysis of quantitative variables,



Figure 1. External (Figure 1.a) and internal (Figure1.b) views of the bucket used in the study

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Spearman's correlation was used when normality assumptions were not satisfied. A significance level of $p<0.05$ was considered statistically significant.

RESULTS

The demographic data of the 30 participants are presented in Table 1. The age variable was analyzed between genders using the Mann-Whitney U test, and no statistically significant difference was found between genders (Z =-0.338; p=0.744).

Table 1. Demographic information of the participants

Participants (n=30)	Male (n=15)	Male (n=15)	p
Age (Years) Median (Q1–Q3)	66 (60-67)	63 (62-67)	0.744

n=Number of individuals, Q1=First quartile, Q3= Third quartile, p= Significance level, p<0.05 was considered statistically significant.

The median clockwise Bucket Test total score of female participants was 1 (0.4–2.0) degrees, while that of male participants was 2 (1.0–2.8) degrees. The mean counterclockwise bucket test score of female participants was 1.34±0.94 degrees, and that of male participants was 1.77±1.48 degrees. The Bucket Test results by gender are presented in Table 2. No significant differences were found between genders in terms of clockwise bucket test results and counterclockwise bucket test results (p=0.161 and p=0.355, respectively) (Table 2).

The median clockwise Bucket Test total score of all participants was 1.2 (0.4–2.8), and the median counterclockwise score was 1.4 (0.5–2.2) (Table 3).

Table 2. Bucket test results by gender

Participants (n=30)	Female (n=15)	Male (n=15)	Test statistic and p Value
Clockwise Rotation Bucket Results (Degrees) [Median (Q1–Q3)]	1 (0.4-2.0)	2 (1.0-2.8)	Z=-1.417; p=0.161
Counterclockwise Rotation Bucket Results (Degrees) [Mean±SD]	1.34±0.94	1.77±1.48	t=-0.94; p=0.355

n=Number of participants, Q1=First quartile; Q3=Third quartile; SD=Standard Deviation; Z=Standardized Value Of The Mann–Whitney U Test; t=Student's t-test statistic, p=Significance level, p<0.05 was considered statistically significant.

Table 3. Overall median scores of the bucket test in all participants

	Overall median scores of the bucket test in all participants
Clockwise Rotation Bucket Results (Degrees) [Median (Q1–Q3)]	1.2 (0.4–2.8)
Counterclockwise Rotation Bucket Results (Degrees) [Median (Q1–Q3)]	1.4 (0.5–2.2)

n=Number of individuals, Q1=First quartile; Q3=Third quartile

The mean score of the Cognitive Vestibular Function Scale for all participants was 36.20±7.86. The mean score of the SM subscale was 10.47±3.09. The median score of the V subscale was 11.50 (8, 14), the SVM subscale median was 6 (5, 7.25), and the TM subscale median was 6 (5.75, 9) (Table 4).

Table 4. Total cognitive vestibular function scale and subscale scores of the all participants

	Total Cognitive Vestibular Function Scale (Degrees) [Mean±SD]	V (Degrees) [Median (Q1-Q3)]	SM (Degrees) [Mean±SD]	SVM (Degrees) [Median (Q1-Q3)]	TM (Degrees) [Median (Q1-Q3)]
Participants (n=30)	36.20±7.86	11.50 (8-14)	10.47±3.09	6 (5-7.25)	6 (5.75-9)

n=Number of participants, Q1=First Quartile, Q3=Third Quartile, SD=Standard Deviation, V=Vestibular, SM=Spatial Memory, SVM=Spatial Visual Memory, TM=Temporal Memory

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The SM subscale scores were compared by gender using Student's t-test. A statistically significant difference was found between genders in SM scores (p=0.031; t =2.272), and the variances between genders were homogeneous (p=0.262; F=1.309) (Figure 2).

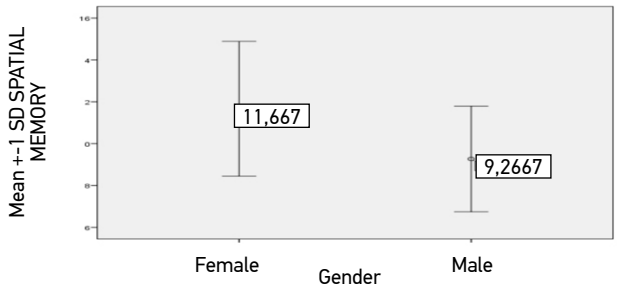

Figure 2. Error bar graph showing spatial memory (sm) subscale scores by gender

No statistically significant difference was found between the clockwise and counterclockwise bucket test results among participants (Z =–0.024; p=0.981).

No significant relationships were found between the clockwise Bucket Test results and the subscales of the Cognitive Vestibular Function Scale-V, SM, SVM, and TM. There was also no significant correlation between the clockwise bucket test results and the total score of the Cognitive Vestibular Function Scale (Table 5).

Similarly, no significant relationships were found between the counterclockwise bucket test results and the V, SM, SVM, and TM subscales. No significant correlation was found between the counterclockwise bucket test results and the total score of the Cognitive Vestibular Function Scale either (Table 5).

DISCUSSION

Balance disorders are among the most important causes of falls in elderly individuals, and there are still gaps in understanding them properly (26). Understanding vestibular disorders associated with aging is crucial for preventing falls and maintaining upright balance in the elderly. In a study by Totilienė et al., upright vertical perception in individuals aged 65 and over was evaluated using the virtual reality-based systemfor SVV assessment (VIRVEST) system (27). The most commonly used test to assess verticality perception is the SVV test (28).

Michelson et al. emphasized that the Bucket Test is a low-cost, simple, and effective method for assessing SVV (28). In line with the literature, our study used the Bucket Test as a practical and affordable method for evaluating vertical perception in older adults (29,30).

In our study, no significant difference was found in clockwise and counterclockwise bucket test results between genders, which aligns with findings in the literature (25,31). The rotation angles in both directions were below the commonly accepted pathological cutoff value of 4 degrees (25). Given that the participants had no health conditions that could affect the test, the bucket test results are considered to be within normal limits. Therefore, the findings may serve as normative data for individuals aged 60 and over.

Previous studies have examined the relationship between dysfunctions in the saccule and semicircular canals and cognitive performance, suggesting that such dysfunctions may significantly affect cognition (32). However, unlike the literature, our study did not find a significant relationship between utricular function and cognitive vestibular function in the elderly. We believe

Table 5. The relationship between clockwise and counterclockwise rotation and the subscales of the cognitive vestibular scale

		V	SM	SVM	TM	Total Scale Score
Clockwise Rotation	rs	0.233	-0.130	0.082	-0.173	0.022
	p	0.216	0.494	0.668	0.362	0.909
Counterclockwise Rotation	rs	0.137	0.019	-0.191	0.015	0.055
	p	0.472	0.919	0.313	0.938	0.772

V= Vestibular, SM= Spatial Memory, SVM=Spatial Visual Memory, TM=Temporal Memory, rs=Spearman's Correlation Coefficient, p=Significance Level, p<0.05 was considered significant.

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this may be due to the absence of vestibular symptoms in our participants. Because no standardized scale exists specifically to assess individuals' perceptions related to utricular function, we used the Cognitive Vestibular Function Scale, which has been standardized in Turkey for evaluating general cognitive vestibular functions.

The vestibular subscales and total scale scores are categorized as follows: scores between 7–14 on Vestibular (V) subscale, 5–10 on the Spatial Memory (SM) subscale, and 4–8 on both the Spatial Visual Memory (SVM) and Temporal Memory (TM) subscales are considered normal. A total score of 20–40 is also considered within the normal range (24). That all participants had scores within normal limits on both subscales and the total scale may reflect the absence of vestibular symptoms.

Although the bucket test used in our study provides an objective assessment of isolated utricular function, the Cognitive Vestibular Function Scale reflects the individual's subjective perception. This may explain why no significant correlation was observed between the two assessments. Our findings underline the need for developing standardized scales that specifically evaluate symptoms associated with isolated utricular dysfunction.

In a study involving both healthy individuals and those with acute peripheral or central vestibular lesions, bucket test results were within normal limits in healthy individuals (mean age 46.1±16.4) but showed pathological deviations in patients (mean age 51.3±17.1) (32). Similarly, the deviations observed in our healthy elderly participants (aged 60+) without balance or systemic problems were also within normal limits, supporting the potential use of the bucket test as a quick, low-cost screening tool in the elderly.

While virtual SVV assessments can be used for evaluating verticality perception (29), the standard bucket test is more cost- and time-efficient (30,33).

One limitation of our study is that only the bucket test was used to assess SVV. Incorporating additional devices or tests could enhance the reliability of the results. Another limitation is the lack of a Turkish scale specifically designed to assess isolated utricular function.

CONCLUSION

As the risk of falling increases with age, it becomes increasingly important to evaluate the utricle, which is responsible for maintaining the perception of verticality. One of the tests that can be used to assess the utricle is the bucket test, which offers several advantages in terms of both cost and time.

Although our study did not find a significant relationship between utricular function, as evaluated by the bucket test, and cognitive vestibular function, as self-reported via questionnaire, we believe our findings can serve as a foundation for future research. The Bucket Test results obtained in this study may be used as normative data for the geriatric population.

Further studies evaluating the relationship between utricular function and cognitive vestibular function in elderly individuals with vestibular symptoms or diagnosed vestibular disorders could provide valuable insights and contribute to fall prevention strategies in older adults.

Acknowledgement: None.

Ethical Approval: This study was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University (approval date: 23.11.2023, decision no: 09-412).

Author Contributions: Idea/Concept: B.M., I.C.G., B.Y., P.S., S.N.A.; Design: B.M., I.C.G., B.Y., P.S., S.N.A.; Supervision: B.M.; Resources: I.C.G., B.Y., P.S., S.N.A.; Materials: I.C.G., B.Y., P.S., S.N.A.; Data Collection and/or Processing: I.C.G., B.Y., P.S., S.N.A.; Analysis and/or Interpretation: I.C.G., B.Y., P.S., S.N.A.; Literature Review: B.M., I.C.G., B.Y., P.S., S.N.A.; Written by: B.M., I.C.G., B.Y., P.S., S.N.A.; Critical Review: B.M., I.C.G., B.Y., P.S., S.N.A.

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

Financial Disclosure: None.

Turk J Clin Res. 2025;1(2):108-115
https://doi.org/10.63909/1453019

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