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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Assessment of Fall Risk, Reaction Time, Spatial Orientation, and Lower Extremity Strength in Dementia Patients: A Correlation Analysis

Demans Hastalarında Düşme Riski, Reaksiyon Süresi, Uzamsal Oryantasyon ve Alt Ekstremite Kuvvetinin Değerlendirilmesi: Bir Korelasyon Analizi

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ABSTRACT

Introduction: Dementia is an important disease leading to cognitive decline and dysfunction in geriatric individuals. The increased risk of falls in patients with dementia leads to decreased quality of life as well as increased health costs. This study aims to evaluate the relationship between fall risk, reaction time, spatial orientation, and lower extremity strength in patients with dementia by analyzing the interaction of cognitive and physical factors.

Materials and Methods: Thirty participants with mild to moderate dementia were recruited from nursing homes in Ankara, Turkey. The participants were administered the Johns Hopkins Fall Risk Assessment Tool (JHDRDA), the Spatial Orientation Test, reaction time measurement and the 30 Second Sit and Stand Test. Correlation analyses were performed to examine the relationships between these factors.

Results: Significant associations were found between JHFRAT scores and reaction time (r=0.518, p=0.004), spatial orientation (r=-0.389, p=0.037), and lower extremity strength (r=-0.478, p=0.009). These findings highlight the need for holistic fall prevention strategies addressing both cognitive impairments and physical limitations in dementia patients.

Conclusion: As a result of the study, cognitive impairments and physical factors were found to be associated with the risk of falls in patients with dementia. To reduce the risk of falls and improve the quality of life of people with dementia, patients should be assessed comprehensively. These findings emphasize the need for holistic fall prevention strategies that address both cognitive impairments and physical limitations in patients with dementia.

Keywords: dementia, falls, reaction time, spatial orientation, muscle strength

ÖZET

Giriş: Demans, geriatrik bireylerde bilişsel gerilemeye ve disfonksiyona yol açan önemli bir hastalıktır. Demans hastalarında artan düşme riski, yaşam kalitesinin düşmesine ve sağlık maliyetlerinin artmasına yol açmaktadır. Bu çalışma, bilişsel ve fiziksel faktörlerin etkileşimini analiz ederek, demans hastalarında düşme riski, reaksiyon süresi, uzamsal yönelim ve alt ekstremite kuvveti arasındaki ilişkiyi değerlendirmeyi amaçlamaktadır.

Materyal ve Metot: Hafif ve orta şiddette demansı olan 30 katılımcı Ankara, Türkiye'deki huzurevlerinden seçilmiştir. Katılımcılara Johns Hopkins Düşme Riski Değerlendirme Aracı (JHDRDA), Uzamsal Oryantasyon Testi, reaksiyon süresi ölçümü ve 30 Saniye Otur Kalk Testi uygulanmıştır. Bu faktörler arasındaki ilişkileri incelemek için korelasyon analizleri yapılmıştır.

Bulgular: JHDRDA skorları ile reaksiyon süresi (r=0,518, p=0,004), uzaysal oryantasyon (r=-0,389, p=0,037) ve alt ekstremite kuvveti (r=-0,478, p=0,009) arasında anlamlı ilişkiler bulunmuştur.

Sonuç: Çalışma sonucunda, demans hastalarında düşme riski ile bilişsel bozukluklar ve fiziksel faktörler ilişikili bulunmuştur. Düşme riskini azaltmak ve demanslı bireylerin yaşam kalitesini artırmak için hastalar kapsamlı bir şekilde ele alınmalıdır. Bu bulgular, demans hastalarında hem bilişsel bozuklukları hem de fiziksel sınırlamaları ele alan bütüncül düşme önleme stratejilerine olan ihtiyacı vurgulamaktadır.

Anahtar Sözcükler: demans, düşme, reaksiyon süresi, uzamsal oryantasyon, kas kuvveti

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Introduction

Millions of people worldwide are struggling with dementia, an intricate and incapacitating neurological condition that causes cognitive decline, memory loss, and a loss of autonomy. This condition presents significant issues in offering the necessary care and support to the affected individuals. One of the most important problems in dementia is the risk of falling, which occurs with the decline in physical and cognitive abilities. The risk of falling and the resulting injuries can be both fatal for the patient and lead to high health expenditures (1).

There is a complex link between the risk of falls in people with dementia and their cognitive abilities as well as their physical health. Memory, attention, and decision-making problems caused by dementia can make it more difficult for the patient to perceive their surroundings and recognize potential fall risks (2,3). Furthermore, impairments in physical fitness, including muscle strength, balance, and coordination, which are common in people with dementia, can further increase the risk of falls (4). Poor muscle strength and balance compromise an individual's capacity to respond to unexpected changes, increasing their vulnerability to falls. In contrast, regular physical exercise tailored to the patient can contribute to maintaining muscle tone, balance, and overall mobility, thus reducing the risk of falls (5).

The relationship between fall risk and various physiological and cognitive factors such as spatial orientation, reaction time and lower limb strength is of great importance in understanding the mechanisms that increase the risk of falls in patients with dementia. Dementia is a disease characterized by progressive deterioration of cognitive functions that impairs an individual's ability to accurately perceive their environment. As spatial orientation decreases, so does the patient's awareness of obstacles, changes in the ground and distances (6,7). This is a major problem that can result in falls.

The effect of cognitive impairment on reaction time is an important factor. Response time is defined as the time between the perception of a stimulus and the initiation of an appropriate response. In patients with dementia, slowing of cognitive processes and decreased attention lead to delayed responses to environmental stimuli. This may cause delayed corrective actions in balance problems (8). This delayed response may further increase the risk of falls, especially in situations where rapid responses are required, such as tripping or stumbling (9).

In addition, lower limb strength plays a crucial role in maintaining balance and preventing falls. People with dementia often have reduced muscle strength due to disuse and the physiological effects of the disease (10). Weak muscles in the lower limbs reduce the ability to respond effectively to sudden changes in balance. Therefore, the patient's lack of muscle strength to counteract balance disturbances increases the risk of falls (11).

Balance, which is essential for the complex coordination of body parts, is also profoundly affected in people with dementia (12). Impaired spatial orientation, weakened muscles and slowed reaction time collectively compromise complex balance control mechanisms. This leads to difficulties in adapting to changes in surface, posture, or movement, increasing the risk of falls (13). Thus, an approach that includes parameters such as spatial orientation, reaction time and lower limb strength is necessary to reduce the risk of falls in patients with dementia.

Despite the critical importance of understanding the relationship between fall risk in patients with dementia and factors such as spatial orientation, reaction time, and lower limb strength, the existing literature lacks a comprehensive investigation of this multidimensional relationship. Although individual studies have addressed some aspects of this relationship, namely cognitive impairments or muscle weakness, a holistic review encompassing the complex interplay between these factors is still lacking. This highlights more inclusive understanding that is needed to create effective strategies to prevent falls in people with dementia. By conducting more in-depth research in this area, critical insights can be gained into the underlying causes of falls in people with dementia. At the same time, both the mental and physical aspects of dementia can be addressed more holistically.

As a result, in our study, we analysed the correlation between reaction time, orientation, and lower extremity strength measures in individuals with dementia to make a comprehensive assessment of the risk of falls.

Materials and Methods

Thirty people, previously diagnosed with dementia by a neurologist, with mild to moderate dementia according to the Clinical Dementia Rating, participated in the study in two nursing homes in Ankara. The participants ranged in age from 65 to 95. The participants were carefully selected to exclude those with additional major diseases, ensuring a clearer understanding of cognitive and functional status in dementia. The participants' medical records and cognitive assessments confirmed the diagnosis and severity of dementia.

This study received ethical approval from the Yüksek Ihtisas University Non-Interventional Research Ethics Committee to ensure the well-being and rights of participants were protected (Reference Number: 2023/02/05). The ClinicalTrials. gov ID of our study is NCT05839743, and the Protocol ID is 24032023.

Assessment Tools

Johns Hopkins Fall Risk Assessment Tool (JHFRAT): JHFRAT is an evidence-based fall risk assessment tool. JHFRAT was developed to detect the fall risk of patients early and to evaluate the unexpected fall risk. In this way, it is used to develop preventive measures and protect at-risk adults. The

JHFRAT covers a wide range of titles, such as medical history, medication use, and mobility. A higher score indicates a larger chance of falling, per the evaluation's findings (14). JHFRAT is used in many recent studies to assess fall risk (15,16).

Spatial Orientation Test: The spatial orientation test, designed by Mary Hegarty et al., was used to evaluate the spatial orientation abilities of the participants. The participants were presented with a series of visual stimuli and were required to make judgments about the spatial relationships between objects. Performance was measured based on accuracy (17).

Reaction Time Assessment: Reaction time was measured using a computer-based task. Participants were given instructions to respond as soon as possible to the color changes they saw on the screen. The time between the color change and the participant's response was recorded as the reaction time (18).

30-Second Sit and Stand Test: The 30 Second Sit and Stand Test was used to measure lower extremity strength and endurance. Participants were asked to sit and stand as many times as possible for 30 seconds. The strength and endurance of the lower extremities were evaluated by recording the number of successful sit-ups (19).

Procedure: Detailed information about the study was given to the participants and their legal guardians. Considering the perception problems of the participants with dementia, necessary permissions were obtained from their legal guardians. Demographic information and medical history were collected. The participants completed the JHFRAT and then proceeded to the spatial orientation test and reaction time assessment, followed by the 30 Second Sit and Stand Test. Adequate breaks were provided to ensure participant comfort.

Data Analysis: Descriptive statistics were used to summarize participant demographics. Before performing the correlation analysis, a normality analysis was performed on the data set. It was determined that all data exhibited a normal distribution, meeting the basic assumption for statistical validity. **To** assess the relationships between fall risk and spatial orientation, reaction time, and lower extremity strength, Pearson correlation analysis was used.

Version 3.1 of the G*Power program (Düseldorf, Germany) was used to determine the sample size. When the power analysis was performed with a sample power ratio β=90% (type II error rate=10%) and type I error rate α=0.05, the number of participants was determined as 30 (20).

The cutoff for statistical significance was $p<0.05$. IBM Statistical Package for Social Sciences (SPSS) program version 23.0 for MacOS (IBM Inc., Chicago, IL) was used to analyze the data.

Results

Subject Characteristics

Table 1 and Table 2 detail the individuals' sociodemographic and clinical characteristics. Women made up the majority of the participants, and most of them were widowed or single. All participants had mild to moderate dementia.

Table 1. Sociodemographics

	N=30
Age, Mean ± SD	83.55±6.69
Years	
Gender, n (%)	
Female	25 (83.3)
Male	5 (16.7)
Education, n (%)	
Primary	3 (10.3)
Secondary	21 (72.4)
University	5 (17.2)

N: Total number of cases, n: Sample size, SD: Standard deviation.

Table 2. Clinical characteristics

N=30	Minimum	Maximum	Mean ± SD
Reaction Time Milliseconds	439	2500	955.68±423.98
JHFRAT Points	5	20	12.65±3.44
30 Second Sit and Stand Test Number of sit-ups	0	13	7.52±2.69
Spatial Orientation Points	0	10	5.68±2.23

N: Total number of cases. SD: Standard deviation.

Correlations

The results of the present study reveal significant correlations between the Johns Hopkins Fall Risk Assessment Tool (JHFRAT) scores and several measures related to cognitive and physical aspects in dementia patients. The following sections provide a detailed overview of the correlations observed in this study.

Correlation with Reaction Time

JHFRAT scores and reaction times were found to be positively correlated in dementia patients ($r=0.518$, $p=0.004$) (Table 3). This indicates that higher JHFRAT scores were associated with longer reaction times, suggesting that increased fall risk is linked to slower reaction times in this population.

Correlation with Spatial Orientation Test

A negative correlation was observed between JHFRAT scores and performance on the spatial orientation test ($r=-0.389$, $p=0.037$) (Table 3). This indicates that higher JHFRAT scores

were associated with poorer spatial orientation abilities, suggesting that increased fall risk is linked to difficulties in spatial orientation in dementia patients.

Correlation with 30-Second Sit and Stand Test

A negative correlation was identified between JHFRAT scores and performance on the 30-second sit and stand test (r=-0.478, p=0.009) (Table 3). This implies that higher JHFRAT scores were associated with decreased performance on the 30-second sit and stand test, indicating that increased fall risk is associated with reduced lower limb strength in dementia patients.

Table 3. Correlation analyses

N=30	JHFRAT	Spatial Orientation	Reaction Time	30-Second Sit and Stand
JHFRAT	1			
Spatial Orientation	-0.389*	1		
Reaction Time	0.518**	-0.162	1	
30-Second Sit and Stand	-0.478**	0.159	-0.246	1

Pearson correlation analysis: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).
N: Total number of cases; JHFRAT: Johns Hopkins Fall Risk Assessment Tool.

Discussion/Conclusion

The present study indicates a positive correlation between JHFRAT scores and reaction time, and negative correlations between JHFRAT scores and the spatial orientation test, the 30-second sit and stand test. These results emphasize the importance of determining the risk of falls in patients with dementia. They suggest that treatments should include both cognitive and physical factors to reduce the risk of falls in this vulnerable group. The results of our study provide important new insights into the complex link between fall risk, cognitive deficits, and physical abilities in patients with dementia, which has been partially demonstrated in the literature (1,2). By examining the correlations between fall risk as assessed by the Johns Hopkins Fall Risk Assessment Tool (JHFRAT) and various measures related to spatial orientation, reaction time and lower extremity strength, we have clarified and provided additional information and knowledge regarding the multifaceted nature of fall risk in this vulnerable population.

Our results demonstrate a positive correlation between JHFRAT scores and reaction time in dementia patients. This suggests that individuals with slow reaction times have a higher risk of falling. It also indicates that low reaction time may affect the ability to respond quickly to environmental changes and lead to an increased risk of falls. Similar to our study, it was emphasized in the meta-analysis study conducted by Okubo et al. with participants over 60 years of age that one of the reasons for the increased risk of falling in this population may be the increase in reaction time (21). In a study conducted by Pijnappels et al. with 294 participants over the age of 62, the relationship between the choice stepping reaction time test and the risk of falling was examined. This study confirmed our findings by showing that prolonged reaction times were related to frequent falls (22). These findings underscore the importance of addressing reaction time deficits as part of fall prevention strategies.

Additionally, we found a negative correlation between JHFRAT scores and spatial orientation scores. This shows that people with dementia with low spatial perception and navigation skills have a higher risk of falling. As far as we are aware, although there are few studies discussing the relationship between spatial orientation and balance, there are no studies examining the relationship between spatial orientation and fall risk directly. In their study on postural control, Wade et al. noted the significance of the link between spatial orientation and balance (23). The results of our study also suggest that impaired spatial orientation may lead to an increased risk of falls by increasing the likelihood of misjudging obstacles, changes in the ground and distances. Therefore, interventions aimed at improving spatial orientation skills may play an important role in reducing the risk of falls by increasing the awareness of people with dementia about their environment and potential hazards.

Our study further revealed a negative correlation between JHFRAT scores and performance on the 30-second sit and stand test, reflecting the association between fall risk and lower extremity strength. This finding highlights the significance of maintaining muscle strength in the lower extremities to support balance and stability. Like our study, Cho et al.'s study with 86 participants over the age of 65 investigated the relationship between falling and balance with the 30-second sit-and-stand test. As a result of the study, it was determined that the elderly with weak lower extremity strength had more impaired balance and had a higher risk of falling (24). Similarly, we obtained results demonstrating the importance of this relationship in dementia patients. Exercise programs aimed at strengthening the lower limbs can reduce the risk of falls by supporting balance.

In conclusion, our study emphasizes the complex relationship between physical and cognitive characteristics, such as lower limb strength and reaction time, in predicting fall risk in dementia patients. These results demonstrate the need for a comprehensive strategy to prevent falls in this population. To effectively reduce the risk of falls and improve the quality of life of people with dementia, interventions must be both cognitive and physical.

Follow-up studies and the creation of specific interventions based on these findings can make a big difference in the treatment and care of people with dementia. It can also reduce the burden on patients, caregivers, and health systems.

Limitations and Future Research

While our study provides important information about the complex relationship between fall risk in dementia patients and cognitive impairments such as spatial orientation and reaction time, and physical factors such as lower extremity strength, it has some limitations. The small sample size, cross-sectional design, and inclusion of a particular cultural context in Ankara, Turkey limit the broader interpretability of our results. Future research should focus on larger and more diverse populations and examine the multiple and broader spectrum of fall risk in people with dementia.

Ethic Committee Approval: Approval was obtained from Yüksek İhtisas University Non-Interventional Research Ethics Committee with the decision dated 05.02.2023 and numbered 2023/02/05.

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Author Contributions: Concept - İG, FC; Design - İG, FC; Supervision - İG, FC; Data Collection and/ or Processing - İG, FC; Analysis and/or Interpretation - İG, FC; Literature Search - İG, FC; Writing - İG, FC; Critical Reviews - İG, FC.

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