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Manual Dexterity, Balance, and Trunk Control in Patients with Alzheimer's Disease: A Cross-Sectional Study

Alzheimer Hastalarında El Becerisi, Denge ve Gövde Kontrolü: Kesitsel Bir Araştırma

Taskin OZKAN[1], Nigar Esra ERKOÇ ATAOGLU[2], Fatih SOKE[3], Selda KARAKOC[4], Suleyman Furkan HANGUN[3], Mustafa Ertugrul YASA[3], Cagri GULSEN[5], Hatice Ayse TOKCAER BORA[2]

[1]Giresun University, Vocational School of Health Services, Department of Therapy and Rehabilitation, Giresun, Türkiye
[2]Gazi University, Faculty of Medicine, Department of Neurology, Ankara, Türkiye
[3]Sağlık Bilimleri University, Gülhane Faculty of Physiotherapy and Rehabilitation, Ankara, Türkiye
[4]Ankara Yıldırım Beyazıt University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Türkiye
[5]Eskişehir Osmangazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Eskişehir, Türkiye

ORCID ID: *Taskin Ozkan 0000-0001-9448-0516, Nigar Esra Erkoc Ataoglu 0000-0001-5465-6089, Fatih Soke 0000-0002-8457-1198, Selda Karakoc 0000-0002-8284-0251, Suleyman Furkan Hangun 0000-0003-1270-8447, Mustafa Ertugrul Yasa 0000-0002-7796-2588, Cagri Gulsen 0000-0001-5830-438X, Hatice Ayse Tokcaer Bora 0000-0003-4363-724X*

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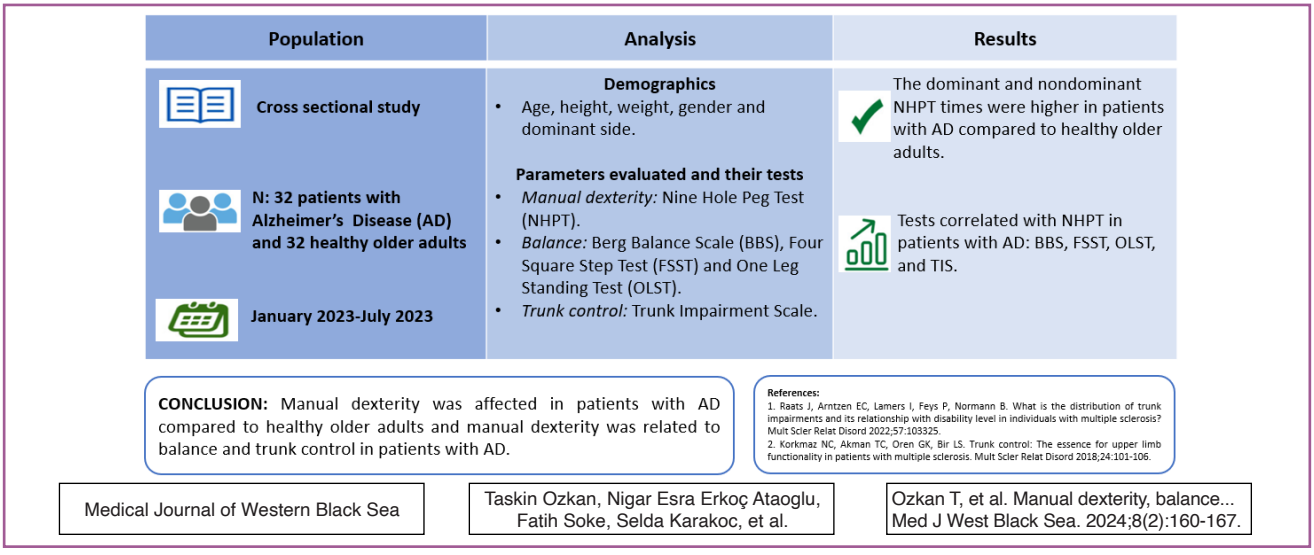
GRAPHICAL ABSTRACT



Corresponding Author: Taskin Ozkan ✉ fzttaskinozkan@hotmail.com **Received:** 14.02.2024 **Revision:** 31.05.2024 **Accepted:** 10.08.2024

ABSTRACT

Aim: It is suggested that trunk control and balance make an important contribution to voluntary upper extremity function, including motor control and manual dexterity. The study's objectives were to assess manual dexterity in those with Alzheimer's Disease (AD) and healthy older adults, as well as to look into the relationships between manual dexterity and balance and trunk control in patients with AD.

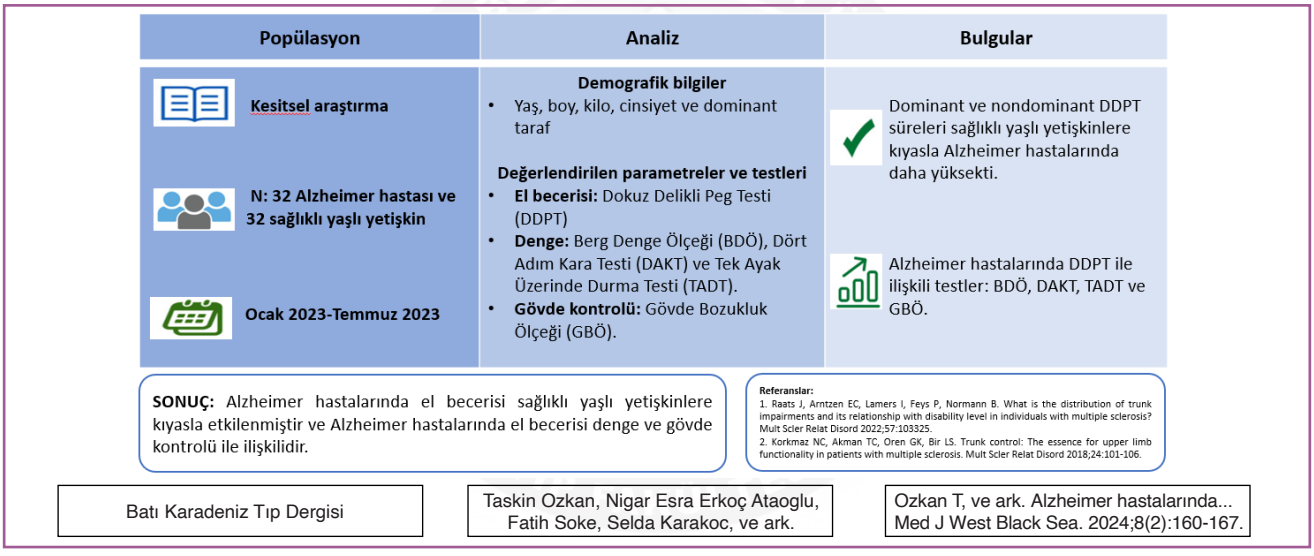
Material and Methods: The study involved 32 patients (15 female and 17 male; age: 74.59±6.53 years) with AD and 32 healthy older adults (14 female and 18 male; age: 73.66±5.60 years) matched for gender and age. The study involved 32 patients with AD and 32 healthy older adults matched for gender and age. Manual dexterity was assessed with the Nine Hole Peg Test (NHPT); balance with The Berg Balance Scale (BBS), The Four Square Step Test (FSST) and The One Leg Standing Test (OLST); trunk control with the Trunk Impairment Scale (TIS).

Results: The dominant and nondominant NHPT times were higher in patients with AD compared to healthy older adults ($p<0.05$). The dominant and nondominat NHPT were associated with BBS, FSST, OLST, and TIS in patients with AD (r between -0.375 and -0.755; $p<0.05$ for all).

Conclusion: Manual dexterity was affected in patients with AD compared to healthy older adults and manual dexterity was related to balance and trunk control in patients with AD. In patients with AD, bilateral hand dexterity should be assessed from an early stage, and it should not be ignored that practices that improve balance and trunk control may have positive effects on hand functions during hand rehabilitation.

Keywords: Alzheimer's Disease, manual dexterity, balance, trunk control

GRAFİKSEL ÖZET



ÖZ

Amaç: Gövde kontrolü ve dengenin, motor kontrol ve el becerisi dahil olmak üzere istemli üst ekstremite işlevine önemli bir katkı sağladığı öne sürülmektedir. Çalışmanın amacı, Alzheimer hastalarında ve sağlıklı yaşlı yetişkinlerde el becerisini değerlendirmek ve Alzheimer hastalarında el becerisi ile denge ve gövde kontrolü arasındaki ilişkileri incelemektir.

Gereç ve Yöntemler: Çalışmaya 32 Alzheimer hastası (15 kadın ve 17 erkek; yaş: 74,59±6,53 yıl) ve cinsiyet ve yaş açısından eşleştirilmiş 32 sağlıklı yaşlı yetişkin (14 kadın ve 18 erkek; yaş: 73,66±5,60 yıl) dahil edilmiştir. Çalışmaya 32 Alzheimer hastası ile cinsiyet ve yaş açısından eşleştirilmiş 32 sağlıklı yaşlı yetişkin katılmıştır. El becerisi Dokuz Delikli Peg Testi (DDPT) ile; denge Berg Denge Ölçeği (BDÖ), Dört Adım Kare Testi (DAKT) ve Tek Ayak Üzerinde Durma Testi (TADT) ile; gövde kontrolü Gövde Bozukluğu Ölçeği (GBÖ) ile değerlendirildi.

Bulgular: Dominant ve nondominant DDPT süreleri sağlıklı yaşlı yetişkinlere kıyasla Alzheimer hastalarında daha yüksekti ($p<0,05$). Alzheimer hastalarında dominant ve nondominat DDPT, BDÖ, DAKT, TADT ve GBÖ ile ilişkiliydi (r -0,375 ile -0,755 arasında; tümü için $p<0,05$).

Sonuç: Alzheimer hastalarında el becerisi sağlıklı yaşlı yetişkinlere kıyasla etkilenmiştir ve Alzheimer hastalarında el becerisi denge ve gövde kontrolü ile ilişkilidir. Alzheimer hastalarda bilateral el becerisi erken dönemden itibaren değerlendirilmeli, el rehabilitasyonu sırasında denge ve gövde kontrolünü geliştiren uygulamaların el fonksiyonları üzerinde olumlu etkileri olabileceği göz ardı edilmemelidir.

Anahtar Sözcükler: Alzheimer hastalığı, el becerisi, denge, gövde kontrolü

INTRODUCTION

One of the most prevalent neurodegenerative disorders, Alzheimer's Disease (AD), is the cause of more than 80% of dementia cases in older adults worldwide. It results in gradual mental, behavioral, functional and learning impairment (1). The cognitive decline that occurs prominently in patients with AD is accompanied by impairments in motor functions. As a result of these disorders, patients with AD experience inadequacies in their daily living activities and their quality of life gradually decreases (2-4).

Many studies on upper extremity performance have documented that manual dexterity declines in patients with AD (5,6). Ott et al. reported that there was a decrease in finger tapping speed with the right index finger in patients with AD compared to the healthy controls of the same age group (5). Kluger et al. reported that finger tapping speed, fine motor function, and complex motor function decreased in patients with AD. In their study, they also noted that motor impairment is a crucial factor in cognitive decline in older adults and that psychomotor/motor assessments can be used to identify individuals impacted by the early stages of AD pathology in a manner similar to standard cognitive function testing (6). Suzumura et al. indicated that there was a decrease in finger dexterity in the in patients with AD and that this was also associated with a decrease in cognitive functions (7). In another study, it was shown that the degree of cognitive impairment was associated with slowing down in fine motor skill measurement and that cognition and fine motor skills were related to activities of daily living (8). Although these results show how important it is to evaluate manual dexterity in AD, it seems that there are not enough studies on bilateral manual dexterity evaluation in patients with AD.

Ideal trunk control reduces postural instability before and during limbs movement, responds to external perturbations, affects one-leg standing, and increases the dexterity and force of the limbs (9). Trunk control has been shown to decrease in patients with AD and is associated with fear of falling, functional mobility, gait, and balance (10). Balance is a fundamental motor function needed for both dynamic and static daily tasks to be carried out safely and steadily, is impaired in patients with AD compared with healthy older adults (11). Clinical studies have shown that impaired balance becomes more common as the severity of AD increases that executive function plays an important role in balance control in patients with AD (12). In clinical practice, it is suggested that trunk control and balance make an important contribution to voluntary upper extremity function, including motor control and manual dexterity. However, it appears that the relationship between manual dexterity and trunk control and balance has not been examined in patients with AD. Because of this, authors think that manual dexterity may be compromised in patients with AD as opposed to healthy older persons and may be linked to balance and trunk control in patients with AD. It was therefore the goal of this study to evaluate manual dexterity in patients with AD and in healthy older adults and to look into the association between manual dexterity and balance and trunk control in patients with AD. The hypotheses of the present study was manual dexterity was affected in patients with AD compared to healthy older adults, and manual dexterity was related with balance and trunk control in patients with AD.

MATERIAL and METHODS

Study Design

This cross-sectional investigation was carried out in the neurology department of the Gazi University Faculty of Medicine, between January 2023 and July 2023. The participants in this study were advised of the process and given written consent. The ethical guidelines outlined in the Helsinki Declaration were followed when conducting this investigation. Written ethical approval was obtained from Gazi University Clinical Research Ethics Committee on 16.05.2022. (Decision Number: 352). Written consent was obtained from all patients who volunteered to participate in the study.

Participants

The study comprised 35 patients with AD who had been given a neurologist's diagnosis as well as 35 healthy older adults of the same gender and age. These were the inclusion criteria for patients with AD: having a diagnosis of AD based on the ARDRA/NINCDS diagnostic criteria by a neurologist, scoring a minimum of 10 on the Mini Mental State Examination (MMSE), possessing a 0,5-2 clinical dementia assessment scale score (mild to moderate dementia), and having an independent walking ability with or without an assistive device (13, 14). Having a history of any other neurological conditions, as well as having an orthopedic, rheumatic, or other vestibular ailment that could impair balance and manual dexterity, were the exclusion criteria for patients with AD. Having an MMSE score of more than 24 was the admission criterion for healthy individuals, while the exclusion criteria were as follows: having any neurological condition, or having a vestibular, rheumatic, or orthopaedic condition that could impair balance and manual dexterity.

Procedure

The demographic and clinical traits of both patients with AD and and healthy older adults were noted. The same assessor conducted each assessment in a distraction-free, calm setting, and the outcome measurements were taken in the same order. Every participant received a two-minute rest break during the assessments.

Outcome Measures

The Nine Hole Peg Test (NHPT), a reliable and valid test, was used to evaluate manual dexterity. During the test, participants use only one hand to pick up nine pegs one by one and insert them into the holes as quickly as possible. Then participants place the pegs back into the container, one by one, as quickly as possible. The completion time of the test is recorded using a stopwatch. The NHPT is performed three times for each hand and lower time indicates better manual dexterity (15, 16).

The Berg Balance Scale (BBS) is designed to evaluate functional balance. The balance levels of individuals is assessed using 14 functional activities. In the test, each item is scored between 0 (inability to perform the activity) and 4 (independent performance of the activity) according to the performance of the participants. The total score ranges from 0-56, with higher scores referring better balance function (17).

The Four Square Step Test (FSST) evaluates dynamic balance. In the test, 4 squares are formed by placing 2 canes on a flat surface. All squares are numbered. The participant is asked to step on the floor as fast as possible with both feet in each square in a certain number order. The test completion time is recorded and lower time indicates better dynamic balance ability (18).

The One Leg Standing Test (OLST) is used to assess static balance. The test is performed by crossing the hands on the chest with the eyes open and asking the participant to lift one foot and stand on the limb on the floor without touching the floor. The test starts with the individual lifting his/her foot and ends when the foot in the air touches the floor, touches the other leg or when the individual's arms are separated from the trunk. It is expected to maintain the position for 30 seconds. The test time is recorded. Longer test time indicates better balance (19).

The Trunk Impairment Scale (TIS) used for the assessment of trunk control, which consists of 3 subscales evaluating the trunk. These include trunk coordination, dynamic sitting balance, and static sitting balance. The subscales have respective maximum scores of 7, 10, and 6. The total score goes from 0 to 23. Higher scores indicate better trunk control (20).

Statistical Analysis

To determine the necessary sample size for the investigation, authors utilized the G*Power software program (21). As a result of the calculation made using research data which the total number of samples is 32, for the correlation analysis, the research's correlation value was determined to be -0.669, and its power (1-β) was assessed to be 0.99 with a 5% margin of error (a= 0.05). The statistical software package Statistical Package for Social Sciences (SPSS) Version 22 was used to perform the statistical analysis of the data. Utilizing the Shapiro-Wilk test, data normalcy was examined. Normally distributed data are represented by the mean and standard deviation, while non-normally distributed data are represented by the median (IQR25-75). The gender and dominant side variables are shown as percentages (%) and frequencies. The differences between the groups in terms of gender and dominant side were assessed with Pearson Chi-square test. The Independent Samples T-Test was used to examine intergroup differences. Using a Spearman and Pearson correlation analysis, the relationship between the variables in patients with AD was ascertained. Alpha was set at <0.05 for statistical significance. Correlation analysis results were categorized as follows: 0.81-1.00 (very good correlation), 0.61-0.80 (good correlation), 0.41-0.60 (moderate correlation), 0.21-0.40 (fair correlation), and 0.00-0.20 (poor correlation).

RESULTS

For the study, 35 patients with AD and 35 healthy older underwent screening. Three individuals in each group did not fit the requirements for inclusion. As a result, with 32 patients with AD and 32 healthy older adults, the study was finished.

Table 1 provides information on the participants' demographics and illness characteristics. There were no significant differences between the groups in terms of age, weight, height, body mass index, gender and dominant side (p>0,05, Table 1). The MMSE scores of patients with AD and healty older adults differed significantly (p<0.05, Table 1).

The dominant and nondominant NHPT results of patients with AD were 32.91±7.62 and 33.83±7.33 seconds, respectively. The dominant and nondominant NHPT results of healthy controls were 25.81±5.02 and 26.44±4.81 seconds, respectively. The findings of the dominant and nondominant NHPT in patients with AD and in healthy controls were compared, and the results indicated a substantial difference (p<0.05, Figure 1).

When manual dexterity and balance were examined, it was found that in patients with AD, dominant and nondominant NHPT were negatively correlated with BBS between moderate and good levels, positively and moderately correlated with FSST, negatively correlated with OLST between moderate and good levels (r between -0.511 and -0.669; p<0.05 for all).

When manual dexterity and trunk control were examined, it was found that dominant and nondominant NHPT were correlated with all subparameters and total point of TIS between fair and good levels in patients with AD (r between -0,375 and -0,755; p<0,05 for all, Table 2).

Table 1: The groups' clinical and demographic characteristics.

Characteristics		Patients with Alzheimer's Disease (n=32)	Healthy Controls (n=32)	p
Age, years, $\bar{X}$±S		74.59±6.53	73.66±5.60	0.540[a]
Height cm, $\bar{X}$±S		166.88±10.86	169.13±9.14	0.373[a]
Weight kg, $\bar{X}$±S		74.66±11.21	72.56±9.33	0.420[a]
BMI, kg/m², $\bar{X}$±S		26.82±3.32	25.43±3.13	0.089[a]
MMSE, point, $\bar{X}$±S		19.84±3.28	27.41±1.58	**<0.001**[a]
Gender, n (%)	Female	15 (46.9)	14 (43.7)	0.802[b]
	Male	17 (53.1)	18 (56.3)	
Dominant side, n (%)	Right	31 (96.9)	32 (100)	0.313[b]
	Left	1 (3.1)	0 (0)	
Duration of illness, years, $\bar{X}$±S		4.57±2.34	NA	NA

p<0.05; **cm:** centimeter; **kg:** kilogram; **m:** metre; MMSE: Mini Mental State Examination; **BMI:** Body Mass Index; **NA:** Not applicable, **a:** Independent Samples T-Test; **b:** Chi-Square Test; **SD:** Standard deviation; **X:** Mean

Table 2: The relationship between manual dexterity, balance, and trunk control in patients with Alzheimer's Disease.

			NHPT			
			Dominant		Nondominant	
		Variables	r	p	r	p
BBS, score, $\bar{X}$±S		51.19±3.37	-0.669	**<0.001**[a]	-0.581	**<0.001**[a]
FSST, second, $\bar{X}$±S		13.57±3.78	0.559	**<0.001**[a]	0.527	**0.002**[a]
OLST, second, $\bar{X}$±S		5.23±3.15	-0.511	**0.003**[a]	-0.629	**<0.001**[a]
TIS, score	Static seating balance, Median (IQR25-75)	8.00 (7.00-10.00)	-0.595	**0.001**[b]	-0.487	**0.005**[b]
	Dynamic seating balance, Median (IQR25-75)	6.00 (5.00-7.00)	0.630	**<0.001**[b]	0.606	**<0.001**[b]
	Coordination, $\bar{X}$±S	4.41±1.48	-0.375	**0.035**[a]	-0.398	**0.024**[a]
	Total, $\bar{X}$±S	18.44±3.05	-0.755	**<0.001**[a]	-0.716	**<0.001**[a]

p<0.05; a: Pearson Correlation Analysis; b: Spearman Correlation Analysis; **r:** Correlation coefficient; **NHPT:** Nine Hole Peg Test; **BSS:** Berg Balance Scale; **OLST:** One Leg Stance Test; **FSST:** Four Square Step Test; **TIS:** Trunk Impairment Scale; **IQR:** Inter quartile range; **SD:** Standard deviation; **X:** Mean

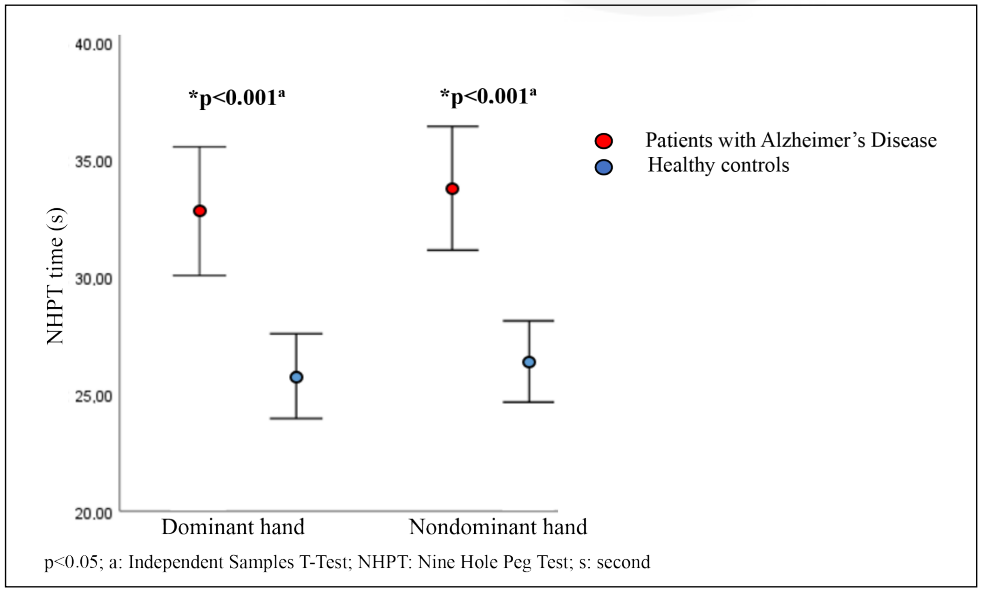


Figure 1: Comparison of the dominant and nondominant manual dexterity of the groups.

DISCUSSION

The goal of this study was to compare the manual dexterity of patients with AD and healthy older adults, and look into the relationship between manual dexterity and balance and trunk control in patients with AD. Our findings indicate that manual dexterity was impacted in patients with AD when compared to healthy older adults, and that manual dexterity was linked to balance and trunk control in patients with AD. This is the first study that, as far as authors know, demonstrates the relationship between balance, manual dexterity, and trunk control in patients with AD.

In previous studies in which upper extremity function, manual-finger dexterity and speed were investigated in patients with AD, it was shown that these parameters were affected compared to healthy older adults (5-8). Regarding the severity of AD, it has been shown that decreased dexterity and movement speed in the dominant hand occur as the disease progresses (22-24). Hebert et al. found that upper extremity performance was associated with and functional impairment in patients with AD, and stated that motor performance contributed to functional impairments independently of cognitive impairment (25). Similarly, in the present study, it was shown that dominant and nondominant NHPT durations were higher in patients with AD compared to healthy individuals. These results suggest that bilateral manual dexterity is affected in patients with AD. Because of this, bilateral hand functions should be evaluated in patients with AD from an early stage and practices to improve manual dexterity should be included in rehabilitation protocols.

Alzheimer's Disease is an important neurodegenerative disease that affects the daily life activities of the individual due to its negative effects on motor function (26). Therefore, determining the factors that negatively affect hand functions is an important issue for rehabilitation applications. In this study, balance and trunk control were shown to be related to upper extremity performance in patients with AD. Previous studies have shown that balance and trunk control are related to upper limb function and/or manual dexterity in the elderly, Parkinson's disease patients, multiple sclerosis patients, stroke patients, healthy individuals and children (27-34).

Kalkan et al. evaluated manual dexterity bilaterally with the NHPT and postural control with the Limit of Stability Test using a computerised balance measurement device in patients with Parkinson's disease over 65 years of age and stated that manual dexterity was related to postural control (27). In their study, Söke et al. evaluated manual dexterity with NHPT and postural control withh BSS in elderly individuals aged 65 years and older and reported that manual dexterity was related to postural control (28). These studies are pertinent to our findings because they shed light on the relationship between manual dexterity and upper extremity function with balance. Proximal stability contributes to the mobility of distal segments and limb functionality. In relation to this, postural adjustments provide proximal stability for distal mobility (10, 27). Therefore, we think that postural control disorders may also affect manual dexterity by decreasing proximal stability in patients with AD.

Studies evaluating trunk control and dexterity have shown that trunk control is associated with dexterity, which is consistent with the results of our study. Korkmaz et al. showed that decreased upper extremity and hand function was associated with trunk control in patients with Multiple Sclerosis (29). Ozkul et al. stated that upper extremity function was related to core stability in patients with Multiple Sclerosis (30). Wee et al. showed that external trunk support application increased function of upper extremity in chronic stroke patients. These results suggest that stabilising or physically restricting the trunk improves upper limb function (31). Fujita et al. evaluated the trunk muscles responsible for postural stability and showed that stroke patients with weak trunk muscles were more dependent on activities of daily living requiring upper extremity function such as dressing, toilet use and transfer activities than stroke patients without weak trunk muscles (32). Miyake et al. stated that trunk stability provides shoulder movement in healthy individuals, and shoulder stability improves elbow, wrist and finger movements (33). Lehman et al. stated that in healthy individuals, the transversus abdominus and multifidus muscles contract 50 msec before shoulder movements to provide trunk stabilisation (34). These studies are pertinent to our findings because they shed light on the relationship between dexterity and upper extremity function with trunk control. In order to perform upper limb functions like reaching, gripping, and moving items, the shoulder girdle must be dynamically stable over a stationary trunk and the head and arms must move independently of the shoulders. The trunk is thought to play a complementary role in postural stabilisation by supporting the control of the extremities during task performance, and a stable trunk provides a solid foundation for the moment produced by the limbs (35-38). All these relationships and the results of our study suggest that static, dynamic and functional balance and trunk control are obvious prerequisites for better manual dexterity in patients with AD, as shown in healthy individuals and other disease groups.

This study has several limitations. First off, the study only covered mildly affected patients with AD, so its findings cannot be generalized to all AD. Our study's second limitation is that it solely assessed manual dexterity; the functions of the upper extremities were not specifically investigated. The third limitation of our study is that conditions such as stroke, trauma, blood pressure and diabetes that may affect neurologic evaluations were not evaluated and were not included in the exclusion criteria (39).

In conclusion, this study demonstrated that manual dexterity was affected in patients with AD compared to healthy older adults and manual dexterity was related to balance and trunk control in patients with AD. For this reason, dominant and nondominat hand functions should be evaluated in patients with AD from an early stage, practices to improve manual dexterity should be included in rehabilitation protocols and it should not be ignored that practices that improve balance and trunk control may have positive effects on hand functions.

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Author Contributions

Concept: **Taskin Ozkan, Nigar Esra Erkoc Ataoglu, Fatih Soke, Hatice Ayse Tokcaer Bora,** Design: **Taskin Ozkan, Nigar Esra Erkoc Ataoglu, Fatih Soke, Hatice Ayse Tokcaer Bora,** Data Collection or Processing: **Taskin Ozkan, Nigar Esra Erkoc Ataoglu, Fatih Soke, Mustafa Ertugrul Yasa,** Analysis or Interpretation: **Taskin Ozkan, Fatih Soke, Selda Karakoc, Suleyman Furkan Hangun, Cagri Gulsen,** Literature search: **Taskin Ozkan, Nigar Esra Erkoc Ataoglu, Fatih Soke, Selda Karakoc, Suleyman Furkan Hangun, Mustafa Ertugrul Yasa, Cagri Gulsen, Hatice Ayse Tokcaer Bora,** Writing: **Taskin Ozkan, Nigar Esra Erkoc Ataoglu, Fatih Soke, Selda Karakoc, Mustafa Ertugrul Yasa, Cagri Gulsen, Hatice Ayse Tokcaer Bora.**

Conflicts of Interest

There were no disclosed conflicts of interest by the authors.

Financial Support

The study's support was provided without any financing.

Ethical Approval

Written ethical approval was obtained from Gazi University Clinical Research Ethics Committee on 16.05.2022. (Decision Number: 352). Written consent was obtained from all patients who volunteered to participate in the study.

Review Process

Extremely and externally peer-reviewed.

REFERENCES

1. Anand R, Gill KD, Mahdi AA. Therapeutics of Alzheimer's disease: Past, present and future. Neuropharmacology 2014;76:27-50.
2. Zucchella C, Bartolo M, Bernini S, Picascia M, Sinforiani E. Quality of life in Alzheimer disease: a comparison of patients' and caregivers' points of view. Alzheimer Dis Assoc Disord 2015;29:50-54.
3. Marshall GA, Fairbanks LA, Tekin S, Vinters HV, Cummings JL. Neuropathologic correlates of activities of daily living in Alzheimer disease. Alzheimer Dis Assoc Disord 2006;20:56-59.
4. Karagülmez AT, Külünkoğlu B. Yaşlı Bireylerde Düşük Yürüme Hızı ve Düşme Riski Faktörleri Arasındaki İlişki: Sistematik Derleme. "Med. J. West. Black Sea 2023;7(3):350-363.
5. Ott BR, Ellias SA, Lannon MC. Quantitative assessment of movement in Alzheimer's disease. J Geriatr Psychiatry Neurol 1995;8:71-75.
6. Kluger A, Gianutsos JG, Golomb J, Ferris SH, George AE, Franssen E, Reisberg B. Patterns of motor impairment in normal aging, mild cognitive decline, and early Alzheimer'Disease. J Gerontol B Psychol Sci Soc Sci 1997;52:28-39.
7. Suzumura S, Osawa A, Nagahama T, Kondo I, Sano Y, Kandori A. Assessment of finger motor skills in individuals with mild cognitive impairment and patients with Alzheimer's disease: Relationship between finger-to-thumb tapping and cognitive function. JJCRS 2016;7:19-28.
8. de Paula JJ, Albuquerque MR, Lage GM, Bicalho MA, Romano-Silva MA, Malloy-Diniz LF. Impairment of fine motor dexterity in mild cognitive impairment and Alzheimer's disease dementia: association with activities of daily living. Braz J Psychiat 2016;38:235-8.
9. Raats J, Arntzen EC, Lamers I, Feys P, Normann B. What is the distribution of trunk impairments and its relationship with disability level in individuals with multiple sclerosis? Mult Scler Relat Disord 2022;57:103325.
10. Ozkan T, Ataoglu NEE, Soke F, Karakoc S, Bora HAT. Investigation of the relationship between trunk control and balance, gait, functional mobility, and fear of falling in people with Alzheimer's disease. Ir J Med Sci 2023;192:2401-2408.
11. Pettersson AF, Engardt M, Wahlund L-O. Activity level and balance in subjects with mild Alzheimer's disease. Dement Geriatr Cogn Disord 2002;13:213-216.
12. Tangen GG, Engedal K, Bergland A, Moger TA, Mengshoel AM. Relationships between balance and cognition in patients with subjective cognitive impairment, mild cognitive impairment, and Alzheimer disease. Phys Ther 2014;94:1123-1134.
13. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group* under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 1984;34:939-944.
14. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-198.
15. Mathiowetz V, Weber K, Kashman N, Volland G. Adult norms for the nine hole peg test of finger dexterity.OTJR 1985;5:24-38.
16. Earhart GM, Cavanaugh JT, Ellis T, Ford MP, Foreman KB, Dibble L. The 9-hole PEG test of upper extremity function: average values, test-retest reliability, and factors contributing to performance in people with Parkinson disease. J Neurol Phys Ther 2011;35:157-163.
17. Telenius EW, Engedal K, Bergland A. Inter-rater reliability of the Berg Balance Scale, 30 s chair stand test and 6 m walking test, and construct validity of the Berg Balance Scale in nursing home residents with mild-to-moderate dementia. BMJ Open 2015;5:e008321.
18. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. Arch Phys Med RehabiL 2002;83:1566-1571.

19. Suttanon P, Hill KD, Dodd KJ, Said CM. Retest reliability of balance and mobility measurements in people with mild to moderate Alzheimer's disease. Int Psychogeriatr 2011;23:1152-1159.
20. Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, Lafosse C, Nieuwboer A. Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil 2006;20:451-458.
21. Faul F, Erdfelder E, Lang A-G, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175-191.
22. Sakamoto M, Kikuchi E, Shigeta M. Relationship between hand dexterity and severity of dementia in alzheimer's disease: changes in handedness superiority in the course of progression. JJRM 2007:391-397.
23. Sakamoto M, Kikuchi E, Shigeta M. The levels of recognition and hand functions of patients with Alzheimer's disease: a pilot study based on the simple test for evaluating hand function. Nihon Ronen Igakkai zasshi Japanese Journal of Geriatrics 2006;43:616-621.
24. Yamada T, Yamada K, Yamaguchi M. Study on healthy elderly people and elderly people with alzheimer's dementia by using subtest on simple test for evaluation hand function. Health Care 2003;45:921-927.
25. Hebert LE, Bienias JL, McCann JJ, Scherr PA, Wilson RS, Evans DA. Upper and lower extremity motor performance and functional impairment in Alzheimer's disease. Am J Alzheimer's Dis 2010;25:425-431.
26. Scherder E, Dekker W, Eggermont L. Higher-level hand motor function in aging and (preclinical) dementia: its relationship with (instrumental) activities of daily life–a mini-review. Gerontology 2008;54:333-341.
27. Kalkan AC, Kahraman T, Ugut BO, Colakoglu BD, Genc A. A comparison of the relationship between manual dexterity and postural control in young and older individuals with Parkinson's disease. J Clin Neurosci 2020;75:89-93.
28. Söke F, Karaali HK, Ilgin D, Yüksel E, Özcan Ö, Arslan T. Relationship between postural control and hand function in the subjects aged 65 years and over. Turk J Physiother Rehabil 2018;29:33-38.
29. Korkmaz NC, Akman TC, Oren GK, Bir LS. Trunk control: The essence for upper limb functionality in patients with multiple sclerosis. Mult Scler Relat Disord 2018;24:101-106.
30. Özkul Ç, Gündüz AG, Esmer M, Yıldırım MŞ, Eldemir K, Irkec C. Mutual relationship between upper extremity function and core muscle endurance in patients with multiple sclerosis. Clin Exp Health Sci 2021;11:42-46.
31. Wee SK, Hughes A-M, Warner MB, et al. Effect of trunk support on upper extremity function in people with chronic stroke and people who are healthy. Phys Ther 2015;95:1163-1171.
32. Fujita T, Sato A, Togashi Y, Kasahara R, Ohashi T, Yamamoto Y. Contribution of abdominal muscle strength to various activities of daily living of stroke patients with mild paralysis. J Phys Ther Sci 2015;27:815-818.
33. Miyake Y, Kobayashi R, Kelepecz D, Nakajima M. Core exercises elevate trunk stability to facilitate skilled motor behavior of the upper extremities. J Bodyw Mov Ther 2013;17:259-265.
34. Lehman GJ, Story S, Mabee R. Influence of static lumbar flexion on the trunk muscles' response to sudden arm movements. Chiropractic & Osteopathy 2005;13:1-5.
35. Rosenblum S, Josman N. The relationship between postural control and fine manual dexterity. Phys Occup Ther Pediatr 2003;23:47-60.
36. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med 2006;36:189-198.
37. Davies PM. Steps to Follow: The Comprehensive Treatment of Patients with Hemiplegia. 2nd ed. Berlin-Heidelberg-New York: Springer Science & Business Media, 2000.
38. Gillen G, Boiangiu C, Neuman M, Reinstein R, Schaap Y. Trunk posture affects upper extremity function of adults. Percept Mot Skills 2007;104:371-80.
39. Tekin E, Küçük A, Kabay SC. Evaluation of Early diagnosis via some blood parameters in alzheimer type dementia and type 2 diabetes mellitus patients. Türkiye Diyabet ve Obezite Dergisi, 2023;7:206-213.