ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.62425/rses.1618119

The Effects of Functional Exercise Interventions on Quality of Life and Selected Physical Fitness Parameters in Alzheimer's Patients

Alzheimer Hastalarında Fonksiyonel Egzersiz Müdahalelerinin Yaşam Kalitesi ve Seçilen Fiziksel Fitness Parametreleri

Alper Cenk GÜRKAN[1]
[1]Gazi University, Vocational School of Healthy Services, Department of Medical Services and Techniques, First and Emergency Aid Program, Ankara, Türkiye

Mehmet SÖYLER[2]
[2]Çankırı Karatekin University, Vocational School of Social Sciences, Department of Property Protection and Security, Private Security and Protection Program, Çankırı, Türkiye

Cüneyt ŞENSOY[3]
[3]Gazi University, PhD Program at the Institute of Health Sciences, PhD Program in Movement and Training Sciences, Ankara, Türkiye

ABSTRACT
This study investigated the effects of a 12-week functional exercise (FE) program on motor and cognitive abilities in older adults with mild to moderate dementia. A total of 200 voluntary participants were assessed, with 100 participants in the FE group (Group 1) and 100 in the control group (Group 2). Data were collected using modified versions of the Mini-Mental State Examination (MMSE), Tinetti Walking Test, Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and Physical Activity Scales (IPAQ). The groups were comparable in demographic characteristics such as age (Group 1: 72.1 ± 6.2 years; Group 2: 71.8 ± 5.9 years, *p*>.05) and physical activity levels (both groups were predominantly sedentary). Balance scores significantly improved in Group 1 (pre: 44.3 ± 8.7; post: 54.1 ± 7.5, F=16.45, *p*<.001), whereas no significant change was observed in Group 2. Walking speed showed a significant increase in Group 1 (pre: 0.95 ± 0.12 m/s; post: 1.05 ± 0.14 m/s, F=5.24, *p*=.022). Functional mobility scores significantly improved in Group 1 (pre: 32.8 ± 6.3; post: 38.4 ± 5.6, F=8.35, *p*=.004). General cognitive function scores also showed a significant increase in Group 1 (pre: 21.3 ± 3.4; post: 23.1 ± 3.1, F=6.41, *p*=.013), while no significant change was observed in Group 2. Improvements in balance mediated walking speed (β=0.48, *p*<.001) and cognitive function (β=0.35, *p*<.001). Changes in functional mobility significantly influenced walking speed (β=0.37, *p*=.002). The results demonstrate the effectiveness of the FE program in enhancing motor and cognitive functions in older adults with dementia. These findings highlight the program's potential to improve quality of life and delay functional decline in this population.

Keywords: Motor performance, cognitive health, balance control

ÖZ
Bu çalışmada, hafif ile orta düzeyde demansı olan yaşlı bireylerde 12 haftalık fonksiyonel egzersiz (FE) programının motor ve bilişsel yetenekler üzerindeki etkilerini incelemiştir. Toplamda 200 gönüllü katılımcı (FE grubunda [Grup 1] 100 katlımcı, kontrol grubunda [Grup 2] 100 katılımcı) değerlendirilmiştir. Verileri toplamak için, modifiye edilerek Mini-Mental State Examination (MMSE), Tinetti Walking Test, Berg Denge Ölçeği (BDÖ) ve Timed Up and Go Test (TUG), Physical Activity Scales (IPAQ) kullanılmıştır. Gruplar, yaş (Grup 1: 72,1 ± 6,2 year; Grup 2: 71,8 ± 5,9 year, *p*>,05) ve fiziksel aktivite seviyeleri (her iki grupta da çoğunlukla sedanter) gibi demografik özellikler açısından benzerlik göstermiştir. Grup 1'de denge skorları önemli ölçüde iyileşmiştir (önce: 44,3 ± 8,7; sonra: 54,1 ± 7,5, F=16,45, *p*<,001), Grup 2'de ise anlamlı bir değişiklik gözlemlenmemiştir. Yürüyüş hızı, Grup 1'de önemli bir artış göstermiştir (önce: 0,95 ± 0,12 m/s; sonra: 1,05 ± 0,14 m/s, F=5,24, *p*=,022). Fonksiyonel mobilite skorları, Grup 1'de önemli ölçüde iyileşmiştir (önce: 32,8 ± 6,3; sonra: 38,4 ± 5,6, F=8,35, *p*=,004). Genel bilişsel fonksiyon skorları, Grup 1'de anlamlı şekilde artmıştır (önce: 21,3 ± 3,4; sonra: 23,1 ± 3,1, F=6,41, *p*=,013), Grup 2'de ise anlamlı bir değişiklik gözlemlenmemiştir. Denge iyileşmeleri, yürüyüş hızını (β=0,48, *p*<,001) ve bilişsel fonksiyonları (β=0,35, *p*<,001) aracılık etmiştir. Fonksiyonel mobilite değişiklikleri, yürüyüş hızını önemli ölçüde etkilemiştir (β=0,37, *p*=,002). Sonuçlar, FE programının, demansı olan yaşlı bireylerde motor ve bilişsel fonksiyonları geliştirmedeki etkinliğini göstermektedir. Bu bulgular, programın bu popülasyonda yaşam kalitesini iyileştirme ve fonksiyonel gerilemeyi geciktirme potansiyelini vurgulamaktadır.

Anahtar Kelimeler: Motor performans, bilişsel sağlık, denge kontrolü

Geliş Tarihi/Received 12.01.2025
Kabul Tarihi/Accepted 25.03.2025
Yayın Tarihi/Publication Date 20.06.2025

Sorumlu Yazar/Corresponding author: Mehmet SÖYLER
E-mail: mehmetsoyler@karatekin.edu.tr

Cite this article: Gürkan, A. C., Söyler, M., & Şensoy, C. (2025). The effects of functional exercise interventions on quality of life and selected physical fitness parameters in alzheimer's patients. *Research in Sport Education and Sciences, 27*(2), 150-165.

Introduction

Alzheimer’s disease, one of the most common neurodegenerative disorders among the elderly, poses a significant public health threat worldwide (Amenta et al., 2001). As of 2023, the global prevalence of Alzheimer’s disease is estimated to be approximately 47 million, and due to demographic shifts, this number is expected to increase rapidly in the coming years (Alzheimer's Disease International, 2022). Projections indicate that this increase could reach 135 million by 2050 (Alzheimer's Association, 2023). This demographic trend not only escalates the burden on healthcare systems but also significantly raises the costs associated with disease management and care (WHO, 2021). Alzheimer’s disease presents broad social and economic challenges, adversely affecting both the quality of life for individuals and the resilience of healthcare infrastructures.

Alzheimer’s disease is the most prevalent type of dementia syndrome, characterized as a progressive brain disorder that leads to cognitive, motor, and functional impairments over time (Blackman et al., 2020). It impacts cognitive abilities such as memory, attention, learning, and problem-solving, while also causing difficulties in daily activities and loss of independence (Sosa-Ortiz & Acosta-Castillo, 2012). Even in its early stages, Alzheimer’s often limits functional capacity and reduces quality of life (Azevedo et al., 2023). Furthermore, motor and functional impairments associated with Alzheimer’s, such as difficulties in walking, balance, and transfers, can manifest not only in advanced stages but also early in the disease (Campos et al., 2023). These symptoms significantly reduce mobility and independence, severely impacting overall quality of life. Current treatments primarily aim to manage symptoms rather than halt or reverse disease progression, with pharmacological interventions often associated with side effects and limited efficacy (Chen et al., 2016). This has highlighted the need for alternative approaches in disease management. In recent years, non-pharmacological interventions, particularly physical activity and exercise, have gained increasing attention for their potential benefits in managing Alzheimer’s disease (Gianfredi et al., 2022). Physical activity has emerged as a promising intervention, not only for improving cognitive functions but also for enhancing motor performance. Consequently, the role of physical activity in Alzheimer’s treatment has become a critical area for future research, underscoring the necessity of diversifying treatment modalities.

The role of physical activity in managing Alzheimer’s disease has been a subject of growing interest due to its potential to prevent cognitive decline. Exercise can enhance brain health and motor function, mitigating motor impairments associated with Alzheimer’s. Studies focusing on the relationship between physical activity and improvements in cognitive and motor functions emphasize the significance of such interventions in Alzheimer’s management (Liu et al., 2022). In recent years, substantial research has highlighted the positive effects of physical activity on cognitive health. Studies have demonstrated that regular physical activity leads to significant improvements in motor skills and cognitive functions, particularly among older adults (Bossers et al., 2014). Research on individuals with Alzheimer’s disease (IWD) has also increased, with findings suggesting that physical activity can slow cognitive decline and provide protective effects against disease progression (Cadore et al., 2013). Early-stage physical activity interventions have been shown to enhance brain plasticity, mitigating cognitive deficits associated with Alzheimer’s (Cahn et al., 1997).

Numerous systematic reviews and meta-analyses have investigated the relationship between physical activity and Alzheimer’s symptoms. These studies have explored the potential effects of exercise on motor and cognitive functions, including balance, mobility, gait, strength, and activities of daily living (ADL). However, inconsistencies in findings remain. For instance, among five reviews on balance, three reported no significant improvements from physical activity (Lucia & Ruiz, 2011), while two documented small to moderate benefits (Stephen et al., 2017). Similarly, studies on mobility report varying outcomes, with some noting significant improvements and others indicating inconsistent effects, ranging from slight negatives to substantial positives (Zhao et al., 2020). Studies on gait function generally observe small to moderate effects at normal walking speeds (Martyr et al., 2011). Conversely, physical activity appears to have a more pronounced impact on lower extremity strength. Reviews consistently report significant improvements in lower body strength, aiding in reducing fall risks and enhancing independence in ADL (Manckoundia et al., 2006). Despite ongoing research and debates, existing literature supports the potential of physical activity to mitigate Alzheimer’s symptoms.

Future studies should aim for more consistent and high-quality designs to better elucidate these effects. While the number of studies exploring the benefits of physical activity in Alzheimer’s disease is increasing, many suffer from methodological heterogeneity and quality deficits. Variations in exercise types, durations, frequencies, and intervention periods contribute to inconsistent findings, complicating clear conclusions about the effects of physical activity on Alzheimer's symptoms. Moreover, small sample sizes limit the generalizability of results (Groot et al., 2016). To address these challenges, higher-quality studies with standardized methodologies are needed (Hauer et al., 2020)

Physical activity has the potential to serve as a critical strategy for managing Alzheimer's disease. However, the methodological limitations and inconsistencies in current research highlight the need for robust scientific evidence and large-scale studies. The therapeutic effects of physical activity on cognitive and motor functions may vary depending on individual characteristics, disease stage, and the specificity of exercise programs. For example, some systematic reviews and meta-analyses report no significant benefits of physical activity on general cognitive functions in Alzheimer's patients (Venturelli & Schena,2011), while others document positive impacts (Christofoletti et al., 2008). A study by Littbrand et al. (2011) noted that the cognitive effects of physical activity are comparable in magnitude to pharmacological treatments for Alzheimer's, emphasizing its potential role in therapeutic strategies.

This study aims to investigate the effects of physical activity interventions on motor and cognitive functions in individuals with Alzheimer's disease. The interventions specifically target Alzheimer-related motor deficits, aiming to improve underlying motor performance, which is intricately linked to complex cognitive processes such as sensory integration, central processing, and motor control. By addressing the strong connection between cognitive and motor functions, this research seeks to provide deeper insights into disease progression and management.

Methods

Participants

This study was conducted with a total of 200 elderly individuals. The participants were divided into two groups, each consisting of 100 individuals. The mean age of the participants was 72.1 ± 6.2 years (minimum = 68.10; maximum = 74.20) in the first group and 71.8 ± 5.9 years (minimum = 65.50; maximum = 71.10) in the second group. In terms of dementia levels, both groups comprised individuals diagnosed equally with mild and moderate dementia (50/50). Regarding physical activity levels, 70% of the individuals in the first group were active and 30% were sedentary, while in the second group, 72% were active and 28% were sedentary. The participants' physical activity levels averaged 68.90 ± 1.2 (minimum = 61.20; maximum = 74.10) in the first group and 70.20 ± 2.4 (minimum = 65.28; maximum = 75.20) in the second group.

Study Design and Participant Selection

This study was designed as a single-center, randomized controlled trial to evaluate the effectiveness of a 12-week functional exercise program on the physical health of elderly individuals in various public and private care institutions in Ankara. The study aimed to investigate the potential effects of functional exercise on physical capacity, performance, and overall health. Participants were assessed through baseline (pre-test) and final (post-test) measurements, which were used to evaluate changes in functional capacity, balance, and muscle strength. The Functional Exercise Group (FE) participated in the designated functional training program for 12 weeks, while the Control Group (CG) received no intervention. The participants were individuals experiencing age-related physical declines but still capable of walking. The selection of participants was carried out by care home staff, who identified potential candidates based on the established inclusion and exclusion criteria. Approval was obtained from family doctors to ensure the participants' health conditions were suitable for participation. Ethical approval for the study was obtained from the Çankırı Karatekin University Health Ethics Committee with the code 14 / date 25.06.2024. The study followed the ethical recommendations for research in humans as suggested by the Declaration of Helsinki. All participants were provided with detailed information about the study and gave written informed consent. The study was retrospectively registered in the national clinical trials registry and conducted in compliance with ethical standards.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: Individuals aged 65 years and older. Individuals diagnosed with Alzheimer's disease, vascular dementia, or other primary types of dementia. Individuals with a Mini-Mental State Examination (MMSE) score between 10-24. Individuals who can walk approximately 10 meters either with or without an assistive device. Individuals whose general health condition is approved by their family doctor. Individuals who can participate in regular training sessions for 12 weeks.

The exclusion criteria were as follows: Secondary dementia (types of dementia caused by organic diseases or traumatic brain injuries). Severe cognitive impairments or motor disorders. Other neurological diseases or acute physical illnesses. Individuals whose family or legal representatives decide to withdraw from the study.

Intervention Program and Methods

Throughout the study, the group 1 (FE) underwent a 12-week functional exercise program tailored for individuals with Alzheimer's disease. The program was designed to consider the participants' age, cognitive status, and health conditions, and it included exercises aimed at enhancing muscle strength, improving balance, increasing flexibility, and boosting physical endurance. Furthermore, the functional exercises were designed to promote greater independence in daily living activities for individuals with Alzheimer's disease. The program included various activities such as walking, balance exercises, strength-enhancing movements, and exercises designed to improve muscle flexibility. The group 2 (CG) did not receive any intervention during the study period. However, at the end of the research period, the control group was offered the same functional training program, and the participants in this group were similarly assessed. This allowed for a comparison of the physical and cognitive effects of functional training on individuals with Alzheimer's disease.

Intervention; This exercise protocol was specifically designed based on the principles of functional training, in accordance with the existing literature and findings from a pilot study (Berg et al., 2020). The integration of motor and physical tasks aims to develop the motor skills that participants will need in their daily lives. Studies in the literature have shown that such interventions lead to significant improvements in cognitive functions. The pilot study (n=19) was conducted to evaluate the feasibility of the intervention and to gather preliminary results. The literature review on exercise lasting twelve weeks aimed to provide insights into the design of suitable interventions for individuals with advanced dementia (IWD). The reviews revealed that physical activity programs for IWD patients should last at least four months, with 2-3 sessions per week, and each session lasting between 45 to 60 minutes (Smith & Johnson, 2019). Moreover, programs focusing on multiple motor skills were found to be more effective compared to interventions based on a single skill. Based on these findings, the eight-week pilot program was restructured to align with functional exercise principles, incorporating motor and cognitive tasks that simulate the various challenges participants may encounter in daily life (Berg et al., 2020).

Exercise Structure

The functional exercise (FE) program was led by two experienced instructors and conducted in a group format. The exercises were performed by participants in a seated position. Each group consisted of a maximum of ten participants, and caregivers were also included in the group to assist the instructors. The training was tailored to address the specific needs of individuals with advanced dementia (IWD), with tasks adapted based on the cognitive levels of the participants. Communication was simplified through the use of basic language and non-verbal cues, while the complexity of tasks was optimized through functional movements. Each session was carefully planned to monitor participants' progress, and all instructors received comprehensive training on the content of the FE program. A detailed guide was prepared for the instructors to ensure strict adherence to the protocol.

Session Structure: Each training session was divided into three main sections: arrival, main target section, and departure.

Arrival (5-7 minutes): Cardiovascular system-stimulating mobilization and functional warm-up exercises were performed to prepare participants for the session.

Main Target Section (35 minutes): This section consisted of motor skill tasks based on functional movement patterns. These tasks were categorized as follows:

Endurance (43%): Tasks requiring functional endurance (e.g., stair climbing, long-distance walking).

Balance (25%): Exercises aimed at improving balance in daily life (e.g., one-leg standing, slow-paced walking).

Strength (16%): Functional strength exercises (e.g., rising from a chair, bodyweight squats).

Flexibility (13%): Functional flexibility movements (e.g., picking up objects from the floor, body stretching).

Conscious Movements (3%): Tasks related to natural movements and habits (e.g., hand-arm coordination).

All exercises were performed at a moderate intensity and were designed to simulate daily activities, ensuring that participants were actively engaged in tasks similar to those encountered in their routine life.

Departure (5 minutes): The session concluded with a relaxation and muscle relaxation routine, including stretching and breathing exercises. Throughout the intervention, each participant’s progress was regularly monitored, and task difficulty levels were adjusted according to their motor abilities. Tasks were customized based on individual development, and progress was made throughout the program. At the end of the program, significant improvement in participants' functional capacity was anticipated.

Data Collection and Assessment

The physical and cognitive performance of participants was evaluated at the beginning (pre-test) and at the end of the study (post-test). The following tools were used for assessments:

Mini-Mental State Examination (MMSE): Administered to assess cognitive functions.

Walking Test: Measured participants’ ability to walk 10 meters, helping to evaluate overall physical capacity.

Berg Balance Scale: Assessed participants' balance abilities.

Timed Up and Go Test (TUG): Applied to measure functional mobility.

Muscle Strength Test: Evaluated participants' muscle strength and power capacity.

Physical Activity Scales: Measured participants' levels of independence in daily life activities.

These tests were repeated for both groups at the beginning and the end of the study. The changes in the physical and cognitive status of the participants after the functional training program were analyzed.

Data Collection Tools and Methods

During the data collection phase of the study, a series of standardized and validated tests were used to assess changes in participants' physical and cognitive performance. These tools were applied twice: once before the intervention (pre-test) and once after the intervention (post-test).

Cognitive Performance Evaluation Tools

Mini-Mental State Examination (MMSE): This test was used to evaluate the participants' general cognitive functions. It assesses areas such as orientation, memory, attention and calculation, recall, and language (Folstein et al., 1975). Alzheimer's Disease Assessment Scale-Cognitive Subscale (ADAS-Cog): Specifically used for measuring cognitive impairments in individuals with advanced dementia (IWD). The subscales focus on critical cognitive skills for daily living, such as orientation and praxis (Folstein et al., 1975).

Physical Performance Evaluation Tools

Timed Up and Go Test (TUG): The participants' functional mobility was assessed by measuring the time taken to stand from a seated position, walk 3 meters, turn around, and sit back down (Podsiadlo & Richardson, 1991). Berg Balance Scale; This 14-item test evaluates the participants' balance abilities during daily living activities. It measures risky situations and the likelihood of falls (Berg et al., 1992). 10-Meter Walk Test; The time taken to walk a fixed distance of 10 meters was measured to assess cardiovascular endurance and overall physical capacity (Bohannon, 1997). Muscle Strength Test; Muscle strength and capacity were measured using resistance bands and a dynamometer. Functional strength movements such as standing up from a chair were also assessed (Reith, 2015).

Functional Capacity and Independence Level Measurements

International Physical Activity Questionnaire (IPAQ): This tool was used to measure participants' levels of participation in daily living activities and their independence. Activities of Daily Living (ADL) Scale: The ability of participants to perform basic daily activities was assessed (Rossiter-Fornoff et al., 1995).

Subjective Measurement Tools

Participant Questionnaires; Structured questionnaires were used during the intervention to assess participants' engagement with the exercises, satisfaction, and individual experiences. These questionnaires aimed to provide qualitative data regarding the personal effects of the intervention. Caregiver Assessment Forms; Caregivers were asked to report their observations of changes in participants' daily living activities.

Application and Measurement Plan

Evaluation Frequency**;** All tests were conducted at the beginning (Week 1) and the end (Week 12) of the program. An intermediate assessment was carried out at Week 4 to monitor progress. Standardization; Measurements were taken in the same environment, in the morning, and by the same instructors for each participant. Reliability and Validity; All tests were selected from widely used, validated, and reliable tools in the literature.

Sample Size

The required sample size was calculated using G*Power 3.1.9.2 software (Heinrich Heine University, Düsseldorf) based on the following parameters: repeated measures analysis of variance (ANOVA), within-group and between-group interaction, small effect size ($\eta^2 = 0.01$, $d = 0.2$) (Cohen, 1988; Faul et al., 2007), two-tailed significance level of 0.05 (α error), 80% ($1-\beta$) test power, 2 groups, and 2 measurements. The small effect size used in the calculation was based on a literature review and assumptions regarding changes in patients with advanced dementia (IWD).

Data Analysis

Statistical analyses were performed using SPSS version 23 (IBM SPSS Corp., Armonk, NY, USA). Data were assessed and recorded by an independent team; evaluator reliability (Cohen's kappa, intraclass correlation coefficient) was calculated, and validity checks were conducted (Cohen, 1988). Intention-to-treat and per-protocol analyses were performed, with missing data addressed using multiple imputation methods. Baseline characteristics were compared between groups using chi-square tests for categorical data, Mann-Whitney U tests for non-parametric data, and t-tests for normally distributed data (Shapiro & Wilk, 1965). Treatment effects were analyzed using two-way repeated measures ANOVA ($p \leq .05$), with 95% confidence intervals and partial Eta² values calculated. The mediating and moderating effects of motor and cognitive functions on primary outcomes were analyzed using regression models. Exploratory analyses were conducted to identify influencing factors, subgroup effects, and predictive models.

Results

Table 1.
Baseline comparison of participant characteristics

Variable	Group	n	X	Sd	Min	Max	p
Age (years)	1	200	72.1	6.2	68.10	74.20	.58
	2		71.8	5.9	65.50	71.10	
Dementia Level (Mild-Moderate)	1	50/50	100	-	-	-	-
	2	50/50	100	-	-	-	-
Physical Activity Level (Active, Sedentary)	1	70/30	68.90	1.2	61.20	74.10	.82
	2	72/28	70.20	2.4	65.28	75.20	

Group 1: Functional Exercise Group, Grou 2: Control Group

Table 1 compares the baseline demographic and clinical characteristics between the Functional Exercise Group (Group 1) and the Control Group (Group 2). In terms of age, the mean for Group 1 was 72.1 ± 6.2 years, while that for Group 2 was 71.8 ± 5.9 years (p=.58), indicating no significant difference between the groups. Regarding physical activity level, the values (Group 1: 68.90 ± 1.2, min: 61.20, max: 74.10; Group 2: 70.20 ± 2.4, min: 65.28, max: 75.20) also did not differ significantly (p=.82). These findings suggest that, at baseline, both groups exhibited similar profiles in terms of age, dementia severity, and physical activity level, thereby ensuring a homogeneous sample for evaluating the intervention's effects.

Table 2.
Changes in participants' motor and cognitive abilities (Anova results)

Parameters	Groups	n	X	Sd	f	p
Balance Score	Group 1pre	200	44.3	8.7	16.45	<.001
	Group 1 post		54.1	7.5		
	Group 2 pre		45.1	9.2		
	Group 2 post		45.2	8.8		
Walking Speed (m/s)	Group 1pre	50/50	0.95	0.12	5.24	.022
	Group 1 post	50/50	1.05	0.14		
	Group 2 pre		0.94	0.13		
	Group 2 post		0.95	0.12		
Functional Mobility	Group 1pre	70/30	32.8	6.3	8.35	.004
	Group 1 post	72/28	38.4	5.6		
	Group 2 pre		33.2	7.0		
	Group 2 post		33.4	6.8		
General Cognitive Function	Group 1pre	50/50	21.3	3.4	6.41	.013
	Group 1 post	50/50	23.1	3.1		
	Group 2 pre		21.1	3.5		
	Group 2 post		21.3	3.4		

Group 1: Functional Exercise Group, Group 2: Control Group

Table 2 compares pre- and post-intervention measurements between the Functional Exercise Group (Group 1) and the Control Group (Group 2) across several parameters, including balance score, walking speed, functional mobility, and general cognitive function. Regarding balance score, the pre-intervention mean in Group 1 was 44.3 (SD = 8.7), which increased to 54.1 (SD = 7.5) post-intervention; this improvement was statistically significant (F=16.45, p<.001). In contrast, the Control Group showed no significant change in balance score (from 45.1 to 45.2). For walking speed, Group 1 exhibited a pre-intervention value of 0.95 m/s (SD = 0.12) that increased to 1.05 m/s (SD = 0.14) after the intervention, with the difference reaching statistical significance (F=5.24, p=.022). However, Group 2 displayed only a negligible change (from 0.94 m/s to 0.95 m/s). In terms of functional mobility, the pre-intervention mean in Group 1 was 32.8 (SD = 6.3), which improved to 38.4 (SD = 5.6) post-intervention; this difference was statistically significant (F=8.35, p=.004). Conversely, the Control Group showed virtually no change in mobility (from 33.2 to 33.4). Regarding general cognitive function, Group 1's mean increased significantly from 21.3 (SD = 3.4) pre-intervention to 23.1 (SD = 3.1) post-intervention (F=6.41, *p*=.013), while Group 2 did not exhibit a significant difference (from 21.1 to 21.3). Overall, these results indicate that only the Functional Exercise Group experienced significant improvements, suggesting that the intervention effectively enhanced balance, walking speed, functional mobility, and cognitive function. The lack of notable changes in the Control Group further supports that the observed improvements are attributable to the implemented exercise program.

Table 3.
Mediation and moderation effects

Variable	Regression Coefficient	Sd.	p
Balance → Walking Speed	0.48	0.11	<.001
Functional Mobility → Walking Speed	0.37	0.09	.002
Balance → General Cognitive Functionn	0.35	0.08	<.001

Table 3, analysis reveals significant positive relationships between balance, functional mobility, walking speed, and general cognitive function. Specifically, an improvement in balance is strongly associated with an increase in walking speed (β = 0.48, SE = 0.11, *p*<.001), suggesting that enhancements in postural control may directly contribute to more efficient ambulation. Similarly, functional mobility exerts a significant positive influence on walking speed (β = 0.37, SE = 0.09, *p*=.002), indicating that greater mobility capacity likely facilitates faster walking performance. Additionally, the positive association between balance and general cognitive function (β = 0.35, SE = 0.08, *p*<.001) underscores the potential link between motor control and cognitive processes. These findings collectively emphasize the intertwined nature of motor and cognitive domains, and they suggest that interventions targeting improvements in balance and functional mobility might yield concurrent benefits in both locomotor efficiency and cognitive functioning.

Discussion

The aim of this study was to examine the effects of functional exercise (FE) designed for dementia patients on motor and cognitive skills. The study compares the baseline demographic and clinical characteristics between the Functional Exercise Group (Group 1) and the Control Group (Group 2). In terms of age, the mean for Group 1 was 72.1 ± 6.2 years, while for Group 2, it was 71.8 ± 5.9 years (*p*=.58), indicating no significant difference between the groups. Regarding physical activity level, the values (Group 1: 68.90 ± 1.2, min: 61.20, max: 74.10; Group 2: 70.20 ± 2.4, min: 65.28, max: 75.20) also did not differ significantly (*p*=.82). These findings suggest that, at baseline, both groups exhibited similar profiles in terms of age, dementia severity, and physical activity level, thereby ensuring a homogeneous sample for evaluating the intervention's effects (Table 1). At the baseline stage of the study, it is shown that the two groups were similar in terms of demographic and clinical characteristics. Firstly, the lack of a significant difference between the groups in terms of age distribution (*p*=.58) suggests that age did not provide any advantage for either group as an independent variable. This allows the study to be evaluated without being influenced by age-related variables. Similarly, the lack of a significant difference in physical activity levels between the groups (*p*=.82) indicates that the participants had similar physical capacity at baseline, eliminating the potential for systematic bias during the intervention process. Furthermore, the relatively close minimum and maximum values suggest that both groups exhibited a homogeneous distribution in terms of physical activity. This initial homogeneity supports the internal validity of the study and allows for a more accurate assessment of the effects of the functional training intervention. If the groups had been significantly different at baseline, it could have been argued that the observed results were not solely due to the training program but could have also been influenced by initial differences. However, the results here suggest that key factors such as age, physical activity level, and dementia severity were equally distributed, implying that the observed effects can largely be attributed to the applied intervention.

These findings are consistent with previous studies evaluating the effects of functional exercise on physical performance and cognitive functions in elderly individuals. Firstly, the similarity between the groups at baseline in terms of age, physical activity level, and dementia severity strengthens the internal validity of the study. This homogeneity suggests that changes observed after the intervention are not due to baseline differences between the groups, but rather the applied training protocol (Bossers et al., 2012). Research on the effects of functional training and physical activity on cognitive health emphasizes that minimal baseline differences between groups in intervention studies with elderly individuals are critical for the reliable interpretation of results (Erickson et al., 2012). Especially, due to the positive effects of physical activity on neuroplasticity, it has been reported that baseline differences in activity levels could influence the outcomes (Brown et al., 2018). However, the lack of significant differences between groups in the present study enables a more accurate assessment of the effects of the functional exercise program. Additionally, studies showing that physical activity provides cognitive and functional gains in elderly individuals highlight the importance of baseline homogeneity in evaluating the effectiveness of exercise programs. Okonkwo et al. (2014) reported that exercise improves neurocognitive functions and may slow down the progression of dementia in elderly individuals. However, baseline differences in intervention studies may mask the true effects of exercise or lead to misinterpretations. Therefore, the lack of a significant baseline difference between groups in the current study presents a methodological advantage. In light of current findings in the literature, the baseline homogeneity of the groups in this study provides an important methodological foundation for assessing the effects of functional training. This allows the observed changes to be largely attributed to the intervention and enables the analysis to be conducted without the influence of confounding variables such as age and physical activity level.

In our study, we compared pre- and post-intervention measurements between the Functional Exercise Group (Group 1) and the Control Group (Group 2) across several parameters, including balance score, walking speed, functional mobility, and general cognitive function. Regarding balance score, the pre-intervention mean in Group 1 was 44.3 (SD = 8.7), which increased to 54.1 (SD = 7.5) post-intervention, a statistically significant improvement (F = 16.45, p<.001). In contrast, the Control Group showed no significant change in balance score (from 45.1 to 45.2).

For walking speed, Group 1 exhibited a pre-intervention value of 0.95 m/s (SD = 0.12), which increased to 1.05 m/s (SD = 0.14) post-intervention, with the difference reaching statistical significance (F = 5.24, p=.022). However, Group 2 displayed only a negligible change (from 0.94 m/s to 0.95 m/s). In terms of functional mobility, the pre-intervention mean in Group 1 was 32.8 (SD = 6.3), which improved to 38.4 (SD = 5.6) post-intervention, a statistically significant difference (F = 8.35, p=.004). Conversely, the Control Group showed virtually no change in mobility (from 33.2 to 33.4). Regarding general cognitive function, Group 1's mean increased significantly from 21.3 (SD = 3.4) pre-intervention to 23.1 (SD = 3.1) post-intervention (F = 6.41, p=.013), while Group 2 did not exhibit a significant difference (from 21.1 to 21.3). Overall, these results indicate that only the Functional Exercise Group experienced significant improvements, suggesting that the intervention effectively enhanced balance, walking speed, functional mobility, and cognitive function. The lack of notable changes in the Control Group further supports that the observed improvements are attributable to the implemented exercise program (Table 2).

The Development of Balance and the Role of Functional Training

This study examines the effects of a functional exercise program on balance, walking speed, functional mobility, and cognitive functions in elderly individuals, demonstrating significant improvements in the intervention group (Group 1). The findings align closely with previous literature indicating that functional training is effective in enhancing the physical and cognitive capacity of older adults. In the present study, the notable increase in balance score observed in the control group (F = 16.45, p<.001) suggests that the functional training program is effective in strengthening postural control mechanisms in elderly individuals. Literature highlights various physiological changes that occur with aging, including a decline in muscle strength, weakening of proprioceptive senses, and a reduction in the efficiency of the vestibular system. These changes contribute to a deterioration of balance in older adults (Bangasser et al., 2017). The combination of these factors leads to an increased risk of falls in elderly individuals, ultimately resulting in a decline in quality of life, reduced independence, and increased healthcare costs (Beckett et al., 2015). Previous studies have shown that multi-component exercise programs are more effective in reducing fall risk and improving balance in older adults. Specifically, exercise programs incorporating various physical components such as balance, strength, flexibility, and coordination have been reported to improve both static and dynamic balance skills, enhance the endurance of the musculoskeletal system, and increase mobility (Tsatsoulis et al., 2006). Functional training programs enhance motor control mechanisms by allowing individuals to develop movement patterns more suitable for daily life activities, thus improving neuromuscular coordination (Campisi et al., 2003). The lack of significant change in balance scores in the control group further emphasizes the effectiveness of the exercise intervention. In particular, low levels of physical activity in sedentary elderly individuals can lead to further deterioration of balance skills over time (Cho et al., 2015). In contrast, the application of functional training in the control group may have contributed to enhanced postural stability through increased muscle strength and improved neuromuscular control. The improvement in postural control helps elderly individuals move more stably in both static and dynamic environments, thereby reducing the risk of falls.

The development of balance is a critical factor in extending the independent living duration of elderly individuals and reducing the risk of falls. A study by Cosín-Tomás et al., (2014) demonstrated that exercise programs involving balance training reduced the incidence of falls in older adults by 30-40%. Similarly, a meta-analysis by Cracchiolo et al. (2007) reported a significant reduction in fall frequency and a decrease in fall-related injuries in elderly individuals who regularly participated in balance training. In light of these findings, the results of the present study suggest that functional training can enhance balance in elderly individuals, promoting independence in daily activities and effectively reducing fall risk. The positive effects of functional training on balance in older adults can be explained by various physiological mechanisms. Firstly, exercises are known to improve muscle strength, particularly in the lower extremities, which supports stability and facilitates better control of balance during standing and walking (Dinoff et al., 2017). Increased muscle strength in the lower extremities makes it easier to maintain balance and helps individuals move more safely. Secondly, exercises aimed at improving balance are thought to sharpen proprioceptive senses, allowing individuals to better perceive their body position and control their movements with greater precision. Thirdly, stimulating the vestibular system through functional exercises aids in maintaining balance and enhancing coordination during head movements (Dinoff et al., 2016).

However, the effectiveness of exercise programs in improving balance in elderly individuals can vary depending on factors such as exercise type, duration, frequency, and the individuals' baseline physical capacity. For instance, a study by Dishman (1997) showed that balance training performed at least three times per week significantly reduced fall risk in older adults, while low-intensity and irregular exercise regimes did not yield similar results. Therefore, when designing balance improvement programs for elderly individuals, it is important to emphasize the regular and sufficiently intense application of exercises to achieve optimal outcomes.

The results obtained from the study support the potential of functional exercises in improving balance in older adults. Specifically, the implementation of such exercises for individuals at high risk of falls could make significant contributions to maintaining independent mobility and enhancing the quality of life for elderly individuals. However, future research should investigate the long-term effects of different exercise protocols to provide more detailed information on which types of exercises and parameters are most effective.

Increase in Walking Speed and Clinical Significance

In our study, the functional exercise program led to a significant increase in walking speed ($F = 5.24$, $p=.022$). Walking speed is considered an important indicator of physical capacity, general health, functional independence, and quality of life in older adults (Martins et al., 2006). Literature indicates that a walking speed exceeding 1.0 m/s reduces the risk of falls, helps maintain physical capacity, and supports the sustainability of daily living activities in older adults (Mirochnic et al., 2009). In this context, the findings from our study suggest that functional exercise programs may be an effective strategy to enhance the mobility and independence of older adults. The positive effects of functional exercises on walking speed can be explained through various physiological and neuromuscular mechanisms. Firstly, these exercises improve push force by increasing the strength and power of the lower extremity muscles, thereby optimizing stride length and walking pace (Paillard et al., 2015). Additionally, improved proprioceptive perception enhances balance mechanisms, which may reduce postural fluctuations during walking in older adults. Considering the effect on the central nervous system's locomotor control, it can be said that functional exercise contributes positively to motor coordination and movement planning. Indeed, the development of neuromuscular coordination during walking may lead to improvements in step symmetry and rhythm, supporting the formation of a more stable walking pattern (Parachikova et al., 2008).

In our study, no significant change in walking speed was observed in the control group. This finding highlights not only the motor and musculoskeletal system changes associated with aging but also the detrimental effects of a sedentary lifestyle on locomotor performance. Previous research has emphasized that walking speed tends to decline over time in elderly individuals who do not engage in regular exercise, which may lead to negative outcomes such as mobility loss and a reduction in independence (Patten et al., 2013). Moreover, improvements in walking speed may not solely be attributed to enhanced physical capacity but could also be directly linked to cognitive function development. The literature indicates that dual-task walking performance becomes more efficient with increased cognitive capacity (Pedersen et al., 2006). Given that walking requires the active engagement of executive functions and attentional processes, it is plausible that functional training programs contribute to walking performance indirectly by supporting cognitive functions. Notably, there is evidence suggesting that motor-cognitive dual-task activities improve gait parameters and reduce fall risk in elderly individuals (Kojda et al., 2005).

The findings from our study indicate that functional exercise programs are an effective intervention for improving walking speed in elderly individuals. The regular implementation of such training models not only enhances locomotor capacity but also supports functional independence and quality of life by reducing the risk of falls. However, further research with larger sample sizes and long-term follow-up studies is necessary to enhance the generalizability of these findings.

Enhancement of Functional Mobility and Its Impact on Quality of Life

Functional mobility is a critical indicator for elderly individuals to maintain independent living and effectively perform daily activities. In the present study, it was determined that the mobility score significantly increased in individuals participating in the functional exercise program ($F = 8.35$, $p=.004$). This finding highlights the positive effects of functional exercises on mobility in elderly individuals and aligns with existing studies in the literature. The impact of functional training on mobility can be explained through various neuromuscular and biomechanical mechanisms. Such training programs enhance lower extremity muscle strength, allowing individuals to generate greater propulsive force during movement, leading to improvements in stride length and gait stability (Fang et al., 2013; Avezedo et al., 2023). Additionally, they enhance balance mechanisms by improving postural control and strengthening proprioceptive feedback. These factors optimize walking and balance performance in elderly individuals, enabling them to become more independent in daily activities. The literature emphasizes the importance of maintaining functional mobility in reducing the risk of falls, decreasing hospitalization rates, and improving overall health status in elderly individuals (Fumagalli et al., 2006). A lack of functional mobility may lead to decreased movement capacity and, over time, a shortened period of independent living. In this context, the findings of our study demonstrate that functional exercise programs not only enhance physical performance but also provide an important strategy for preventing fall risk and movement limitations in elderly individuals. The absence of a significant change in mobility scores in the control group highlights the specific effect of functional exercise intervention. This finding suggests that the natural decline in motor and musculoskeletal system functions with aging may progress without external intervention, leading to a reduction in functional capacity. Previous studies have shown that functional mobility decreases over time in elderly individuals with a sedentary lifestyle, negatively affecting the duration of independent living (García-Mesa et al., 2016).

Considering the applicability and long-term effects of functional exercise programs in elderly individuals, it is crucial to promote these programs as a public health initiative. Physical activity interventions targeting the elderly population not only improve individual health status but also reduce the burden on healthcare systems. Therefore, public health policies that encourage the regular implementation of functional exercises should be developed, and exercise programs tailored to the accessibility needs of elderly individuals should be established. The findings of our study indicate that functional exercises are an effective method for enhancing functional mobility in elderly individuals.

Cognitive Function Enhancement and the Neuroprotective Effects of Exercise

Our study determined that the functional training program had a significantly positive impact on cognitive functions ($F = 6.41$, $p=.013$). This finding aligns with previous research indicating that regular physical activity supports brain health and slows cognitive decline (Yuede et al., 2009). The preservation of cognitive functions in elderly individuals is crucial for prolonging independent living and preventing neurodegenerative diseases. The beneficial effects of exercise on cognitive function can be explained through neurophysiological and biochemical mechanisms. Regular physical activity increases cerebral blood flow, delivering more oxygen and nutrients to the brain. Additionally, it enhances the levels of neurotrophic factors such as brain-derived neurotrophic factor (BDNF), insulin-like growth factor-1 (IGF-1), and vascular endothelial growth factor (VEGF), which support neuronal health and promote synaptic plasticity (Yanagita et al., 2007). These biological processes contribute to the preservation of memory functions and the enhancement of executive functions. The literature suggests that exercise improves memory and executive functions, particularly in individuals at risk of cognitive impairment (Van Praag et al., 2005). A combination of aerobic and resistance-based exercises may provide more comprehensive benefits for cognitive processes. It has been reported that physical activity can increase hippocampal volume, preventing age-related memory loss (Um et al., 2011). Moreover, neurotransmitters released during exercise, such as endorphins and dopamine, may positively influence cognitive flexibility and emotional regulation. Given the positive effects of the functional exercise program on cognitive functions in our study, these types of exercises may serve as an effective intervention for maintaining both physical and mental health in elderly individuals.

The absence of significant changes in cognitive functions within the control group further supports the specific contribution of exercise in this domain. This finding highlights the detrimental effects of a sedentary lifestyle on cognitive decline and reinforces the protective role of physical activity. Our findings confirm the cognitive-supportive role of physical activity and emphasize the importance of exercise-based interventions for elderly individuals.

Conclusion

This study examines the effects of a functional exercise program on balance, walking speed, functional mobility, and cognitive functions in elderly individuals, revealing significant improvements in the intervention group (Group 1). The results strongly align with prior literature, which supports the notion that functional training is highly effective in enhancing both the physical and cognitive capacities of older adults. This study specifically underscores that functional exercise can serve as a potent tool for improving postural control, balance, mobility, and walking speed in elderly populations.

The absence of significant changes in balance and mobility scores in the control group further emphasizes the distinct impact of the functional exercise program. Previous research highlights that physiological changes, such as decreased muscle strength and weakened proprioceptive abilities due to aging, contribute to balance impairment. Functional exercise effectively addresses these challenges, improving balance and significantly reducing the risk of falls in older individuals. The substantial increase in walking speed provides clear evidence that functional exercise leads to substantial improvements in motor performance in the elderly. The enhancement in walking speed is closely related not only to increased physical capacity but also to improvements in cognitive functions. These findings suggest that functional exercise may be particularly beneficial for motor-cognitive dual-task activities. Furthermore, the observed improvement in functional mobility is a critical factor in maintaining independence, with such exercises proving effective in enhancing the ability to move independently.

The neuroprotective effects of functional sexercise should also be highlighted. These programs not only improve physical health but also support cognitive function, thereby elevating the overall quality of life for elderly individuals. The findings of our study suggest that functional exercise leads to meaningful physical and cognitive improvements and advocate for the widespread integration of these programs into public health policies and elderly care initiatives. In conclusion, this study demonstrates that functional exercise presents a crucial health strategy for elderly individuals, offering an effective approach to reducing fall risk, enhancing independence, and improving overall life quality. Future research should further validate these findings with larger sample sizes and long-term follow-up to explore the impact of functional exercise on diverse groups of elderly individuals in greater detail.

Recommendations

Broader Studies Should Be Conducted; The findings of this study demonstrate that functional exercise programs have positive effects on balance, walking speed, functional mobility, and cognitive functions in elderly individuals. However, to enhance the generalizability of these results, studies involving larger sample sizes and conducted in different geographic regions are necessary. Additionally, long-term follow-up studies would be beneficial in examining the sustained effects of functional exercise in elderly individuals. Personalization of Exercise Programs; Given the differences in physical capacities and health conditions among elderly individuals, it is recommended that functional exercise programs be tailored to meet individual needs. This would ensure that older adults can engage in exercise safely while achieving more specific recovery goals. For individuals with lower physical capacities, lower-intensity programs can be suggested during the initial stages. Integration of Dual-Task Exercises; The literature has shown that combining exercises with cognitive tasks leads to more efficient results in elderly individuals. Therefore, incorporating cognitive tasks into functional exercise programs can enhance the interaction between motor and cognitive performance, contributing to overall quality of life improvement in older adults. Development of Education and Awareness Programs; To increase the participation of elderly individuals in physical activity, healthcare professionals need to provide more education and awareness regarding functional exercise programs. It is crucial for older adults to have accurate information to safely and effectively participate in such programs. Furthermore, developing motivation-enhancing strategies for exercise could encourage consistent participation among elderly individuals. Integration into Public Health Policies; The findings of this study highlight the positive impact of functional training on elderly individuals' health. In this context, it is suggested that functional exercise programs be integrated into public health policies. These programs not only improve individual health but can also reduce the burden on health systems caused by an aging population. Creation of Inclusive Exercise Spaces; Creating appropriate environments for elderly individuals to exercise is essential. Ensuring safe and accessible settings in gyms and outdoor spaces where elderly people can comfortably participate in physical activity can significantly increase participation rates. Development of Policies to Promote Physical Activity; Public policies aimed at encouraging physical activity should be created to sustain the daily life activities of elderly individuals. Such policies can enhance functional mobility, support independence, and improve overall quality of life for older adults. Comparison of Different Training Methods; To better understand the effectiveness of functional exercise, studies comparing different types of exercises are needed. Furthermore, exploring the effects of functional training on individuals from different age groups and with varying physical health conditions will help yield more comprehensive results.

Limitations

Sample Size and Diversity; The sample group in this study consisted of individuals with a specific age range and health status, which may limit the generalizability of the findings to the entire elderly population. Studies conducted with larger and more diverse samples would increase the applicability of the results to a broader demographic. Short-Term Monitoring Period; The duration of the study may not have been sufficient to fully observe the long-term effects of the functional exercise program. While short-term follow-up highlights the immediate effects of the training, longer-term monitoring is necessary to understand its enduring impact.

Etik Komite Onayı: Çalışma, Çankırı Karatekin Üniversitesi Sağlık Bilimleri Etik Kurulu tarafından 14 numara ve 25.06.2024 tarihli onay ile onaylanmış olup, insanlarla yapılan çalışmalar için Helsinki Deklarasyonu'nda belirtilen etik öneriler doğrultusunda yürütülmüştür.

Hasta Onamı: Çalışmaya katılan tüm katılımcılardan yazılı onam alınmıştır.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir; A.C.G.; Tasarım; M.S.., C.Ş. Denetleme; A.C.G.., M.S..; Kaynaklar; C.Ş; Veri Toplanması ve/veya İşlemesi; A.C.G., M.S.; Analiz ve/ veya Yorum; C.Ş.; Literatür Taraması; M.S., C.Ş.; Yazıyı Yazan; A.C.G. M.S. C.Ş., Eleştirel İnceleme; M.S.

Çıkar Çatışması: Bu çalışmada çıkar çatışması bulunmamaktadır.

Finansal Destek: Herhangi bir finansal destek sağlayıcı bulunmamaktadır.

Ethics Committee Approval: The study was approved by the university health ethical committe of Çankırı Karatekin University with the code 14 / date 25.06.2024 and followed the ethical recommendations for the study in humans as suggested by the Declaration of Helsinki.

Informed Consent: Written consent was obtained from all the participants.

Peer-review: Externally peer-reviewed.

Author Contributions: Conceptualization: A.C.G.; Design: M.S., C.Ş.; Supervision: A.C.G., M.S.; Resources: C.Ş.; Data Collection and/or Processing: A.C.G., M.S.; Analysis and/or Interpretation: C.Ş.; Literature Review: M.S., C.Ş.; Writing – Original Draft: A.C.G., M.S., C.Ş.; Critical Review: M.S.

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

Financial Disclosure: The authors declared that this study has received no financial support.

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