



# E J G G

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# Primary Hyperparathyroidism Across the Age Spectrum: A Comparative Study of Clinical and Biochemical Profiles in Older and Younger Patients

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## Abstract

**Objective:** Primary hyperparathyroidism (PHPT) is characterized by elevated serum calcium (Ca) levels due to excessive parathyroid hormone (PTH) secretion and is traditionally associated with skeletal and renal complications, such as osteoporosis and nephrolithiasis. With routine measurements of serum Ca, most cases are now diagnosed asymptotically although subclinical complications like osteoporosis or hypercalciuria may still occur. This study investigated the impact of aging on the clinical and biochemical profiles of PHPT by comparing a large cohort of older and younger patients, thereby addressing the gap in understanding the disease's age-related characteristics.

**Materials and Methods:** This retrospective study analyzed patients diagnosed with PHPT who underwent surgical treatment. Demographic data, including age and gender, along with biochemical parameters serum Ca, corrected calcium (cCa), phosphorus, albumin, PTH, 24-hours urinary Ca, estimated glomerular filtration rate (eGFR), fractional calcium excretion (FE<sub>Ca</sub>), and 25-hydroxyvitamin D (25OHD) were collected. Renal imaging and dual-energy X-ray absorptiometry were used to assess nephrolithiasis and osteoporosis, respectively. Patients were stratified into two groups: those younger than 60 (Group 1) and those aged 60 and older (Group 2). The groups were compared according to the prevalence of osteoporosis, nephrolithiasis, and biochemical parameters.

**Results:** The cCa levels were significantly higher in Group 2, with a median of 11.1 mg/dL, compared with 10.8 mg/dL in Group 1 ( $p=0.002$ ). The median serum 25OHD level was lower in Group 1 (13.2 ng/mL) than in Group 2 (17 ng/mL,  $p<0.001$ ). Median 24-hours urinary Ca excretion was higher in Group 1 (375.5 mg) than in Group 2 (308 mg,  $p=0.003$ ). FE<sub>Ca</sub> was similar between the groups, with a median of 0.02 in Group 1 and 0.02 in Group 2 ( $p=0.88$ ). eGFR was significantly higher in Group 1 median, 102 mL/min/1.73 m<sup>2</sup>, compared to 84 mL/min/1.73 m<sup>2</sup> in Group 2 ( $p<0.001$ ). The prevalence of nephrolithiasis was similar between the groups, affecting 33.5% of patients in Group 1 and 31.8% in Group 2 ( $p=0.69$ ). Osteoporosis was significantly more common in Group 2 (62.3% of patients) than in Group 1 (40% in Group 1 ( $p<0.001$ )).

**Conclusion:** Aging plays a pivotal role in the clinical presentation of PHPT, with distinct patterns emerging across different age groups. In particular, older adults exhibit a higher prevalence of osteoporosis.

**Keywords:** Primary hyperparathyroidism, aging, hypercalcemia, nephrolithiasis, osteoporosis

## Introduction

Primary hyperparathyroidism (PHPT) is characterized by elevated blood calcium (Ca) levels, which is caused by the overproduction of parathyroid hormone (PTH) from one or more parathyroid glands (1). It is widely considered the most common cause of

hypercalcemia. Elevated PTH leads to hypercalcemia by increasing Ca reabsorption in the kidneys, enhancing bone resorption, and stimulating renal production of 1,25-dihydroxyvitamin D (25OHD), which promotes intestinal absorption of Ca and phosphate. Most cases are sporadic and are caused by a single

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adenoma (80%) or multiglandular disease (10–15%). Less than 1% of cases are caused by parathyroid carcinoma (1). The incidence of PHPT varies widely, with estimates ranging from about 13 to 120 cases per 100,000 individuals (2). The incidence of PHPT increases with age and is higher in women than in men. Historically, PHPT was diagnosed based on symptomatic presentations affecting the skeletal and renal systems. Common manifestations included decreased bone mineral density, fragility fractures, kidney stones, and nephrocalcinosis. However, with the routine inclusion of serum Ca measurements in metabolic panels, many cases are identified before symptoms develop, with about 70–80% of patients presenting asymptotically (3). Even in asymptomatic cases, patients may exhibit subclinical skeletal and renal complications, such as osteoporosis and hypercalciuria, which may remain unnoticed. Data on the impact of aging on the clinical presentation and biochemical profile of PHPT, particularly in individuals aged 60 years and older, remain limited. Although few studies have examined the relationship between patient age and PHPT characteristics (4–11), we investigated a large cohort of sporadic PHPT cases to compare clinical features and laboratory parameters between older and younger adults.

## Materials and Methods

This retrospective study evaluated patients with primary PHPT who were followed up at Ankara Atatürk Training and Research Hospital between July 2007 and January 2019 and Ankara Bilkent City Hospital between February 2019 and March 2021. The study included individuals who underwent surgery for PHPT, as confirmed by histopathological analysis. The exclusion criteria included patients younger than 18 years, those diagnosed with secondary hyperparathyroidism or familial hypocalciuric hypercalcemia, and individuals without histological confirmation due to either non-surgical management or surgeries performed at external centers. Data collection included patient demographics, including age at diagnosis and sex, and comprehensive biochemical markers. These included serum Ca, corrected calcium (cCa), phosphorus (P), albumin, PTH, 24-hours urinary Ca, estimated glomerular filtration rate (eGFR), fractional excretion of calcium (FE<sub>Ca</sub>), creatinine (Cr), and serum 25-hydroxyvitamin D (25OHD). cCa was calculated using the formula:  $cCa = \text{total Ca} + [0.8 \times (4.0 - \text{albumin})]$ , with reference ranges for the markers defined as follows: Ca (8.5–10.3 mg/dL), albumin (3.5–5.2 g/dL), P (2.5–4.5 mg/dL), PTH (18.4–80.1 ng/L), Cr (0.5–1.1 mg/dL), and 25OHD (30–100 µg/L). Nephrolithiasis was assessed using renal ultrasound or computed tomography. At the same time, osteoporosis was evaluated via dual-energy X-ray absorptiometry at the lumbar spine, femoral neck, and distal third of the radius, adhering to the World Health Organization criteria (12). Histopathological findings from the surgical specimens were also reviewed to

confirm the accuracy of the surgery. The study population was stratified into two groups based on age: patients younger than 60 years (Group 1) and those 60 years or older (Group 2). Comparisons were made between the groups regarding the prevalence of osteoporosis and nephrolithiasis and serum and urinary biochemical parameters. This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Ankara Bilkent City Hospital (approval number: E1–22–2425, date: 09.03.2022).

## Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to assess the normality of data distribution. Non-normally distributed variables are reported as medians with ranges (minimum–maximum), whereas categorical variables are expressed as absolute numbers and percentages. The chi-square test was used for comparisons of categorical variables, and the Mann-Whitney U test was used for non-parametric data. A p-value of <0.05 was considered statistically significant.

## Results

Six hundred fifty-nine patients were analyzed, with 499 in group 1 and 160 in Group 2. The majority of patients in both groups were female, comprising 87.6% (437/499) in Group 1 and 79.4% (127/160) in Group 2 ( $p=0.01$ ). The median age was 50 years (range 19–59) in Group 1 and 66 years (range 60–85) in Group 2.

Thyroid-stimulating hormone levels were comparable between the groups, with medians of 1.76 mU/L (range 0.008–15) in Group 1 and 1.70 mU/L (range 0.009–8.28) in Group 2 ( $p=0.36$ ). Comparisons of biochemical markers in serum and urine are presented in Table 1. cCa levels were significantly higher in Group 2, with a median of 11.1 mg/dL (range 8.76–13.32) compared with 10.8 mg/dL (range 8.79–18.63) in Group 1 ( $p=0.002$ ). The median serum 25OHD level was lower in Group 1 (13.2 ng/mL) than in Group 2 (17 ng/mL,  $p<0.001$ ). The median 24-hour urinary Ca excretion was higher in Group 1 (375.5 mg, range 24–1438) than in Group 2 (308 mg, range 38–1038,  $p=0.003$ ). FE<sub>Ca</sub> was similar between the groups, with a median of 0.02 (range 0.01–0.39) in Group 1 and 0.02 (range 0.01–0.18) in Group 2 ( $p=0.88$ ). eGFR was significantly higher in Group 1, with a median of 102 mL/min/1.73 m<sup>2</sup> (range 55–202), compared with 84 mL/min/1.73 m<sup>2</sup> (range 24–198) in Group 2 ( $p<0.001$ ). The prevalence of nephrolithiasis was similar between the groups, affecting 33.5% of patients in Group 1 and 31.8% in Group 2 ( $p=0.69$ ) (Table 2). Osteoporosis was significantly more common in Group 2 (62.3% of patients) than in Group 1 (40% in Group 1 ( $p<0.001$ )). The lumbar T-score was comparable between Groups 1 and 2. However, the median femoral T-score was significantly



lower in the elderly group at -1.3 (range -4.1 to 2.6) compared with 1.0 (range -5.1 to 2.7) in the younger group (p=0.028). The distal radius one-third T-score was also lower in the elderly group at -2.5 (range -6.5 to 3.0) compared with 1.5 (range -6.2 to 7.1) in the younger group (p<0.001). A higher proportion of elderly patients received osteoporosis treatment (8.8% vs. 2.2%, p<0.001). Additionally, hypertension and diabetes were significantly more prevalent in the elderly group (p<0.001). The detailed comparisons are presented in Table 2.

### Discussion

In this study, we retrospectively evaluated older and younger patients with PHPT who underwent surgery. There was a clear female predominance in hyperparathyroidism, which was even more pronounced in younger patients. cCa levels were higher in the older group, whereas PTH levels were similar between the groups. Vitamin D therapy was administered more frequently in the older group; however, the difference was not statistically significant. Notably, 25OHD levels were higher in the older population. The 24-hours urinary Ca level and eGFR

were higher in the younger group, whereas the incidence of nephrolithiasis was similar in both groups. Osteoporosis was more prevalent among the older group, as characterized by significantly lower femoral and distal radius T-scores, while lumbar T-scores remained comparable. The clinical presentation of PHPT according to patient age has been subject to limited investigation (4-11). Existing studies have characterized the clinical manifestations of juvenile PHPT (7,8,10,11), with findings suggesting that these younger patients may be equally (8) or even more symptomatic (7,10,11) than their adult counterparts. In contrast, there is a dearth of data on PHPT presentation among older adults (4,6,9). A notable surgical series conducted by Udén et al. (6) involving 250 patients in the 1990s highlighted that the incidence of nephrolithiasis was significantly greater in younger patients (those under 60 years). In contrast, the prevalence of osteoporosis was comparable across the age groups. Although our current study also observed a higher incidence of nephrolithiasis among younger patients, this difference was not statistically significant. Conversely, our findings indicated a substantial increase in osteoporosis

**Table 1. Clinical and biochemical characteristics of patients undergoing parathyroidectomy for primary hyperparathyroidism by age group**

	Group 1 (n=499)	Group 2 (n=160)	p
Age median years	50 (19-59)	66 (60-85)	<0.001
Female n (%)	437 (87.6%)	127 (79.4%)	0.01
TSH mU/L	1.76 (0.008-15)	1.70 (0.009-8.28)	0.36
TPO Ab positivity (%)	20.8	18.9	0.61
Corrected calcium (mg/dL)	10.8 (8.79-18.63)	11.1 (8.76-13.32)	0.002
PTH (ng/L)	178 (44-2,050)	171 (48.7-1,276)	0.27
25OHD (µg/L)	13.2 (2.9-94)	17 (2.2-101)	<0.001
FECa	0.02 (0.01-0.39)	0.02 (0.01-0.18)	0.88
24 hours urinary Ca level (mg)	375.5 (24-1,438)	308 (38-1,038)	0.003
eGFR (mL/min/1.73 m²)	102 (55-202)	84 (24-198)	<0.001
Phosphorus (mg/dL)	2.5 (0.7-5.7)	2.5 (1.1-3.6)	0.43

Categorical variables are expressed as absolute numbers and percentages. Non-normally distributed variables are reported as medians with ranges (minimum-maximum), eGFR: Estimated glomerular filtration rate, TPO Ab: Thyroid peroxidase antibodies, PTH: Parathyroid hormone, TSH: Thyroid-stimulating hormone, 25OHD: 25-hydroxyvitamin D, FECa: Fractional excretion of Ca

**Table 2. Complications and additional conditions of patients**

	Group 1 (n=499)	Group 2 (n=160)	p
Nephrolithiasis %	33.5	31.8	0.69
Osteoporosis %	40	62.3	<0.001
Lomber T- score	-1.8 (-5.2-3.9)	-2 (-4.9-2.4)	0.08
Femoral T-score	-1 (-5.1-2.7)	-1.3 (-4.1-2.6)	0.028
Distal third radius T-score	-1.5 (-6.2-7.1)	-2.5 (-6.5-3.0)	<0.001
Vitamin D therapy %	8.6	10.6	0.44
Osteoporosis therapy %	2.2	8.8	0.001
Hypertension %	28.1	66.2	<0.001
Diabetes mellitus %	13	33.1	<0.001

prevalence among older patients. It is pertinent to note that the analysis by Udén et al. (6) primarily relied on patient self-report questionnaires to assess the symptoms and signs of PHPT, thereby lacking comprehensive radiological and densitometric data regarding bone involvement. Castellano et al. (4) documented a markedly different clinical profile of PHPT between younger and older patients, wherein the older demographic exhibited a greater prevalence of bone involvement, consistent with our findings. Notably, older patients experienced a significantly lower incidence of renal stones. Recently, a study by Gasior et al. (9) involving a substantial cohort of PHPT patients corroborated the findings of elevated nephrolithiasis rates in younger individuals and a higher prevalence of osteoporosis in older patients (>40 years). Although the criteria for age stratification varied, the dominance of osteoporosis in the elderly population was consistent with the results of our study. Osteoporosis is more prevalent in older individuals, with bone loss initially affecting trabecular sites at younger ages and progressively targeting cortical bone with advancing age (13). In PHPT, structural and density deterioration predominantly involves the cortical bone (14,15). Our findings revealed a more pronounced cortical osteoporosis in older patients, highlighting the distinct impact of PTH. In the study conducted by Udén et al. (6), there were no notable differences in the biochemical profiles, such as Ca and PTH levels, between the two age groups. In contrast, our findings revealed that older patients had higher levels of 25OHD, possibly linked to vitamin D supplementation, perhaps contributing to elevated Ca levels in this older group. In a study by Castenollo et al. (4), no differences were found in the mean serum PTH, Ca, or vitamin D levels. However, urinary Ca levels were significantly lower in older patients compared with younger patients, which is consistent with our study. Gasior et al. (9) demonstrated that median 24-hours urinary Ca levels were higher in younger patients, mirroring our findings, whereas there was no difference in median serum Ca or serum PTH levels between the cohorts. Epidemiological studies have established a significant relationship between urinary Ca excretion and the risk of kidney stone formation in the general population (16) and individuals diagnosed with PHPT (17-19). In our study, we noted that younger patients exhibited significantly higher Ca excretion; however, the incidence of nephrolithiasis did not differ significantly between age groups. Although hypercalciuria is recognized as a contributing factor to renal stone development (17), it alone does not fully account for the increased risk of nephrolithiasis among all patients with PHPT. This observation implies the involvement of additional risk factors (18,20) involved, such as hyperuricosuria, hypomagnesuria, hyperoxaluria, hypocitraturia, or cystinuria (21,22), which were not examined in our study. In patients with PHPT, a reduced eGFR can significantly affect urinary Ca levels (23,24). PHPT is characterized by increased renal Ca reabsorption

due to elevated PTH levels. However, as eGFR decreases and renal function declines, the kidneys' ability to filter Ca is compromised. Nevertheless, persistent hyperparathyroidism can lead to ongoing renal Ca loss because PTH stimulates Ca mobilization from bone and enhances intestinal absorption. Our study found that the older cohort had a lower glomerular filtration rate, which may have contributed to decreased urinary Ca excretion. These findings are corroborated by Black et al. (25) who identified a correlation between 24-hours urinary Ca levels and renal function and a negative correlation with age. In addition, in our study, the number of elderly patients receiving osteoporosis treatment was higher than that of younger patients, and it is known that osteoporosis treatments may reduce urinary Ca excretion (26). Despite the similar incidence of nephrolithiasis, the low urinary Ca values may also be explained by higher osteoporosis treatment in the older group. The frequency of hypertension and diabetes mellitus was higher in the older group in this study and may predispose older patients with PHPT to impaired renal function. It remains unclear whether impaired renal function is solely caused by PHPT or by traditional risk factors, such as age, diabetes mellitus, and blood pressure. Walker et al. (24) showed that traditional risk factors for renal failure in the non-hyper parathyroid population, such as age, diastolic blood pressure, and blood glucose, were associated with worse renal function in PHPT (24).

### Study Limitations

Our study has some limitations. Despite the large cohort, we conducted a retrospective single-institution study, which may have been influenced by selection bias. All patients in the study indicated and underwent surgery for PHPT; therefore, the findings cannot be generalized to all patients with PHPT. Furthermore, although we included patients on bone-active medications, we could not exclude the potential effects of these drugs on bone and serum.

### Conclusion

This study encompasses a substantial patient cohort. Limited research has focused on the impact of PHPT in both elderly and younger populations, underscoring the significance of this study's findings. Osteoporosis is more frequently observed in elderly individuals. Unlike osteoporosis in the general population, it predominantly affects the cortical bone. This pattern appears to reflect the influence of PTH. Thus, it can be concluded that PHPT leads to more pronounced bone deterioration in older adults than in younger individuals, highlighting the potential need for earlier intervention.

### Ethics

**Ethics Committee Approval:** This study was conducted in accordance with the principles of the Declaration of Helsinki

and was approved by the Ethics Committee of Ankara Bilkent City Hospital (approval number: E1-22-2425, date: 09.03.2022).

**Informed Consent:** Retrospective study.

## Footnotes

### Authorship Contributions

Surgical and Medical Practices: B.Ç., R.E., O.T., Concept: B.Ç., R.E., Design: O.T., R.E., Data Collection or Processing: N.İ., B.E.Ö., Analysis or Interpretation: B.E.Ö., B.Ç., Literature Search: N.İ., Writing: B.E.Ö., N.İ.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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# Predictors of Early Mortality After Percutaneous Endoscopic Gastrostomy in Geriatric Patients

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## Abstract

**Objective:** We aimed to determine the risk factors that may be responsible for early mortality in patients planned for percutaneous endoscopic gastrostomy (PEG).

**Materials and Methods:** This study was retrospectively designed, including patients over 65 years of age who underwent PEG between January 2014 and March 2019. Early mortality rates (within 30 days) following the PEG procedure were evaluated. Variables analyzed included demographic characteristics, blood samples, and the Charlson Comorbidity Index (CCI). Predictors of 30-day mortality were identified using logistic regression.

**Results:** Of the 178 patients who underwent PEG placement, 93 were female (52.2%) and 85 were male (47.8%). Early mortality was observed in 115 patients, accounting for 64.6% of the cohort. Age was positively associated with early mortality [odds ratio (OR)=1.049 (95% confidence interval (CI)=1.013-1.086), p=0.007]. A CCI greater than 7 was associated with a 6.147-fold increase in the risk of early mortality (95% CI=1.221-30.951, p=0.028). Elevated C-reactive protein levels (>3.99 mg/L) increased the risk of early mortality by 3.991-fold (95% CI=1.614-9.968, p=0.003). Conversely, lower sodium levels (<130.5 mmol/L) and phosphorus levels (<2.25 mg/dL) were also associated with higher mortality risks [OR=3.610 (95% CI=1.524-8.548, p=0.004) and OR=2.976 (95% CI=1.075-8.240, p=0.036), respectively].

**Conclusion:** When planning a PEG procedure, especially for elderly patients, it is crucial to consider risk factors associated with early mortality.

**Keywords:** Percutaneous endoscopic gastrostomy, elderly patients, early mortality, risk factors, Charlson Comorbidity Index

## Introduction

Nutritional disorders, impaired oral intake, and comorbidities are becoming increasingly significant issues in geriatrics (1). Enteral nutrition is the preferred method as long as the gastrointestinal system remains functional, due to its lower cost, reduced bacterial translocation, and decreased risk of sepsis (2). Percutaneous endoscopic gastrostomy (PEG) is a reliable method with low morbidity, commonly used to provide sustained enteral nutrition for individuals who cannot maintain adequate oral intake (3). The increasingly common indications for PEG placement include elderly patients who have lost the ability to eat due to cerebrovascular diseases, chronic neurological

disorders, and advanced dementia (4). Although procedure-related complication rates are low, PEG placement has been associated with early mortality rates in patients of advanced age and those with comorbid conditions (5,6). This study aims to determine the risk factors linked to early mortality that may assist in decision-making for elderly patients scheduled for PEG placement.

## Materials and Methods

### Study Design

This study was retrospectively designed and conducted by reviewing the records of 258 patients who underwent PEG

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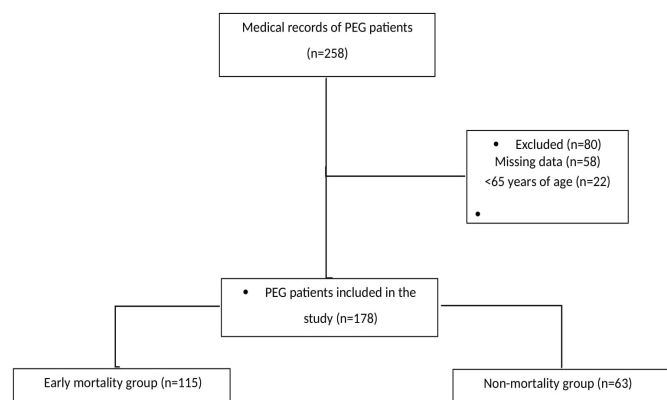


placement between January 2014 and March 2019 at Ankara Yıldırım Beyazıt University Yenimahalle Training and Research Hospital. Patients who underwent endoscopy-guided PEG were included in the study (7). Participants with incomplete records and individuals younger than 65 were not included in the study. A total of 178 patients were included. Mortality status was analysed at the end of the first month following the PEG procedure (Figure 1). Patient backgrounds and hematological data were compared between the two groups. Ethical approval was obtained from the Ankara Yıldırım Beyazıt University Yenimahalle Training and Research Hospital Ethics Committee (approval number: 2019.03.05 date: 26.03.2019). A waiver of the requirement for informed written consent under the Helsinki Declaration was granted, as only the medical data from the patients' electronic records were obtained.

**Data Collection**

The records of patients undergoing PEG were reviewed for age, gender, primary diagnosis (chronic neurological diseases, tumors, dementia, head and neck tumors), comorbidities, and laboratory data [albumin; C-reactive protein (CRP); hemoglobin (HB); white blood cell count (WBC); sodium (Na); potassium (K); phosphorus (P); alanine aminotransferase (ALT); blood urea nitrogen]. The laboratory tests and comorbidities were collected from data obtained concurrently with the PEG procedure. Complications related to the procedure (such as wound site infection, bleeding, peritonitis, dislodgement of the PEG set, etc.) were evaluated within the one-month period following the PEG procedure.

The Charlson Comorbidity Index (CCI) was used to evaluate patients' comorbidities based on detailed medical histories. The CCI includes various medical conditions weighted between 1 and 6 points (Figure 2). A score of 0 was considered associated with a low risk of mortality, 1-2 points with a moderate risk of mortality, and ≥3 points with a high risk of mortality (8).



**Figure 1.** Flowchart of the study

PEG: Percutaneous endoscopic gastrostomy

**Statistics**

Whereas categorical variables were displayed as counts and percentages, continuous variables were represented as means ± standard deviations, medians, and interquartile ranges. The Kolmogorov-Smirnov test was used to assess the normality of the data distribution. The Mann-Whitney U test was used to compare continuous variables between survivors and non-survivors. For nominal variables, group comparisons in contingency tables were performed using the chi-square test or Fisher's Exact test. The diagnostic performance of laboratory parameters was evaluated by analyzing the area under the receiver operating characteristic (ROC) area under the curve (AUC). The optimal cut-off value was determined using Youden's Index. Risk factors associated with early mortality were analyzed through multivariate logistic regression. IBM SPSS 20.0 (SPSS Inc., Chicago, IL) was utilized for statistical analysis, with the significance level set at p<0.05.

**Results**

The average age of the 178 patients included in the study was 79.25±10.97, with 52% of them being female. Early mortality was observed in 115 patients, accounting for 64.6% of the cohort. The general characteristics and laboratory findings of the patients are summarized in Table 1 and Table 2. Laboratory findings revealed that individuals with early mortality had higher CRP levels and lower albumin, Na, and p values (all p<0.05). There were no notable differences in K, urea, creatinine, HB, WBC, or ALT levels between the groups (all p>0.05). Factors that may influence early mortality are presented in Table 3. Patients who experienced early mortality were older and had higher CCI scores compared to those who survived (both p<0.01). When the comorbid diseases identified during the PEG procedure were analyzed separately, they were found to have no significant impact on early mortality. No major complications

Diseases	
Ischemic heart disease, heart failure, peripheral arterial disease, cerebrovascular disease, dementia, chronic lung disease, mild liver disease, uncomplicated diabetes mellitus	1 points each
Complicated diabetes mellitus, renal failure, hemiplegia or paraplegia, non-metastatic cancer	2 points each
Liver cirrhosis	3 point
Metastatic cancer, acquired human immunodeficiency syndrome	6 points each

**Figure 2.** Charlson Comorbidity Index

Calculation of the Charlson Comorbidity Index: The total CCI score is calculated by summing the assigned points for each comorbid condition present in a patient. Higher scores indicate greater comorbidity and are associated with an increased risk of 1-year mortality

CCI: Charlson Comorbidity Index

**Table 1. Demographic and clinical characteristics (n=178)**

Characteristic	Value	Percentage (%)
Age (Mean ± SD)	79.25±10.97	-
Charlson Comorbidity Index (Median, IQR)	6 (5-7)	-
Female	93	52.2%
Male	85	47.8%
Diabetes mellitus	34	19.1%
Chronic lung disease	33	18.5%
Coronary artery disease	57	32.0%
Pneumonia	56	31.5%
Chronic kidney disease	12	6.7%
Urinary tract infection	10	5.6%
Alzheimer's disease	81	45.5%
Stroke	48	27.0%
Parkinson's disease	13	7.3%
Dementia	18	10.1%

SD: Standard deviation, IQR: Interquartile range

such as bleeding, perforation, or peritonitis, which could lead to mortality, were observed in association with the PEG procedure.

### Regression Analysis

Binary logistic regression analysis demonstrated significant predictors of early mortality among PEG patients (Table 4). Age was positively associated with early mortality [OR=1.049 (95% CI=1.013-1.086), p=0.007]. A CCI greater than 7 was associated with a 6.147-fold increase in the risk of early mortality (95% CI=1.221-30.951, p=0.028). Elevated CRP levels (>3.99 mg/L) increased the risk of early mortality by 3.991-fold (95% CI=1.614-9.968, p=0.003). Conversely, lower Na levels (<130.5 mmol/L) and p levels (<2.25 mg/dL) were also associated with higher mortality risks [OR=3.610 (95% CI=1.524-8.548, p=0.004) and OR=2.976 (95% CI=1.075-8.240, p=0.036), respectively].

### Threshold Values and ROC Analysis

ROC curve analysis identified critical thresholds for predicting early mortality. For CRP, p value of >3.99 mg/L was determined to be the optimal threshold [AUC=0.631 (95% CI: 0.536-0.726)].

**Table 2. Laboratory findings and comparison between groups**

Laboratory	Non-mortality (n=63)	Early mortality (n=115)	p
CRP (mg/L)	5.80 (1.44-12.5)	8.54 (5.37-13.01)	0.004
Albumin (g/dL)	2.88 (2.50-3.22)	2.60 (2.22-2.90)	<0.001
Sodium (mmol/L)	134 (132-136)	130 (128-134)	<0.001
Phosphorus (mg/dL)	3.2 (2.5-4.0)	2.5 (2.0-3.3)	<0.001
Potassium (mmol/L)	3.9 (3.6-4.0)	3.8 (3.0-4.0)	0.058
Urea (mg/dL)	43 (31-52)	45 (32-54)	0.126
Creatinine (mg/dL)	1.1 (0.9-1.5)	1.3 (1.0-1.4)	0.242
Hemoglobin (g/dL)	10.0 (9.5-10.9)	9.9 (9.2-11.0)	0.317
WBC (x10 <sup>3</sup> /μL)	8800 (6000-11000)	7200 (4800-10000)	0.102
ALT (U/L)	49 (28-65)	55 (40-67)	0.056

Data are presented as median (25%-75% interquartiles) or mean ± SD. Statistically significant values are marked in bold. CRP: C-reactive protein, ALT: Alanine aminotransferase, WBC: White blood cell count

**Table 3. Comparison of demographic characteristics between non-mortality and early mortality group patients**

Characteristic	Non-mortality (n=63)	Early mortality (n=115)	p
Age (years)	76 (68-84)	84 (77-89)	<0.001
Charlson Comorbidity Index	5 (4-6)	6 (5-8)	0.002
Gender			
Female	35 (55.6%)	58 (50.4%)	0.513
Male	28 (44.4%)	57 (49.6%)	
Diabetes mellitus (%)	14 (22.2%)	20 (17.4%)	0.453
Chronic lung disease (%)	10 (15.9%)	23 (20.0%)	0.498
Coronary artery disease (%)	24 (38.1%)	33 (28.7%)	0.199
Pneumonia (%)	16 (25.4%)	40 (34.8%)	0.197
Chronic kidney disease (%)	2 (3.2%)	10 (8.7%)	0.218
Urinary tract infection (%)	2 (3.2%)	8 (7.0%)	0.498

Variable	Odds ratios	95% confidence intervals	p
Age	1.049	1.013-1.086	0.007
Charlson Index >7	6.147	1.221-30.951	0.028
CRP >3.99 mg/L	3.991	1.614-9.968	0.003
Sodium <130.5 mmol/L	3.610	1.524-8.548	0.004
Phosphorus <2.25 mg/dL	2.976	1.075-8.240	0.036

CRP: C-reactive protein

Similarly, Na levels <130.5 mmol/L [AUC=0.721 (95% CI: 0.648-0.794)] and p levels <2.25 mg/dL [AUC=0.684 (95% CI: 0.606-0.763)] were significant predictors of early mortality. These thresholds align with the observed clinical trends and suggest critical markers for prognosis.

## Discussion

In our study, we investigated the relationship between risk factors and early mortality following the PEG procedure. Our results showed that early mortality was 6 times higher ( $p<0.05$ ) in patients with CCI >7, 4 times higher ( $p<0.01$ ) in those with CRP >3.99 mg/L, 3.6 times higher ( $p<0.01$ ) in those with Na <130.5 mmol/L, and 3 times higher ( $p<0.05$ ) in those with p<2.25 mg/dL. Age was a risk factor for early mortality ( $p<0.01$ ). Albumin was not associated with early mortality ( $p>0.05$ ). It is recommended to encourage hand feeding, especially in malnourished patients with dementia (9). Nevertheless, if patients show early signs of malnutrition, nasogastric feeding may be preferred with a multidisciplinary approach (4). In a study conducted by Bond et al. (10), it was observed that the multidisciplinary approach reduced the 30-day mortality rate. The 2021 guidelines recommend early PEG in selected patients with chronic diseases who experience weight loss despite continued oral nutrition (11). PEG tube placement is not advised for individuals whose expected survival is under 30 days (11). Studies on the timing of PEG tube placement have been performed (12,13). In their large-scale study investigating the timing of PEG indications, Teno et al. (14) found that the timing of PEG tube placement did not affect survival in patients with dementia.

Complications associated with PEG, along with risk factors related to early and late mortality, have been evaluated in an effort to establish certain criteria (15,16). High CRP levels have been identified as an independent factor predicting early mortality, with each unit increase in CRP shown to raise the mortality risk by 0.8% (17). High CRP levels, low albumin levels, advanced age, and diabetes mellitus (DM) were found to be associated with early mortality after PEG (15,18). Muratori et al. (19) found that Na  $\geq$ 150 mmol/L, and high CRP levels was associated with an early mortality. In our study, we similarly found an association between high CRP levels and early mortality. Conversely, we identified an association between early mortality and patients with Na <130 mmol/L and low Phosphorus levels. However, no

association was observed between early mortality and albumin levels. Sanders et al. (20) found a 28% mortality rate in the early period after PEG, with a mortality rate of 54% in patients with dementia. Abuksis et al. (21) found an early mortality rate of 72% in hospitalized PEG patients, 46% of whom had dementia, while in nursing home patients, 87% of whom had dementia, the mortality rate was 39.5%. Zopf et al. (6) found a 30-day early mortality rate of 6.5% after PEG procedures in patients 75% of whom had malignancies. The predictive factors for the increase in early mortality were found to be older age and the presence of DM.

In our study, approximately 90% of our patients were diagnosed with Alzheimer's or other dementias, and cerebrovascular disorders, while 2% had malignant diseases. We found an early mortality rate of 64.6%. These rates are similar to the early mortality rates in hospitalized patients reported by Abuksis et al. (21). The significant difference in mortality between our study and that of Zopf et al. (6) can be explained by the very small number of malignant patients in our study. This suggests that underlying diseases and hospitalization have a significant impact on mortality in patients undergoing PEG. We found that comorbidities such as DM, coronary artery disease, pneumonia, chronic kidney disease, and urinary tract infections did not independently affect mortality. However, when we used the CCI, we observed a significant increase in early mortality. Each year of increase in patient age was associated with a 4.9% increase in early mortality, which is consistent with the literature. Based on these findings, we believe that the CCI could be an important indicator in determining the indication for PEG.

In particular, life expectancy in elderly patients with comorbidities who are hospitalized in intensive care units should be evaluated by considering risk factors, and the limits of nasogastric feeding should be carefully reconsidered. In high-risk patients, a multidisciplinary approach should be adopted when making the decision to proceed with PEG, balancing social, economic, and ethical values.

## Study Limitations

The limitations of this retrospective study are that some laboratory and comorbidity data were missing and that the clinical status of the patient before PEG was not fully known.

## Conclusion

When planning a PEG procedure, especially for elderly patients, it is crucial to consider risk factors associated with early mortality. This not only helps prevent unnecessary invasive interventions but also guides the selection of alternative treatment options.

## Ethics

**Ethics Committee Approval:** It was obtained from the Ankara Yıldırım Beyazıt University Yenimahalle Training and Research Hospital Ethics Committee (approval number: 2019.03.05 date: 26.03.2019).

**Informed Consent:** Retrospective study.

## Footnotes

### Authorship Contributions

Surgical and Medical Practices: S.S., Ş.A., Concept: S.S., Ş.A., Design: S.S., Ş.A., Supervision: S.S., Ş.A., Resources: S.S., Ş.A., Material: S.S., Ş.A., Data Collection or Processing: S.S., Ş.A., Analysis or Interpretation: Ş.A., Literature Search: S.S., Ş.A., Writing: S.S.

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# The Efficacy of the Computer-Based Multi-Domain Cognitive Training Program on the Cognitive Performance of Healthy Older Adults: A Pilot Randomized Controlled Study

© Merve Aliye Akyol<sup>1</sup>, © Özlem Küçükçüçlü<sup>1</sup>, © Ahmet Turan Işık<sup>2</sup>, © Görsev Yener<sup>3</sup>

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## Abstract

**Objective:** There has been great interest in using computer-based cognitive training (CBCT) to prevent or reduce pathological and normal age-related cognitive decline. This study was carried out to examine the efficacy of a CBCT program on the cognitive functions of healthy older adults. An online CBCT program provided exercises for five cognitive domains.

**Materials and Methods:** In a randomized controlled trial, the experimental group (EG) (EG, n=28) implemented CBCT while the comparison group (CG) (CG, n=31) was given standard services. Participants completed approximately 30-minute sessions over the course of eight weeks for a total of 24 sessions. Data were collected using the mini mental state examination, Oktem Verbal Memory Processes test (OVMPT), Wechsler Memory Scale-Revised (WMS-R) Visual Reproduction Subtest, WMS-R digit span forward and backward tests, verbal fluency tasks (category and phonemic), Stroop test Çapa form, Trail Making test (TMT) (part A and B), Benton Judgment of Line Orientation test (JLO), Benton Facial Recognition test, and the 15-item version of the Boston Naming test. The data were examined using number, percentage, arithmetic mean, chi-square test, Mann-Whitney U test, Paired Sample t-test, and Wilcoxon test.

**Results:** The EG showed greater improvements than CG on verbal memory (OVMPT,  $z=-3.386$ ,  $p=0.001$ ) and effect was moderate ( $r=-0.4524$ ). EG significantly improved simple attention in WMS-R digit span forward ( $z=-1.995$ ,  $p=0.046$ ) with a low effect ( $r=-0.2665$ ). EG showed significant differences in verbal fluency tasks (category:  $z=-3.152$ ,  $p=0.002$ , phonemic:  $z=-2.859$ ,  $p=0.004$ ) with low effects ( $r=-0.4212$ ,  $r=-0.3820$ , respectively) and set shifting (TMT A:  $z=-2.906$ ,  $p=0.004$ ) with low effect ( $r=-0.3883$ ). The EG group improved visuospatial functions for JLO ( $z=-2.894$ ,  $p=0.004$ ) with moderate effect ( $r=-0.3867$ ).

**Conclusion:** It is recommended that CBCT can be used for improving several cognitive domains of healthy older adults.

**Keywords:** Cognitive training, healthy older adults, aged

## Introduction

The number of older adults is increasing at an unprecedented rate globally, and the prevalence of age-related cognitive decline, as well as that of neurodegenerative diseases such as dementia, is rising correspondingly. When taking into account the physical, psychological, social, and economic effects (1), it is becoming increasingly important to promote successful entire-

lifetime cognitive aging to maintain or improve brain health and cognition (2), and in particular, to identify and assess strategies that support healthy cognitive aging (3). Studies on humans and animals demonstrate that the brain is capable of neuroplasticity even in later life (4). Over the past decade, cognitive training (CT) has drawn more scientific attention, due to its promising approach to enhancing cognitive functions and preventing or

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delaying cognitive deterioration in old age (5). A striking study found similar results for the extent and nature of CT benefits for both older (50–80) and younger (18–49) participants (6). This metaphor's underlying idea is that repeated activation of brain regions causes a variety of changes, a process known as neuroplasticity, both at the cellular and larger network levels (7,8). Furthermore, CTs provide easy facilitation into daily routines, and are cost-effective (9). Researchers have given significant consideration to both traditional activities and novel interventions due to their potential to prevent cognitive decline or its effects through cognitive engagement (6). The methods and formats used in CTs vary depending on factors such as the modality [paper-pencil (traditional) vs. computer-based], setting (individual vs. group), or the number of targeted domains (single vs. multi-domain training) (10). Multi-domain CTs target at least two cognitive domains, while single-domain CTs focus on a single cognitive function, which could be memory, executive functions, attention, visual-spatial functions, or language. The former rather than the latter has been recommended for improving cognition in healthy older adults (11).

Computer-based cognitive training (CBCT) aimed at preventing and reducing cognitive impairment has emerged as a result of technological advances in information and communication. Many of these programs offer significant benefits. They allow for an individualized approach based on each person's needs and characteristics, are more accessible because they avoid problems associated with limited mobility and/or access to health resources, have a lower economic cost, and permit objective performance evaluation and immediate feedback (12–14). A meta-analysis examining the effectiveness of CBCTs found that the outcomes varied depending on the targeted cognitive domain and the training program used (15). A number of studies have found that cognitive performance improves after interventions, but others have not, and questions remain about the efficacy of specific CT interventions (16). With the rapid increase in the number of commercially available CBCT programs in recent years, the evidence for these commercial products, while promising, is limited and uncertain. More research is needed to better understand the effectiveness of CBCT on cognitive functions (17). This pilot study is the first study, to our knowledge, to investigate the effectiveness of a computer-based multi-domain CT program progressively challenging on the cognitive performance of healthy older adults in Türkiye. We believe that a pilot study this is required to detect potential study failures or issues, and to limit the likelihood of squandering time, effort, and money on a larger population investigation. We hypothesized that using the program known as "MentalUP" would improve cognitive abilities compared to the control, as measured by a battery of neuropsychological tests. This improvement may provide information on the use of CBCT in healthy older adults, helping such individuals gain

the greatest possible benefits for health promotion and disease prevention.

## Materials and Methods

### Participants

Participants were recruited from Narlıdere Residential and Nursing Home, affiliated with the İzmir Provincial Director of Family and Social Services. The institution's capacity is 678 people in the healthy older adult blocks and 269 in the geriatric care center. Participants in the study were healthy older adults. Those in the healthy older adult blocks undergo cognitive [mini mental state examination (MMSE), clock drawing etc.] and physical assessments (activities of daily living, timed up and go test etc.) every six months. Those who do not meet the healthy older adult criteria are referred to the geriatric care center. The following requirements must be met in order to live in these blocks: being capable of performing daily living activities independently; having no psychiatric disorder that could endanger themselves or others; having no infectious disease; and having no addiction to alcohol or drugs (18). The following were the study's inclusion criteria: age 65 to 84, a mini-mental state examination score of  $\geq 23$ , the ability to speak Turkish fluently, having basic computer skills, the absence of hearing or vision problems (institution records as well as the older people's self-report), and educational level  $\geq 5$  years. The exclusion criteria were: usage of antipsychotics, antidepressants, antiepileptics, or acetylcholinesterase inhibitors; color blindness or color vision deficiency; hearing and vision problems; and a diagnosis of hypothyroidism, stroke, transient ischemic attack, and/or traumatic brain injury.

### Study Design and Procedure

This study was conducted as a single-blind, prospective, randomized control trial with a pre-post, and comparison group (CG) between March 2018 and March 2020. Using the Random Integer Generator method from random.org, single-group numbers between 1 and 70 were produced, and the older adults were then randomly assigned to these groups (<https://www.random.org/integers/?num=70&min=1&max=2&col=1&base=10&format=html&rnd=new>). Following the drawing of lots, lot number 1 was assigned as the CG and the lot number 2 as the experimental group (EG); the EG received training through the computer-based online multi-domain CT program, while the CG received no form of intervention. Group assignments were made based on participant arrival order. The participants were not informed about which group they were in, but the researchers were aware. During this time, participants were given reminders about training days. Throughout the CBCT program, all participants used the institute's room and a desktop computer with a 21.5-inch screen. The program was scheduled in line with participants' preferences. A nurse was in

the room during the exercise process. Participants who found that they were unable to attend at the specified time and date were later contacted to arrange a new schedule. Figure 1 shows a CONSORT flow diagram of the study.

### Cognitive Training Program

MentalUP was used as the CBCT program since it is simple to use, easy to access, and available in not only Turkish but also German, English, Portuguese, and Spanish. The website or the application can be used to access MentalUP, an internet-based program, via a computer or a mobile device. MentalUP is a participant of the University College London Institute of Education EDUCATE Program (19). The program requests a username and password; therefore, each participant was given an anonymous user ID number and password. No personal information was recorded. It was originally designed primarily for children, but the adult version was used in this case. Prior to commencing the program, users select the appropriate level

from children’s age groups, and a separate adult version. The purpose and target population of the study had been previously explained during interviews with developers of the program. They explicitly stated that the adult version was appropriate for older adults. As far as we know, Other similar commercial games only have versions designed for adults in general, rather than specifically older adults. EG participants received the same training experience (adult version) as MentalUP subscribers over the same time period. MentalUP automatically records the accuracy and failure rate. The game advances to the next level after achieving a critical level of performance. Additionally, two features are provided to encourage participant participation. An avatar is displayed at the outset of the activities as a guide who explains the objectives and steps of the exercises. The aim is to reduce anxiety about engaging with the program. Users are rewarded for their performance at the conclusion of each exercise with one, two, or three virtual stars. This type of feedback fosters competitiveness and a sense

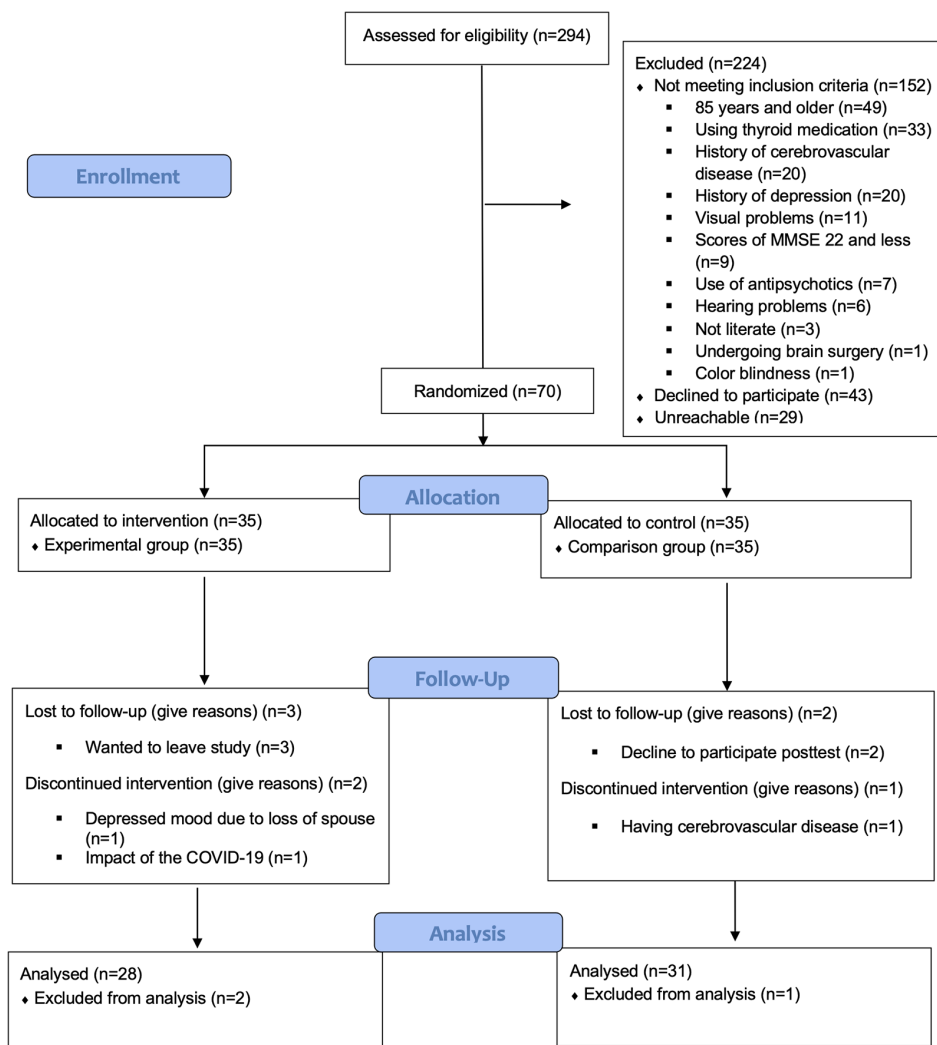


Figure 1. Flow diagram of the participants in the study

MMSE: Mini mental state examination

of accomplishment. The daily exercise consisted of ten games covering five cognitive domains. An algorithm chooses the ten games for each training session on any given day, attempting to optimize a balance of training activities. The daily training program comprises a total of 10 games. Depending on the response times, the whole duration could range from twenty to thirty minutes. During each of these sessions, different tasks are carried out, assessing memory, attention, executive functions, visual-spatial functions, and language (19). CBCT programs are designed to encourage constant effort and help people extend their cognitive abilities (20). This provides individuals with motivation to continue (21). It also has the advantage of being adaptable in terms of training and allowing for the systematic development of cognitive abilities that may be weaker than

others (21,22). This was an important component of the CBCT program used in the current study. Players who outperformed the average in the current game were able to raise the level. Furthermore, there were opportunities to get more practice in the area(s) where they were weaker. Following each game, participants had the possibility to assess their own performance and progress. Figure 2 shows some of these tasks.

### Intervention

The computer-based multi-domain online CT program consisted of a total of 24 sessions over 8 weeks for the participants assigned to the EG, while the control group continued to receive standard care. The optimal intensity for CT is 30 minutes per session, with three sessions per week being optimal (23). The program gives

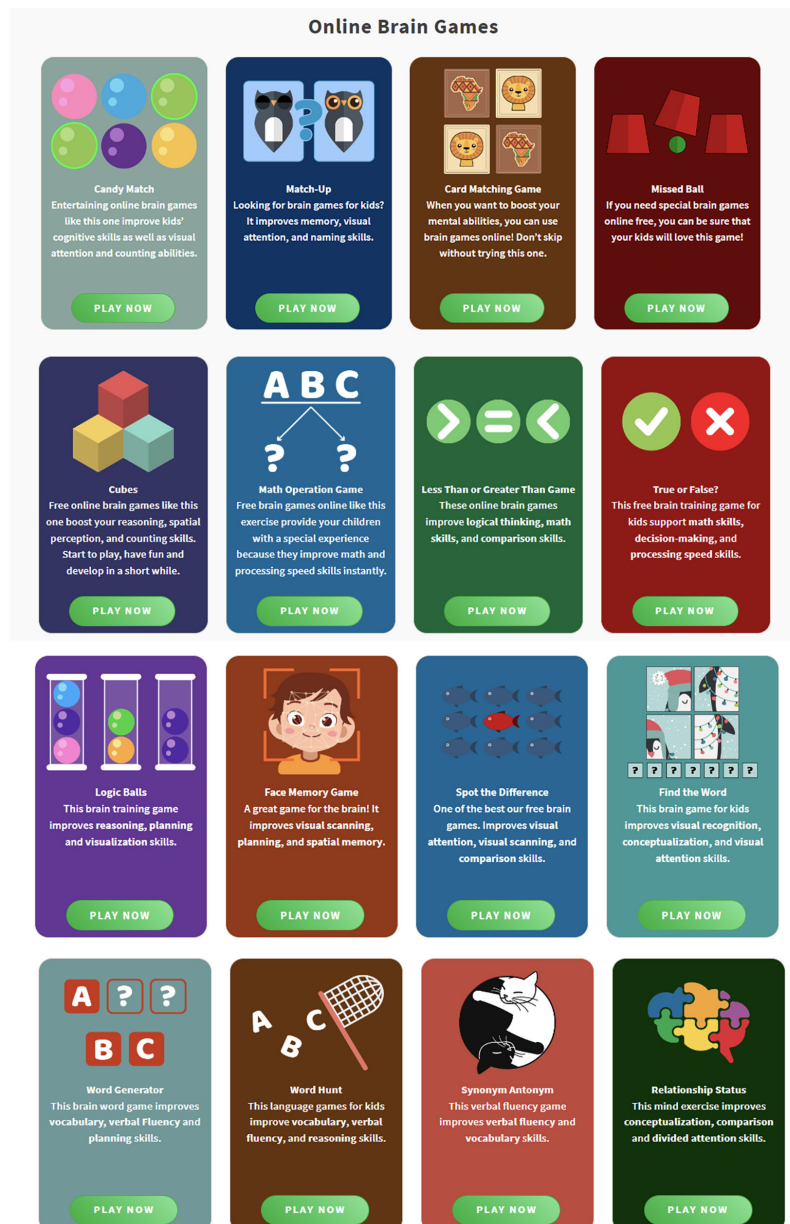


Figure 2. Some of the MentalUP games

participants brief instructions on how to complete each exercise before they begin. After a familiarization period, participants began to play and received access to their initial score, any gains they made, as well as the average score for their age group. To reduce retest effects, counterbalanced parallel forms of the Oktem Verbal Memory Processes test (OVMPT) were used.

### Outcome Measures

A neuropsychologist administered a comprehensive battery of neuropsychological tests to all individuals.

### Global Cognition and Memory

The MMSE test was used to evaluate global cognition. It consists of items for orientation, working memory, memory recall, language, concentration, and (24). The MMSE scores range from 0 to 30, and higher scores indicate greater cognitive function. The Turkish version of the MMSE demonstrated adequate psychometric properties for the diagnosis and screening of dementia in an older Turkish population living in the community (25).

OVMPT, which measures both immediate and delayed recall, was used to assess verbal episodic memory. It involves recall of a 15-item word list that is read aloud ten times (26).

The Wechsler Memory Scale-Revised (WMS-R) was used to evaluate visual episodic memory (immediate and delayed recall) visual reproduction subtest, which consists of 3 cards and 4 shapes (27,28).

### Attention

WMS-R digit span forward and backward tests were used to assess attention. This involves participants repeating a series of numbers in the same order (forward), followed by another series of numbers in the reverse order (backwards) (29,30).

### Executive Functions

Verbal fluency tasks (category and phonemic) (31,32), the Stroop test, and the Trail Making test (TMT) (part A and B) were used to evaluate executive functions. The Stroop test is used to examine executive functions, which measure selective attention, speed of information processing, response inhibition, and cognitive flexibility (33,34). TMT has two sections. Drawing lines sequentially linking circles with consecutive numbers from 1 to 25 in part A of the test is a visual scanning task; part B of the task measures cognitive flexibility by connecting the same number of circles with an alternating sequence of numbers and letters (35,36).

### Visuospatial Functions

The f of Jordan Line Orientation test (JLO) (37) and the Benton Facial Recognition test (BFRF) (38) were used to assess visuospatial abilities. The JLO test evaluates the accuracy of angular

orientation based on perceptions of a pair of angled lines, which visually resemble another pair that is encircled by an 11-line semicircular array (39). The BFRF assesses perceptual discrimination as well as the ability to identify and distinguish photographs of unfamiliar faces with non-emotional/neutral expressions. Validity and reliability studies were conducted for Türkiye by Karakaş (40) and Keskinçilic (41), respectively.

### Language

The Boston Naming test, a 15-item version, was used to assess language (42). The participant is asked to name drawings of 15 objects.

### Sample Size

G\*Power 3.1 was used to calculate the sample size. With 80% power and an alpha of 0.05 (two-sided), each group needed a minimum of 22 participants (43). A total of 70 participants (35 per group) were recruited and allocated to either the experimental or CG.

### Statistical Analysis

All data were analyzed with SPSS statistical package version 22.0 (SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Numbers, mean, and standard deviation were used in descriptive statistics. Percentage was used to evaluate the descriptive characteristics of the older adults, while the Mann-Whitney U test and chi-square test were used to compare the characteristics of the individuals in the experimental and CG. The Wilcoxon test was performed to compare the pre- and post-test mean scores of the EG. A paired t-test was used to compare the mean scores of the CG for the pre- and post-test. To assess the effectiveness of the computer-based CT program, the effect size ( $r$ ) was calculated ( $r=Z/\sqrt{N}$ ) (44). The effect size is interpreted as 0.20 for a small effect, 0.50 for a medium effect, and 0.80 for a large effect. The statistical significance level was determined as  $p<0.05$ .

### Ethical Consideration

The Dokuz Eylül University Non-Interventional Clinical Research Ethics Committee approved the study (approval number: 2017/27-44, date: 23.11.2017). Narlıdere Residential and Nursing Home, affiliated with the İzmir Provincial Director of Family and Social Services, provided institutional permission. People who were interested in the study were initially provided with standardized information, including the aim of the study, a timeline, and a brief explanation of the neuropsychological assessment. Participants' suitability for the study was confirmed via interview and MMSE cognitive screening, and a signed written informed consent form was obtained before the first neuropsychological assessment. A specialist psychologist, assessed the baseline and follow-up neuropsychological testing.

No payment was made to participants. The researchers obtained MentalUP at no cost. The founders and partners of MentalUP offered free access to their CBCT program for research purposes. However, no one connected to the commercial program was present during any of the project's stages: study design, data analysis, or decision to publish.

## Results

The descriptive statistics between groups are shown in Table 1. No significant differences were found in the baseline data, which included sociodemographic factors such as age ( $p=0.903$ ), education years ( $p=0.489$ ), and sex ( $p=0.859$ ). There were no significant baseline differences between the groups in the neuropsychological test mean or the standard deviation.

Within global cognition, neither group improved significantly (EG:  $z=-1.269$ ,  $p=0.204$ ; CG:  $t=0.769$ ,  $p=0.448$ ). In the EG, outcomes for memory tests were consistently better after the posttest, whereas in the CG, they were inconsistent. In the EG, significantly higher values post-test compared to pre-test were found in verbal immediate recall (OVMPT,  $z=-3.386$ ,  $p=0.001$ ), and the effect was moderate ( $r=-0.4524$ ). Within the domain of attention, EG significantly improved in WMS-R digit span forward ( $z=-1.995$ ,  $p=0.046$ ), with a small effect size ( $r=-0.2665$ ). Within the domain of executive functions, EG showed significant differences in verbal fluency tasks (category:  $z=-3.152$ ,  $p=0.002$ , phonemic:  $z=-2.859$ ,  $p=0.004$ ) with low effects ( $r=-0.4212$ ,  $r=-0.3820$ , respectively) and set shifting (TMT A:  $z=-2.906$ ,  $p=0.004$ ) with a low effect ( $r=-0.3883$ ). The EG group improved visuospatial functions for JLO ( $z=-2.894$ ,  $p=0.004$ ) with moderate effect ( $r=-0.3867$ ), while there were no significant differences between groups for BFRF pre- and posttest scores. With regard to language pre- and posttest findings, there were no noticeable changes between the groups (Table 2).

## Discussion

There has been a considerable amount of interest in using CBCT to maintain or enhance older people's cognitive functions. The focus of this study was to compare the effect of a multi-domain CBCT program with that of an untrained control group on the cognitive performance of healthy older adults. The findings revealed that MentalUP had an immediate positive effect on certain cognitive domains in cognitively healthy older adults.

The training program had no significant effect on global cognition scores (45-47). In these studies, older adults worked out five days a week for four to twelve weeks for 15 to 90 minutes each time. In contrast, Active Mind, a local Chinese CT program (providing eight 1-hour sessions of CT), was shown to be effective in improving global cognition (48). However, it should be noted that different measurement tools were used in these studies. Also, the current Cochrane review stated that, in the aforementioned study, evidence on global cognitive function at the end of the trial was of low quality, and the study was characterized by imprecision and risk of bias. The study stated that there was only low-quality evidence indicating that after 12 weeks of training, CBCT might slightly enhance global cognitive function in comparison to an active control (49). In addition, it should be noted that in our study, the baseline global cognitive scores of the individuals participating were higher. There is a phenomenon known as the "ceiling effect", when the post-test cannot be increased because the already very high pre-test global cognition scores of a large portion of study participants (50). When cognitive baseline performance is low, improvement in cognitive domains is more likely (11). Therefore, this ceiling effect may partially explain our findings.

The finding that verbal immediate recall showed significant improvements in the EG provides support for the efficacy of CBCT in healthy older adults in the short term. Studies showed that CT can improve the performance of verbal immediate recall in trained groups (51-53) (30 to 90 minutes' sessions, four-five days a week, for one to twelve weeks); but other studies note no improvement (11,47,54). The majority of the memory games in the MentalUP training program focused on immediate recall. Garcia-Campuzano et al. (55) observed that the CT program for improving memory performance enhanced verbal delayed recall (30-minute sessions, three times per week, for 8 consecutive weeks) (55). According to the current Cochrane database of systematic review, there is low-quality evidence indicating that CBCT may marginally improve episodic memory in comparison to an inactive control. Reportedly, a 12-week CT program improves immediate recall, but no studies have shown substantial evidence demonstrating improved delayed recall (49). There was no statistically significant difference in delayed recall in our study, even though the CT program sessions was a similar intensity as in Garcia-Campuzano et al. (55) This may be because the CBCT program utilized in this study has fewer

**Table 1. The demographic characteristics of groups**

	Experimental (n=28)	Comparison (n=31)	Test value	p
Age	75.10±5.87	75.16±5.37	MWU=426.000	0.903
Education (years)	11.50±3.19	12.19±2.28	MWU=389.500	0.489
Sex (F/M)	16/12	17/14	$\chi^2=0.032$	0.859

MWU: Mann Whitney U test,  $\chi^2$ : Pearson chi-square test, F/M: Female/Male

tasks for delayed recall memory, and thus may be ineffective in improving older adults' performance in this area.

On visual episodic memory measures, individuals in the CBCT group performed no better than those in the CG group, consistent with the findings of Oh et al. (47), who found that CT has no statistically significant effects on visual episodic memory. In contrast to our findings, Kalbe et al. (11) found a statistically significant difference in long-term visual memory mean scores after 12 hours of CT. This disparity could be explained by the fact that participants in that study had lower visual memory scores than participants in our study. Cognitively healthy people can use CT programs to enhance their weaker cognitive functions, but individuals with higher cognitive performance may need more challenging and intensive training programs to maximize their cognitive functions.

The study results showed significant effects on the participants' simple attention scores after CBCT. The current study's findings, which show that CT has an effect on simple attention, are consistent with those of Buitenweg et al. (51). On the other hand, CT has been shown to have no effect on simple attention in another study (43). In the last-mentioned study, the program was implemented for 15 minutes five days a week for four weeks (5 hours in total). This study's training period was shorter, which may have contributed to participants' attention scores remaining constant.

In healthy older adults, CBCT has been shown to improve executive functions. The findings of our study are consistent with previous research (60- to 75-minute session, two to four days a week, for two to eight weeks) (53,56). Contrary to our research, some investigations have demonstrated that CT has no impact on phonemic and semantic fluency (11,51). However, a

**Table 2. Pre-/Post-test comparison of test performance in both groups**

	Experimental (n=28)			Comparison (n=31)		
	Pretest	Posttest	Test value, p	Pretest	Posttest	Test value, p
<b>Global cognition</b>						
MMSE	28.64±1.16	28.96±0.83	z=-1.269, 0.204	29.12±0.99	29.03±0.98	t=0.769, 0.448
<b>Memory</b>						
<b>Verbal episodic memory</b>						
Immediate recall OVMPT	5.10±1.39	6.17±1.44	z=-3.386, 0.001*	5.61±1.25	5.67±0.90	t=-0.373, 0.712
Delayed recall OVMPT	10.82±2.10	11.25±1.75	z=-1.403, 0.160	11.38±1.99	11.03±1.74	t=-1.688, 0.102
<b>Visual episodic memory</b>						
Immediate recall WMS-R	8.42±3.37	8.89±2.45	z=-1.250, 0.211	8.35±3.19	8.61±2.57	t=-1.114, 0.274
Delayed recall WMS-R	7.46±3.96	8.03±3.07	z=-1.685, 0.092	8.48±3.41	8.80±3.07	t=0.952, 0.349
<b>Attention</b>						
WMS-R digit span forward	5.10±1.09	5.46±0.63	z=-1.995, 0.046*	5.19±0.87	5.03±0.54	t=1.541, 0.134
WMS-R digit span backward	3.71±0.80	3.89±0.68	z=-1.291, 0.197	3.70±0.86	3.58±0.71	t=-1.438, 0.161
<b>Executive functions</b>						
Stroop D	54.85±18.83	51.28±13.61	z=-1.283, 0.199	60.29±22.55	59.83±21.28	t=0.234, p=0.816
<b>Verbal fluency tasks</b>						
Category	19.35±3.64	21.32±3.64	z=-3.152, 0.002*	20.74±4.75	21.19±3.63	t=-0.980, 0.335
Phonemic	37.42±10.51	40.42±9.11	z=-2.859, 0.004*	37.20±9.43	38.80±8.97	t=-1.461, 0.154
<b>Information processing speed</b>						
TMT A	59.28±28.63	51.85±20.01	z=-2.906, 0.004*	52.03±13.92	51.16±10.86	t=0.645, 0.524
<b>Set Shifting</b>						
TMT B	127.57±50.84	121.60±51.07	z=-1.732, 0.083	122.35±35.37	118.29±28.89	t=1.198, 0.240
<b>Visuospatial functions</b>						
JLO	20.50±3.37	21.39±2.64	z=-2.894, 0.004*	19.93±3.26	20.25±3.10	t=-1.718, 0.096
BFRF	44.21±4.30	44.64±4.06	z=-0.920, 0.358	45.35±3.95	44.70±3.85	t=1.470, 0.152
<b>Language</b>						
BNT	14.28±0.97	14.42±0.83	z=-1.414, 0.157	14.22±0.80	14.32±0.70	z=-1.000, 0.325

\* p<0.05  
 MMSE: Mini mental state examination, OVMPT: Oktem verbal memory processes test, WMS-R: Wechsler memory scale-revised, TMT: Trail Making test, JLO: Benton Judgment of Line Orientation test, BFRF: Benton Facial Recognition test, BNT: Boston Naming test, z: Wilcoxon test, t: Paired Samples t-test

CT program may help with verbal fluency, specifically phonemic fluency, which is a well-known executive function (53). Phonemic fluency is thought to more accurately reflect executive functioning because participants are required to list the words according to a rule that goes against the natural organization of words in the brain (56). According to the current Cochrane database of systematic reviews, low-quality evidence suggests that, when compared with an inactive control, CBCT may have little or no effect on executive function, working memory, or verbal fluency (49). A possible reason is that the CBCT program (MentalUP) contains numerous words and categories. The repetition of similar words is thought to help participants learn them and enhance their verbal fluency test scores. For example, words found during the "word hunt" exercise recur during the "wise owl" and "ripped words" exercises. Furthermore, natural intelligence allows repetition and learning of the names of animals and flowers.

The participants in the EG had statistically significant improved information processing speed scores after CBCT. The current study's findings support previous research (46,47,51,56-58). However, studies have shown that CT has no effect on information processing speed (11,53,54). According to the current Cochrane database of systematic reviews, the quality of the evidence on processing speed was very low (49). One of the primary goals of CT for older people should be to improve these functions (47), given that both executive functions and information processing speed decline with age (59,60), and that these functions are linked to daily life activities (61).

In this study, JLO and BFRF were used to assess visuospatial functions. Following CBCT, the JLO scores of those in the EG increased significantly, whereas the BFRF did not differ. According to Kalbe et al. (11), CT had no statistically significant effect on visuospatial function test scores because in the CBCT, there was no exercise designed to enhance the perception of faces. This was believed to be the reason for the lack of statistically significant change in the BFRF scores.

Language scores did not differ significantly, and we could not find any CT study that included this test in outcome measures. Despite the fact that the MentalUP contains exercises to name objects, there was no improvement; this could be due to the ceiling effect (high baseline scores) the ease of the exercises. Those with lower language scores may need more challenging tasks.

### Study Limitations

This study had some limitations that needed to be noted. One of the study's shortcomings is the lack of follow-up measurements to determine whether the effects were maintained after the CBCT had ceased. Mood and general affectivity may have an effect on cognitive functions by the MentalUP program. These

potential factors were not taken into account in evaluating our program. Another possible limitation of the study is the lack of an active control group. Additionally, this study was single-blind. In some cases, parallel forms of a particular neuropsychological test are utilized in the literature to reduce the learning effect on tests. However, only the parallel forms (A and B forms) of the OVMPT were employed in this study. There are no Turkish parallel versions of other tests. Finally, CBCT programs may be useful for enhancing the weaker cognitive domains of healthy people. High cognitive performers might benefit from more challenging training programs to maximize their functions. We believe that by extending CT protocols, these weaknesses may be overcome, in light of this.

### Recommendations for Future Research

The specific strength of the current study is that it is the first to our knowledge that examines the immediate effectiveness of a computer-based multi-domain CT program on the cognitive performance of healthy older adults in Türkiye. MentalUP implemented in our research allows for the use of German, English, Portuguese, Turkish, and Spanish. Further studies can be carried out in countries where these languages are spoken, taking into account the following key points. We suggest that further studies be carried out with a larger sample size, longer follow-up, and double-blind design. Since only a passive control group was used in this study, future studies should employ both active and passive control groups to gain deeper insight into the changes in cognitive functions enabled by the implementation of CBCT. Additional possible predictors that influence multi-domain CT gains are sociodemographic variables (i.e., age, sex, and education), further psychological variables (i.e., quality of life, depression), genetic variables (i.e., apolipoprotein E4), functionality (i.e., activities of daily living), brain imaging measures, and EEG markers. Future studies may also take these variables into account. Effects of multi-domain CT interventions could be observed in trained tasks in healthy older people, and also, transfer effects in untrained tasks. Another area for study is the assessment of the transfer of improvements in participants' daily living activities or functional results in social participation.

### Conclusion

Health professionals have great responsibilities in determining the needs of older people and providing appropriate care. Because of the importance of cognitive functions, cognitive activities should be incorporated into the care of the elderly, in order to maintain and improve them. The promotion of positive neuroplasticity in older adults can enhance their cognitive reserve and functions. Health professionals can inform them and their families about CBCT programs to encourage their utilization. Despite the limitations of the current study, the



findings of this study indicate that 24 sessions over the course of 8 weeks of computer-based multi-domain online CT program can lead to measurable improvements regarding the immediate positive effects in some cognitive domains in cognitively healthy older adults. The findings further support the findings in the literature that this CBCT program, marketed under the brand-name MentalUP, could be used to support cognitive functions in older adults, and could function as a trial protocol for intervention by health professionals, especially by nurses. Also, it is simple to administer and not overly expensive, which makes it a potentially useful tool in any strategy to support healthy cognitive aging in older adults.

### Ethics

**Ethics Committee Approval:** The Dokuz Eylül University Non-Interventional Clinical Research Ethics Committee approved the study (approval number: 2017/27-44, date: 23.11.2017).

**Informed Consent:** Informed consent was obtained from the older people included in this study.

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### Note

This article is based on the PhD. thesis titled 'The impact of cognitive training program on cognitive functions of healthy elderly individuals: A randomized controlled study' by Merve Aliye AKYOL, dated 30.06.2020. Thesis number: 630732

### Footnotes

#### Authorship Contributions

Concept: M.A.A., Ö.K., A.T.I., G.Y., Design: M.A.A., Ö.K., A.T.I., G.Y., Data Collection or Processing: M.A.A., Analysis or Interpretation: M.A.A., Literature Search: M.A.A., Ö.K., A.T.I., G.Y., Writing: M.A.A., Ö.K.

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# The Impact of Anticholinergic Burden on Geriatric Syndromes: Screening in Community-Dwelling Older Adults

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## Abstract

**Objective:** Anticholinergic burden (ACB) could be an important factor that may exacerbate or contribute to geriatric syndromes in older adults. Our objective was to examine the prevalence of ACB and the relationship between ACB and geriatric syndromes among community-dwelling older adults focusing on commonly used medications with anticholinergic side effects.

**Materials and Methods:** In this cross-sectional study, community-dwelling older adults aged 60 years and above, residing in Altındağ, Ankara, Türkiye, were screened. Comprehensive geriatric assessment was applied to all participants, and their ACB scores were calculated using the Anticholinergic Cognitive Burden Scale. The participants were then categorized as no ACB (score =0), low ACB (score =1), and high ACB (score ≥2).

**Results:** Five hundred twenty one participants (median age: 68 years) were included. The prevalence of high ACB was 7.5%, with anticholinergic medication use observed in 24.6% of community-dwelling older adults. The three most prevalent drugs with anticholinergic effects used among participants were metoprolol, colchicine, and warfarin. A high ACB was significantly associated with various geriatric syndromes, including polypharmacy ( $p<0.001$ ), urinary incontinence ( $p=0.046$ ), frailty ( $p<0.001$ ), probable sarcopenia ( $p<0.001$ ), cognitive dysfunction ( $p=0.015$ ), and depression ( $p<0.001$ ). In multivariate logistic regression analysis, after adjusting for age and the Charlson Comorbidity Index, polypharmacy and frailty remained significant predictors of high ACB [odds ratio (OR)=5.317,  $p\leq 0.001$  and OR=3.042,  $p=0.002$ ].

**Conclusion:** A high ACB score was associated with a greater number of geriatric syndromes, particularly increasing the risk of polypharmacy and frailty among community-dwelling older adults. Cardiovascular medications made a significant contribution to the ACB in this population. Regular medication reviews, along with deprescribing or substituting drugs with anticholinergic effects, when possible, may help reduce the risk of developing geriatric syndromes, especially in frail older adults.

**Keywords:** Cholinergic antagonists, geriatric assessment, frailty, polypharmacy, deprescription

## Introduction

Geriatric syndromes are complex health problems that develop from multiple system impairments, making older adults vulnerable to specific challenges (1). Traditional disease frameworks typically address problems within a single organ, but geriatric syndromes involve a variety of conditions like frailty, incontinence, falls, sarcopenia, and cognitive impairment that do not conform to specific disease categories. Having one

or more geriatric syndromes is linked to adverse outcomes, including higher morbidity rates, prolonged hospital stays, increased healthcare expenses, diminished quality of life, and greater levels of dependency (2,3).

Anticholinergic burden (ACB) describes the cumulative impact of using multiple medications with anticholinergic effects (4). These medications interact with the muscarinic acetylcholine receptors, affecting the central and peripheral nervous systems

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and leading to various side effects throughout the body (5). In terms of their impact on the central nervous system, these medications may even induce cognitive impairment, confusion, delirium, and elevate the risk of developing dementia. Conversely, on a peripheral level, they can cause dry mouth, constipation, urinary retention, impaired sweating, tachycardia, and blurred vision (6). These side effects present substantial risks, especially in older adults. Their vulnerability to these outcomes is affected by age-related physiological changes, such as increased blood-brain permeability, decreased acetylcholine receptors, reduced anticholinergic clearance, and a higher likelihood of polypharmacy (7,8). Moreover, a high ACB in older adults has been associated with elevated rates of falls, hospitalizations, and mortality (9,10). Given that geriatric syndromes often result in similar outcomes, it is possible that a high ACB not only exacerbates, but also contributes to the development of these syndromes.

In clinical practice, the ACB can be assessed using various scales that assign points to medications based on their anticholinergic activity (11). While these scales may differ in their scoring, antidepressants, medications for urinary incontinence, and antipsychotics consistently receive high anticholinergic scores (6). These medications are often used to manage symptoms of geriatric syndromes such as depression, urinary incontinence, and delirium, either individually or in combination with other drugs. Although their use can lead to a high ACB and potential side effects, these medications are sometimes necessary since effectively managing these symptoms can substantially enhance the well-being and functional abilities of certain older patients. Therefore, it may be necessary to assess the risks and benefits of prescribing anticholinergic medications to older patients by evaluating the ACB within this population.

Numerous studies have assessed the ACB among older adults using multiple scales. However, most of these studies have focused on older individuals with specific diseases, either as outpatients or in hospital settings, when they require acute care. In our study, we investigated the prevalence of ACB among community-dwelling older adults, with a particular focus on commonly used medications with anticholinergic side effects. Additionally, we sought to investigate the connection between ACB and geriatric syndromes, considering their common significant outcomes in this population.

## Materials and Methods

This cross-sectional study, designed to screen community-dwelling older adults, was conducted between January 2019 and June 2019. The study was announced by the municipality of Altındağ, a district in Ankara, Türkiye, inviting individuals who wished to participate. Participants were required to attend a

designated location for examination. The inclusion criteria were being 60 years or older, having knowledge of their medications, and bringing them to the examination. Individuals were excluded if they had communication problems that made them unable to comprehend the study materials or answer the questions. This study adhered to the principles of the Declaration of Helsinki and obtained ethical approval from Ankara University's Ethical Committee (approval number: 11-747-18, date: 25.06.2018).

### Evaluation of Participants

The participants were evaluated by geriatricians and internal medicine doctors from Ankara University Faculty of Medicine. Patient demographics, including age, place of residence, comorbidities, and medications, were recorded. The Charlson Comorbidity Index (CCI) was calculated to assess the patients' comorbidity burden (12).

Height, weight, handgrip strength, and gait speed were measured for all participants. Handgrip strength (kg) was measured using an electronic hand dynamometer (Takei Scientific Instruments, Niigata, Japan). Patients were seated with their elbow flexed at a 90-degree angle and instructed to squeeze the dynamometer as forcefully as possible. Measurements were taken three times for each hand, allowing sufficient rest between each trial. The highest value obtained from these measurements was recorded as the final handgrip strength. Gait speed was determined by the time taken to walk 4 meters, with the corresponding speed calculated in meters per second. Low muscle strength was identified as handgrip measurements below 32 kg for men and below 22 kg for women, and low physical performance was characterized by a gait speed of less than 0.8 m/s (13).

Polypharmacy was defined as using at least 5 medications. Dependency was defined if participants showed dependency in at least one area on the Katz activities of daily living (ADL), with a maximum score of 6, or Lawton instrumental activities of daily living (IADL), with a maximum score of 8 (14,15). A score of 21 or lower on the mini-mental status examination (MMSE), selected in this study to account for the limited education levels within our sample that can affect MMSE performance, indicated cognitive impairment (16). Meanwhile, a score of 5 or higher on the Yesavage Geriatric Depression Scale (GDS) suggested depression (17). Based on Fried Frailty Index scores, participants were categorized as robust (0 points), prefrail (1-2 points), or frail (3-5 points) (18). Fall histories in the last year and presence of urinary incontinence in the last 3 months were recorded. Nutritional status was classified as normal (12-14 points), at risk of malnutrition (8-11 points), or malnourished (0-7 points) according to the short form of the Mini-Nutritional Assessment tool Scores (19). Individuals scoring between 4 and 10 on the SARC-F and exhibiting low muscle strength, as described above, were classified as having probable sarcopenia (20,21).

### Determining ACB Scores

We utilized the updated "Anticholinergic Cognitive Burden Scale" to determine the ACB scores of participants based on their medications (22,23). The anticholinergic effects of medications taken by each participant for at least 3 months were evaluated and scored according to this scale. The participants were then categorized as no ACB (score =0), low ACB (score =1), and high ACB (score ≥2).

### Statistical Analysis

Statistical analyses were conducted using PASW Statistics (version 18.0. Chicago: SPSS Inc.). Counts and percentages were used to summarize categorical variables, while continuous variables were summarized using medians and interquartile ranges (IQR). Patient categorization was based on their ACB score (0, low, or high). Categorical variables were compared using the chi-square test, while continuous variables were assessed using the Kruskal-Wallis test for multiple group comparisons. Multivariate logistic regression analysis was performed to assess parameters associated with a high ACB score, and odds ratios were calculated. Statistical significance was set at p<0.05.

### Results

Of the 608 individuals who applied to participate in the study, 521 met the criteria and were included. Table 1 provides details on the characteristics of the study participants and the distribution of ACB scores. The participants had a median age of 68 years (IQR 65-72). The age distribution revealed that 61% were aged 60-69 years, 34.9% were aged 70-79 years, and 4% were aged 80 years or older. Females constituted 63% (n=328) of the participants, while males accounted for 37% (n=193). The median BMI was 31.1 (IQR 28-35). Regarding comorbidities, the median CCI was 3 (IQR 2-4). The most prevalent comorbidities included hypertension (58.2%), diabetes mellitus (29.4%), and coronary artery disease (17.5%). One hundred and twenty-eight participants (24.6%) were taking at least one anticholinergic medication. The ACB scores were distributed as follows: 75.4% of participants had a score of 0, 17.1% had a low score, and 7.5% had a high score.

Table 2 presents the association between the ACB categories and patients' characteristics as well as geriatric syndromes. The median age increased slightly with higher ACB scores: 67 years (no ACB), 69 years (low ACB), and 69 years (high ACB), with a significant difference (p=0.040). The CCI scores were also significantly higher in the high ACB group (median of 4) compared to the no ACB (median of 3) and low ACB (median of 3) groups (p<0.001). While the median Katz ADL and Lawton IADL Scores were similar across the groups, individuals with higher ACB scores tended to have slightly lower functional scores, indicating greater dependence. Statistically significant differences were observed for both measures (p<0.001 for both

measures). The number of medications was significantly higher in the high ACB group (median of 6) compared to the no ACB (median of 2), and low ACB (median of 5) groups (p<0.001). The number of geriatric syndromes also increased significantly with higher ACB scores, with a median of 4 in the high ACB group, 2 in the low ACB group, and 1 in the no ACB group (p<0.001). Polypharmacy and urinary incontinence were most

	<b>All participants</b>
<b>Age (median)</b>	68 (65-72)
60-69 years (n, %)	318 (61%)
70-79 years (n, %)	182 (34.9%)
≥80 years (n, %)	21 (4%)
<b>Female (n, %)</b>	328 (63%)
<b>Male (n, %)</b>	193 (37%)
<b>Education status</b>	
Illiterate	122 (23.4%)
Literate	71 (13.6%)
Primary school graduate	220 (42.2%)
Middle school graduate	39 (7.5%)
High school graduate	51 (9.8%)
University graduate	18 (3.5%)
<b>BMI (median)</b>	31.1 (28-35)
<b>CCI (median)</b>	3 (2-4)
<b>Comorbidities (n, %)</b>	
Hypertension	303 (58.2%)
Diabetes mellitus	153 (29.4%)
Coronary artery disease	91 (17.5%)
Heart failure	12 (2.3%)
Cerebrovascular disease	11 (2.1%)
Chronic kidney disease	3 (0.6%)
Dementia	3 (0.6%)
Chronic pulmonary obstructive disease	8 (1.5%)
Depression	30 (5.8%)
<b>Number (%) of patients on anticholinergic meds</b>	
Number (%) of patients on at least 2 anticholinergic meds	23 (4.5%)
Number (%) of patients on at least 3 anticholinergic meds	5 (1%)
Number (%) of patients on ≥4 anticholinergic meds	1 (0.2%)
<b>ACB Score (n, %)</b>	
ACB Score 0	393 (75.4%)
ACB Score 1 (low)	89 (17.1%)
ACB Score ≥2 (high)	39 (7.5%)
The values are shown as counts and percentages (%) BMI: Body Mass Index, CCI: Charlson Comorbidity Index, ACB: Anticholinergic burden	

	<b>No ACB (ACB Score =0) (n=393, 75.4%)</b>	<b>Low ACB (ACB Score =1) (n=89, 17.1%)</b>	<b>High ACB (ACB Score ≥2) (n=39, 7.5%)</b>	<b>p</b>
Age (median)	67 (65-72)	69 (66-71)	69 (65-74)	<b>0.040</b>
Female (n, %)	238 (60.6%)	58 (65.2%)	32 (82.1%)	<b>0.027</b>
Male (n, %)	155 (39.4%)	31 (34.8%)	7 (17.9%)	
BMI (median)	30.8 (27.7-34.7)	31.7 (28.7-34.6)	34.4 (29-37.5)	<b>0.043</b>
CCI (median)	3 (2-4)	3 (3-4)	4 (3-5)	<b>&lt;0.001</b>
Katz ADL (median)	6 (6-6)	6 (5-6)	6 (5-6)	<b>&lt;0.001</b>
Lawton IADL (median)	8 (8-8)	8 (8-8)	8(7-8)	<b>&lt;0.001</b>
Number of medications (median)	2 (1-4)	5 (3-6)	6 (4-8)	<b>&lt;0.001</b>
Number of geriatric syndromes (median)	1 (1-2)	2 (1-4)	4 (2-5)	<b>&lt;0.001</b>
Polypharmacy (n, %)	73 (18.6%)	50 (56.2%)	29 (74.4%)	<b>&lt;0.001</b>
Urinary incontinence (n, %)	143 (36.4%)	36 (40.4%)	22 (56.4%)	<b>0.046</b>
Fall history (n, %)	93 (23.7%)	28 (31.5%)	14 (35.9%)	<b>0.107</b>
Frailty (n, %)				<b>&lt;0.001</b>
Robust	167 (42.5%)	27 (30.3%)	6 (15.4%)	
Prefrail	166 (42.2%)	36 (40.4%)	13 (33.3%)	
Frail	60 (15.3%)	26 (29.2%)	20 (51.3%)	
Probable sarcopenia (n, %)	40 (10.2%)	20 (22.5%)	14 (35.9%)	<b>&lt;0.001</b>
Muscle strength (kg) (median)	24.8 (19.1-33.3)	22.6 (17.6-30.3)	19.4 (14-24.1)	<b>&lt;0.001</b>
Low muscle strength (n, %)	194 (49.6%)	49 (55.1%)	30 (76.9%)	<b>0.004</b>
Gait speed (m/s) (median)	0.57 (0.44-0.8)	0.66 (0.5-0.8)	0.5 (0.35-0.64)	<b>&lt;0.001</b>
Low physical performance (n, %)	291 (74.8%)	55 (61.8%)	36 (92.3%)	<b>0.001</b>
MMSE Scores (n, %)				
≤21 points	51 (13%)	10 (11.2%)	7 (17.9%)	<b>0.015</b>
GDS Scores (n, %)				
≥5 points	133 (34%)	45 (50.6%)	23 (59%)	<b>&lt;0.001</b>
MNA Scores (n, %)				0.447
Malnutrition risk	13 (3.3%)	4 (4.5%)	3 (7.7%)	
Malnutrition	2 (0.5%)	1 (1.1%)	0 (0%)	

The values are shown as counts and percentages (%) or medians (interquartile range).  
 ACB: Anticholinergic burden, ADL: Activities of daily living, BMI: Body Mass Index, CCI: Charlson Comorbidity Index, GDS: Geriatric Depression Scale, IADL: Instrumental activities of daily living, MMSE: Mini-mental state examination, MNA: Mini nutritional assessment

prevalent in the high ACB group (74.4% and 56.4%, respectively,  $p < 0.001$  and  $p = 0.046$ ). Frailty was significantly higher in the high ACB group, with 51.3% classified as frail compared to 15.3% in the no ACB group and 29.2% in the low ACB group ( $p < 0.001$ ). Probable sarcopenia and low muscle strength were more prevalent in the high ACB group (35.9% and 76.9%, respectively,  $p < 0.001$  and  $p = 0.004$ ). Gait speed was significantly slower in the high ACB group (median of 0.5 m/s) compared to the no ACB (0.57 m/s), and low ACB (0.66 m/s) groups ( $p < 0.001$ ). Low physical performance was also more prevalent in the high ACB group (92.3%) compared to the group no ACB (74.8%) and low ACB (61.8%) groups ( $p = 0.001$ ). GDS scores of  $\geq 5$ , indicating depression, were significantly higher in the high ACB group

(59%) compared to the no ACB (34%) and low ACB (50.6%) groups ( $p < 0.001$ ).

The list of drugs used by participants with anticholinergic effects and their ACB scores was provided in Table 3. Among the 451 participants taking at least one medication, the most commonly used drugs with anticholinergic effects included metoprolol (17.3%), colchicine (2%), warfarin (1.8%), and furosemide (1.6%). Among participants taking medication, thirty-one (6.8%) were using a medication with a score of 3 on the Anticholinergic Cognitive Burden Scale. The number of patients using anticholinergic drugs for each medication is shown in Figure 1.

**Table 3. List of drugs used by participants with anticholinergic effects and their ACB Scores according to the Anticholinergic Cognitive Burden Scale**

Medications with anticholinergic side effects	Number of participants (among those taking at least one medication) (n= 451)	Medication Scores on Anticholinergic Cognitive Burden Scale
<b>Urinary incontinence medications</b>		
Trospium	2 (0.4%)	3
Solifenacin	4 (0.9%)	3
Tolterodine	3 (0.7%)	3
Oxybutynin	1 (0.2%)	3
Fesoterodine	1 (0.2%)	3
Propiverine	1 (0.2%)	3
<b>Antidepressants</b>		
Paroxetine	3 (0.7%)	3
Amitriptyline	1 (0.2%)	3
Venlafaxine	1 (0.2%)	1
Trazodone	4 (0.9%)	1
<b>Antipsychotics</b>		
Quetiapine	4 (0.9%)	3
Olanzapine	1 (0.2%)	3
Risperidone	1 (0.2%)	1
<b>Cardiovascular system medications</b>		
Metoprolol	78 (17.3%)	1
Nifedipine	5 (1.1%)	1
Digoxin	2 (0.4%)	1
Captopril	1 (0.2%)	1
Warfarin	8 (1.8%)	1
Furosemide	7 (1.6%)	1
Isosorbide	5 (1.1%)	1
<b>Gastrointestinal system medications</b>		
Hyoscine butylbromide	3 (0.7%)	3
Dimenhydrinate	2 (0.4%)	3
Alverine	1 (0.2%)	1
<b>Anti-inflammatory medications</b>		
Prednisolone	1 (0.2%)	1
Colchicine	9 (2%)	1
<b>Antihistamines</b>		
Desloratadine	2 (0.4%)	1
Hydroxyzine	5 (1.1%)	3
Levocetirizine	2 (0.4%)	1
Cetirizine	2 (0.4%)	1
<b>Others</b>		
Carbamazepine	1 (0.2%)	2
Theophylline	3 (0.7%)	1

The values are shown as counts and percentages (%), ACB: Anticholinergic burden

After adjusting for age and the CCI, the multivariate logistic regression analysis indicated that polypharmacy (OR=5.317, 95% CI 2.303-12.275, p≤0.001) and frailty (OR=3.042, 95% CI 1.482-6.242, p=0.002) were strongly linked to higher odds of high ACB (Table 4).

### Discussion

In this study, we found that the prevalence of high ACB among community-dwelling older adults was 7.5%. However, a notable 24.6% of participants were taking medications with anticholinergic properties. This prevalence is lower than the 55% to 65% rates reported among older adults in long-term care facilities and hospital outpatients, which can be explained by differences in ACB scales, residency areas, age, and functional status of participants (24-26). Our study participants had a relatively lower median age (68 years) and were more active, as indicated by high ADL and IADL scores, reflecting lower dependency. Similarly, a recent study found a 19% ACB prevalence among community-dwelling older adults aged 65 and above, aligning with our findings (27).

As people age, the number of comorbidities and medications they use increases, elevating their risk of polypharmacy and ACB (28). In our study, participants with a high ACB score were more likely to use multiple medications, have more comorbidities, and present with geriatric syndromes such as urinary incontinence, frailty, sarcopenia, cognitive dysfunction, and depression. It is not surprising that these conditions are associated with high ACB, given the frequent use of antimuscarinics and antidepressants for treatment. Even patients not using these medications may have a high ACB due to other drugs with anticholinergic properties, such as diuretics or beta-blockers, commonly used for managing comorbidities.

The most prevalent medications with anticholinergic effects in our study were metoprolol, colchicine, and warfarin. Cardiovascular drugs, including metoprolol, warfarin, and furosemide, were the most common category, followed by urinary incontinence drugs like solifenacin and antihistamines such as hydroxyzine. These findings are consistent with previous studies in older adults, particularly a study among elderly Turkish individuals aged 85 and above, which also identified metoprolol and furosemide as frequently used medications with anticholinergic properties (24).

The impact of anticholinergic drugs on cognitive function is well established, with studies showing that these medications can lead to dementia and cognitive decline (29). For instance, a two-year decline of 0.33 points in MMSE scores has been associated with anticholinergic medications, and even short-term use (>60 days) can double the risk of cognitive impairment (30,31). The mechanisms behind this effect are still unclear, but may involve increased amyloid-β accumulation and reduced brain

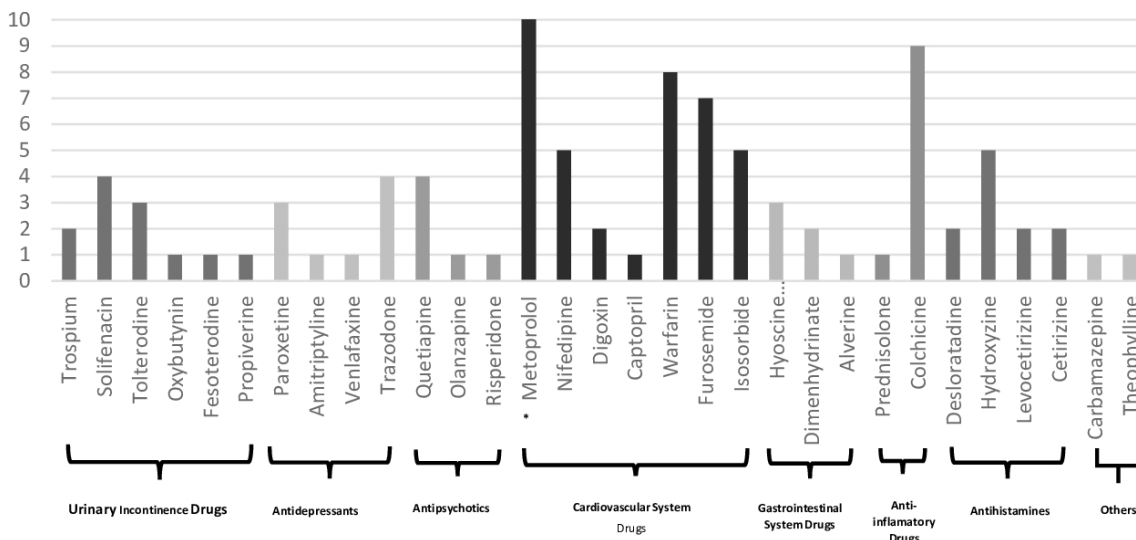


Figure 1. Number of participants based on the use of anticholinergic medications

\*The y-axis scale is 0-10 for clarity; 78 participants were using metoprolol

Variable	Univariate			Multivariate		
	OR	95% CI	p	OR	95% CI	p
Age (continuous)	1.034	0.976-1.095	0.260	0.978	0.912-1.048	0.529
CCI (continuous)	1.798	1.368-2.364	<0.001	1.291	0.906-1.841	0.158
Polypharmacy	8.464	4.009-17.871	<0.001	5.317	2.303-12.275	<0.001
Frailty	4.847	2.481-9.470	<0.001	3.042	1.482-6.242	0.002

The values are reported as odds ratios with 95% confidence intervals (CI).  
CCI: Charlson Comorbidity Index, ACB: Anticholinergic burden

synapse numbers, contributing to Alzheimer's disease-related pathology and brain atrophy. In line with previous research, our data also indicate a higher prevalence of low MMSE scores among participants with higher ACB scores, which aligns with the existing evidence linking ACB to cognitive impairment.

Beyond cognitive decline, anticholinergic drugs have also been linked to falls, balance issues, and reduced physical activity in older adults (32,33). In our study, participants with high ACB scores showed increased dependency in ADL and IADL, decreased muscle strength, and slower gait speed. Probable sarcopenia was also highly prevalent in this group. These effects could be related to the anticholinergic impact on neuromuscular junctions, potentially disrupting movement and posture, contributing to muscle weakness and reduced physical activity, as seen in other studies (34,35).

Our findings suggest that polypharmacy and frailty are significant predictors of high ACB, even after adjusting for age and the CCI. Frailty is defined by a reduced physiological reserve and heightened susceptibility to negative health outcomes, including falls, disabilities, hospitalizations, nursing home admissions, and increased mortality (36). Frail older adults often

have a high burden of comorbidities and concomitant geriatric syndromes, including malnutrition, cognitive dysfunction, and urinary incontinence (37). Therefore, they also may take an increased number of medications, leading to polypharmacy and a higher risk of high ACB (38). However, establishing a cause-and-effect relationship between frailty and high ACB is challenging, as high ACB can also contribute to low muscle strength, gait speed, weakness—all of which are components of frailty—ultimately leading to frailty.

Most studies on ACB focus on hospitalized or nursing home residents, but our study highlights the ACB among community-dwelling older adults. While antidepressants, antipsychotics, and urinary incontinence drugs are well-known for their high anticholinergic effects, our findings show that commonly used cardiovascular medications—such as metoprolol, furosemide, and warfarin—are the most prevalent contributors to the ACB in this population, despite having a lower ACB. This underscores the importance of being knowledgeable about which drugs have anticholinergic properties, regularly reviewing medications, and deprescribing anticholinergic medications when possible to improve outcomes for frail older adults. Reducing the ACB can



enhance cognition, mitigate adverse effects, improve quality of life, and help decrease the prevalence of geriatric syndromes.

### Study Limitations

Our study has several limitations. The cross-sectional nature of the design restricts our ability to determine causality between ACB and geriatric syndromes. Additionally, we only assessed ACB using the Anticholinergic Cognitive Burden Scale, without considering the dosage or duration of medication use, which may also affect outcomes. Furthermore, the number of participants in the high ACB group was relatively low, limiting the generalizability of our findings. Another limitation is that we investigated probable sarcopenia based on SARC-F scores and low muscle strength, rather than diagnosing sarcopenia, as we did not directly measure muscle mass. Additionally, cognitive impairment was diagnosed using the MMSE rather than a comprehensive neuropsychological assessment.

### Conclusion

In conclusion, high ACB was present in 7.5% of participants. Additionally, anticholinergic medication use was observed in 24.6% of community-dwelling older adults. Participants with a high ACB score exhibited a greater number of geriatric syndromes. A high ACB correlated with a heightened risk of polypharmacy and frailty within this population. Cardiovascular medications were the most commonly used drugs contributing to the ACB. There is a need for prospective studies to investigate the causal link between high ACB and geriatric syndromes in older adults.

### Ethics

**Ethics Committee Approval:** This study adhered to the principles of the Declaration of Helsinki and obtained ethical approval from Ankara University's Ethical Committee (approval number: 11-747-18, date: 25.06.2018).

**Informed Consent:** Written informed consent was obtained from all participants prior to their inclusion in the study.

### Footnotes

#### Authorship Contributions

Surgical and Medical Practices: D.M.S., R.B., Ç.C., T.T., H.S.Ö., M.V., Concept: D.M.S., M.V., Design: D.M.S., M.V., Data Collection or Processing: D.M.S., R.B., Ç.C., T.T., H.S.Ö., Analysis or Interpretation: D.M.S., M.V., Literature Search: D.M.S., R.B., T.T., Writing: D.M.S., M.V.,

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# “Get Ready!” The Vulnerability and Resilience of Older Adults in Disasters

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## Abstract

**Objective:** The concepts of vulnerability and resilience dictate the experiences that older adults have in times of disaster. Our primary purpose is to shed light on the heavy losses experienced by older adults during the Coronavirus disease 2019 (COVID-19) pandemic.

**Materials and Methods:** In line with this purpose, this phenomenological qualitative study was conducted from March 2022, when the obligation to wear a mask outside was lifted, until the end of December 2022 with 50 participants aged 65 and over living in İstanbul, using the snowball method. To understand the participants' vulnerability and resilience, they were asked about their experiences in these areas. The results were given in a mixed manner in line with the statements of older citizens.

**Results:** It has been concluded that older people's existing health and structural problems break their resilience at the point of vulnerability, and factors such as socializing, staying connected to others through digital platforms, and receiving social support increase their social resilience.

**Conclusion:** The older participants in the present study not only expressed their vulnerability; they also recounted their resilience during the COVID-19 pandemic. As older adults provide intergenerational solidarity to fight against disasters, specific frameworks should be designed to support this effort.

**Keywords:** COVID-19, disasters, older adults, vulnerability, resilience

## Introduction

Coronavirus disease 2019 (COVID-19), which emerged as a biological disaster on March 12, 2020, is still being discussed. Understanding how this disaster has affected vulnerable groups is essential for strengthening their resilience in the face of future crises. When we add biological sex to the age parameter, women face even greater challenges during disasters. Adding variables such as race, religion, language, immigration, disability, lack of education, widowhood, social insecurity, and/or poverty to the equation makes the situation more difficult for female members of the older population (1).

Preparation for future disasters is contingent upon learning lessons from past disasters. Otherwise, societies face significant consequences during catastrophic events. For example, since municipal and state-level governments failed to account for the socio-demographic characteristics of individuals living in the impacted zone of Hurricane Katrina, in the United States of America (USA) in 2005, older adults suffered high casualties because of the disaster (2). Despite the previous lessons learned from disasters across the globe, the disparities in health outcomes and access to resources across age lines during the COVID-19 pandemic highlight the urgent need for further study on the impact of such crises on older populations.

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Vulnerability means the low capacity of individuals to prepare for, resist, and recover from disasters, which is exacerbated by various factors, including advanced age (3). In the context of older adults, vulnerability is evaluated from both physical and psychosocial perspectives. While physical vulnerabilities are associated with increased injuries and health problems of older adults in disasters, psychosocial vulnerabilities are caused by their social issues and psychological traumas that may be deepened after the catastrophic events (4). Resilience in disasters encompasses what individuals can do for themselves and others to survive a crisis, how they can readapt to life after catastrophe, their capacity to cope with stress, and their ability to stay in touch with others, and receive secure support (5). It has been observed that people may undergo a transformative process, finding balance and developing positive attitudes despite the problems they experience after the trauma, thus showing their psychological resilience (6). Resilience studies can make it easier to predict the risks faced by older adults in times of catastrophe, as well as to plan interventions to address their needs. There are various gerontological approaches examining the experiences of the older population in disasters in terms of vulnerability and resilience (7-10).

Discussions of vulnerability and resilience among older adults relate to activity theory, which mentions that older adults stay active in different roles; and disengagement theory, which focuses on their withdrawals. Therefore, COVID-19 studies have set out from two different approaches: older people are more affected by the disaster and either continue the activities presented as "successful aging" or withdraw from life because they have become vulnerable due to ageist approaches during the disaster process (11). Therefore, in this study, we have acted according to both of these approaches without one conflicting with the other.

Literature in disaster research has highlighted the disproportionate impact of disasters on older populations due to a combination of physical, cognitive, and social factors that change with age. For example, Carter et al. (12) emphasize that older adults often have reduced mobility, chronic health conditions (such as cardiovascular diseases, diabetes, and sensory impairments), and weakened immune systems, making them more susceptible to disaster-related harms. This vulnerability is compounded by age-related cognitive decline, which can impair the ability to make quick decisions or react appropriately during an emergency (13). Disaster literature also identifies social isolation as a critical risk factor for older adults during disasters. According to Fothergill and Peek (14), social isolation limits access to information, emergency services, and physical help during crises. Many older adults live alone, which increases their dependency on external assistance during disasters; their ability to evacuate or receive care may be compromised by reduced community engagement (14). Aging studies contribute to this

body of knowledge by exploring how these social and physical factors evolve over time and by identifying specific needs for disaster preparedness among older individuals.

Research on resilience in disaster literature, such as that by Morrow (15), highlights how certain factors can help older adults recover after disasters, including strong social support networks, financial resources, and community-based emergency preparedness programs. A study by Zhang et al. (16) explored the role of social support networks and technology in enhancing the disaster resilience of older adults, highlighting how digital tools can help bridge gaps in communication and aid during emergencies. Additionally, research by Williams et al. (17) examined the mental health outcomes of older adults after disasters, showing that psychological resilience can be strengthened by community engagement and mental health resources, which are often underutilized in disaster preparedness plans for the older population. Another study by Chen et al. (18) focused on disaster risk reduction strategies for older adults in urban settings, emphasizing the need for targeted infrastructure improvements, such as accessible evacuation routes and emergency shelters.

Despite an extensive body of literature published on COVID-19 over the past four years, this study adopts a distinctive interdisciplinary approach. It represents a collaborative effort between gerontologists and geriatricians to examine the vulnerability and resilience of the older population within the context of a specific disaster. In addition, unlike the existing literature, which typically focuses on health, social isolation, and economic challenges, our study provides an in-depth analysis of how these factors are shaped within socio-demographic, familial, and institutional contexts. Additionally, the study uniquely focuses on the use of digital technologies as resilience mechanisms and the heightened visibility of ageism due to social distancing measures, offering a distinct and innovative perspective compared to other research in the literature. Therefore, this study examines vulnerability and resilience concurrently, in light of the limited research available on the specific resilience strategies utilized by older adults during the COVID-19 pandemic. It presents significant insights for future research, suggesting that socio-economic, cultural, and institutional factors should be considered in the development of more effective support mechanisms for older adults.

## Materials and Methods

This study seeks to answer the question of "What do 'vulnerability' and 'resilience' mean for older adults during times of disaster?" Therefore, the study used a qualitative approach, specifically phenomenology, by examining older adults' perspectives on disasters, determining their fundamental challenges, and developing solutions to respond to those problems.

In phenomenological studies, the meaning and experiences that individuals attribute to a phenomenon are essential (19). For this reason, this research relied upon information on the lived experiences of older adults on this subject, from the data pool of other qualitative studies conducted in İstanbul on living in the same place regardless of a specific ethnic, religious, gender, or geographic background after the COVID-19 pandemic. The reason İstanbul is the research site is that, as Türkiye's largest city, it can simultaneously reflect problems and opportunities in areas such as health, care, education, technological literacy, hobby gardens, social participation, and taking the initiative in terms of the silver economy. These are essential factors in shaping both the resilience and vulnerability of older adults during disasters.

Data were collected from 50 participants aged 65 and over from March 2022, when the obligation to wear a mask outside was lifted, until the end of December 2022. The age threshold of 65 years or above was considered the primary criterion for inclusion. As the study was qualitative in nature, data saturation was the guiding principle in determining the sample size and selection. Data saturation was only reached with the 50<sup>th</sup> participant due to the multicultural composition and large population size of İstanbul, which results in a diverse older demographic. This indicates that the sample size was adequate for the qualitative nature of the study. The data collection process was as follows: semi-structured in-depth questions were prepared rather than standard questions to collect high-quality data from older adults. In addition, socio-demographic questions were included in the interview form, to assess the socio-economic status of the participants, thereby enhancing the overall quality of the study. Given İstanbul's multicultural characteristics, the study sample was limited to residents of this city.

Participants from various districts of İstanbul were selected as key informants through a snowball sampling method where interviewees suggest other participants. Data were obtained through in-depth interviews conducted both via telephone and face-to-face with participants. No significant differences were observed between the telephone and face-to-face interviews in terms of data quality, indicating that the mode of interview did not affect the results. From an ethical standpoint, informed consent was obtained from all participants. They were provided with detailed information regarding the confidentiality and security of their data before the interviews commenced. Due to the participants' age, interviews were generally limited to 30 minutes, unless the older adults wished to extend the conversation. Some researchers have noted that older adults may diverge into tangents that generate valuable insights for research (20). After the interviews, the raw files were stored on an external hard drive and secured in a locked drawer that only the principal investigator could open.

After the data obtained from the interviews were transcribed, the transcripts underwent thematic analysis. The interviews were manually coded according to established coding guidelines. Categories were derived in alignment with the coding framework and were then synthesized into main themes. The categories that have emerged to capture the theme of vulnerability include medical health issues, such as chronic diseases; structural issues, including poverty, social exclusion, and ageism; and official restrictions, encompassing measures such as social distancing. The theme of resilience was captured through categories related to efforts to maintain social connections despite challenges, such as socializing through digital platforms and receiving social support from external sources. These categories were identified across the interviews to uncover the core issues faced by this group of Turkish older adults during the COVID-19 pandemic. This study was approved by the Ethics Committee of Social and Humanities Research of Yıldız Technical University (approval number: 2023.09, date: 03.09.2023).

### Statistical Analysis

The interviews were transcribed, and codes were identified. Based on these codes, categories were created. From these categories, the main themes were derived, leading to a qualitative analysis.

### Findings

The socio-demographic characteristics of the participants in this study revealed a diverse group, with 24 males and 26 females. In terms of educational background, 5 participants had no formal education. Among the remaining 45, 18 had completed primary school, 12 had secondary school education, 10 were high school graduates, and 5 had university degrees. Regarding socio-economic status, 10 participants received low pensions, 25 received medium pensions, and the remaining 15 had other sources of income in addition to their pensions.

The themes that emerged from the lived experiences of older adults in Türkiye during the COVID-19 pandemic demonstrated vulnerability and resilience. The following two sections shed light on these factors.

### The Vulnerability Experiences of Older Adults in Disasters

Pre-existing health problems make older individuals psychologically vulnerable to disasters. A 66-year-old married female participant said, "I have high blood pressure." Also, my feet hurt; they restrict my movement. When we had to stay at home, our mental health also deteriorated. Whatever this is. What further disturbed our psychology were the deaths of the people we loved. Co/multimorbidity increases sharply with age. Such compounding conditions can increase older adults' risks of poor outcomes and mortality (21), particularly during catastrophes. The complex relationship between chronic health conditions and psychological vulnerability further underscores

the heightened risks older adults face during crises. Chronic health conditions amplify the negative psychological impacts of disasters, often leading to a vicious cycle where the worsening of physical health triggers increased mental stress, making it even more difficult to cope. This exacerbated vulnerability is evident in the experiences of other participants as well. A 67-year-old widowed female participant described her experience as follows: "I was receiving treatment for my eyes, [but] out of fear, I couldn't go to the hospital because of the pandemic". This anecdote demonstrates how older adults postponed even very necessary treatment during the surge of COVID-19 because the pandemic presented more pressing issues. The pandemic, therefore, not only interrupted routine care but also deepened the mental distress of older adults, who were faced with the dilemma of risking exposure to a deadly virus versus the ongoing deterioration of their health. Another 69-year-old married female participant also indicated disruptions in treatment and medical care during disaster, explaining, "I have heart, stomach, and foot problems. We could not find an appointment to continue the treatment of these diseases during the pandemic". This disruption of essential healthcare services further illustrates how health systems' strain during disasters disproportionately affects older adults, leading to worsened chronic conditions and increasing the physical and emotional toll of the disaster.

The compounded effect of multiple health conditions during a pandemic significantly exacerbates older adults' vulnerability. The health problems that older adults experience put them at risk for complications during disasters, which can necessitate intensive care. A 78-year-old widowed male participant illustrated these risk factors through his experience: "I had bypass surgery a few years ago. I had cancer surgery in February this year. My children hired me as a babysitter because they were working. When chemotherapy made me weak, I caught COVID-19. The children took me to the hospital, and I stayed in the intensive care unit for 36 days". This account highlights the cumulative impact of pre-existing medical conditions on older adults' ability to recover from new health challenges, such as a viral infection, further increasing the risk of mortality and the need for intensive medical care during crises. Moreover, the pandemic created an environment where older adults had to re-evaluate their living situations, and sometimes, due to the severity of their conditions, they were led to long-term care facilities. Older adults who fall ill because of disasters may need to spend the rest of their lives in long-term care institutions away from their families. Such was the case for a 78-year-old male participant, who explained, "I had a stroke in 2003. Just as I was recovering and starting to do everything myself, COVID-19 emerged, and I found myself here (referring to the nursing home)". This exemplifies how the pandemic forced unexpected transitions in the lives of many older adults, who, despite making progress in their recovery, found themselves in

institutionalized care settings due to the sudden health risks posed by the pandemic.

Additionally, the pandemic exacerbated existing structural inequalities, such as poverty, social exclusion, and ageism were exacerbated during the pandemic, further deepened the vulnerability of older adults. These issues were reflected in the experience of one 70-year-old married male participant, who said, "I am sick. Since I had surgery twice, I live in the basement of my sister's house as a person who does not have a social life". His statement reflects how social isolation—an issue that was already prevalent among older adults—was intensified by the pandemic, making them feel even more marginalized within their families and communities. Furthermore, the economic repercussions of the pandemic disproportionately affected older adults, particularly those who were already living on fixed or limited incomes. A 67-year-old widower, described how older adults face increased poverty during disasters, saying, "The salary I received in the pandemic was only enough for me. When my children were laid off and became unemployed, the whole burden of the house was on my shoulders". A 72-year-old married female participant echoed this experience, recalling that the support from her family members declined because of the disaster. "We were barely living on our pension", she explained, "Even when we had a big expense, our son supported us. When my son came to the position of closing his workplace due to the pandemic, we started to have difficulties". Rising inflation and falling wages created a double burden of poverty for older adults as well, as explained by a 65-year-old male participant who said, "prices have doubled in the pandemic. While our needs have increased, our earnings have decreased". The economic strain faced by older adults during the pandemic not only led to increased financial stress but also contributed to family tensions and a sense of helplessness as many older adults found themselves unable to support both themselves and their families.

The "social distancing" measures used to minimize the transmission of COVID-19 and thus protect vulnerable populations like older adults and the immunocompromised from the virus's effects created a profound sense of social exclusion and stigmatization for this demographic, intensifying ageism in society. According to a 68-year-old male participant, "In the beginning, we could not go out at all for months". They treated us as if we were spreading the disease. Likewise, people who saw us outside were looking at us with evil eyes. This experience reflects the ageist attitudes that were heightened by the pandemic, in which older adults were stigmatized and viewed with suspicion by the general public, exacerbating their feelings of social isolation and further alienating them from their communities. The confinement and rejection of the oldest segments of the population during disasters can feed ageist ideologies in the subconscious of other age groups, as indicated

by an 80-year-old married male participant, who claimed that his younger counterparts were "running away from us wherever we go".

### **The Resilience Experiences of Older Adults in Disasters**

Older adults protect themselves and demonstrate social resilience against disasters by reshaping their habits and practices, considering changing conditions. For example, a 65-year-old married female participant sought to bolster her psychosocial resilience by socializing outdoors in the early days of the COVID-19 pandemic. She explained that over time, she adopted social media tools to connect with friends and family from home, replacing her previous face-to-face modes of communication with virtual ones: "we are socializing at home-not outside anymore". We have the conversations that we would have outside with friends over the phone remotely. This participant's experience demonstrates the methods of coping with stress that build the resilience of older adults. This shift to online socialization not only provided a means of coping but also highlighted the adaptability and psychological resilience of older adults in the face of unprecedented social isolation. By adopting digital communication tools, this participant not only maintained her social connections but also built psychological resilience by continuing to engage with others, thus alleviating the sense of loneliness that could have intensified her vulnerability.

Older adults show resilience during disasters when they stay in touch with others, especially their families, and receive support from them. A 70-year-old married male participant said, "this disaster has re-established our ties with family members with whom we have been increasingly disconnected". We appear to have understood each other's worth once more. We see our children who work daily and our grandchildren who we had difficulty seeing before because of school. Since the grandchildren take their lessons online at home, I overheard them and mentally returned to my student life. This illustrates how disasters, while disruptive, can also lead to a reevaluation of familial relationships and the strengthening of family bonds, which in turn enhances the resilience of older adults.

Moreover, community-based support systems played a crucial role in reinforcing the resilience of older adults during the pandemic. Receiving material and moral support from different institutions and organizations, including the government, can also increase the resilience of older adults in times of disaster. Referring to this situation, a 68-year-old widowed woman said, "young people from Vefa (It is one of the social support groups established in provinces and districts for citizens to meet their basic needs without going out on the streets during the pandemic in Türkiye.) came and gave me strength. Everything is not material, my son. Somebody is knocking on our door". This statement reflects the psychological and emotional boost that

came from receiving support from local organizations, not only through the delivery of physical necessities but also through the social interaction that alleviated feelings of isolation and loneliness. Such support networks were instrumental in providing older adults with the resources they needed to weather the hardships of the pandemic, thus mitigating the psychological toll of social distancing. Though social distancing kept older adults safe from a potentially deadly virus, it also cut them off from their communities, thereby compounding already prevalent feelings of social isolation, which could create significant health risks (22). The visit from the young people combated the loneliness that the 68-year-old widowed woman experienced, demonstrating the support of other generations for their older adult neighbors in difficult times. In essence, the experiences of older adults during the pandemic reveal that their resilience is rooted in adaptive coping strategies, familial solidarity, and the crucial support of both community organizations and institutional systems. These findings emphasize the importance of integrating psychological and social support into disaster management strategies to better support older adults during crises.

### **Discussion**

Our study demonstrates that the factors that make older adults more vulnerable to disasters should be examined from every angle, not just numerically. Since demographic change affects every aspect of society, it is critical to understand how population ageing affects the impact of disasters, as well as how disasters impact the oldest segments of the population.

As the experiences of participants indicate, medical conditions and physical ageing are the main contributors to the fragility of older adults in disasters. The fragility of the body and immune system can be compounded by chronic health conditions, which makes the body and immune system more vulnerable to injury or death and may require inpatient or hospice care in times of catastrophic events.

This vulnerability is not limited to physical health, however. The above findings also illustrate how the psycho-social health of older adults can suffer due to isolation and grief. For example, since emotionality increases with age, older adults may experience more intense bereavement if their loved ones die from a disaster (23). Persistent social inequalities such as ageism can affect older adults, and are exacerbated in times of catastrophe. Recent studies show that older adults face increased risks of mental health issues and greater social exclusion during disasters, and ageism becomes a significant concern during such times (24). For example, a study covering five different disasters in Canada concluded that the media discriminated against older adults by stigmatizing them as passive individuals (25). A study on ageism during the COVID-19

pandemic in Türkiye similarly revealed that older people were marginalized as passive individuals (26,27).

Some of the measures taken to respond to disasters can also intensify older adults' psycho-social vulnerability. For example, although social distancing regulations were implemented to reduce the risk of contracting COVID-19 for older adults (and other immunocompromised populations), they also led to social isolation and discriminatory behaviors against older adults that further marginalized this already vulnerable population (1,28,29). This discrimination stemmed from ageism perpetuated by the media, which centered on perceptions of older adults' fragility, and ignored their resilience.

Disasters can also highlight the vulnerability of economically disadvantaged groups (30). Recent studies underscore the correlation between economic distress and heightened vulnerability of older adults during the pandemic, with many older individuals falling deeper into poverty due to economic downturns (31). The experiences of this study's participants demonstrate how economic gaps widen during times of catastrophe; for example, one retired participant had to rely on his small pension to care for his children, whose workplaces closed during the lockdown period. Many disasters bring economic downturns with them, which can increase prices and decrease earnings, creating a precarious financial situation for already vulnerable older adults. For example, in the USA and Sri Lanka, disasters have been seen to increase pre-existing economic inequalities (32,33). Also, in Türkiye, it has been observed that the post-disaster fragility of older people, including poverty, is closely related to their pre-disaster socioeconomic situation (30,34).

The older participants in the present study not only expressed their vulnerability, but they also recounted their resilience. Practices that bolstered older adults' resilience fall under three categories: the social support they received, the methods that they discovered for staying in touch with others, and their various social activities.

First, sustainable social support for older adults is critical for ensuring their welfare and promoting intergenerational justice (35). For example, the experience of the participant who was encouraged by a visit from the support group from Vefa, clearly demonstrates how significantly this type of support can increase the psycho-social resilience of an older woman experiencing financial and emotional stressors.

Second, staying in touch with others is another practice that increases older adults' resilience, regardless of the circumstances. COVID-19 illustrated how this contact does not have to be face-to-face, digital technologies enabled older adults to maintain contact during periods of social distancing, which greatly benefited this vulnerable population during a time when they

would have been otherwise isolated from society (36). As our findings show, this disaster even strengthened the social ties in some families that had grown distant by keeping home from school and work, thus bringing them together.

Third, creating opportunities for older adults to meet and socialize can reduce their feelings of social exclusion after a disaster (37). As indicated by our findings, when members of older age cohorts come together, they engage in a resilience strategy that provides stability in the wake of catastrophe. For example, participants tried to protect their resilience by continuing their typical outside meetings and social activities at home using social media. Thus, the pandemic created an exigency for older adults to adopt technological innovations that they otherwise may not have considered to maintain their social lives and stay safe. Recent research also suggests that virtual community support systems have played a crucial role in combating loneliness and enhancing resilience during crises, particularly for older adults (38).

It is important to both understand the vulnerability and the resilience of the older population, and create concrete plans for addressing their unique needs before catastrophe strikes. This preparation process should involve three key elements: a comprehensive plan, effective communication strategies, and accurate information that accounts for older individuals' needs.

Specific resources should be created to address the needs of older adults. For example, relevant stakeholders (e.g., governmental councils on ageing, hospitals and long-term care facilities, emergency management agencies) should coordinate to build an inclusive plan that addresses older adults' vulnerabilities and capitalizes on their resiliencies. Such a plan should be developed in conjunction with older adults themselves, as well as their family members and caregivers, to ensure their participation in decision-making processes about issues that have an impact on them.

Secondly, effective communication is essential for coordinating disaster response. After the Marmara Earthquake in Türkiye in 1999, damage to the national communication infrastructure led to a lack of information, which hampered response efforts and ultimately decreased public trust in the state (2). Effective communication affects both decision-makers and the public because it builds public confidence and enables governmental officials and agencies to make quick and informed decisions (39). For older adults, just-in-time communication can facilitate rescues and provide reassurance. While previous disaster responses have relied upon media such as radio and telegram, digital tools like short message services, email, and social media have helped facilitate more immediate and local responses to catastrophes (40). However, older adults tend to adopt new technologies, such as smartphones, at lower rates than their younger counterparts (41); making it important to use more



traditional communication channels to reach this segment of the population. Recent studies indicate that older adults' access to and use of digital platforms for disaster management is still limited, necessitating further development of both technological and non-technological communication strategies (42). Thus, older adults should be trained to use battery-operated emergency radios or simple one-touch smartphone apps to maximize their ability to receive important messages during disasters. In Türkiye, the Ministry of the Interior's Disaster and Emergency Management Presidency developed an emergency mobile application for Android and iOS systems, which provides one-touch emergency calling, information on nearby shelters and assembly areas, and disaster training videos (43). Since natural disasters like earthquakes and tornadoes may destroy communications infrastructure, cutting off access to the internet, decision-makers should consider creating both digital and analog methods for communication and disseminating information.

Finally, it is important to ensure the dissemination of accurate information and mitigate misinformation during disasters because older adults are particularly vulnerable to mis/disinformation including "fake news, scams, fraud, and digital privacy/security breaches." Therefore, pointing disaster survivors to official governmental communication channels can prevent information pollution, as well as create information verification systems, like verified social media accounts for sharing official updates and fact-checking databases.

Since this study focused on the vulnerability and resilience of older adults in disasters, it was limited to the risks faced by this population. For this reason, many additional opportunities available to older adults in other fields (e.g., business and economics, sports and leisure, biomedicine) were excluded from the scope of this study. Our study had several limitations. We could not use a psychometrically valid test to support the interviews. Secondly, the study was carried out in a single center with a small study group. Increasing the sample size could strengthen the generalizability of our findings. Thirdly, we focused on the experiences of older adults living solely in İstanbul, which reduces the generalizability of the results. Further studies may consider cross-disciplinary approaches, exploring the intersection of economic, health, and technological interventions in reducing the vulnerability of older adults during crises (44). Future studies could explore the applications of these and other disciplines to address the vulnerability and resilience of older adults.

## Conclusions

This study found that the vulnerabilities of older adults, particularly those with disabilities and social inequalities, deepen during times of disaster. This study indicated the need

for the development of a gerontological framework for mapping the factors that contribute to older adults' vulnerability and resilience in disasters. Older adults have unique knowledge and experiences that can help actively defend themselves and others. This perspective not only combats stereotypes about older individuals but also fosters intergenerational solidarity by encouraging older people to collaborate with other generations in the fight against disasters.

In conclusion, this study suggests that studies on biological disasters such as COVID-19 and other types of disasters should be conducted holistically, without pitting one generation against another, and ensure that they act together. To mitigate the diverse threats posed by disasters to our shared world, scientific assessments and studies should inclusively address the needs of older adults alongside other age groups. One effective approach to achieving this is to first understand the vulnerability and resilience of older individuals in disaster contexts, thus enabling intergenerational studies as demonstrated in this research.

## Ethics

**Ethics Committee Approval:** This study was approved by the Ethics Committee of Social and Humanities Research of Yıldız Technical University (approval number: 2023.09, date: 03.09.2023).

**Informed Consent:** Informed consent was obtained from all participants.

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The authors certify that they comply with the ethical guidelines for authorship and publishing of the European Journal of Geriatrics and Gerontology.

## Footnotes

### Authorship Contributions

Surgical and Medical Practices: Ş.E., Concept: Ş.E., Design: Ş.E., Data Collection or Processing: Ş.E., Analysis or Interpretation: Ş.E., N.M.Ç., M.A.K., Literature Search: Ş.E., Writing: Ş.E.

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# Osteosarcopenic Obesity's Role in Older Adults' Falls and Vertebral Fractures

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## Abstract

**Objective:** The co-occurrence of osteoporosis, sarcopenia, and obesity is known as osteosarcopenic obesity (OSO). This study examined the frequency of OSO in older adult outpatients and its connection to falls and spinal fractures.

**Materials and Methods:** Participants in this cross-sectional study were outpatients 60 years of age or above. The European Working Group on Sarcopenia in Older People 2 (EWGSOP2) determined that the patients had sarcopenia EWGSOP2, had bone densitometry, completed a comprehensive geriatric examination, and were categorized as obese based on their body fat percentage. The researchers diagnosed patients with OSO by selecting those who fulfilled the criteria for poor bone density, diminished muscle strength, decreased walking velocity, and increased body fat percentile. The patients were categorized into four groups: only obese, exclusively osteoporotic obese, purely sarcopenic obese, and OSO patients and thereafter assessed. Fractures detected with radiological assessment.

**Results:** All 317 elderly people contributed to this research, with 12.2% (39 out of 317) identified as having OSO. The occurrence of falls was significantly elevated in OSO patients relative to those in the sarcopenic obese, the osteoporotic obese, and the obese cohorts ( $p < 0.001$ ). Moreover, OSO patients demonstrated a markedly higher incidence of vertebral fractures in comparison to the obese, osteoporotic obese, and sarcopenic obese cohorts ( $p = 0.001$ ).

**Conclusion:** Older adults with OSO face a heightened risk of falls and vertebral fractures relative to those classified as sarcopenic obese, osteoporotic obese, or obese.

**Keywords:** Falls, elderly individuals, osteosarcopenic obesity, vertebral fractures

## Introduction

Osteosarcopenic obesity (OSO), a newly recognized condition, is defined by the combination of osteoporosis, sarcopenia, and obesity (1,2). A significant amount of evidence exists regarding the prevalence, risk factors, and effects of osteoporosis and obesity, and increasing research on sarcopenia.

Despite the increasing importance of OSO, there exists a paucity of publications, and its frequency is markedly diverse, contingent upon the diagnostic criteria employed for

osteopenia, sarcopenia, and obesity. This results from the lack of consensus on the diagnosis of OSO. The National Bone Health Alliance Working Group advocates for the use of Dual-energy X-ray absorptiometry (DXA) in diagnosing osteopenia (3). Moreover, bioelectrical impedance analysis (BIA) for bone mass assessment has recently gained popularity in clinical practice (4). Sarcopenia can be evaluated through various methodologies, including imaging techniques (e.g., BIA, DXA), anthropometric measurements, muscle strength assessments, and physical performance evaluations [e.g., handgrip strength (HGS), chair

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stand, short physical performance battery] (5). The definition of obesity remains a topic of considerable debate. Obesity can be evaluated using body mass index (BMI), body fat percentage, or waist-hip ratio, with the latter indicating visceral fat levels. Few studies have looked at the possible negative impacts of OSO, despite the known link between the rising incidence of OSO components with age and common risk factors and poor health outcomes. OSO correlates with functional impairments, leading to severe problems such as falls and fractures, hence imposing an increased burden on healthcare costs (2,4,6,7).

According to some research, individuals with OSO are significantly more likely to experience falls and fractures than those who only have obesity, sarcopenia, or osteoporosis (4,8,9). It is imperative for each nation to ascertain the prevalence of OSO, assess its link with adverse outcomes such as falls and fractures, and prevent and treat its detrimental repercussions.

This study suggests that the occurrence of falls and spinal fractures is higher in the OSO group relative to the sarcopenic obese, osteoporotic obese, and obese groups. Establishing the prevalence of OSO among older adult outpatients in Türkiye and investigating a correlation between OSO and further fall and fracture episodes were the goals of this study.

## Materials and Methods

### Study Participants

Participants in the study had to be at least 60 years old and outpatients. Before the trial began, each participant provided written informed consent. The exclusion criteria encompassed dementia, parkinsonism and its symptomatic manifestations; malignancy; multiple myeloma; secondary osteoporosis; metabolic bone disorders; medications that may disrupt bone metabolism, including systemic steroid therapy, immunosuppressive agents, heparin, anticonvulsants, and diuretics, as well as patients unable to undergo BIA due to joint prostheses or observable edema.

### Ethical Considerations

This study was authorized by Erciyes University's Clinical Research Ethics Committee (approval number: 2019/136, date: 20.02.2019).

### Clinical Assessments

All patients underwent laboratory tests for serum calcium, albumin, creatinine, plasma parathyroid hormone, and serum 25-hydroxyvitamin D.

### Comprehensive Geriatric Assessment

A geriatric assessment was performed with the patients. A questionnaire was distributed to patients to evaluate their activities of daily living (ADL) and instrumental ADL (IADL).

The ADL item on the questionnaire was derived from Katz's Index (10,11), whereas the IADL component was informed by Lawton's Scale (12,13). An ADL score of 6 indicated the patient's independence, whereas a score of 0 indicated dependence. The IADL scale was utilized to assess the total score for each of the eight items, where a score of 0 represents dependence and a score of 8 signifies independence.

Patients' frailty levels were assessed using the FRAIL scale. The FRAIL scale consists of five domains. These factors encompass fatigue, resistance, ambulation, illnesses, and weight loss (14). The categorization of older adults into non-frail, pre-frail, or frail was determined by their overall score on the FRAIL scale. A score of 0 indicated non-frailty, a score of 1-2 indicated pre-frailty, and a score of 3-5 signified frailty.

The following metrics were used to perform anthropometric assessments of the groups: (BMI, kilograms (kg)/m<sup>2</sup>), weight in kg, and height in centimeters.

The fracture risk assessment tool (FRAX) tool evaluates fracture risk by considering several clinical factors, such as age, weight, height, history of low-trauma fractures, parental hip fractures, smoking status, glucocorticoid use, rheumatoid arthritis, secondary osteoporosis, and alcohol consumption, in addition to bone mineral density (BMD) measurements at the femoral neck. The algorithm forecasts the probability of osteoporotic fractures and major hip fractures over the next ten years (15).

The abridged (7-item) international physical activity questionnaire measured physical activity (16,17).

### Sarcopenia Assessment

All participants completed the a simple questionnaire to rapidly diagnose sarcopenia SARC-F questionnaire (18), which evaluates five key domains: strength, ambulation, chair rise ability, stair climbing, and history of falls. A score of four or above on the SARC-F is considered indicative of a high risk for sarcopenia.

Based on the standards set by the European Working Group on Sarcopenia in the Older 2 (EWGSOP 2), the only indicator of probable sarcopenia is decreased muscle strength. Both decreased muscle mass and decreased muscle strength must be present at the same time for sarcopenia to be diagnosed. The three characteristics of severe sarcopenia are low muscle mass, decreased muscular strength, and decreased walking velocity (19).

Sitting with elbows bent, participants were tested for muscle strength with a Takei TKK5401 Handgrip Dynamometer (Niigata City, Japan). With a minimum (min.) of one minute between each of the three measurements made from the dominant hand, The average value of the three measurements made from the dominant hand, with a min. of one minute between each measurement, was noted. BIA was used to collect electrical

resistance data in ohms. The Janssen et al. (20) equation, which takes into account the impedance data from the BIA instrument (Bodystat Quad Scan 1500, United Kingdom), was used to compute skeletal muscle mass (SMM).

It is recommended that SMM measurements be adjusted using weight or BMI instead of height squared, as the latter can underestimate sarcopenia in overweight or obese older adults (21,22). A recent study in Türkiye indicated that adjustments of SMM based on BMI exhibited a stronger correlation with functioning, physical performance, and frailty than adjustments based on height or weight (21). Accordingly, SMM was standardized to BMI, resulting in the SMM Index (SMMI), expressed in kg per BMI unit (kg/BMI).

Sarcopenia was classified according to EWGSOP 2 criteria, which include an SMMI of less than 1.049 kg/BMI for males and 0.823 kg/BMI for females, as well as HGS levels below 27 kg for males and 16 kg for females. A gait speed of less than 0.8 m/s is indicative of sarcopenia and decreased physical capabilities (19).

### Obesity Assessment

The weight in kg divided by the height in meters squared yields BMI. Using BIA measurements, the body fat percentage (BF%) was computed to determine obesity, with threshold values of BF%  $\geq 37.3$  for men and  $\geq 51.1$  for women. Using the Zoico approach, the cut-off values for BF% were established based on the 60<sup>th</sup> percentile of our study sample (23-25).

### Osteoporosis Assessment

The lumbar spine (L1-L4), entire hip, and femoral neck were evaluated for BMD using DXA (DXA; Hologic, QDR 4500 W, Hologic Inc., Waltham, MA, USA). The WHO classified patients by their lowest T-scores: T-scores  $\leq -2.5$  standard deviations classified patients as having osteoporosis, T-scores between -1.0 and -2.5 as having osteopenia, and T-scores  $> -1.0$  as having normal BMD (26).

### Falls Assessment

The frequency of falls was assessed to ascertain if they occurred in the previous year. A 12-month self-reported fall history was also collected.

### Fracture Assessment

An expert physician used radiological evaluation to identify fractures. When the vertebral body's height loss in the anterior, middle, or posterior dimensions exceeds 20%, a diagnosis of vertebral fracture is necessary (27).

### Osteosarcopenic Obesity Assessment

Sarcopenia, obesity, and osteopenia/osteoporosis in one person were considered OSO.

### Statistical Analysis

Data were examined using the Shapiro-Wilk test to identify non-normal distribution median and normal distribution mean  $\pm$  standard deviation. Categorical variables were shown as frequencies and percentages. The Kruskal-Wallis test and Bonferroni correction were used to compare clinical features in obesity only, osteoporotic obesity only, sarcopenic obesity only, and OSO. A p-value of 0.008 was deemed to be significant following the Bonferroni adjustment for multiple comparisons. The chi-square test compared categorical variables between the four groups.

Univariate analysis was employed to determine risk factors for falls and spinal fractures. A multivariate analysis was conducted to find independent predictors of falls and vertebral fractures, employing relevant variables from the univariate analysis ( $p < 0.05$ ). We examined the correlations between OSO and clinical outcomes (falls and vertebral fractures) using multivariable binary logistic regression models, controlling for age, sex, physical activity level, ADL, IADL, and isolated osteoporotic obesity. All statistical analyses were conducted using SPSS software (version 26.0), with  $p < 0.05$  deemed significant.

### Results

The study initially included 458 patients. A total of 141 participants were eliminated from the trial for not satisfying the predetermined inclusion criteria. Thus, the conclusive sample size for the investigation comprised 317 patients (Figure 1).

Our data demonstrated that 18.3% (58/317) of the patients exhibited obesity, 5.4% (17/317) exhibited both osteoporosis and obesity, and 4.1% (13/317) exhibited sarcopenia and obesity. A total of 12.2% of the study sample (39/317) was OSO (Figure 2).

The median age of the research's sample was 71 (range: 66-76 years), with 83.6% of participants being female. Table 1 presents the demographic and clinical features of the four groups: obese, osteoporotic obese, sarcopenic obese, and OSO. The median age of the OSO cohort was 76 (range: 66-83 years), significantly exceeding that of the other groups ( $p < 0.001$ ). The four groups demonstrated similar BMI and smoking status ( $p = 0.437$  and  $p = 0.994$ , resp.).

Compared to the other three groups, the OSO group had significantly higher FRAX major and neck values and correspondingly lower lumbar total T score, femoral neck T score, and femoral total T score values ( $p < 0.001$  for all parameters) (Figure 3). The osteoporotic obese group exhibited a significantly lower level of dependence on ADL than the other groups ( $p = 0.024$ ). Furthermore, sarcopenic obese patients demonstrated a significantly lower level of dependence based on the IADL scoring system than the other groups ( $p = 0.039$ ).

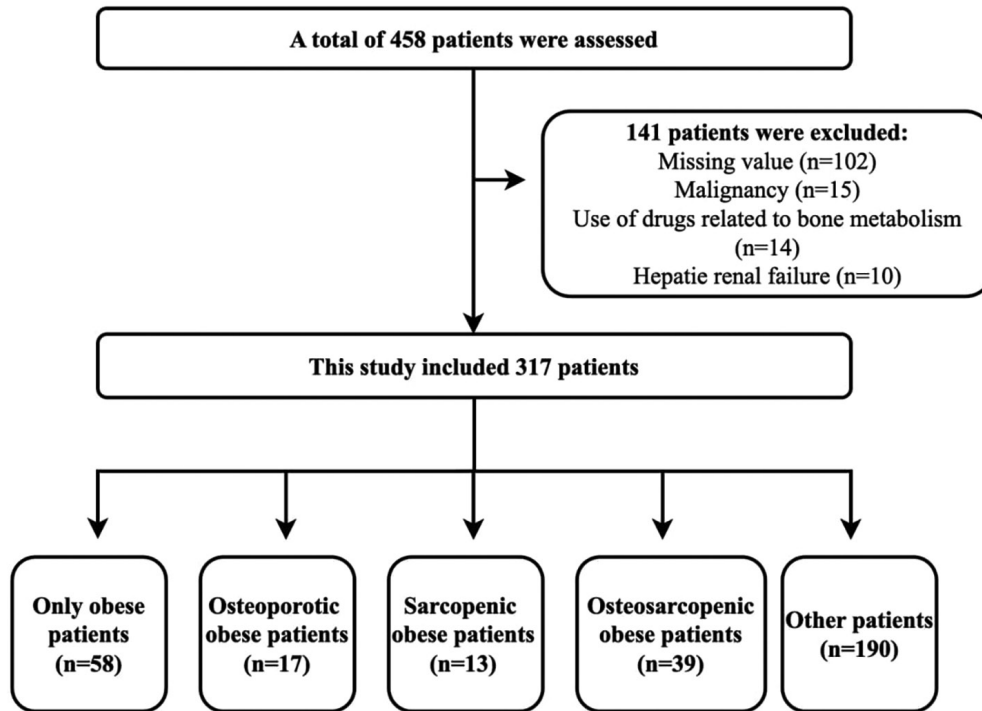


Figure 1. Study patient flow chart

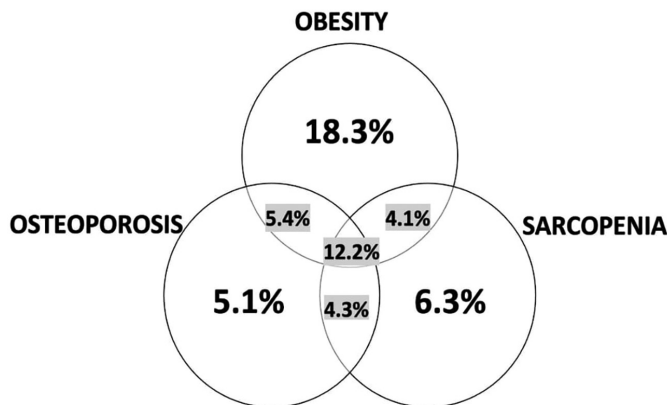


Figure 2. The prevalences of obesity, osteoporosis, sarcopenia, and their combinations

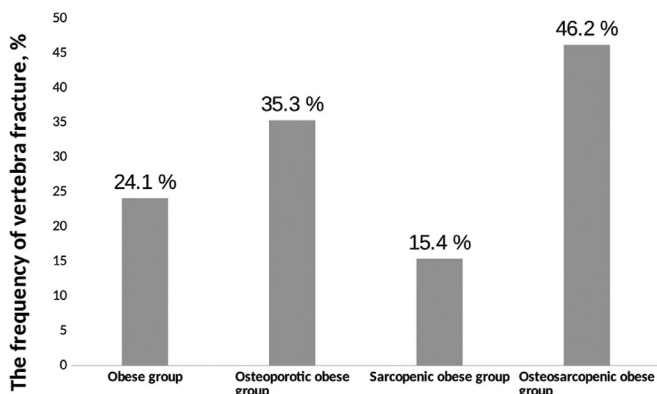


Figure 3. Bar chart demonstraing frequency of vertebra fracure distribution according to groups

OSO patients exhibited significantly higher SARC-F scores than those in the other groups ( $p=0.025$ ). OSO patients exhibited a significantly lower gait speed than both osteoporotic obese and sarcopenic obese patients; (median: 1.17, 1.25, 1.30 m/sec, respectively;  $p=0.043$ ). In comparison to the other three groups, the OSO participants demonstrated significantly higher TUG test points than the other three groups ( $p=0.024$ ).

The HGS of female OSO patients was 12.1 kg (10.3-15.6), significantly lower than the other three groups ( $p=0.001$ ). Based on the calculation of the metabolic equivalent of task, low levels of physical activity were observed in 53.4% of obese patients, 58.8% of osteoporotic obese patients, and 51.3% of OSO patients (Table 1).

The study found that participants with OSO exhibited a significantly lower SMMI than the other groups ( $p=0.039$  for males and  $p=0.028$  for females). In comparison, to the obese female group (median: 0.93,  $p=0.008$ ), the osteoporotic obese female group (median: 0.88,  $p=0.008$ ), and the sarcopenic obese female group (median: 0.88,  $p=0.008$ ), the OSO female participants had a median waist-to-hip ratio of 0.98, which was significantly higher (Table 1). A total of 36.2%, 47.1%, 30.8%, and 74.4% of obese, osteoporotic obese, sarcopenic obese, and OSO patients experienced falls, respectively. The highest incidence of falls was observed in OSO patients ( $p<0.001$ ). Additionally, OSO patients demonstrated a markedly greater incidence of vertebral fractures than their counterparts who were only obese, osteoporotic obese, or sarcopenic obese ( $p=0.001$ ) (Table 1).

<b>Table 1. Demographic and clinical characteristics of patients</b>						
	<b>Total (n=317)</b>	<b>Obese group (n=58)</b>	<b>Osteoporotic obese group (n=17)</b>	<b>Sarcopenic obese group (n=13)</b>	<b>Osteosarcopenic obese group (n=39)</b>	<b>p</b>
<b>Demographic characteristics</b>						
Age (years)	71 (66-76)	71 (65-74) <sup>a</sup>	70 (66-76) <sup>a</sup>	70 (67-76) <sup>a</sup>	76 (66-83) <sup>b</sup>	<0.001
Gender						
Male	52 (16.4)	7 (12.1) <sup>a</sup>	4 (23.5) <sup>a</sup>	2 (15.4) <sup>a</sup>	5 (12.8) <sup>a</sup>	<b>0.047</b>
Female	265 (83.6)	51 (87.9)	13 (76.5)	11 (84.6)	34 (87.2)	
BMI, kg/m <sup>2</sup>	30.3 (26.2-34.7)	32.8 (29.4-36.6) <sup>a</sup>	32.7 (31.1-35.4) <sup>a</sup>	32.9 (29.8-37.1) <sup>a</sup>	34.0 (31.8-39.6) <sup>b</sup>	0.437
Smoking status	27 (8.5)	4 (6.9)	2 (11.8)	3 (23.1)	6 (15.4)	0.994
<b>Dexa measurement</b>						
FRAX major	6.00 (4.00-9.43)	4.75 (3.43 to 6.65) <sup>a</sup>	8.00 (5.90 to 11.50) <sup>b</sup>	4.80 (3.80 to 6.05) <sup>a</sup>	11.50 (4.60 to 23.75) <sup>c</sup>	<0.001
FRAX neck	1.5 (0.50-3.23)	0.76 (0.23 to 1.98) <sup>a</sup>	1.80 (0.95 to 4.65) <sup>b</sup>	1.00 (0.55-1.90) <sup>a</sup>	4.05 (0.78 to 8.70) <sup>c</sup>	<0.001
Lumbar total T score	-1.80 (-2.60 to -1.00)	-1.30 (-2.05 to -0.65) <sup>a</sup>	-2.20 (-3.00 to -1.40) <sup>b</sup>	-1.5 (-1.95 to -0.45) <sup>a</sup>	-3.00 (-3.50 to -2.58) <sup>c</sup>	<0.001
Femoral neck T score	-1.40 (-2.00 to -0.80)	-0.95 (-1.50 to -0.50) <sup>a</sup>	-2.10 (-2.32 to -0.78) <sup>b</sup>	-1.30 (-1.75 to -0.75) <sup>a</sup>	-2.20 (-2.85 to -1.23) <sup>c</sup>	<0.001
Femoral total T score	-1.00 (-1.60 to -0.30)	-0.70 (-1.10 to 0.20) <sup>a</sup>	-2.25 (-2.57 to -0.60) <sup>b</sup>	-0.50 (-1.20 to 0) <sup>a</sup>	-2.40 (-3.10 to -0.90) <sup>c</sup>	<0.001
<b>Geriatric assessment</b>						
Dependent on ADL, n (%)	61 (19.2)	13 (22.4) <sup>a</sup>	3 (17.6) <sup>a</sup>	3 (23.1) <sup>a</sup>	9 (23.1) <sup>a</sup>	<b>0.024</b>
Dependent on IADL, n (%)	146 (46.1)	28 (48.3) <sup>a</sup>	8 (47.1) <sup>a</sup>	5 (38.5) <sup>a</sup>	19 (48.7) <sup>a</sup>	<b>0.039</b>
Frailty, n (%)						
Frail	91 (30.2)	15 (25.9)	5 (29.4)	5 (38.5)	16 (41.0)	0.096
Prefrail	167 (55.5)	40 (69.0)	10 (58.8)	7 (53.8)	19 (48.7)	
Normal	43 (14.3)	3 (5.1)	2 (11.8)	1 (7.7)	4 (10.3)	
SARC-F	3.0 (1.0-5.0)	2.0 (1.0-6.0) <sup>a</sup>	2.5 (0.8-5.0) <sup>a</sup>	3.0 (2.0-5.0) <sup>a</sup>	4.0 (2.0-5.0) <sup>b</sup>	<b>0.025</b>
Gait speed (m/sec)	1.21 (0.91-1.50)	1.18 (0.99-1.90) <sup>a</sup>	1.25 (0.79-1.82) <sup>b</sup>	1.30 (0.98-1.52) <sup>b</sup>	1.17 (0.94-1.96) <sup>a</sup>	<b>0.043</b>
TUG	12.0 (9.6-14.6)	11.5 (9.0-14.0) <sup>a</sup>	12.8 (11.6-14.2) <sup>a</sup>	12.3 (8.7-18.9) <sup>a</sup>	14.1 (9.8-15.6) <sup>b</sup>	<b>0.024</b>
Handgrip strength (kg)						
Male	30.0 (19.0-37.5)	18.5 (12.4-30.7) <sup>a</sup>	30.0 (30.0-32.0) <sup>b</sup>	30.0 (27.2-30.0) <sup>b</sup>	21.5 (11.7-30.0) <sup>a</sup>	0.052
Female	17.4 (12.3-20.9)	18.0 (14.0-22.3) <sup>a</sup>	18.3 (12.9-21.5) <sup>a</sup>	16.5 (11.3-20.6) <sup>a</sup>	14.3 (8.9-18.3) <sup>b</sup>	<b>0.014</b>
MET (minute/week)	693.0 (57.8-4491.0)	693.0 (49.5-4410.0)	2970 (0-3559.0)	1188.0 (165.0-3039.8)	4126.50 (470.3- 6522.8)	0.053
Low Physical activity, n (%)	94 (29.7)	31 (53.4) <sup>a</sup>	10 (58.8) <sup>a</sup>	6 (46.2) <sup>a</sup>	20 (51.3) <sup>a</sup>	<b>0.047</b>
<b>Anthropometric measurements</b>						
SMI (kg/BMI)						
Male	0.91 (0.75-1.11)	0.86 (0.73-1.24) <sup>a</sup>	0.78 (0.72-0.78) <sup>a</sup>	0.86 (0.73-0.95) <sup>a</sup>	0.77 (0.63-1.09) <sup>a</sup>	<b>0.039</b>
Female	0.55 (0.48-0.66)	0.50 (0.44-0.54) <sup>a</sup>	0.46 (0.42-0.53) <sup>a</sup>	0.49 (0.45-0.55) <sup>a</sup>	0.41 (0.38-0.46) <sup>a</sup>	<b>0.028</b>
Fat (%)						
Male	32.1 (27.0-37.1)	39.0 (36.2-51.8) <sup>a</sup>	39.3 (30.1-41.3) <sup>a</sup>	32.9 (26.4-43.0) <sup>a</sup>	37.0 (33.7-42.1) <sup>a</sup>	<b>0.032</b>
Female	47.8 (43.8-51.6)	54.1 (50.0-55.0) <sup>a</sup>	53.0 (51.0-55.8) <sup>a</sup>	51.7 (48.9-54.6) <sup>a</sup>	55.9 (53.7-57.1) <sup>a</sup>	<b>0.044</b>

**Table 1. Continued**

	Total (n=317)	Obese group (n=58)	Osteoporotic obese group (n=17)	Sarcopenic obese group (n=13)	Osteosarcopenic obese group (n=39)	p
BMR (kcal)	1324.0 (1246.0-1438.0)	1339 (1257-1442)	1302 (1136-1449)	1377 (1179-1572)	1290 (1253-1477)	0.907
Waist/hip ratio						
Male	0.96 (0.92-0.98)	0.98 (0.90-1.01) <sup>a</sup>	0.92 (0.86-0.92) <sup>a</sup>	0.94 (0.89-0.96) <sup>a</sup>	0.99 (0.90-1.02) <sup>a</sup>	<b>0.017</b>
Female	0.91 (0.87-0.97)	0.93 (0.89-0.98) <sup>a</sup>	0.88 (0.84-0.98) <sup>a</sup>	0.88 (0.84-0.92) <sup>a</sup>	0.98 (0.85-0.96) <sup>b</sup>	<b>0.008</b>
<b>Clinical outcomes</b>						
Fall, n (%)	140 (44.2)	21 (36.2) <sup>a</sup>	8 (47.1) <sup>b</sup>	4 (30.8) <sup>a</sup>	29 (74.4) <sup>c</sup>	<b>&lt;0.001</b>
Vertebra fracture, n (%)	89 (28.1)	14 (24.1) <sup>a</sup>	6 (35.3) <sup>a</sup>	2 (15.4) <sup>a</sup>	18 (46.2) <sup>b</sup>	<b>0.001</b>

Bold values indicate p<0.05  
 P shows the differences among obese, osteoporotic obese, sarcopenic obese, and osteosarcopenic obese groups based on the Kruskal-Wallis test or chi-square test.  
 a, b, c were shown based on the Bonferroni post-hoc test results for study groups. Different letters specify the differences among the groups, vice versa  
 ADL: Activities of daily living, IADL: Instrumental ADL, BMI: Body mass index, BMR: Basal metabolic rate, SMI: Skeletal muscle index, TUG: Timed up go test, SARC-F: A simple questionnaire to rapidly diagnose sarcopeni, MET: Metabolic equivalent of task, FRAX: Fracture risk assessment tool

The multivariate logistic regression model indicated that OSO was strongly correlated with both falls (odds ratio (OR): 2.82, 95% confidence interval (CI): 1.23-5.78, p=0.011) and vertebral fractures (OR: 3.11, 95% CI: 1.32-6.82, p=0.002) (Table 2).

**Discussion**

This study examined how OSO affects fractures and falls. The findings indicated that falls and vertebral fractures were markedly more common in people with OSO than in those with obesity, osteoporotic obesity, and sarcopenic obesity.

An examination of prevalence indicated that OSO, obesity, sarcopenic obesity, and osteoporotic obesity occurred at rates of 12.2%, 18.3%, 4.1%, and 5.4%, respectively. Previous investigations in Türkiye revealed OSO prevalence rates of 15.2% and 10.7% (28,29). The research indicates a significant variation in the prevalence of OSO between nations, with rates between 0.88% and 19.0% (2,6).

The criteria used to define each OSO component may vary across studies, leading to inconsistencies in the observed prevalence rates. Various factors, including age, gender, ethnicity, lifestyle, and comorbidities, may affect the incidence of OSO. No consensus exists regarding the optimal strategy for correcting SMM in the diagnosis of sarcopenia among obese older adults. A measurement of BMI or weight, which more accurately represents body size than the square of height, has been suggested to provide more precise outcomes for estimating SMM (30). To diagnose sarcopenia, we employed SMMI (kg/BMI). This was determined by adjusting the SMM with BMI, derived from BIA.

Additionally, BF% was employed to diagnose obesity, in accordance with the recent consensus document from the European Society for Clinical Nutrition and Metabolism and

**Table 2. Logistic regression analyses of independent factors associated with fall and vertebra fracture**

	Odds ratio	95% CI	p
<b>Fall</b>			
Osteosarcopenic obesity	3.12	1.50-6.45	<b>0.002</b>
Age	1.02	0.98-1.05	0.342
ADL	1.49	0.79-2.80	0.223
IADL	1.10	0.64-1.87	0.735
Low physical activity	2.04	0.93-3.71	0.072
Presence of osteoporotic obesity	0.67	0.26-1.70	0.402
<b>Vertebra fracture</b>			
Osteosarcopenic obesity	3.36	1.58-7.12	<b>0.001</b>
Age	1.09	0.93-1.15	0.057
ADL	1.75	0.84-3.64	0.134
IADL	1.12	0.58-2.18	0.731
Low physical activity	0.79	0.39-1.62	0.520
Presence of osteoporotic obesity	0.69	0.24-1.03	0.061

Model 1 is adjusted for age, ADL, IADL, low physical activity, and only the presence of osteoporotic obesity.  
 Model 2 is adjusted for age, ADL, IADL, low physical activity, and only the presence of sarcopenic obesity.  
 ADL: Activities of daily living, IADL: Instrumental ADL, CI: Confidence interval

the European Association for the Study of Obesity regarding sarcopenic obesity, which recommends the use of BF% over waist circumference and BMI for obesity diagnosis (30). In the study by Okyar Baş et al. (28) which focused on OSO in Türkiye, ultrasound imaging was used to assess muscle mass for sarcopenia diagnosis, BMI was applied for obesity diagnosis, and the relationship between OSO and frailty was investigated. The results demonstrated a substantial connection between OSO and frailty (28).



A study by Kolbaşı et al. (29) used BIA to measure muscle mass in order to evaluate sarcopenia. Unlike current practice, muscle mass was standardized by height squared. The inquiry into the relationship between OSO and fall risk demonstrated no correlation. Contrarily, we determined that OSO is a risk factor for falls. The study population's demographics, the inconsistent obesity diagnosis criteria, and the SMMI diagnostic criteria used to diagnose OSO, are all responsible for the disparities in results.

The interrelationship among bone, muscle, and adipose tissue has been established. OSO, defined as the coexistence of sarcopenia, osteoporosis, and obesity, is gaining recognition as a significant issue among the elderly (31). Research has shown that older adults with sarcopenic obesity had decreased BMD in the femoral neck compared to those who were just obese (32). This reinforces earlier research showing that those with sarcopenic obesity have lower BMD, highlighting the idea that sarcopenia may increase the risk of low bone mass and fractures. The rise in muscle mass is posited to be essential for the enhancement of BMD, although it may be accompanied by an increase in fat mass. According to the study, sarcopenic obese patients had lower lumbar total and femoral neck BMD than patients who are solely obese, according to the study. Compared to the obese group alone, the sarcopenic obese group had a higher FRAX fracture risk score. Compared to the other groups, the OSO cohort had significantly higher FRAX fracture risk scores and lower lumbar total and femoral neck BMD.

Falling risk is linked to osteosarcopenia. Fall and fracture rates were significantly higher in OSO people than in obese, osteoporotic obese, and sarcopenic obese individuals. This finding emphasises the importance of considering OSO as a newly recognized condition contributing to falls and fractures in patients.

This study represents the inaugural report of this association. The findings of our study indicate people with OSO exhibit a heightened risk of vertebral fractures, as assessed by the FRAX tool, in comparison to obese, osteoporotic obese, and sarcopenic obese patients. By proving that OSO is a separate risk factor for vertebral fractures, our study contributes to the body of existing research.

There was no correlation between gender and outcome variables in the study. This may be attributed to the number of male patients being smaller than the number of female patients. According to the results of our investigation, OSO may have greater clinical effects than any of its constituent parts. It is logical to believe that our findings will stimulate more research, because the vicious loop that OSO causes may result in additional negative outcomes.

The SARC-F questionnaire serves as an immediate screening instrument for clinicians to identify older adults who may be experiencing sarcopenia. FRAX can identify individuals with osteoporosis at elevated risk for fractures without requiring a BMD measurement (33). Although there are several validated

screening tests for sarcopenia and osteoporosis (such as SARC-F, Ishii, SARC-CalF, and FRAX), there is currently no screening test for OSO. As research on OSO progresses, it is anticipated that specific screening tools or guidelines may be developed to address this condition and provide targeted recommendations for prevention and management. There is a distinct necessity for more comprehensive interventions and treatment approaches for OSO, which encompasses three critical clinical conditions, exhibits high prevalence, and serves as a major risk factor for falls and fractures. Also, treating these three clinical entities simultaneously may further increase treatment success.

This study is significant since it represents the first examination of the prevalence of OSO in older adults receiving outpatient treatment in Türkiye, along with its association with falls and vertebral fractures. Our study's cross-sectional methodology and the majority of participants being female are drawbacks. No endpoints or clinical consequences were detected. Notwithstanding the compelling findings, we could not ascertain causal linkages or the underlying processes of OSO. Subsequent study ought to concentrate on discovering novel screening instruments for OSO assessment in the elderly and assessing the impact of concurrently treating each component of OSO.

### Study Limitation

A limitation of our study is its cross-sectional methodology, which, combined with the predominance of female participants, may limit generalizability. Additionally, no endpoints or clinical consequences were identified. Despite the compelling findings, we were unable to establish causal relationships or identify the underlying mechanisms of OSO.

### Conclusion

Consequently, it is recommended that elderly patients be screened for fall risk and fracture risk, with appropriate precautions being taken. To effectively investigate the prevalence of OSO, it is essential to establish a universal definition, identify a reliable biomarker, or create validated risk assessment tools for this condition. It is recommended that OSO be considered as an additional component of comprehensive geriatric evaluation.

### Ethics

**Ethics Committee Approval:** This study was authorized by Erciyes University's Clinical Research Ethics Committee (approval number: 2019/136, date: 20.02.2019).

**Informed Consent:** It was obtained.

### Footnotes

### Authorship Contributions

Surgical and Medical Practices: B.E.C., D.K., Concept: Y.S.S.A., Design: S.A., Data Collection or Processing: B.E.C., N.Ö.D.,

Analysis or Interpretation: N.T.Ö., Literature Search: B.E.C., Writing: B.E.C.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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# Indicators of Low Handgrip Strength and its Association with Poor Sleep Quality among Community-dwelling Older Adults: A Cross-Sectional Study in Egypt

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## Abstract

**Objective:** Handgrip strength (HGS) has several clinical implications. The study aimed to determine indicators of low HGS and its association with sleep quality among community-dwelling geriatric persons.

**Materials and Methods:** A cross-sectional study included 120 older adults in the community. Charlson Comorbidity Index (CCI) assessed multi-morbidity. Anthropometrics included body mass index (BMI) and waist-hip ratio (WHR) measurements. The Pittsburgh Sleep Quality Index (PSQI) and Jamar dynamometer determined sleep quality and HGS in kilograms (kg), respectively. Low HGS was determined according to adjusted cut-offs based on participants' BMI and sex. PSQI score >5 defined as poor sleep quality. The short physical performance battery (SPPB), activities of daily living (IADLs), and instrumental IADLs were performed. The mini-mental state examination, the patient health questionnaire-9 (PHQ-9), and the general anxiety disorder questionnaire-7 (GAD-7) were conducted. Statistical analyses were executed.

**Results:** The mean age and HGS were 67.26 years and 27.06 kilograms, respectively. Median PSQI score was 7. Seventy-six (63.3%) patients had low HGS while 97 (80.0%) had poor sleep quality. Indicators of low HGS were BMI >27.3 kg/m<sup>2</sup>, CCI >2, PHQ-9 >3, and total balance test score ≤2. PSQI score was significantly related to BMI, depression, and low HGS with P 0.007, 0.00, and 0.006, respectively. PSQI scores inversely correlated with IADL (r: -0.197), HGS (r: -0.254), SPPB (r: -0.338) and positively correlated with BMI (r: 0.336), WHR (r 0.189), PHQ-9 (r: 0.457), and GAD-7 (r 0.438). PSQI score >6 identified low HGS with sensitivity 63.16% and specificity 68.18%.

**Conclusion:** The study identified low HGS indicators. HGS was inversely correlated with PSQI score.

**Keywords:** Clinical geriatrics, functional performance, handgrip strength, older adults, sleep quality

## Introduction

Muscle strength is integral to healthy aging and predicts disability and mortality in older adults (1). Muscle weakness occurs due to age-related changes, malnutrition, and a sedentary lifestyle. It starts in middle age with a gradually progressive decline in physical performance (1). Currently, the handgrip strength (HGS) test using handgrip dynamometers is one of the most applicable methods to assess muscle strength (1). HGS is a surrogate for muscle strength in both upper and lower limbs among healthy

individuals and older individuals with illnesses (1). Low HGS represents declined muscle performance and increases the hazards of disease, frailty, and all-cause mortality (2). However, there are different definitions of low HGS. First, "sarcopenia low HGS" defined as a maximum of grip strength less than 26 kilogram (kg) in men or less than 16 kg in women (2). Second, "low reference HGS" is defined as HGS below the population reference HGS value as calculated by a formula in accordance with the age, sex, height, and weight of the sampled population.

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Third, "lowest 20% HGS", is defined as the lowest 20% of HGS among participants adjusted to body mass index (BMI) and sex (2). Factors affecting HGS include socio-demographic factors as age, educational level, and income. Also, behavioral factors such as smoking, alcohol consumption, and physical activity are related to HGS. Furthermore, BMI and comorbidities such as hypertension, diabetes mellitus, and malignancy could markedly affect HGS (1). Therefore, HGS should be routinely evaluated in geriatric patients.

On the other hand, aging is associated with alterations in sleep architecture and a higher prevalence of sleep disorders. That necessitates meticulous assessment of sleep quality to improve physical performance and quality of life among older adults (3). Poor sleep quality has been linked to deterioration in the muscular system with adverse health outcomes including poor physical performance and mobility limitations (4). Recently, investigators have studied the association between muscle strength and sleep characteristics in various populations (4). HGS was strongly associated with sleep duration, subjective sleep quality, and poor daytime functioning (4). Despite studying the indicators of low HGS in previous studies (1), few studies assessed the association between sleep quality, HGS and physical performance with objective tests among geriatric persons in the community. Accordingly, the study intended to define the indicators of low HGS by several objective tests and evaluate its association with sleep quality among older adults in the community.

## Materials and Methods

### Ethical Consideration

The study protocol was reviewed and accepted by the institutional ethical committee members in the Faculty of Medicine, Ain Shams University (approval number: FMASU MS 456/2023, date: 22.08.2023). It was obtained from each participant before inclusion in the study.

### Calculation of the Required Sample Size

Based on another study (5), low HGS prevalence was found to range from 34 to 51 percent with a power of 90 percent and an alpha error of 5 percent. The estimated number of participants was 120 older people. The program for sample size calculation was Stata 10.

### Study Design and Participants' Selection Criteria

An observational cross-sectional study involved 120 participants. The inclusion criteria were patients aged  $\geq 60$  years who attended the clinics at the geriatrics hospital, a specialized hospital in geriatric health services and care at Ain Shams University, Cairo, Egypt. Data collection was conducted through simple random sampling from April 1, 2023 to January 4, 2024. Exclusion criteria

included patients admitted to the hospital, patients who had a disabling deformity or a fracture preventing the performance of assessment tools, those diagnosed with dementia, and patients on medications affecting sleep such as sedative-hypnotics and psychoactive medications.

## Study Procedures

### History Taking and Physical Examination

Clinical variables, demographics, and special habits were obtained through medical history taking. Co-morbidity burden estimated by the Charlson Comorbidity Index (CCI) (6). Anthropometric measurements included body weight in kg, height, waist circumference (WC), and hip circumference (HC) all in centimeters (cm). BMI is calculated by dividing weight in kg by the height in meters squared ( $\text{kg}/\text{m}^2$ ) (6). Obesity is defined as a BMI  $\geq 30 \text{ kg}/\text{m}^2$ , with obesity class I (BMI 30-34.9  $\text{kg}/\text{m}^2$ ) and obesity class II (BMI 35-39.9  $\text{kg}/\text{m}^2$ ) (7). The waist-hip ratio (WHR) is calculated by dividing WC by HC, utilizing the same units of measurement for both (8).

### Evaluation of Sleep Quality

Sleep quality was determined for each participant based on the Pittsburgh Sleep Quality Index (PSQI) questionnaire. It is a reliable tool for assessing the overall sleep quality among different populations. It includes 19 items, divided into 7 domains reflecting the intensity of sleep in the following ways: personal sleep quality, sleep disturbance, sleep latency, habitual sleep efficiency, sleep duration, daily dysfunction, and sleeping pills consumption. Each component of the previously mentioned domains has a score range from 0 of 3. Accordingly, a total PSQI score can range from 0 to 21. A higher total score of PSQI reflects poorer sleep characteristics (9). A total PSQI score of more than five defined poor sleep quality among participants in the study (10).

### Evaluation of Handgrip Strength

A hydraulic hand dynamometer (Jamar hydraulic dynamometer, J00105) was utilized to evaluate HGS in kg. The participants completed 3 trials for the dominant hand. The measurements were recorded in kg. The highest value of the 3 measurements was selected as the final measurement of HGS (11). Low HGS (kg) was defined according to different cut-offs based on BMI and sex of each participant (12). As follows:

Females:

- $\leq 17 \text{ kg}$  (BMI  $\leq 23$ )
- $\leq 17.3 \text{ kg}$  (BMI 23.1-26)
- $\leq 18 \text{ kg}$  (BMI 26.1-29)
- $\leq 21 \text{ kg}$  (BMI  $> 29$ )

Males:

- $\leq 29$  kg (BMI  $\leq 24$ )
- $\leq 30$  kg (BMI 24.1–26)
- $\leq 30$  kg (BMI 26.1–28)
- $\leq 32$  kg (BMI  $> 28$ )

Accordingly, participants were classified as those with normal or low HGS.

### Evaluation of Physical and Mental Performance

We implemented several geriatric assessment tools for functional and cognitive evaluation. Basic activities of daily living (ADL) reflected the participants' capabilities to perform basic self-care tasks including transfer, dressing, toileting, feeding, bathing, and continence (13). Instrumental activities of daily living (IADLs) reflected the participant's capabilities for maintaining an independent life including financial dealing, telephone use, laundry, shopping, transportation, cooking, and taking their medications (14). Additionally, short physical performance battery (SPPB) was used to reflect physical performance status through the assessment of lower limb functions. SPPB included an assessment of gait speed, balance, and chair standing ability (15). These tasks reflect independence in physical performance (15). Conversely, mini-mental state examination (MMSE) assessed cognitive performance with a total score of 30 points (16). MMSE assesses various intellectual aspects including time and place orientation, recall capabilities, language, calculation abilities, attention, and visuo-spatial skills (16).

### Evaluation of Anxiety and Depression

The general anxiety disorder questionnaire-7 (GAD-7) was utilized to assess anxiety. It is a self-report anxiety questionnaire with total scores ranging from 0 to 21. A higher GAD-7 score reflects a higher anxiety level (17). The patient health questionnaire-9 (PHQ-9) was utilized to assess depression. It consists of 9 items with a total score of 0 to 27 (18). A total PHQ-9 score  $\geq 5$  defines depression (18). Accordingly, patients were categorized into 2 groups including those with and without depression.

### Statistics

The Statistical Package for the Social Sciences (SPSS) version 27 was utilized for data analysis. Qualitative variables were presented as numbers and percentages. Quantitative variables were shown as the mean and the standard deviation (SD) for parametric data, and the median and the interquartile range (IQR) for non-parametric data. The analogy between groups regarding qualitative data was conducted by the chi-square test and/or Fisher Exact test if the expected count was less than five in any cell. The analogy between two independent

groups with quantitative data and parametric distribution was performed by an independent t-test while the analysis of nonparametric distributions was conducted using the Mann-Whitney test. The area under the curve (AUC) of the receiver operating characteristic (ROC) was utilized to detect the best cut-offs of factors associated with low HGS. The Kruskal-Wallis test was used to compare groups. The Spearman correlation was used to evaluate the relationship between two quantitative parameters. Correlation coefficient ( $r$ ) values were positive or negative, and are interpreted as follows:  $0 < r \leq \pm 0.19$  means very low correlation,  $\pm 0.2 \leq r \leq \pm 0.39$  means low correlation,  $\pm 0.4 \leq r \leq \pm 0.59$  means moderate correlation,  $\pm 0.6 \leq r \leq \pm 0.79$  means high correlation, and  $\pm 0.8 \leq r \leq \pm 1.0$  means very high correlation. Significant indicators of low HGS were determined based on logistic regression analyses. The confidence interval (CI) was set to 95 percent, and the margin of error was set to 5 percent. Interpretation of p-value included: p-value  $> 0.05$  (non-significant),  $< 0.05$  (significant), and  $< 0.01$  (highly significant).

### Results

The analysis included 120 community-dwelling older adults comprising 37 (30.8%) females and 83 (69.2%) males. The mean age was  $67.2 \pm 5.4$  years. Mean BMI and HGS were  $27.53 \pm 4.1$  (kg/m<sup>2</sup>) and  $27.06 \pm 5.34$  (kg), respectively. The median (IQR) of SPPB and PSQI was 7 (6–9) and 7 (5–8), respectively. Ninety-seven (80.8%) and 76 (63.3%) patients had poor sleep quality and low HGS, respectively. Baseline characteristics are described in Table 1 and Table 2.

There were significant differences between those with normal or low HGS regarding BMI, WC, and WHR, with p-values of 0.001, 0.016, and 0.018, respectively. Hypertension and ischemic heart disease were significantly prevalent among those with low HGS with P-values of 0.040 and 0.023, respectively. Median (IQR) of CCI, PHQ-9, GAD-7, SPPB, and PSQI was significantly higher among those with low HGS with p-values of 0.002 and 0.001, 0.005, 0.000 and 0.006 respectively as described in Table 1 and Table 2.

The ROC curve specified cut-off values to differentiate between normal or low HGS levels as shown in Figures 1 and 2. PSQI  $> 6$  had a sensitivity of 63.16% and a specificity of 68.18% with an AUC of 0.65 to identify those with low HGS as described in Table 3.

Regression analyses revealed the indicators of low HGS including: BMI  $> 27.3$  kg/m<sup>2</sup> [(odds ratio (OR) 4.686, p-value 0.001, 95% CI 1.807–12.152), CCI  $> 2$  (OR 2.475, p-value 0.049, 95% CI 1.003–6.111)], PHQ-9  $> 3$  (OR 3.252, p-value 0.012, 95% CI 1.300–8.140), and total balance test score  $\leq 2$  (OR 3.938, p-value 0.030, 95% CI 1.146–13.531) as described in Table 4.

Table 1. Participants' characteristics based on handgrip strength: demographic and clinical characteristics							
Variables		Whole sample	Handgrip strength		Test value	p	Sig.
			Normal	Low			
			No.=44 (36.7%)	No.=76 (63.3%)			
Age	Mean $\pm$ SD	67.26 $\pm$ 5.4	66.3 $\pm$ 4.6	67.82 $\pm$ 5.76	-1.495 $\bullet$	0.138	NS
	Range	60-84	60-78	60-84			
Sex	Female	37 (30.8%)	15 (34.1%)	22 (28.9%)	0.346*	0.557	NS
	Male	83 (69.2%)	29 (65.9%)	54 (71.1%)			
Marital status	Widow	24 (20%)	10 (22.7%)	14 (18.4%)	0.323*	0.570	NS
	Married	96 (80%)	34 (77.3%)	62 (81.6%)			
Educational level	Illiterate	15 (12.5%)	8 (18.2%)	7 (9.2%)	3.675*	0.299	NS
	<6 years	32 (26.7%)	9 (20.5%)	23 (30.3%)			
	6 to 12 years	18 (15%)	5 (11.4%)	13 (17.1%)			
	>12 years	55 (45.8%)	22 (50%)	33 (43.4%)			
Employment	Unemployed	61 (50.8%)	22 (50%)	39 (51.3%)	0.019*	0.889	NS
	Employed	59 (49.2%)	22 (50%)	37 (48.7%)			
Smoking	No smoking	80 (66.7%)	30 (68.2%)	50 (65.8%)	0.527*	0.913	NS
	Ex-smoker	8 (6.7%)	2 (4.5%)	6 (7.9%)			
	Cigarette smoker	29 (24.2%)	11 (25%)	18 (23.7%)			
	Shisha smoker	3 (2.5%)	1 (2.3%)	2 (2.6%)			
BMI	Mean $\pm$ SD	27.53 $\pm$ 4.17	25.83 $\pm$ 3.03	28.52 $\pm$ 4.43	-3.564 $\bullet$	0.001	HS
	Range	17.3-38.3	20-33	17.3-38.3			
Categories of BMI	Underweight	1 (0.8%)	0 (0%)	1 (1.3%)	13.814*	0.008	HS
	Normal weight	30 (25%)	16 (36.4%)	14 (18.4%)			
	Overweight	60 (50%)	25 (56.8%)	35 (46.1%)			
	Obese (class I)	23 (19.2%)	3 (6.8%)	20 (26.3%)			
	Obese (class II)	6 (5%)	0 (0%)	6 (7.9%)			
Waist circumference	Mean $\pm$ SD	96.21 $\pm$ 10.65	93.14 $\pm$ 9.72	97.99 $\pm$ 10.81	-2.455 $\bullet$	0.016	S
	Range	73 -120	73-110	74 -120			
Hip circumference	Mean $\pm$ SD	101.35 $\pm$ 9.39	99.89 $\pm$ 9.01	102.2 $\pm$ 9.55	-1.304 $\bullet$	0.195	NS
	Range	80-130	80-121	81-130			
Waist-hip ratio	Mean $\pm$ SD	0.95 $\pm$ 0.06	0.93 $\pm$ 0.05	0.96 $\pm$ 0.06	-2.405 $\bullet$	0.018	S
	Range	0.75-1.12	0.78-1.06	0.75-1.12			
Calf circumference	Mean $\pm$ SD	35.1 $\pm$ 2.74	34.61 $\pm$ 2.53	35.38 $\pm$ 2.83	-1.488 $\bullet$	0.140	NS
	Range	28-42	28-40	28-42			
<b>Comorbidities</b>							
Diabetes mellitus	No	87 (72.5%)	32 (72.7%)	55 (72.4%)	0.002*	0.966	NS
	Yes	33 (27.5%)	12 (27.3%)	21 (27.6%)			
Hypertension	No	70 (58.3%)	31 (70.5%)	39 (51.3%)	4.200*	0.040	S
	Yes	50 (41.7%)	13 (29.5%)	37 (48.7%)			
Ischemic heart disease	No	96 (80%)	40 (90.9%)	56 (73.7%)	5.167*	0.023	S
	Yes	24 (20%)	4 (9.1%)	20 (26.3%)			
Heart failure	No	111 (92.5%)	43 (97.7%)	68 (89.5%)	2.736*	0.098	NS
	Yes	9 (7.5%)	1 (2.3%)	8 (10.5%)			
Old stroke	No	110 (91.7%)	42 (95.5%)	68 (89.5%)	1.305*	0.253	NS
	Yes	10 (8.3%)	2 (4.5%)	8 (10.5%)			
Atrial Fibrillation	No	116 (96.7%)	43 (97.7%)	73 (96.1%)	0.243*	0.622	NS
	Yes	4 (3.3%)	1 (2.3%)	3 (3.9%)			
CCI	Median (IQR)	2 (2-3)	2 (2-3)	3 (2-3)	-3.173 $\neq$	0.002	HS
	Range	0-9	0-4	2-9			

The used tests,  $\bullet$ : Independent t-test, \*: Chi-square test,  $\neq$ : Mann-Whitney U test.

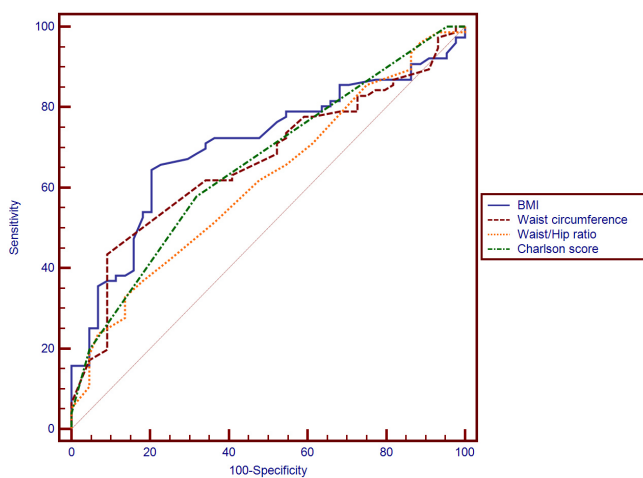
CCI: Charlson Co morbidity Index, Sig.: Significant, No.: Number, SD: Standard deviation, BMI: Body mass index, IQR: Interquartile range, NS: Not significant, HS: Highly significant, S: Significant

**Table 2. Participants' characteristics based on handgrip strength: geriatric assessment tools and sleep characteristics**

Variables		Whole sample	Handgrip strength		Test value	p-value	Sig.
			Normal	Low			
			No.=44 (36.7%)	No.=76 (63.3%)			
MMSE	Mean ± SD	27.25±2.18	27.41±2.43	27.16±2.03	0.607•	0.545	NS
	Range	21-30	22-30	21-30			
ADL	Mean ± SD	5.75±0.71	5.91±0.29	5.66±0.86	1.879•	0.063	NS
	Range	2-6	5-6	2-6			
IADL	Mean ± SD	7.23±1.4	7.41±1.19	7.12±1.51	1.098•	0.275	NS
	Range	3-8	4-8	3-8			
PHQ-9	Median (IQR)	3 (1-7)	1 (0-4)	5 (1.5-8.5)	-3.442≠	0.001	HS
	Range	0-18	0-13	0-18			
	Negative	70 (58.3%)	35 (79.5%)	35 (46.1%)	12.861*	0.000	HS
	Positive	50 (41.7%)	9 (20.5%)	41 (53.9%)			
GAD-7	Median (IQR)	0 (0-6)	0 (0-2.5)	3 (0-6)	-2.795≠	0.005	HS
SPPB							
Total balance test score	Median (IQR)	4 (2-4)	4 (3-4)	3 (2-4)	-2.844≠	0.004	HS
	Range	0-4	2-4	0-4			
Gait speed test score	Median (IQR)	2 (1-3)	3 (1-4)	1 (1- )	-3.342≠	0.001	HS
	Range	1-4	1-4	1-4			
Chair stand test score	Median (IQR)	2 (1-3)	3 (2-3.5)	2 (1-3)	-3.094≠	0.002	HS
	Range	1-4	1-4	1-4			
Total SPPB score	Median (IQR)	7 (6-9)	9 (7-11)	7 (6-8)	-4.241≠	0.000	HS
	Range	2-12	4-12	2-11			
PSQI score	Median (IQR)	7 (5-8)	6 (5-7)	7 (6-9)	-2.752≠	0.006	HS
	Range	0-15	1-13	0-15			
Sleep quality	Poor	97 (80.8%)	34 (77.3%)	63 (82.9%)	0.569*	0.451	NS
	Good	23 (19.2%)	10 (22.7%)	13 (17.1%)			

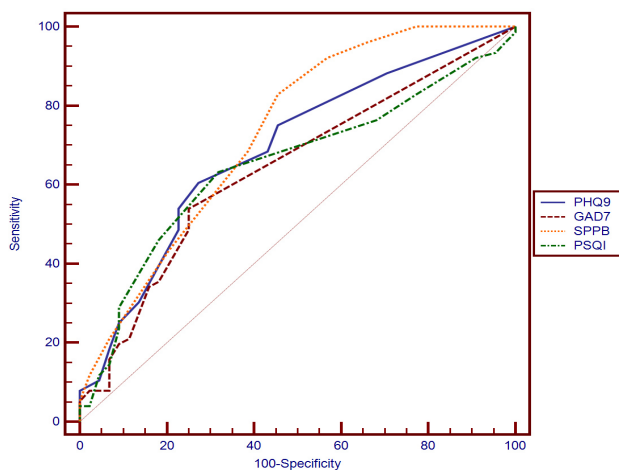
The used tests, •: Independent t-test, \*: Chi-square test, ≠: Mann-Whitney U test.

Sig.: Significance, No.: Number, MMSE: Mini-mental state examination, ADL: Activities of daily living, IADL: Instrumental activities of daily living, PHQ-9: Patient health questionnaire-9, GAD-7: General anxiety disorder questionnaire-7, SPPB: Short physical performance battery, PSQI: Pittsburgh sleep quality index, IQR: Interquartile range, NS: Not significant, HS: Highly significant



**Figure 1.** Receiver operating characteristic curve to identify low handgrip strength.

BMI: Body Mass Index



**Figure 2.** Receiver operating characteristic curve to identify low handgrip strength.

PHQ9: Patient health questionnaire 9, GAD7: General anxiety disorder 7, SPPB: Short physical performance battery, PSQI: Pittsburg Sleep Quality Index

Additionally, we analyzed factors related to PSQI score. The presence of low HGS, depression, and obesity was significantly related to PSQI scores with p-values of 0.006, 0.000, and 0.007, respectively. We reported significant differences in median PSQI (IQR) score, between those having ISHD and stroke with p-values of 0.030 and 0.045, respectively. The association between the median PSQI (IQR) score and each variable is described in Table 5.

Correlation between PSQI scores and quantitative parameters revealed positive correlations with BMI, PHQ-9, and GAD-7 scores, with r values of 0.336 (low correlation), 0.457 (moderate correlation), and 0.438 (moderate correlation), respectively,

with and p-values of 0.000. There were inverse correlations with physical assessment scores, including HGS, IADL, and total SPPB scores, with r values of -0.254 (low correlation), -0.197 (very low correlation), and -0.338 (low correlation) respectively, with p-values of 0.005, 0.031, and 0.000, respectively, as demonstrated in Table 6.

### Discussion

This research had several advantages compared to others. Firstly, we utilized several robust physical performance measures such as SPPB, ADL, and IADL in addition to the HGS assessment. Secondly, it is the first study to reveal indicators of low HGS

**Table 3. Cut-off values defining low handgrip strength based on the receiver operating characteristic curve**

Variables	Cut-offs	AUC	Sensitivity	Specificity	PPV	NPV
BMI	>27.3 kg/m <sup>2</sup>	0.704	64.47	79.55	84.50	56.50
WC	>100 cm	0.664	43.42	90.91	89.20	48.20
WHR	>0.97	0.615	32.89	86.36	80.60	42.70
CCI	>2	0.659	57.89	68.18	75.90	48.40
PHQ-9	>3	0.688	60.53	72.73	79.30	51.60
GAD-7	>1	0.640	53.95	75.00	78.80	48.50
Total balance test score	≤ 2	0.641	36.84	90.91	87.50	45.50
Gait speed test score	≤ 2	0.674	73.68	56.82	74.70	55.60
Chair stand test score	>2	0.663	57.89	68.18	75.90	48.40
Total SPPB score	≤8	0.730	82.89	54.55	75.90	64.90
PSQI score	>6	0.650	63.16	68.18	77.4	51.7

AUC: Area under the curve, PPV: Positive predictive value, NPV: Negative predictive value, BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio, CCI: Charlson Comorbidity Index, PHQ-9: Patient health questionnaire-9, GAD-7: General anxiety disorder questionnaire-7, SPPB: Short physical performance battery, PSQI: Pittsburgh sleep quality index

**Table 4. Indicators of low handgrip strength based on regression analyses**

Variables	Univariate analysis				Multivariate analysis			
	p	OR	95% CI for OR		p-value	OR	95% CI for OR	
			Lower	Upper			Lower	Upper
BMI >27.3 kg/m <sup>2</sup>	<b>0.000</b>	7.058	2.956	16.849	<b>0.001</b>	<b>4.686</b>	<b>1.807</b>	<b>12.152</b>
WC >100 cm	<b>0.000</b>	7.674	2.495	23.602	0.259	2.843	0.463	17.462
WHR >0.97	<b>0.033</b>	2.923	1.089	7.847	0.574	0.628	0.124	3.184
Hypertension	<b>0.042</b>	2.262	1.028	4.977	0.375	1.550	0.589	4.077
Ischemic heart disease	<b>0.030</b>	3.571	1.134	11.253	0.671	1.378	0.313	6.063
CCI >2	<b>0.007</b>	2.946	1.349	6.433	<b>0.049</b>	<b>2.475</b>	<b>1.003</b>	<b>6.111</b>
PHQ-9 >3	<b>0.001</b>	4.089	1.824	9.167	<b>0.012</b>	<b>3.252</b>	<b>1.300</b>	<b>8.140</b>
GAD-7 >1	<b>0.003</b>	3.514	1.551	7.963	0.954	1.045	0.233	4.678
Total balance test score ≤2	<b>0.002</b>	5.833	1.887	18.032	<b>0.030</b>	<b>3.938</b>	<b>1.146</b>	<b>13.531</b>
Gait speed test score ≤2	<b>0.001</b>	3.684	1.680	8.079	0.818	1.249	0.188	8.291
Chair stand test score >2	<b>0.000</b>	4.189	1.903	9.220	0.697	0.766	0.200	2.928
Total SPPB score ≤8	<b>0.000</b>	5.815	2.506	13.495	0.876	1.202	0.118	12.270
PSQI score >6	<b>0.001</b>	3.673	1.672	8.071	0.233	1.870	0.668	5.235

Bold = Significant.  
 BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio, CCI: Charlson Comorbidity Index, PHQ-9: Patient health questionnaire-9, GAD-7: General anxiety disorder questionnaire -7, SPPB: Short physical performance battery, PSQI: Pittsburgh sleep quality index, OR: Odds ratio, CI: Confidence interval



with a specified cut-off for each. Thirdly, we defined low HGS according to BMI and adjusted for sex rather than utilizing a single cut-off value, unlike most other studies. Lastly, the study examined the impact of cognitive and psychiatric domains on both physical performance and sleep quality. The study confirmed the necessity of the multi-dimensional approach toward the geriatric population.

The study explored the predominance of declined physical performance as represented by low HGS and highlighted its association with total PSQI score among community-dwelling older adults. It reflected the high frequency of decreased muscle strength, as indicated by the prevalence of low HGS, affecting 76 (63.3%) participants. Additionally, the median (IQR) PSQI score was statistically higher among this vulnerable group of

**Table 5. Relationship between PSQI score and the studied variables**

		PSQI score		Test value	p-value	Sig.
		Median (IQR)	Range			
<b>Sex</b>	Female	7 (6-8)	1-14	-1.093•	0.274	NS
	Male	6 (5-8)	0-15			
<b>Marital status</b>	Widow	7 (5.5-9.5)	2-13	-0.725•	0.468	NS
	Married	7 (5-8)	0 -15			
<b>Educational level</b>	Illiterate	6 (4-7)	4-12	4.715#	0.194	NS
	<6 years	7 (6-8.5)	1-14			
	6 to 12 years	7 (6-10)	2 -12			
	>12 years	6 (4 -8)	0-15			
<b>Employment</b>	Unemployed	7 (6 -8)	1-14	-1.813•	0.070	NS
	Employed	6 (48)	0-15			
<b>Smoking</b>	Negative	7 (5.5-8)	1-14	1.799#	0.615	NS
	Ex-smoker	5 (2-8)	1-15			
	Cigarette smoker	7 (6-8)	0-12			
	Shisha smoker	6 (4-11)	4-11			
<b>Categories based on BMI</b>	Underweight	12 (12-12)	12-12	14.024#	0.007	HS
	Normal weight	6 (4-7)	1-13			
	Overweight	7 (5-8)	0-12			
	Obese (class I)	7 (6-9)	2-15			
	Obese (class II)	8.5 (6-14)	6-14			
<b>Comorbidities</b>						
<b>Diabetes mellitus</b>	No	7 (6-8)	0-15	-0.801•	0.423	NS
	Yes	6 (5-8)	1-14			
<b>Hypertension</b>	No	6 (5-8)	0-15	-1.432•	0.152	NS
	Yes	7 (6-8)	1-14			
<b>Ischemic heart disease</b>	No	6 (5-8)	1-14	-2.173•	0.030	S
	Yes	7.5 (6.5-10)	0-15			
<b>Heart failure</b>	No	7 (5-8)	1-15	-0.719•	0.472	NS
	Yes	8 (4-9)	0-14			
<b>Old stroke</b>	No	6 (5-8)	0-15	-2.009•	0.045	S
	Yes	8 (7-10)	2-12			
<b>Atrial fibrillation</b>	No	7 (5-8)	0-15	-0.081•	0.935	NS
	Yes	6.5 (5-10)	4-13			
<b>PHQ-9</b>	Negative depression	6 (4-7)	0-13	-4.668•	0.000	HS
	Positive depression	8 (6-11)	1-15			
<b>HGS</b>	Normal HGS	6 (5-7)	1-13	-2.752•	0.006	HS
	Low HGS	7 (6-9)	0-15			

The used tests •: Mann-Whitney U test; #: Kruskal-Wallis test.  
 BMI: Body mass index, PSQI: Pittsburgh sleep quality index, PHQ-9: Patient health questionnaire-9, IQR: Interquartile range, HGS: Handgrip strength, NS: Not significant, HS: Highly significant, S: Significant

**Table 6. Correlation between PSQI score and the other studied variables**

	PSQI score	
	r	p-value
Age	-0.149	0.105
BMI	<b>0.336**</b>	<b>0.000</b>
Waist circumference	<b>0.335**</b>	<b>0.000</b>
Hip circumference	<b>0.219*</b>	<b>0.016</b>
Waist-hip ratio	<b>0.189*</b>	<b>0.038</b>
Calf circumference	0.178	0.051
CCI	0.067	0.469
MMSE	0.019	0.838
ADL	-0.135	0.143
IADL	<b>-0.197*</b>	<b>0.031</b>
PHQ-9	<b>0.457**</b>	<b>0.000</b>
GAD-7	<b>0.438**</b>	<b>0.000</b>
HGS	<b>-0.254**</b>	<b>0.005</b>
SPPB score	<b>-0.338**</b>	<b>0.000</b>

Bold = Significant, \*: Significant at p-value <0.05; \*\*: Significant at p-value < 0.01.  
 PSQI: Pittsburgh sleep quality index, BMI: Body mass index, CCI: Charlson Comorbidity Index, MMSE: Mini-mental state examination, ADL: Activities of daily living, IADL: Instrumental activities of daily living, PHQ-9: Patient health questionnaire-9, GAD-7: General anxiety disorder questionnaire-7, HGS: Handgrip strength, SPPB: Short physical performance battery

patients, reflecting the significant association between muscle strength and total PSQI scores a representative of sleep quality. These data are supported by several studies (1,4).

The study revealed indicators of low HGS with a specified cut-off value as the following regarding anthropometrics: BMI >27.3 kg/m<sup>2</sup> was a significant indicator of weak HGS, coinciding with previous studies (1). This significant association between low HGS and higher BMI indicates a tendency toward sarcopenic obesity as an ongoing syndrome characterized by increased visceral adiposity declined muscle quality, and subsequent higher health problems, including mortality among older populations (19). In addition, PHQ-9 score >3 was another indicator for low HGS. It supports the significant association between depression and low HGS as found in a previous study among 162, 167 participants in the United Kingdom (20). Additionally, CCI >2 was another significant indicator. Low HGS could be a biomarker of physiological limitations within the body. It is also associated with multi-morbidity in both sexes. Hence, stronger handgrip could reduce disease burden, improve health, and decrease mortality (21). Low HGS is indicative of higher morbidity and mortality in various chronic health conditions including cardiovascular diseases among older adults (4). The study showed hypertension and ischemic heart disease as significant comorbidities affecting HGS, in agreement with several studies (1,21).

The study showed a significant association between HGS and both total, and individual SPPB testing scores. A total balance test score ≤2 was a significant indicator of low HGS. Similarly, a previous study revealed that physical performance metrics, including gait speed, SPPB, time and balance test, and five-times-sit-to-stand test showed poorer outcomes when transitioning from normal HGS to both low HGS and asymmetrical groups (22). Accordingly, HGS testing is a feasible tool for assessing physical functioning among older adults (22).

On the other side, the study showed the clinical implications of physical performance on sleep quality. There was an inverse correlation between total PSQI score, HGS, and SPPB scores. Consistent with the previous studies, our results confirmed the clinical implication of both HGS and SPPB on sleep quality and overall physical performance (4,23). Similarly, IADL scores were inversely related to total PSQI supporting the inverse relationship between functional status and sleep quality as found in several studies (23,24).

The study showed additional factors affecting PSQI scores. Regarding co-morbidities, the median PSQI score was significantly related to both depression and anxiety. It is consistent with a previous analysis of co-morbidities associated with poor sleep where mental health disorders including depression and anxiety had the greatest impact on sleep quality with β values of 1.76 and 1.72, respectively (25). Additionally, obesity, old stroke, and ischemic heart disease significantly affect PSQI scores. Similarly, a previous meta-analysis and systematic review of 108 cohort observational studies showed that shorter sleep periods were associated with the same comorbidities, indicating their negative impact on sleep quality (26). PSQI score was significantly related to higher CCI, which reflects a greater number of comorbidities, that significantly contributed to poorer sleep, as supported by a previous study (25).

Regarding anthropometrics, the analysis revealed a positive correlation between PSQI score and both BMI and WHR, indicating that obesity and visceral adiposity could be related to worse sleep characteristics among geriatric populations. It coincides with another study that revealed a remarkable relationship between higher BMI and WHR with higher PSQI scores (p<0.05) (24). These findings supported the negative consequences of metabolic syndrome on sleep quality among older adults (24).

**Study Limitations**

The study included a relatively small sample. Its cross-sectional design impaired the assessment of causality of the association between the studied variables. Also, PSQI is a subjective sleep assessment tool. The study lacked objective methods such as polysomnography or actigraphy. These assessment methods could capture different parameters and domains of sleep quality

(27). However, the study has contributed to the literature in several aspects. First, the study revealed the indicators of among community-dwelling older adults. It provided age-specific cut-off values for each indicator. Second, the study demonstrated that higher total PSQI scores are significantly and inversely correlated with physical performance parameters including HGS, SPPB, and IADL. Third, the study identified factors related to total PSQI score, as a representative of sleep quality. These data could be beneficial in supporting the limited research on the associations between sarcopenia and sleep quality among older adults in the community.

## Conclusion

HGS has several clinical implications among community-dwelling older adults. Indicators of low HGS were BMI >27.3 kg/m<sup>2</sup>, CCI >2, PHQ-9 >3, and total balance test score ≤2. PSQI scores were inversely correlated with HGS. PSQI score >6 identified low HGS with a good discriminative ability. Thus, HGS and sleep evaluation are advocated as an integral part of geriatric assessment.

## Ethics

**Ethics Committee Approval:** The study protocol was reviewed and accepted by the institutional ethical committee members in the Faculty of Medicine, Ain Shams University (approval number: FMASU MS 456/2023, date: date: 22.08.2023).

**Informed Consent:** It was obtained from each participant before inclusion in the study.

## Footnotes

### Authorship Contributions

Surgical and Medical Practices: A.M.Y., N.N.A., R.M.S.E., K.E.E., Concept: A.M.Y., N.N.A., R.M.S.E., K.E.E., Design: A.M.Y., N.N.A., R.M.S.E., K.E.E., Data Collection or Processing: A.M.Y., N.N.A., R.M.S.E., K.E.E., Analysis or Interpretation: A.M.Y., N.N.A., R.M.S.E., K.E.E., Literature Search: A.M.Y., N.N.A., R.M.S.E., K.E.E., Writing: A.M.Y., N.N.A., R.M.S.E., K.E.E.

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# Review of Elder Abuse in South Korea Based on 15-year National Data

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## Abstract

Elder abuse, any intentional or negligent act that causes harm, distress, or suffering to an adult aged 65 or older, has become a significant social issue in South Korea. Based on a 15-year nationwide report on elder abuse from 2008 to 2022, this study aims to thoroughly examine current trends and issues surrounding elder abuse. Three key issues emerged: 1) family members as primary perpetrators, 2) increases in elder abuse in nursing homes, and 3) co-occurrence of multiple types of elder abuse. To effectively address this growing concern and uphold the human rights of older individuals, six recommendations are proposed: 1) expanding employment opportunities for older adults, 2) addressing the reluctance to report elder abuse, 3) developing tailored strategies for preventing and addressing different types of elder abuse, 4) enhancing family education and therapy in elder abuse prevention, 5) providing elder abuse education for long-term care staff, and 6) improving monitoring systems for elder abuse prevention in nursing homes. This study provides a foundation for effective elder abuse prevention through policy measures aimed at addressing the human rights challenges associated with elder abuse.

**Keywords:** Social gerontology, ageism, age discrimination, aging, social work, human rights

## Introduction

As of 2024, South Korea (hereafter, Korea) is projected to have a total population of just over 50 million (1). The population growth rate is expected to turn negative from 2021, possibly falling below 50 million by 2041, with projections of decrease to 30 million by 2066 (1). However, the proportion of people aged 65 and older in the total population is expected to rise annually from 17.5% in 2022 to 40% in 2050. The aging index (i.e., the ratio of people aged 65 and over to 100 people aged 14 and under) is projected to increase from 152 in 2022 to 456.2 in 2050, reaching 620 by 2070, propelling Korea into an ultra-aging society (2). The country's rapid economic growth, enhanced living standards, and advancements in disease prevention and treatment have led to a significant increase in the proportion of the older population as a result of increasing life expectancy (3,4). With the swift rise in the older population, combined with the rapid increase in nuclear families, diminishing sense of dependency, and inadequate personal, social, and national preparation to support aging

individuals, elder abuse has emerged as a pressing and unprecedented social issue (5).

In 2018, South Korea's Welfare of Senior Citizens Act defined "elder abuse" as any act of physical, mental, emotional, or sexual violence, as well as economic exploitation, abandonment, or neglect, directed toward individuals aged 65 or older (5). Instances of elder abuse encompass actions, ranging from neglecting the essential needs of older individuals to negligence by nursing facilities that are obligated to provide care, constituting a serious anti-social and criminal offense (6). Compared to other social issues such as child and marital abuse, elder abuse has gained significantly less public attention, remaining largely overlooked (7). Conversely, the risk of elder abuse is likely to escalate with the increasing number of vulnerable populations, including older adults who are economically disadvantaged, chronically ill, socially isolated, and those with dementia, who struggle with communication (7).

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According to the Status Report on Elder Abuse by the South Korean Ministry of Health and Welfare, the reported cases of elder abuse have almost doubled in a decade, escalating from 2,674 in 2009 to 5,243 in 2019, and further to 6,259 in 2020, marking a 19.4% increase from the previous year (8). Elder abuse is now beyond an individual or household problem. The demand and need to protect abused individuals and enhance their rights and interests has transcended the individual level, becoming imperative at a societal level. It is recognized that Korea is still lagging behind other developed nations in terms of social awareness, as well as in the legal and institutional frameworks regarding elder abuse. Thus, this paper aims to examine three major issues in elder abuse cases reported from 2008 to 2022, obtained by the Korea Elder Protection Agencies, and provide six suggestions to foster a societal environment where elder abuse issues can be openly discussed and effectively addressed.

## Current Issues

### Family Members as a Primary Perpetrator

The most distinctive characteristic of elder abuse in Korea is that it predominantly occurs within families and is often influenced by family dynamics and cultural context within the country. Over the course of 15 years from 2008 to 2022, family members including spouse, son, daughter-in-law, daughter, son-in-law, grandchild, and other relatives were identified as the most frequent perpetrators of elder abuse (9). Particularly, sons and spouses, who play crucial roles in elder care, account for more than 70% of the total cases (9). What makes it worse is that elder abuse is much less reported than it actually occurs because it is regarded as a private family issue. Older adults who suffer abuse tend to endure silently, treat their pain as a family shame, and hesitate to report it, fearing further harm and retaliation from family members.

The fact that family members are the primary perpetrators of elder abuse can be understood in the context of Korea's traditional family culture. In Confucianism, which is deeply embedded in Korean society, close family members are culturally and customarily responsible for supporting their aging parents (10). However, in the absence of sufficient support systems for families, this responsibility can lead to overwhelming caregiver burden and fatigue, which may ultimately result in elder abuse. Notably, sons often bear the greatest pressure among family members due to traditional expectations that they, as male children, are primarily responsible for the care of their aging parents. As a result, there has been a significant increase in abuse perpetrated by sons.

### Increase of Elder Abuse in Nursing Homes

A notable increase in elder abuse has been observed in nursing homes. The percentage of older Koreans residing in nursing

homes rose from 40% in 2011 to 76.2% in 2018 (11). Since the implementation of the Long-term Care Insurance Act in 2008, there has been a rise in the number of older individuals residing in long-term care facilities along with an increase in abuse incidents in this setting (11). Reported abuse in nursing homes was about 10% in 2017 and soared to 25.8% in 2021, equating to nearly a quarter of all reported cases (9). The issue of elder abuse in nursing homes, is much more complicated because it involves not only mistreatment by staff as well as conflicts among residents, direct care workers' job satisfaction and turnover, and inadequate facility resources and support (12). In addition, nursing home residents with multiple conditions such as dementia or mental illness are more vulnerable to abuse (9). Some major reasons behind elder abuse in facilities include a lack of standardized nursing home quality assessments by the government, a lack of elder abuse prevention training or continued education for staff, and differing understandings and expectations among residents regarding cohabitation (13,14).

### Co-Occurrence of Multiple Types of Elder Abuse

The last issue of elder abuse is the co-occurrence of multiple types of abuse. These types often happen simultaneously, exacerbating the physical and psychological harm experienced by older adults. Among various types—such as physical abuse, emotional abuse, financial abuse, neglect, sexual abuse, self-neglect, and abandonment—emotional abuse consistently had the highest average rate over the 15-year period (2008–2022); at 40.6%, followed by physical abuse at 30.8% (9). Notably, in 2021, emotional and physical abuse combined accounted for over 80% of total cases (9).

Physical abuse involves using force or using tools to inflict harm, pain, or disability on an older adult, including actions like handcuffing or imposing non-consensual labor (15). Emotional abuse encompasses behaviors like blame, insults, or threats that cause distress, as well as deliberate social isolation and exclusion from important decisions (15). Research indicates that the physical trauma and emotional scars resulting from elder abuse can lead to long-lasting adverse effects, such as depression, anxiety, post-traumatic stress disorder, a decline in quality of life, and even suicide (16).

In addition, sexual abuse—which includes both sexual humiliation and acts of sexual violence such as unwanted physical contact and verbal harassment—has doubled over the past 15 years. Its prevalence rose from 1% in 2008 to 2.5% in 2022, with older adults suffering from cognitive impairments being particularly vulnerable (9). Furthermore, there is a pressing need to address mistreatment against bisexual and gay older adults. LGBTQ older adults often face discrimination in accessing government benefits, including housing, pensions, and healthcare, and are frequently pressured into unwanted disclosure of their sexual orientation (9).

## Suggestions

### Expanding Employment Opportunities for Older Adults

High economic dependence on children due to poverty is a major contributor to elder abuse (17). To address this, stable employment policies for older adults are essential, including the creation of suitable jobs and the provision of ongoing employment opportunities to ensure financial independence. Empowering older individuals to live independently as active members of society is crucial for fostering a sense of pride and self-sufficiency. Expanding employment opportunities for older adults has been shown to positively impact not only their financial stability but also their physical and mental health, as well as their social relationships.

### Addressing the Reluctance to Report Elder Abuse: The Role of Education and Support Systems

Older adults' deep love for their children often makes it difficult for them to report elder abuse. Even when abuse occurs, they are frequently hesitant to come forward, fearing the exposure of their children's actions and the potential for worsening the situation or facing re-abuse (18). This reluctance to report abuse contributes significantly to its persistence. To address this, it is crucial to establish a system that enables immediate reporting of elder abuse by the elderly themselves, preventing further abuse and promoting prevention measures. As a practical solution, nursing homes should educate older adults about behaviors that constitute elder abuse, ensuring both residents and staff have a clear understanding. Those who experience abuse should be institutionally protected and supported in reporting it promptly.

### Developing Tailored Strategies for Preventing and Addressing Different Types of Elder Abuse

To effectively prevent and address various forms of abuse, tailored strategies should be developed specific to the prevention and intervention of each type of abuse. Clear and specific response strategies, including defined reporting methods and procedures, are essential for optimal prevention and treatment. Currently, elder abuse is addressed in a broad, undifferentiated manner, without distinguishing between its various types (9). To improve outcomes, differentiated prevention and post-intervention measures should be developed for each type of abuse, beginning with the most prevalent forms and gradually expanding to cover all types.

### Enhancing Family Education and Therapy in Elder Abuse Prevention

As family members are often the primary perpetrators of elder abuse, the issue is frequently seen as an internal family matter. This reluctance to disclose abuse and the tendency to deny its existence contribute to its recurrence (18). To address this, family education is essential to help members recognize

and manage their emotions. Additionally, older victims should receive social education to prevent strong attachments and biases from disrupting healthy family dynamics. Social workers or related-field consultants may play a key role in facilitating these efforts by guiding both families and victims. Implementing family therapy and family-strengthening programs is also vital to support the overall well-being of the entire family.

### Elder Abuse Education for Long-term Care Staff

The number of long-term care service workers serving older individuals is significantly increasing (11). To appropriately leverage this growing workforce, it is essential to establish a system that uses these workers to detect elder abuse early and prevent it through ongoing monitoring (7). Effective elder abuse prevention requires both active educational efforts and responsive actions that are supported by nursing home providers. For example, nursing staff and direct care workers should develop a strong understanding of residents' rights and elder abuse to prevent themselves from unintentionally becoming perpetrators. Ongoing training programs should be implemented for nursing home staff to reinforce their role in preventing and identifying abuse. Additionally, clear procedures and methods for intervening in cases of elder abuse should be established.

### Improving Monitoring Systems for Elder Abuse Prevention in Nursing Homes

Older individuals living in nursing homes often experience physical and mental discomfort, making it difficult for them to properly express themselves if they are being abused. While the installation of security cameras in public areas of these facilities can raise concerns about privacy violations, their potential to protect residents and prevent elder abuse should be carefully considered. Security cameras should be viewed as a tool for enhancing public safety, preventing abuse, and supporting legal action, rather than merely as a violation of personal rights. Currently, emergency telephones are available in long-term care facilities but are ineffective due to lack of awareness (9). To improve their effectiveness, emergency numbers should be simplified for easier memorization by residents, and stronger confidentiality measures should be implemented to ensure swift responses to elder abuse while maintaining privacy.

## Conclusion

This paper makes a significant and original contribution to the existing literature on elder abuse in two ways. It is one of the first trials to examine 15 years of national data, spanning from 2008 to 2022, obtained by the Korea Elder Protection Agencies. This extensive review provides a comprehensive and longitudinal perspective on elder abuse trends in Korea, offering a depth of analysis rarely seen in previous studies. Second, the

study extends beyond simply reviewing the prevalence and types of elder abuse. It takes an actionable approach by offering evidence-based suggestions to prevent elder abuse, addressing a critical gap in the literature that often stops at listing findings without exploring practical interventions. The study holds strong policy implications by directly linking its findings to actionable strategies, making it a valuable resource for policymakers aiming to create more effective elder protection frameworks.

Given the increasing prevalence of elder abuse and its significant societal impacts, a comprehensive response to this issue is necessary. The three characteristics of elder abuse in Korea observed in this paper are entangled in complex family dynamics and are interconnected in the country's financial, economic, political, and cultural context. Thus, it is vital to address elder abuse comprehensively and explore various dimensions, including individual, social, legal, and institutional, to develop effective preventive and responsive strategies against elder abuse.

## Footnotes

### Authorship Contributions

Concept: K.K., J.H.K., Design: K.K., J.H.K., Data Collection or Processing: K.K., J.H.K., Analysis or Interpretation: K.K., J.H.K., Literature Search: K.K., J.H.K., Writing: K.K., J.H.K.

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