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Contents

EDITORIAL

FROM THE EDITOR IN CHIEF IX
Yeşim GÖKÇE KUTSAL

INVITED REVIEW ARTICLE

ADVANCES IN SARCOPENIA TREATMENT FOR A HEALTHIER FUTURE 119
Sibel EYİGOR, Yeşim GÖKÇE KUTSAL

ORIGINAL ARTICLES

THE RELATIONSHIP BETWEEN EPICARDIAL AND PARACARDIAL FAT THICKNESS AND DISEASE SEVERITY IN ELDERLY PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE 130
Gülhan AYHAN ALBAYRAK, Mustafa İLTERİŞ BARDAKÇI, Goncagül BÜLBÜN

INTEGRATING MACHINE LEARNING INTO ALZHEIMER'S RESEARCH: A CLINICAL DECISION SUPPORT SYSTEM APPROACH 137
Ceyda ÜNAL, Yılmaz GÖKŞEN

THE IMPACT OF THE CLINICAL FRAILTY SCALE ON PROSTHESIS SELECTION AND EARLY MORTALITY IN ELDERLY PATIENTS UNDERGOING AORTIC VALVE REPLACEMENT 150
Murat KOÇ, Ufuk MUNGAN, Kaan KAYA, Özer KANDEMİR, Bahadır GÜLTEKİN, Süleyman SÜRER, Mustafa SEREN, İbrahim DUVAN, Emre KAYMAKÇI, Burçin ÇAYHAN KARADEMİR, Renda CIRCI, Hasan KARAYAKA, Ferit ÇİÇEKÇİOĞLU

THE EFFECTS OF VIRTUAL REALITY-BASED EXERCISE ON PAIN AND FUNCTION IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS: A RANDOMIZED CONTROLLED STUDY 159
Suheyla DAL ERDOĞAN, Funda BERKAN, Onur ARMAĞAN, Merih ÖZGEN, Ayşe Merve ÇIRACIOĞLU, Fezan ŞAHİN MUTLU

DOES OBESITY AFFECT THE EFFICACY AND SAFETY OF EPIDURAL STEROID INJECTIONS IN OLDER ADULTS? 170
Yücel OLGUN

ANALYSIS OF URINARY TRACT INFECTIONS IN GERIATRIC PATIENTS 179
Sümeyra KAYALI, Ayşe SAĞMAK TARTAR, Nuray ARI, Mehmet Ali AŞAN, Beyza ERDEM, Hatice Handan AKBULUT

CLINICAL PERFORMANCE COMPARISON OF THE I-GEL AND LARYNGEAL MASK AIRWAY SUPREME IN GERIATRIC PATIENTS: A PROSPECTIVE STUDY 191
Nursen KARACA, Işık ALPER, Özgecan KAYNARCA

ADAPTATION AND PSYCHOMETRIC EVALUATION OF THE TURKISH VERSION OF THE MATCH SCALE: ASSESSING MOTIVATION AND ATTITUDES TOWARD CHANGING HEALTH BEHAVIOR IN OLDER ADULTS WITH TYPE 2 DIABETES 200
Dilek BÜYÜKKAYA BESEN, Mehtap ERTAŞ, Merve DERVİŞOĞLU

EFFECT OF OLD AGE ON PNEUMONIA 212
Zeliha DEMİR GİDEN, Elif DEMİR

COLORECTAL CANCERS OCCURRING WITH ILEUS 219
Filiz TAŞÇI, İsmail ATAŞ, Mümin Murat YAZICI, Enes GÜLER, Özlem BİLİR

EVALUATION OF THE LEVEL OF KNOWLEDGE ABOUT ALZHEIMER DISEASE IN THE TEKIRDAĞ PROVINCE, TURKEY: A CROSS-SECTIONAL STUDY 229
Filiz DİLEK, Aysun ÜNAL

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CROSS-CULTURAL ADAPTATION AND VALIDATION OF THE TURKISH VERSION OF THE 25-QUESTION GERIATRIC LOCOMOTIVE FUNCTION SCALE **239**
Barış GÜRPINAR, Hülya TUNA, Nursen İLÇİN

AGE-RELATED THORACIC LYMPHADENOPATHIES AND DISEASE PROGRESSION IN PATIENTS WITH MODERATE-TO-SEVERE ASTHMA: AN EVALUATION OF CLINICAL AND IMAGING FINDINGS **250**
Şerife TORUN, Öznur GÜVENÇ UZUNAY, Selim KAHRAMAN, Semiha HİDAYETOĞLU, İrfan Fırat ÖZCAN, Tuğba ERDOĞAN, İrem KARAMAN, Gülbahar DARILMAZ YÜCE, Kezban KARABULUT UÇAR, Mehmet MERMER

RELATIONSHIP BETWEEN VARIOUS NUTRITION SCREENING TOOLS AND MORTALITY AMONG GERIATRIC PATIENTS ADMITTED TO THE INTENSIVE CARE UNIT **262**
Arzu YILDIRIM AR, Yıldız YİĞİT, Öznur DEMİROLUK, Gamze Nur KOCA, Cansu OFLUOĞLU

From The Editor In Chief

The Turkish Journal of Geriatrics, with a publication history spanning over 27 years, holds a distinguished place within the fields of aging and geriatric medicine.

Its inclusion in both the Science Citation Index Expanded (SCI-Exp) and the Social Sciences Citation Index (SSCI) under the Web of Science Core Collection highlights the journal's interdisciplinary scope and scholarly impact.

This dual indexing is a testament to the journal's scientific rigor, editorial quality, and its contribution to both clinical and social dimensions of aging.

As Turkey's first and foremost academic platform dedicated exclusively to geriatrics, the journal has played a pivotal role in promoting research on aging populations, age-related diseases, long-term care, healthy aging, and social policies for the elderly.

The journal not only facilitates academic exchange within Turkey but also serves as a bridge between regional and global geriatric research communities.

Its longevity and continued presence in internationally recognized indexes reflect its commitment to advancing the science and policy of aging in a rapidly aging world.

Yeşim GÖKÇE KUTSAL

INVITED REVIEW ARTICLE

ADVANCES IN SARCOPENIA TREATMENT FOR A HEALTHIER FUTURE

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Abstract

Sarcopenia is a common, costly condition linked to falls, fractures, disability, and death. Initially defined in 1989 as age-related muscle loss, sarcopenia is now recognized as a progressive disorder involving declines in muscle strength, mass, and function, influenced by inactivity, malnutrition, chronic disease, and hormonal changes. Despite its prevalence—affecting 10–27% of people over 60—diagnosis and treatment remain limited due to the lack of consensus. Current research highlights cellular aging, chronic inflammation, oxidative stress, and anabolic resistance as key mechanisms.

Exercise is the cornerstone of treatment. Resistance training improves strength and mass, while aerobic and high-intensity interval training enhance endurance and metabolic health. Combined exercise regimens yield better outcomes than single modalities. Personalized exercise programs considering age and health status are essential.

Nutrition also plays a critical role. Adequate protein intake (1.0–1.5 g/kg/day), leucine supplementation, and balanced energy intake support muscle maintenance. Mediterranean-style diets are encouraged, while excessive protein or restrictive diets are discouraged. Supplements like Omega-3, probiotics, creatine, and vitamin D show promise, but results are mixed.

Pharmacological treatments are under investigation, including hormonal therapies, selective androgen receptor modulators, myostatin inhibitors, and agents targeting the renin-angiotensin system. However, side effects and insufficient evidence limit their use. Stem cell therapies and ghrelin analogs offer future possibilities.

Ultimately, early intervention with exercise, proper nutrition, and a holistic lifestyle approach remains the most effective strategy against sarcopenia.

Keywords: Sarcopenia; Therapeutics; Exercise; Proteins.

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INTRODUCTION

Sarcopenia is a common and costly health problem associated with adverse outcomes including falls, fractures, physical disability, and death. Although sarcopenia was defined in 1989 as the loss of muscle mass associated with age, it has undergone some definitional changes over time. Sarcopenia is not only an age-related condition, but can also result from various factors such as inactivity, malnutrition, chronic diseases, and hormonal changes. Today, in light of the data obtained over time, it is defined as a progressive, generalized muscle disorder due to changes in muscle strength, mass, and function. In 2016, it was tried to emphasize its importance in clinical practice by receiving the ICD diagnosis code M62.84 (1,2).

Depending on the diagnostic criteria, target populations, and regional variations, the global prevalence of sarcopenia in individuals over the age of 60 is estimated to vary between 10% and 27%. According to different study results, higher prevalence rates are also seen. However, despite being so common, neither diagnosis is made nor adequately treated in clinical practice. The biggest reason for this is the lack of international consensus for diagnosis and the existence of confusion (3). Perhaps this uncertainty and confusion contribute to the lack of awareness. Currently, the Global Leadership Initiative in Sarcopenia (GLIS) organization is conducting studies under different working groups, and it is possible that GLIS reports will shed light on this issue in the future (1,3,4)

The exact causes of sarcopenia are complex and not fully understood. A combination of factors such as poor nutrition, physical inactivity, and age-related chronic diseases contribute to the gradual decline in muscle function with age. Common pathophysiological pathways, including low-grade chronic inflammation, mitochondrial dysfunction, oxidative stress, insulin and anabolic resistance, and other hormonal changes, may help explain the onset and progression of this deteriorating condition. Chronic low-grade inflammation in the body inhibits muscle protein synthesis and increases protein catabolism, contributing to the development of sarcopenia. In addition, inflammation is closely linked to oxidative stress and anabolic resistance and exacerbates the loss of muscle mass, strength and function (2,5-8). Although skeletal muscle is known as a locomotor organ associated with falls, physical impairment, disability and mortality, skeletal muscle is actually also a metabolic organ. It is associated with inflammation, fatigue, diabetes, wound healing, respiratory capacity, infection/complication, hospitalization and mortality. Its definition as a metabolic organ is due to the fact that skeletal muscle is related to amino acid, lipid, glucose and bone metabolism (6,9). Therefore, at this point, skeletal muscle plays a key role in all diseases and life.

Different data regarding the diagnosis and mechanism of sarcopenia also complicate the treatment part. Treatment strategies appropriate to the causes and mechanism of sarcopenia continue to be studied. Sarcopenia treatment involves a range of strategies to prevent muscle loss and increase strength and function. This article will discuss various aspects of sarcopenia treatment in light of recent information.

Sarcopenia Treatment

Recent studies show that cellular aging worsens degenerative diseases by affecting skeletal health. Therefore, treatment of aging cells is promising for sarcopenia. Treatment approaches that may be effective on cellular aging include exercise, healthy nutrition, senolytic and senomorph defined treatments. Exercise and nutrition strategies within these treatments may also be effective on preventing cellular aging (5,10,11). Sarcopenia treatment often requires a multidisciplinary approach. It does not seem possible for a one-way approach to be sufficient in such a complex mechanism.



Exercise

Exercises are considered the most important approach in preventing, delaying and treating sarcopenia. Exercise is also one of the most effective interventions to promote healthy aging. Its effect on aging muscles is multifaceted. Exercise has positive effects on inflammation, insulin resistance, microbiota, satellite cell proliferation, myogenesis, nitric oxide-guided vascularization, improvements in mitochondrial bioenergetics and reduced myonuclear apoptosis. In addition, exercises are known to have positive effects on body composition, fall risk, physical performance, quality of life, psychological problems, metabolic syndrome and chronic diseases (10,12,13).

When it comes to sarcopenia, the question of which type of exercise is more effective also comes to the agenda. Different study results on this subject still show the superiority of different exercises.

Resistance exercises have long been prominent as one of the most effective components of exercise therapies in the treatment of sarcopenia. Resistance exercises increase muscle mass and muscle strength and promote neuromuscular plasticity (10,12,13). There are also conflicting results in the literature. However, considering the current literature, it seems important to include resistive exercises in one step of the sarcopenia treatment program (14, 15). It has been reported that low/moderate intensity resistive exercises and low-load exercises increase lean body mass, muscle mass and muscle strength. In resistive exercises, body weight, dumbbells, kettlebells, resistance bands or machines can be used. In addition, marked irregularities in myofiber shape are a hallmark of human skeletal muscle aging and can be reversed by heavy resistance training (16). Resistive exercises are recommended 2-3 times/week, 8-12 repetitions, 1-3 sets, 70-80% 1 repetition maximum (RM) target, with a load starting at 30-40% of 1RM (10,15,17).

Until recent publications, resistive exercises were presented as the most important exercise in sarcopenia treatment. Although Type 2 fibers are important, some researchers have recently stated that aerobic exercises are also very effective (18-21). Aerobic and High Intensity Interval Exercise have positive effects on cardiorespiratory fitness, insulin sensitivity, muscle mass, and muscle function (10). It has been stated that the positive effects on muscle strength and physical functions are particularly striking. Aerobic exercises play a role in improving cardiovascular health as well as increasing muscle endurance. Regular aerobic exercises help increase general physical capacity and provide endurance for long-term use of muscles. Effective aerobic training, characterized by sufficient intensity (70–80% heart rate reserve), duration (30–45 min), and frequency (4–5 days per week), contrasts with resistance training's focus on hypertrophy, offering a high-volume, low-load workout that significantly engages muscles and promotes overall muscle function and growth (10). Recent reviews also indicate that the greatest and most significant muscle gains can be achieved with a multimodal exercise approach. It has been observed that combined exercise treatments are more successful than single exercise treatments (8,22) (Table 1).

Table 1. Components of combined exercise treatments

Resistance exercises Aerobic exercises Endurance exercises	2-3 times/week 20-60 min 1-2 sets 8-10 repetitions
Balance exercises	2-3 times/week
Flexibility exercises	2-3 times/week 10-15 min 15-30 sec stretching
Functional training	2-3 times/week 20-30 min

Exercise programs should be customized according to age, physical condition and health history. Over time, the frequency, intensity and duration of exercises can be increased. Early targeted therapies, including resistance exercise alone or in combination with aerobic exercise or balance training may be required to mitigate the loss of muscle and function that older persons experience during aging (23). Of course, since the main thing will be to prevent sarcopenia, regular physical activity in the early stages and lifelong approaches together with diet strategies will be much more important.

Nutrition

Nutrition plays a critical role in the treatment of sarcopenia. Protein is an essential component for the preservation of muscle mass and muscle recovery. Routine intake of dietary protein directly affects skeletal muscle protein turnover, promotes muscle damage repair, and improves physical activity performance (10,24,25). In older individuals, 1.0-1.5 grams of protein per kilogram of body weight per day is recommended to prevent muscle loss. Both animal- and plant-based proteins can be beneficial, although careful planning may be needed with plant-based diets to ensure sufficient essential amino acid intake. In addition, it is emphasized that daily protein intake should be distributed equally into 3 main meals (0.6 g/kg of high-quality protein per meal) (26). It is also stated that protein intake within the first 30-60 minutes after exercise can increase the positive effect on muscle. The potential of protein supplementation as an effective intervention for managing sarcopenia, particularly in improving muscle mass and strength and muscle function (1,8). However, the benefits of combining it with exercise remain uncertain (27).

Leucine plays a number of roles in the regulation of muscle metabolism, including protein synthesis and conversion, maintenance of glucose homeostasis and provision of nitrogen for muscle alanine and glutamine synthesis. Leucine can reverse the age-related decline of muscle protein synthesis. Meat, fish, eggs, milk, cheese, soy products, nuts such as peanuts and legumes are rich in leucine (8). Total protein intake, with three meals containing 0.6 g/kg of high-quality protein and at least 5 g of leucine per meal, has been recommended. Some studies show that taking 3 g of leucine supplements per day can be effective in increasing muscle mass and strength (28). Positive results have also been obtained with amino acids such as beta-hydroxy-beta-methyl butyrate (HMB) (leucine metabolite), arginine, lysine, glutamine. It has been stated that taking 1-3 g of HMB per day is effective on muscle strength and body composition, but its effect on muscle mass is small. However, interestingly, it has been stated that its positive effects are observed not especially in active individuals but in bed rest (29,30). Therefore, it is clear that more studies are needed on the effects of products to be given as supplements.

Not only adequate protein but also adequate energy intake is important. The benefits of excessively restrictive diets that only include protein intake are debatable. The harms of diets with excessive protein intake, especially animal proteins, are discussed due to the risk of dysbiosis, cardiovascular disease and non-alcoholic liver disease. The Mediterranean diet is seen to be effective on muscle mass and physical performance in terms of its richness of content (17,31). Adequate energy intake is necessary for muscle repair and maintenance. The combination of protein and carbohydrates is especially beneficial for recovery after exercise and increasing muscle mass. This combination increases muscle protein synthesis and supports muscle repair.

Omega 3 is one of the most researched supplements. However, although its beneficial effects are mentioned in many diseases, conflicting results confuse us. The most reliable data in terms of evidence regarding Omega-3 is that it is effective



on inflammation. Long-chain polyunsaturated fatty acids are anti-inflammatory molecules that have a positive effect on the anabolic processes associated with aging and insulin sensitivity. In the treatment of sarcopenia, it is seen that Omega 3 supplementation is effective on lean body mass and skeletal muscle mass, but conflicting results are obtained regarding muscle strength. It is controversial whether it can improve functional results in muscle wasting disorders such as sarcopenia and cancer cachexia. It is also thought to be effective in preventing sarcopenia. However, it is stated that it can be effective on physical performance in use for more than 6 months, and 2 g (400 mg EPA-300 DHA) should be used per day for muscle mass/strength effect. However, there is no clear data on long-term effect, how long and in what dose it should be used. Practically, the nutritional recommendation is to eat fish 4 times a week for Omega 3 (3,32,33).

Research points to gut microbiota dysbiosis, a disturbance in microbial communities within the gut, as a potential key player in the pathogenesis of these age-related conditions. Therefore, the effects of microbiota have begun to be investigated in all diseases. Some studies show that intestinal microflora can also be associated with sarcopenia. With age, intestinal flora diversity and richness decreases, and Actinobacteria and Fusobacteria species decrease. f-Ruminococcaceae; g Faecalibacterium, g-Prevotella, Lachnoclostridium and other genera decrease, g-Bacteroides, Parabacteroides, Shigella increase and a relationship has been reported with sarcopenia. Probiotic oral supplementation (Bifidobacterium and Lactobacillus supplements) enhanced muscle strength, muscle mass, muscle endurance and physical performance and function. Interestingly, the effects of Bifidobacteria on sarcopenia differ between Asian and European individuals. It is stated that Lactobacillus Rocheand- Lactobacillus galaei provides a decrease in pro-inflammatory cytokines. Therefore, this issue seems to be a subject that needs to be investigated in different populations with different probiotics and different doses. However, it is more important to keep the intestinal microbiota healthy with healthy foods in general, to provide flora diversity and to increase physical activity (34-36).

Unfortunately, there are conflicting results regarding the effects of nutritional support treatment-supplements on muscle strength and muscle mass. Recently, the concept of nutritional rehabilitation has started to be used frequently. In this context, the importance of nutritional screening is actually emphasized. It is emphasized that a holistic approach can be beneficial by including healthy components of nutrition and supporting it with regular exercise. As a result, the following is basically recommended for nutrition; the focus is on natural intake of less processed foods, the Mediterranean diet, age- and person-specific treatment, and a healthy diet throughout life (17,31,37).

Pharmacological Treatments

With the developments in the field of molecular physiology, potential drugs that can cause changes in skeletal muscle have begun to be identified. However, unfortunately, the molecules in the literature are not yet in a quality that will meet our expectations due to both their side effects and lack of evidence. Potential molecules that can affect any step of muscle metabolism continue to be studied. As a result of the studies conducted, the popularity of some molecules has decreased over time. Here, an attempt has been made to present molecules that are more emphasized (Table 2).

Positive effects of creatine supplements on muscle aging, bone and fat mass, muscle and bone strength and physical performance have been shown. However, while these effects are observed in healthy individuals, the fact that the same effect is not obtained in sarcopenic elderly, immobilization

Table 2. Present molecules

Creatine supplements	Recommended dosage is 3-5 grams/day.
Vitamin D	Older adults looking to maintain skeletal muscle mass and function should avoid vitamin D insufficiency (<50 nmol/L) and deficiency (<25–30 nmol/L).
Estrogen	It's usage is not recommended primarily.
Testosterone	It is the therapeutic option particularly in older men with low testosterone levels (< 200–300 ng/dl).
Insulin-like Growth Factor 1	Not recommended due to potential side effects.
Growth hormone	Not recommended due to potential side effects.
Myostatin pathway inhibitors	More clinical studies are needed.
ACE inhibitors	Studies are ongoing.
Ghrelin	Data on safety are insufficient.
Mesenchymal stem cells	May promote muscle regeneration, but more research is needed.

and chronic disease conditions creates a question mark in terms of treatment. It is recommended that it should be taken in 3-5 grams per day and supported by resistance exercises (38).

Hormonal treatments have always been popular due to their effects on the pathophysiology of sarcopenia. It can help increase muscle mass, but should be used with caution due to its side effects.

Vitamin D receptor is expressed in muscle tissue, albeit in low concentrations, and the expression of this receptor decreases with aging. Vitamin D has important roles in calcium-mediated muscle functions such as contractility, mitochondrial function, and insulin sensitivity by regulating calcium and phosphate absorption. In addition, it regulates genes involved in calcium and phosphate homeostasis. In fact, it has been suggested that vitamin D and its receptors support cellular/molecular mechanisms involved in myogenesis. In addition, vitamin D acts as a mediator in the interaction between muscle and bone tissue through its effects on myokines (myostatin, vascular endothelial growth factor, osteoglycin) and osteokines (sclerostin, osteocalcin, fibroblast growth factor). Vitamin D deficiency negatively affects skeletal muscle and causes a decrease in muscle strength (39,40). The effect of vitamin D supplementation on muscle mass has been shown in experimental models (41). There are studies indicating that it has a slight effect or no effect on muscle strength. There is also a decrease in the risk of falling. There are studies indicating that vitamin D can be potentiated by using it together with protein, leucine, whey protein, probiotics and exercise (13,40). It has been stated that vitamin D and protein combination therapy has no effect on muscle mass and performance, but provides improvement in muscle strength. It has been stated that vitamin D supplementation does not contribute to handgrip strength, timed up and walk test, muscle strength, physical performance and ALM (42). If there is a vitamin D deficiency at the last point, it is recommended to detect and treat it.

Estrogen has a direct effect on the muscle by binding to skeletal muscle estrogen receptors. Although the evidence regarding its effectiveness in the treatment of sarcopenia is insufficient and contradictory, its use is not recommended primarily due to the side effects of estrogen. However, although there have been hopes with selective estrogen receptor modulators, there is no reliable data proven to date (43).

Testosterone supplements are the most frequently used drugs for enhancing muscle



mass and promoting muscle-protein anabolism. Testosterone is the therapeutic option particularly in older men with low testosterone levels (< 200–300 ng/dl). It is stated that it has positive effects on muscle mass and strength. It is also mentioned that testosterone has positive effects on life expectancy. However, testosterone therapy in elderly men is known to pose potential risks such as sleep apnea, erythrocytosis, thrombotic complications, cardiovascular side effects, and prostate cancer. There are also conflicting results regarding side effects. However, it can be said that testosterone therapy is promising. According to our current knowledge, what is really important is the detection and treatment of deficiency (44). Selective androgen receptor modulators can be considered as a new alternative because they provide the same anabolic effect and have fewer side effects. Selective androgen receptor modulators, while working similarly to anabolic steroids, provide a more targeted effect on muscle tissue and aim to avoid side effects on other organs. These substances bind to androgen receptors to stimulate muscle growth, resulting in increased muscle mass. However, long-term safety and efficacy have not yet been tested in clinical trials (3,45-47).

Insulin-like Growth Factor 1 (IGF) and growth hormone treatments can stimulate muscle growth, but are not recommended due to potential side effects (e.g., increased risk of diabetes, cancer development, increased mortality). More research is needed on the long-term effects of these treatments (3).

Myostatin pathway inhibitors, including myostatin-neutralizing antibodies and activin receptor blockers, hold promise in early trials, but their effectiveness compared with that of exercise alone remains unclear (1). This treatment may be a promising option, especially in older individuals with muscle loss such as sarcopenia. Myostatin inhibitors are being tested in a laboratory setting to increase muscle mass and strength (6). More clinical studies are needed to evaluate whether these treatment methods are effective in humans. Bimagrumab and Landogrozumab are promising as potential drugs in sarcopenic obesity. Bimagrumab is effective on body composition, with little effect on muscle strength and physical performance, and a decrease in fat mass and an improvement in muscle mass have been observed. Bimagrumab (BYM-338), a drug that inhibits ACVR2B, a receptor for ligands like myostatin and activins, has been approved by the FDA for sporadic inclusion body myositis (sIBM). However, it has shown limitations in clinical studies related to sarcopenia. Molecules such as Garetosmab, PINTA-745, Ramatercept and Trevogrumab are also under investigation. Although myostatin and activin II receptor inhibitors are generally well tolerated, further studies are needed to reduce side effects (3,6,23,44,48).

Although there are data on ACE inhibitors increasing IGF-1 levels and mitochondria, it seems insufficient to reflect on clinical practice. As the anabolic and protective role of non-classical RAS, its anabolic effects on skeletal muscle have created excitement for a new agent in the treatment of sarcopenia. However, there is a need for further studies on this molecule as well. The MARS activator BIO 101 molecule is in Phase 3 study and appears to be the most potential drug (3,49,50).

Ghrelin exhibits positive effects on muscle protein synthesis by activating the PI3K/Akt/mTOR pathway, anti-inflammatory effects, and mitochondria. Ghrelin analogs have been reported to increase appetite, weight, and LBM in catabolic states such as cancer cachexia, but data on safety are insufficient (1). Amarolein, a ghrelin analog, is also promising in osteosarcopenia (1,3,51).

Mesenchymal stem cells (MSCs) are cells that can differentiate into muscle tissue-specific cells and promote muscle repair. Injecting these cells into the body can reverse muscle loss and improve muscle

function. There are clinical studies investigating MSCs as a potential treatment for sarcopenia. This treatment may promote muscle regeneration, but more research is needed to determine whether it is effective in humans. In addition, miRNAs are claimed to be potential biomarkers and targets of gene therapy for sarcopenia (1).

When the target of sarcopenia treatment is considered as mitochondria, the prominent treatment options in this regard are; exercise, mitoQ (mitochondria targeted coenzyme Q10); 20 mg/day, Urolithin A; 500-1000 mg/day, Eicosapentaenoic a (EPA), docosahexaenoic acid (DHA), Glycine and N acetyl cysteine; 100 mg/kg/day, NAD; 250-2000 mg/day (52).

Experimental treatment options for sarcopenia offer significant promise in treating muscle loss. Myostatin inhibitors, SARMs, growth hormone and IGF-1 supplements, microbiome manipulation, and stem cell therapies are the focus of research in this area. However, many of these treatments are still in the experimental phase and long-term safety and efficacy data are needed. In the future, these innovative treatment methods are expected to play an important role in treating sarcopenia and improving the quality of life of older adults.

When we look at the literature, we see that electrical stimulation and whole body vibration treatments have positive effects on muscles. It is thought that electrical stimulation treatment can prevent muscle mass loss and increase muscle mass/muscle strength. However, current data are not clear in terms of its effects on muscle strength and muscle function and therefore sarcopenia in the long term (10).

CONCLUSION

Sarcopenia, which can be defined as muscle loss and functional deterioration with age, is a serious health problem faced by the elderly population. Treatment can be done by using a number of different approaches such as exercise, nutrition, and pharmacological interventions. A multidisciplinary treatment plan can be effective in reducing the effects of sarcopenia and improving quality of life. Healthcare professionals play a critical role in managing this process by recommending personalized treatment and lifestyle changes to help individuals reduce their risk of sarcopenia. Exercises and effective nutrition, in which protein-amino acids play a key role, are effective in the prevention and treatment of sarcopenia (16).

In conclusion, there have been no significant advancements in the treatment of this major health issue among the elderly.

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ORIGINAL ARTICLE

THE RELATIONSHIP BETWEEN EPICARDIAL AND PARACARDIAL FAT THICKNESS AND DISEASE SEVERITY IN ELDERLY PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Abstract

Introduction: Cardiovascular diseases are frequently observed in patients diagnosed with chronic obstructive pulmonary disease. The Body-mass index, airflow Obstruction, Dyspnea and Exercise index was used to assess the prognosis of patients with chronic obstructive pulmonary disease. Although epicardial fat thickness is associated with cardiovascular diseases, few studies have investigated its relationship with the Body-mass index, airflow Obstruction, Dyspnea and Exercise index. Therefore, we investigated this relationship in patients diagnosed with chronic obstructive pulmonary disease.

Materials and Method: We enrolled 78 patients with severe chronic obstructive pulmonary disease and 65 healthy controls. All patients underwent pulmonary function tests and a six-minute walk test. We used thoracic computerized tomography at admission to measure the epicardial and paracardial fat thickness. Participants' demographic data (age, sex, body mass index, and smoking status) and biochemical parameters (e.g., glucose, urea, creatinine) were measured.

Results: The epicardial fat thickness values of patients with chronic obstructive pulmonary disease were higher than those of the control group ($p < 0.05$). The B-Modified Medical Research Council dyspnea scale scores and Body-mass index, airflow Obstruction, Dyspnea and Exercise indices did not differ significantly between the low and high paracardial fat thickness/body mass index ratios.

Conclusion: This study demonstrated an independent and negative relationship between epicardial fat thickness with the Body-mass index, airflow Obstruction, Dyspnea and Exercise index, which indicates the severity of chronic obstructive pulmonary disease.

Keywords: Pulmonary Disease, Chronic Obstructive; Epicardial Adipose Tissue; Severity of Illness Index.

INTRODUCTION

Epicardial fat tissue (EFT) is the visceral adipose tissue of the heart. The relationship between visceral fat metabolic syndrome (MS) and cardiovascular diseases has previously been demonstrated. Many studies have identified a correlation between visceral fat tissue and EFT. Unlike other visceral fat tissues, the EFT has several local effects on the heart and supports the thermoregulation, and mechanical protection of the myocardium, anti-inflammatory cytokine release, and free fatty acid provision for the myocardium. However, its adverse effects have also been observed, including intrinsic inflammatory effects, high free fatty acid synthesis and release, reduction of glucose uptake and glucose delivery, high lipolysis, intrinsic insulin resistance, fat infiltration into the myocardium, proinflammatory transcriptome, proinflammatory secretome, atherogenic lipid and glucose metabolism, and mechanical obstruction of the heart (1). Several studies have investigated the relationship between EFT thickness, coronary artery disease (CAD), development of atrial fibrillation, and left ventricular diastolic dysfunction (2–4).

The thickness of EFT is a potential diagnostic marker or treatment target for cardiometabolic diseases because it can be measured using imaging methods and responds rapidly to pharmacological and surgical treatments targeting fat burning. EFT is located between the myocardium and the visceral layer of the pericardium. A local interaction occurs between the EFT and the underlying coronary arteries and myocardium (5). The EFT is defined as an endocrine and inflammatory organ that secretes proatherogenic and proinflammatory cytokines. The relationship between the EFT and MS, diabetes mellitus, and CAD has been demonstrated in many studies (6). Various imaging methods have been used to measure the EFT. Transthoracic echocardiography (TTE) is the preferred method for measuring EFT because of its superior advantageous features such as easy accessibility, low cost, lack of radiation exposure, and simultaneous acquisition of other cardiac parameters. The thickness of EFT measured using TTE is strongly correlated both with the epicardial and abdominal visceral fat volume and the anthropometric and metabolic parameters measured using magnetic resonance imaging (7).

Previous research studies indicated that visceral fat tissue is metabolically more active than subcutaneous fat tissue and is, therefore, imposes a greater burden on the cardiovascular system. EFT is the visceral fat tissue located around the heart and is approximately 5 mm thick in healthy individuals (8). It surrounds the coronary arteries and exerts paracrine, endocrine, and inflammatory effects. It is also implicated in the development of CAD, MS, insulin resistance, and hypertension (9). Although epicardial fat tissue is essential for regulating vascular functions and providing energy in healthy conditions, an increase in epicardial fat tissue makes it a lipolytic, prothrombotic, and pro-inflammatory organ. Studies have shown that EFT thickness increases significantly in hypertensive patients compared with normotensive individuals and that the amount of EFT is positively correlated with blood pressure levels (10). This study aimed to elucidate the relationship between EFT and the Body-mass index, airflow Obstruction, Dyspnea and Exercise (BODE) index in patients diagnosed with chronic obstructive pulmonary disease (COPD).

MATERIALS AND METHOD

A total of 143 patients were enrolled in this single center, retrospective study. Ethics committee approval was granted by our institution (protocol number 2695/09.07.2024), and since the data of the study were obtained by scanning patients' files from the hospital automation system, informed consent was not obtained from the participants

The study group comprised 78 patients with severe COPD, and the control group comprised 65 individuals. All patients underwent pulmonary function tests and a six-minute walk test. Thoracic computed tomography at admission measured parameters such as EFT and paracardial fat

thickness (PFT). Participants' demographic data (age, gender, body mass index [BMI], and smoking status) and biochemical parameters (e.g., glucose, urea, creatinine, alkaline transaminase (ALT), aspartate transaminase (AST), C-reactive protein (CRP), hemoglobin (Hgb) levels, white blood cell (WBC), and platelet (PLT) counts) were analyzed.

Statistical Analysis

We analyzed the patients' data using Statistical Package for the Social Sciences for Windows 26.0 (IBM Corp., Armonk, NY). The frequencies and percentages for the categorical data and the means and standard deviations for the continuous data were assessed as the descriptive values. For comparisons between the two groups, an independent samples *t*-test was used. Pearson's chi-square test was used to compare the categorical variables. The results were considered statistically significant when the *p*-value was less than 0.05.

RESULTS

Based on our study data, COPD courses more severely in our male patients, and older population

Table 1. Demographic, biochemical data and pulmoner function tests findings, BODE index, EFT and PFT thickness parameters of the patient, and control groups.

Variables	Patient group (n = 78)	Control group (n = 65)	p-value
Sex n (%)			
Female	19 (24.4)	32 (49.2)	0.002**[1]
Male	59 (75.6)	33 (50.8)	
Age , years: median (Min–Max)	69.5 (64–96)	68 (65–83)	0.033*[2]
BMI kg/m^2 median (Min–Max)	26.1883 (15.57–46.66)	26.2227 (20.55–33.2)	0.651[2]
Smoking history median (Min–Max)	40 (26–56)	40 (22–52)	0.855[2]
FBG, mg/dL median (Min–Max)	99 (75–197)	98 (76–135)	0.361[2]
BUN, median (Min–Max)	38.5 (17–153)	33 (13–72)	0.028*[2]
Creatinine median (Min–Max)	0.965 (0.32–3.82)	0.96 (0.48–1.55)	0.053[2]
ALT median (Min–Max)	15 (7–71)	23 (8–59)	0.0001**[2]
AST median (Min–Max)	20 (10–62)	25 (6–60)	0.015*[2]
CRP median (Min–Max)	6.16 (0.52–199.81)	4.15 (0.39–19.33)	0.001**[2]
WBC, 10^9/L: median (Min–Max)	8.165 (3.6–16.07)	7.3 (4.21–12.45)	0.022*[2]
HB, g/dL mean ± SD (Min–Max)	13.31 ± 1.8 (9.9–17.6)	13.5 ± 1.7 (8.4–17.3)	0.526[3]
HCT (%) mean ± SD (Min–Max)	40.38 ± 5.2 (30.1–53.2)	40.33 ± 4.7 (27.7–51.2)	0.953[3]
PLT. 10^9/L median (Min–Max)	241 (108–713)	258 (110–412)	0.534[2]
FVC (L) median (Min–Max)	1.34 (0.41–2.58)	1.88 (0.97–4.46)	0.0001**[2]
FVC (%) median (Min–Max)	43.5 (15–68)	63 (43–104)	0.0001**[2]
FEV1 (L) median (Min–Max)	0.95 (0.38–1.57)	1.47 (0.85–3.39)	0.0001**[2]
FEV1 (%) median (Min–Max)	38 (15–49)	64 (38–101)	0.0001**[2]
FEV1/FVC mean ± SD (Min–Max)	71.41 ± 13.1 (39–100)	80.98 ± 8.2 (61–101)	0.0001**[3]
BODE index median (Min–Max)	8 (4–11)	3 (0–8)	0.0001**[2]
EFT median (Min–Max)	17.25 (6.9–24.8)	14.6 (6.8–27.8)	0.0001**[2]
PFT, mm median (Min–Max)	205.555 (54.2–585.32)	157.3 (16.63–412.39)	0.022*[2]

[1] Chi-square test; [2] Mann–Whitney U test; [3] Independent samples t-test; * $p < 0.05$; ** $p < 0.01$. Abbreviations: BMI: Body mass index, FBG: Fasting blood glucose, BUN: Blood urea nitrogen, ALT: Serum alanine aminotransferase, AST: Aspartate aminotransferase, CRP: C-reactive protein, WBC: White blood cell count, HB: Hemoglobin, HCT: hematocrite, PLT: Platelet, FVC:Forced vital capacity; FEV1: Forced expiratory volüme in 1 sec; BODE index: (B) Body mass index; (O) airflow obstruction measured by the forced expiratory volume in one second (FEV_1); (D) dyspnoea measured by the modified Medical Research Council (MRC) scale; and (E) exercise capacity measured by the 6 minute walk distance (6MWD), EFT: Epicardial fat thickness, PFT: Paracardial fat thickness



relative to the age-matched healthy study participants (p = 0.002 and p = 0.033, respectively). Serum urea (p = 0.028), CRP (p = 0.001), and WBC (p = 0.022) levels were significantly higher in the patient group. The ALT (p = 0.0001) and AST (p = 0.015) levels were significantly higher in the control group (Table 1). Forced vital capacity (FVC [L; p = 0.0001]), forced expiratory volume in 1 second (FEV1 [L; p = 0.0001]), FEV1 (%; p = 0.0001), and FEV1/FVC (p = 0.0001) were significantly lower in the patient group. Additionally, the BODE index was significantly higher in the patient group than in the control group (3; p = 0.0001; Table 1). The EFT thickness was significantly higher in the patient group (17.09 ± 4) than in the control group (14.86 ± 3.6; p = 0.0001). Similarly, the PAT was significantly higher in the patient group (229.69 ± 109.9) than in the control group (187.03 ± 95.6; p = 0.022; Table 2). We found that the BODE index was significantly higher in the patient group than in the control group (3; p = 0.0001). There was a statistically significant difference between the FEV1 (%) of those with low and high PFT/BMI ratios (p = 0.013). Accordingly, the cutoff values for EFT/BMI and PFT/BMI were determined as 0.64 and 8.48, respectively. The cut-off values were determined by taking the averages of the epicardial fat thickness/BMI (EFT/BMI), and paracardial fat thickness (PFT/BMI) parameters in the patient group (Table 3).

DISCUSSION

The BODE index is a significant prognostic predictor of COPD. It is a multidimensional scoring system that combines information on various clinical factors, including the BMI, airflow obstruction (forced expiratory volume in 1s [FEV1]), dyspnea (Medical Research Council Dyspnea Scale), and exercise capacity (six-minute walk distance), with scores ranging from 0 to 10 (11). Our study detected

Table 2. Comparison of EFT and PFT between patient and control groups

	Patient group (n = 78)			Control group (n = 65)			p-value
	Median	Min–Max	Mean ± SD	Median	Min–Max	Mean ± SD	
EFT	17.25	6.9–24.8	17.09 ± 4.00	14.6	6.8–27.8	14.86 ± 3.6	0.0001**
PFT	205.555	54.2–585.32	229.69 ± 109.9	157.3	16.63–412.39	187.03 ± 95.6	0.022*

Abbrevistions: EFT, Epicardial fat thickness; PFT: Paracardial fat thickness Statistically significant at levels:;* p < 0.05; ** p < 0.01.

Table 3. Comparisons based on parameters of EFT and PFT

EFT/BMI	Low (< 0.64; n = 44)			High (≥ 0.64; n = 34)			p-value
	Median	Min–Max	Mean ± SD	Median	Min–Max	Mean ± SD	
FEV1 (%)	39	15–49	38.32 ± 8.8	36	15–49	36.41 ± 9.2	0.371
B-mMRC	3	1–4	2.89 ± 0.9	3	1–4	2.91 ± 1.0	0.849
BODE index	8	4–10	7.3 ± 1.8	8	4–11	7.82 ± 2.1	0.223
PFT/BMI	**Low (< 8.48; n = 46)**			**High (≥ 8.48; n = 32)**			**p-value**
	Median	**Min–Max**	**Mean ± SD**	**Median**	**Min–Max**	**Mean ± SD**	
FEV1 (%)	40.5	15–49	39.46 ± 9.00	34.5	15–49	34.66 ± 8.2	0.013*
B-mMRC	3	1–4	2.8 ± 1.0	3	1–4	3.03 ± 0.9	0.302
BODE index	7	4–11	7.2 ± 2.1	8	4–10	8.0 ± 1.7	0.073

Abbreviations: EFT: Epicardial fat thickness; BMI: Body mass index; BODE: Body-mass index, airflow Obstruction, Dyspnea and Exercise; B-mMRC; B-modified Medical Research Council Scale; PFT: paracardial fat thickness; FEV1. Forced Expiratory Volume in 1 sec

no statistically significant differences between the FEV1, B-mMRC, or BODE index of those with low and high EFT/BMI ratios.

Extensive research has demonstrated that a significant proportion of individuals diagnosed with COPD also exhibit characteristics of metabolic syndrome (MS) and obesity. The coexistence of MS has been strongly correlated with elevated systemic inflammation levels, which play a crucial role in the pathophysiology of both conditions. Epicardial fat, a specialized type of visceral adipose tissue, is located between the myocardium and the visceral layer of the epicardium. This fat depot serves as a source of various endocrine and inflammatory mediators, contributing to metabolic dysregulation and cardiovascular complications (12). Evidence suggests that epicardial fat accumulation plays a pivotal role in the development of atherosclerosis and is linked to unfavorable cardiometabolic outcomes. A study by Demir et al. revealed that patients with COPD exhibit significantly increased epicardial fat thickness (EFT) compared to healthy individuals (13).

The observed elevation in EFT is believed to be a direct consequence of the systemic inflammatory nature of COPD. Moreover, an EFT measurement exceeding 6.75 mm has been identified as a reliable biomarker for predicting MS in COPD patients, with a sensitivity of 83% and a specificity of 65%. These findings support the notion that the presence of MS further exacerbates the expansion of epicardial fat in individuals with COPD. Key diagnostic indicators of MS, such as elevated plasma glucose levels and hypertension, may also be influenced by the long-term administration of corticosteroids, which are commonly prescribed for COPD management. These metabolic alterations can persist over an extended period, further complicating disease progression. However, the accumulation of epicardial fat is typically a gradual and progressive process. Consequently, the non-invasive assessment of EFT may serve as a valuable tool for early detection and monitoring of MS in COPD patients. Additionally, our findings indicate that both EFT and pulmonary function test (PFT) values were substantially higher in COPD patients, underscoring a potential link between epicardial fat expansion and impaired respiratory function (13).

Zagaceta et al. examined the relationship between COPD, epicardial fat thickness (EFT), and the BODE index, highlighting their significance as indicators of disease severity (14). Kiraz et al. were the first to conduct a comprehensive study assessing the link between EFT and COPD progression, as measured by the BODE index, in a cohort comprising 157 COPD patients and 45 healthy control subjects (15). To better understand this association, patients were stratified into four distinct quartiles based on their BODE index scores: Q1 (0–2 points), Q2 (3–4 points), Q3 (5–6 points), and Q4 (7–10 points). The results demonstrated that individuals with COPD exhibited markedly higher EFT levels compared to those in the control group, suggesting a possible connection between increased epicardial fat deposition and disease advancement. Among patients with COPD, the highest EFT values were observed in Q1 compared with the other BODE index quartiles ($p < 0.05$ for all). The EFT values decreased from Q1 to Q4. Furthermore, EFT was independently associated with the BODE index ($\beta = 0.405$, $p < 0.001$), CRP ($\beta = 0.300$, $p < 0.001$), and diabetes ($\beta = 0.338$, $p < 0.001$). The EFT was independently and negatively associated with disease severity, as indicated by the BODE index, in patients with COPD (15).

A study involving 202 patients examined the link between EFT thickness and the severity of CAD, suggesting that EFT measurements may serve as a useful marker for risk assessment in CAD patients. (16). Ahn et al. conducted an echocardiographic evaluation of EAT thickness in 527 patients undergoing coronary angiography for the first time and reported a significant correlation between EFT thickness and both the activation and

progression of CAD. Additionally, their findings indicated a strong association between EFT, insulin resistance, and systemic inflammation, highlighting its potential role in metabolic dysregulation. (17). Ulucan et al. demonstrated that an increase in EFT thickness was closely linked to a higher incidence of long-term major adverse cardiovascular events, further emphasizing its prognostic importance (18).

In research by Sridhar and Bhaskar, a sensitivity of 95.6% and a specificity of 77.8% were determined for a threshold EFT measurement of 6.5 mm (Area Under the ROC Curve AUC = 0.872; 95% confidence interval [CI]: 0.697–1.000) (19). Similarly, Naik et al. observed that EFT thickness was 4.82 ± 1.31 mm in CAD patients compared to 4.06 ± 1.25 mm in the control group, with a cutoff value of 3.9 mm found to be statistically significant (p = 0.005) (20). For a cut-off value of 3.9 mm, the sensitivity and specificity were 84% and 55%, respectively (AUC = 0.68, 95% CI: 0.58–0.79). Park et al. investigated the effect of the BMI on the relationship between CAD and EFT thickness in 643 participants (21). The patients were divided into two groups according to their BMI values (BMI < 27 kg/m^2 and ≥ 27 kg/m^2). The median EFT thickness values were higher in the low (3.5 mm and 1.5 mm, $p < 0.001$) and high (4 mm and 2.5 mm, $p = 0.001$) BMI groups compared to the control group. An ROC analysis showed that the EAT thickness measurement was more effective in predicting CAD in the low BMI group (AUC = 0.735 and 0.657) compared with the high BMI group. Park et al. hypothesized that the EFT is more potent in predicting CAD in patients with a BMI < 27 kg/m^2 (21). Ahn et al. found a significant relationship between the BMI of groups with an EFT above and below 3mm (22).

CONCLUSION

The results of this study suggest that BODE index which measures the severity of COPD increases in line with the increase in epicardial, and paracardial fat tissue thickness.

Conflict of Interest: The authors declare that they have no conflict interests.

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ORIGINAL ARTICLE

INTEGRATING MACHINE LEARNING INTO ALZHEIMER'S RESEARCH: A CLINICAL DECISION SUPPORT SYSTEM APPROACH

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Abstract

Introduction: Alzheimer's Disease is defined as a progressive brain disease that affects memory, thinking, and behavior. It accounts for 50-80% of all dementia cases. Diagnosis can be challenging, particularly in the early stages and notably in mild cognitive impairment. The growing number and diversity of health-related data have led to the widespread use of machine learning algorithms in the early detection of Alzheimer's Disease. This study focuses on developing an Artificial Intelligence-based clinical decision support system that classifies individuals as individuals with Alzheimer's Disease, Mild Cognitive Impairment, or healthy individuals.

Materials and Method: The dataset used in the study was obtained from the Brain Aging and Dementia Unit of the Geriatrics Department. All patients aged between 45 and 96 years and followed up in the clinic were examined. Classification was performed using the Logistic Regression, Naive Bayes, K-Nearest Neighbor, Artificial Neural Networks, Support Vector Machines, Decision Trees, and ensemble methods.

Results: The CatBoost algorithm outperformed the other models in terms of accuracy. Ensemble learning methods outperformed traditional methods for 176 samples in the Alzheimer class. Random Forest method exhibited the highest precision for Mild Cognitive Impairment classification.

Conclusion: Machine learning techniques according to the purpose of the study can serve experts as a low-cost and non-invasive diagnostic tool. The clinical decision support system developed in this study has been designed as a tool to assist the clinicians.

Keywords: Machine Learning; Alzheimer Disease; Clinical Decision Support Systems.

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INTRODUCTION

Machine learning (ML) is a subset of Artificial Intelligence (AI) that integrates concepts from several disciplines, including computer science, statistics, and optimization, and fundamentally investigates tools and techniques for pattern recognition in data. Essentially, almost all ML problems can be formulated as optimization problems concerning a dataset. In such problems, the goal is to find a model that best describes the data. This explains the concept of "learning" in ML terminology (1).

Implementing developments in AI technologies at every stage of healthcare services offers convenience in early diagnosis, treatments, and follow-up of diseases. Dementia, a progressive brain disease, manifests with memory loss and diminishes cognitive abilities, disrupting daily functioning. With the growing elderly population, dementia has become more common worldwide and emerged as a global public health concern. Alzheimer's Disease (AD), which constitutes a large proportion of the recent progressive diseases, is a clinical syndrome that increases in prevalence with age, progresses with impairment in multiple cognitive domains, and eventually affects daily life.

According to statistics published by the Turkish Statistical Institute (2024), the proportion of the elderly population in the total population increased from 8.8% in 2018 to 10.2% in 2023. According to population projections, the proportion of elderly population is expected to become 12.9% in 2030, 16.3% in 2040, 22.6% in 2060 and 25.6% in 2080 (2). According to World Health Organization (2023) estimates, the number of patients with dementia, currently over 55 million, will reach 75 million by 2030 and 132 million by 2050. Studies show that "a new diagnosis of dementia is made every three seconds" 60-80% of which are Alzheimer's patients (3). In 2024, another study found that an estimated 6.9 million Americans aged 65 and older have AD and it could rise to 13.8 million by 2060 unless medical breakthroughs are developed to prevent or treat the disease (4).

A comprehensive approach to diagnosis entails the utilization of a multifaceted array of assessment techniques, including clinical, biochemical, and cognitive evaluation and brain imaging methods, which are inherently time-consuming and demand utmost professionalism (5). Nevertheless, for the reasons previously outlined, the present clinical status of older adults may result in relatively subtle cognitive symptoms, with cognitive problems being overlooked or associated with existing noncognitive complaints. Conversely, in certain cases, findings such as simple forgetfulness may be interpreted in a manner that favors AD due to the age of the patients, which may result in overdiagnosis and overtreatment (6). These handicaps can be eliminated and the effect of personal factors on the diagnosis or exclusion of AD can be minimized with the potential of current AI technologies to provide guidance and stimulation to healthcare professionals working under heavy workload. Furthermore, AI technologies may be invaluable for physicians regarding the dementia syndromes, which are highly prevalent in older adults. In such cases, clinical evaluation remains essential, as biomarkers may be insufficient or unavailable for early diagnosis. In recent years, the increase in the number and diversity of health data has facilitated the use of several techniques for analyzing large-scale data for early AD diagnosis. Thus, cognitive status of older adults can be accurately classified as cognitively healthy, mild cognitive impairment (MCI), or AD based on a set of ML-based classification techniques (7). Most ML studies in AD diagnosis have focused on neuroimaging data, particularly MRI or PET scans. However, access to imaging tools may be limited in many clinical settings due to cost, infrastructure, or patient-specific contraindications. Therefore, there is a growing need for reliable diagnostic approaches using easily obtainable, non-



imaging data. This study addresses this gap by integrating neuropsychological assessments, laboratory findings, demographic variables and comprehensive geriatric assessment to classify AD and distinguish it from MCI and healthy aging. This study aimed to classify older adults with AD, MCI, or cognitively healthy based on risk factors and clinical features determined using classification methods.

MATERIALS AND METHOD

Dataset

The dataset used in the study was obtained retrospectively from the Dokuz Eylül University Hospital, Department of Geriatrics, Unit for Brain Aging and Dementia (Approval of Non-Interventional Research Ethics Committee). Within the scope of the study, the file records of all patients aged between 45 and 96 years who were followed up in the Geriatrics Clinic of the Geriatrics Department at Dokuz Eylül University Hospital were examined. The demographic data, chronic diseases, dementia diagnosis, laboratory data, and detailed geriatric assessment parameters of the patients included in the study were recorded. In other words, the independent variables included age, gender, educational status, smoking status, comorbidities, detailed geriatric assessment tests (cognition, emotion, activities of daily living) and laboratory data whereas the dependent variables comprised the presence of AD, MCI and healthy controls.

Considering an average of 1000 new case records per year applying to Outpatient Clinic of the Dokuz Eylül University Faculty of Medicine, Department of Geriatrics, and given that the prevalence of cognitive impairment in patients over 60 years of age with subjective memory complaints was 26% according to the study conducted by (8), it was decided to include at least 228 patients in the study with 5% acceptable error rate and 95% confidence level. The initial dataset comprises 176 AD cases, 73 MCI cases, and 351 healthy cases, totaling 600 cases. Table 1 presents the dataset.

Validated and commonly used instruments including the MMSE and CDR mostly formed cognitive assessment. Usually applied in both clinical and research environments, the MMSE is a quick 30-point questionnaire extensively validated for identifying cognitive impairment. Conversely, well-known in staging AD, the CDR offers a thorough rating of dementia severity by means of semi-structured interviews with both patients and carers. Strong psychometric qualities, simple administration, and regular usage in geriatric and dementia-related studies led to the selection of these tools.

As illustrated in Table 1, the dataset did not include imaging data and was ethically approved for the use of only clinical, demographic, neuropsychological and comprehensive geriatric assessment features. The phases of Cross-Industry Standard Process Model for Data Mining (CRISP-DM) (9) were followed and applied to the data in Table 1.

Data Preprocessing

In the data preprocessing phase, the "File Number" feature, which would not be used in the analyses, was first removed from the dataset. The "Label Encoding" approach was utilized in numerical representation of categorical features. The relevant library was imported as a Python module. Consequently, the categorical features in the dataset as "present" and "absent", were coded as 0 for "present" and 1 for "absent".

Concurrently, the target variable (class) "DIAGNOSIS" was recoded as 0 for AD, 1 for MCI, and 2 for healthy subjects. Regarding the "Gender" feature, no coding was made since it was already expressed with numerical representations in the dataset. Accordingly, the "Gender" feature

Table 1. Dataset with Descriptions

Feature	Description
File Number	Archive number
Age	Patient age
Gender	Gender of the patient
Education (year)	Years of education
Smoking	Smoking status
Family History	Whether there is a family history of dementia
COMORBIDITIES	
Hypert	Hypertension status
DMM	Diabetes status (as of patient's visit)
CAD	Whether the patient has coronary artery disease
Depression	Whether the patient has depression
CHF	Heart failure (Congestive Heart Failure)
PAD	Peripheral arterial disease (vascular disease) status
LAB TESTS	
VITB12	Vitamin B
VITD	Vitamin D
TSH	Thyroid hormone
FOLAT	Folic acid
COMPREHENSIVE GERIATRIC ASSESSMENT	
NEUROCOGNITIVE TESTS	
MMSE-MOCA	Mini Mental State Examination/Montreal Cognitive Assessment Scores
Attention-AttMOCA	Saying words carefully
Orientation (time)	Score when asked for time
Language	Identification
Memory-Recall	Remembering words after a certain period of time
Visuospatial	Visual skills
Orientation (place)	Score when asked about location (where are you now?)
Reg-Naming	Repeating spoken words
Clock Drawing Test	Clock drawing test score
CDR	Dementia Stages -Clinical Dementia Rating Scale
YGDS	The Yesavage Geriatric Depression Scale
CORNELL	Depression in patients with dementia
ACTIVITIES OF DAILY LIVING (ADL)	
BASIC (BARTEL)	Activities of Daily Living Scale
INSTRUMENTAL (LAWTON-BRODY)	Instrumental Activities of Daily Living Scale
DIAGNOSIS	Diagnosis feature-consists of three classes (0: AD, 1: MCI, 2: healthy controls)



was included in the dataset as 0 for "female" and 1 for "male". There were outlier observations in Vitamin B, Vitamin D, TSH, and Folic Acid values. At this point, the strategy to follow regarding outliers was decided upon. Outliers were included in the dataset to minimize data loss; however, the possibility that models working with outliers would provide better performance results for this dataset was also considered. Missing values were imputed using the "missingno" library, one of the Python libraries. This library was adopted because it provided information about the columns in a dataset containing missing data and enabled visualization of the general model of missing data practically. The MinMaxScaler module from the Scikit-learn library was employed in the normalization process due to the varying ranges of the dataset's features.

Modelling

Some models that are suitable for the classification problem were utilized in the modeling phase. In this context, the preprocessed dataset was analyzed using ML algorithms. The 5-fold cross-validation method was administered during the analyses. In 5-fold cross-validation, the entire dataset was systematically partitioned into five subsets to be used for training and testing.

Following the preprocessing steps previously outlined and the implementation of 5-fold cross-validation, the following ML models were employed.

- Logistic Regression (LR): A regression method utilized to predict two or multiple dependent variables (10).
- Multinomial LR: LR outputs two classes, whereas multinomial LR accepts multiple data classes.
- Naïve Bayes (NB): This method can estimate the probabilities of class membership, specifically the likelihood that a specific sample is associated with a certain class. The Bayesian classifier is built upon Bayes' theorem (11).
- K-Nearest Neighbor (KNN): The KNN approach classifies new unlabeled data by identifying the classes of its neighboring data points.
- Artificial Neural Networks (NN): Computational systems designed to autonomously simulate the functions of the human brain, including the derivation, creation, and discovery of new information through self-learning. The network is trained with suitable data to enable generalization. This generalization identifies output sets that may correlate to similar events (12).
- Support Vector Machine (SVM): This method delineates margins between classes. The margins seek to optimize the separation between classes, hence reducing classification error (13). SVMs aim to identify the separating hyperplane that maximizes the margin between the classes to be categorized (14).
- Decision Trees (DTs): The primary objective is to derive significant insights from extensive datasets through applying decision rules.
- Random Forest (RF): The RF algorithm (15) is an ensemble learning method that integrates several classifiers to enhance model performance. The RF approach was developed to address the issues of prolonged model performance resulting from the complexities associated with overfitting or memorizing when the number of observations in decision trees is substantial.
- XGBoost: The XGBoost algorithm is based on the "boosting" approach of ensemble learning techniques. Boosting implies that a high-performing learner can be constructed by combining ensembles with poor-performing learners, each of which surpasses the others solely by chance (16).

- LightGBM: The primary distinction between LightGBM and conventional decision tree algorithms is that the tree is expanded leaf-wise rather than evaluating all preceding leaves for each new leaf.
- CatBoost: CatBoost (17) is a combination of the terms "Category" and "Boosting". It is a more sophisticated variant of gradient boosting-based decision trees that can effectively handle categorical variables within a dataset.
- ChefBoost: ChefBoost (18) is a basic decision tree framework for Python that supports categorical features. This method clearly illustrates the decisions taken by the tree to reach a specific prediction and supports Explainable Artificial Intelligence (XAI).

Ensemble methods were subjected to both manual and automated hyperparameter optimization strategies to guarantee best model performance. GridSearchCV and RandomizedSearchCV were used to manually tune combinations of important parameters including learning_rate, max_depth, n_estimators. Apart from manual tuning, AutoML-based systems—specifically Optuna, Hyperopt, and TPOT—were employed to quickly investigate a larger hyperparameter area. These techniques find high-performing configurations using sophisticated search techniques including genetic programming and Bayesian optimization.

Clinical Decision Support Systems Prototype (Deployment)

There are different and various risk assessment methods for AD. Currently, data-driven/data-informed "Clinical Decision Support Systems (CDSS)" automate these assessments and assist clinicians in their decision-making processes. In the most general sense, CDSS are computer systems to assist the clinician in patient-related decisions such as diagnosis and treatment (19). CDSS is also defined as "software designed to directly assist the clinical knowledge base with patient-specific assessments or recommendations, presented to the clinician or patient to make a decision (20). These systems, which were previously designed as rule-based, are currently handled within a ML-based approach thanks to the increase in health data. Therefore, systems trained from existing data and offer decision support accordingly can detect undiscovered patterns in the diagnosis of a disease. In the case of AD, a ML-based decision support system prototype has been presented within the scope of the study using the data described in Table 1.

The prototype for the CDSS was developed using Flask, a microframework designed in the Python programming language. Initially, the CatBoost model, which had been previously trained and achieved the highest score (refer to Results for details), was integrated into the system using the Flask structure. The model was saved as ***predMed.pkl***, and the test data was evaluated on the Web utilizing Flask technology. For this purpose, an interface was developed, and the trained model was activated by clicking the "Analyze Cognitive Status" button after inputting the value of each feature in the dataset into the system.

Figure 1 presents a sample data entry. As previously stated, the system defines 0 for "present" and 1 for "absent" values.

At this stage, validation procedures were also conducted. The objective was to verify whether the outcomes from the expert physician aligned with those generated by the developed prototype. For instance, experiments were conducted on a patient diagnosed with AD by a specialist physician, and it was observed that the same result was supported by the system.

Although a formal usability study did not test the CDSS interface with end users, a small-scale consistency check was carried out to compare the system's output with the decisions made by clinical experts. In certain cases, this first step helped the

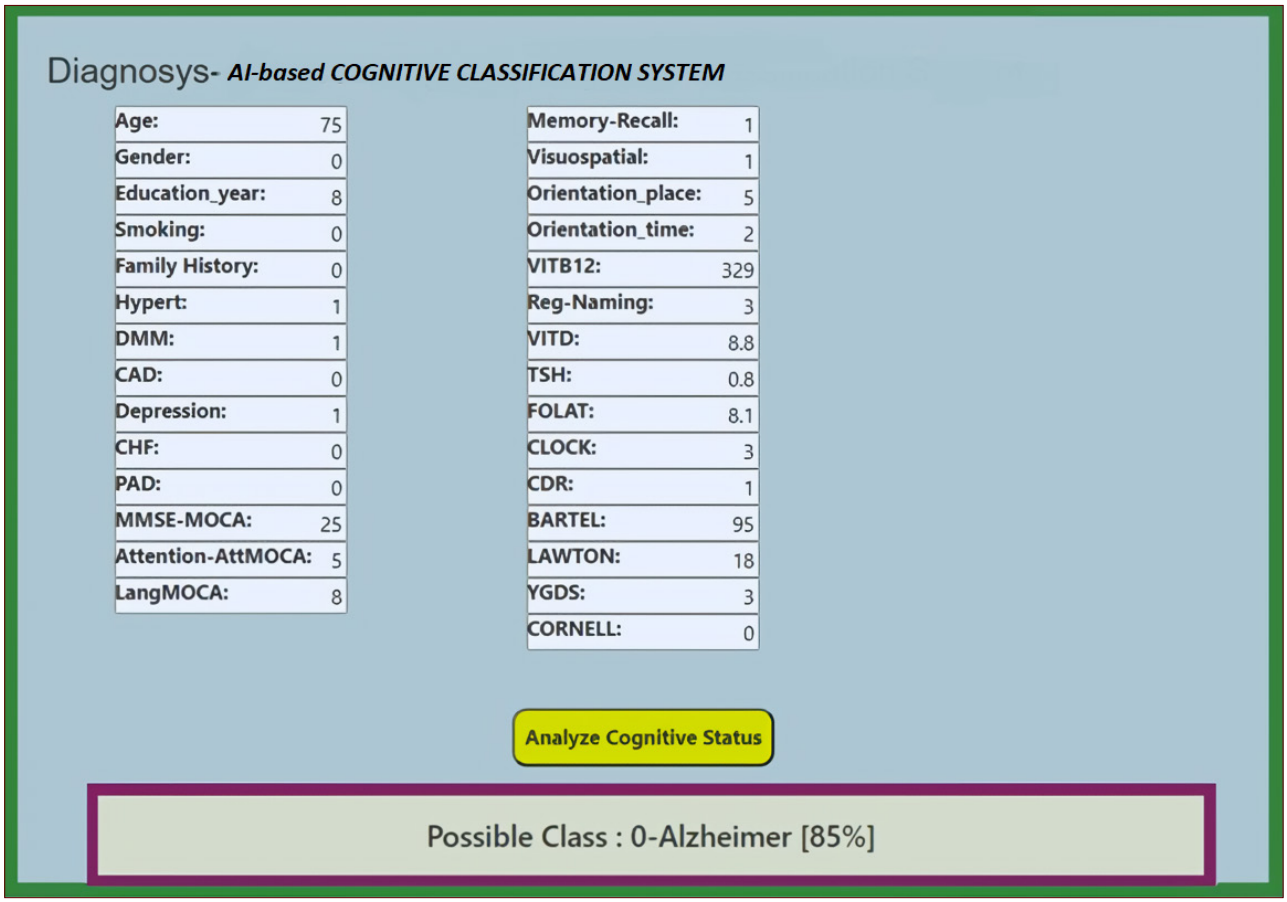


Figure 1. User Interface of the Prototype Clinical Decision Support System

model match expert judgment. As shown in Figure 1, the user interface allows input of patient data and displays the predicted cognitive class. In order to improve the system's clinical integration, future research might concentrate on thorough usability assessments conducted with medical experts.

RESULTS

This part presents the findings and interpretations derived from the application of several ML methods outlined in the "Modeling" section to the dataset. In overall accuracy, CatBoost algorithm (with hyperparameter optimization) demonstrated the highest performance (87.5%).

This was particularly advantageous in health datasets where domain knowledge might be scarce and hyperparameter optimization may provide challenges. In addition, precision, recall (TPR/sensitivity), and F1-Score were presented for each class specifically.

Table 2 illustrates the performance metrics for the AD classification. It can be asserted that ensemble learning methods outperform traditional methods for 176 samples in the AD class. Upon detailed analysis of Table 2, the XGBoost (fine-tuned) and CatBoost approaches were observed to exhibit the maximum recall. In the context of AD classification, recall quantifies a classification model's or diagnostic test's capacity to correctly

Table 2. Precision, Recall, and F1-Score for AD Class

Algorithm / Model	Precision (PPV)	Recall (TP rate)	F1-Score
LR	0.83	0.86	0.84
NB	0.86	0.72	0.79
KNN	0.81	0.78	0.79
MLP	0.78	0.82	0.8
SVM	0.79	0.83	0.81
DTs	0.73	0.72	0.73
RF	0.78	0.84	0.81
RF (fine-tuned)	0.78	0.93	0.85
XGBoost (fine-tuned)	0.71	1.00	0.83
LightGBM	0.7	0.97	0.81
CatBoost	0.74	1.00	0.85
ChefBoost	0.81	0.69	0.63

Table 3. Precision, Recall, and F1-Score for MCI Class

Algorithm / Model	Precision (PPV)	Recall (TP rate)	F1-Score
LR	0.65	0.55	0.60
NB	0.33	0.56	0.41
KNN	0.20	0.04	0.07
MLP	0.70	0.63	0.67
SVM	0.74	0.49	0.59
DTs	0.30	0.30	0.30
RF	0.75	0.18	0.29
RF (fine-tuned)	1.00	0.12	0.21
XGBoost (fine-tuned)	0.40	0.18	0.25
LightGBM	0.40	0.18	0.25
CatBoost	0.50	0.18	0.27
ChefBoost	0.14	0.20	0.17

identify all actual cases of AD, emphasizing the reduction of false negatives, wherein individuals with Alzheimer's are erroneously classified as non-AD.

The MCI class had the smallest sample size within the dataset; however, it could be regarded as an intermediate class. Diagnosing MCI is a challenging task, even for specialist clinicians, and marks the onset of cognitive decline, as well as the increased risk of developing AD. There are 73 instances of MCI in the sample. Analysis of Table 3 revealed that the MCI classification exhibits lower performance compared to the AD classification. This was mainly due to the insufficient quantity of data. As illustrated in Table 3, the RF method exhibited the highest precision value for MCI classification.



Table 4. Precision, Recall, and F1-Score for Healthy Subjects Class

Algorithm / Model	Precision	Recall (TP rate)	F1-Score
LR	0.88	0.95	0.91
NB	0.91	0.85	0.88
KNN	0.80	0.95	0.87
MLP	0.86	0.93	0.89
SVM	0.92	0.95	0.93
DTs	0.84	0.85	0.85
RF	0.84	0.98	0.91
RF (fine-tuned)	0.87	0.97	0.91
XGBoost (fine-tuned)	0.96	0.89	0.92
LightGBM	0.96	0.90	0.93
CatBoost	0.96	0.93	0.94
ChefBoost	0.85	0.81	0.83

Table 4 illustrates the classification outcomes for the "Healthy" class. Healthy cases comprised 351 instances within the sample. In this setting, analysis revealed that the healthy class attained better results in both statistical methods and more sophisticated ensemble learning models. The substantial volume of data was the primary explanation behind these outcomes.

DISCUSSION

The first notable result of the study was that the performance of the CatBoost model after hyperparameter optimization was observed as the highest compared to the other models, considering the accuracy rate. This finding is consistent with existing literature, which shows that RF or XGBoost performed better in clinical assessment (21,22).

The combined use of manual and AutoML-based hyperparameter tuning (including Bayesian and evolutionary strategies) contributed to the model's robustness and adaptability. This multi-pronged optimization approach may be especially valuable for clinical datasets where fine-tuning directly impacts diagnostic reliability.

In particular, as in the problem at hand, overfitting becomes a major concern due to the often small, imbalanced, and noisy nature of health datasets. The regularization mechanisms of CatBoost, including depth control and learning rate optimization, mitigate this issue. Another factor contributing to CatBoost's efficacy in the examined problem was the presence of missing values within the dataset, a common characteristic of health data. The CatBoost algorithm employs distinctive mechanisms to address missing values without necessitating imputation. It offers competitive performance relative to other algorithms with minimum hyperparameter tuning. In this sense, CatBoost's ability to perform high-scoring classification can also be attributed to its robustness to outliers. Health-related datasets can contain outliers that can affect model performance. Therefore, the robustness of CatBoost to outliers can be advantageous in these scenarios. CatBoost can effectively leverage multi-core CPUs and GPUs for accelerated training, which is essential for managing extensive health datasets.

The dataset exhibited class imbalance (AD: 176, MCI:73 HC: 351) among groups. To address this, class weights were adjusted during model training

to penalize misclassification of the minority class. In addition, model performance was evaluated using F1-Score which are more reliable in imbalanced classification problems. As a result, the CatBoost model was able to distinguish between healthy and AD class more efficiently.

RF method exhibited the highest precision value for MCI classification. The emphasis is on accurately identifying actual positive MCI cases. In other words, it assesses the model's efficiency in differentiating between cases that genuinely have MCI and those that do not. A high precision score indicates that the model effectively identifies individuals with MCI while maintaining a low false positive rate. In medical practice, it is crucial to reduce the probability of misdiagnosing an individual with MCI when they are not affected, as this may result in unnecessary stress and redundant testing.

Accurate differentiation of the healthy cohort is critical for research and therapeutic trials. This enables researchers to enhance their comprehension of AD progression and the efficacy of prospective treatments. Moreover, the recognition of healthy people can aid in pinpointing potential risk factors for AD by concentrating on their cognitive health. This may facilitate a deeper comprehension of the disease's etiology and possible prevention strategies. Consequently, the primary contribution of identifying healthy individuals would be to understand and, if necessary, redefine "healthy cognition" to uncover the deviations associated with AD.

While the developed model was able to differentiate the healthy and AD groups with high performance, it showed poorer performance in differentiating the MCI class from the healthy class. This result was also supported by another study (23). It was suggested that the reason for the relatively lower performance for the MCI class may be the smaller amount of data and, more importantly, the fact that the features defined for MCI but not for the other two classes (AD/HC) were not included in the dataset. At this point, the experiments conducted by increasing the number of data and the performance for the MCI class did not increase support this view.

Increasing the number of data, repeating the training process by feeding data to the model at certain intervals and examining the model performance, adding image data obtained as a result of brain imaging methods to the dataset, and combining different data types (such as using multimodal data) could increase the accuracy of the model.

Correlation analysis was performed to examine the relationships between key demographic and neuropsychological variables such as age, education, and test scores. Although these insights informed the understanding of feature interactions, explicit modeling of interaction effects was not implemented in the final CDSS model due to concerns related to model complexity and overfitting. Future studies could benefit from integrating feature interactions to enhance predictive accuracy and system interpretability.

When the study is considered within the scope of original value, the use of ML techniques (particularly, deep learning, ensemble learning, etc.) based on the purpose of the study can be made available to experts as a low-cost and non-invasive diagnostic tool. As far as examined, the literature contains no active decision support system.

In other words, it was observed that limited studies, especially studies using data based on neuropsychological and geriatric assessment, lacked the decision support part of deployment, especially when considered from the perspective of management information systems. In this sense, as the study suggested, an approach for automatic detection of Alzheimer's type dementia with ML-based methods can contribute to literature considering the diagnosis, treatment, and cost of AD.

The developed CDSS was designed as a tool to assist the clinicians. In other words, AI technologies



are not expected to replace the physicians, but to improve the decision process within the framework of human-AI collaboration.

LIMITATIONS

The most significant limitation of this study is the absence of neuroimaging data, which may enhance diagnostic performance when combined with clinical and cognitive features. However, the dataset used in this research was ethically approved for the use of only structured non-imaging data, including clinical, demographic, neuropsychological and comprehensive geriatric assessment features. Future studies may benefit from incorporating multimodal data, including neuroimaging, to further improve the predictive power and generalizability of ML models in AD classification.

While the interaction between age, education, and MMSE scores was not explicitly modeled, a partial dependence analysis conducted during the development phase showed that age had a relatively limited marginal effect on model predictions. Nevertheless, it is widely acknowledged in the literature that age and education level significantly influence MMSE scores.

Although interaction-based interpretability methods such as SHAP (SHapley Additive exPlanations) and PDP (Partial Dependence Plots) were not elaborated in this paper, they were explored in detail in a complementary study focused on the same dataset (24). Different XAI methods for comprehensive interaction analysis between these factors should be considered in future studies.

The application developed within the scope of the study can be characterized as context-specific research; therefore, its generalizability is limited. The most important reason is modeling of the decision-making process of two specialist physicians as decision makers. It is believed that the more expert opinions are included in the decision-making process, the higher the generalizability.

CONCLUSION

In this age with paramount data, the healthcare sector experiences a significant data revolution. In recent years, advancements in AI within healthcare have been accelerated by hardware and software solutions that enhance data collection. The healthcare ecosystem comprises several distinct stakeholders, including patients and their families, clinical care teams, public health program managers, hospital administrators, and researchers. Patients constitute a fundamental component of this ecosystem. They consistently produce data and transmit it to various applications.

The use of ML methods in the early diagnosis of neurodegenerative diseases like AD has attracted the attention of both researchers and clinicians. As a subfield of AI, ML methods can detect AD in advance. These approaches possess the capability to forecast MCI during the progression to AD.

The study aimed to classify patients as healthy, having MCI, or diagnosed with AD through classification techniques. Given the group's considerable heterogeneity and sensitivity to external influences, it is anticipated that employing ML to derive uniform outcomes from this data, particularly in forecasting the impact of these external factors on the results, will enhance the originality of the study.

The CDSS is positioned as an aid to expert clinicians. (25) supports this view by stating that AI can contribute to a more efficient and modern healthcare system by redesigning roles in the healthcare ecosystem, and human-in-the-loop highlights a collaborative partnership between AI and human expertise to optimize outcomes.

Given the proposed system will form an infrastructure for further research, the potential to facilitate the follow-up of individuals with AD is another advantage of the study. It is thought that the system proposed within the study can help detect the disease before it progresses, slow down

the course of the disease by focusing on modifiable risk factors in the early period, or apply existing treatment approaches.

In this context, the suggested and planned studies can be summarized as follows:

- Especially in the context of AD, the datasets available in Türkiye are quite limited. Considering the cultural effects of the disease, studies should be carried out to create a dataset.
- Results with data from different hospitals should be compared.
- Since the health status is dynamic and changing over time, especially when neurodegenerative diseases are considered, it is planned to obtain the data of the same patient at different time intervals to monitor the course of the disease more effectively.

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ORIGINAL ARTICLE

THE IMPACT OF THE CLINICAL FRAILTY SCALE ON PROSTHESIS SELECTION AND EARLY MORTALITY IN ELDERLY PATIENTS UNDERGOING AORTIC VALVE REPLACEMENT

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Abstract

Introduction: This study explored the impact of the Clinical Frailty Scale on prosthesis selection and early postoperative outcomes in elderly patients undergoing surgical aortic valve replacement.

Materials and Method: In this retrospective cohort study conducted at a single center, patients aged ≥ 65 years who underwent isolated aortic valve replacement between January 2023 and January 2025 were examined. The Clinical Frailty Scale was used to evaluate preoperative frailty and categorize patients into three frailty levels. Data on implanted valves (mechanical, conventional bioprosthesis, and sutureless bioprosthesis), operative details, and 30-day mortality were collected. Multivariate regression models were used to identify significant associations.

Results: A total of 122 patients were included in the study. Patients with higher Clinical Frailty Scale scores were more likely to receive sutureless valves ($p<0.001$). Clinical Frailty Scale was a moderate predictor of early mortality, with an odds ratio of 3.66 and 95% confidence interval of 1.31–10.18 ($p = 0.010$), outperforming EuroSCORE II in predictive accuracy (AUC 0.71 compared to 0.63). Patients with sutureless valves had shorter intensive care unit and hospital stays ($p<0.001$), whereas complications remained consistent across the valve types. A weak but significant positive correlation was observed between prosthesis size/body surface area ratio and 30-day mortality (Spearman's $\rho=0.186$; $p=0.040$).

Conclusion: The Clinical Frailty Scale is a significant indicator of valve selection and prediction of early postoperative mortality in elderly patients undergoing aortic valve replacement. Incorporating frailty evaluation into pre-surgery planning could improve outcomes in this at-risk group.

Keywords: Transcatheter Aortic Valve Replacement; Frailty; Aged; Mortality; Heart Valve Prosthesis; Risk Assessment.

INTRODUCTION

By 2030, one in every six people in the world will be aged 60 years or older, according to the World Health Organization (WHO) (1). As the population ages and life expectancy increases, the number of elderly patients requiring cardiac surgical interventions will also increase. Aortic stenosis is one of the most common valvular heart diseases across all age groups, but particularly among individuals > 65 years of age, surgical aortic valve replacement (AVR) is the most effective therapy (2). However, for older patients, the decision to proceed with AVR is increasingly complicated because of aging-associated health burdens and frailty.

Frailty is a multifactorial syndrome characterized by an age-related decline in physiological reserves, leading to increased vulnerability to stressors. It is not just a function of age and may vary significantly between people of the same age. It has been widely documented that frailty independently predicts poor surgical outcomes in older adults, including longer length of stay, higher complication rates, and higher mortality (3-5).

Risk assessment tools, such as EuroSCORE II and the Society of Thoracic Surgeons (STS) score, analyze patient demographics and pre-existing comorbidities to determine surgical risk. However, frailty is often omitted from these models, which may underestimate perioperative risks in patients, especially in older and frail populations (6).

The Clinical Frailty Scale (CFS) is a simple and widely used measure of frailty (7). This scale, which ranges from 1 (very fit) to 9 (terminally ill), covers a 9-point spectrum and enables rapid assessment of a patient's frailty at the bedside. The CFS is a sensitive clinical test for predicting postoperative complications and mortality (8-10); therefore, it is increasingly incorporated into preoperative evaluations. The increasing prevalence of aortic valve disease in the aging population necessitates a comprehensive approach to preoperative risk assessment, with a particular focus on frailty, as chronological age alone is not a sufficient indicator of surgical suitability (11).

Although frailty is gaining recognition as an essential factor, limited data exist regarding its impact on prosthetic valve choice in this population undergoing surgical AVR. Age, life expectancy, comorbidities, and anatomical characteristics generally dictate the decision of mechanical versus traditional stented bioprosthetic versus sutureless valves. However, the impact of frailty on clinical decision-making has yet to be fully studied (12).

This study aimed to evaluate the impact of CFS on prosthetic valve selection and early postoperative outcomes, particularly 30-day mortality, in elderly patients undergoing AVR. We hypothesized that higher frailty scores would be associated with poor early outcomes and a higher tendency to choose less invasive valve types in this high-risk cohort.

MATERIALS AND METHOD

This retrospective observational cohort study was a single-center study conducted at a tertiary cardiac surgery center. Ethical approval was granted by the institutional ethics committee before data collection (approval number: AEŞH-BADEK-2025-0660).

All patients aged ≥ 65 years who underwent surgical AVR at our center between January 2023 and January 2025 were included in the study. Patients who underwent emergency surgery, had active malignancy, had incomplete preoperative or postoperative data, or did not have documented CFS evaluation were excluded. After excluding patients based on these criteria, 122 patients were included in the final analysis.

Preoperative frailty was measured using the Clinical Frailty Scale (CFS) derived from the Canadian Study of Health and Aging (CSHA) (Table 1) (10). The CFS is measured on a 9-point scale, where scores can range from 1 (very fit) to 9 (terminally ill), allowing for a quick assessment of frailty in patients. The patients were classified into three groups according to their

Table 1. Canadian Study of Health and Aging (CSHA) Clinical Frailty Scale.

CFS Score	Clinical Description
1	Very fit
2	In good condition
3	Well managed
4	Vulnerable (mild frailty)
5	Mild frailty
6	Moderate frailty
7	Severe frailty
8	Very severe frailty
9	Terminally ill

CFS = Clinical Frailty Scale

CFS scores: low (1–3), moderate (4–5), and high (≥ 6) frailty. These assessments were conducted by trained personnel from the cardiovascular surgery team during the preoperative evaluation. The individual EuroSCORE II was calculated to estimate the surgical risk (13). Transthoracic echocardiography was performed before surgery in all patients to evaluate valvular problems and left ventricular function. The body surface area (BSA) was calculated using the Mosteller formula, and the prosthesis size/BSA ratio was calculated for each patient.

The surgical approach was through median sternotomy with cardiopulmonary bypass and moderate hypothermia. Decisions regarding prosthetic valves (mechanical, stented bioprosthetic, or sutureless bioprosthetic) were based on patient age, concomitant illness, anatomical features, and frailty status. Prosthesis selection was not dictated by a rigid institutional algorithm; rather, it was informed by a combination of clinical judgment and consensus among the attending surgeons. Considerations included patient age, anatomical suitability, comorbid burden, functional capacity, and notably, frailty status as assessed by the CFS. Patients and their families participated in the final shared decision-making process, consistent with institutional patient-centered care protocols. Postoperative care was performed according to the institution's standardized protocol. The primary endpoint was all-cause mortality 30 days post-surgery. The secondary outcomes were notable complications after the procedure (bleeding, arrhythmia, and infection), duration of intensive care unit (ICU) stay, and total hospital stay length. Surgical complications were defined according to the Society of Thoracic Surgeons (STS) criteria (14).

Statistical Analysis

IBM SPSS Statistics software (version 26; IBM Corp., Armonk, NY, USA) was used for statistical analyses. Continuous variables were evaluated for normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as frequencies and percentages. Depending on the valve type, group comparisons were made for continuous variables: CFS, EuroSCORE II, ICU and hospital stay, and prosthesis size/BSA ratio. Normally distributed variables were analyzed using one-way analysis of variance (ANOVA), whereas the Kruskal–Wallis test was applied to non-normally distributed variables. For post-hoc tests, we used Tukey's test after ANOVA and the Mann–Whitney U test after the Kruskal–Wallis test. Independent predictors of prosthetic valve type were identified using a multinomial logistic regression approach, and the independent variables included CFS, EuroSCORE II score, age, sex, and significant comorbidities (diabetes mellitus, chronic obstructive pulmonary disease, and chronic kidney disease). Multivariable analysis using logistic regression was performed to identify 30-day mortality predictors, with results presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Receiver operating characteristic (ROC) curve analysis was used to assess the power of the CFS and EuroSCORE II in predicting 30-day mortality, with the AUC calculated. The relationships between the selected variables were evaluated using Spearman's rank correlation coefficient. The Youden Index



was used to establish the optimal cutoff points in the ROC analysis. A p-value of less than 0.05 was considered statistically significant.

Our cohort analysis revealed significant findings regarding the impact of frailty on surgical outcomes.

RESULTS

The baseline demographic and clinical characteristics of the 122 patients included in the study are summarized and organized according to their frailty levels in Table 2. There was a notable correlation between increased frailty and older age; individuals in the high frailty category (CFS ≥6) had an average age of 72.6 ± 3.9 years, whereas those in the low frailty category (CFS 1–3) had an average age of 68.1 ± 3.5 years ($p < 0.001$). Additionally, EuroSCORE II values increased with the severity of frailty, with the high frailty group showing an average of 5.2 ± 1.3%, compared to 1.9 ± 0.8% in the low frailty group ($p < 0.001$), suggesting a heightened surgical risk for frail patients.

Patients with frailty exhibited a higher incidence of comorbidities. Hypertension and diabetes mellitus were notably more common in individuals with moderate-to-high frailty than in those with low frailty ($p = 0.046$ and $p = 0.049$, respectively). Conversely, there were no significant differences between the groups regarding sex distribution or prevalence of chronic obstructive pulmonary disease (COPD) ($p = 0.673$ and $p = 0.121$, respectively).

Table 3 outlines the postoperative outcomes categorized according to the valve type. Patients received days and hospital stay, with an average stay of 1.6 ± 0.6 days, and the hospital stay averaged 5.1 ± 1.9 days. In comparison, those with conventional bioprosthetic valves experienced longer ICU stays (2.4 ± 0.8 days) and hospital stays (7.6 ± 2.4 days).

Table 2. Baseline Characteristics of Patients by Frailty Group (CFS)

Characteristic	CFS 1–3 (n=27)	CFS 4–5 (n=58)	CFS ≥6 (n=37)	p-value
Age (mean ± SD)	68.1 ± 3.5	70.3 ± 4.2	72.6 ± 3.9	<0.001
Male sex (%)	66.7%	65.5%	59.5%	0.673
EuroSCORE II (%)	1.9 ± 0.8	3.6 ± 1.1	5.2 ± 1.3	<0.001
Hypertension (%)	55.6%	70.7%	78.4%	0.046
Diabetes Mellitus (%)	18.5%	31.0%	40.5%	0.049
COPD (%)	7.4%	13.8%	18.9%	0.121

P-values were calculated using ANOVA or chi-square tests as appropriate. CFS: Clinical Frailty Scale, SD: Standart Deviation, COPD: Chronic Obstructive Pulmonary Disease

Table 3. Postoperative Outcomes by Valve Type

Outcome	Mechanical (n=45)	Bioprosthetic (n=41)	Sutureless (n=36)	p-value
ICU stay (days, mean ± SD)	2.9 ± 1.0	2.4 ± 0.8	1.6 ± 0.6	<0.001
Hospital stay (days)	8.3 ± 2.7	7.6 ± 2.4	5.1 ± 1.9	<0.001
Post-op complications (%)	22.2%	17.1%	16.7%	0.622
30-day mortality (%)	8.9%	9.8%	13.9%	0.547

ICU: Intensive Care Unit

Similarly, individuals with mechanical valves spent 2.9 ± 1.0 days in the ICU and 8.3 ± 2.7 days in the hospital ($p < 0.001$ for both comparisons). These data suggest that sutureless valves may promote more rapid recovery.

Postoperative complication rates were not significantly different between the groups ($p = 0.622$). Major complications, including atrial arrhythmias and sternal wound infections, occurred at comparable rates across all groups. The 30-day mortality rate was similar across valve types, with mechanical valves at 8.9%, conventional bioprosthetic valves at 9.8%, and sutureless valves at 13.9 %($p = 0.547$), suggesting that sutureless valves may enhance operative efficiency without affecting short-term safety. Prosthesis–patient mismatch was assessed using the prosthesis size-to-body surface area (size/BSA) ratio. This ratio was highest in patients with conventional bioprostheses (mean, 12.97) and slightly lower in those with mechanical and sutureless valves. Among the valve types, patients with mechanical valves exhibited significant variations in size/BSA ratios (Kruskal–Wallis $H = 8.53$, $p = 0.014$).

Analysis of the relationship between the size/BSA ratio and 30-day mortality revealed a weak but statistically significant positive correlation (Spearman $\rho = 0.186$, $p = 0.040$). This finding indicates that smaller ratios may be associated with increased early mortality rates. Conversely, no significant correlation was observed between the size/BSA ratio and incidence of complications. The optimal cutoff for the size/BSA ratio, determined through ROC analysis, was 11.17, which resulted in 100% sensitivity but only 29% specificity. While this suggests a theoretical potential for identifying high-risk patients, its practical value in discrimination may be limited owing to its low specificity. The overall 30-day in-hospital mortality rate was 10.7% (13 of 122 patients). In the multivariable logistic regression analysis, CFS emerged as the sole significant independent predictor of early mortality (odds ratio [OR], 3.66; 95% CI: 1.31–10.18; $p = 0.010$). Neither EuroSCORE II nor valve type was independently associated with 30-day mortality ($p = 0.185$ and $p = 0.481$, respectively) (Table 4). The size/BSA ratio approached statistical significance ($p = 0.098$).

In the ROC analysis assessing the predictive capabilities of CFS and EuroSCORE II, CFS demonstrated a superior AUC of 0.71 (95% CI: 0.61–0.81) compared to EuroSCORE II, which had an AUC of 0.63 (95% CI: 0.56–0.71) (Figure 1). Notably, the group with moderate frailty (CFS 4–5) exhibited the highest 30-day mortality rate at 13.8%, followed by the high frailty group (CFS ≥6) at 10.8% and the low frailty group (CFS 1–3) at 3.7%. A regression model was developed to explore this nonlinear pattern, which included both CFS and its squared term (CFS^2) in the model. Both variables were statistically significant ($p = 0.039$ for CFS and $p = 0.047$ for CFS^2), suggesting a nonlinear inverse U-shaped relationship between frailty and early mortality.

Table 4. Multivariate Logistic Regression for 30-day mortality

Variable	Odds Ratio (OR)	95% CI	p-value
Clinical Frailty Score	3.66	1.31 – 10.18	0.010
EuroSCORE II	1.19	0.92 – 1.54	0.185
Valve Type (Sutureless vs others)	1.44	0.52 – 3.98	0.481
Size/BSA	2.03	0.87 – 4.75	0.098

CI: Confidence Interval; BSA: Body Surface Area

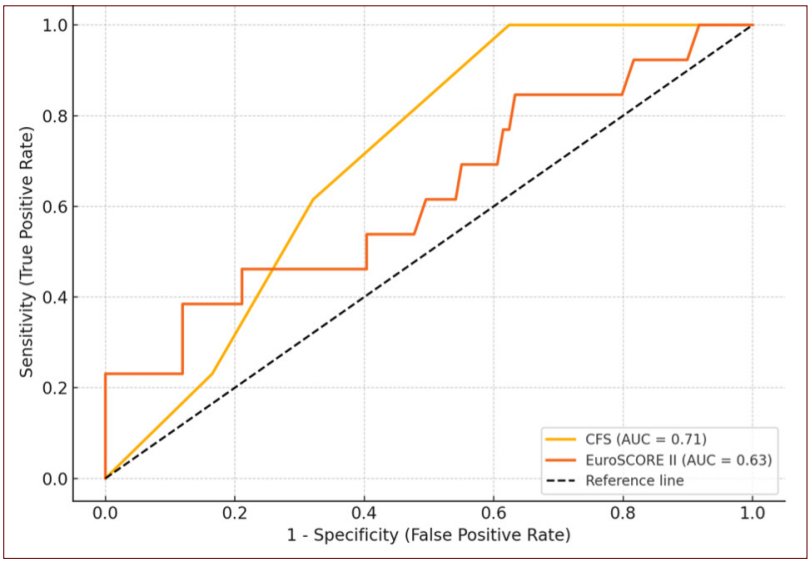


Figure 1. Receiver operating characteristic (ROC) curves comparing the predictive performance of the Clinical Frailty Score (CFS) and EuroSCORE II for 30-day mortality. The CFS demonstrated better discrimination with an AUC of 0.71 compared to EuroSCORE II (AUC = 0.63). The reference line represents the performance of the non-informative classifier.

DISCUSSION

As the global population ages, the number of elderly patients presenting with aortic stenosis and requiring surgical intervention is expected to rise substantially, making the accurate assessment of surgical risk in this vulnerable population increasingly critical. The aging process results in greater susceptibility to frailty, a multifaceted syndrome characterized by decreased physiological reserve and increased vulnerability to stressors. Frailty is not merely a consequence of age but a distinct clinical entity that significantly impacts surgical outcomes, leading to increased morbidity and mortality and prolonged hospital stays (8).

This study explored the association between frailty and early postoperative outcomes in older patients undergoing isolated surgical aortic valve replacement (AVR). Our results emphasize that frailty, as measured by the Clinical Frailty Scale (CFS), is not only a crucial indicator of early mortality but also significantly influences prosthesis selection. The notably higher use of sutureless bioprosthetic valves in patients with higher CFS scores indicates a conscious choice to reduce operative time and invasiveness in frail individuals with aortic stenosis. This is consistent with increasing evidence supporting sutureless valves as a suitable option for high-risk groups, mainly because they can decrease cardiopulmonary bypass and aortic cross-clamp duration. Filip et al. also showed that sutureless valves provide hemodynamic benefits and promote quicker recovery in frail patients (15).

However, frequent mechanical valve implantation in patients with low CFS scores indicates an expected longer lifespan and a remarkable ability to manage lifelong anticoagulation therapy. This trend supports the growing perspective that treatment choices should be based on a detailed evaluation of functional status and biological reserves rather than age (16, 17). Notably, the group with moderate frailty (CFS 4–5) experienced the highest 30-day mortality rate, which was unexpected, as it was not the severely frail group. This surprising outcome might be due to a "selective patient effect," where those with severe frailty were more thoroughly screened, optimized before surgery, or given nonsurgical treatment options (18, 19). In contrast, those with moderate frailty might be marginally operable but still have significant physiological risks. These findings imply

that the link between frailty and mortality may not be straightforward but could follow an inverse U-shaped pattern, a theory supported by our regression analysis that includes both linear and quadratic CFS terms. It is important to note that less invasive valve implantation options should be considered, especially in patients with moderate fragility.

Moreover, CFS showed a more remarkable ability to predict early mortality than EuroSCORE II, as indicated by the higher AUC in the ROC analysis. These results align with those of earlier studies, such as that of Afilalo et al., who found that frailty offers additional prognostic value beyond conventional surgical risk scores (20). In our multivariate analysis, CFS was identified as a significant independent predictor of 30-day mortality, highlighting its importance as a vital element in the preoperative evaluation of older adult patients undergoing cardiac surgery. This implies that including frailty assessments in risk stratification can improve the accuracy of predicting surgical results, enabling clinicians to make better decisions and customize treatment plans for each patient (21).

Although the prosthesis size-to-BSA ratio (size/BSA) was not an independent predictor of mortality, it exhibited a slight but significant link to 30-day mortality rates. This ratio may indicate prosthesis–patient mismatch (PPM), which has been associated with poor hemodynamics and unfavorable long-term outcomes, particularly in individuals with smaller body surface areas (22). However, its low specificity at the determined threshold limits its effectiveness as a standard tool in clinical settings. The shorter ICU and hospital stays observed in the sutureless valve group have practical implications for healthcare systems, indicating the potential for decreased resource utilization and cost savings. These operational benefits, coupled with similar safety profiles, could support the broader adoption of sutureless technology in certain elderly and frail patients (23). It is essential to recognize that the selection of prostheses was guided by individualized clinical judgment rather than standardized institutional protocols. While this approach reflects real-world decision-making, it introduces the potential for selection bias. For example, surgeons may have opted for sutureless valves for more frail patients to minimize cross-clamp and bypass durations. Although this aligns with pragmatic care strategies, it complicates causal inference regarding the relationship between valve type and early outcomes. Future research should consider stratifying valve selection within protocolized frameworks to better isolate treatment effects. Overall, our findings advocate for the inclusion of frailty assessment in routine preoperative evaluation. The CFS can facilitate more tailored decision-making and risk assessment owing to its simplicity and clinical significance. Incorporating frailty into surgical planning may enhance patient outcomes and boost system efficiency in the context of an aging population with increasingly complex health needs.

However, certain limitations should be recognized. The retrospective nature of this study, which was conducted at a single location, may limit its applicability to broader contexts. A significant methodological limitation of this study is the reliance solely on the Clinical Frailty Scale (CFS) for assessing frailty. Although the CFS is a validated and expedient bedside tool commonly utilized in cardiovascular surgery, alternative frailty indices, such as the Fried Frailty Phenotype, which focuses on physical performance, and the Edmonton Frailty Scale, which includes broader multidimensional domains (e.g., cognition, mood, social support), could have offered a more comprehensive evaluation (24). The lack of comparative assessment may constrain the generalizability and robustness of the findings across diverse geriatric populations.

Additionally, the study did not evaluate outcomes beyond a 30-day period, leaving the long-term effects unexamined.

CONCLUSION

This study highlights that the Clinical Frailty Scale (CFS) serves as a strong and independent indicator of prosthesis choice and early mortality in older patients undergoing surgical aortic valve replacement (AVR). Unlike traditional surgical risk models, such as EuroSCORE II, CFS offers a more precise biological resilience and functional reserve assessment, allowing for more detailed risk stratification in this susceptible group. Our findings indicate that patients with higher frailty scores were more inclined to receive sutureless valves, which were linked to notably shorter stays in the ICU and hospital without compromising early safety. Notably, the highest early mortality rate was observed in the moderately frail group, indicating a nonlinear association between frailty and negative outcomes, underscoring the importance of more detailed preoperative evaluations.

Regularly incorporating frailty assessments, especially using a practical and scalable tool such as the CFS, can aid in tailoring treatment plans, optimizing resource use, and ultimately improving surgical outcomes in older adults. Frailty should be evaluated along with traditional risk scores to guide valve selection and surgical strategy. Future multicenter prospective studies are needed to confirm these findings, evaluate long-term survival and quality of life outcomes, and create standardized protocols for integrating frailty into surgical decision-making processes. As cardiac surgery advances in the aging population, adopting approaches that consider frailty will be crucial for providing high-value and patient-centered care.

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ORIGINAL ARTICLE

THE EFFECTS OF VIRTUAL REALITY-BASED EXERCISE ON PAIN AND FUNCTION IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS: A RANDOMIZED CONTROLLED STUDY

Abstract

Introduction: This study aimed to investigate the effects of virtual reality therapy on pain, joint stiffness, physical function, balance, and fall risk in patients with knee osteoarthritis.

Materials and Method: A total of fifty-four patients with primary knee osteoarthritis were randomly assigned into three equal groups. The first group received conventional physiotherapy, the second group received conventional physiotherapy combined with virtual reality-based training, and the third group received virtual reality-based training alone. All participants underwent fifteen sessions over a three-week period. Pain was evaluated using the visual analog scale; functional status, stiffness, and physical function were assessed with the Western Ontario and McMaster Universities Osteoarthritis Index. Balance was assessed with the Berg Balance Scale, and fall risk was evaluated using the Tetrax posturography system.

Results: Statistically significant improvements were found in all groups in terms of pain, stiffness, physical function, and balance after treatment ($p < 0.001$). However, pain, physical function, and total osteoarthritis index scores were significantly better in the first and second groups compared to the third group ($p < 0.05$). In the stiffness subscale, the first group showed greater improvement than the second group ($p = 0.026$). No significant differences were detected among the groups in balance or fall risk scores ($p > 0.05$).

Conclusion: Although virtual reality therapy alone has positive effects on patients with knee osteoarthritis, it appears to be less effective than conventional physiotherapy or its combination with virtual reality. Virtual reality may serve as a supportive method within conventional rehabilitation programs.

Keywords: Osteoarthritis; Pain; Virtual Reality; Accidental Falls.

INTRODUCTION

Osteoarthritis (OA) is the most common chronic joint disease and one of the leading causes of disability worldwide (1). It is a degenerative joint disorder characterized by articular cartilage destruction, subchondral sclerosis, osteophyte formation at the joint margins, synovial inflammation, and thickening of the joint capsule (2).

Pathological differences in osteoarthritis are observed not only in the cartilage but also in all joint structures (3). These changes lead to pain, muscle weakness, decreased proprioception, and functional impairment (4). In addition to pain, patients may experience loss of function and muscle strength, muscle atrophy, exercise intolerance, and difficulty walking. As a result, the risk of falling increases, and quality of life decreases. The primary goals of treatment are to restore functional status, reduce pain, improve range of motion, and ultimately enhance quality of life (5).

Virtual reality therapy (VRT) is an effective computer-assisted application in which patients are exposed to stimuli in fully controllable environments. Virtual reality (VR) systems facilitate correct use of the body's balance mechanisms and promote proper exercise through visual and auditory biofeedback. They also enhance individual motivation by providing an engaging and interactive environment (6). Virtual Reality has been successful in a variety of applications, including acquired brain injury, neurological disorders, orthopedic problems, and anxiety (7).

The BTS Nirvana is a device that analyzes a patient's movements in a virtual environment with optoelectronic infrared sensors. The system is projected onto a main screen via a projector and includes a wide range of exercises targeting the trunk, lower and upper extremities, as well as cognitive functions (8).

Recent studies have investigated the integration of virtual reality in the rehabilitation of knee OA, particularly for improving balance and reducing pain. For instance, Wibelinger et al. reported that VR exercises improved WOMAC stiffness and balance in elderly OA patients, while conventional physiotherapy was more effective in reducing pain and physical limitations (9). Similarly, Lin et al. found that active video game therapy showed similar pain relief compared to traditional exercises. However, these studies often differ in terms of patient population, treatment protocols, and outcome measures, making their findings difficult to generalize (10). Moreover, there is limited data directly comparing VR alone, VR combined with conventional physiotherapy, and conventional physiotherapy alone. Therefore, further investigation is needed to clarify the specific contributions and effectiveness of VR-based interventions in knee OA rehabilitation.

In our study, we used the BTS Nirvana virtual reality system and we planned this randomized-controlled prospective study to compare the effects of the VR system combined with conventional exercises on pain, disability, fall risk, and balance in patients with primary knee OA.

MATERIALS AND METHOD

Patients

This single-blinded randomized controlled and prospective trial was conducted at the Physical Therapy and Rehabilitation Clinic between February 2020 and February 2021. Fifty-four patients with primary knee OA were included in the study. The inclusion criterion was patients with Kellgren-Lawrence stage 2 or 3 knee OA , who agreed to participate in the study, and were 40-75 years of age. The exclusion criteria were as follows: cognitive dysfunction; inability to stand without support; visual and auditory disorders; knee surgery or injection in the last 6 months; systemic or localized infection; cancer, and systemic diseases that affect balance and participation in exercise (neurological



disorders such as cerebrovascular diseases and multiple sclerosis).

The participants were randomly allocated to three groups via a computer-generated randomization sequence. The demographic data of all participants were obtained at baseline. Clinical measurements were taken before and after treatment. Eighteen patients received a conventional rehabilitation program. The second group (n=18) received a VRT program in addition to conventional therapy. The third group (n=18) received only one VRT program. All patients completed the study and participated in all the measurements. Written and verbal consent was obtained from all patients. In accordance with the Helsinki Declaration, the study complied with all ethical standards. The present study was approved by the Clinical Research Ethics Committee with the decision number 80558721-050.99-E.26788.

Intervention

The first group received a 40-minute conventional exercise therapy program consisting of strengthening, stretching, and range of motion (ROM) exercises targeting the lower extremities, particularly the quadriceps, hamstrings, gastrocnemius, and hip abductors. Strengthening exercises were performed using body weight and resistance bands in 3 sets of 10 repetitions, with a 30-second rest between sets. Stretching exercises focused on the hamstrings, calves, and hip flexors, and were held for 20–30 seconds each. Active and passive ROM exercises for the knee joint included flexion and extension movements to maintain or improve joint mobility.

The second group received the same 40-minute conventional program followed by an additional 20-minute VR-based exercise session using the BTS Nirvana system. The third group participated in VR-based training only, for 20–25 minutes per session. All patients underwent treatment five days a week for three weeks, completing a total of 15 sessions.

Virtual Reality Training

In our study, the virtual reality training BTS Nirvana system (BTS, Italy) was used. This system incorporates optoelectric infrared sensors to enable patients to interact with their movements in a virtual environment, projected onto a large screen. The system analyzes patient movements and generates various exercises targeting the trunk, lower extremities, upper extremities, and cognitive processes. Exercise lists and scores are displayed on the screen for monitoring (7). A total of 15 sessions of treatment, 5 sessions per week, were applied to the participants. Considering the variability in rest periods, each session lasted between 20–25 minutes. Five predetermined virtual applications were used (Panda tracking, leaf sweeping, guitar stringing, mole catching, and moonwalking). The application was carried out under the supervision of a clinician, with verbal or physical intervention when necessary. Beyond this intervention, the clinician was not involved in patient evaluations (Figure 1).

Measurements

A blinded physician unaware of the treatment allocation performed the clinical assessments at baseline and at the end of the therapy. The visual analog scale (VAS) was used for pain, the Western Ontario and McMaster Universities Arthritis Index (WOMAC) was used for functional capacity and disability, the Berg balance Scale (BBS) was used for balance, and the Tetrax system was used for fall risk. In addition, knee joint range of motion, including flexion and extension angles, was measured using a standard goniometer by the same physician, following standardized procedures.

Visual Analog Scale

The pain levels of the patients at rest and with activity were evaluated with the VAS. No pain was reported as 0, the most severe pain felt in life was 10, and the patients were asked to indicate the

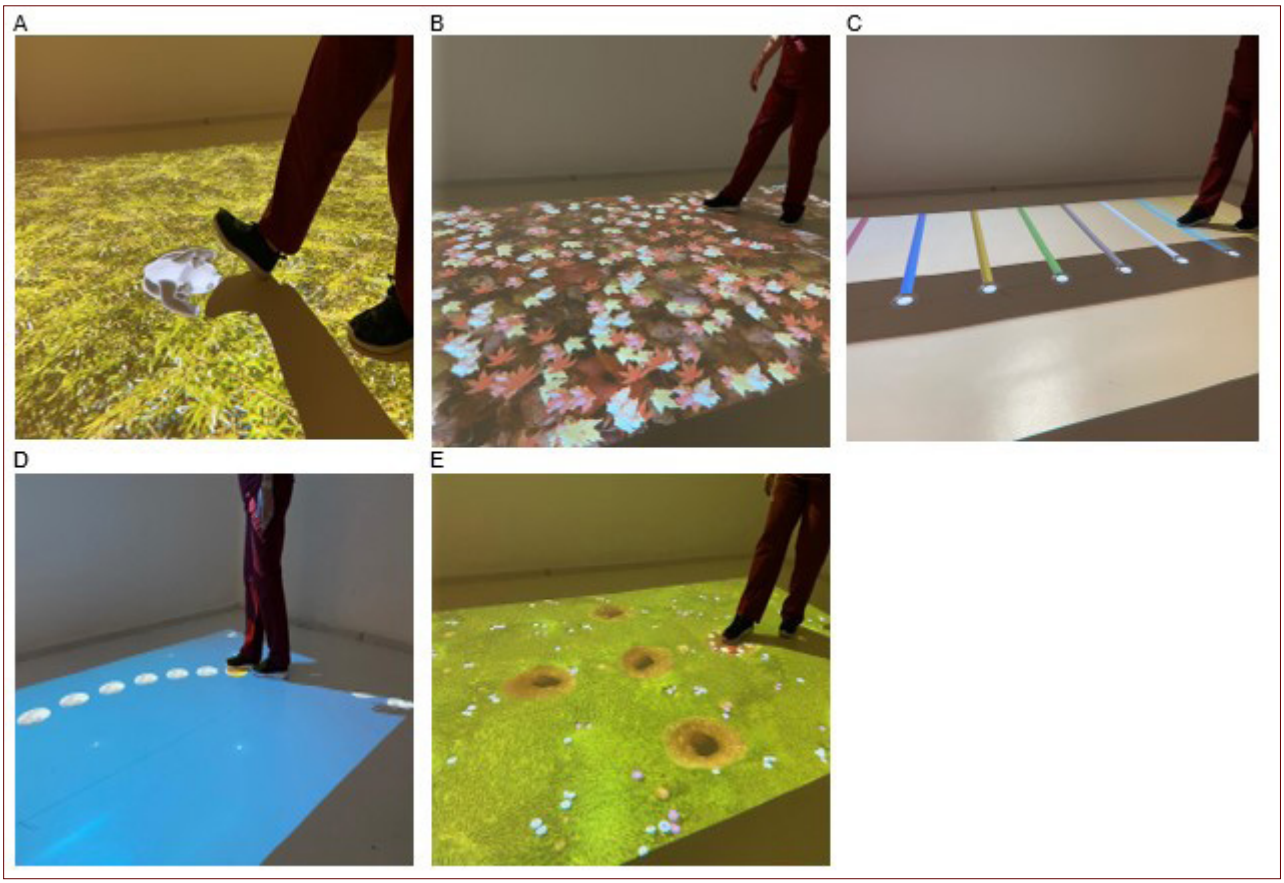


Figure 1. Virtual Reality Applications
A) Patients track a projected panda to enhance agility. B) Leaf-Sweeping: Balancing on one leg, patients sweep leaves to improve stability. C) Guitar String Walking: Virtual string steps produce sounds, aiding coordination. D) Moon-Stepping: Stepping on moons alters their color, enhancing balance. E) Mole Catching: Catching random moles improves reaction speed and control.

average pain intensity experienced in the previous week (11).

Western Ontario and McMaster Universities Arthritis Index

The WOMAC is the most widely used scale to determine functional capacity and disability in patients with knee osteoarthritis. It is evaluated in 3 categories: pain, stiffness, and physical function. It consists of 24 questions, 5 for pain, 2 for stiffness, and 17 for physical function. In the Likert version, each question is scored between 0 and 4, with scores of 0: none; 1: light; 2: moderately severe; 3: severe; 4: very severe; low scores indicate low-level symptoms. The maximum scores that can be obtained are 20, 8, and 68 points for pain, stiffness, and physical function, respectively (12). The validity and reliability of the WOMAC osteoarthritis index in Turkey were assessed by Tüzün et al (13).

Falling Risk

A static posturography device (Tetrax, Sunlight Medikal Ltd) was used to assess the risk of falling. The system consists of 4 platforms sensitive to



pressure changes coming from both fingertips and both heels, and a computer where the information coming from it is combined and processed digitally. These digital data are calculated with a special algorithm and documented as visual and numerical data. Patients are evaluated in 8 different positions. Each position time consists of 32 seconds. With the data obtained as a result of the measurements, the falling index is calculated via the Tetrax software program. The higher the fall index is, the greater the risk of falling. 0-36 indicates minimal fall risk, 37-58 indicates moderate fall risk, and 59-100 indicates high fall risk (14).

Berg balance scale

The Berg balance scale is a reliable test that measures the ability of individuals to maintain their balance while performing functional activities. The highest score that can be obtained is 56. The score is evaluated as 'poor balance' between 0 and 20 and as 'good balance' between 40 and 56 (15). Sahin et al. demonstrated the validity and reliability of the Turkish version of the BDI (16).

Statistical Analyses

The required sample size was determined via power analysis based on previous studies. Power analysis was performed with G-Power 3.0.10. Since the study will be examined with 3 independent groups and 2 repeated measurements, calculations were made by considering the analysis of the variance method in repeated measurements. Considering the medium effect size (f=0.25), the significance level of 0.05, and the power of 90%, a total of 54 patients were included in the study. The number of people was evenly distributed among the groups. Eighteen patients were planned as 18 patients for each group.

In this study, the Shapiro–Wilk test was used to evaluate the conformity of continuous variables to a normal distribution. Paired t-tests and one-way ANOVA were used for normally distributed variables. All demographic and quantitative data are presented as the means (SDs). A paired t test was used to evaluate changes before and after treatment, and one-way ANOVA was used to evaluate differences between multiple variables. In the case of a significant difference according to the ANOVA test, the differences among the groups were evaluated with the Tukey test. The relationships between categorical variables were evaluated with the chi-square test, and the values are presented as frequencies and percentages. The IBM SPSS Statistics 20.0 (SPSS Inc., Chicago, Illinois) program was used for data analysis. The statistical significance level was set at $P<0.05$.

RESULTS

The study was conducted with 54 patients, 43 women (79.6%) and 11 men (20.4%). When the occupational status of the patients was examined, 3 (5.6%) were working, 11 (20.4%) were retired and 40 (74%) were housewives. There was no statistically significant difference between the treatment groups in terms of sex, occupation, or educational status (Table 1).

The mean age, weight, height, and body mass index (BMI) were 60.83 ± 6.06 years, 81.64±10.38 kilograms, 1.605±0.062 meters, and 31.69±3.6 kg/m2, respectively. A total of 34 (63%) patients with stage 2 disease and 20 (37%) patients with stage 3 disease were included in the study. At baseline, there were no statistically significant differences between the three groups in any of the evaluated parameters, including pain, stiffness, physical function, balance, or fall risk scores ($p > 0.05$). This indicates that all groups were comparable before treatment.

Within-group comparisons revealed that all three groups showed statistically significant improvements in pain, stiffness, physical function, and balance scores after the three-week treatment period ($p < 0.001$ for VAS and WOMAC subscales; $p < 0.05$ for BBS). No statistically significant changes

Table 1. Demographic and clinical characteristics of the groups

	Group 1 (N=18)	Group 2 (N=18)	Group 3 (N=18)
Gender (Female/Male)	14/4	14/4	15/3
Age (years)	61.1 (6.15)	60.77 (6.46)	60.6 (5.95)
Job			
Worker	0	1 (%5.6)	2 (%11.1)
Housewife	13 (%72.2)	13 (%72.2)	14 (%77.8)
Retired	5 (%27.8)	4 (%22.2)	2 (%11.1)
Body mass index (kg/m2)	32.8 (4.1)	31.8 (3.18)	30.45 (3.22)
K-L radiological stage 2/3	11/7	8/10	15/3
Affected extremity (right/left)	10/8	9/9	8/10
Flexion angle	126.66 (5.1)	126.66 (5.1)	126.66 (5.1)
Extension angle	0	0	0
Education			
Literate	1 (%5.6)	2 (%11.1)	2 (%11.1)
Primary school	9 (%50)	13 (%72.2)	10 (%55.6)
Middle School	1 (%5.6)	0	0
High school	6 (%33.4)	2 (%11.1)	4 (%22.2)
License	1 (%5.6)	1 (%5.6)	2 (%11.1)

Date are mean (SD), Group 1: Conventional treatment group Group 2: VR in addition to conventional treatment Group 3: VR applied group

were observed in fall risk scores within any group ($p > 0.05$).

Between-group comparisons demonstrated that Group 1 (conventional therapy) and Group 2 (combined therapy) achieved significantly greater reductions in VAS scores and improvements in WOMAC total, pain, and physical function subscales compared to Group 3 (virtual reality therapy alone) ($p < 0.05$). In the WOMAC stiffness subscale, Group 1 showed significantly more improvement than Group 2 ($p = 0.026$). No statistically significant differences were found among the three groups in terms of post-treatment balance or fall risk scores ($p > 0.05$).

The detailed values for pre- and post-treatment changes are presented in Table 2 and Table 3.



Table 2. Comparison of the VAS, WOMAC, BBS and fall risk scores within groups

	Group 1 (N=18)	Group 2 (N=18)	Group 3 (N=18)
VAS movement			
Before treatment	6.1 (0.96)	6.4 (1.24)	6.27 (0.95)
After treatment	2.38 (1.57)*	2.6 (1.57)*	4.38 (1.33)*
VAS rest			
Before treatment	6.05 (1.21)	6.05 (1.21)	5.88 (1.18)
After treatment	2.1 (1.81)*	1.5 (1.5)*	3.66 (1.18)*
WOMAC pain			
Before treatment	10.3 (1.81)	10.3 (1.8)	10.66 (1.57)
After treatment	4.6 (2.4) ‡	3.7 (2.1) ‡	6.8 (1.75) ‡
WOMAC stiffness			
Before treatment	4.7 (1.07)	3.9 (1.1)	3.77 (1.35)
After treatment	3.4 (1.14) ‡	2.3 (1.2) ‡	2.77 (1.2) ‡
WOMAC function			
Before treatment	49.07 (6.4)	47.3 (7.3)	50.1 (8.2)
After treatment	28.3 (7.8) ‡	23.4 (13.4) ‡	41.7 (9.4) ‡
WOMAC total			
Before treatment	65.04 (6.9)	61.9 (7.9)	65.2 (9.2)
After treatment	35.57 (7.79) ‡	29.7 (15.4) ‡	51.78 (11) ‡
Fall risk			
Before treatment	42.3 (27.39)	46.4 (19.4)	55.56 (19.69)
After treatment	38.77 (24.6)	42.3 (21.3)	49.67 (4.78)
BBS			
Before treatment	50.6 (3.29)	49.5 (2.7)	50.5 (1.79)
After treatment	53.3 (2.47)*	52.7 (2.1)‡	52.16 (2.6)†

Data are mean (SD), VAS; visual analog scale WOMAC; Western Ontario and McMaster Universities Arthritis Index BBS; Berg Balance Scale
* $p<0.001$, ‡ $p<0.01$, † $p=0$

Table 3. Comparison of the VAS and WOMAC scores among the groups

	Before Treatment			P*	After Treatment			P*	** Multiple comparision
	Group 1	Group 2	Group 3		Group 1	Group 2	Group 3		
VAS motion	6.1 (0.96)	6.4 (1.24)	6.27 (0.95)	0.546	2.38 (1.57)	2.6 (1.57)	4.38 (1.33)	0.01 0.02	1-2 1-3
VAS rest	6.05 (1.21)	6.05 (1.21)	5.88 (1.18)	0.891	2.1 (1.81)	1.5 (1.5)	3.66 (1.18)	0.01 0.02	1-2 1-3
WOMAC pain	10.3 (1.81)	10.3 (1.8)	10.66 (1.57)	0.807	4.6 (2.4)	3 .7 (2.1)	6.8 (1.75)	<0.001	1-3 2-3
WOMAC stiffness	4.7 (1.07)	3.9 (1.1)	3.77 (1.35)	0.047	3.4 (1.14)	2.3 (1.2)	2.77 (1.2)	0.026	1-2
WOMAC function	49.07 (6.4)	47.3 (7.3)	50.1 (8.2)	0.508	28.3 (7.8)	23.4 (13.4)	41.7 (9.4)	0.03	1-3 2-3
WOMAC total	65.04 (6.9)	61.9 (7.9)	65.2 (9.2)	0.401	35.57 (7.79)	29.7 (15.4)	51.78 (11)	<0.001	1-3 2-3

Data are mean (SD). *p<0.05 one-way ANOVA test **Tukey test

DISCUSSION

We aimed to evaluate the effectiveness of conventional treatment, VRT combined with conventional treatment, and VRT alone in improving pain, fall risk, and balance parameters in patients with primary knee OA). In all three treatment groups, the VAS (rest and movement), WOMAC (pain, stiffness, physical function, and total), and Berg balance scale scores values improved after treatment. The results of our study showed that all three treatments were effective in patients with knee OA. The improvements in WOMAC and VAS scores associated with both VRT combined with conventional exercise and conventional exercise alone were greater than those associated with VRT alone. According to the systematic analysis data covering the years 1990-2017, symptomatic knee OA is more common in women, especially in the 55-59 age range (1). The demographic characteristics of the patients in our study were consistent with this data across all treatment groups. The mean age of the participants was 60.83 ± 6.06 years, and the majority of the population was women (79.6%).

Pain, loss of function, loss of muscle strength, muscle atrophy, loss of condition, exercise intolerance, and deterioration in ambulation can be observed in patients with knee OA, seriously affecting people's daily living activities (6). Knee OA affects the body's balance mechanism, leading to postural balance issues and an increased risk of falling. Although reduced muscle strength in the knee flexors and extensors contributes to this, the effectiveness of muscle strengthening in reducing fall risk remains uncertain—possibly due to impaired sensory integration (17).

The guidelines, recommend range of motion, aerobic, strengthening, and proprioceptive



exercises as effective treatments for OA (18). Additionally, virtual reality applications are increasingly being incorporated into rehabilitation programs, although their potential benefits for knee OA remain unclear due to the limited number of studies involving various VR systems (10,19).

Wibelinger et al. compared conventional exercises with VRT (with Nintendo Wii Fit) and reported a more significant improvement in WOMAC stiffness and BBS scores in the VR group. There was a more significant decrease in WOMAC pain and physical function scores in the conventional exercise group (9).

The reduction in pain with VRT is explained by the gate control theory proposed by Melzack and Wall. According to this theory; individuals may perceive stimuli differently depending on factors such as attention to pain, feelings associated with pain, and past painful experiences. With VRT, attention is diverted and the perception of pain is reduced (20). Lin et al., in a randomized controlled single-blind trial with stage 2 or 3 knee OA patients, compared the effectiveness of active video games with that of conventional therapy. Both groups showed a significant reduction in WOMAC pain, with no difference in treatment effectiveness between them. No superiority was observed in WOMAC stiffness or physical function between the treatment groups (10). Despite some differences in methods and materials, our results are similar to those of these studies. In our study, significant improvements in the VAS and WOMAC scores were observed in all the groups posttreatment. Compared with the VR group, the conventional treatment group and the VR and conventional treatment groups showed greater improvement. Although no statistically significant difference was observed between the combined and conventional therapy groups, both showed superior outcomes compared to VR alone. However, more significant improvements in conventional and VR methods may make this application preferable as an alternative adjunctive treatment option. In addition, a significant reduction in pain in patients who only receive VR may save time and labor in the rehabilitation program. This significant reduction in pain likely occurred because patients focus their attention on games in the created virtual environment, their participation in treatment, and their motivation-enhancing effect.

In a pilot study evaluating the efficacy of Nintendo Wii Fit video games involving a small number of elderly patients, significant improvement in the BBS scale was found after treatment (21). In another randomized controlled trial with Nintendo Wii Fit in elderly women with knee OA, significant improvements in BBS were observed in the VR group (9). In their study, Wi et al. compared VRT with conventional treatment in elderly women with knee OA to evaluate its effect on balance. Posttreatment balance improvement, assessed via using postural sway, was greater in the VRT group than in conventional treatment group (19). A meta-analysis concluded that active video games are more effective than conventional exercises or no treatment in improving the BBS scale in older individuals (22). Our study demonstrated improvement in the BBS across all three treatment groups, indicating enhancement in both dynamic and static balance. While this contrasts with our original hypothesis regarding the superiority of VRT, it supports its efficacy in balance enhancement, whether used alone or with traditional exercise.

In VRT, participants engage with targets on the screen, encouraging the active use of lower extremities to achieve higher scores. Compared with traditional therapeutic exercises, this dynamic interaction often yields superior outcomes in terms of dynamic balance, physical function, and overall physical health (23). Moreover, such games stimulate dopamine release, which is associated with improved learning, behavior reinforcement, attention, and sensorimotor integration. All these effects contribute in part to the potential positive effect of the treatment (24). Despite these positive

effects, the results of a meta-analysis suggest that conventional exercise is more effective than active video games in the healthy elderly population (25). In our study, games enhanced patient participation and helped ensure consistency in treatment sessions.

There is no clear consensus on the frequency and duration of VRT sessions. In a study of elderly female knee OA patients, 18 sessions were conducted 3 days a week, with 40 patients completing at least 15 sessions (19). Lin et al. treated 80 patients 3 days a week for 4 weeks, totaling 12 sessions (10). In our study, we enrolled 54 patients and administered 15 sessions to each group, in alignment with similar protocols in the literature.

The limitations of our study are that the patients participating in the study were not blinded to treatment, they were evaluated at a single time point after treatment, there was no long-term follow-up, the difference in treatment duration, and the small size of the study sample. While stratified randomization was not used, baseline group characteristics were statistically comparable, minimizing the risk of confounding. The exclusion of individuals with comorbidities or cognitive and neurological impairments, while necessary to improve internal validity, limits the generalizability of the findings to the broader knee osteoarthritis population. Moreover, treatment under surveillance may not accurately reflect real-world adaptability to home settings with advancing technology. In addition, the absence of a sham virtual reality control group limits the ability to differentiate specific therapeutic effects from expectation-driven responses.

CONCLUSION

The potential therapeutic effects of VRT in OA patients remain unclear. Our study aimed to assess whether VRT yielded greater improvements in pain, disability, and balance parameters than did conventional therapy. While VR did not show superiority over conventional treatment, it improved pain parameters, suggesting its potential as an adjunctive therapy. Larger, longer-term studies are needed to explore this potential further. Our study sets a precedent for future research in this area, highlighting the need for larger sample sizes and longer follow-up periods. VRT can be a time- and labor-saving method by increasing patient participation and providing an engaging treatment environment.

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ORIGINAL ARTICLE

DOES OBESITY AFFECT THE EFFICACY AND SAFETY OF EPIDURAL STEROID INJECTIONS IN OLDER ADULTS?

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Abstract

Introduction: Obesity is an increasing concern among older adults and may affect the clinical outcomes of epidural steroid injections. This study assesses the impact of obesity on the treatment outcomes of epidural steroid injections in geriatric patients.

Materials and Method: A retrospective analysis was conducted on 101 older adults who received epidural steroid injections. Patients were categorized into three groups based on their body mass index: normal weight (<25 kg/m²), overweight (25–29.9 kg/m²), or obese (≥30 kg/m²). Pain scores were documented before the procedure, one hour after the procedure, and one month after the procedure.

Results: The average age of the participants was 73.95 years (range: 65–89 years), and the mean body mass index was 29.44 ± 4.75 kg/m². The mean pre-procedural numeric rating scale score was 8.17 ± 1.21. Average pain scores at one hour (0.66) and one month (4.32) following the procedure were significantly lower than the pre-procedural scores ($P < 0.001$). Radiation time ($P = 0.044$) and radiation dose ($P = 0.047$) were significantly higher in the obese group. Nevertheless, no significant differences were observed between the groups concerning gender, age, symptom duration, procedure type, complications, pain scores, or treatment success.

Conclusions: Obesity does not adversely affect the treatment outcomes of epidural injections in older adults. Epidural steroid injections can be safely administered to obese elderly patients with a low complication rate.

Keywords: Aged; Low Back Pain; Injection, Epidural; Obesity; Body Mass Index.

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INTRODUCTION

Low back pain is a prevalent health issue affecting up to 75% of geriatric patients and significantly impairing quality of life and functional capacity (1). Obesity is a well-established risk factor for low back pain, and its rising prevalence among the aging population is contributing to increased rates of chronic pain and functional decline (2,3). In individuals aged 65 years or older, obesity is rapidly escalating due to factors such as sedentary lifestyles, poor diet quality, reduced basal metabolic rate, low socioeconomic status, urban stress, and gender-specific influences (4,5). Furthermore, age-related muscle loss (sarcopenia) combined with increased fat accumulation—a condition known as sarcopenic obesity—disrupts energy balance and further promotes weight gain (6).

Obesity not only places additional mechanical stress on the spine but also triggers systemic inflammation, which accelerates intervertebral disc degeneration and intensifies low back pain. The increased number of adipocytes elevates the release of pro-inflammatory cytokines, leading to neural tissue irritation and heightened pain perception (7,8). For low back pain patients who do not respond to conservative treatments, epidural steroid injection (ESI) has emerged as a preferred invasive option. ESI, administered via caudal, interlaminar, or transforaminal approaches, has demonstrated desirable short- and mid-term outcomes in selected cases based on clinical and radiological criteria (9). For instance, Cohen and colleagues observed significant improvements in pain and functionality over three months in older adults with lumbar spinal stenosis treated with lumbar ESI, while Curatolo et al. confirmed the long-term benefits of lumbar ESI in individuals aged 65 years and older (10,11). Another investigation reported that patients with disc herniation derived greater benefit from lumbar ESI compared to those with lumbar spinal stenosis or failed back surgery syndrome (12).

Nevertheless, the confluence of increasing obesity rates, age-related spinal degeneration, altered biomechanical properties, and chronic inflammation may complicate invasive procedures and potentially diminish treatment efficacy. Most available studies have focused on younger or mixed-age populations, leaving the specific influence of obesity on the outcomes of ESIs in older adults relatively under investigated (8,13,14). Unique age-related factors such as reduced muscle mass, altered fat distribution, and spinal degeneration are critical determinants of treatment response that limit the generalizability of current guidelines and raise concerns about the adequacy of treatment in obese elderly patients.

In order to address this research gap, our investigation explored how excess body weight influences both the outcomes and complications associated with ESIs in elderly patients. Participants were categorized into three groups based on their body mass index (BMI). To our knowledge, this is the first comprehensive study to specifically and comprehensively examine the influence of obesity—and its subcategories—on ESI outcomes in an elderly population.

MATERIALS AND METHOD

This investigation was carried out in accordance with the principles outlined in the Declaration of Helsinki, and written informed consent was secured from every participant. Following approval from the institutional ethics committee (27.02.2025/76), the cases were retrospectively reviewed from patients who underwent fluoroscopy-guided lumbar ESIs between June 2024 and January 2025 at the pain management center of a tertiary hospital. Data were retrieved from hospital records and comprised demographic information, numeric rating scale (NRS) scores, BMI, details of the procedure, radiation dose and duration, any complications, symptom duration, and specifics of medical treatment. Patients included were 65 years of age or over and had received an ESI using caudal, lumbar interlaminar, or lumbar transforaminal techniques

[see Figures 1 and 2]. Patients were excluded if they had a history of significant psychiatric disorders, a malignancy diagnosis, incomplete one-month follow-up data, or insufficient demographic or clinical data, or had undergone epidural steroid injection or spinal surgery within the past year.

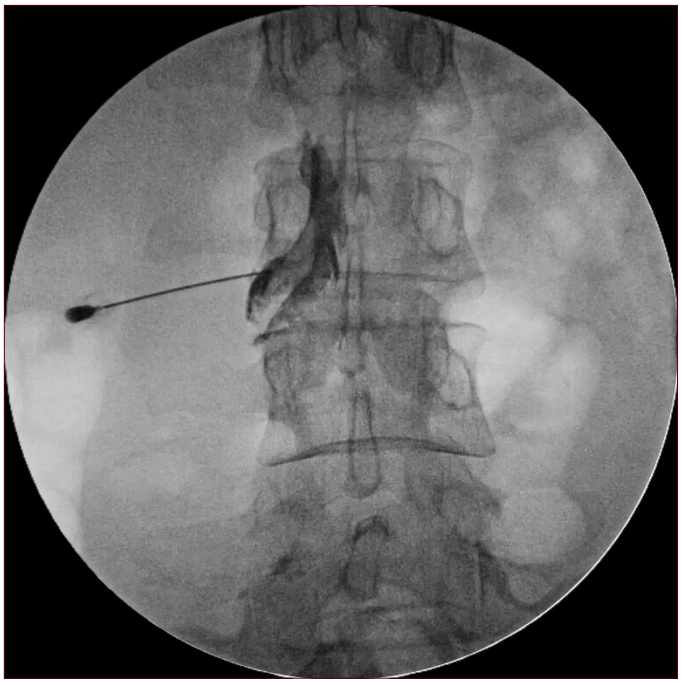


Figure 1. Anteroposterior view showing contrast distribution during a left L3 transforaminal epidural steroid injection



Figure 2. Lateral view showing contrast distribution during a left L3 transforaminal epidural steroid injection



All interventions were carried out by a pain medicine specialist with more than three years of clinical experience. A single fluoroscopy unit was used throughout, providing intermittent imaging. To minimize radiation exposure, both linear and circular collimation techniques were consistently employed in accordance with the ALARA (As Low As Reasonably Achievable) principle. For analytical purposes, patients were categorized into three groups according to BMI: obese (BMI ≥30 kg/m²), overweight (BMI 25–29.9 kg/m²), or normal weight (BMI <25 kg/m²). NRS scores were documented both before the procedure and at a one-month follow-up, with a decrease of 50% or more being defined as treatment success (8).

Statistical Analysis

Data analysis was conducted using SPSS version 27.0.1 (IBM Corp., Armonk, NY). Categorical variables are presented as frequencies and percentages, while continuous variables are expressed as the mean ± standard deviation along with their range (minimum–maximum). The normality of continuous data was assessed using the Shapiro-Wilk test. For comparisons between two independent groups with non-normally distributed data, the Mann-Whitney U test was utilized; the Kruskal-Wallis test was applied when comparing the three groups. For data that followed a normal distribution, within-group comparisons were conducted using the t-test, and for comparisons across multiple groups, one-way analysis of variance was conducted. Categorical variables were assessed using either the chi-square test or Fisher's exact test. A P-value below 0.05 was deemed statistically significant.

RESULTS

A total of 101 patients were included in the study, with a mean age of 73.95 ± 5.86 years (range: 65–89 years). The overall mean BMI was 29.44 ± 4.75 kg/m², with 20 patients (19.8%) classified as normal weight, 42 patients (41.6%) as overweight, and 39 patients (38.6%) as obese. The average duration of symptoms was 27.16 ± 22.35 months, and the pre-procedural NRS score was 8.17 ± 1.21, which decreased to 0.66 ± 1.43 at one hour and to 4.32 ± 2.79 at one month after the injection. The most frequently performed injection type was lumbar ESI via the interlaminar approach (ILESI) (42.6%), followed by transforaminal ESI (TFESI) (39.6%) and caudal ESI (CESI) (17.8%). Regarding medication, opioid usage was recorded in 12.9% of the patients,

Table 1. Demographic and Clinical Characteristics

Variable		Value (n:101)
Age (years)		73.95 (65-89)
BMI (kg/m2)		29.44 ± 4.75
Symptom duration (months)		27.16 ± 22.35
PreNRS		8.17 ± 1.21
First-hour NRS		0.66 ± 1.43
First-month NRS		4.32 ± 2.79
Radiation time (s)		32.67 ± 11.06
Radiation dose (mGy)		7.90 ± 5.83
Gender (n)	Male	48 (47.5 %)
	Female	53 (52.5 %)
Obesity	Normal weight	20 (19.8 %)
	Overweight	42 (41.6 %)
	Obese	39 (38.6 %)
Treatment success	Yes	61 (60.4 %)
	No	40 (39.6 %)
Type of approach	TFESI	40 (39.6 %)
	ILESI	43 (42.6 %)
	CESI	18 (17.8 %)
Medication (n)	Opioid use	13 (12.9 %)
	Pregabalin use	18 (17.8 %)
	Gabapentin use	27 (26.7 %)
	Duloxetine use	9 (8.9 %)

BMI: Body mass index, NRS: Numeric rating scale, TFESI: Transforaminal epidural steroid injection, ILESI: Interlaminar epidural steroid injection, CESI: Caudal epidural steroid injection

while gabapentin, pregabalin, and duloxetine were administered to 26.7%, 17.8%, and 8.9% of the patients, respectively. The mean radiation time was 32.67 ± 11.06 seconds, and the mean radiation dose was 7.90 ± 5.83 mGy (Table 1).

When stratified by BMI, no statistically significant differences were observed in age (P = 0.120), symptom duration (P = 0.109), gender distribution (P = 0.708), or the type of procedural approach (p = 0.884). The mean BMI was 23.22 ± 1.85 kg/m² in the normal weight group, 28.28 ± 1.11 kg/m² in the overweight group, and 33.87 ± 3.79 kg/m² in the obese group (P < 0.001). Pre-procedural NRS scores were similar among groups (P = 0.161); although the obese group showed the lowest NRS scores at one hour post-procedure, this difference was not statistically significant (P = 0.340). At one month, the NRS score in the obese group was slightly higher (4.89 ± 3.12) compared to the overweight (3.69 ± 2.58) and normal weight (4.55 ± 2.37) groups, yet this difference did not reach significance (P = 0.173). Both radiation time and dose were significantly higher in the obese group, with P-values of 0.044 and 0.047, respectively. No major complications were observed during the procedures. Minor complications occurred in two patients in the overweight group, two patients in the obese group, and one patient in the normal weight group, with no statistically significant difference among the groups (P = 0.997) (Table 2).

A significant reduction in NRS was observed across all BMI groups at both one hour and one month post-injection (P < 0.001 for all comparisons) (Table 3).

Table 2. Comparison of Demographic and Clinical Characteristics by Weight Group

		Normal weight (n=20)	Overweight (n=42)	Obese (n=39)	P value
Age (years)		76.30 ± 6.12	73.66 ± 6.20	73.05 ± 5.32	0.120
BMI (kg/m2)		23.22 ± 1.85	28.28 ± 1.11	33.87 ± 3.79	<0.001
Symptom duration (months)		25.45 ± 22.33	24.07 ± 22.31	31.38 ± 22.32	0.109
PreNRS		8.30 ± 1.34	7.90 ± 1.18	8.41 ± 1.14	0.161
First-hour NRS		1.15 ± 2.0	0.71 ± 1.56	0.35 ± 0.74	0.340
First-month NRS		4.55 ± 2.37	3.69 ± 2.58	4.89 ± 3.12	0.173
Radiation time (s)		28.84 ± 8.81	32.29 ± 13.48	35.04 ± 8.56	0.044
Radiation dose (mGy)		5.43 ± 2.72	6.84 ± 4.42	10.30 ± 7.37	0.047
Minor complication		1 (5%)	2 (4.8%)	2 (5.1%)	0.997
Gender	Male	11 (55%)	20 (47.6%)	17 (43.6%)	0.708
	Female	9 (45%)	22 (52.4%)	22 (56.4%)	
Treatment success	Yes	12 (60 %)	26 (61.9%)	23 (59 %)	0.964
	No	8 (40 %)	16 (38.1%)	16 (41 %)	
Procedure type	TFESI	7 (35%)	15 (35.7%)	18 (46.1%)	0.884
	ILESI	9 (45%)	19 (45.3%)	15 (38.5%)	
	CESI	4 (20%)	8 (19%)	6 (15.4%)	

BMI: Body mass index, NRS: Numeric rating scale, TFESI: Transforaminal epidural steroid injection, ILESI: Interlaminar epidural steroid injection, CESI: Caudal epidural steroid injection

Table 3. Changes in NRS Score (Preoperative vs. Postoperative 1 Hour and 1 Month) by Weight Group

		P value
Normal weight	NRS preop – postop 1st hour	<0.001
	NRS preop – postop 1st month	<0.001
Overweight	NRS preop – postop 1st hour	<0.001
	NRS preop – postop 1st month	<0.001
Obesity	NRS preop – postop 1st hour	<0.001
	NRS preop – postop 1st month	<0.001
Total	NRS preop – postop 1st hour	<0.001
	NRS preop – postop 1st month	<0.001

NRS: Numeric rating scale

DISCUSSION

Obesity, with its rising prevalence, constitutes a major public health concern by elevating the risk of low back pain among older adults. For elderly patients who do not experience sufficient relief from conservative treatments and are unsuitable or ineligible for surgery, lumbar ESIs are commonly performed to manage low back pain (9-12). However, when an individual is both elderly and obese, there is a common belief among clinicians that they will derive less benefit from ESI. Although several investigations have assessed the relationship between ESIs and obesity, many of these investigations either did not focus specifically on elderly individuals or did not differentiate outcomes based on BMI categories, which is a major limitation. In this study, elderly patients were stratified into three categories according to their BMI, and the effect of BMI on short-term treatment outcomes was investigated. Our findings indicate that obesity does not adversely affect treatment success in the elderly and that ESI can be safely administered in obese patients. Additionally, an increase in BMI was linked to longer radiation exposure times and higher doses of radiation.

Globally, as life expectancy increases and economic development progresses, the number of older adults is rising, and chronic pain is becoming more prevalent (15,16). In older individuals, pain is often multifactorial in that multiple pathologies contribute (17). This complex etiology limits treatment options and reduces the effectiveness of analgesics. Moreover, decreased liver and kidney function in the elderly population lowers drug tolerance and increases the incidence of analgesic-related side effects (18). Increased multimorbidity with age further restricts the suitability for surgical interventions (15-18). Therefore, ESI represents an important treatment option for elderly patients who do not benefit from conservative methods, are unsuitable for surgery, or carry high surgical risks (9-12). Our study demonstrated that ESI significantly reduced pain scores and that this effect was independent of BMI, thereby confirming its short-term efficacy in both normal-weight and obese elderly individuals.

ESIs can be administered via caudal, transforaminal, or interlaminar approaches. In our study, the interlaminar approach was most frequently used (42.6%), followed by the transforaminal and caudal approaches. However, the choice of injection route did not differ significantly between the BMI groups.

The link between obesity and low back pain remains controversial. Some studies suggest no association between the two, while others have established a potential causal connection (19-21). One review suggested that obesity is not the direct cause of low back pain but rather a risk factor (19). Two meta-analyses by Shiri et al. found that both obesity and being overweight are associated with a higher likelihood of developing low back pain. Conversely, they also noted the possibility of publication bias in studies reporting this association (20,21). In our study, no association was observed between obesity and pre-procedural low back pain scores.

The literature presents conflicting opinions on how obesity affects the effectiveness of ESI. Among clinicians, there is a belief that obese patients derive less benefit from epidural injections (8,14). In addition to perceived lower efficacy, technical procedural difficulties—such as difficult long needle maneuvering and reduced fluoroscopic image quality—also deter clinicians from performing ESIs in obese patients (8,22). However, the scientific evidence supporting this belief is not definitive. In our study, elderly patients were stratified into obese, overweight, and normal weight groups according to BMI. ESI was effective in controlling pain across all BMI groups, and obesity did not negatively impact treatment success. Therefore, a high BMI should not be regarded as a contraindication for administering ESIs in elderly patients.

Studies by Taşdoğan et al. reported the effectiveness of ESI in elderly patients over a 3-month follow-up (10), while Curatolo et al. demonstrated more pronounced pain and functional improvements over a 24-month follow-up compared to control groups (11). Similarly, Olgun et al. found that older individuals with disc herniation responded more favorably to treatment than those with lumbar spinal stenosis or failed back surgery syndrome (12). In our study, both one-hour and one-month post-injection pain scores were significantly lower than pre-procedural scores, further emphasizing the short-term effectiveness of ESI.

Furthermore, no major complications were observed in our study; only a minor complication rate of 4.9% (five patients) was noted, with a low incidence across all BMI groups and no statistically significant difference among them. This finding suggests that ESI is not only an effective treatment option for older adults but also a safe one.

Cushman et al. reported higher radiation time and dose in obese individuals in a study on lumbar TFESI in patients with a mean age of 56 years (23). Sencan et al. found that during L5 and S1 TFESI in a study of 83 patients aged 19-65 years, obese patients received a higher radiation dose (24). In 2025, Manchikanti et al. demonstrated that higher BMI was linked to increased radiation doses and longer procedure times in lumbar and caudal ESIs (25). However, none of these studies specifically examined elderly patients. Our study focused exclusively on the elderly and showed that as BMI increases, both radiation dose and procedure time increase. This can be attributed to reduced image quality due to increased adipose tissue and tissue thickness, which leads to higher radiation output from the automatic dose modulation system and to increased difficulty in needle positioning, necessitating longer fluoroscopy time to obtain optimal imaging.

This study has several limitations. First, obesity was assessed solely using BMI, which may have overlooked other important aspects of body composition. Metrics such as total body fat mass, subcutaneous fat index, and waist-to-hip ratio might yield different results. Second, our study is retrospective and single-centered, which limit the generalizability of the findings. Third, the Numeric Rating Scale (NRS) is a useful tool for assessing pain intensity but does not capture functional outcomes, quality of life, or psychological well-being. Relying on a single subjective pain score limits the ability to



understand the broader impact of the intervention. Prospective, randomized controlled studies with larger sample sizes are needed to validate our results.

CONCLUSION

This study demonstrated that the short-term efficacy of ESI in elderly adults is independent of BMI. Although higher radiation time and dose were observed in obese patients during the procedure, these factors did not adversely affect treatment success or increase complication rates. Therefore, high BMI should not be considered a contraindication for ESI, and this interventional treatment can be safely administered in obese elderly patients. Further prospective, comparative studies with larger sample sizes are warranted to more robustly support the findings.

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ORIGINAL ARTICLE

ANALYSIS OF URINARY TRACT INFECTIONS IN GERIATRIC PATIENTS

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Abstract

Introduction: There are some differences in the clinical approach to urinary tract infections in geriatric patients. The aim of this study was to investigate the clinical characteristics of symptomatic urinary tract infections in geriatric patients in a tertiary care hospital and to determine the infectious agents and antibiotic susceptibilities.

Materials and Method: The study included geriatric patients (aged over 65) who were followed up for symptomatic urinary tract infection at Fırat University Medical Faculty Hospital between March and September 2023.

Results: The study included 258 patients, of whom 164 (63.6%) were male. Clinical analysis of the patients showed that 85.7% of the patients had complicated urinary tract infections, 51.2% had lower urinary tract infections and 61.6% had community-acquired urinary tract infections. A total of 274 isolates were identified, including two uropathogens in 16 patients. Of these, 70.8% belonged to *Enterobacterales* species and *E. coli* (42.7%) was the most common isolate. Extended-spectrum beta-lactamase production in *Enterobacterales* species was 50% in community-acquired strains and 68.9% in hospital-acquired strains. The ampicillin susceptibility of *Enterococcus* species was 72.7% for community-acquired isolates and 54.5% for hospital-acquired isolates. 68.8% of community-acquired *Staphylococcus spp.* and 68.8% of hospital-acquired *Staphylococcus spp.* isolates were methicillin-resistant.

Conclusion: In our study, the high prevalence of male patients with complicated urinary tract infections was notable. Furthermore, the antibiotic resistance profiles identified emphasise the need to update treatment strategies and maintain surveillance of resistance in geriatric patients. These findings highlight the importance of a multidisciplinary approach to managing UTIs in geriatric patients, with close collaboration between clinicians and microbiologists.

Keywords: Tertiary Care Centers; Community-Acquired Infections; Anti-Bacterial Agents; Methicillin Resistance; *Escherichia coli*; *Enterococcus*.

INTRODUCTION

Urinary tract infection (UTI) is caused by infection of the organs of the genitourinary system, such as the renal parenchyma, ureters, bladder and urethra. In geriatric patients, the presence of chronic genitourinary symptoms, the high frequency of asymptomatic bacteriuria and communication disorders (such as deafness, cognitive impairment, neurological diseases, etc.) make diagnosis more difficult in clinical practice. In addition, co-morbidities, residence in nursing homes, cognitive decline, physiological deterioration of the genitourinary system, and immunodeficiency contribute to UTI susceptibility and lead to more severe infections. Due to co-morbidities, hospital admission rates and the likelihood of hospital-acquired infections are higher compared to the adult age group. This factor should also be taken into account when choosing empirical treatment. Although there are some differences in the diagnosis and management of UTI in the geriatric population, there is no definitive protocol for the management of UTI in the elderly (1, 2).

The aim of this study is to investigate the epidemiology and clinical characteristics of UTI in geriatric patients in a tertiary hospital, and to determine the pathogens and antibiotic susceptibilities.

MATERIALS AND METHOD

Study Design, Setting, Participants and Clinical Assessment

In this study, geriatric patients (>65 years-old) diagnosed with UTI and being followed up at Firat University Faculty of Medicine Hospital between March 2023 and September 2023 were examined. Patients with symptomatic UTI, defined as pyuria, bacteriuria and genitourinary symptoms, were included in the study. Due to the prevalence of chronic genitourinary symptoms in the geriatric age group, acute or worsening genitourinary symptoms were included. Patients in intensive care were excluded.

Patients were evaluated for predisposing factors for UTI, origin of infection (community-acquired/hospital-acquired), upper/lower UTI, complicated/uncomplicated UTI, bacteraemia and final outcome (survival/mortality).

Definitions

Upper UTIs were classified as cases of bacteriuria accompanied by genitourinary symptoms, systemic signs (nausea, vomiting, fever, lateral pain and costovertebral angle tenderness, etc.) and systemic laboratory findings (elevated white blood cell count, C-reactive protein and erythrocyte sedimentation rate etc.) associated with UTIs.

Lower UTIs were classified as the presence of bacteriuria and genitourinary symptoms, in the absence of UTI-related systemic signs (nausea, vomiting, fever, lateral pain and costovertebral angle tenderness, etc.) and laboratory findings (elevated white blood cell count, C-reactive protein and erythrocyte sedimentation rate etc.).

Complicated UTIs were classified in the presence of predisposing factors such as structural or functional abnormalities of the urinary tract, urinary catheterization, urinary tract obstruction, or chronic systemic conditions that impair immune function.

Hospital-acquired UTIs are classified as infections that develop between 48 and 72 hours after admission to hospital, or within 10 days of discharge (1, 2). In addition, infections that occur within 10 days of a urological intervention (urodynamic test, etc.) performed in an outpatient setting were also considered nosocomial infections.

Data Sources

The hospital information system and laboratory information system were searched retrospectively, and patients' electronic records were accessed. Demographic data (age and sex), co-morbidities,

clinical features of UTI, treatment setting (outpatient/clinic), treatment history (UTI in the past 12 months, antibiotic use in the past 3 months and hospitalisation history), microorganisms grown in urine culture and antibiotic susceptibilities were recorded.

Microbiological studies

Urine samples received by our laboratory were inoculated onto EMB (eosin methylene blue) and blood agar media and incubated in an incubator. When evaluating urine cultures, identification and antibiotic susceptibility testing were performed for uropathogens forming ≥104 cfu/ml in the presence of ≤2 uropathogens and ≥105 cfu/ml in the presence of ≥3 uropathogens in non-invasive specimens (midstream urine, foley catheter, etc.). For invasive specimens (direct catheterisation, nephrostomy, cystoscopy, etc.), identification and antibiotic susceptibility tests were performed for uropathogens forming ≥103 cfu/ml in the presence of ≤2 uropathogens, or ≥104 cfu/ml in the presence of ≥3 uropathogens.

Identification and antibiotic susceptibility of microorganisms grown on the media were evaluated using a fully automated bacterial identification and susceptibility system (Phoenix™, BD, USA). The disk diffusion method with cefoxitin was used to determine methicillin resistance in *S. aureus* isolates. Carbapenem resistance in Gram-negative bacteria and vancomycin resistance in enterococci, as detected by the automated system, were confirmed by the reference disk diffusion method. Test results were interpreted according to the criteria of the European Committee on Antimicrobial Susceptibility Testing (EUCAST). The antibiotics used in the study were selected according to the recommendations of the Turkish Society of Microbiology Standardisation of Antibiotic Susceptibility Testing working group.

In line with EUCAST recommendations, the presence of extended-spectrum beta-lactamases (ESBLs) was investigated in isolates exhibiting a minimum inhibitory concentration (MIC) of greater than or equal to 1 µg/mL for ceftriaxone, cefotaxime, or ceftazidime. The presence of ESBLs was determined using either the double-disk synergy test or the combined disk method.

Statistical Analysis

IBM SPSS Statistics version 23 package (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. The Shapiro-Wilk test was used to analyse the normality of quantitative data. Mean ± standard deviation was used for normally distributed continuous variables. For continuous variables that are not normally distributed, median and 1st Quarter (Q1) - 3rd Quarter (Q3) are used. Classified data were presented as frequencies and percentages.

Compliance with Ethical Standards

This study was conducted in accordance with the tenets of the Declaration of Helsinki and approved by the Non-Interventional Ethics Committee of Firat University Faculty of Medicine (decision no. 2024/12-27 dated 11.09.2024).

RESULTS

A total of 258 patients, 164 (63.6%) male and 94 (36.4%) female, were included in the study. The mean age was 75.55±7.45 years. Of the patients, 159 (61.6%) were classified as having community-acquired infections, and 99 as having hospital-acquired infections. A total of 221 patients (85.7%) were diagnosed with complicated infections, while 37 (14.3%) had uncomplicated infections. In addition, 132 patients (51.2%) were identified as having lower urinary tract infections (UTIs), and 126 (48.8%) as having upper UTIs. The clinical characteristics of the patients are shown in Table 1. Results of urine microscopy are presented in Table 2. None of the patients lived in a nursing home. Bacteraemia was observed in 12 (4.7%) of the patients, all of whom

Table 1. Clinical Characteristics of the Patients

Parameters	**Total** n=258	**Community-acquired UTI** n=159	**Hospital-acquired UTI** N=99	**Complicated UTI** n=221	**Uncomplicated UTI** n=37	**Lower UTI** n=132	**Upper UTI** n=126
Gender n (%)							
Male	164 (63.6)	96 (60.4)	68 (68.7)	164 (74.2)	-	80 (60.6)	84 (66.7)
Female	94 (36.4)	63 (39.6)	31 (31.3)	57 (25.8)	37 (100)	52 (39.4)	42 (33.3)
Age Mean±standard deviation	75.55±7.45	75.72±7.46	75.29 ±7.45	75.72±7.50	77.62±7.07	75.92±7.00	75.16±7.89
Co-morbidities n (%)							
Hypertension	116 (45)	66 (41.5)	50 (50.5)	100 (45.2)	16 (43.2)	67 (50.8)	49 (38.9)
Chronic heart disease	95 (36.8)	55 (34.6)	30 (30.3)	78 (35.3)	17 (45.9)	60 (45.5)	35 (27.8)
Diabetes mellitus	82 (31.8)	54 (34)	28 (28.3)	82 (37.1)	-	39 (29.5)	43 (34.1)
Chronic renal failure	30 (11.6)	14 (8.8)	16 (16.2)	24 (10.9)	6 (16.2)	19 (14.4)	11 (8.7)
Other neurological diseases	23 (8.9)	17 (10.7)	6 (6.1)	19 (8.6)	4 (10.8)	11 (8.3)	12 (9.5)
Chronic obstructive pulmonary disease	20 (7.8)	13 (8.2)	7 (7.1)	17 (7.7)	3 (8.1)	11 (8.3)	9 (7.1)
Delirium and dementia	18 (7)	17 (10.7)	1 (1)	10 (4.5)	8 (21.6)	8 (6.1)	10 (7.9)
Non-urinary malignancy	10 (3.9)	4 (2.5)	6 (6.1)	10 (4.5)	-	8 (6.1)	2 (1.6)
Rheumatological diseases	9 (3.5)	5 (3.1)	4 (4)	5 (2.3)	4 (10.8)	7 (5.3)	2 (1.6)
Presence of at least one chronic disease	183 (70.9)	113 (71.1)	70 (70.7)	157 (71)	26 (70.3)	104 (78.8)	79 (62.7)
Predisposing factors n (%)							
Benign prostatic hyperplasia	86 (33.3)	48 (30.2)	38 (38.4)	86 (38.9)	-	47 (35.6)	39 (31)
History of urinary intervention	50 (19.4)	-	50 (31.4)	50 (22.6)	-	20 (15.2)	30 (23.8)
Urological malignancy	44 (17.1)	22 (13.8)	22 (22.2)	44 (19.9)	-	18 (13.6)	26 (20.6)
Nephrolithiasis	35 (13.6)	21 (13.2)	14 (14.1)	35 (15.8)	-	5 (3.8)	30 (23.8)
Urological instrumentation	40 (15.5)	19 (13.2)	21 (21.2)	40 (18.1)	-	20 (15.2)	20 (15.8)
Urostomy or nephrostomy	5 (2)	2 (1.3)	3 (3)	5 (2.3)	-	-	5 (4)
Urethral stricture	5 (1.9)	-	5 (5.1)	5 (2.3)	-	2 (1.5)	3 (2.4)



Table 1. Continued...							
Symptoms and signs n (%)							
Dysuria	225 (87.2)	140 (88.1)	85 (85.9)	192 (86.9)	33 (89.2)	114 (86.4)	111 (88.1)
Increased urinary frequency	123 (47.7)	72 (45.3)	51 (51.5)	103 (46.6)	20 (54.1)	66 (50)	57 (45.2)
Suprapubic tenderness	123 (47.7)	72 (45.3)	51 (51.5)	111 (50.2)	12 (32.4)	45 (34.1)	78 (61.9)
Lateral pain and costovertebral angle tenderness	122 (47.3)	77 (48.4)	45 (45.5)	122 (55.2)	-	-	122 (96.8)
Urgency	56 (21.7)	29 (18.2)	27 (27.3)	49 (22.2)	7 (18.9)	37 (%28)	19 (15.1)
Nausea and vomiting	40 (15.5)			40 (18.1)	-	-	40 (31.7)
Fever	30 (11.6)	19 (11.9)	11 (11.1)	30 (13.6)	-	-	30 (23.8)
Treatment background n (%)							
History of UTI in the past twelve months	127 (29.2)	64 (40.3)	63 (63.6)	114 (51.6)	13 (35.1)	60 (45.5)	67 (53.2)
History of antibiotic use in the past three months	126 (48.8)	56 (35.2)	70 (70.7)	112 (50.7)	14 (37.8)	64 (48.5)	62 (49.2)
History of hospitalisation in the past three months	74 (28.7)	8 (5)	66 (66.7)	68 (30.8)	6 (16.2)	36 (27.3)	38 (30.2)
Treatment setting n (%)							
Polyclinic	192 (74.4)	129 (81.1)	63 (63.6)	164 (74.2)	28 (75.7)	102 (77.3)	90 (71.4)
Clinic	66 (25.6)	30 (18.9)	36 (36.4)	57 (25.8)	9 (24.3)	30 (22.7)	36 (28.6)

UTI: Urinary tract infection

Table 2. Results of urine microscopy

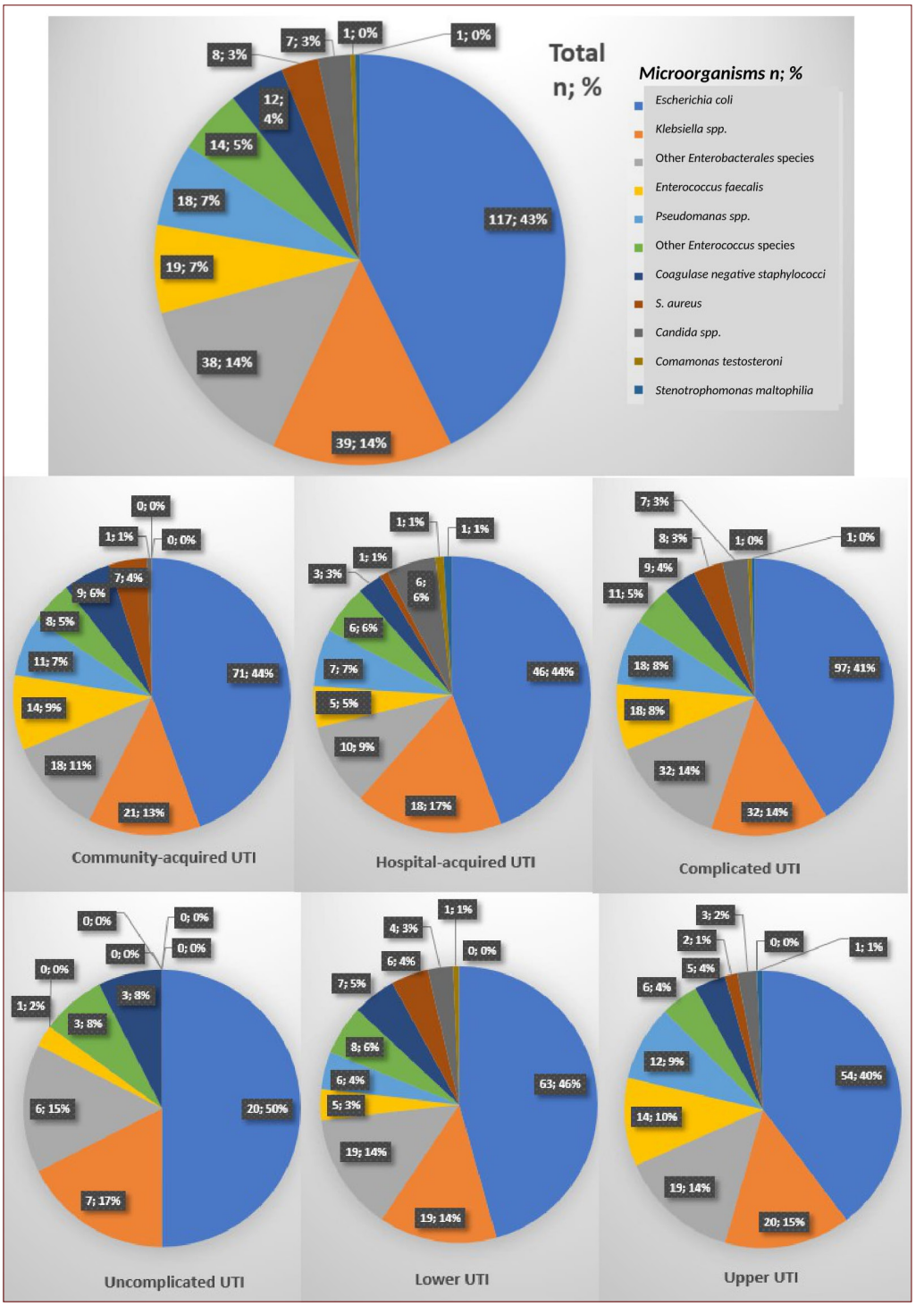
Parameters Median (Q1-Q3)	**Total** n=240	**Community-acquired UTI** n=148	**Hospital-acquired UTI** n=92	**Complicated UTI** n=207	**Uncomplicated UTI** n=33	**Lower UTI** n=125	**Upper UTI** n=115
White blood cell/HPF Median (Q1-Q3)	106.5 (33-542)	87 (33-420)	127 (36-743)	108 (33-554)	57 (14-455)	87 (30-547)	155 (43-480)
Red blood cell/HPF Median (Q1-Q3)	32 (6.5-136)	23 (6-77)	61 (7-222)	33 (7-139)	14 (4-122)	33.5 (6-136)	30 (8-129.5)
Pyuria* n (%)	234 (97.3)	143 (96.8)	90 (98.2)	202 (97.8)	31 (93.3)	121 (96.8)	112 (97.7)
Hematuria** n (%)	216 (90)	131 (88.4)	85 (92.7)	187 (90.4)	29 (86.7)	119 (95.2)	99 (86.4)

UTI: Urinary tract infection, Q1: 1st Quarter. Q3: 3rd Quarter

HPF: High Power Field

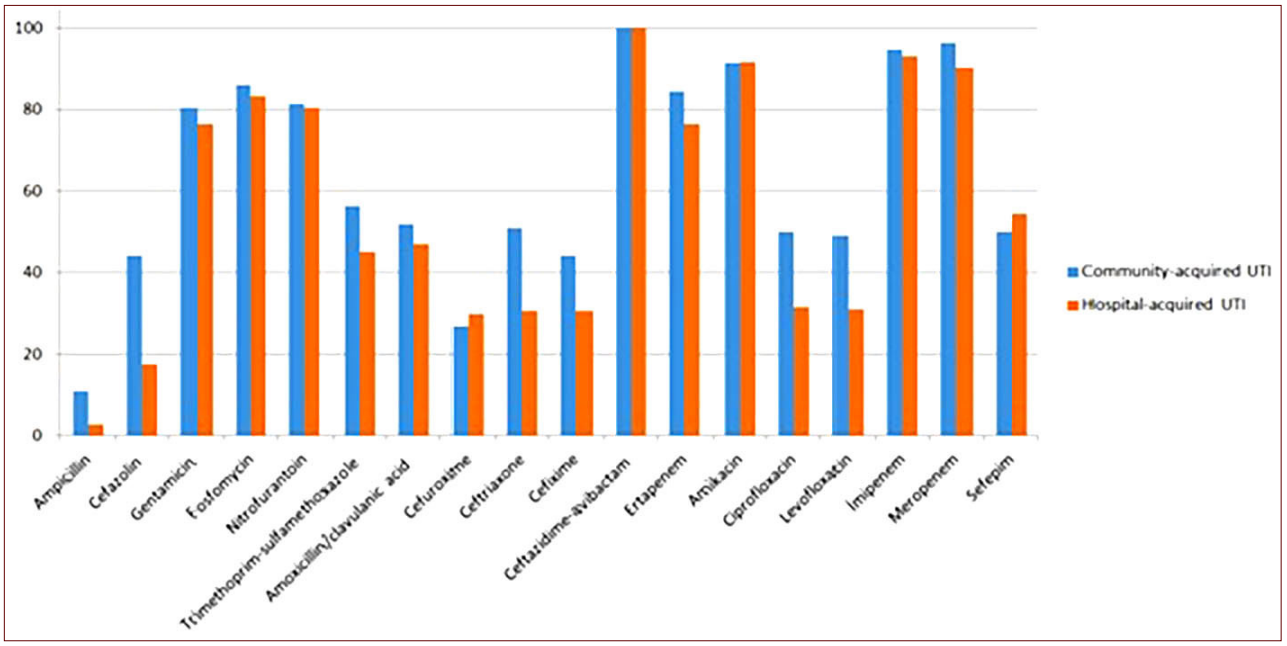
* Pyuria: ≥ 5 White blood cell/HPF

** Hematuria: ≥ 3 Red blood cell/HPF



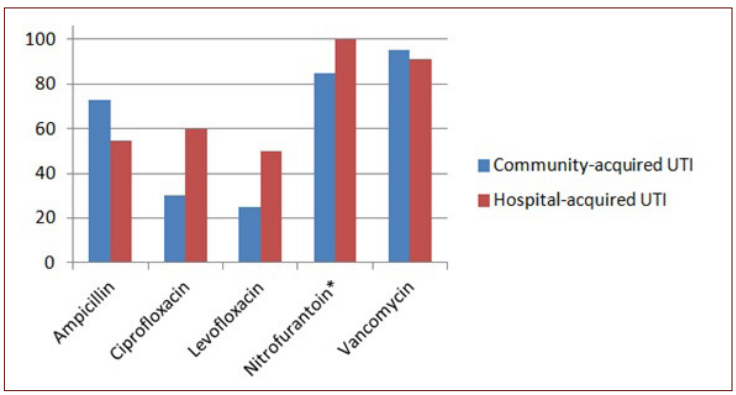
UTI: Urinary tract infection

Figure 1. Distribution of microorganisms grown in urine culture



UTI: Urinary tract infection

Figure 2. Antibiotic susceptibility percentages of *Enterobacterales* species



UTI: Urinary tract infection

Figure 3. Susceptibility percentages of *Enterococcus spp.* isolates
*Only *Enterococcus faecalis* isolates were included.

were followed up as inpatients. Two (0.8%) of the patients died.

Two different microorganisms were found in urine cultures of 16 (6.2%) patients. The colony count was 104-105 cfu/ml in 38 (13.9%) isolates and >105 cfu/ml in 236 (86.1%) isolates. Of the 274 isolates, 214 (78.1%) were gram-negative, 53 (19.3%) were gram-positive and 7 (2.6%) were yeast-type fungi. The distribution of microorganisms grown in urine culture is shown in Figure 1. ESBL production was detected in 60 of 120 (50%) community-acquired *Enterobacterales* isolates and in 51 of 74 (68.9%) hospital-acquired isolates. The antibiotic susceptibility percentages of *Enterobacterales* species are shown in Figure 2. Antibiotic susceptibility percentages of *Enterococcus* spp. isolates are shown in Figure 3. Of the *S. aureus*

isolates, one was hospital-acquired and seven were community-acquired. The hospital-acquired isolate and three (42.8%) of the community-acquired isolates were resistant to methicillin.

DISCUSSION

The number of elderly people worldwide is increasing every day. In Türkiye, 10.2% of the population will be over 65 years of age by 2023 (3). UTI occurs in both sexes and all age groups and is the most common bacterial infection in geriatric patients. UTIs are more common in women due to anatomical structure, but studies have reported that men are more common in geriatric patients (4). In our study, the sex distribution was 63.6% male and 36.4% female. This may be associated with the fact that female patients with uncomplicated UTI received treatment by referring to primary and secondary healthcare institutions and referred less to tertiary hospitals where our study was conducted.

Healthcare costs are high in the geriatric population due to the high incidence of chronic diseases (1, 2). In our study, 70.9% of patients had at least one chronic disease. In an Indian study, diabetes mellitus (63.3%), chronic renal failure (21.6%) and cerebrovascular events (14.1%) were the most common, whereas in a Greek study, dementia (34.3%), diabetes mellitus (25%) and cerebrovascular disease (21.6%) were the most common (4, 5). In our study, hypertension (45%), chronic heart disease (36.8%) and diabetes mellitus (31.8%) were the most common. This may be due to the fact that co-morbidities vary from country to country and region to region.

In geriatric patients; weakening of the immune system, use of urological catheters, decreased water consumption, cognitive disorders, structural and functional abnormalities of the urinary system causing urinary retention are common predisposing factors for UTI (1, 2). Benign prostatic hyperplasia, which causes urinary retention and provides a favourable environment for bacterial growth, was the most common predisposing factor in our study and was found in more than half of the men. The second most common predisposing factor was a history of urinary intervention, which may be related to the fact that our study was conducted in a tertiary care hospital where interventional procedures such as transurethral prostate resection and urodynamic testing are frequently performed.

Chronic infections causing immune deficiency or presence of predisposing factors are classified as complicated UTI (1, 2). In our study, diabetes mellitus and malignancy were observed in 31.8% and 21%, respectively. Uncomplicated infections are usually observed in young women. In the elderly population, factors that predispose individuals to UTIs, such as structural or functional abnormalities of the urinary tract, urinary catheterisation, urinary tract obstruction and chronic systemic conditions that impair immune function, are more common. Therefore, complicated UTIs are more frequent in this population than in other age groups (1, 6). In our study, complicated UTIs also predominated, accounting for 85% of cases.

Although invasive methods are mentioned for the differentiation of upper/lower UTI, it is very important in clinical practice to start appropriate antibiotic treatment without delay. Therefore, the distinction is usually made on the basis of symptoms. According to the traditional symptomatic distinction, the presence of symptoms such as flank pain, nausea-vomiting, fever, etc. indicates an upper *UTI*. Symptoms such as dysuria, increased urinary frequency, urgency and suprapubic tenderness indicate lower *UTI* (1, 6). In our study, symptoms of lower *UTI* were present in more than half of the patients.

The fact that culture and antibiotic susceptibility testing takes at least two days has made the use of empirical treatment mandatory. The most appropriate antibiotic treatment should be decided



by asking about the medical history (history of UTI, previous UTI agent and antibiotic susceptibility, history of hospitalisation for any reason and antibiotic use), predisposing factors for UTI and co-morbidities (complicated/uncomplicated UTI). In addition, it should be determined whether the UTI is of community or hospital origin. A study of geriatric patients with UTI in Greece reported that 18.1% of patients had UTI in the past 12 months, 30.4% had used antibiotics in the past 3 months and 42.2% had been hospitalised (5). In a study of adult patients in Germany, hospital-acquired UTI was found to be 50.6%, and hospital-acquired UTI was found to be higher than community-acquired UTI only in intensive care units and surgical wards (7). When we compared the data from our study with these studies, we found a higher rate of UTI (29.2%) and antibiotic use (48.8%) and a lower rate of hospitalisation (28.7%). In addition, the rate of hospital-acquired UTI (38.4%) was lower in our study, probably due to the exclusion of intensive care patients.

A study analysing the adult age group admitted to the emergency department in our country reported that 9% of patients diagnosed with UTI were admitted to hospital (8). In our study, this rate was 25.6%, which is an expected result due to other co-morbidities apart from UTI and the more severe course of UTI in geriatric patients.

Although hematuria can be observed in UTIs, it is not specific to them. It may also occur in conditions such as urinary tract stones, trauma, tumors, glomerular diseases and anticoagulant use. Similarly, pyuria can be detected in the absence of a UTI in cases involving inflammation due to stones, tumors or catheterisation. Therefore, urinalysis findings should always be interpreted alongside the patient's clinical presentation (6). In a study investigating UTIs in elderly patients, haematuria was reported in 15.8% of cases and pyuria in 10.0% (4). Another study reported these rates as 77% and 94%, respectively (9). Hematuria is more commonly observed in lower UTIs than in upper UTIs, whereas pyuria is more commonly observed in upper UTIs than in lower UTIs (2, 6). Our findings were consistent with those of previous studies.

Residence in a nursing home has been identified as a predisposing factor for UTI due to poor hygiene and the frequent use of urological catheters. UTI is the most common cause of bacteraemia in nursing home residents and the mortality rate is lower than other bacteraemia-causing infections (pneumonia, etc.). In a study conducted in Pittsburgh, Pennsylvania, 55% of bacteraemia cases were caused by UTI. The mortality rates were 15.5% for UTI-associated bacteraemia and 50% for pneumonia (10). Residence in a nursing home is rare in Türkiye (0.36%) compared to Western countries (11). There were no nursing home residents in our study. In a study of geriatric patients hospitalised for UTI in Türkiye, bacteraemia was reported in 29% of patients and 2.5% of patients died (12). In a study conducted in Spain, bacteraemia was reported in 16.3% of patients and 10.3% of patients died (13). In our study, bacteraemia was seen in 4.7% of patients and 0.8% of patients died. The fact that our data are lower than previous studies is related to the inclusion of outpatients in the study. This is also supported by the fact that all patients with bacteraemia in our study were hospital patients.

In our study, the colony count was 10^4-10^5 cfu/ml in 38 patients (13.9%) and $\geq 10^5$ cfu/ml in the rest (14). Polymicrobial UTI is more common in geriatric patients, those with chronic infections leading to immunodeficiency, those with indwelling catheters and those in intensive care (15). Although polymicrobial UTI was not mentioned in some studies of geriatric patients, a study of inpatients in Spain reported 9.2% polymicrobial UTI. In our study, the rate of polymicrobial UTI was 6.2% (13). It is an expected finding that the rate was lower due to the exclusion of ICU patients and inclusion of outpatients.

As in other age groups, ***E. coli*** was the most common organism found in UTI in geriatric patients (5, 9, 12). However, it has been reported that ***E. coli*** is less common and ***Klebsiella spp.***, ***Proteus spp.*** and ***Pseudomonas aeruginosa*** are more common in the geriatric age group compared to other age groups (16). The second most common organism in geriatric UTIs was ***Klebsiella pneumoniae***, and Gram-negative bacteria accounted for more than 75%. Among gram-positive bacteria, enterococci were the most common (5, 9, 12). ***Staphylococcus*** species, accepted as causative agents in symptomatic patients, are rare uropathogens (17, 18). Studies have reported that more than 65% of ***Staphylococcus*** species are coagulase positive (*S. aureus*) (19, 20). The distribution of bacteria identified in our study was consistent with previous research, and the three most common microorganisms remained consistent across subgroups of *UTI*s. In addition, ***Comamonas testosteroni***, detected in one patient in our study, has been associated with many hospital-acquired infections, including a *UTI*, and its prevalence has been reported to be increasing (21).

Bacteria producing broad-spectrum beta-lactamase are resistant to penicillin, cephalosporins and azithromycin, limiting treatment options. ESBL prevalence is high in Mediterranean countries where ***Enterobacterales*** species are common. However, it varies from country to country depending on many factors such as geographical location, population density, hygiene and antibiotic use. According to the European Centre for Disease Prevention and Control (ECDC) 2023 report, resistance to third-generation cephalosporins in ***E. coli*** and ***Klebsiella spp.*** isolates from invasive samples in Türkiye in 2021 was reported to be 49.6% and 92.3%, respectively (22). In a study conducted in our country analysing geriatric *UTI*s, the frequency of ESBL was reported to be 56.0% in ***E. coli*** and 40.0% in *K. pneumoniae* (12). In our study, ESBL production was found in more than 50% of both community-acquired and hospital-acquired ***Enterobacterales*** isolates. Due to genetic proximity, ESBL production may be associated with quinolone, TMP/SMX and aminoglycoside resistance (23). In our study, although similar susceptibility rates to TMP/SMX and quinolone were found, high susceptibility rates to gentamicin and amikacin were detected among the aminoglycosides.

Enterococci have become more common in both hospital-acquired and community-acquired *UTI*s in recent years due to their ever-increasing pathogenicity, such as biofilm formation. Ampicillin is a good option for the treatment of enterococci because it reaches high concentrations in the urinary system (24). In our study, ampicillin susceptibility was found to be 72.7% in community-acquired isolates and 54.5% in hospital-acquired isolates. Although nitrofurantoin has been shown to be effective in the treatment of UTI caused by *E. faecium*, EUCAST has recommended that it only be used for uncomplicated UTI caused by *E. faecalis* (25). Quinolones are used orally or intravenously in complicated and uncomplicated UTIs (24). In our study, high sensitivity rates (90%) were found for nitrofurantoin and low rates (33.3%-40%) for quinolones. *E. gallinarum* and *E. casseliflavus/* flavescens are naturally resistant to vancomycin and are rare. Acquired vancomycin resistance is most commonly observed in al-acquired *E. faecium* isolates (24). In our study, one of the two isolates with vancomycin resistance was *E. gallinarum* and the other was hospital-acquired *E. faecium*, in line with the literature.

Staphylococcus species are increasingly isolated from *UTI*s. Uropathogenic ***Staphylococcus*** species have virulence factors such as biofilm formation, which makes the bacteria more resistant to antibiotics (20). In our country, methicillin resistance was found in ***S. aureus*** isolates from invasive isolates at a rate of 25.8%-33.4% between 2017 and 2021, while 68.8% of community-acquired ***Staphylococcus spp.*** isolates and all hospital-acquired ***Staphylococcus spp***. isolates were methicillin-resistant in our study

(22). The high rate of methicillin resistance in our study may be related to the higher incidence of hospital-acquired methicillin-resistant pathogens in the geriatric age group and the high antibiotic resistance of uropathogenic *Staphylococcus* isolates. The high antibiotic resistance of uropathogenic *Staphylococcus* isolates should be taken into account in clinical practice.

As our study was retrospective, this represents a significant limitation. There is a possibility that patient records may contain missing or inaccurate data. Additionally, since laboratory tests related to UTIs were not performed for all patients, there are missing data in this regard. Another limitation is that the clinical presentation of UTIs in geriatric patients may not be fully elucidated due to communication difficulties, comorbidities, and polypharmacy. Furthermore, the single-centre nature of the study and the absence of follow-up data should also be considered as limitations.

In our study, the high prevalence of male patients with complicated *UTI*s was notable. The high rate of ESBL production in *Enterobacterales* species, the presence of ampicillin- and vancomycin-resistant *Enterococcus* species, and the high prevalence of methicillin-resistant *Staphylococcus* species underscore the need to update treatment strategies and maintain surveillance of antimicrobial resistance in geriatric patients. These findings highlight the importance of a multidisciplinary approach to managing UTIs in geriatric patients, with close collaboration between clinicians and microbiologists.

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ORIGINAL ARTICLE

CLINICAL PERFORMANCE COMPARISON OF THE I-GEL AND LARYNGEAL MASK AIRWAY SUPREME IN GERIATRIC PATIENTS: A PROSPECTIVE STUDY

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Abstract

Introduction: This study compares the clinical performance and pharyngolaryngeal complications of two second-generation supraglottic airway devices, the I-gel and the laryngeal mask airway supreme, in geriatric patients undergoing elective surgery under general anesthesia.

Materials and methods: Following approval from the hospital ethics committee and written informed consent, patients aged 65 years and older, classified with an American Society of Anesthesiologists score of I-III, and scheduled for elective urological surgery under general anesthesia were prospectively included. Participants were randomly allocated into two equal-sized groups: I-gel and laryngeal mask airway-supreme. We compared the successful insertion on a first attempt and ease of insertion as a primary outcome, and the secondary outcomes were insertion time, ease of gastric tube insertion, oropharyngeal leak pressure, and intraoperative and postoperative complications.

Results: A total of 120 patients were recruited, with 60 in each group. Insertion time for the supraglottic airway device was significantly shorter in the I-gel group ($p<0.001$). A greater proportion of patients in the I-gel group demonstrated optimal oropharyngeal leak pressure across all measurement points ($p<0.001$). However, gastric tube placement was facilitated more easily in the laryngeal mask airway supreme group ($p=0.018$). Furthermore, intraoperative complications were significantly higher in the laryngeal mask airway-supreme group ($p=0.008$). No notable differences were detected between the groups regarding ease of insertion, success rate on the first attempt, or postoperative complication rates.

Conclusion: The I-gel may be preferred for geriatric patients due to its shorter insertion time, lower oropharyngeal leak pressure, and reduced incidence of intraoperative complications.

Keywords: Physical Functional Performance; Geriatric Anesthesia; Laryngeal Masks.

INTRODUCTION

A definitive cut-off value for defining "geriatric" age remains unestablished; however, individuals aged 65 years and older are commonly recognized as belonging to this group. Age-related anatomical and physiological changes, increase the risk of perioperative respiratory and hemodynamic complications in older patients during endotracheal intubation and extubation (1,2). Supraglottic airway devices (SGADs) offer distinct advantages over traditional endotracheal intubation for patients aged 65 years and older, requiring fewer pharmacological agents and providing greater hemodynamics stability (3). Furthermore, many geriatric patients lack teeth, which often results in poor fit of standard face masks and subsequent difficulties in mask ventilation (4). Consequently, SGADs may serve as a superior alternative to face masks for older, edentulous patients (5).

The Laryngeal Mask Airway Supreme (LMA-Supreme; Teleflex Incorporated, Limerick, Maine, USA), a second-generation, cuffed SGAD introduced in 2007, features a curved oval shape with a rigid tunnel to facilitate insertion. A gastric drainage channel reduces the risk of gastric regurgitation and subsequent aspiration, while the modified cuff minimizes air leakage and airway obstruction (6).

The I-gel™ (Intersurgical Ltd, Wokingham, UK), another second-generation SGAD, is designed to minimize pressure on laryngeal and pharyngeal structures. It incorporates a soft, gel-like, transparent thermoplastic elastomer at the distal end and lacks an inflatable cuff. This configuration eliminates the need to inflate or monitor pressure in a cuff-like structure (7). Potential benefits include rapid and straightforward insertion, a reduced likelihood of increased pharyngeal pressure due to high cuff pressure, a gastric drainage channel, and a single-use design that eliminates the risk of infectious disease transmission (8).

The clinical performance of second-generation SGADs, including the LMA-Supreme and I-gel, has been evaluated in numerous studies (9–11). However, most investigations included participants across various age groups, leading to variability in clinical performance, efficacy, and applicability among poorly defined older populations. This study therefore aimed to compare the performance of these two supraglottic airway devices in a well-defined geriatric population.

MATERIALS AND METHOD

Following approval from the Institutional Review Board (19-4.1T/40; 17.04.2019), patients aged 65 and older, classified with an American Society of Anesthesiologists (ASA) score I-III, and scheduled for elective urological surgery under general anesthesia were prospectively enrolled. Informed consent was obtained from all patients or their legal representative. Exclusion criteria included patients scheduled for emergency surgery, those with unstable vital signs, a history or suspicion of a difficult airway, preoperative sore throat, or a high risk of aspiration. High aspiration risk encompassed individuals with a body mass index exceeding 35 kg/m², gastroesophageal reflux, hiatal hernia, diabetic gastroparesis, or a history of medications affecting gastrointestinal motility. In addition, patients with a high risk of respiratory complications—such asthma, chronic obstructive pulmonary disease, recent pneumonia—abnormalities of the oral cavity or pharynx, communication difficulties, or those scheduled for surgeries exceeding 90 minutes were also excluded.

The study was conducted from April 2019 to April 2020. Participants were randomly assigned to two equal-sized groups: the LMA-Supreme group and the I-gel group. Randomization was performed using a computer-assisted method (www.randomizer.org). Insertion of the supraglottic airway device (SGAD) was carried out by a single anesthesiologist with experience in at least 200 insertions of each device type and a first-attempt failure rate below 5% in the general patient population. Patients were positioned



supine with a standard pillow supporting their heads during the procedure. Each device was prepared according to the manufacturer's recommendations, with the posterior and lateral surfaces lubricated using a water-soluble gel. Device size was selected based on patient weight, adhering to manufacturer guidelines.

Upon admission to the operating room, standard monitoring was implemented, including noninvasive blood pressure measurement, pulse oximetry (SpO2), and electrocardiography. Pre-oxygenation was performed for at least 3 minutes using 100% oxygen at a fresh gas flow rate of 8 L/min. Anesthesia was induced intravenously with 1 mg/kg 2% lidocaine, 1–2 µg/kg fentanyl, and 2–3 mg/kg propofol. Neuromuscular blocking agents were not used. Manual ventilation was provided with 100% oxygen and 2% sevoflurane until adequate anesthesia depth was achieved, confirmed by sufficient jaw relaxation during the jaw-thrust maneuver and absence of the eyelash reflex. Once these criteria were met, the SGAD was inserted.

For I-gel insertion, the device was held at the bite block and advanced while the patient was positioned in the "sniffing" posture, involving head extension at the atlanto-occipital joint, neck flexion, and downward jaw displacement. The device was guided toward the palate through the mouth and advanced backward and downward until resistance was encountered.

For LMA Supreme insertion, the cuff was fully deflated prior to placement. The distal tip was positioned against the upper teeth or gum, and the device was gently slid inward using a slight crosswise motion, following the tongue, until resistance was felt. After correct placement, the cuff of the LMA-Supreme was inflated to a pressure of 60 cmH2O (measured with a VBM pressure gauge from Germany) and monitored regularly to maintain a constant cuff pressure. Adequate ventilation was confirmed by bilateral chest expansion, auscultation of lung sounds, and observation of end-tidal CO2 (ETCO2) waveforms. If ventilation was inadequate, the "jaw thrust maneuver" was attempted, along with neck extension or flexion, and made gentle adjustments to the position of the SGAD to ensure proper placement. Following successful placement, mechanical ventilation was initiated in a volume-controlled mode using a mixture of 50%/50% oxygen-air mixture. Tidal volume was set at 5–6 mL/kg, with a respiratory rate of 10–12 breaths per minute, and ETCO2 levels were maintained between 35–40 mmHg. Anesthesia was maintained with 1.0–2.0% sevoflurane in an oxygen-air mixture and an infusion of remifentanil at 0.25–0.5 µg/kg/min.

Oropharyngeal leak pressure (OLP) was measured intraoperatively after SGAD placement, with assessments conducted at 15-minute intervals during the procedure and immediately before device removal at surgery's end. OLP was determined by observing the pressure at which air leaked from the mouth, using a fixed fresh-gas flow of 5 L/min, with the adjustable pressure-limiting (APL) valve closed at 30 cmH2O to ensure peak airway pressure did not exceed 40 cmH2O. OLP was evaluated on a five-point scale: 1= excellent (no air leak at 30 cmH2O); 2= good (air leak at 18-20 cmH2O); 3= moderate (air leak at 10-16 cmH2O); 4= poor (air leak at ≤ 8 cmH2O); and 5= placement/ventilation failure (12).

Placement time for the SGADs was defined as the interval from face mask removal to the appearance of the first ETCO2 waveform. Ease of insertion was assessed on a three-point scale: 1= easy (successful placement on the first attempt without resistance or additional maneuvers), 2= difficult (successful placement on the first attempt with slight resistance, requiring device adjustment or chin lift), and 3= very difficult (placement achieved only on the second attempt despite maneuvers). The ease of gastric tube insertion was evaluated on a three-point scale after lubrication and advancement through the gastric channel following SGAD placement: 1= first attempt (successful); 2= second attempt (successful); or 3= failure (unsuccessful). Additional parameters recorded

included LMA Supreme cuff pressure, operative duration, anesthesia duration, and intraoperative complications. The complications noted included dental, lip, and tongue injuries, hiccups, respiratory issues, such as desaturation SpO2 ≤ 92%, sudden increase in peak airway pressure, regurgitation/aspiration, laryngospasm, and apnea.

At the conclusion of surgery, pain management was provided with 1 mg/kg tramadol and 10 mg/kg paracetamol. The SGAD was removed once spontaneous respiration and responsiveness to verbal commands were confirmed. During this process, any adverse events such as laryngospasm, coughing, desaturation, and injuries to the tongue, teeth, or lips, as well as blood contamination on the laryngeal mask, were recorded. Postoperative assessments for throat pain, hoarseness, and dysphagia were conducted at two and twelve hours, with symptoms recorded as present or absent.

We compared the successful insertion on a first attempt and ease of insertion as a primary outcome, and the secondary outcomes were insertion time, ease of gastric tube insertion, oropharyngeal leak pressure, and intraoperative and postoperative complications.

Statistical Analysis

In this study, the sample size was determined to be 60 patients for each group based on power analysis from a similar study in the literature (13).All the statistical analyses were performed using SPSS version 24 (IBM Inc., Armonk, NY, USA). Data are reported as mean ± standard deviation (SD), median (minimum-maximum), or percentage (%). Normality of the continuous variables was assessed using the Shapiro-Wilk test. For pairwise and multiple comparisons, the chi-square test and Fisher's exact test were used for categorical variables, whereas the Independent T-test and One-Way ANOVA were used for quantitative variables. Nonparametric comparisons were performed using the Mann-Whitney U test. For multiple group comparisons of continuous variables, Dunn-Bonferroni and Tukey tests were applied. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 120 patients were enrolled, with 60 assigned each group: the LMA-Supreme group and the I-gel group. Of these, 16 (13.3%) underwent transurethral prostate resection, 22 (18.3%) underwent transurethral bladder resection, 61 (50.8%) underwent control cystoscopy, and 21 (17.5%) underwent endoscopic ureterorenoscopy. Patient demographics and procedure durations are presented in Table 1. A significant age difference was observed between the groups, with the patients in the I-gel group being approximately 2 years older.

Table 1. Demographic data, surgical duration, and anesthesia duration (values are presented as mean ± standart deviation or numbers)

	I-gel group (n= 60)	**LMA-Supreme group** (n= 60)	**p**
Age (years)	72.9 ± 5.8	70.8 ± 5.3	0.03*
Sex (M/F)	52/8	49/11	0.61
Body mass index (kg/m2)	27.03 ± 4.2	27.52 ± 4.1	0.52
Surgical time (min)	25.36 ± 15.6	27.18 ± 15.7	0.46
Duration of anesthesia (min)	34.8 ± 17.5	36.85 ± 16.05	0.25

M: male, F: female The t-test was applied to compare independent variables between groups, *p< 0,05 statistically significant



The success rate of SGAD placement on the first attempt was determined to be 85% (n=51) in the LMA-Supreme group and 86.6% (n=52) in the I-gel group. On the second attempt, success rates were recorded as 15% (n=9) in the LMA-Supreme group and 13.3% (n=8) in the I-gel group. No significant difference in first-attempt success rates was detected between the groups (p=0.79). Ease of SGAD placement was assessed, with 38 patients (63.3%) in the LMA-Supreme group and 42 patients (70%) in the I-gel group categorized as grade 1 (easy). Grade 2 (difficult) placement was noted in 18 patients (30%) in the LMA-Supreme group and 13 patients (21.7%) in the I-gel group, while grade 3 (very difficult) placement was observed in 4 patients (6.7%) in the LMA-Supreme group and 5 patients (8.3%) in the I-gel group. No significant difference in ease of placement was found between the groups (p=0.57). Gastric tube placement was evaluated, with successful first-attempt insertion achieved in 95% (n=57) of patients in the LMA-Supreme group compared to 78.3% (n=47) in the I-gel group, indicating significantly easier placement in the LMA-Supreme group (p= 0.018). Finally, the average placement time for the SGAD was 17.4 ± 3.3 seconds in the LMA-Supreme group and 15.6 ± 6.95 seconds in the I-gel group (p< 0.001).

Table 2. Intraoperative oropharyngeal leak pressure values (cmH2O)

		I-gel group n= 60 (%)	**LMA-Supreme group** n= 60 (%)	**p**
After the placement of SGAD	1	51 (85.0)	24 (40.0)	< 0.001*
	2	7 (11.7)	25 (41.7)	
	3	1 (1.7)	11 (18.3)	
	4	1 (1.7)	0	
At the fifteenth minute	1	49 (83.1)	20 (35.1)	< 0.001*
	2	7 (11.9)	24 (42.1)	
	3	3 (5.1)	13 (22.8)	
	4	0	0	
At the thirtieth minute	1	23 (82.1)	8 (25.0)	< 0.001*
	2	3 (10.7)	14 (43.8)	
	3	2 (7.1)	9 (28.1)	
	4	0	1 (3.1)	
At the forty-fifth minute	1	9 (75.0)	4 (30.8)	0.186
	2	1 (8.3)	3 (23.1)	
	3	2 (16.7)	5 (38.5)	
	4	0	1 (7.7)	
At the sixtieth minute	1	4 (66.7)	2 (28.6)	0.301
	2	1 (16.7)	1 (14.3)	
	3	1 (16.7)	4 (57.1)	
	4	0	0	

SGAD: supraglottic airway device; data are presented as numbers with percentage values and assessed of OLP used a five-point scale: 1= excellent, 2= good, 3= moderate, 4= poor, and 5= placement/ventilation failure; *p<0.05

Table 3. Intraoperative complications

	I-gel group n= 60	LMA-Supreme group n= 60	p
Intraoperative complications, n (%)	2 (3.3)	11 (18.3)*	0.008*
Hiccup (n)	0	4	
Lip injury (n)	0	2	
Laryngospasm (n)	1	2	
Desaturation (n)	0	2	
Blood contamination on SGAD (n)	1	1	

SGAD: supraglottic airway device Data are presented as numbers with percentage values; *p<0.05

Table 4. Postoperative complications

	I-gel group n= 60 (%)	LMA-Supreme group n= 60 (%)	p
Postoperative second hour			
Dyspagia	4 (6.7)	3 (5)	0.69
Sore throat	1 (1.7)	4 (6.7)	0.17
Hoarseness	-	1 (1.7)	0.31
Postoperative twelfth hour			
Dyspagia	-	-	
Sore throat	-	-	
Hoarseness	-	1(1.7)	0.31

Data are presented as numbers with percentage values; *p< 0.05, statistically significant

Oropharyngeal leak pressure was evaluated using a 5-point scale. A significantly higher number of patients in the I-gel group demonstrated excellent OLP (grade 1) at placement, 15. minutes, and 30. minutes compared to the LMA Supreme group (p< 0.001) (Table 2).

When comparing intraoperative complications between the two groups, the LMA-Supreme group experienced significantly more complications than the I-gel group. In the LMA-Supreme group, intraoperative complications were reported in 11 (18.3%), whereas only 2 patients (3.3%) in the I-gel group experienced complications (p= 0.008) (Table 3).

Postoperative pharyngolaryngeal complication rates, including dysphagia, hoarseness, and/or sore throat, were evaluated at two and twelve hours. No significant differences were observed between the groups (p> 0.05) (Table 4).

DISCUSSION

In this study, we aimed to compare the clinical performance of the second-generation supraglottic airway devices, I-gel and LMA-Supreme, in geriatric patients. In our study, I-gel insertion time was shorter than LMA-Supreme, and the number of patients who had optimal oropharyngeal leakage



pressure at all-time points was higher, and the rate of intraoperative complications was lower in I-gel. However, gastric tube placement was facilitated more easily in the LMA-Supreme. No notable differences were detected between the supraglottic airway devices regarding ease of insertion, success rate on the first attempt, or postoperative complication rates.

In the present study, no significant difference in placement ease was observed between the groups, although placement was assessed as easier in the I-gel group. A study by In et al. (13) involving 38 geriatric patients reported that 78.9% of patients in the I-gel group were classified as "easy," compared to only 36.8% in the LMA-Supreme group. The straight and flexible structure of the I-gel was suggested to facilitate easier advancement in the pharyngeal direction. In contrast, the more rigid and curved design of the LMA-Supreme may complicate positioning. However, other studies have reported that the LMA-Supreme offers advantages placement ease (14). Ease of placement may vary depending on the practitioner's experience.

No significant difference was observed between the two groups in first-attempt placement success. Similarly, a meta-analysis by Chen et al. (1), encompassing ten studies, and a study by In et al. (13) reported no notable differences in first-attempt placement success between groups. Conversely, Ragazzi et al. (15) noted a higher first-attempt success rate in the LMA-Supreme group, attributed to challenges posed by the larger I-gel design for inexperienced users.

Geriatric patients are susceptible to respiratory and neurological complications due to reduced functional reserves. A delayed respiratory response to desaturation or hypercapnia can increase mortality and morbidity, underscoring the importance of timing SGAD placement in this population (16,17). Varying results have been reported for different SGADs. In this study, the time required to achieve adequate airway patency with SGAD placement was significantly shorter in the I-gel group. Kim et al. (18) compared LMA-Supreme and I-gel in geriatric patients and observed a shorter placement time in the I-gel group, though the difference was not statistically significant. A longer placement time was anticipated for the LMA-Supreme due to its inflatable cuff, but practitioner experience likely minimized the difference. Similarly, In et al. (13), reported a significantly shorter placement time in the I-gel group, attributed to the absence of an inflatable cuff. The time required to inflate the cuff, approximately 2–3 seconds, may account for the difference between the groups. The ease of insertion also likely contributed to this time disparity. In geriatric patients, the I-gel's thermoplastic elastomer cuff may facilitate correct positioning by applying pressure to the tongue, whereas the LMA-Supreme curved, fixed shape may pose greater challenges (19). In summary, the shorter placement time in the I-gel group may be due to factors such as the absence of an inflatable cuff and enhanced ease of insertion.

In this study, the success rate of gastric tube placement on the first attempt was significantly higher in the LMA-Supreme group. Multiple studies have similarly reported higher success rates for gastric tube placement using the LMA-Supreme (11,15). This improved performance may be attributed to the more rigid structure of the LMA-Supreme, the centrally positioned cuff, and smoother gastric drainage channels. By contrast, the smaller gastric tube drainage channel in the I-gel may complicate the passage of the gastric tube. Moreover, anatomical variations in geriatric patients may further influence success rates when comparing SGADs.

Oropharyngeal leak pressure (OLP), a critical factor in SGAD safety and effectiveness (20), refers to the pressure at which gas begins to leak around the device. Generally, higher leak pressures suggest that sufficient ventilation can be achieved without air leakage during positive-pressure ventilation,

even at an elevated inspiratory pressure. In this study, OLP was evaluated, and the proportion of patients with "excellent" OLP was significantly higher in the I-gel group than in the LMA-Supreme group. After SGAD placement, leak pressures below 20 cmH_2O were recorded in approximately 12% of patients in the LMA-Supreme group and 3% in the I-gel group. No ventilatory deterioration or increased complications were observed among patients. Ragazzi et al. (15) and Chew et al. (14) reported more effective leak resistance in the LMA-Supreme group at higher pressures. However, In et al. (13) and the meta-analysis by Chen et al. (1) found no significant difference in OLP between the devices. In a randomized controlled trial by Kim et al. (18), involving 106 geriatric patients, a trend of progressively decreasing oropharyngeal leakage was noted in the I-gel group, attributed to its broad, blunt tip and thermoplastic structure, which adapt to the airway over time. In this study, we inflated the cuff pressure, a factor that can influence OLP, to 60 cmH2O after placing the LMA-Supreme. Although the I-gel lacks a cuff, suggesting a higher theoretical leak volume, its ability to conform to supraglottic anatomy may reduce air leakage. These findings support this hypothesis.

Intraoperative complication rates were significantly lower in the I-gel group than in the LMA-Supreme group. However, no significant differences were observed between the groups in complications at the second and twelfth postoperative hours. In et al. (13) also reported no notable differences in intraoperative and postoperative complications between the groups. Conversely, Chen et al. (1), in a study of adult patients aged 18–80 years, noted more frequent throat pain in the LMA-Supreme group; however, the broad age range may limit applicability to geriatric patients. In this study, the use of a pressure manometer to adjust the cuff pressure to the optimal level after inflation in the LMA-Supreme group may explain why no differences in postoperative pharyngolaryngeal complications were observed between the groups.

Our study does have some limitations. Firstly, although it was a randomized prospective study, it lacked blinding. The researcher recording perioperative data was aware of the supraglottic airway device used. Secondly, the participants in our study were aged between 65 and 89 years, and this wide age range may hinder the consistent distribution of patients regarding airway management and anatomical variations. To address this, patients could be categorized into subgroups based on age groups, and further research could be conducted with a larger geriatric population.

In conclusion, both the LMA-Supreme and I-gel exhibited similar characteristics in terms of ease of placement, first attempt success, number of attempts required, and postoperative complications. However, I-gel demonstrated a shorter insertion time, a greater number of patients achieving "excellent" OLP, and a lower incidence of intraoperative complications. These factors may make the I-gel a more favorable choice than the LMA-Supreme for geriatric patients. In addition, the use of a cuff pressure manometer is necessary to ensure appropriate cuff pressure in the LMA-Supreme. When a cuff pressure manometer is unavailable, the I-gel may be the preferred option.

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ORIGINAL ARTICLE

ADAPTATION AND PSYCHOMETRIC EVALUATION OF THE TURKISH VERSION OF THE MATCH SCALE: ASSESSING MOTIVATION AND ATTITUDES TOWARD CHANGING HEALTH BEHAVIOR IN OLDER ADULTS WITH TYPE 2 DIABETES

Abstract

Introduction: This study aimed to adapt the Motivation and Attitudes Toward Changing Health Scale into Turkish and to evaluate its validity and reliability in older adults with type 2 diabetes.

Materials and Method: This research was designed as a psychometric study. A total of 135 individuals aged 65 years and older with type 2 diabetes participated in the study. The scale was evaluated through various validity and reliability analyses. The language validity of the scale was confirmed through translation, back-translation, expert evaluation, and pre-application. Reliability and validity assessments included item analysis, criterion validity for construct validity, confirmatory factor analysis, and test-retest reliability.

Results: The content validity index was calculated at 0.91 based on expert evaluations. The three-factor structure of the scale explained 72% of the total variance. The statistical indicators used to evaluate the model fit showed that the model had an acceptable level of fit with the data. Specifically, the root mean square error of approximation was 0.11, the goodness of fit index was 0.90, the adjusted goodness of fit index was 0.82, the comparative fit index was 0.94, and the chi-square value was 66.18. These results were statistically significant ($p < 0.001$). The test-retest reliability result was statistically significant ($r:0.98$, $p<0.001$), indicating high reliability, with a Cronbach's alpha value of 0.85.

Conclusion: The scale is valid and reliable, making it an effective tool for measuring the motivation and attitudes of older adults with diabetes toward changing their health related behaviors.

Keywords: Motivation; Attitude; Health; Psychometrics; Aged.

INTRODUCTION

Diabetes, which is increasingly common worldwide, affects more individuals every day. Effective disease management is crucial in preventing diabetes related complications and achieving optimal health outcomes. Understanding diabetic patients' motivation and attitudes toward changing health behaviors plays a significant role in sustaining long-term self-management strategies (1,2). The management of diabetes is of paramount importance due to its rising prevalence, particularly among older adults, and the numerous acute and chronic complications it can cause. In aging individuals, diabetes not only contributes to increased mortality and morbidity rates but also exacerbates age-related health concerns, diminishes overall quality of life, and places a substantial burden on healthcare systems (1,2). The primary objective of diabetes management in older adults is to prevent both acute and chronic complications while maintaining functional independence and overall well-being. Older adults with diabetes should actively engage in self-management and integrate essential self-care practices into their daily routines to preserve their health and autonomy (3,4). Given the physiological changes associated with aging, such as altered metabolism, reduced physical mobility, and cognitive decline, maintaining motivation for self-care behaviors becomes even more critical. These behaviors include adopting a healthy lifestyle with a balanced diet, appropriate physical activity, and effective stress management strategies tailored to the needs and capabilities of older individuals (4,5). Achieving targeted health outcomes in diabetes management among older adults requires both optimal clinical care and the implementation of effective, individualized self-management strategies (6,7). In this population, both internal and external motivations play a crucial role in shaping diabetes-specific behaviors and maintaining glycemic control. However, diabetes management in older individuals presents additional challenges due to age related factors, making continuous self-regulation more complex. Therefore, structured support in the form of tailored education, motivation, and behavioral change interventions is of paramount importance (1,6,7).

A multidisciplinary approach is essential for preventing diabetes-related complications, enhancing self-management capabilities, and promoting sustainable lifestyle modifications in older adults (8-12). Education remains the cornerstone of effective diabetes self-management, as increased knowledge fosters meaningful behavioral changes that contribute to improved health outcomes and overall quality of life in this population (8-12).

The concept of empowerment has gained traction in contemporary diabetes care, emphasizing patient centered, collaborative processes. This approach enables individuals with diabetes to take an active role in their health, make informed decisions, and manage their condition more effectively while maintaining their independence (9,10,12). Older adults with diabetes can be empowered and motivated to overcome challenges in maintaining glycemic control, adapting to the complexities of disease management, implementing positive behavioral changes, and adhering to treatment recommendations despite age-related limitations (13). Motivation plays a crucial role in shaping effective self-management strategies, which in turn contribute to better metabolic outcomes, improved physical and mental well-being, enhanced quality of life, and reduced healthcare costs (13). Various theoretical models, including empowerment, health belief models, social support, and self-efficacy, can support diabetes self-management in older adults. While these models differ in their approach and terminology, they all emphasize personalized care tailored to diabetic patients' unique needs, expectations, and capabilities (14–17). However, despite the availability of evidence-based strategies for diabetes management, many older adults continue to struggle with glycemic control.

Sustaining positive lifestyle changes in older individuals can be particularly challenging due

to factors such as age-related cognitive and physical decline, long-standing habits, health beliefs, knowledge on diabetes, culture, language proficiency, health literacy, financial limitations, comorbidities, social support, lack of urgency, and fear of failure. These barriers can significantly impact treatment adherence and hinder effective self-management behaviors (16). To ensure effective diabetes management, support adaptation to treatment, and prevent complications in individuals, it is essential to assess their motivation and attitudes before implementing behavioral changes. Therefore, this study aims to adapt The Motivation and Attitudes Toward Changing Health (MATCH) scale into Turkish and assess its psychometric properties, including validity and reliability, among older individuals with type 2 diabetes.

MATERIALS AND METHOD

Study Design

This research was a psychometric study designed to evaluate the validity and reliability of the Turkish version of the Motivation and Attitudes Toward Changing Health (TR-MATCH) scale. The study was conducted at the Diabetes Education Unit of a hospital in western Türkiye. In scale development and validation studies, it is generally recommended that the sample size be at least 5 to 10 times the number of scale items (18). To form the sample for the research, 90 diabetic individuals were sufficient, and 135 individuals were reached. All participants were aged 65 years or older, lived independently in their own homes, and were able to communicate verbally. Individuals with any diagnosed neurological or psychological disorders were excluded. Participants reported no comorbid chronic conditions or medication use unrelated to diabetes. Demographic and clinical characteristics of the participants are summarized in Table 1.

Table 1. Demographic and Clinical Characteristics of the Participants (n = 135)

Characteristic	Value
Age (years) Mean ± SD / Range	71.4 ± 5.03 (Range: 65–85)
Gender n(%)	
Female	83(61.5%)
Male	52 (38.5%)
Living Status n(%)	
Living with spouse	111(82.2%)
Living alone or with others	24(17.8%)
Education Level n(%)	
No formal education	34(25.2%)
Primary school	68(50.4%)
Secondary school or higher	33(24.4%)
Income Status n(%)	
Lower than expenses	79(58.5%)
Equal to or higher than expenses	56(41.5%)
Diabetes Treatment n(%)	
Oral antidiabetic drugs	11(8.1%)
OAD + Insulin	88(65.2%)
Insulin	36(26.7%)
Duration of Diabetes (years) Mean ± SD / Range	12 (Range: 1–32)

OAD: Oral antidiabetic drugs

Data Collection Method

The data were collected through face-to-face interviews by a trained diabetes nurse educator in the diabetes education unit. All participants were volunteers. The MATCH scale is a self-report tool developed by Hessler et al. in 2018 to evaluate individuals' motivation and attitudes toward changing health behaviors (4). The MATCH scale focuses on three important points, which are often neglected, that prevents behavioral change in individuals: (1) willingness to make a change, (2) perceived ability to make or maintain a change, and (3) belief regarding whether or not a change is truly worthwhile. The items of the MATCH scale are scored between 1 to 5. Each MATCH subscale has a cut-off point (low = mean subscale score of 1.0 to 3.49; high = 3.5 to 5.0). In the analysis of this



nine-item scale, three consistent and significant factors were found, constituting 61.5% of the variance. Scoring of the MATCH scale: Willingness: Calculate the mean/average of items 1, 4, and 7. Ability: Calculate the mean/average of items 5, 9, and 2 (item 2: reverse-scored). Worthwhileness: Calculate the mean/average of items: 3, 6, and 8 (all three items are reverse-scored*) Total score: Calculate the mean/average of Willingness, Ability, and Worthwhileness (4).

Data Analysis

In this study, the data collected from diabetic patients were evaluated using the SPSS 22.0 statistical package software. The basic statistical analysis methods, including number, percentage, mean, standard deviation, minimum and maximum, were employed. The 95% confidence interval (CI) and $p < 0.05$ were considered significant. Validity and reliability analyses were applied for the TR-MATCH scale.

Validity Analysis

- **Language validity:** The TR-MATCH scale was translated and back-translated by two translators. The language of the TR-MATCH scale was evaluated by 10 experts, including academics, nurses, and doctors. No modifications were made to the original items during the translation and back-translation process. The wording was found to be culturally and linguistically appropriate by all experts.
- **Content validity:** Content validity was assessed by 10 experts who rated each item as "appropriate," "needs revision," or "not appropriate." Based on their evaluations, the Content Validity Ratio (CVR) and Content Validity Index (CVI) were calculated following Lawshe's method. Items marked as "needs revision" were revised accordingly. No items were rated as "not appropriate." Although the MATCH scale is a previously developed instrument, content validity analysis was applied in this study to ensure that the translated items retained conceptual relevance and clarity for the Turkish older adult population. The expert evaluations were used to assess the cultural and contextual appropriateness of the items in the target population.
- **Construct validity:** The adequacy of the sample size for factor analysis was determined using the Kaiser Meyer Olkin (KMO) test. Exploratory factor analysis was conducted to establish the construct validity of the TR-MATCH scale. Exploratory factor analysis was conducted using principal component analysis with Varimax rotation. Although EFA is commonly used during initial scale development, it was employed in this adaptation study to confirm whether the original factor structure was retained in the Turkish version and to explore any cultural variations that may affect the construct dimensionality. Compliance with the theoretical framework was evaluated through confirmatory factor analysis.

Reliability Analysis

- Internal consistency analysis: Item–total correlation coefficient analysis was employed, with each item being required to exceed 0.30. This analysis indicates the compatibility of each item in the TR-MATCH scale with the whole. The item discrimination was evaluated by comparing the 27% upper and lower groups. This analysis, although more commonly applied during development, was included to provide supporting evidence of how well each item differentiates between individuals with low and high motivation levels.
- Cronbach's alpha confidence coefficient: This coefficient serves as the most crucial indicator of scale reliability, with a recommended value exceeding 0.70.

- Test-retest: The MATCH scale was re-administered to the sample after 3 weeks, with the results being required to demonstrate statistical significance.

Ethical Considerations

Prior to the commencement of this study, ethical approval was obtained from the relevant ethics committee. In addition, institutional permission was obtained from the hospital authorities. Furthermore, permission for the use of the MATCH scale was obtained from the authors who developed it. Finally, informed consent was obtained from all diabetic patients participating in the study. This study adheres to the provisions of the Declaration of Helsinki.

RESULTS

Validity Analysis

Content Validity

The content validity ratio and content validity index of the TR-MATCH scale items were found to be higher than 0.62.

Construct-Concept Validity

The Kaiser Meyer Olkin (KMO) value of the TR-MATCH scale was determined to be 0.78. According to the Bartlett test results, it was established that the data were suitable for factor analysis ($p < 0.001$). In this study, both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to examine the psychometric properties of the TR-MATCH scale. The EFA was initially used to explore the underlying factor structure of the Turkish version. Following this, CFA was performed using AMOS 24.0 with the maximum likelihood estimation (MLE) method to test the fit of the factor structure that emerged from the EFA. The model fit was assessed using the fol-lowing indices and cut-off values: Chi-square/df (<3), comparative fit index (CFI > 0.90), Tucker–Lewis index (TLI > 0.90), and root mean square error of approximation (RMSEA < 0.10). Although the original MATCH scale provided the conceptual foundation, the CFA focused on testing the structure derived from the EFA conducted with Turkish participants, rather than directly replicating the original structure. Although the RMSEA value exceeded the desired threshold, given the favorable results of the scale's factor loadings and explained variance analyses, the RMSEA value was deemed acceptable due to the sample size. The confirmatory factor analysis (CFA) results showed that the scale has a clear three-factor structure, with satisfactory factor loadings ranging from 0.67 to 0.97, and a total variance explained of 71.87%. Item 9 had a relatively low factor loading (0.30), which may suggest weaker representation of the underlying construct; this is also reflected in its lower squared multiple correlation (0.36). Results of the confirmatory factor analysis indicated that the structural equation model of the scale was significant, with a value of $p < 0.001$, and no improvements were required in the model (Table 2, Table 3, Figure 1).

Reliability Analyses

Internal Consistency Analysis

The item means of the TR-MATCH scale ranged from 2.91 to 3.45. Item-total score correlations were found to range between 0.36 and 0.74, and all correlation coeffi-cients were statistically significant. The item analysis results indicate good internal consistency for the TR-MATCH scale, with a total Cronbach's alpha of 0.85. Corrected item–total correlations ranged from 0.47 to 0.60, showing that all items contribute adequately to overall reliability. Among these, item 7 had the highest item–total correlation (0.60), while item 6 had the lowest (0.47). The "Cronbach's Alpha if Item Deleted" values varied slightly between 0.82 and 0.83, demonstrating that removing any item would not significantly improve internal consistency. Squared multiple correlations were moderate to high for most items, with item 1 (0.74) and item 4 (0.71) performing particularly well. In contrast, item 9 had a relatively low squared multiple correlation

Table 2. MATCH Scale Factor Analysis

Scale items	Willingness	Worthwhile	Ability
I am interested in finding new ways to better manage my health problems	.89		
I am ready to do more to better manage my health problems now.	.83		
I want to find a better way to take care of my health problems.	.87		
I see little or no benefit to putting time and energy into managing my health problems now (Reverse)		.88	
Working to manage my health problems has only a little payoff or benefit (Reverse)		.83	
It is not really worth it to do all the things that I am asked to do to manage my health problems (Reverse)		.79	
I don't have enough time to take care of my health problems the way I think I should (Reverse)			.97
I am able to make the changes in my life that are needed to improve my health.			.67
I am able to fit the tasks of managing my health problems into my life.			.30
Total Variance Explained: 71.87			

Table 3. MATCH Scale Multi-Factor Model Confirmatory Factor Analysis Fit Indices.

RMESA	NFI	CFI	IFI	GFI	TLI	AGFI	CMIN	CMIN/df
0.11	0.91	0.94	0.94	0.90	0.91	0.82	66.180	2.75

*RMSEA: Root mean square error of approximation; NFI: Normed fit index; CFI: Comparative fit index; IFI: Incremental fit index; GFI: Goodness of fit index; TLI: Tucker-Lewis index; AGFI: Adjusted Goodnees of fit index; CMIN:x^2; CMIN/df :x^2/ sd.

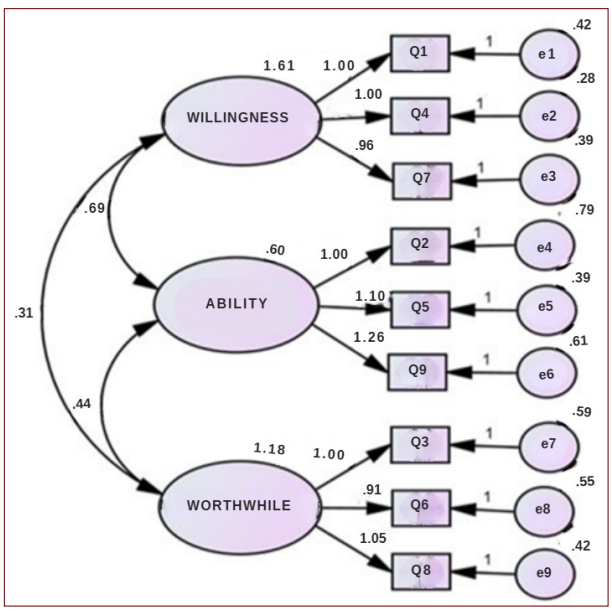


Figure 1. Confirmatory factor analysis model

(0.36), indicating that it may be less aligned with the underlying construct. Although all items met the accepted psychometric criteria, items 6 and 9 may require further investigation in future studies to optimize the scale's measurement properties. Additionally, there was a statistically significant difference between the upper and lower groups for each item on the scale ($p < 0.001$), indicating strong item discrimination (Table 4).

Test-Retest

The test-retest reliability of the TR-MATCH scale was assessed by re-administering the scale to 41 participants after a three weeks interval. The Pearson correlation coefficient between the two administrations was $r = 0.98$ ($p < 0.001$), indicating a strong positive correlation. Additionally, the intraclass correlation coefficient (ICC) was calculated

using a two-way mixed-effects model with absolute agreement. The ICC value was 0.978 (95% CI: 0.955–0.989), demonstrating excellent test-retest reliability.

DISCUSSION

Making and maintaining behavioral changes in diabetes management can prove challenging. Given that individuals with diabetes must contend with the condition for the duration of their lives, along with the associated responsibilities of effective disease management, it can become overwhelming. Diabetes distress encompasses the negative emotions experienced by people with diabetes, including emotional stress, behavioral difficulties, and ongoing concerns related to the burden of self-management. This can be particularly challenging for older individuals. Assessing diabetic patients' knowledge, distress levels, perceived abilities, attitudes, and motivation for behavioral changes is crucial to help them navigate this challenging process (4,14,17). The application of the TR-MATCH scale in an older adult population offers valuable insights into the motivational barriers that may hinder diabetes self-management in this age group. Older adults often face unique challenges, including physical limitations, cognitive decline, and long-standing habits, which can affect their readiness and ability to adopt behavioral changes (3,7–9). By assessing three critical components willingness, ability, and perceived worthwhileness the TR-MATCH scale helps identify specific motivational gaps that may not be readily observable in standard clinical assessments. For instance, an older adult may express willingness but score low in perceived ability due to age-related health concerns or past failed attempts at behavior change. Conversely, some may have the ability but question the value or relevance of new health behaviors at an advanced age. Understanding these nuances can allow healthcare providers to tailor interventions more effectively,

Table 4. Item Analysis Based on Lower and Upper Groups.

Scale items		n	Mean± SD	t (p)
Item 1	Lower group	37	2.13±1.20	-8.242
	Upper group	37	4.24±0.98	(p<0.001)
Item 2	Lower group	37	1.86±0.85	-8.233
	Upper group	37	3.67±1.02	(p<0.001)
Item 3	Lower group	37	2.10±1.17	-8.459
	Upper group	37	4.02±0.72	(p<0.001)
Item 4	Lower group	37	1.94±1.12	-9.819
	Upper group	37	4.13±0.75	(p<0.001)
Item 5	Lower group	37	1.89±0.77	-9.994
	Upper group	37	3.75±0.83	(p<0.001)
Item 6	Lower group	37	2.08±1.03	-8.934
	Upper group	37	3.97±0.76	(p<0.001)
Item 7	Lower group	37	1.83±0.98	-11.349
	Upper group	37	4.24±0.83	(p<0.001)
Item 8	Lower group	37	2.43±1.28	-7.869
	Upper group	37	4.29±0.66	(p<0.001)
Item 9	Lower group	37	1.70±1.05	-8.005
	Upper group	37	3.83±1.23	(p<0.001)

* p<0.001.



emphasizing realistic goal setting, supportive communication, and reinforcing the personal relevance of diabetes self-care. Therefore, the TR-MATCH scale not only serves as a psychometric tool but also enhances patient-centered care by aligning educational content with motivational readiness in older adults (19). This study conducted psychometric research on the Turkish Motivation and Attitudes Toward Health Changing Health scale to provide support by focusing on the motivation and attitude dimension of the challenging process experienced by diabetic patients. The language validity of the TR-MATCH scale was confirmed through translation, back-translation, expert opinion, and pilot testing.

The content validity of the TR-MATCH scale was assessed using expert opinions, confirming that the items effectively capture the relevant motivational constructs for health behavior change in individuals with diabetes. The high content validity index supports the scale's ability to accurately measure these factors, reinforcing its relevance and applicability for this population. Confirmatory factor analysis results provided empirical support for the theoretical structure of the scale, suggesting that the adapted Turkish version aligns well with the original conceptual framework. The KMO value of 0.78 indicates that the sample size was adequate for conducting factor analysis, albeit at a moderate level. This finding reinforces the statistical appropriateness of the dataset for structural modeling. Additionally, the significance of the Bartlett's test value ($p < 0.001$) confirmed the presence of sufficient correlations among the items to justify the use of factor analysis. Together, these results strengthen the construct validity of the TR-MATCH and support its use as a theoretically grounded tool for assessing motivational constructs in health behavior change. The three-factor structure identified in the Turkish adaptation of the MATCH scale explained 72% of the total variance, which indicates a strong representation of the construct by the scale items. This percentage is notably higher than that reported in the original study by Hessler et al., where the three-factor solution accounted for 61.5% of the variance and factor loadings ranged from 0.60 to 0.92 (4). The higher ex-plained variance in the current study suggests that the Turkish version of the scale may demonstrate a robust factor structure within this population, potentially reflecting a strong conceptual clarity and cultural relevance of the constructs in the Turkish context. This finding supports the cross-cultural applicability of the MATCH scale and its consistent dimensional integrity across different populations. The confirmatory factor analysis in this study indicated that the structural equation model of the TR-MATCH scale was meaningful and aligned with previous findings, supporting the validity of the scale. While the RMSEA value was slightly above the traditional cutoff, this may be influenced by the small sample size, as smaller samples tend to produce higher RMSEA values. Despite this, the other fit indices, such as CFI and SRMR, were at acceptable levels, suggesting that the model fit is still adequate. This reinforces the scale's robustness, even in the context of a smaller sample, and supports its applicability for further use in similar studies (19). In this study, the item–total score correlations of the Turkish version of the Motivation and Attitudes Toward Changing Health (TR-MATCH) scale were found to range between 0.36 and 0.74, with all correlations being statistically significant. Additionally, a significant difference was observed between the upper and lower groups of items on the scale ($p < 0.001$), indicating good discriminant validity. These findings are consistent with the results from Hessler et al.'s study, where correlations between the sub-dimensions of the scale ranged from $r = \pm 0.22$ to $r = \pm 0.35$. The Cronbach's alpha for the TR-MATCH scale in the current study was 0.85, suggesting good internal consistency. In comparison, Hessler et al. reported lower Cronbach's alpha values for the sub-dimensions, with 0.69 for the willing-ness sub-dimension, 0.74 for the ability sub-dimension, and 0.61 for the worthwhileness subdimension.

Despite these lower values, Hessler et al. (2018) recommended the scale's use in interventional studies aimed at improving motivation and attitudes in individuals with chronic diseases like diabetes, highlighting its utility in fostering behavioral change and promoting better disease management. The overall consistency of the TR-MATCH scale in this study supports its reliability and potential for use in similar contexts, includ-ing diabetes care.

Clinical Use of the TR-MATCH Scale

The Turkish version of the Motivation and Attitudes Toward Changing Health (TR-MATCH) scale offers valuable insights into the motivational factors that influence health behavior change in individuals, particularly those with chronic conditions such as diabetes. Given the challenges in diabetes self-management, especially in older adults, the TR-MATCH scale can be used in a variety of clinical settings to assess and address spe-cific barriers to motivation, attitudes, and readiness for change. Below follow some key practical applications of the scale in clinical practice.

Identifying Motivational Barriers in

The TR-MATCH scale helps healthcare providers pinpoint specific motivational factors that can either facilitate or hinder self-management behaviors in people with diabetes. It evaluates three core components: willingness, ability, and perceived worthwhileness. These dimensions can offer a deeper understanding of why a diabetic patient may be struggling with their diabetes care.

In case a healthcare professional encounters an elderly patient struggling to adhere to dietary recommendations, the TR-MATCH scale could be administered to assess the patient's motivation and attitudes toward behavior change, particularly in relation to diabetes management. The results could reveal that the diabetic patient is highly willing to make chang-es (high willingness score) but scores lower on ability due to physical limitations or lack of confidence in their ability to prepare meals. This insight allows the clinician to offer targeted support, such as providing meal planning tools or referring the diabetic patient to a nutritionist for tailored advice.

Tailoring Interventions Based on Motivational Readiness

With the results from the TR-MATCH scale, clinicians can tailor interventions to match the individual's specific motivational needs. For example, diabetic patients with low willingness but high ability may require interventions focused on increasing motivation, while those with high willingness but low ability may benefit from skill-building or confidence enhancing strategies.

In cases where a diabetic patient scores low on the "willingness" subscale, motivational interviewing (MI) may be utilized to explore the reasons behind their resistance to change and identify potential barriers to behavior modification. MI techniques can help the patient articulate their concerns and build motivation to engage in diabetes management behaviors, such as regular exercise and blood sugar monitoring.

Setting Realistic and Personalized Goals

The scale's ability to assess perceived worthwhileness can help clinicians understand whether diabetic patients view the proposed behavioral changes as worthwhile. This can be crucial in setting realistic and personalized goals that align with the patient's values and life circumstances.

For example, an elderly diabetic patient may feel that adopting a rigorous exercise regimen is not worth the effort due to age-related fatigue. A clinician using the TR-MATCH scale may learn that, while the diabetic patient does not value traditional exercise, they might be more open to light physical activities, such as walking or chair exercises. The clinician could set a goal for the diabetic patient



to engage in 10 min of walking daily, which is more feasible and personally meaningful for them.

Monitoring Progress over Time

The TR-MATCH scale can be used as a tool for tracking changes in motivation and readiness for health behavior change over time. By administering the scale at multiple time points, healthcare providers can assess the effectiveness of interventions and make adjustments as necessary.

In case an intervention (e.g., a diabetes education program or telehealth support) has been implemented, the clinician may reassess the diabetic patient using the TR-MATCH scale to evaluate any changes in motivation and attitudes toward health behavior. A positive shift in the willingness or ability scores may indicate that the diabetic patient is becoming more motivated and empowered to manage their condition, whereas stagnation in these scores may suggest that the intervention needs to be adjusted or intensified.

Identifying Psychological and Emotional Barriers

In addition to motivation, the TR-MATCH scale also provides insight into the psychological and emotional aspects of diabetes self-management. For example, older adults may experience diabetes distress, which can negatively impact their willingness and ability to engage in health behaviors. The scale can help identify such distress, which might not always be obvious during routine clinical assessments.

For example, a diabetic patient who reports chronic fatigue or feelings of helplessness regarding their condition might have a low perceived worthwhileness. The TR-MATCH scale would help the clinician identify these emotional barriers and prompt them to offer emotional support, such as counseling or mental health resources, to address these underlying issues.

Supporting Multidisciplinary Care Teams

The TR-MATCH scale can also serve as a tool for multidisciplinary healthcare teams working with patients who have diabetes. By using the scale's results, different team members such as endocrinologists, nurses, dietitians, and psychologists can develop a coordinated plan to address various aspects of the patient's self-management.

For example, if a diabetic patient exhibits low willingness to engage in insulin therapy but demonstrates high perceived ability, the healthcare team may involve a diabetes educator to enhance the diabetic patient's motivation and understanding of insulin usage. At the same time, a dietitian may focus on teaching the diabetic patient how to adjust their meals according to insulin therapy.

Improving Patient-Provider Communication

The TR-MATCH scale fosters open communication between diabetic patients and providers by offering a structured framework for discussing the barriers to behavior change. The scale's clear categorization of willingness, ability, and worthwhileness allows diabetic patients to express their concerns, and clinicians can respond more effectively to these concerns with empathy and specific solutions.

In case a clinician observes that a diabetic patient is very willing to improve their diet but has concerns about their ability to make those changes due to time constraints, they might ask, "I see that you're very willing to improve your diet but have concerns about your ability to make those changes due to time constraints. Let's talk about how we can work within your schedule to find a diet plan that fits your life." This approach demonstrates that the clinician is listening to the patient's concerns and is prepared to collaborate in creating a realistic plan.

In this context, the TR-MATCH scale offers a practical and patient-centered tool for understanding the motivational dynamics in chronic disease management, contributing to the development of personalized, multidisciplinary care

strategies and the support of sustainable health behavior change.

LIMITATION

There are several limitations in this study. First, the sample size used in this study may limit the generalizability of the findings. Future research with larger and more diverse samples could enhance the validity of the results. Additionally, the instrument was tested in a specific group, and it is possible that the results may differ in populations of varying age, gender, or socio-economic status. Therefore, it is recommended that similar analyses be conducted in diverse populations in future studies. This study was conducted in a specific geographical region, further research is needed to explore the applicability of the findings in other cultural contexts. A limitation of this study is the small sample size (n = 100), which may have contributed to the relatively high RMSEA value. RMSEA values tend to be higher in small samples (19). Despite other fit indices showing acceptable levels, the small sample size may limit the generalizability of the findings. Larger samples are needed for more robust conclusions. In addition, although modification indices were reviewed during confirmatory factor analysis, no error terms were correlated solely based on statistical criteria. To preserve the theoretical structure of the original scale, no post hoc modifications were applied. However, future studies with larger samples may consider correlating certain error terms based on strong conceptual justification to improve model fit. Also one limitation of this study is that, although participants were observed by the researchers for signs of cognitive impairment, no standardized cognitive screening tools were used. The lack of formal cognitive assessment may have influenced participants' responses related to motivation and should be addressed in future studies through the use of validated cognitive evaluation method. Cut-off values were adopted from the original scale. However, no ROC analysis was conducted to validate these thresholds within the Turkish context. This limits the cultural specificity of interpretations based on cut-off scores.

CONCLUSION

This study provides strong evidence for the validity and reliability of the Turkish version of the Motivation and Attitudes Toward Changing Health (TR-MATCH) scale in older individuals with type 2 diabetes. The scale's high internal consistency and test-retest reliability indicate its robustness for assessing motivation and attitudes toward behavioral change regarding health in this population. Additionally, the study contributes to the existing literature by adapting and validating a tool that can be used in clinical and outpatient settings to guide interventions for diabetes management in older adults.

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Institutional Review Board Statement: The study was conducted in accordance with the Decla-ration of Helsinki, and approved by the Ethics Committee of Dokuz Eylul University Non-Interventional Research (protocol code 2020/09-04 and date of approval 11.05.2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

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ORIGINAL ARTICLE

EFFECT OF OLD AGE ON PNEUMONIA

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Abstract

Introduction: Pneumonia is one of the leading causes of mortality and morbidity in older persons. In this study, the effect of age on various parameters was investigated within a sample of pneumonia patients followed by a pulmonology clinic.

Materials and Method: In this study, the age, gender, comorbidities, white blood cell counts, albumin values and sputum culture results of the patients were recorded. These patients were divided into two groups (aged 65 years or older and under 65 years), and the recorded values were statistically compared between these groups.

Results: Most of the patients were older persons, and the ratio of male patients was higher than that of female patients. Most patients had one or more comorbidities. A causative pathogen of pneumonia was detected in most of the patients for whom sputum cultures could be taken. When the two age groups were compared in terms of laboratory results, significant between-group differences were found only for albumin values and C-reactive protein/albumin ratios.

Conclusions: In this study, the average age of the patients diagnosed with pneumonia was high, most of them were male, and most of them had one or more comorbidities. These findings indicate that preventive health services and control of additional diseases in older patient likely play important roles in preventing bad outcomes and reducing health costs associated with pneumonia. In addition, the findings of this study indicate that albumin and C-reactive protein/albumin ratio values can be used to evaluate the course of pneumonia or the inflammatory response pneumonia causes.

Keywords: Pneumonia; Aged; Sputum.

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INTRODUCTION

Pneumonia is a common disease with serious mortality and morbidity rates that has important implications for society and public health (1). Data from the World Health Organization show that 7% of all deaths each year are due to pneumonia (2). Aging is a normal process defined as the irreversible loss of an individual's mental and physiological capacities. In both Turkey and reports published by the World Health Organization, it is stated that the onset of old age occurs at 65 years. More specifically, the World Health Organization defines age 65 years or older as old and defines age 85 years or older as very old (3). Prior studies have shown that the incidence of pneumonia increases with age (4).

Old age is a special period that should be evaluated from a perspective that considers the unique psychological, physiological, and socioeconomic changes that occur during this period, as well as the excess of accompanying chronic and acute diseases with atypical signs and symptoms. Pneumonia is one of the leading causes of morbidity and mortality in old age (4). Furthermore, the population of older persons is increasing rapidly, and diseases are detected more quickly and more frequently in old age. Most older persons have more than one health problem, and accordingly, they use the hospital provided at frequently. In general, geriatric patients stay in the hospital longer and experience increased mortality rates and treatment costs. For these reasons, it is necessary to further investigate the problems experienced by older persons (5).

In the present study, pneumonia patients followed by a pulmonology clinic were grouped into those aged 65 years or older and those under 65. Then, the laboratory values, sputum culture results, and comorbidities of these groups were compared.

MATERIALS AND METHOD

This study received the necessary permissions and ethics approval. In present study, covid 19 negative and community-acquired pneumonia patients without covid pneumonia who were hospitalised in the Chest Diseases Clinic of a district State Hospital were included. The ages, genders, comorbidities, C-reactive protein (CRP) values, white blood cell (WBC) counts, albumin levels, and sputum culture results of these patients were recorded. Then, the patients were divided into two groups (aged 65 years or older and under 65 years), and the recorded data were compared.

Statistical Analysis

A statistical analysis of the recorded data was completed using IBM SPSS 25.0. A Kolmogorov–Smirnov test was used for normality testing of the parameters. Descriptive statistics for continuous variables suitable for normal distribution are given as mean and standard deviation, for not normal distribution median and Q1- Q3. Then, an independent samples test was used for parameters suitable for normal distribution, and a Mann–Whitney U test was used for parameters that did not exhibit normal distribution. $P < 0.05$ was accepted as a statistically significant difference between groups. Cohen's d was used in the effect size calculation of parametric tests ($0.2 \leq d < 0.5$ for small effects, $0.5 \leq d < 0.8$ for medium effects and $d > 0.8$ for large effects) and Cliff's Delta was used in the effect size calculation of non parametric tests ($|\delta| < 0.147 \rightarrow$ Small effect, $0.147 \leq |\delta| < 0.33 \rightarrow$ Medium effect, $0.33 \leq |\delta| < 0.474 \rightarrow$ Large effect, $|\delta| \geq 0.474 \rightarrow$ Very large effect). Frequency (%) was given for the categorical data, and statistical analysis of the groups in terms of gender was measured by Chi-square test.

RESULTS

The present study, 54 patients, 29 of whom were 65 years age or older and 25 of whom were under 65 years age, were included. It was observed that the ratio of male patients was higher than the ratio of female patients in both groups. When the groups were evaluated in terms of gender, no significant

difference was observed. In the grouping according to age, there was a statistically significant difference between the groups in terms of mean age and this difference was close to large effect size (Table 1).

A causative pathogen of pneumonia was detected in the sputum cultures of 14 patients 65 years or older and 12 patients under 65 years age (Table 2). When the sputum culture results of the patients were compared, it was shown that the most common reproducing factor in both groups was *Klebsiella* spp.

When the two groups were compared, it was observed that albumin values were statistically significantly lower in patients aged 65 years or older than in patients aged under 65 years and the difference was close to a large effect size (Table 3). When the CRP values and CRP/albumin ratios of the groups were compared, it was showed that the CRP

Table 1. Age and gender distribution of groups

	65 years or older (n=29)	**Under 65 years old** (n=25)	
Age (Years)	73.69 ± 7.19	49.44 ± 11.43	p<0.001 d=2.539
Gender			
Male	22(76%)	17(68%)	Φ=0.088
Female	7(24%)	8(32%)	p=0.735

Table 2. Pathogen distribution of patient sputum cultures

Pathogens	**65 years or older** (n=29)	**Under 65 years old** (n=25)
Klebsiella spp.	5	10
Acinetobacter spp.	2	-
Enterobacter spp.	2	-
Escherichiacoli	2	-
Serratia spp.	1	-
Pseudomonas spp.	1	1
Streptococcus pneumonia	1	1
Oropharyngeal flora elements	10	11
No sputum culture	5	2

Table 3. Laboratory data of groups

Parameters	**65 years or older** (n=29)	**Under 65 years old** (n=25)	**p-value**	**effect size**
CRP (mg/L)	47(10.1-106.5)	10.1(3-71)	0.067	0.291
ALBUMIN (g/L)	29.97 ±3.54	33.51 ±5.48	0.009	0.767
CRP/ALBUMIN	1.46(0.35-3.73)	0.23(0.1-2.27)	0.044	0.320
WBC (10^3/uL)	12.58±4.57	10.74±3.9	0.122	0.433



values and CRP/albumin ratios of patients 65 years and over were higher than those of patients under 65 years. There was a difference close to statistical significance and the difference was medium effect size (Table 3).

DISCUSSION

Aging is a physiological process that progresses with nearly the same phenotypic changes across all intraspecies individuals, in which adaptation to internal and external conditions decreases over time. Today, in parallel with recent medical developments, the average life expectancy has increased due to improved social conditions and quality of life. While the ratio of older persons in the world population was 1% in the 1900s, it is predicted to reach 20% by 2050 (6). Prior studies have shown that the incidence of pneumonia increases with age (3). In the present study the average age of pneumonia patients was found to be high, and the number of patients aged 65 years or older was higher than the number of patients under 65.

Prior studies have shown that pneumonia is more common in men than in women (7). In one study, Angela et al. showed that female sex steroids protect the immune system in cases of trauma and sepsis and that cellular immunity is more developed in women than in men (8). In the present study, the number of male pneumonia patients was higher than that of female pneumonia patients in both age groups.

Furthermore, comorbidities accompanying pneumonia were significantly increased among the older age group compared to the younger age group. Cardiovascular diseases, chronic respiratory diseases, and cerebrovascular diseases are particularly prevalent diseases among pneumonia patients (9). In a study by Erdede et al., chronic respiratory system disease was found to be the most common comorbid condition, occurring at a rate of 37% among pneumonia patients (10). Meanwhile, Köksal et al. reported chronic obstructive pulmonary disease (COPD) in 42.7%, hypertension in 29.8%, and heart failure in 9.6% of 218 pneumonia patients (11). In the present study, comorbidities were found to be more common in patients aged 65 years or older than in patients under 65 years, and the most common comorbidity in both age groups was COPD, in line with the findings of prior studies.

The factors that facilitate the development of pneumonia in older persons and patients with comorbidities include the amount of pathogenic microorganisms to which the patient is exposed, the virulence of these pathogens, and the deterioration of defense mechanisms. Oropharyngeal secretion aspiration, pathogen inhalation, and blood circulation (septic embolism) facilitate the transport of microorganisms to the lungs (12). *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moroxella (Branhamella) catarrhalis*, and other atypical microorganisms are often responsible for pneumonia. However, the agents of pneumonia in older persons (those aged 65 years or older) differ from those of the normal population (13). Erdem et al. In a study of mortality markers in patients with community-acquired pneumonia in need of intensive care—which included 413 patients in 19 intensive care units across 12 centers—the most frequently isolated factors were Gram-negative bacteria, *Staphylococcus aureus*, and *Streptococcus pneumoniae*, in order of frequency (14). In a study of 92 geriatric patients with community-acquired pneumonia, Küçükardalı et al. reported that a bacteriological diagnosis was reached in 31% of these patients and that the causative agents were S*treptococcus pneumoniae*, *Escherichia coli*, *Enterobacter* spp., *Klebsiella pneumoniae*, and *Staphylococcus aureus*, in order of frequency (13). Detection of the causative pathogen is important for both guiding treatment and reducing the cost of treatment. In addition, the presence of the agent helps prevent antibiotic resistance and reduce mortality. In the present study, 7 of 54 patients could

not produce sputum cultures, 21 patients were found to have oropharyngeal flora elements, and *Klebsiella* spp. was found to be the most common causative agent in both age groups. Potential reasons for which *Klebsiella* spp. was the most common reproducing pathogen—in contrast with the findings of many similar studies—include the older age range of the present patient population, the prevalence of comorbidities within this population, and the fact that different geographical conditions may correspond to different frequencies and types of etiological agents.

It is difficult to distinguish pneumonia from other respiratory tract infections by history and physical examination alone (15). The patient's complete blood count, liver and kidney function tests, and serum electrolytes are important in the decision of whether to hospitalize, treatment selection, and determining prognosis. It is known that WBC count is an indicator of disease severity (16). Meanwhile, CRP is an acute phase reactant synthesized by the liver in response to interleukin-6 (17). In a prior study conducted in our country, the severity of pneumonia was found to be associated with elevated CRP and WBC values (18). Melbye et al. reported that WBC and especially CRP have high diagnostic value (19). With respect to age, Vazquez et al. found no significant difference in CRP values between patients aged younger than 65 years and those aged 65 years or older (20). Meanwhile, Bircan et al. found no difference between these same age groups in terms of mean CRP, WBC, or erythrocyte sedimentation rate values (21). Although high WBC levels were found in most of the patients in both groups in our study, no significant difference was found between the groups, in accordance with the findings of the two studies mentioned above. CRP values were close to significantly higher in patients aged 65 years and over than in patients under 65 years, but the effect of this difference was medium.

Albumin is a negative acute phase reactant in case of acute inflammation. Hypoalbuminemia is more common in older patients due to malnutrition and causes a worse course of the disease (22). In one prior study, hypoalbuminemia was found to be an important determinant of mortality in patients with community-acquired pneumonia-related sepsis and septic shock (23). In the present study, albumin values were significantly lower in patients aged 65 years or older than in those under 65. Prior studies have shown that CRP level, albumin level, or the CRP/albumin ratio can be a useful prognostic factor for inflammatory or nutritional status, and the CRP/albumin ratio can be a particularly strong indicator of inflammatory response (24). Kim et al. evaluated patients with sepsis and septic shock and suggested that the CRP/albumin ratio could be used to predict three-month mortality (23). Conversely, in a study of community-acquired pneumonia patients by Hoşgün et al., the CRP/albumin ratio was not found to have significant prognostic value for mortality (25). In present study, the CRP/albumin ratio showed a significant difference between the two age groups of pneumonia patients, but the effect of this difference was medium.

Since present study was conducted during the peak period of the Covid 19 pandemic, patients with Covid 19 positive pneumonia were excluded from the patient sample. The limitations of the study include the exclusion of patients with high probability of community-acquired pneumonia because they could not be differentiated as covid pneumonia or community-acquired pneumonia because they were covid positive, the fact that the study centre was a district state hospital and the short duration of the study.

CONCLUSION

Similar to previous studies, the present study showed the average age of patients diagnosed with pneumonia to be high. The number of patients aged 65 years or older was higher than that of patients under 65 years, the majority of patients were male, and most patients had one or more comorbidities.



Furthermore, the majority of the patients with comorbidities were aged 65 years or older. For this reason, preventive health services, vaccination, and the control of additional diseases in older patients are important in terms of both preventing bad outcomes and reducing health costs associated with pneumonia.

Most of the patients in the present study had elevated CRP and WBC levels, but there were no significant differences in these values between the age groups. However, albumin values were significantly lower and CRP/albumin ratio values were significantly higher in patients aged 65 years or older than in patients under 65 years. Therefore, multicenter and large sample size studies of older pneumonia patients are needed to assess the use of albumin and the CRP/albumin ratio for evaluation of the disease course or the associated inflammatory response.

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ORIGINAL ARTICLE

COLORECTAL CANCERS OCCURRING WITH ILEUS

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Abstract

Introduction: To establish the clinical profiles of the newly diagnosed colorectal cancers in patients presenting to the emergency service with ileus symptoms.

Materials and Method: The study was carried out with the retrospective examination of the patients who presented to a tertiary emergency service with non-specific ileus symptoms and were diagnosed with colorectal cancer for the first time. The clinical, laboratory and radiologic data of the patients were recorded in the study form compiled from the Hospital Information Management System and the emergency service presentation files.

Results: 102 patients who presented to the emergency service due to ileus and were diagnosed with a mass were included in the study. Of these patients mean age was 66.50±12.30 (mean±standard deviation). During the presentation, the Charlson Comorbidity Index was considered as 1.00 [Interquartile Range 0.00 – 2.00] while the median value of the modified Glasgow Prognostic Score was 1.00 [Interquartile Range 0.00 - 2.00]. The modified Glasgow Prognostic Score was statistically significant ($p<0.001$), especially in the patients in whom perforation developing as a late complication was observed.

Conclusion: The frequency of being diagnosed with colorectal cancers by presenting to the emergency service with non-specific symptoms is increasing despite the routine cancer screening in the healthcare systems. In this process, the difficulties in making appointments during the hospital presentations under elective conditions and the long time interval until the diagnosis gave rise to the necessity for patients to consider faster diagnosis and treatment options through the emergency service.

Keywords: Colorectal Neoplasms; Ileus; Emergency; Prognosis.

INTRODUCTION

Although emergency services are intended to be the entry point for patients into the healthcare system if acute conditions emerge, they have become areas in which chronic diseases are diagnosed over time. In particular, diseases such as cancer, which should be detected in primary or polyclinical areas, have also begun to be diagnosed in emergency services. As patients often present with indefinite symptoms of their diseases, limited resources and time make the detection of this circumstance difficult (1). While most of the colorectal cancers in this group are diagnosed electively, some of them occur as emergency cases (2). During presentations due to the need for acute medical care, a high suspicion level is important in making diagnoses.

Colorectal cancers are the most encountered type of malignancy throughout the world. Colorectal cancer is correlated with an increase in risk factors such as smoking and obesity, as well as the changes in the dietary and living habits of an increasingly aging population (3). While approximately 20% of patients present with obstructive symptoms, such as abdominal pain, nausea, vomiting, bloating, or an inability to excrete gas/stool prior to diagnosis, some of them are diagnosed in emergency services with a complication, such as perforation, which may lead to unstable physiologic parameters (4,5). These complications are correlated with poor survival due to the preoperative mortality and postoperative morbidity rates, which are highly related to comorbidities such as sepsis and acute kidney damage (6,7). Furthermore, adverse outcomes may also occur due to an advanced disease stage at presentation to emergency services, as well as high American Society of Anesthesiologists (ASA), mGPS (modified Glasgow Prognostic Score), and CCI (Charlson Comorbidity Index) scores (8-11). Our study was intended to evaluate the characteristics of patients who presented to the emergency service with non-specific ileus-dependent symptoms and were diagnosed with colorectal cancer for the first time, as well as the factors affecting emergency service management.

MATERIALS AND METHOD

Study Design

The study was carried out via the retrospective examination of the patients who presented to the tertiary hospital emergency service with non-specific ileus symptoms and were diagnosed with colorectal cancer for the first time between January 2020 and June 2023. Approval was obtained from the local ethics committee prior to the study (Decision number: 2024/115). Informed consent was obtained from the participants whose images were used in the publication.

For the collection of clinical and radiological data for the patients included in the study, the local computer-based hospital information management system (HIMS) program was used. Patients who were under the age of 18 and those whose clinical and laboratory data were incomplete were excluded from the study. Masses were detected in 124 of 622 patients who presented to the emergency service with non-specific bowel obstruction symptoms and were diagnosed with ileus, and 22 patients were excluded from the study because their data could not be obtained. Ultimately, 102 patients were included in the study (Figure 1).

Clinical Parameters

The complaints at presentation to the emergency service, the duration of the complaints, the demographic data regarding the patients, the treatment administered in the emergency service, mGPS scores, CCI scores, the hospitalization area, and the treatment method used after hospitalization were recorded. The data on the patients regarding tumor stage were derived from the contrast-

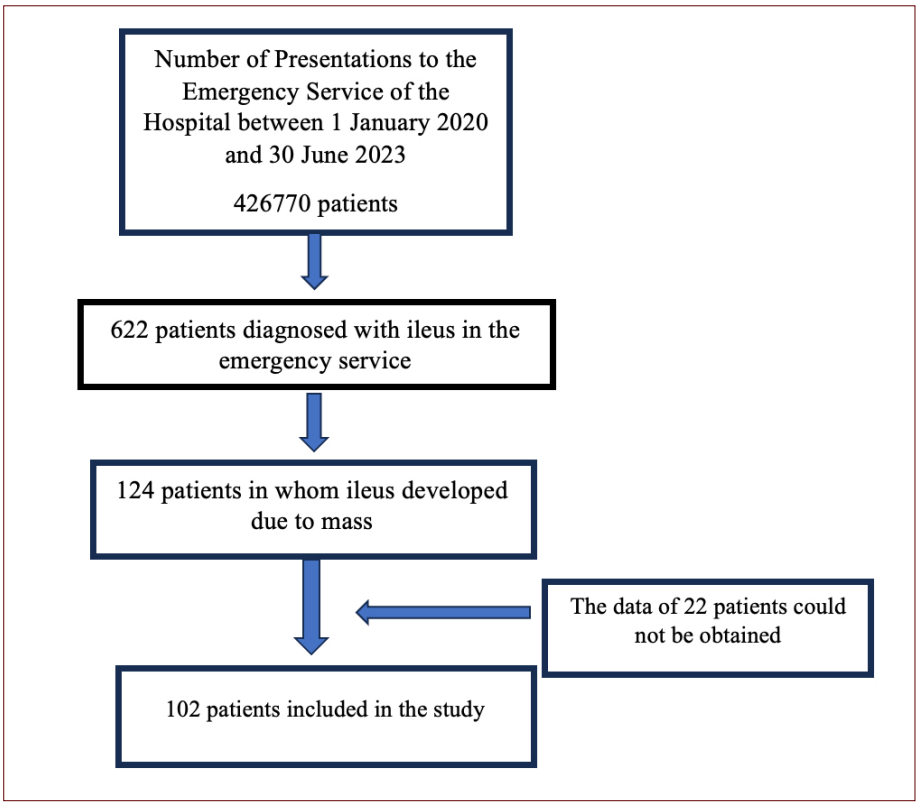


Figure 1. Study flow chart

enhanced abdominal computerized tomography (CT) images taken in the emergency service, and the data regarding the pathological diagnoses during their inpatient treatment were derived from the patient files. Whether the patients presented to the emergency service or polyclinic for any reason that might be related to colorectal cancer before diagnosis, such as abdominal pain, nausea, vomiting, and changes in bowel movements, was evaluated.

Emergency Service Management

For patients who present to the emergency service with non-specific symptoms, such as nausea, vomiting, abdominal pain, or an inability to excrete gas or stool, a physical examination is made, laboratory and imaging tests are requested according to the current clinical view, and fluid resuscitation is initiated. If the examination findings suggest an obstruction, abdominal plain radiography is performed to verify the preliminary diagnosis. For eligible patients, contrast-enhanced abdominal computerized tomography (CT) is performed to determine the degree of obstruction, etiology and complications, and a consultation is requested with the relevant polyclinic. For patients for whom the use of contrast agent is contraindicated and pregnant patients, bedside abdominal ultrasonography (USG) is performed. USG is used only in specific patient groups because it has limited efficacy in imaging gas-filled structures and restrictions regarding determining the location, cause, and potential complications of an obstruction.

Imaging Technique and Radiological Findings

Intravenous contrast-enhanced CT scanning (12) was performed with a 16-slice CT scanner (Alexion TSX-034A, Toshiba, Shimoishigomi, Shimoishigomi, Otawara-Shi, Toschigi-Ken, Japan), in line with the recommendations of the American College of Radiology (ACR). Iodine-based contrast medium (Iopromide, Ultravist, 300mg I/mL, Bayer Schering Pharma, Berlin, Germany) was administered intravenously through a peripheral venous vascular access at a rate of 4.0 ml s-1.

Each CT scan performed in the emergency service is simultaneously interpreted by the radiologist in charge via remote access after the scanning. The CT images of the patients included in the study were re-evaluated by a radiologist with 20 years of experience to ensure the standardization of the measurements retrospectively, after the initial evaluation. Tumor size, location, perforation, necrosis, proximal and paraaortic lymph node metastasis, and distant organ metastasis were recorded.

Statistical Analysis

All analyses were conducted in Jamovi V.1.6 statistical software (The Jamovi Project (2021) Computer Software (Sydney, Australia.) The categorical data were expressed as frequencies (n) and percentages. The continuous variable data with normal distributions were defined as means and standard deviations (SDs), while the data with non-normal distributions were defined as medians and interquartile ranges (IQRs). The normality of the distributions was evaluated using the Shapiro–Wilk test. In the comparison of the continuous variables, a t-test was performed in the case of normal distributions, and the Mann–Whitney U test was performed in the case of non-normal distributions. To compare the categorical variables between the groups, a Chi-squared test was used. In all statistical analyses, p values <0.05 were considered significant.

RESULTS

Masses were detected in 124 (19.9%) of 622 patients diagnosed with ileus within the time interval in which the study was planned. However, 22 patients were excluded from the study, as their data could not be obtained, and 102 patients (16.4%) were included in the study. Of these patients, 60.8% were male, and their mean age was 66.50 ± 12.30 (mean ± standard deviation). The most common reason for presentation to the emergency service was abdominal pain (43.1% of patients; n = 44), an inability to excrete gas or stool (22.5%; n = 23), and constipation accompanying abdominal pain in (14.7%; n = 15). Before the presentation to emergency services, 78.4% of the patients (n = 80) had previously presented to any department of the hospital due to their existing complaints, and 56.2% of these patients (n = 45) presented to both the emergency service and the polyclinic due to their existing abdominal pain (59.7%; n = 61). The median onset value of the pre-diagnostic complaints of the patients was 20 days (IQR 10.00–30.00; 3–60 days). Upon physical examination, 3.9% of the patients (n = 4) were diagnosed with unstable vital signs, and a vasoconstrictor agent was added to their treatment, along with fluid resuscitation. Furthermore, nasogastric catheters were inserted into 78.4% of the patients before hospitalization upon the detection of obstructions during the imaging examinations. Ninety-eight percent of the patients (n = 100) were admitted to the polyclinic to arrange their follow-up and treatment, and 90.1% (n = 92) were operated on. Their demographic and presentation characteristics are indicated in Table 1.

CCI was 1.00 [IQR 0.00–2.00], while the median value of mGPS before diagnosis in the emergency service was 1.00 [IQR 0.00–2.00]. The median value obtained from the laboratory examinations was 38.00 [IQR 33.00–41.00] for albumin, 1.20 [IQR 0.92–1.67] for lactate, and 27.50 [IQR 9.25–76.50] for C-reactive protein (CRP). In 36.3% (n = 37) of the masses detected in the patients who presented



Table 1. The Patients' Demographic Data and Baseline Characteristics

Characteristics, n = 102	Value
Gender	
Male, n (%)	62 (60.8)
Female, n (%)	40 (39.2)
Age (years), mean ± sd	66.50 ± 12.30
Comorbidities	
Hypertension, n (%)	60 (58.8)
CAD, n (%)	16 (15.7)
Diabetes, n (%)	15 (14.7)
Atrial fibrillation, n (%)	11 (10.8)
COPD, n (%)	9 (8.8)
Presentation Complaints	
Abdominal pain, n (%)	44 (43.1)
Inability to excrete gas/stool, n (%)	23 (22.5)
Abdominal pain + constipation, n (%)	15 (14.7)
Nausea/vomiting + abdominal pain, n (%)	10 (9.8)
The other presentation*, n (%)	10 (9.8)
Duration of the Presentation Complaint (days), median (IQR)	20.00 (10.00 – 30.00)
Presentation to any Department	
Emergency and polyclinic presentation, n (%)	45 (44.1)
Polyclinic presentation, n (%)	20 (19.6)
Emergency presentation, n (%)	15 (14.7)
No presentation, n (%)	22 (21.6)
Complaints for the Previous Hospital Presentations	
Abdominal pain, n (%)	61 (59.7)
Nausea/vomiting, n (%)	10 (9.8)
Dyspepsia, n (%)	6 (5.9)
The other presentation*, n (%)	3 (2.9)
No presentation, n (%)	22 (21.6)
Treatment after Hospitalization	
Surgical treatment, n (%)	92 (90.1)
Medical follow-up, n (%)	10 (9.8)
mGPS during Emergency Presentation, median (IQR)	1.00 (0.00-2.00)
CCI during Emergency Presentation, median (IQR)	1.00 (0.00-2.00)
Mortality rate within the 3-Month, n (%)	13 (12.7)
Mortality rate within the 1-Year, n (%)	31 (30.4)

IQR: Interquartile Range (25p, 75p), sd: standard deviation, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, *: Atypical causes of admission (such as shortness of breath, back pain, etc.), mGPS: modified Glasgow Prognostic Score, CCI: Charlson Comorbidity Index

to the emergency service with non-specific obstruction findings and were diagnosed with ileus upon contrast-enhanced CT, which was performed according to ACR recommendations, Most of the masses were located in the sigmoid colon in 36.3% (n=37) of the cases, in 11.8% (n=12) of the cases the masses were located in the rectosigmoid colon, the locations in the right or left colons were identical in both areas, and the masses in these locations occurred at a rate of 17.7% (n=18). The median value for tumor size was 53.00 [IQR 38.00– 73.30] x 16.00 [IQR 12.00– 20.00] mm. Upon CT, proximal lymph nodes (87.3% of the patients; n = 89), paraaortic lymph nodes (9.8%; n = 10), invasion of the surrounding adipose tissue (52%, n = 53), necrosis of tumoral tissue (41.2%; n = 42), distant organ metastasis (25.5%; n = 26), and perforation (11.8%; n = 12), were encountered. Upon the pathologic evaluation of the masses, adenocarcinoma was detected in 94.1% (n = 96; Table 2).

No statistical difference was detected between the twelve patients with perforation and non-perforation patients in terms of presentation complaints, duration of complaints, tumor localization, and tumor type. No significance difference could be found regarding CCI (p = 0.76), while mGPS was statistically significantly higher in perforation group as compared with non-perforation group (p < 0.001; Table 3).

Table 2. Characteristics on Computerized Tomography

Characteristics, n = 102	Value
Location Area of the Mass	
Sigmoid colon, n (%)	37 (36.3)
Left colon, n (%)	18 (17.6)
Right colon, n (%)	18 (17.6)
Rectosigmoid colon, n (%)	12 (11.7)
Rectum, n (%)	7 (6.8)
The other location, n (%)	10 (9.8)
Size of the Mass	
Height (mm), median (IQR)	53.00 (38.00-73.30)
Width (mm), median (IQR)	16.00 (12.00-20.00)
CT Findings of the Mass*	
Tumoral tissue necrosis, n (%)	42 (41.2)
Invasion to surrounding adipose tissue planes, n (%)	53 (52.0)
Proximal lymph node metastasis, n (%)	89 (87.3)
Paraaortic lymph node metastasis, n (%)	10 (9.8)
Distant organ metastasis, n (%)	26 (25.5)
Perforation, n (%)	12 (11.8)
Histopathologic Characteristic of the Mass	
Adenocarcinoma, n (%)	96 (94.1)

IQR: Interquartile Range (25p, 75p), sd: standard deviation, CT: Computerized Tomography, *: More than one pathology can be seen on CT



Table 3. Characteristics of the Patients Detected with Perforation

Characteristics	Total Group (n=102)	Perforation Group (n=12)	Non-Perforation Group (n=90)	P value
Presentation complaints				
Abdominal pain, n	44	6	38	
Nausea/vomiting, n	23	2	21	
Inability to excrete gas/stool, n	15	0	15	0.398
Nausea/vomiting and abdominal pain, n	10	2	8	
The other presentation*, n	10	2	8	
Duration of the presentation complaint, (days), median (IQR) 20.00 (10.00 - 30.00)		27.50 (20.80-41.30)	20.00 (10.00-30.00)	0.081
Presentation to any Department				
Emergency and polyclinic presentation, n	45	6	39	
Polyclinic presentation, n	20	2	18	0.950
Emergency presentation, n	15	2	13	
No presentation, n	22	2	20	
Complaints for the Previous Hospital Presentations				
Abdominal pain, n	61	8	53	
Nausea/vomiting, n	10	1	9	
Dyspepsia, n	6	1	5	
The other presentation*, n	3	0	3	0.975
No presentation, n	22	2	20	
mGPS during Emergency Presentation, median (IQR)	1.00 (0.00-2.00)	2.00 (2.00-2.00)	1.00 (0.00-1.75)	**<0.001**
CCI during Emergency Presentation, median (IQR)	1.00 (0.00-2.00)	1.00 (0.00-2.00)	1.00 (0.00-2.00)	0.764
Histopathologic Characteristic of the Mass				
Adenocarcinoma, n	96	11	85	0.500
Location Area of the Mass				
Sigmoid colon, n	37	4	33	
Left colon, n	18	4	14	
Right colon, n	18	2	16	
Rectosigmoid colon, n	12	1	11	0.364
Rectum, n	7	1	6	
The other location, n	10	0	10	

IQR: Interquartile Range (25p, 75p), sd: standard deviation, *: Atypical causes of admission (such as shortness of breath, back pain, etc.), mGPS: modified Glasgow Prognostic Score, CCI: Charlson Comorbidity Index

DISCUSSION

Emergency services have become an area in which patients with chronic diseases, such as cancer, frequently present with non-specific complaints and are diagnosed coincidentally. In particular, the masses detected on CT scans performed for acute, emerging conditions, such as trauma, dyspnea, abdominal pain, and changes in consciousness, allow for diagnosis in these patients (13). In this study, the patients presented to various departments of the hospital, including emergency services, due to their existing complaints; however, they were not diagnosed until the development of ileus. The rates of such delays ranges widely, from 17% to 40%, due to differences in healthcare systems across countries, as well as socio-demographic differences (14-16). In our study, this rate was found to be 19.9%, which is similar to that reported in the literature.

Although colorectal cancers are one of the most frequently detected tumors (17), there has been an increase in the number of the diagnoses upon the presentation of patients to the emergency service with non-specific complaints (5). The patients diagnosed in the emergency service frequently present with complications such as ileus, perforation, and peritonitis. In the study, the patients presented with complaints such as abdominal pain, an inability to excrete gas and stool, and constipation, which may be indicative of pathology, both in their previous presentations and their presentations to the emergency service. This indicates the necessity of presenting to the emergency service due to the mere presence of ongoing symptoms rather than the severity of such symptoms. This is also supported by the fact that the duration of symptoms described by the patients ranged widely, from 3 to 60 days. Also, the diagnostic interval for these patients was shorter than for the elective group because the healthcare services provided through the emergency service are more accessible as compared to those received at polyclinics. Another indicator of accessibility is that 98% of the patients included in the study were hospitalized by the relevant polyclinic following presentation and 90% were treated surgically following hospitalization.

The studies carried out in relation to the newly diagnosed cancer patients in the emergency service show that age, gender, and socioeconomic status increase the possibility of being diagnosed (18). In our study, age was found to be effective in the diagnosis of colorectal cancer. However, a difference was found in terms of gender. While female patients are more prominent in the literature, male patients appeared at a higher rate (60.8%) (1,16) in our study. We believe that this difference arises from the fact that the sample group used in this study has a different socio-cultural structure than other samples.

The morbidity and mortality rates of patients who present due to complications are higher than those diagnosed under elective conditions (19). In our study, 12.7% of the patients died within the first 3 months and 30.4% died within the first year after diagnosis. The results obtained are similar to the data available in the literature (7,20). The usability of GPS and CCI, which are included among the practical scoring systems used for the evaluation of prognosis, especially in the patients who present to the emergency service, has been accepted as reliable for this patient group (9,11). Also, in this study, mGPS and CCI were evaluated, and mGPS was found to be statistically significant in the subgroup of the patients with perforation. However, no difference could be detected between this subgroup and the other patients in terms of tumor size, localization, and pathological type.

Differences are observed between patients in terms of tumor localization, clinical view, and histopathologic characteristics. Most tumors are endoluminal adenocarcinomas originating from the mucosa, and 55–70% of these are located in the distal part of the colon (21,22). In our patients who were newly diagnosed in the emergency

service, parallelism with the literature was found in terms of histopathologic diagnosis and localization. At the time of diagnosis, if distant metastasis is found, the involvement of the lymph nodes, liver, and lungs is observed most frequently in patients (20%) (23). Although dissemination is considered an adverse prognostic factor, it also constitutes the starting point of the symptoms that trigger patients to consult with a physician. In this study, the rates of lymph node and distant organ metastasis were similar to those observed in other studies.

The fact that the study was carried out retrospectively with a limited sample group limits the reliability of the results. The fact that our findings were mainly obtained from the hospital records suggests that certain data may have been affected by these limits. Since the study was retrospective, we did not calculate the sample size. Another limitation of our study was that we did not examine the previous screening tests of the patients included in it. Moreover, the fact that the sample group consisted of only the patients diagnosed coincidentally renders our results prejudicial. The fact that there are uncertainties regarding patients' ability to recall the emergence of the first symptoms and the time at which this occurred also leads to restrictions.

CONCLUSION

Ileus may be encountered as a complication in colorectal cancer patients, and the multidisciplinary approach is important in the detection of masses during presentation to the emergency service. In Turkey, family physicians and public health clinics offer free screening programs for colorectal cancers. Despite this, we believe that community-based screening programs for undiagnosed colorectal patients can increase awareness and reduce overall mortality rates, as well as the number of emergency cases. However, extensive well-designed studies are required to test this hypothesis.

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ORIGINAL ARTICLE

EVALUATION OF THE LEVEL OF KNOWLEDGE ABOUT ALZHEIMER DISEASE IN THE TEKIRDAĞ PROVINCE, TURKEY: A CROSS-SECTIONAL STUDY

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Abstract

Introduction: The prevalence of Alzheimer disease is increasing worldwide with increasing life expectancy. Increasing the level of community knowledge is important for early diagnosis and improving the quality of life of patients and their relatives. This study aimed to examine the level of community knowledge about Alzheimer disease and determine the areas that need to be improved with education.

Materials and Method: This descriptive and cross-sectional study was completed with 407 participants aged 18 years and older. Data were collected via Google Surveys using snowball sampling. "Alzheimer´s Disease Knowledge Scale" and "Socio-demographic form" were used to collect data.

Results: Women, younger population, health personnel, and those with higher education have more knowledge. On the other hand, there is a lack of knowledge about symptoms and caregiving. Most of the respondents were unaware of the risk factors that may increase susceptibility to the development of Alzheimer disease. While the level of knowledge about Alzheimer disease was higher in individuals who received education earlier, it was observed that living in the same house with an Alzheimer patient did not affect the level of knowledge.

Conclusion: There is a need to increase society's knowledge about the symptoms, risk factors, and caregiving related to Alzheimer disease. Regular training programs to raise public awareness should be planned face-to-face or online by the authorities of the subject, especially researchers, and should be included in health policies.

Keywords: Alzheimer Disease; Awareness; Knowledge.

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INTRODUCTION

Since the beginning of the twentieth century, developments in medicine and public health have led to an increase in life expectancy and an increase in the elderly population (1). According to the estimates of the World Health Organization, one out of every six people in the world will be 60 years of age or older by 2030, and this number is expected to double by 2050 (2). According to the data of the Turkish Statistical Institute, while the population aged 65 years and over constituted 12.9% of the population in 2023, this number is expected to increase to 25.6% in 2080 (3). Alzheimer's Disease (AD), the incidence of which increases with age, affects 10% of individuals over the age of 65 and approximately 50% of individuals over the age of 85 (4). AD affects more than 6.5 million adults aged 65 years and older in the United States and accounts for approximately one-third of all deaths among the elderly (5). According to the data of the Turkish Ministry of Health in 2018, there are approximately 500 thousand diagnosed Alzheimer's patients in Turkey, and according to the 2019 Health Statistics Yearbook, 6% of the health problems experienced by individuals aged 65 years and over in the last 12 months are caused by AD (6).

Memory disorders that occur in the early stages of the disease are generally considered a normal aging process by the relatives of the patients due to the absence of behavioral problems and significant effects on social life (7). Associating forgetfulness with aging may cause the diagnosis process to be delayed for up to four years, even if the symptoms are advanced (8). The addition of impairment in non-memory cognitive functions and behavioral problems, as well as the effects on daily living activities usually causes the patient's relatives to realize that there is a problem that requires applying to a health institution (4,9,10). As the disease progresses, the need for caregiver support increases. In countries where nursing homes are limited, this situation increases the caregiver burden of individuals within the family and causes a loss of labor force and social problems. Informing people about the disease will lead to earlier diagnosis and early initiation of supportive treatments. In addition to medical treatment, early initiation of rehabilitation and social support services for the patient's relatives will reduce the caregiver burden by supporting the preservation of the individual's independence (4,7).

Since AD poses a medical, social, and economic burden, the WHO determined in 2011 that early diagnosis should be the primary goal for Alzheimer's patients to receive effective support, treatment, and care (11). Different countries have developed different cultures of science communication and citizen participation. The most developed countries have well-organised public participation and science communication processes (12). Since the development of a country and its people depends to a large extent on the maturity of scientific and technological development, it is essential to reflect on how this development takes place, particularly with regard to the involvement of citizens in research projects and the dissemination of knowledge to society. Researchers, research units and universities have a responsibility to make information accessible, user-friendly and usable. Its other mission is to synthesise evidence to support informed health decision-making and to provide the best information and products to end users (health professionals, citizens and policy-makers).

The motivation for this research was to identify gaps to increase people's level of knowledge about AD and to create projects to disseminate information in this direction. Therefore, in this study, we aimed to examine the community's level of knowledge about Alzheimer's disease and to determine the areas that need to be improved with education.

MATERIALS AND METHOD

Design of Research

The study was planned as a descriptive and cross-sectional type. The convenience sampling method



was used in the study, and data were collected from December 2023 to March 2024 with an electronic questionnaire form.

Population and sample of the research

In determining the sample size, the data of the Turkish Statistical Institute for the year 2022 were used. The population of Tekirdağ is 1,142,451 people. These individuals constitute the finite universe of the study, and individuals over the age of 18 who agree to participate in the study constitute the study sample. The sample number was determined as 385 people with a regular distribution of 95% confidence by calculations made with the Raosoft Sample Size Calculator program (http://www.raosoft.com/samplesize.html). The data collection form was prepared using the Google forms application and a link was created for this form. Each item was marked as 'necessary/required' to ensure that there was no missing data. The link created was delivered to 407 people by snowball sampling method and data were collected.

Inclusion criteria

Individuals who volunteered to participate in the study, were over 18 years of age, could read and write, and could use the Internet were included in the study.

Data Collection Tools

The self-designed socio-demographic questionnaire form and the Alzheimer's Disease Knowledge Scale (ADKS) were used as measurement tools in the study. At the beginning of the questionnaire sent to the participants, the purpose of the study and the information that participation in the study was voluntary were included. Participants' names were not included in the questionnaire. The response time of the questionnaire is 5-10 minutes.

Socio-demographic form: The form, which was created in order to determine the descriptive characteristics of the participants, includes eleven questions.

Alzheimer's Disease Knowledge Scale (ADKS): The 30-item, seven-subscale scale developed by Brian Carpenter in 2009 assesses AD knowledge. Scores range from 0 to 30, with one point awarded for each correct answer. Higher scores indicate better knowledge. The Turkish adaptation by Yılmaz and Çolak showed test-retest reliability of 0.81 and a Kuder-Richardson 20 coefficient of 0.74 (13).

Statistical Analysis

Jamovi 2.3.28 statistical program was used to evaluate the data obtained from the study. Descriptive statistical techniques (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used to analyse the study data. The normality test was performed with the Shapiro-Wilk Test. Since the data did not show normal distribution, the Mann-Whitney U test was used to compare two groups, and the Kruskal-Wallis test was used to compare more than two groups. Dwass-Steel-Critchlow-Fligner (DSCF) post-hoc analysis was used for significant differences between groups in the Kruskal-Wallis test. $p<0.05$ was accepted as significant.

Ethical approval

Ethical approval has been obtained from the Ethics Committee of the Faculty of Medicine (approval number: 2023.206.11.20 dated November 28, 2023).

RESULTS

Participants socio-demographic characteristics

64.6% of the participants were female. The mean age was 28.6±13.0 years (min:18-max:65), and the mean duration of education was 12.1± 3.33 years (min:4-max:2). It was observed that more than 80% of the participants had not received any education about AD or had not known any Alzheimer's patient. Half of the participants stated that they heard about AD from their neighborhood (family, friends, etc.). The data related to the socio-demographic characteristics of the individuals included in the study are presented in Table 1.

Table 1. Participants Socio-demographic characteristics

Variable	Category	n	%
Gender	Female	263	64.6
	Male	144	35.4
Age	≤ 25 years	258	62.9
	26-50 years	47	11.5
	≥ 51 years	104	25.6
Education status	5 years	47	11.5
	6-12 years	104	25.6
	≥13 years	256	62.9
Marital status	Married	120	29.5
	Single	287	70.5
Employment status	Yes	150	36.9
	No	257	63.1
Income-level	Income = expenditure	213	52.3
	Income < expenditure	138	33.9
	income > expenditure	56	13.8
Status of being a health care worker	Yes	65	16.0
	No	342	84.0
Alzheimer's disease recognition	Yes	136	33.4
	No	271	66.6
Living in the same house with an Alzheimer's patient	Yes	54	13.3
	No	353	86.7
Receiving education on Alzheimer's disease	Yes	66	16.2
	No	341	83.3
How they first heard about Alzheimer's disease	From the environment (family, friends, etc.)	204	50.1
	Book- journal-school	62	15.2
	Internet-television	141	34.7

Table 2. ADKS and sub-dimension scores and correct answer percentages (n=407)

Sub-dimension of the questions	Point range	Mean±SD	Min-Max (Median)	Correct answers%
Life impact (1,11,28)	0-3	2.14±0.79	0-3 (2)	70.7
Risk factors (2,13,18,25,26,27)	0-6	2.94±1.23	0-6 (3)	48.1
Symptoms (19,22,23,30)	0-4	2.19±0.89	0-4 (2)	54.8
Treatment and management (9,12,24,29)	0-4	2.48-0.79	0-4 (3)	62.1
Caregiving (5,6,7,15,16)	0-5	1.77 ±0.89	0-5 (2)	35.4
Assessment and diagnosis (4,10,20,21)	0-4	2.83±0.87	0-4(3)	70.8
Course (2,8,14,17)	0-4	2.79±0.85	0-4(3)	69.9
ADKS (Total)	0-30	17.10±2.53	9-24(17)	58.8



AKDS sub-dimension and question analysis

The mean ADKS score was found to be 17.1±2.53. The sub-dimension with the lowest knowledge level was caregiving (35.4%). The highest levels of knowledge were found in the sub-dimensions of the life impact (70.7%) and assessment and diagnosis (70.8%). ADKS sub-dimension and total scores of the participants are presented in Table 2.

It was observed that the three items with the highest rate of incorrect answers were *"Carers should take over as soon as people with AD start to have difficulty caring for themselves," "Once people have developed AD, they are no longer able to make informed decisions about caring for themselves,"* and *"Mental exercise can prevent a person from developing AD has been*

Table 3. Participants' correct answer percentages according to the scale items (n = 407)

		% of correct answers
1	People with AD are especially susceptible to depression.	76.4
2	Mental exercise can prevent a person from developing AD has been scientifically proven.	17.2
3	The average life expectancy after AD symptoms is 6 to 12 years.	56.3
4	If a person with AD becomes agitated, a medical examination may reveal other health problems that are causing the agitation.	82.8
5	People with AD do best with simple, step-by-step instructions.	46.4
6	Carers should take over as soon as people with AD start to have difficulty caring for themselves.	4.4
7	If a person with AD becomes alert and agitated at night, a good strategy is to try to make sure they get plenty of exercise during the day.	84.5
8	In rare cases, people have recovered from AD.	46.4
9	Psychotherapy for depression and anxiety can benefit people whose AD is not yet severe.	86.5
10	If you start having problems remembering and thinking confusedly, AD is likely.	43.0
11	Most people with AD live in a nursing home.	63.4
12	AD symptoms can be worsened by poor diet.	75.4
13	AD can affect people in their 30s.	56.5
14	A person with AD is more likely to fall as the disease gets worse.	91.4
15	When people with AD repeat the same question or story several times, it is helpful to remind them that they are repeating themselves.	25.3
16	Once people have developed AD, they are no longer able to make informed decisions about caring for themselves.	16.2
17	Eventually, a person with AD will be in need of 24-hour care.	85.3
18	A risk factor for AD may be high blood cholesterol.	52.8
19	Hand or arm tremor is a common symptom in people with AD.	42.0
20	AD symptoms can be mistaken for symptoms of severe depression.	69.8
21	AD is one type of dementia.	87.7
22	Problems with money or bills are common early symptoms of AD.	59.2
23	One of the symptoms that can occur in AD is the belief that other people are trying to steal their things.	63.6
24	When a person has AD, the use of reminder notes is a crutch that can contribute to their decline.	21.9
25	Prescription drugs prevent AD.	41.5
26	Hypertension may increase the risk of AD.	47.2
27	Genes can only partly explain why AD develops.	78.4
28	It is safe for people with AD to drive as long as they're accompanied.	74.2
29	AD cannot be cured.	64.4
30	Most people with AD have a better memory of recent events than of things in the past.	54.3

scientifically proven." The three items that most of the participants answered correctly were *"A person with AD is more likely to fall as the disease gets worse," "AD is one type of dementia," and "Psychotherapy for depression and anxiety can benefit people whose AD is not yet severe."* Table 3 shows the number of correct answers according to the items of the ADKS scale.

Analysis of socio-demographic characteristics related to ADKS

Females had higher ADKS total scores than males ($p<0.05$). Among the age groups, the ADKS total score of the group aged 25 years and younger was found to be higher than the other groups ($p<0.05$).

It was determined that the AD knowledge level of the participants was affected by the level of education. In the post-hoc analysis, it was found that the knowledge of life impact sub-dimension was significantly higher in those with 13 years of education and above than in those with five years of education ($p=0.006$). The total scale score, risk factors and symptom knowledge dimensions were found to be higher in those who were healthcare professionals and had received education about Alzheimer's disease compared to those who were not healthcare professionals and had not received education about Alzheimer's disease ($p<0.05$). The mean scores of the care sub-dimension of the scale were higher in those with poor economic status. Those who lived in the same house with an AD patient had higher 'symptom' subscale scores but lower 'treatment management' subscale scores than those who did not ($p<0.05$). Alzheimer's knowledge levels of the participants according to their socio-demographic characteristics are presented in Table 4.

DISCUSSION

In this study, the level of knowledge in a group of a individuals between the ages of 18-65 was analyzed by using the online survey method. Results revealed that the level of knowledge was higher in women, the younger, those with higher education levels, and health care staff. In today's world where internet usage and online health platforms have become widespread, although access to information is easier, information pollution makes it difficult to access accurate information. The data we obtained supports the need for more accurate dissemination of correct information through organized educational activities. It is important that regular training programs on the early diagnosis and treatment of AD, which poses the risk of an economic burden in the future, should be implemented face-to-face or online by the authorities of the subject, especially researchers, and should be included in health policies to raise public awareness (14,15). Ma et al. in their study evaluating the effectiveness of offline and online training with community health service center staff with a mean age of 35 years reported that no difference was found in terms of information between the types of training (14). In this study, the level of knowledge was higher in the younger age group. Considering the studies that emphasize regional and cultural differences in community information activities (15,16,17,18,19,20), starting education programs at a younger age, perhaps in the compulsory education processes of countries, can be an important investment to ensure accurate and reliable knowledge about health among society members.

According to previous studies, being a healthcare staff is a positive factor in terms of knowledge level. In the studies conducted for healthcare staff, the mean score of ADKS varies between 10 and 26 [Malaysian study 18.47 and 19.05 (21), Australia evaluated 23.6 (22), Brazilian 23.46 (20), Norwegian 24.10 (23), Saudi Arabia 10.77 and 26,7 (16,17)]. Healthcare staff constituted 16% of our study group, and most were not medical professionals or physicians. Although the mean ADKS score was

Table 4. Alzheimer's knowledge level according to socio-demographic characteristics

	Variables	Life impact	p	Risk factors	p	Symptoms	p	Treatment and management	p	Caregiving	p	Assessment and diagnosis	p	Disease course	p	ADKS	p
Gender	Female	2.18	0.379	3.00	0.187	2.16	0.308	2.48	0.669	1.78	0.476	2.92	**0.009**	2.86	0.060	17.42	**0.006**
	Male	2.07		2.83		2.25		2.49		1.74		2.68		2.68		16.72	
Age	≤ 25 years	2.17	0.303	3.03	0.166	2.23	0.253	2.50	0.940	1.80	0.578	2.88	0338	2.78	0.683	17.38	**0.023**
	26-50 years	2.12		2.78		2.08		2.47		1.72		2.78		2.85		16.78	
	≥ 51 years	1.97		2.79		2.27		2.42		1.70		2.70		2.73		16.58	
Education status	5 years	1.87	**0.002**	3.09	0.096	2.19	0.238	2.47	0.388	1.64	0.390	2.72	0.311	2.77	0.754	16.74	**0.003**
	6-12 years	2.01		2.73		2.09		2.40		1.74		2.76		2.82		16.55	
	≥ 13 years	2.24		2.99		2.23		2.52		1.80		2.88		2.79		17.46	
Married Single	Married	2.08	0.431	2.82	0.257	2.17	0.675	2.52	0.327	1.15	0.611	2.80	0.620	2.82	0.798	17.03	0.253
	Single	2.16		2.99		2.20		2.47		1.78		2.85		2.78		17.22	
Employment status	Yes	2.09	0.595	2.88	0.497	2.11	0.076	2.49	0.893	1.75	0.650	2.76	0.162	2.79	1000	16.87	0.066
	No	2.17		2.97		2.24		2.47		1.78		2.88		2.80		17.30	
Income-level	Income = expenditure	2.11	0.501	2.86	0.197	2.13	0.081	2.66	0.103	1.73	**0.004**	2.91	0.187	2.83	0.580	17.04	0.315
	Income < expenditure	2.15		3.09		2.20		2.52		1.93		2.72		2.79		17.43	
	income > expenditure	2.23		2.82		2.66		2.41		1.52		2.82		2.66		17.14	
Status of being a health care worker	Yes	2.32	**0.039**	3.29	**0.011**	2.38	**0.049**	2.42	0.184	1.85	0.325	2.98	0.083	2.75	0.754	18.00	**0.001**
	No	2.11		2.87		2.15		2.49		1.75		2.80		2.80		16.98	
Alzheimer's disease recognition	Yes	2.20	0.258	2.99	0.506	2.31	0.061	2.49	0.938	1.63	0.064	2.79	0.322	2.88	0.118	17.29	0.452
	No	2.11		2.91		2.13		2.48		1.84		2.85		2.75		17.07	
Living in the same house with an Alzheimer's patient	Yes	2.15	0.940	2.96	0.854	2.46	**0.041**	2.39	0.345	1.48	**0.010**	2.72	0.181	2.93	0.111	17.09	0.848
	No	2.14		2.93		2.15		2.50		1.81		2.88		2.77		17.15	
Receiving education on Alzheimer's disease	Yes	2.23	0.474	3.23	**0.028**	2.45	**0.003**	2.62	0.187	1.79	0.651	3.06	0.024	2.80	0.880	18.17	**0.001**
	No	2.12		2.88		2.14		2.45		1.77		2.79		2.79		16.95	

higher in the healthcare personnel group (18.0 vs. 17.0), it was lower compared to most of the publications in the literature. It has been reported that medical professionals and physicians have a higher level of knowledge (24,25). Considering that this group was not included in our study sample, it can be said that the low mean values are due to the data of the auxiliary health personnel. In accordance with the literature, it was observed that the level of knowledge about the impact of the disease on life, risk factors, and symptoms was higher in health workers. All these results emphasize that health professionals have a more accurate understanding of AD than the general population, confirming the expectations.

There are fewer studies in the literature assessing the level of knowledge of society members other than health professionals. Our results revealed that respondents had a good understanding of some items in all categories. The category 'assessment and diagnosis' received the highest mean percentage of correct responses (70.8%), followed by 'life impact' (70.7%), 'course' (69.9%), 'treatment and management' (62.1%), and 'symptoms' (54.8%). However, there was a lack of knowledge about the 'risk factors' (48.1%) and 'caregiving' (35.4%). Although the level of knowledge of our sample about risk factors was found to be higher than the studies examining the level of knowledge of the population in the UK, Brazil, and Saudi Arabia, it was observed to be lower than two studies conducted in different regions of the UK and Saudi Arabia (16,17,19,20). A considerable proportion of participants believed that using reminder notes could contribute to a decline in Alzheimer's patients and were not aware that mental exercise was important for brain health. Also, few participants were aware that HT and hyperlipidemia may be risk factors, supporting previous studies (16,19,20). The level of knowledge about caregiving was found to be significantly lower than other studies in the literature. In particular, 95% of the respondents incorrectly answered the question *''Carers should take over as soon as people with AD start to have difficulty caring for themselves.*" The evaluation of the two items with the lowest level of knowledge reveals the insufficient level of knowledge about mental exercise and rehabilitation in our society. Educational programs emphasizing the importance of mental exercise along with environmental factors and healthy living requirements in the prevention of neurodegenerative diseases of the brain such as AD will increase the level of knowledge among people on this subject. In support of previous research, knowledge of AD differed between age groups and educational levels (17,18,20). While the knowledge levels of those who had a diagnosis of AD among their relatives did not differ, it was found that individuals living with AD had more knowledge about the symptoms. However, it was noteworthy that individuals living with AD had a lack of knowledge about caregiving. AD is a disease with a high caregiver burden and therefore creates serious financial and moral problems within the family (16,18,20). Informing and supporting family members about the disease and caregiving is important in reducing the caregiver burden. In addition to cognitive rehabilitation of the patient, family training can increase the quality of life of individuals by reducing the caregiver burden. It was observed that the participants who stated that they had received education before had a higher level of knowledge, especially about symptoms and risk factors.

The study has several limitations. Firstly, this study used a cross-sectional design, so it was not possible to establish a causal relationship between the independent variables and the AD knowledge score. Since this study was conducted to determine the Alzheimer's knowledge of individuals living in a region with a scale whose validity and reliability study has been conducted in our country, it does not include inter-regional differences. Using such

a convenience sample might limit the capability to generalize findings. The study, whose data were collected through Google Surveys, was limited by the fact that individuals with digital literacy and high educational status participated in the study. Future research should be carried out in a larger sample, and regional differences in the level of AD knowledge should be explained by considering socio-demographic data. The study included participants between 18 and 65 years old, and data were collected with an electronic questionnaire form which could have a bias for older adults.

CONCLUSION

The level of knowledge was higher in women, the young population, healthcare staff, and those with higher education levels. However, there are gaps in knowledge about symptoms and caregiving. Most crucially, a considerable proportion of those surveyed were unaware of risk factors that may increase one's predisposition to developing AD. In line with the findings obtained; healthcare professionals' informing the community to change cultural thought patterns (forgetfulness is the result of the aging process etc.) is important for early diagnosis. A delayed diagnosis is expected to increase the burden of family care. To increase people's level of knowledge about AD, we recommend that correct information should be conveyed by healthcare professionals through the Internet, social media, support groups, and awareness campaigns.

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ORIGINAL ARTICLE

CROSS-CULTURAL ADAPTATION AND VALIDATION OF THE TURKISH VERSION OF THE 25-QUESTION GERIATRIC LOCOMOTIVE FUNCTION SCALE

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Abstract

Introduction: Locomotive syndrome, characterized by gait disorders, loss of balance, and cognitive difficulties, significantly impacts older adults by increasing morbidity and reducing independence. This study aimed to adapt the 25-item Geriatric Locomotive Function Scale into Turkish and evaluate its validity and reliability.

Materials and Method: The translation process involved forward and backward translations by bilingual experts to ensure linguistic and conceptual equivalence with the original scale. A total of 250 individuals aged ≥65 years participated, completing the Turkish version of the scale alongside functional mobility tests; the timed up-and-go, five repetitions of sit-to-stand, two-step, and standing tests. Participants repeated the scale 1 week after the initial evaluation to assess the test–retest reliability.

Results: The internal consistency of the Turkish version was excellent (Cronbach's alpha = 0.952). Test–retest reliability, assessed 1 week apart, yielded an intraclass correlation coefficient of 0.974, indicating excellent reliability. Concurrent validity was examined by correlating scale scores with functional test results. Significant correlations were observed ($p < 0.001$), with Pearson's correlation coefficients of 0.472 for timed up-and-go, 0.504 for five repetitions of sit-to-stand, -0.871 for the two-step test, and -0.518 for the standing test. These findings demonstrate that the Turkish version is a valid and reliable tool for assessing mobility impairment and functional limitation in older adults.

Conclusion: The adaptation and validation of the 25-item Geriatric Locomotive Function Scale into Turkish provide a comprehensive measure for evaluating and monitoring locomotor function, supporting early detection and intervention in this population.

Keywords: Geriatric Assessment; Locomotion; Aged.

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INTRODUCTION

Problems with the locomotor system, resulting from gait disorders and loss of balance, are significant causes of mortality and morbidity among older adults (1). Maintaining mobility in later life is crucial for sustaining metabolic homeostasis, preventing frailty, and maintaining independence. Loss of mobility negatively impacts these aspects, creating a vicious cycle for older adults (2).

In 2007, the Japanese Orthopedic Association (JOA) introduced the term "locomotive syndrome" (LoS) to raise public awareness of this condition and its management strategies (3).

LoS, observed in geriatric populations, is defined as a combination of slowness, movement abnormalities, and cognitive difficulties that can result in poor performance in activities of daily living and increased bone fragility (4). Developing effective health policies and practices to prevent LoS and its associated morbidities is among the significant healthcare challenges of the twenty-first century. Monitoring and early intervention in pre-symptomatic older adults can potentially prevent musculoskeletal and musculotendinous deterioration associated with long-term LoS (3). Maresova et al. that mobility assessments for older adults should adopt a multifactorial approach, considering their functional abilities rather than relying solely on limited factors (5). From this perspective, the 25-question Geriatric Locomotive Function Scale (GLFS-25), developed by Seichi et al., is an effective tool for detecting early mobility disorders. This assessment tool requires respondents to rate their experiences of pain, activities of daily living, social functions, and mental health status over the past month using a 4-point Likert scale. (6)

Existing literature on LoS predominantly addresses the syndrome's presence and severity without considering the participants' age ranges. Clinical studies have shown that the GLFS-25 correlates with specific functional assessments, such as grip strength, time to stand on one leg, and time to walk 6 meters. Additionally, research highlights the GLFS-25's utility in determining falls (7), lower extremity muscle strength (8), level of independence in activities of daily living (9), and physical performance (10).

While these functional assessments are acknowledged as valuable, the two-step and standing tests are the most widely accepted methods for evaluating LoS (4). However, studies on the GLFS-25's validity and reliability in Brazil, Iran, and China employed other validation methods, without using these tests (11-13) In this study, the GLFS-25's validity was analyzed using the timed up-and-walk test, five repetitions of sit-to-stand, two-step, and stand-up tests.

This study aimed to examine the Turkish language adaptation, validity, and reliability of the GLFS-25.

MATERIALS AND METHOD

Design

This epidemiologic cross-cultural adaptation and psychometric analysis study was conducted per the Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects) and approved by the Ethics Committee of Dokuz Eylul University (No: 2021/28-24).

Participants:

The study announcement was disseminated via social media platforms, including Facebook, WhatsApp groups, Instagram, and Twitter. Individuals residing in Izmir province who volunteered for the study were included. To ensure scale validity and reliability, at least 10 individuals were included per scale item (14). Since the scale contained 25 items, a minimum of 250 participants were required.

The study population included voluntary individuals aged ≥65 years living in Izmir. Individuals



with acute conditions affecting mobility, such as a history of fracture of the lower extremities and/or spine within the past 6 months or those who had undergone acute trauma treatment, were excluded.

Signed written informed consent was obtained from participants. Data were collected in a single session. Rest periods of 5 minutes were allowed between physical measurements. Demographic data were gathered through interviews conducted at the session's outset, followed by a self-administered questionnaire.

Study outcome measures:

Turkish Translation of GLFS-25: Necessary permissions were obtained from the original study's author. Forward translation of the original questionnaire was performed by two native Turkish speakers with advanced English proficiency, one being a health professional. The translations were consolidated into a consensus version, which was back-translated into English by two bilingual (English-Turkish) non-healthcare professional and compared with the original questionnaire. Expert committee review confirmed no discrepancies in meaning or structure. A pilot test involving 20 healthy individuals determined the translation was linguistically comprehensible, requiring no modifications.

Data were collected in person at the Dokuz Eylul University School of Physical Therapy and Rehabilitation. Study objectives and evaluation methods were explained to participants before obtaining informed consent. After demographic data collection, participants completed the GLFS-25 and underwent the timed up-and-go test, 5-repetition sit-to-stand test, two-step test, and standing-up test to assess concurrent validity.

To evaluate test-retest reliability of the Turkish version, participants completed GLFS-25 again 1 week after the initial evaluation.

The GLFS-25, a self-administered scale, consists of 25 items: four questions on pain in the past month, 16 on daily activities in the past month, three on social functioning, and two on mental health status in the past month. Items are scored on a 5-point Likert scale from no difficulty (0) to severe difficulty (4), with a total possible score of 100. Higher scores indicate more severe LoS (6). Scores of 7–15 indicate Level 1 LoS, and scores ≥16 indicate Level 2 LoS (4).

Two-Step Test: The test was considered complete if the participant starts upright, takes two steps forward without losing balance, and holds the final standing position for ≥3 seconds. The test is performed twice and the best result is recorded. The distance covered was divided by the participant's height and the resulting value was recorded as the two-step test result (15).

Timed Up-and-Go Test: In the timed up and go test, participant sits on a standard chair (43 cm high) with his/her back on the chair, and a point 3 m away from the chair is marked. The participants were asked to get up from the chair, walk 3 m, and return to the chair. The completion time of the test was measured in seconds. The test was performed three times and the best result was recorded. Times of ≥14 seconds indicate high fall risk (16).

Five Repetitions of the Sit-to-Stand Test: Participants were asked to stand up and sit down five times as fast as they could in a chair with no arm support and a height of 43 cm with the arms crossed over the chest. The test started from a sitting position, and repetitions where the participants did not fully stand up or make contact with the chair were not counted. The time required to complete the test was measured in seconds. The test was performed three times and the best result was recorded (17).

Standing up test: Participants were asked to stand up from 40-, 30-, 20 and 10 cm high stools first using two legs and then one leg (right and left foot). The test starts with the participant standing

up with two legs using a 40 cm stool, which is the easiest size, and then using increasingly difficult heights downwards by 10 cm each time. The same method is then applied using one leg. If the person being evaluated manages to hold the position after standing up for >3 seconds without any additional steps, the test is considered complete, and the person is expected to stand up with both legs from a specified level in single-leg steps. The scoring of the test was based on the values listed in Table 1 for the most difficult step completed (15). A high score on the test was indicative of good mobility.

Statistical Analysis: Cronbach's alpha coefficient measured the internal consistency of the scale. Values ≥0.80 were considered excellent, 0.70–0.79 adequate, and <0.50 inadequate (18).

The intraclass correlation coefficient (ICC) was used to determine test-retest reliability. Reliability was categorized as poor (<0.50), moderate (0.50–0.75), good (0.75–0.90), and excellent >0.90 (19).

To examine concurrent validity, the correlation between the GLFS-25 score and the results of the two-step test, the timed up-and-go test, and five repetitions of the sit-to-stand test was analyzed with Pearson correlation coefficient r.

All data were analyzed using SPSS for Windows (version 21.0; SPSS Inc., Chicago, IL, USA).

Table 1. Clinic Features of The Participants

		Min	Max	Mean X ± SD
Total (n=250)	GLFS-25	0	86	20.82 ± 17.83
	Age (year)	65	85	69.50 + 4.37
	BMI (kg/m2)	17.58	38.46	27.49 +3.87
	TUG (sec)	5.30	24.00	8.36 ± 2.37
	5RSTS (sec)	5.35	56.50	9.96 ± 6.14
	SUT	1.00	6.00	3.84 ± 1.14
	2ST	0.29	1.28	0.84 ± 0.19
LoS1 (n=74)	GLFS-25	7	15	11.02 ± 2.87
	Age (year)	65	78	68.32 ± 2.88
	BMI (kg/m2)	19.72	35.56	20.07 ± 3.82
	TUG (sec)	5.30	11.10	8.01 ± 1.34
	5RSTS (sec)	5.45	15.70	8.61 ± 1.97
	SUT	1.00	6.00	4.22± 0.95
	2ST	0.36	1.08	0.91 ± 0.10
LoS 2 (n=124)	GLFS-25	16	86	33.98 ± 16.64
	Age (year)	65	85	70.67 ± 5.11
	BMI (kg/m2)	17.58	35.64	27.41 ±3.95
	TUG (sec)	5.89	24.00	9.06 ± 2.93
	5RSTS (sec)	5.30	56.50	8.61 ± 1.97
	SUT	1.00	6.00	3.36 ± 1.09
	2ST	0.29	1.28	0.71 ± 0.16

TUG: Timed Up and Go, 5RSTS: Five Repetitions of Sit-to-Stand, SUT: Standing up Test, 2ST: Two-step test, GLFS-25: Geriatric Locomotive Function Scale, BMI: Body Mass Index.



RESULTS

Of the 250 study participants 186 were females (74.4%), and 160 (64.0%) were married. Participants demonstrated no difficulty completing the GLFS-25 independently and repeated it after a 1-week interval. No unanticipated problems or adverse events were reported by any participants.

The mean GLFS-25 score for the initial assessment was 20.82+17.83, and the re-test score was 21.13+17.48. Based on GLFS-25 scores, 29.6% of participants were classified as Level 1 LoS, and 49.6% as Level 2 LoS. Table 1 presents the clinical features of participants by LoS levels.

Internal consistency was assessed using Cronbach's alpha revealed excellent reliability with a value of 0.952. The distribution of item-specific results is shown in Table 2.

During the adaptation of the GLFS-25 scale into Turkish, the suitability of its factor structure

Table 2. Distribution of the results

	Range	Mean (SD)	Lowest n (%)	Highest n (%)	Cronbach's Alpha if item deleted
Total Score	0-100	20.82(17.84)	8 (3.2)	0 (0)	
1	0-4	1.54+ 1.01	33 (13.2)	9 (3.6)	0.951
2	0-4	1.60+ 1.7	51 (20.4)	12 (4.8)	0.950
3	0-4	0.52+0.86	65 (26.0)	17 (6.8)	0.950
4	0-4	0.58+ 0.83	99 (39.6)	3 (1.2)	0.949
5	0-4	0.56+ 0.97	171 (6.4)	4 (1.6)	0.950
6	0-4	0.44+ 0.81	177 (70.8)	4 (1.6)	0.950
7	0-4	0.52+ 1.02	173 (69.2)	14 (5.6)	0.950
8	0-4	0.33+ 0.74	202 (80.8)	0 (0)	0.926
9	0-4	0.58+ 0.83	153 (61.2)	1 (0.4)	0.925
10	0-4	0.77+ 1.19	165 (66.0)	10 (4.0)	0.936
11	0-4	0.24+ 0.56	207 (82.8)	0 (0)	0.928
12	0-4	1.44+ 1.34	89 (35.6)	19 (7.6)	0.926
13	0-4	0.47+ 0.94	112 (44.8)	4 (1.6)	0.923
14	0-4	0.52+ 0.86	192 (76.8)	14 (5.6)	0.935
15	0-4	0.80+ 1.16	138 (55.2)	16 (6.4)	0.926
16	0-4	0.39+ 0.80	188 (75.2)	0 (0)	0.929
17	0-4	0.81+ 1.13	149 (59.6)	6 (2.4)	0.935
18	0-4	0.33+ 0.74	192 (76.8)	1(0.4)	0.926
19	0-4	0.58+ 0.83	174 (69.6)	0 (0)	0.925
20	0-4	1.82 + 1.41	65 (26.0)	37 (14.8)	0.952
21	0-4	0.94 + 1.02	107 (42.8)	5 (2.0)	0.949
22	0-4	0.41 + 0.80	185 (74.0)	0 (0)	0.949
23	0-4	0.59 + 0.98	170 (68.0)	0 (0)	0.949
24	0-4	0.96 + 0.99	108 (43.2)	0 (0)	0.950
25	0-4	1.11 + 1.07	95 (38.0)	4 (1.6)	0.951

SD: Standard Deviation

was assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. The KMO value was 0.884, indicating excellent sampling adequacy, while Bartlett's test of sphericity was significant (χ^2 = 5726.841, p < 0.001). These results confirm that the Turkish version is highly suitable for factor analysis (Table3).

Following the Exploratory Factor Analysis, the factor structure of the Turkish version of GLFS-25 was identified as comprising five distinct factors, as presented in Table 3.

The Exploratory Factor Analysis identified five distinct subscales. Confirmatory Factor Analysis revealed factor loadings ranging from 0.61 to

Table 3. Exploratory factor analysis: Factor loading of 25 items (n=250)

	Body Pain	Movement Related Difficulty	Usual Care	Social Activities	Cognitive
Item 19	0.890				
Item 22	0.890				
Item 16	0.822				
Item 23	0.776				
Item 18	0.774				
Item 21	0.735				
Item 17	0.713				
Item 15	0.624				
Item 13	0.585				
Item 20	0.530				
Item 12	0.503				
Item 8		0.927			
Item 11		0.916			
Item 9		0.816			
Item 10		0.798			
Item 14		0.795			
Item 3			0.880		
Item 4			0.851		
Item 2			0.813		
Item 1			0.735	0.301	
Item 7				0.753	
Item 5				0.727	
Item 6				0.677	
Item 25					0.946
Item 24					0.893
Explained Total Variance			75.942 %		
KMO Coefficient			0.884		
Barlett test		X2= 5726.841		(p<0.001)	

KMO Coefficient: Kaiser-Meyer-Olkin.



0.88, indicating that the items demonstrated good concurrent validity and good compatibility (Fig. 1).

The fit indices of the Turkish version of GLFS-25 were found to be within acceptable standards (Table 4)

To assess the reliability of the GLFS-25 Turkish version and its five factors, internal consistency reliability was evaluated in this study. The analysis revealed that the Cronbach's alpha values for the total scale and each of its sub-dimensions,

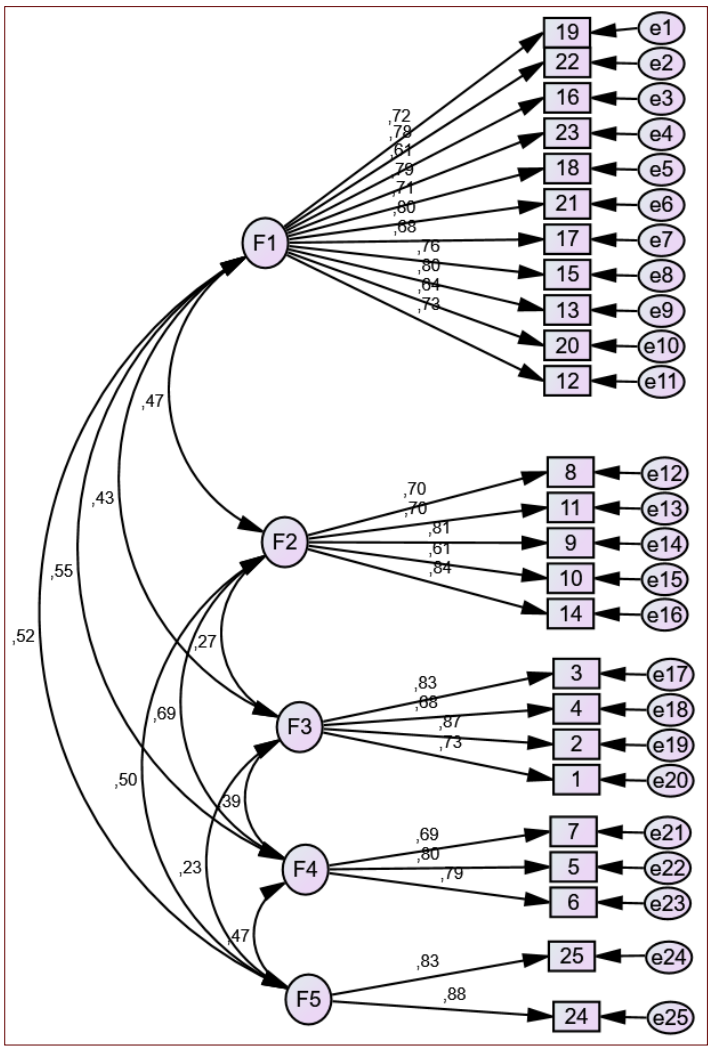


Figure 1. Confirmatory factor analysis of Turkish version of GLFS-25

F1:Body Pain, F2: Movement Related Difficulty, F3: Usual Care, F4: Social Activities, 5: Cognitive

Table 4. Goodness of fit indices (n=250)

Models/Data-model fit indices	X2	Df	X2/Df	sRMR	RMSEA	CFI	IFI	TLI	GFI
Five Factor Model	762.893	265	2.878	0.043	0.078	0.92	0.92	0.91	0.90

Notes: X^2, Chi-square; df, Degrees of Freedom; RMSEA, Root Mean Standard Error Approximation; sRMR, Standardized Root Mean Square Residual; CFI, Comparative Fit Index; IFI, Incremental Fit Index; TLI, Trucker-Lewis Index; GFI, Goodness of Fit.

Table 5. Results of reliability analysis of scale and subdimensions

GLFS-25 subdimension	Item number	Cronbach's α internal consistency coefficient	Test–retest reliability coefficients
Body Pain	4	0.784	0.894
Movement Related Difficulty	3	0.892	0.931
Usual Care	5	0.793	0.879
Social Activities	11	0.834	0.784
Cognitive	2	0.835	0.842

Table 6. Correlation between the GLFS-25 and other scales

	GLFS-25 Total	Body Pain	Movement Related Difficulty	Usual Care	Social Activities	Cognitive
TUG (sec)	0.472*	0.336*	0.530*	0.287*	0.438*	0.214*
5RSTS (sec)	0.504*	0.370*	0.559*	0.360*	0.444*	0.130*
SUT	-0.518*	-0.296*	-0.391*	-0.332*	-0.371*	-0.267*
2ST	-0.871*	-0.554*	-0.708*	-0.702*	-0.773*	-0.574*

*Correlation is significant at the 0.05 level (2-tailed).

TUG: Timed Up and Go, 5RSTS: Five Repetitions of Sit-to-Stand, SUT: Standing up Test, 2ST: Two-step test.

indicating acceptable levels of internal consistency reliability for the GLFS-25 Turkish version (Table 5).

Seven days after the initial assessment, all participants were asked to complete the questionnaire again. Analysis of mean total scores from both assessments using the Pearson correlation coefficient yielded an intraclass correlation coefficient (ICC) of 0.974. The internal consistency and test-retest reliability results for all subscales are presented in Table 5.

All performance tests exhibited statistically significant correlations with the total score of GLFS-25 ($p < 0.001$). Pearson's correlation coefficients were as follows: 0.472 for the Timed Up-and-Go test, 0.504 for the Five-Repetition Sit-to-Stand test, -0.871 for the Two-Step test, and -0.518 for the Stand-Up test. Additionally, all performance tests demonstrated statistically significant correlations with the subscales of GLFS-25 ($p < 0.005$) (Table 6).

DISCUSSION

This study investigated the validity and reliability of the Geriatric Locomotor Function Scale-25 in a sample of older adults (> 65 years old) in Izmir.

The findings demonstrate excellent internal consistency (Cronbach's alpha = 0.952) of locomotor function in this population. Seichi et al. determined the Cronbach's alpha score of the original test as 0.961 (6). Similarly, studies validating the scale in other languages reported substantial consistency, with Cronbach's alpha values of 0.942 in Brazilian Portuguese (11) and 0.932 in Farsi (12) language.

The study's findings indicate that the GLFS-25 exhibits excellent test-retest reliability, achieving a satisfactory ICC. These results are consistent with previous research, further supporting the stability and consistency of the GLFS-25 as a measurement instrument (6, 12).



The significant correlations between the GLFS-25 and the two-step and stand-up tests further support the scale's validity and comprehensive nature (20, 21). These correlations align with those of previous research demonstrating the GLFS-25's relationship with various functional assessments, indicating its ability to capture essential aspects of locomotor function. Inanaga et al. reported a weak correlation between the GLFS-25 and the stand-up test and two-step test. However, the GLFS-25 scores of the participants were lower than expected, and a post-hoc test revealed statistically significant correlations among the three tools (22). Muramoto et al. examined the threshold value in individuals diagnosed with LoS according to GLFS-25 was examined through the use of physical performance tests. The results of the two-step and timed up-and-go tests were statistically significant in individuals with LoS (23).

The moderate strength of these correlations suggests that while the GLFS-25 measures key components of locomotor function assessed by these performance tests, it also evaluates unique constructs not fully captured by these tests. This underscores the GLFS-25's potential as a comprehensive assessment tool that provides a holistic evaluation of overall locomotor abilities rather than relying solely on a limited set of performance-based measures.

The findings of this study revealed a strong negative correlation between GLFS-25 and the two-step test and stand-up tests, a positively moderate correlation with TUG, and a positively strong correlation with five repetitions of sit-to-stand. Although the GLFS-25 is widely employed to assess physical function, literature findings remain limited. A recent systematic review demonstrated its relevance to the TUG test and maximum stride length. The GLFS-25 also showed sensitivity and specificity for LoS categories. Specifically, TUG times of ≥6.7 seconds for males and ≥7.5 seconds for females corresponded to sensitivities of 73%–81% and specificities of 65%–83%. Similarly, maximum stride lengths of ≤119 cm for males and ≤104 cm for females were associated with sensitivities of 65%–71% and specificities of 57%–79% (24).

Seichi stated that the GLFS-25 was developed as a tool for early detection of LoS. Additionally, Kobayashi et al. reported that the total GLFS-25 score might predict recurrent falls during a one-year follow-up study. However, their findings revealed that recurrent falls were correlated primarily with the physical pain and anxiety domains of the GLFS-25 (25). These results suggest that the GLFS-25 alone may not comprehensively capture functional impairment. Therefore, combining the GLFS-25 with a test assessing functional strength, particularly in the lower extremities, could provide more clinically meaningful insights into physical impairment.

The adequate sample size in this study enhances the generalizability of the findings to the older adult population. However, the voluntary recruitment process may have introduced selection bias, potentially affecting the representativeness of the sample. Furthermore, since the study was advertised on social media, individuals who are not digitally literate may have been excluded. Future research should examine the validity and reliability of the GLFS-25 in more diverse samples, including individuals with varying mobility impairments and across different cultural contexts.

Further investigation of the relationship between the GLFS-25 scores and specific aspects of LoS, such as slowness, movement abnormalities, and cognitive difficulties, would enhance the clinical utility of this scale. Longitudinal studies examining the predictive validity of the GLFS-25 for future mobility decline and adverse health outcomes such as falls and loss of independence are warranted.

CONCLUSION

This study provides strong evidence for the validity and reliability of the Turkish version of the GLFS-25

as a measure of locomotor function in older adults. The scale's comprehensive nature and correlation with established performance tests suggests its potential as a valuable tool for assessing and monitoring mobility in this population. Further research is required to explore the clinical utility and predictive validity of this scale in diverse populations and settings.

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ORIGINAL ARTICLE

AGE-RELATED THORACIC LYMPHADENOPATHIES AND DISEASE PROGRESSION IN PATIENTS WITH MODERATE-TO-SEVERE ASTHMA: AN EVALUATION OF CLINICAL AND IMAGING FINDINGS

Abstract

Introduction: Asthma is a prevalent chronic respiratory disease affecting individuals of all ages. Thoracic lymphadenopathies, commonly observed in computed tomography scans of elderly patients, may reflect lymphatic and immune changes. However, their relationship with asthma is not well understood. This study aims to explore the impact of age on thoracic lymphadenopathies' characteristics in patients with moderate-to-severe asthma and their associations with clinical and imaging findings.

Materials and Method: In this retrospective study, 114 adult patients with moderate-to-severe asthma underwent multi-slice computed tomography. Lymph node size and number were analyzed alongside demographic data, pulmonary function test results, asthma control test scores, and clinical parameters. Statistical analyses assessed correlations between thoracic lymphadenopathies, and these factors.

Results: Enlarged lymph nodes were identified in 19.2% of patients, predominantly in stations 4R, 7, and 5. Lymph node size and number positively correlated with age, smoking, prolonged asthma duration, frequent attacks, female gender, and elevated CRP levels, while negatively correlating with forced expiratory volume in 1 second and forced vital capacity ($p < 0.05$).

Conclusions: Thoracic lymphadenopathies in asthma patients are closely associated with age, inflammation, and disease progression. In elderly patients, increased number of thoracic lymphadenopathies may result from immunosenescence and chronic inflammation. These findings emphasize the need to evaluate lymphatic changes in asthma, particularly in older adults, to improve clinical management and therapeutics.

Keywords: Asthma; Aging; Lymph Nodes.



INTRODUCTION

Asthma is a chronic, heterogeneous inflammatory disease affecting over 300 million people worldwide, with significant clinical and pathological variations observed in older populations due to age-related physiological changes (1). Aging alters immune and inflammatory responses, potentially modifying the severity, progression, and structural manifestations of asthma (2). These changes, driven by chronic inflammation, include airway remodeling, subepithelial fibrosis, airway narrowing, and stiffening, all of which exacerbate asthma symptoms and increase the disease burden (3).

To date, few studies have explored the relationship between the lungs and the lymphatic system. Over the past decade, however, research on this topic has gained momentum, revealing close associations between pulmonary diseases and the lymphatic system. The lymphatic system plays a crucial role in modulating lung inflammation and immune responses (4).

Li et al. were the first to investigate the relationship between asthma and the lymphatic system. They demonstrated increased lymphangiogenesis and vascularization in the bronchial mucosa of asthmatic animal models, suggesting potential lymphatic involvement in asthma pathophysiology (5). Subsequent studies have revealed a more complex picture. While allergic sensitization in asthma is associated with increased lymphangiogenesis, severe or fatal cases are often characterized by impaired lymphatic circulation, indicating a multifaceted relationship between the lymphatic system and asthma (6). Animal models further demonstrated that inflammation-related lymphangiogenesis in the lungs may persist even when steroid treatment is delayed, although newly initiated lymphangiogenesis is inhibited by such treatment. Studies have also suggested that asthma may be linked to decreased lymphangiogenesis (7).

Molecular studies and preclinical research have undoubtedly shed light on the impact of the lymphatic system in asthma, reducing the uncertainties surrounding this relationship. However, for clinicians, the management of asthma becomes increasingly challenging as patients grow older, especially with the rising prevalence of comorbidities. The need to better understand chronic inflammation and its manifestations is paramount. Thoracic lymphadenopathies may serve as a valuable indicator of chronic inflammation when evaluating asthma patients, especially in diagnostic imaging.

Chronic inflammation has been linked to increased lymphangiogenesis, which can contribute to thoracic lymph node enlargement. Multi-slice computed tomography (MSCT) is widely used to assess structural airway changes and differentiate benign from malignant causes of lymph node enlargement, particularly in the hilar and mediastinal regions (8). Although prior research has correlated airway and parenchymal changes with asthma severity (9), the relationship between thoracic lymph node size and asthma remains unexplored.

Thoracic lymphadenopathies are frequently observed in individuals of advanced age, often reflecting systemic immune dysregulation and chronic inflammation (10). In asthma, chronic airway inflammation and immune activation may synergize with immunosenescence to exacerbate lymphatic remodeling and lymph node hypertrophy. However, the precise role of these changes in thoracic lymphadenopathy in asthma remains poorly understood.

This study aims to evaluate the size and diameter of thoracic lymph nodes in asthmatic patients and to investigate their relationship with aging and the lymphatic system. By focusing on the interplay between asthma, age, and lymphatic adaptations, this research seeks to provide new

insights into the role of lymphatic changes in the pathophysiology of asthma and its implications for clinical management.

MATERIALS AND METHODS

Study Population

This retrospective study included 114 adult patients with moderate-to-severe asthma who were followed up in our outpatient clinic for 2 years. All participants had undergone MSCT imaging of the lungs for reasons such as uncontrolled asthma or suspicion of potential comorbidities (e.g., hemoptysis, emphysema, or bronchiectasis). Patients referred to our clinic from other institutions were also included if their up-to-date MSCT records were available and if they met the inclusion criteria.

The study resumed with renewed focus, emphasizing the effects of aging on thoracic lymph node changes in asthma patients. Written informed consent for the utilization of clinical data was obtained from all participants at the time of their initial evaluation.

Inclusion and Exclusion Criteria

The patients included in this study were adults diagnosed with moderate-to-severe asthma, as defined by the Global Initiative for Asthma (GINA) guidelines (1), with no evidence of alternative lung diseases. Individuals were excluded if they had a history of malignancy or recent thoracic lymphadenopathy (within the last three months) due to conditions such as pneumonia or other diseases that could potentially cause thoracic lymphadenopathy, including interstitial lung diseases, pneumoconiosis, chronic obstructive pulmonary disease (COPD), heart failure, or sarcoidosis. Patients with acute lower respiratory tract infections or insufficient data in their medical records were also excluded.

To ensure that the study focused on the association between aging and thoracic lymph node characteristics, patients with confounding factors, such as fatal asthma requiring oral corticosteroids during severe exacerbations, were excluded. The final analysis concentrated on the size, diameter, and characteristics of thoracic lymph nodes, with particular attention given to their relationship with age.

Data Collection and Imaging Analysis

Demographic and clinical data, including age, sex, asthma severity, and comorbidities, were collected from the medical records. The MSCT scans were evaluated by two radiologists blinded to the patient's clinical data. Thoracic lymph nodes were assessed for size, diameter, and distribution with measurements obtained from mediastinal and hilar stations. Additional lung parenchymal changes and airway abnormalities were recorded but were not the primary focus of this study.

Clinical and Functional Analyses

Asthma was diagnosed by a pulmonologist based on the most recent version of the GINA guidelines at the time of diagnosis (1). Patients were categorized as having moderate or severe asthma. All patients were treated with inhaled corticosteroids, long-acting or short-acting beta-agonists, or leukotriene receptor antagonists according to their asthma severity.

Demographic and clinical data were retrospectively collected from the patients' files. These data included age, sex, smoking status (pack-years), duration of asthma, frequency of asthma exacerbations, serum C-reactive protein (mg/L), and total serum IgE (kU/L) levels. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2) and recorded. The presence or absence of obstructive sleep apnea syndrome (OSAS) was also documented. Patients with mild OSAS symptoms



(e.g., snoring only) were classified as OSAS1, while those with both snoring and apnea were classified as OSAS2.

Pulmonary function tests (PFTs) were performed using a ZAN 100 spirometry device (ZAN 100, Messgeraete Gmbh, Munich, Germany) in a sitting position. Forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, and peak expiratory flow (PEF) values were calculated. Symptom control was evaluated using the Asthma Control Test (ACT), which assesses the patient's clinical condition during the preceding 4 weeks (3).

Computed Tomography Imaging and Lymph Node Assessment

All patients underwent computed tomography (CT) scans using the PHILIPS MX 16-Slice CT scanner. Glazer et al. described 10 mm as the upper reference limit for the short axis of mediastinal lymph nodes depending on the regional nodal station (11). In this study, lymph node analyses were performed from at least two reconstruction planes (typically axial and coronal). The lymph node map published by the American Thoracic Society (ATS) was used as a reference for nodal classification (11).

The features of mediastinal and hilar enlarged lymph nodes (ELNs) were characterized on MSCT by two radiology specialists. Correlations between the number, diameter, and location of ELNs and asthma-related factors were analyzed. Based on these findings, patients were divided into two groups according to a threshold diameter: the "control lymph nodes" group (short axis < 10 mm in the mediastinum; 92 patients) and the "ELN" group (short axis > 10 mm in the mediastinum; 22 patients). Since the largest lymph node in this study was in station 7, the upper limit threshold for the short axis was set at 15 mm for station 7 and 10 mm for all other locations.

Statistical Evaluation

Statistical analyses were performed using SPSS version 17.0 (IBM, Armonk, NY, USA). Nominal and ordinal parameters were described with frequency analyses, while quantitative parameters were summarized using means and standard deviations. The Kolmogorov-Smirnov test was used to evaluate the normality of the scale parameter distributions. The independent samples *t*-test was used for normally distributed scale parameters, while the Mann-Whitney U test was applied for non-normally distributed parameters. Chi-squared tests were employed to analyze the differences in nominal and ordinal parameters between the groups. Spearman's rho correlation coefficients were calculated to evaluate directional relationships between scale parameters (Tables 1 and 3). All analyses were conducted at a 95% confidence level, with *p*-values below 0.05 considered statistically significant.

One of the closest studies to the current research, conducted by Taile et al. (2016), reported an effect size of 0.6430260 (12). Using this effect size, a power analysis was conducted using the GPower 3.1.9.2 program. With a 95% confidence interval and a 0.05 margin of error, the minimum sample size required was 28 patients.

RESULTS

ELNs were detected in 22 of 114 patients. The majority of the patients were female (83.7% in the control group and 86.4% in the ELN group). The mean age was 47.41 ± 10.95 years in the control group and 53.77 ± 7.84 years in the ELN group. A total of 154 lymph nodes were classified as ELNs across 114 CT scans. Eight patients (7%) had no detectable lymph nodes (7 females, 1 male). Lymph node diameters were less than 7 mm in 11 patients, and completely calcified lymph nodes were identified in 3 patients. Six patients had ELNs only in the 2R region, with no ELNs detected in the other regions.

Table 1. Baseline characteristics, FEV1, FVC, PEF, OSAS, and biomass differences between patient groups

	Control (n=92)	ELN* (n=22)	P
Gender, n (%)			
Male	15 (16.3)	3 (13.6)	0.754a
Female	77 (83.7)	19 (86.4)	
Age(years), mean ± SD	**47.41±10.95**	**53.77±7.84**	**0.012b**
Asthma Control Test Score, mean ± SD	15.99±5.09	15.23±4.58	0.577b
Disease duration(years), mean ± SD	8.23±9.69	10.76±9.20	0.061c
Number of attacks(per year), mean ± SD	4.21±6.48	5.45±5.47	0.120c
Number of cigarette(pack/year), mean ± SD	3.09±6.72	3.95±7.99	0.710c
IgE(kU/l), mean ± SD	98.31±229.58	73.14±100.63	0.975c
CRP(mg/L), mean ± SD	**6.47±7.23**	**12.99±25.30**	**0.043c**
BMI(kg/m2), mean ± SD	31.39±5.66	33.84±4.89	0.070b
FEV1, mean ± SD	**2.05±0.45**	**1.32±0.58**	**<0.001b**
FEV1 percent, mean ± SD	78.89±16.45	66.00±25.32	0.053b
FVC, mean ± SD	**3.09±4.78**	**1.63±0.60**	**0.000c**
FVC percent, mean ± SD	**80.64±15.51**	**69.17±19.08**	**0.009b**
FEV1/FVC, mean ± SD	79.62±4.33	76.20±4.44	0.176b
FEV1/FVC percent. , mean ± SD	84.54±10.76	86.50±15.34	0.885c
PEF, mean ± SD	**4.40±1.16**	**2.88±1.00**	**<0.001b**
PEF percent, mean ± SD	**71.68±20.47**	**58.41±22.90**	**0.021b**
OSAS1, mean ± SD	200.96±0.28	200.94±0.24	0.842c
OSAS2, mean ± SD	202.42±1.00	202.67±1.21	0.479c
Biomass, mean ± SD	18.90±9.94	22.86±14.39	0.393b

a. Chi-Square Test, b. Independent Samples T-Test, c. Mann Whitney-U Test, SD: Standard Deviation.
*ELN: Patients with enlarged lymph nodes
FEV: Forced expiratory volume, FVC: Forced vital capacity, PEF: Peak expiratory flow,
OSAS: obstructive sleep apnea syndrome, Ig:Immunoglobulin, CRP: C-reactive protein, BMI: Body mass index

The average number and diameter of lymph nodes were higher in females than in males; however, this difference was not statistically significant. The mean age and CRP levels were significantly higher in the ELN group compared to the control group ($p < 0.05$). No statistically significant differences were observed between the control and ELN groups in terms of gender, ACT score, disease duration, number of attacks, smoking (pack-years), IgE levels, or BMI (Table 1).

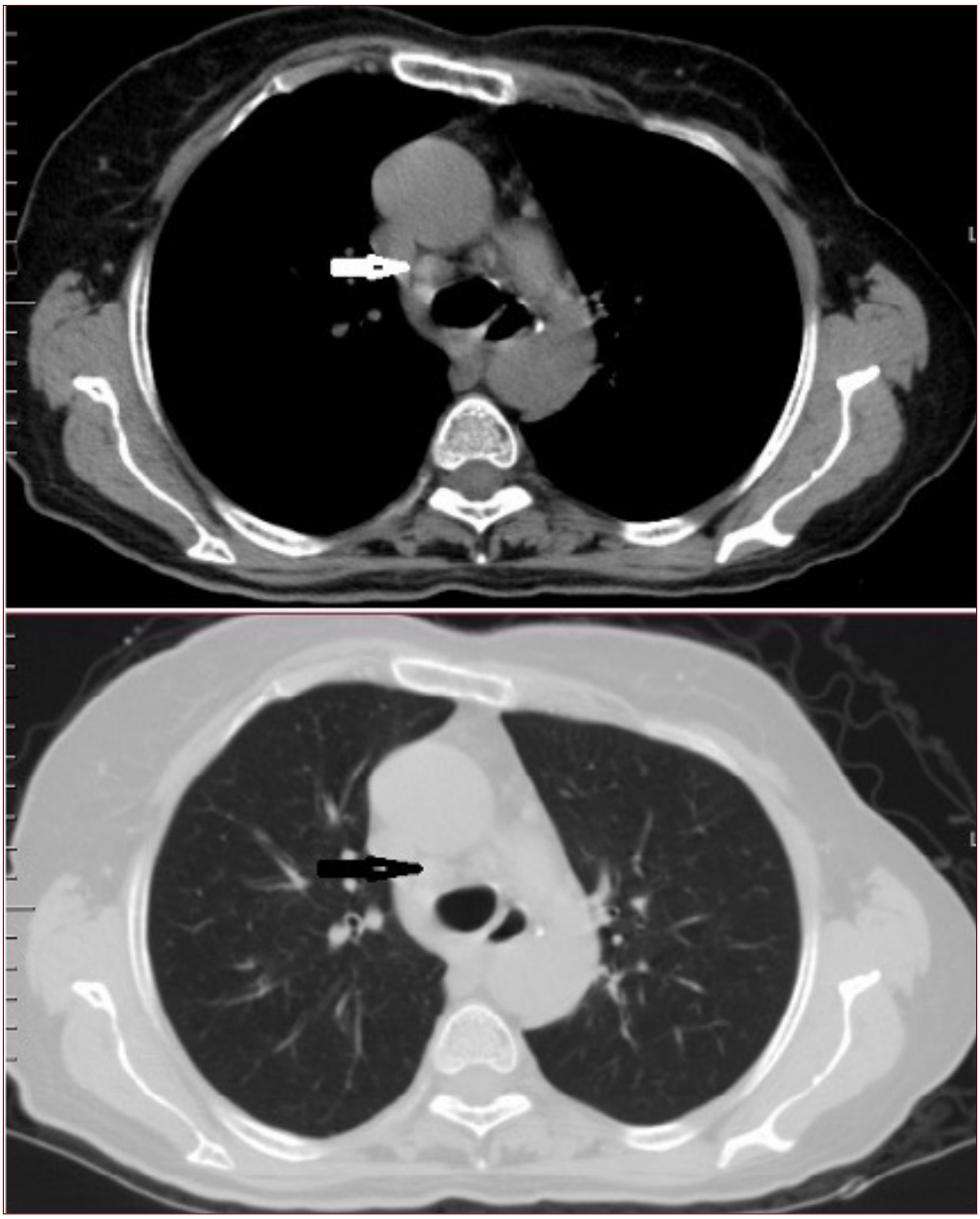


Figure 1. Multislice helical chest CT scan of a 49-years old woman with asthma. In the mediastinal and lung windows of CT scan, black and white arrows are showing the enlarged lymph node in the station 4R.

A positive correlation was found between the number and diameter of lymph nodes in asthmatic patients. Enlarged lymph nodes were most prominent in stations 4R, 7, and 5 (Figure 1). An increased number of lymph nodes was also primarily detected in these regions. The increase in ELN number and diameter was significantly associated with PFT findings, ACT scores, smoking, disease duration, number of attacks, and CRP levels ($p < 0.05$).

Table 2. Lymph node properties and difference analysis results based on lymph node regions

	Control (n=92) Mean	S.D	ELN* (n=22) Mean	S.D.	p
Short2R	-	-	10.00	4.55	p<0.05
Short4R	6.06	1.79	9.39	2.68	<0.001a
Short4L	6.22	1.39	8.25	2.55	0.056a
Short5	4.75	1.86	6.82	2.60	0.016a
Short7	5.79	1.27	9.83	2.73	<0.001b
Short10R	6.50	1.00	9.00	3.00	0.158a
Short11L	6.00	0.01	9.00	1.41	0.333a
Long2R	-	-	13.75	2.87	p<0.05
Long4R	10.13	2.50	13.06	3.49	0.000a
Long4L	10.78	2.95	12.13	3.00	0.366a
Long5	10.95	3.58	13.27	4.31	0.119a
Long7	11.58	2.50	16.11	5.16	0.002a
Long10R	12.00	2.58	12.20	2.59	0.911a
Long11L	9.00	0.01	11.50	3.54	0.667a
C2R	-		11.88	3.50	p<0.05
C4R	8.10	1.93	11.22	2.93	0.000a
C4L	8.50	1.77	10.19	2.53	0.129a
C5	7.85	2.46	10.05	3.27	0.043a
C7	8.68	1.66	12.97	3.57	<0.001a
C10R	9.25	1.71	10.60	2.63	0.407a
C11L	7.50	0.01	10.25	2.47	0.531a

a. Independent Samples T-Test, b. Mann Whitney-U Test, SD: Standard Deviation.

*ELN: Patients with enlarged lymph nodes

The mean FEV1, FVC, FVC%, PEF, and PEF% values were significantly higher in the control group compared to the ELN group ($p < 0.05$). In contrast, no significant differences were observed between the groups in terms of FEV%, FEV1/FVC, FEV1/FVC%, OSAS1, OSAS2, and biomass parameters (Table 1). In the ELN group, the short-axis diameters of stations 4R, 5, and 7; the long-axis diameters of stations 4R and 7; and the coronal axis diameters of stations 4R, 5, and 7 were significantly larger compared to the control group ($p < 0.05$) (Table 2).

The effects of aging and its relationship with lymph node characteristics were analyzed in detail. In the control group, the diameter of station C4R was negatively correlated with FEV1 ($r = −0.331$, $p < 0.05$) and FVC% ($r = −0.350$, $p < 0.05$). The diameter of station C7 was positively correlated with BMI ($r = 0.373$, $p < 0.05$) (Table 3). In the ELN group, the number of asthma attacks was positively correlated with the diameter of station C7 ($r = 0.620$, $p < 0.01$) (Table 3) In the control group, FVC was positively correlated with the number of lymph nodes ($r = 0.301$, $p < 0.05$) (Table 4).



Table 3. The relationship between clinical and laboratory parameters and the size of lymph nodes

Parameters	Control (n=92)				ELN* (n=22)			
	C4R	C4L	C5	C7	C4R	C4L	C5	C7
Asthma Control Test	-0.256	-0.075	0.047	-0.238	-0.267	-0.610	0.437	0.339
Disease duration	-0.115	-0.189	0.290	-0.108	-0.462	-0.258	-0.559	-0.169
Number of attacks	0.223	0.367	-0.091	0.028	0.230	0.194	0.082	**0.620****
Smoking	0.179	0.003	0.001	-0.070	-0.375	0.380	-0.049	0.094
FEV	-0.200	0.045	-0.064	-0.227	-0.108	-0.618	0.135	0.333
FEV percent	**-0.331***	-0.642	-0.057	0.013	-0.175	-0.271	0.163	0.337
FVC	-0.310	0.608	-0.029	-0.187	-0.203	-0.708	0.108	0.167
FVC percent	**-0.350***	-0.566	0.098	0.019	-0.246	-0.338	0.192	0.276
FEV/FVC	-0.600				0.500		-0.916	0.826
FEV/FVC percent	-0.090	0.013	0.287	0.354	0.286	0.015	0.250	0.330
PEF	0.165	0.621	-0.559	0.048	-0.069	-0.502	0.218	0.523
PEF percent	-0.197	-0.340	-0.511	0.023	-0.041	0.002	0.090	0.367
IgE	-0.026	0.133	-0.174	0.116	0.362	0.261	-0.072	-0.230
CRP	0.120	-0.248	0.065	-0.054	0.388	-0.102	0.112	0.440
BMI	0.278	-0.035	0.187	0.373*	-0.201	-0.067	-0.450	0.001

p<0.05 **p<0.01

FEV: Forced expiratory volume, FVC: Forced vital capacity, PEF: Peak expiratory flow, Ig: Immunoglobulin, CRP: C-reactive protein, BMI: Body mass index

*ELN: Patients with enlarged lymph nodes

Table 4. The association between clinical and laboratory parameters and the number of lymph nodes

Parameters	Control (n=92)	ELN* (n=22)
Asthma Control Test	-0.080	0.100
Duration	0.029	0.243
Number of attacks	-0.001	-0.130
Smoking	-0.016	-0.251
FEV	0.107	0.052
FEV percent	0.109	0.167
FVC	0.301*	0.067
FVC percent	0.087	0.088
FEV/FVC	0.091	-0.856
FEV/FVC percent	-0.184	0.061
PEF	0.070	-0.032
PEF percent	0.190	0.081
IgE	0.126	-0.346
CRP	0.114	-0.008
BMI	-0.164	0.021

*p<0.05

FEV: Forced expiratory volume, FVC: Forced vital capacity, PEF: Peak expiratory flow, Ig:Immunoglobulin, CRP: C-reactive protein, BMI: Body mass index

*ELN: Patients with enlarged lymph nodes

DISCUSSION

Aging is collectively associated with various changes in lung physiology and immune function. Termed immunosenescence can influence the clinical presentation and progression of asthma. Older adults often experience a decline in lung elastic recoil, increased chest wall rigidity, and reduced respiratory muscle strength, all of which can exacerbate asthma symptoms and complicate disease management (13). Additionally, immunosenescence may promote chronic low-grade inflammation, known as inflammaging, further contributing to respiratory conditions such as asthma in the elderly (14).

A key finding of this study is the marked enlargement and increased number of TLNs in patients with moderate-to-severe asthma over time, with these changes showing a strong correlation with disease severity. The size and count of TLNs were significantly correlated with CRP levels, frequent asthma exacerbations, reduced PFT values, and prolonged disease duration, highlighting their potential role as markers of disease progression. A particularly noteworthy finding was the significant correlation between age and the presence of ELNs in asthma patients. ELNs were detected in 19.2% of the patients, with a higher prevalence among older individuals. The number and size of these lymph nodes increased with age, suggesting that advancing age may contribute to lymph node enlargement in asthma patients.

The presence of ELNs in older asthma patients may reflect an amplified inflammatory response due to age-related immune changes. Chronic inflammation in asthma leads to airway remodeling and lymphangiogenesis, processes that may be more pronounced in the elderly due to the cumulative effects of aging and prolonged disease duration. This is supported by studies indicating that, even after the resolution of inflammation, lymphangiogenesis can persist, potentially contributing to sustained lymph node enlargement (15,16,17).

Incidental mediastinal ELNs are observed in 1% of the general population and are associated with various clinical conditions. These lymph nodes are frequently linked to benign or, more commonly, malignant diseases (18). For instance, lymphoma is the most common cause of mediastinal ELNs, while benign disease causes include granulomatous diseases, tuberculosis, silicosis, and heart failure. Evison et al. (2014) reported that the size of hilar or mediastinal lymph nodes is a strong predictor of etiology, with sizes of 15 mm or less suggesting reactive nodes, and sizes larger than 25 mm associated with pathological etiologies (19). In our study, the largest lymph node in asthma patients was detected at station 7. Therefore, the upper limit threshold for the short axis of the lymph nodes was set at 15 mm for station 7 and 10 mm for all other locations. Station 7 was identified as the most common site for lymph node enlargement. Following station 7, the greatest increase in lymph node number and size was observed at stations 4R and 5, which were found to be associated with asthma-related factors. Our study revealed that the degree, number, and localization of ELNs in asthma patients are significantly associated with worse pulmonary function, a more severe disease course, and increased inflammatory markers. Therefore, ELNs can be utilized as prognostic factors in patients with asthma. In moderate and severe asthma patients who do not respond adequately to treatment and do not exhibit the expected improvement in pulmonary function tests, increased systemic inflammation, as indicated by elevated inflammatory markers and ELNs, may be the primary reason for worsening pulmonary function.

Kirchner et al. conducted a similar study in patients with COPD, comparing the size, diameter, and localization of mediastinal and hilar ELNs according to COPD stages, and demonstrated a relationship between the clinical severity of the patients and ELN characteristics (20). Another study mentioned COPD as a benign disease leading



to ELNs. Recently, Grecuccio et al. reported the prognostic value of mediastinal lymph node enlargement in chronic interstitial lung disease (21). They found that enlarged mediastinal lymph nodes predict survival in patients with idiopathic pulmonary fibrosis (IPF) and nonspecific interstitial pneumonia, and that ELNs were associated with greater frequency of hospitalization, poor lung function, and more severe fibrosis. They also reported that the presence of ELNs could be related to a hyperplastic reaction in response to chronic inflammation in IPF. Chronic inflammation, as the cause of ELNs and a worsening clinical course, has recently been recognized as a major entity in many diseases, including COPD and asthma (22).

One of the most significant findings of this study was the relationship between pulmonary function tests and the number and size of lymph nodes. Among asthma-related factors, the strongest association with lymph node enlargement was observed with FVC, followed by FEV1. Chronic inflammation in asthmatic patients leads to airway remodeling, resulting in reduced FVC and FEV1 values (1). Notably, this study highlights the association between pulmonary function test parameters and the number of ELNs. Persistent inflammation and the increased lymphatic network surrounding the small airways in asthma patients cause pressure on the airways, leading to edema, increased airway resistance, and reduced airflow. This, in turn, explains the observed decline in FVC and FEV1 levels (3).

Animal studies on asthma models have shown that lymphangiogenesis can continue for up to a year, even after inflammation subsides (23). This could explain why some patients with asthma-triggering infections experience persistent symptoms even after the infection has been treated. In older asthma patients, the enlargement of lymph nodes may contribute to worsening lung function by exerting pressure on the airways, increasing resistance, and reducing airflow, thereby exacerbating respiratory symptoms. Furthermore, the decline in pulmonary function, as evidenced by the reduced FEV1 and FVC values, was more pronounced in the older patients with ELNs in this study.

It is also important to note that older adults with asthma often have comorbidities, such as chronic obstructive pulmonary disease (COPD), which can further complicate their condition. The overlap between asthma and COPD, known as asthma-COPD overlap syndrome (ACOS), presents unique diagnostic and therapeutic challenges (24). The presence of ELNs in this population may reflect the combined inflammatory processes of both conditions, further contributing to airway obstruction and decreased pulmonary function.

The ACT is an easy and practical test that is widely applied in clinical practice. It has good clinical accuracy in identifying patients with poor asthma control and in detecting clinically meaningful changes in asthma control over time (1). Here, the increased number and diameter of ELNs were significantly associated with ACT scores, disease duration, and the number of attacks.

Studies have shown that mediastinal lymph nodes may grow in the presence of chronic bronchitis due to smoking (25). Kirchner et al. also reported ELNs in COPD patients, particularly in those with chronic bronchitis. In our study, there was a positive association between smoking and lymph node size; however, no such correlation was observed between smoking and the number of ELNs. No study has yet explored these relationships in patients with asthma. Since smoking has a pro-inflammatory effect and smokers have increased levels of angiogenic factors, such as vascular endothelial factor (VEGF) and angiotensin-2, it may not be possible to determine whether the lymphangiogenic effect is due to smoking alone or to asthma, or both (26). The fact that smoking is commonly observed in the patients examined in this study may also suggest that patients may have concurrent COPD development. To explain the effect of smoking on the lymphatic system, a

study including only people who smoke and do not have any other comorbid pulmonary diseases can be conducted. As other contributing factors, female gender and advanced age were also among the risk factors for increased lymph node count and diameter, which may both contribute to ongoing inflammation.

Factors such as BMI, OSAS1, OSAS2, and gender were also analyzed. Female patients had larger lymph node diameters than males, possibly reflecting gender differences in immune and inflammatory responses. Intermittent hypoxia in OSAS can promote systemic inflammation, perhaps resulting in the enlargement of mediastinal lymph nodes (12). The study revealed no significant difference in lymph-node size between patients with snoring simply and those with snoring + apnea. This might be due to restricted sample size and subjective categorization of symptoms, advocating for larger studies to elucidate the link between OSAS and lymphadenopathy.

This study has several limitations. The retrospective and single-center nature of the study limits the generalizability of the findings. Additionally, the benign or malignant nature of the observed TLNs was not confirmed through histopathological analysis or PET imaging. The inclusion of smokers may have introduced confounding variables unrelated to asthma. The oldest patient in our study was 68 years old. When it comes to aging, it would be necessary to observe the changes in older patients; however, advanced anatomical disorders in the lungs due to aging, changes due to heart diseases, and the effects of other systemic diseases on the lungs would make it challenging for us to classify the patients as asthma patients who meet the inclusion criteria of this study. Finally, the lack of longitudinal data prevents an understanding of the dynamic changes in TLNs and systemic inflammation over time. Future multi-center, prospective studies are necessary to address these limitations and validate the findings.

CONCLUSION

This study highlights the significant relationship between TLNs and age, systemic inflammation, and lung function in asthma patients. Evaluating TLNs, particularly in older individuals, provides valuable insights into disease progression and severity. Future studies should assess the functional consequences of TLN enlargement, particularly regarding lymphatic drainage efficiency and systemic inflammation. Additionally, examining the molecular pathways linking immunosenescence, inflammaging, and lymphangiogenesis could help identify therapeutic targets to mitigate disease progression in older adults. These insights could inform tailored interventions aimed at improving the outcomes and quality of life of elderly asthma patients.

Conflict of Interest: The authors declare no potential conflicts of interest.

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ORIGINAL ARTICLE

RELATIONSHIP BETWEEN VARIOUS NUTRITION SCREENING TOOLS AND MORTALITY AMONG GERIATRIC PATIENTS ADMITTED TO THE INTENSIVE CARE UNIT

Abstract

Introduction: Various scoring systems (modified Nutrition Risk in Critically ill, Nutritional Risk Screening 2002, Nutritional Risk Index, Geriatric Nutritional Risk Index, and Malnutrition Universal Screening Tool) are used to evaluate nutrition in patients admitted to the intensive care unit. This study examined the relationship between 5 screening scores and mortality on day 1 of intensive care unit admission.

Materials and Method: This observational, prospective study was approved by the local Ethics Committee (FSMEAH-KAEK-2021/60).Data from 103 patients, hospitalized in the intensive care unit> 24 h between June 1 and September 30, 2021, were included. Informed consent was provided by their relatives, and 5 different nutrition scores were recorded on day 1 of intensive care unit hospitalization. Correlations between mortality and scores were examined, and mechanical ventilation and intensive care unit hospitalization days were compared between low- and high-risk patients in both score groups

Results: According to the modified Nutrition Risk in Critically ill score, mortality rate, intensive care unit length of stay, and duration of mechanical ventilation were significantly higher among high-risk patients than those in low-risk patients. As risk increased with the Malnutrition Universal Screening Tool score, an increase in mortality was observed. The area under the receiver operating characteristic curves for mortality were greatest for the modified Nutrition Risk in Critically ill score and Nutritional Risk Index scores.

Conclusion: The modified Nutrition Risk in Critically ill and Nutritional Risk Index scores were the most effective predictors of mortality among geriatric patients admitted to the intensive care unit and may be used according to clinician preference.

Keywords: Geriatrics; Intensive Care Unit; Mortality; Nutrition Assessment.

INTRODUCTION

Geriatric patients admitted to the intensive care unit (ICU) are a high-risk population requiring close monitoring. Mortality in this age group is influenced not only by ICU admission, but also by comorbidities, infections, age, and nutritional status. Various methods and scoring systems have been used to assess nutritional status in ICU practice. Protein–energy malnutrition is frequently observed among elderly patients, with varying reported incidences due to different indices and threshold values in anthropometric and biological evaluations (1, 2). Nutritional screening tools are valuable tools for early detection of malnutrition, particularly among elderly patients (3).

The Nutrition Risk in Critically ill (NUTRIC) score, developed by Heyland et al. (4), is a scoring system designed to predict 28-day mortality in critically ill patients. The NUTRIC score incorporates parameters such as acute and chronic malnutrition, markers of acute and chronic inflammation (age, Acute Physiology and Chronic Health Evaluation [APACHE II] score, Sequential Organ Failure Assessment [SOFA] score, number of comorbidities, time from hospital admission to ICU admission, and interleukin [IL]-6 levels). A high NUTRIC score (6–10) indicates a high risk for mortality, whereas a low score (0–5) suggests a lower risk for malnutrition. However, because routine monitoring of IL-6 levels is not always feasible, a modified version of the NUTRIC score (mNUTRIC) excludes IL-6. An mNUTRIC score of 5–9 is classified as high risk and 0–4 as low risk (Table 1) (4).

The Nutritional Risk Screening (NRS 2002) score is another tool routinely used in ICU practice to evaluate nutritional status. This score assesses 2 components—malnutrition and disease severity—and patients are scored based on the absence, or mild, moderate, or severe severity of these components, with a total score ranging from 0 to 6. A total score ≥ 3 indicates nutritional risk (5).

Table 1. Mean scores, duration of mechanical ventilation, ICU stay and patient comorbidities

	Mean±SD	Median
APACHE II	15.7±8.3	14
SAPS II	36.6±15.7	36
SOFA	5.0±5.1	3
NRS 2002	2.4±2.0	2
mNUTRIC	4.4±1.9	4
NRI	96.7±16.9	95
GNRI	95.7±16.8	94
MUST	0.4±0.8	0
ICU Stay (days)	11.8±18.1	3
Duration of Mechanical Ventilation (days)	10.0±18.2	1
Patient comorbidities	**n**	**%**
Hypertension	72	69.9
Diabetes	36	35
Coronary Artery Disease	21	20.4
Congestive Heart Failure	20	19.4
Chronic Renal Failure	18	17.5
Cerebrovascular Accident	12	11.7
Dementia	17	16.5
Thyroid Dysfunction	11	10.7
COPD	11	10.7
Valve Disease	6	5.8
Benign Prostate Hyperplasia	5	4.9
Parkinson's Disease	4	3.9
Epilepsy	3	2.9
Rheumatoid Arthritis	3	2.9
Gout	3	2.9
Psychiatric Disease	3	2.9
Liver Failure	2	1.9
Meniere's Disease	1	1
OSAS	1	1

APACHE II: Acute Physiology and Chronic Health Evaluation Score, SAPS II: Simplified Acute Physiology Score, SOFA: Sequential Organ Failure Assessment Score, NRS 2002: Nutritional Risk Screening 2002 Score, mNUTRIC: modified NUTRIC score, NRİ: Nutritional Risk Index, GNRI: Geriatric Nutritional Risk Index, MUST: Malnutrition Universal Screening Tool, ICU: Intensive Care Unit, COPD: Chronic Obstructive Pulmonary Disease, OSAS: Obstructive Sleep Apnea Syndrom

The Nutritional Risk Index (NRI) evaluates nutritional status using objective parameters. The NRI is calculated using body weight and serum albumin level according to the following equation:

NRI = (1.519 × serum albumin [g/L]) + 41.7 × (current body weight [kg]/ideal body weight [kg]).

Based on the result, a score >100 indicates no malnutrition, 97.5<NRI<100 indicates low malnutrition, 83.5<NRI<97.5 indicates moderate malnutrition, and <83.5 indicates severe malnutrition.

The Geriatric Nutritional Risk Index (GNRI) is calculated using serum albumin level and body mass index (BMI). The method was first described by Bouillanne et al. The GNRI is determined using the following equation:

GNRI = (1.489 × serum albumin [g/L]) + (41.7 × current body weight/ideal body weight).

A score >98 indicates no nutrition-related risk, 92<GNRI<98 indicates low risk, 82<GNRI<92 indicates moderate risk, and <82 indicates major risk.

The Malnutrition Universal Screening Tool (MUST) is another widely used screening tool. Using this tool, individuals are first scored based on BMI, as follows: 0, BMI > 20 kg/m2; 1, BMI 18.5–20 kg/m2; and 2, BMI < 18.5 kg/m2. A BMI > 30 kg/m2 is defined as obese. In the second step, scores are assigned based on weight loss over the past 3–6 months, as follows: 0, < 5%; 1, 5%–10%; and 2, ≥ 10%. In the third step, a score of 2 is assigned if the individual had an acute illness or likely had no nutritional intake for > 5 days; otherwise, a score of 0 is assigned. The total risk for malnutrition is calculated by summing the scores for the 3 steps, as follows: 0, low risk; 1, moderate risk; and ≥ 2, high risk (6).

Different nutritional screening tools are used in geriatric patient groups. The use of acute malnutrion and inflammation, chronic malnutrion and inflammation markers SOFA, APACHE II etc. scorings that we routinely use in our intensive care practice in the mNUTRIC score has made this score important. The European Society of Clinical Nutrition and Metabolism (ESPEN) recommends the routine use of NRS 2002 in inpatients. NRI and GNRI are screening tools that are mostly applied using objective parameters. These two screening tools evaluate malnutrition with objective parameters such as albumin value. The MUST screening tool is again the screening tool that ESPEN recommends us to use especially in outpatients. This cross-sectional prospective study investigated the relationship between mortality and 5 different nutritional screening scores used in ICU practice on day 1 of ICU admission. The primary aim of this study was to determine which score was most strongly correlated with mortality to promote its use in routine ICU practice. Considering that IL-6 monitoring can be costly and time consuming, we used the mNUTRIC score in our analysis. To account for other factors influencing mortality among patients in the ICU, we incorporated the APACHE II score to standardize patient assessment.

MATERIALS AND METHOD

The present study was conducted at the Anesthesiology and Reanimation Clinic of the Health Sciences University Fatih Sultan Mehmet Teaching and Research Hospital. The study protocol was approved by the hospital's Ethics Committee (FSMEAH-KAEK-2021/60). Data from 103 patients over the age of 65, whose ICU stay exceeded 24 h between June 1 and September 30, 2021, and whose relatives provided informed consent for participation were included. Hospitalizations of less than 24 hours, cases under the age of 65, and cases for which we could not access the necessary data to calculate the scores were not included. The authors' clinic is a 23-bed, level-3 ICU. The primary hospitalization diagnoses were categorized as primary respiratory failure, secondary respiratory failure, postoperative care, cerebrovascular



accident(s), and post-cardiopulmonary resuscitation monitoring.

Demographic data, comorbidities, APACHE II scores, Simplified Acute Physiology Score (SAPS II), mNUTRIC, NRS 2002, NRI, GNRI, and MUST scores were recorded. The length of ICU stay, duration of invasive and noninvasive mechanical ventilation (MV), presence of malignancy, tracheostomy status, home ventilator use, mortality rate, discharge mode, and 30-day mortality rate were also documented. The scores from day 1 of hospitalization were recorded and their correlations with mortality were analyzed. Furthermore, the number of MV days and ICU hospitalization days between low- and high-risk patients within each scoring system were compared. For the scoring, patients' weight information at the time of admission to the ICU was obtained from the patients' relatives.

Statistical analyses were performed using SPSS version 22 (IBM Corporation, Armonk, NY, USA). Data distribution was assessed using the Shapiro–Wilk test, which indicated that the parameters did not exhibit a normal distribution. Descriptive statistics (mean, standard deviation, median, and frequency) were used to summarize the data. The Mann–Whitney U test was used for comparisons between 2 groups, whereas the Kruskal–Wallis test was used for comparisons involving > 2 groups. Qualitative data were compared using the chi-squared test, Fisher–Freeman–Halton exact test, and Yates Continuity Correction. The predictive ability of the scores for mortality was evaluated using receiver operating characteristic (ROC) curve analysis. Differences with $p < 0.05$ were considered to be statistically significant.

RESULTS

Data from 103 patients were included in the study. The mean (± SD) age of the cohort was 78.8 ± 8.6 years (range 65–97 years), 48 (46.6%) patients were male, and 55 (53.4%) were female. The mean length of ICU stay was 11.8 ± 18.1 days and the mean duration of MV was 10.0 ± 18.2 days. The mean scores, lengths of hospital stay, and durations of MV are summarized in Table 1.

Hypertension and diabetes were the most common comorbidities, present in 69.9% and 35% of patients, respectively. The distribution of comorbidities is reported in Table 1. Primary respiratory failure accounted for 14.6% of cases, secondary respiratory failure for 23.3%, and postoperative ICU hospitalization for 55.3%.

According to the NRS 2002 scoring system, 35.9% of patients were classified as high risk, whereas 39.8% were identified as high risk according to the mNUTRIC score. Additionally, 22.3% and 19.4% of the patients were categorized as serious risk according to the NRI and GNRI scoring systems, respectively. The proportion of high-risk patients, based on the MUST score, was 11.7%. Malignancy was observed in 21.4% of patients; 14.6% underwent tracheotomy during their ICU stay; and the home ventilator use rate was 14.6%. Mortality occurred in 40.8% of cases, and the 30-day mortality rate was 37.9% (Table 2).

When comparing the length of ICU stay and duration of MV between the risk groups, the high-risk group, based on the mNUTRIC score, had significantly longer ICU stay and MV duration than the low-risk group ($p<0.001$). However, no significant differences were observed in ICU stay or MV duration according to NRS 2002, NRI, GNRI, or MUST scores ($p>0.05$) (Table 3).

According to the mNUTRIC score, the mortality rate among high-risk patients was significantly greater than that in low-risk patients (70.7% versus [vs.] 16.1%; $p<0.001$). The MUST score was also significantly associated with mortality ($p=0.014$), with the mortality rates increasing as the risk level increased. However, no significant correlation was found between mortality rates and the NRS 2002, NRI, or GNRI scores (Table 4).

Table 2. Primary Diagnosis of patients, risk scores, presence of malignancy, home mechanical ventilator use, mode of exit and 30-day mortality

		n	%
Primary Diagnosis	Primary respiratory failure	15	14.6
	Secondary respiratory failure	24	23.3
	Postoperative admission	57	55.3
	CVA	4	3.9
	Post-CPR	3	2.9
	Total	103	100
NRS 2002	No Risk	66	64.1
	Risk	37	35.9
	Total	103	100
mNUTRIC	Low risk	62	60.2
	High risk	41	39.8
	Total	103	100
NRI	No Risk	39	37.9
	Low Risk	6	5.8
	Moderate Risk	35	34
	Severe Risk	23	22.3
	Total	103	100
GNRI	No Risk	39	37.9
	Low Risk	19	18.4
	Moderate Risk	25	24.3
	Severe Risk	20	19.4
	Total	103	100
MUST	Low risk	77	74.8
	Moderate risk	14	13.6
	High risk	12	11.7
	Total	103	100
Malignancy	No	81	78.6
	Yes	22	21.4
	Total	103	100
Tracheotomy	No	88	85.4
	Yes	15	14.6
	Total	103	100
Home mechanical ventilator use	No	88	85.4
	Yes	15	14.6
	Total	103	100
Mode of exit	Transfer to ward	61	59.2
	Exitus	42	40.8
	Total	103	100
30-day mortality	No	64	62.1
	Yes	39	37.9
	Total	103	100

CPR: Cardiopulmonary resuscitation, CVA: Cerebrovascular accident, NRS 2002: Nutritional Risk Screening 2002 Score, mNUTRIC: modified NUTRIC score, NRI: Nutritional Risk Index, GNRI: Geriatric Nutritional Risk Index, MUST: Malnutrition Universal Screening Tool



Table 3. Intensive Care Unit stay and duration of mechanical ventilation of risk categories of different scores

		ICU stay (days)	Duration of MV (days)
		Mean±SD (Median)	Mean±SD (Median)
NRS 2002	Low risk	12.02±19.62 (2)	10.23±19.82 (0)
	High risk**	11.49±15.23 (4)	9.59±15.04 (3)
	[1]p	0.273	0.468
mNUTRIC	Low risk	9.65±19.98 (2)	7.48±19.93 (0)
	High risk**	15.12±14.4 (11)	13.8±14.56 (7)
	[1]p	0.000*	0.000*
NRI	No risk	14.59±18.65 (3)	12.31±18.93 (0)
	Low risk	12.67±20.07 (2)	11.67±20.72 (1)
	Moderate risk	8.94±12.89 (2)	6.97±12.18 (0)
	Severe risk**	11.3±23.26 (3)	10.26±23.67 (3)
	[2]p	0.747	0.745
GNRI	No risk	14.59±18.65 (3)	12.31±18.93 (0)
	Low risk	8±13.4 (2)	6.68±13.73 (0)
	Moderate risk	9.88±13.81 (2)	7.72±12.93 (0)
	Severe risk**	12.5±24.79 (3)	11.5±25.21 (3)
	[2]p	0.559	0.608
MUST	Low risk	10.9±15.08 (2)	8.86±15.05 (0)
	Moderate risk	11.43±19.3 (3)	10.21±19.08 (3)
	Severe risk**	18.25±31.19 (5.5)	17.08±31.69 (4.5)
	[2]p	0.596	0.439

*[1]Mann Whitney U Test [2]Kruskal Wallis test *p<0.05, ** high risk of malnutrition*

ICU: Intensive Care Unit, NRS 2002: Nutritional Risk Screening 2002 Score, mNUTRIC: modified NUTRIC Score, MV: Mechanical Ventilation, NRI: Nutritional Risk Index, GNRI: Geriatric Nutritional Risk Index, MUST: Malnutrition Universal Screening Tool

ROC analysis was used to evaluate the accuracy of the scoring systems for predicting mortality. The areas under the ROC curve (AUC) for the NRS 2002, mNUTRIC, NRI, GNRI, and MUST scores were 0.562, 0.778, 0.778, 0.610, and 0.630, respectively. The AUC for the mNUTRIC score was significantly greater than those for the NRS 2002 (p=0.001), GNRI (p=0.025), and MUST (p=0.027) scores. Similarly, the AUC for the NRI was significantly greater than that for the NRS 2002 (p=0.001), GNRI (p=0.025), and MUST (p=0.027) scores. No significant differences were observed in the AUCs for the NRS 2002, GNRI, and MUST (p>0.05) scores (Table 5).

Table 4. Evaluation of risk scores and mortality

		Mortality		p
		No	Yes	
		n (%)	n (%)	
NRS 2002	Low risk	44 (66.7%)	22 (33.3%)	[1]0.292
	High risk**	20 (54.1%)	17 (45.9%)	
mNUTRIC	Low risk	52 (83.9%)	10 (16.1%)	[1]0.000*
	High risk**	12 (29.3%)	29 (70.7%)	
NRI	No risk	28 (71.8%)	11 (28.2%)	[2]0.136
	Low Risk	3 (50.0%)	3 (50.0%)	
	Moderate Risk	23 (65.7%)	12 (34.3%)	
	Severe Risk**	10 (43.5%)	13 (56.5%)	
GNRI	No risk	28 (71.8%)	11 (28.2%)	[3]0.101
	Low Risk	11 (57.9%)	8 (42.1%)	
	Moderate Risk	17 (68.0%)	8 (32.0%)	
	Severe Risk**	8 (40.0%)	12 (60%)	
MUST	Low Risk	54 (70.1%)	23 (29.9%)	[3]0.014*
	Moderate Risk	6 (42.9%)	8 (57.1%)	
	Severe Risk**	4 (33.3%)	8 (66.7%)	

*[1]Continuity (yates) correction [2]Fisher Freeman Halton Exact Test [3]Chi-square test *p<0.05, ** high risk of malnutrition*

NRS 2002: Nutritional Risk Screening 2002 Score. mNUTRIC: Modified NUTRIC Score. NRS: Nutritional Risk Index. GNRI: Geriatric Nutritional Risk Index. MUST: Malnutrition Universal Screening Tool

Table 5. ROC analysis of the efficacy of risk scores for mortality

	AUC	SE	95% CI	NRS2002 p	mNUTRIC p	NRİ p	GNRİ p
NRS2002	0.562	0.049	0.460 - 0.659				
mNUTRIC	0.778	0.043	0.685 - 0.854	0.001*			
NRİ	0.778	0.043	0.685 - 0.854	0.001*	1.000		
GNRİ	0.610	0.056	0.509 - 0.704	0.460	0.025*	0.025*	
MUST	0.630	0.046	0.529 - 0.723	0.235	0.027*	0.027*	0.695

AUC: Area Under Curve, NRS 2002: Nutritional Risk Screening 2002 Score, mNUTRIC: modified NUTRIC score, NRI: Nutritional Risk Index, GNRI: Geriatric Nutritional Risk Index, MUST: Malnutrition Universal Screening Tool

DISCUSSION

The present study examined the relationship between the mNUTRIC score, NRS 2002 score, NRI, GNRI, and MUST score—measured on day 1 of ICU admission—and mortality. We observed that the mortality rate was significantly greater in high-risk than that in low-risk patients according to the mNUTRIC score and, similarly, the MUST score. Based on the mNUTRIC score, high-risk patients experienced longer ICU stays and durations of MV



than those of low-risk patients. The AUC for the mNUTRIC score was greater than that for the NRS 2002, GNRI, and MUST scores. The AUC for the NRI was also greater than those for the NRS 2002, GNRI, and MUST scores.

In a prospective observational study, Zhang et al. (7) evaluated nutritional risk using 3 different scores (NUTRIC and mNUTRIC scores, and NRS 2002) in 140 patients admitted to the neurology ICU for > 24 h. The study found that 87.1% of patients were at nutritional risk according to the NRS 2002 score, whereas 15.7% and 28.6% were at high nutritional risk according to the NUTRIC and mNUTRIC scores, respectively. Age ≥ 60 years, nosocomial infection, prolonged MV, and high nutritional risk (mNUTRIC score ≥ 5) were independently associated with increased 28-day mortality after multivariate analysis. The NUTRIC and mNUTRIC scores were both independently predictive of 28-day mortality risk.

In a prospective cohort study investigating the association between nutritional risk and clinical outcomes in 200 critically ill patients treated in the ICU, Marchetti et al. (8) collected data from patient records as well as from patients, care teams, and family members. Patients with scores ≥ 5 were considered to be at high nutritional risk. According to the NRS 2002 and NUTRIC scores, 55% and 36.5% of patients, respectively, were classified as high risk. The mean patient age in their study was 59 years.

High nutritional risk—based on the NRS 2002 score—was associated with MV use, infection, and mortality, whereas high nutritional risk based on the NUTRIC score was associated with renal replacement therapy and mortality.

In a prospective study involving 384 critically ill patients, Machado dos Reis et al. (9) examined the association between the mNUTRIC score alone and in combination with the NRS 2002 score and mortality. High nutritional risk was identified in 54.4% of patients using the NRS 2002 score and in 48.4% using the mNUTRIC score. Furthermore, multiple logistic regression analysis was used to evaluate associations with mortality. Mortality was observed in 140 (36.5%) patients. The risk for in-hospital mortality was twice as high in patients identified as high-risk by both the mNUTRIC and NRS 2002 scores (score ≥ 5). The authors concluded that both scores were similarly effective in predicting in-hospital mortality; however, the mNUTRIC score demonstrated better discrimination in assessing mortality risk in critically ill patients. Patients who died more commonly had higher APACHE II and SOFA scores, longer ICU stay, use of MV, and renal replacement therapy.

Our study, unlike the studies conducted by Zhang et al. (7), Marchetti et al. (8) and Machado dos Reis et al. (9), was conducted on geriatric cases, and our average age was 78.8. According to the NRS 2002 score, we identified 35.9% of patients at risk, and 39.8% of patients at high nutritional risk according to the mNUTRIC score. In addition, according to the mNUTRIC score, the mortality rate was higher in high-risk patients. Zhang et al. (7) conducted their study on a single patient group, the neurological patient group. Our cases were not single-type homogeneous patient groups. The mNUTRIC score, which evaluates malnutrition inflammation markers, APACHE II and SOFA scores, which we think is suitable and specific for evaluating malnutrition especially in ICU patients, was more significant in our study, unlike Machodo dos Reis et al. We think that age groups and patient numbers are effective in these results.

In a retrospective study involving 191 geriatric ICU patients diagnosed with respiratory failure, Yenibertiz et al. (10) evaluated nutritional status using the GNRI, Onodera Prognostic Nutritional Index (OPNI), NRS 2002, and NUTRIC scores. The authors examined the predictive ability of these tools for one-month mortality by dividing patients into survivor (n=105) and non-survivor (n=86) groups based on 30-day mortality and found an

overall 30-day mortality rate of 45%. The NUTRIC score, prealbumin level, and GNRI were identified as significant independent risk factors for 30-day mortality. BMI was positively correlated with OPNI and GNRI scores, whereas age and NRS 2002, NUTRIC, and SOFA scores were negatively correlated with GNRI.

Peng et al. (11) investigated the association between the GNRI and hospital mortality in a study involving 3696 geriatric ICU patients. Using multivariate Cox regression models, the prevalence of major risk factors was found to be 28.6%. The authors concluded that the simple malnutrition screening tool GNRI could predict poor prognosis in this patient population. More specifically, a GNRI < 79 was negatively correlated with both hospital and ICU mortality rates.

Bektaş et al. (12) examined the nutritional status of 60 geriatric patients treated in the ICU and the relationship between different nutritional screening tools (NRS 2002, Mini Nutritional Assessment-Screening Form [MNA-SF], NRI, GNRI) and mortality. They found that 1.7%–33.3% of patients were within the normal nutritional range, whereas 28.4%–60% were at risk for malnutrition or severe nutritional risk. Length of ICU stay, and duration of hospitalization and MV were shorter among survivors than those in non-survivors. Male sex, NRS 2002 ≥ 5, and NRI ≥ 81.2 were associated with higher mortality. The study revealed that the NRS-2002 yielded the highest sensitivity, whereas the NRI demonstrated the highest specificity among the screening tools evaluated.

In our study, we found the patient rates with serious risk according to NRI and GNRI scores as 22.3% and 19.4%, respectively. Our mortality rate was 40.8% and our 30-day mortality rate was 37.9%, which is different from the study conducted by Yenibertiz et al. (10) BMI and albumin values are required to determine nutritional risk status based on objective parameters such as GNRI and NRI. However, we think that due to the long half-life of albumin, it is limited in reflecting nutritional status changes in a timely manner. In addition, the body weight of the patients must be known for the calculation of BMI. We calculated the body weight of the patients on admission to the ICU by asking the relatives of the patients to calculate BMI.

Majari et al. (13) highlighted the lack of data regarding the validity of the mNUTRIC and NRS 2002 scores among Iranian ICU patients, noting that the MUST score is more commonly used in Iranian ICUs, and aimed to evaluate the validity of these scores. This prospective observational cohort study included 440 patients from 4 different ICUs. Using multivariate logistic regression, they assessed the association of nutritional risk scores with prolonged hospitalization, extended MV, and 28-day mortality. They found that both the mNUTRIC and NRS 2002 scores were associated with all 3 outcomes, whereas the MUST score was not. The authors concluded that the mNUTRIC score could serve as a useful tool to select patients for aggressive nutritional therapy. Their results indicated that the mNUTRIC score had moderate performance in predicting 28-day mortality, consistent with previous validation studies (4, 12, 13). They also suggested that providing enhanced nutritional support to patients with high mNUTRIC scores may improve survival rates. However, the NRS 2002 and MUST scores were ineffective in identifying patients who would benefit from nutritional interventions.

In a study by Poulia et al. (6), the effectiveness of 6 different nutritional screening tools (NRI, GNRI, Subjective Global Assessment [SGA], MNA-SF, MUST, and NRS 2002) was evaluated in 248 geriatric patients on hospital admission. A composite index was generated by combining the results of these tools with those of patients classified as malnourished if they were identified as malnourished using ≥ 4 of the 6 tools. This study found that the prevalence and risk of malnutrition varied significantly with the screening tool used.



The composite index found 66.9% of the patients to be malnourished to some degree, whereas individual tools yielded rates ranging from 47.2% with the GNRI to 97.6% with the NRS 2002. The proportion of patients with normal nutritional status ranged from 2.4% with NRS 2002 to 52.8% with GNRI. The highest agreement with the composite index was observed with the SGA, followed by MUST, while NRS 2002 demonstrated the lowest agreement. The MUST score had the strongest and the NRS 2002 had the weakest correlation with the actual nutritional status. The results obtained for elderly patients admitted to secondary healthcare institutions were similar to those of other studies. Although the NRS 2002 demonstrated the highest sensitivity among the tools, it also had the lowest specificity and positive predictive value, potentially leading to the overclassification of patients at risk for malnutrition. The authors emphasized that, while high sensitivity is desirable for nutritional screening tools, it may result in an overestimation of malnutrition risk. They also noted that the low positive predictive value of NRS 2002 could lead to incorrect patient classification (6). The variability in the parameters used across different scoring methods, as well as their application in diverse patient populations, may have contributed to these differing results.

We believe that the combination of parameters used in various scores complements different aspects of the scores and that using them in different patient populations can also be effective in these results. In our study, the mortality rate according to the mNUTRIC score was significantly greater among high-risk cases than that in low-risk cases. The mortality rate increased with higher risk levels based on the MUST score. High-risk patients identified using the mNUTRIC score experienced longer ICU stays and longer durations of MV. ROC analysis for mortality prediction revealed that the AUC for the mNUTRIC score and NRI were greater than those for the other scoring systems.

A limitation of our study was its small sample size; as such, the results may differ from those obtained from a larger patient cohort.

CONCLUSION

Results of the present study demonstrated that the mNUTRIC score and NRI were more effective in predicting mortality among geriatric patients admitted to the ICU. Incorporating the mNUTRIC score and NRI into daily clinical practice based on the preferences of the clinical team could be beneficial for improving patient follow-up, treatment, and overall ICU management.

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FROM THE EDITOR IN CHIEF
Yeşim GÖKÇE KUTSAL

INVITED REVIEW ARTICLE

ADVANCES IN SARCOPENIA TREATMENT FOR A HEALTHIER FUTURE
Sibel EYİGOR, Yeşim GÖKÇE KUTSAL

ORIGINAL ARTICLES

THE RELATIONSHIP BETWEEN EPICARDIAL AND PARACARDIAL FAT THICKNESS AND DISEASE SEVERITY IN ELDERLY PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE
Gülhan AYHAN ALBAYRAK, Mustafa İLTERİŞ BARDAKÇI, Goncagül BÜLBÜN

INTEGRATING MACHINE LEARNING INTO ALZHEIMER'S RESEARCH: A CLINICAL DECISION SUPPORT SYSTEM APPROACH
Ceyda ÜNAL, Yılmaz GÖKŞEN

THE IMPACT OF THE CLINICAL FRAILTY SCALE ON PROSTHESIS SELECTION AND EARLY MORTALITY IN ELDERLY PATIENTS UNDERGOING AORTIC VALVE REPLACEMENT
Murat KOÇ, Ufuk MUNGAN, Kaan KAYA, Özer KANDEMİR, Bahadır GÜLTEKİN, Süleyman SÜRER, Mustafa SEREN, İbrahim DUVAN, Emre KAYMAKÇI, Burçin ÇAYHAN KARADEMİR, Renda CIRCI, Hasan KARAYAKA, Ferit ÇİÇEKÇİOĞLU

THE EFFECTS OF VIRTUAL REALITY-BASED EXERCISE ON PAIN AND FUNCTION IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS: A RANDOMIZED CONTROLLED STUDY
Suheyla DAL ERDOĞAN, Funda BERKAN, Onur ARMAĞAN, Merih ÖZGEN, Ayşe Merve ÇIRACIOĞLU, Fezan ŞAHİN MUTLU

DOES OBESITY AFFECT THE EFFICACY AND SAFETY OF EPIDURAL STEROID INJECTIONS IN OLDER ADULTS?
Yücel OLGUN

ANALYSIS OF URINARY TRACT INFECTIONS IN GERIATRIC PATIENTS
Sümeyra KAYALI, Ayşe SAĞMAK TARTAR, Nuray ARI, Mehmet Ali AŞAN, Beyza ERDEM, Hatice Handan AKBULUT

CLINICAL PERFORMANCE COMPARISON OF THE I-GEL AND LARYNGEAL MASK AIRWAY SUPREME IN GERIATRIC PATIENTS: A PROSPECTIVE STUDY
Nursen KARACA, Işık ALPER, Özgecan KAYNARCA

ADAPTATION AND PSYCHOMETRIC EVALUATION OF THE TURKISH VERSION OF THE MATCH SCALE: ASSESSING MOTIVATION AND ATTITUDES TOWARD CHANGING HEALTH BEHAVIOR IN OLDER ADULTS WITH TYPE 2 DIABETES
Dilek BÜYÜKKAYA BESEN, Mehtap ERTAŞ, Merve DERVİŞOĞLU

EFFECT OF OLD AGE ON PNEUMONIA
Zeliha DEMİR GİDEN, Elif DEMİR

COLORECTAL CANCERS OCCURRING WITH ILEUS
Filiz TAŞÇI, İsmail ATAŞ, Mümin Murat YAZICI, Enes GÜLER, Özlem BİLİR

EVALUATION OF THE LEVEL OF KNOWLEDGE ABOUT ALZHEIMER DISEASE IN THE TEKIRDAĞ PROVINCE, TURKEY: A CROSS-SECTIONAL STUDY
Filiz DİLEK, Aysun ÜNAL

CROSS-CULTURAL ADAPTATION AND VALIDATION OF THE TURKISH VERSION OF THE 25-QUESTION GERIATRIC LOCOMOTIVE FUNCTION SCALE
Barış GÜRPINAR, Hülya TUNA, Nursen İLÇİN

AGE-RELATED THORACIC LYMPHADENOPATHIES AND DISEASE PROGRESSION IN PATIENTS WITH MODERATE-TO-SEVERE ASTHMA: AN EVALUATION OF CLINICAL AND IMAGING FINDINGS
Şerife TORUN, Öznur GÜVENÇ UZUNAY, Selim KAHRAMAN, Semiha HİDAYETOĞLU, İrfan Fırat ÖZCAN, Tuğba ERDOĞAN, İrem KARAMAN, Gülbahar DARILMAZ YÜCE, Kezban KARABULUT UÇAR, Mehmet MERMER

RELATIONSHIP BETWEEN VARIOUS NUTRITION SCREENING TOOLS AND MORTALITY AMONG GERIATRIC PATIENTS ADMITTED TO THE INTENSIVE CARE UNIT
Arzu YILDIRIM AR, Yıldız YİĞİT, Öznur DEMİROLUK, Gamze Nur KOCA, Cansu OFLUOĞLU