RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Harran Üniversitesi Tıp Fakültesi Dergisi (Journal of Harran University Medical Faculty) 2025;22(4):x-x.
DOI: 10.35440/hutfd.1704590

Relationship between Handgrip Strength and Hematological Markers in Older Adult Patients with Type 2 Diabetes Mellitus

Tip 2 Diyabetli Yaşlı Hastalarda El Kavrama Gücü ile Hematolojik Belirteçler Arasındaki İlişki

Mehmet Göl[1], İbrahim Halil Türkbeyler[2], Güzin Çakmak[3], Ayşe Fulya Özkanlı[4], Ayşe Elkoca[5], Sedat Özademir[6]

[1]Gaziantep Islam Science and Technology University, Department of Physiology, Gaziantep, TÜRKİYE
[2]Gaziantep Islam Science and Technology University, Department of Internal Medicine, Division of Geriatric Medicine, Gaziantep, TÜRKİYE
[3]Şanlıurfa Research and Training Hospital, Department of Internal Medicine, Division of Geriatric Medicine, Şanlıurfa, TÜRKİYE
[4]Gaziantep Dr. Ersin Arslan Training and Research Hospital, Clinic of Public Health, Gaziantep, TÜRKİYE
[5]Gaziantep Islam Science and Technology University, Departman of Midwife, Gaziantep, TÜRKİYE
[6]Gaziantep Islam Science and Technology University, Department of Internal Medicine, Gaziantep, TÜRKİYE

Abstract

Background: This study evaluated the relationship between inflammatory and hematological parameters and handgrip strength (HGS) in older adults with type 2 diabetes mellitus (T2DM).

Materials and Methods: 227 patients were enrolled in the study. HGS was assessed according to the European Working Group on Sarcopenia in Older People 2 criteria and analyzed against white blood cell count (WBC), neutrophil count (NC), lymphocyte count (LC), mean platelet volume (MPV), platelet distribution width (PDW), red cell distribution width (RDW), C-reactive protein (CRP), and glycated hemoglobin (HbA1c). Data were analyzed with SPSS version 27.0.

Results: The cohort included 85 women and 142 men (mean age 70.2±4.9 years). Low HGS was observed in 82 patients and was strongly correlated with CRP (r=-0.504, p<0.001). WBC, NC, LC, neutrophil-to-lymphocyte ratio, RDW, and PDW were also associated, while Mini-Mental Status Examination, Katz Index of Independence in Activities of Daily Living, Lawton-Brody Instrumental Activities of Daily Living, Geriatric Depression Scale, and HbA1c were not. Lower Tinetti scores and longer Timed Up and Go times correlated with reduced HGS. In logistic regression analysis, MPV (OR=2.956, 95% CI=1.630-5.350, p<0.001) and RDW (OR=0.549, 95% CI=0.360-0.850, p=0.007) emerged as the strongest independent predictors of low HGS, while NC, LC, and CRP also reached statistical significance.

Conclusions: HGS is closely associated with inflammatory and hematological markers, supporting its role as a simple indicator of physical function in older adults with T2DM.

Keywords: Comprehensive geriatric assessment, Handgrip strength, Inflammation, Older adult, Type-2 diabetes mellitus

Öz

Amaç: Bu çalışmada, tip 2 diabetes mellitus (T2DM) tanılı yaşlı bireylerde inflamatuvar ve hematolojik parametreler ile el sıkma gücü (ESG) arasındaki ilişkiyi değerlendirmek amaçlandı.

Materyal ve metod: Toplam 227 hasta çalışmaya dahil edildi. ESG, European Working Group on Sarcopenia in Older People 2 kriterlerine göre değerlendirildi ve beyaz küre sayısı (BKS), nötrofil sayısı (NS), lenfosit sayısı (LS), ortalama trombosit hacmi (OTH), trombosit dağılım genişliği (TDG), eritrosit dağılım genişliği (EDG), C-reaktif protein (CRP) ve glike hemoglobin (HbA1c) ile ilişkilendirildi. Veriler SPSS sürüm 27.0 (IBM Corp., Armonk, NY, ABD) kullanılarak analiz edildi.

Bulgular: Çalışma grubunu 85 kadın ve 142 erkek oluşturdu (ortalama yaş 70,2±4,9 yıl). Düşük ESG, 82 hastada gözlendi ve CRP ile güçlü bir korelasyon gösterdi (r=-0,504, p<0,001). BKS, NS, LS, nötrofil/lenfosit oranı ile EDG ve TDG de düşük HSG ile ilişkili bulundu. Buna karşılık, Mini Mental Durum Muayenesi, Katz Günlük Yaşam Aktiviteleri Bağımsızlık İndeksi, Lawton-Brody Enstrümantal Günlük Yaşam Aktiviteleri, Geriatrik Depresyon Ölçeği ve HbA1c ile anlamlı ilişki saptanmadı. Daha düşük Tinetti skorları ve daha uzun Zamanlı Kalk ve Yürü testi süreleri, azalmış ESG ile anlamlı şekilde ilişkiliydi. Lojistik regresyon analizinde düşük ESG için bağımsız öngördürücüler arasında OTH (OR=2.956, %95 GA=1.630-5.350, p<0,001) ve EDG (OR=0,549, %95 GA=0,360-0,850, p=0,007) öne çıkarken, ek olarak NS, LS ve CRP de istatistiksel olarak anlamlı bulundu.

Sonuç: ESG, inflamatuvar ve hematolojik parametrelerle yakından ilişkilidir ve bulgular T2DM'li yaşlı bireylerde fiziksel fonksiyonun basit ve değerli bir göstergesi olarak kullanılabileceğini desteklemektedir.

Anahtar Kelimeler: Kapsamlı geriatrik değerlendirme, El sıkma gücü, Inflammation, Yaşlı, Type-2 diabetes mellitus

Corresponding Author: Mehmet Göl, Gaziantep Islam Science and Technology University, Department of Physiology, Gaziantep, TÜRKİYE
E-mail: mehmet.gol@gibtu.edu.tr / **ORCID ID:** 0000-0003-4593-3990

Received: 22.05.2025 / **Accepted:** 20.10.2025
Cite this article as: Göl M, Türkbeyler İH, Çakmak G, Özkanlı AF, Elkoca A, Özademir S. Relationship between Handgrip Strength and Hematological Markers in Older Adult Patients with Type 2 Diabetes Mellitus. Harran Üniversitesi Tıp Fakültesi Dergisi (Journal of Harran University Medical Faculty) 2025;22(4):x-x. DOI: 10.35440/hutfd.1704590.

Introduction

Globally, a majority of the patients with diabetes possess type 2 diabetes mellitus (T2DM), and almost half of these patients are older than 65 years (1,2). Diabetes causes both microvascular (retinopathy, nephropathy, neuropathy) and macrovascular (myocardial infarction, stroke) complications (3). Handgrip strength (HGS) is a method of measuring muscle strength that is particularly used in the elderly and is assessed by the voluntary exertion of muscle strength. In addition to being associated with many clinical conditions, according to the European Working Group on Sarcopenia in Older People 2 (EWGSOP-2), if an individual's HGS value is normal, there is no need for further investigation and treatment for sarcopenia (4). Reduced HGS has been linked to increased risk of diabetic complications, all-cause mortality, and accelerated microvascular damage, suggesting its potential as a practical marker of vascular health (5,6).

Inflammatory processes are key drivers in both the initiation and progression of T2DM, contributing to insulin resistance and β-cell dysfunction, while inflammatory biomarkers including C-reactive protein (CRP) are consistently linked with poor physical performance (7, 8). Hematological markers including mean platelet volume (MPV), platelet distribution width (PDW), and red cell distribution width (RDW) have been connected to inflammatory disorders of different types (9-11).

The connection between HGS and such hematological indices has rarely been explored in older adults with T2DM. The main aim of this study was to evaluate the relationship between HGS and hematological parameters such as white blood cell count (WBC), neutrophil count (NC), lymphocyte count (LC), MPV, PDW, and RDW; inflammatory marker CRP; and metabolic marker glycated hemoglobin (HbA1c), as well as comprehensive geriatric assessment (CGA) tests including the Mini-Mental Status Examination (MMSE), the Katz Index of Independence in Activities of Daily Living (ADL), the Lawton-Brody Instrumental ADL (IADL), the Geriatric Depression Scale (GDS), the Mini Nutritional Assessment Short Form (MNA-SF), the Tinetti Performance-Oriented Mobility Assessment (Tinetti), and the Timed Up and Go (TUG) test in older adults with T2DM.

Material and Methods

Study Population

This study was performed using a retrospective review of patient records. Medical records of patients admitted between September 2022 and January 2023 were examined. The ethical approval for the analysis of these past data was obtained later from the Gaziantep Islam Science and Technology University Non-Interventional Clinical Research Ethics Committee of (approval no: 650.48.24, date: June 18, 2025). Since this was a retrospective design, no additional patient consent was required.

A total of 227 patients with T2DM, all aged ≥65 years, were recruited for the study.

Patient Eligibility and Ineligibility

Patients undergoing cancer chemotherapy or with any malignant disease were excluded. In addition, those with acute infections in the last month (such as upper respiratory tract infections, pneumonia, or gastroenteritis) or chronic infectious diseases (including chronic hepatitis) were excluded. Patients diagnosed with chronic diseases (e.g., COPD, asthma, rheumatoid arthritis, heart failure) or with acute coronary syndromes were not considered eligible for inclusion. Based on the CGA records of 227 patients, 57 patients lacked data for the Tinetti and/or the TUG tests. Additionally, 12 patients had missing data for the GDS, six for the IADL, five for the ADL, and four for the MMSE. Therefore, analyses of the CGA tests were performed on 143 patients.

Assessment of Smoking and Alcohol Consumption

Older adults with T2DM were categorized as current or former smokers if they acknowledged smoking every day or sometimes when asked "Do you currently smoke?" and reported a lifetime cigarette use exceeding five packs (12). Patients were considered alcohol users if they reported moderate intake, defined as daily consumption of ≥1 unit of alcohol for women and ≥2 units for men for a minimum of one year(13).

Assessment of Physical Activity

Participants who reported engaging in regular activity totaling ≥150 minutes per week, corresponding to 30 minutes per day for 5 days, primarily consisting of brisk walking, muscle-strengthening, and balance exercises, were classified as physically active. Alternatively, those who participated in jogging or running combined with muscle-strengthening and balance exercises for at least 75 minutes per week were also considered physically active. A combination of these two approaches was likewise accepted (14).

Comprehensive Geriatric Assessment

Participants underwent assessments covering cognition, basic and instrumental daily activities, depressive symptoms, nutritional status, and balance.

MMSE is a brief, standardized screening tool that is widely used to evaluate cognitive function in older adults. It is structured as a set of questions targeting multiple aspects of cognition, including orientation, memory, attention, language, and visuospatial skills. The MMSE takes about 10 minutes to complete, and scores range between 0-30, with lower scores reflecting more impairment and poorer function (15).

The Katz ADL Index measures functional independence in older adults by rating six basic self-care activities: bathing, dressing, toileting, transferring, continence, and feeding.

On the ADL, possible scores span from 0 to 6; higher scores

correspond to a greater level of independence (16).

The IADL scale is used to assess more complex tasks that require some degree of cognitive functioning, such as using the telephone, preparing meals, managing medications and handling finances. Comprising eight tasks, the scale is rated from 0 to 8 points, with higher scores signifying better autonomy in IADL performance (17).

The GDS is widely established and dependable tool for evaluating depressive symptoms in older adults. It includes a set of questions designed to explore mood, guilt feelings, energy, appetite, and general well-being. The short form of the scale yields an aggregate score ranging between 0-15. Although it does not establish a definitive diagnosis of depression, higher scores indicate more pronounced depressive features and suggest a greater likelihood of an underlying depressive disorder (18).

The MNA is a tool that is employed to examine the nutritional profile of geriatric patients. The MNA-SF is a brief version of the MNA, consisting of six items. The tool assesses various aspects of nutritional status, including weight loss, appetite, mobility, and overall health. Scores range from 0-14, with higher scores indicating better nutritional status (19).

The Tinetti is used to evaluate gait and balance across two domains. The balance section consists of nine items, while the gait section is composed of seven items. An armless chair, a stopwatch, and a 15-meter walkway are required to conduct the test, which typically takes 10-15 minutes to complete. Each task is rated on a three-point scale (0, 1, 2), where 2 reflects correct performance, 1 indicates the task is completed with compensations, and 0 shows that the task cannot be performed. The combined scores of balance and gait yield a total score. The balance subscore ranges up to 16 points, with values below 11 indicating a high risk of falls, whereas the gait subscore has a maximum of 12 points, with scores lower than 8 suggesting fall risk (20).

The TUG test is widely used as an expedient and reasonable implement to assess mobility in older adults. During the assessment, the participant is instructed to stand up from where he seats, step three meters, turn, move to the seat, and sit down again. The duration of the task is measured in seconds, with shorter completion times reflecting better mobility performance (21).

Measurement of Handgrip Strength

We measured HGS employing a Jamar hand dynamometer manufactured by Sammons Preston (Bolingbrook, USA). The participants were seated with their arms at a 90-degree angle to the elbow and forearm supported. The older adults were invited to clasp the dynamometer with their maximum grip strength for three seconds, and three trials were recorded. A one-minute rest was given between each trial. The highest recorded value from each hand was used for analysis (22).

Evaluation of Handgrip Strength

HGS was interpreted using the EWGSOP-2 cut-off values: 16 kg for female and 27 kg for male (4).

Assessment of Polypharmacy

The number and name of the drugs used were recorded. The use of 5 to 9 drugs was accepted as polypharmacy, and ≥10 drugs were accepted as excessive polypharmacy (23).

Measurement of NLR, MPV, PDW, RDW, CRP, and HbA1c

Venous blood samples were collected under aseptic conditions using EDTA tubes. Blood collection tubes were properly labeled with patient identification details to avoid mixing up samples. Blood samples were transported to the laboratory within four hours of collection to avoid sample degradation. Hematology analyzers were calibrated and quality control materials were run to ensure the preciseness and truth of the measurements.

Blood was analyzed using a Beckman Coulter analyzer. The analyzer automatically measures neutrophil/lymphocyte ratio (NLR), MPV, PDW, and RDW from the same blood sample (24).

CRP values were measured by ELISA (Enzyme-Linked Immunosorbent Assay) method (25).

HA1c was measured using a Roche analyzer designed specifically for HbA1c measurement. HbA1c was measured by exploiting the different charges of glycated and non-glycated hemoglobin. The difference in charge is detected by the analyzer and reported as a share of the overall hemoglobin present in the sample. The analyzer produces a report that provides the HbA1c value along with other related parameters (26).

Statistical Analyses

For continuous variables, expressions took place in terms of mean ± SD, and distributional assumptions were found out by putting the Kolmogorov-Smirnov test in use. Student's t-test was utilized for comparison of variables if all groups of which display totally normal distribution, while the Mann-Whitney U test was the selection otherwise. Categorical data were introduced as being counts and proportions. The association between HGS and demographic characteristics, CGA outcomes, and inflammatory markers was examined using Pearson's correlation analysis. The correlation coefficients (r-values) were interpreted according to Cohen's criteria: small (0.1-0.3), moderate (0.3-0.5), and large (>0.5). To determine predictors of decreased handgrip strength, binary logistic regression analysis was carried out with inflammatory parameters as independent variables. Model fit was checked using the Nagelkerke R^2 statistic. A p-value of less than 0.05 was considered markedly significant. Data analyses were run with SPSS version 27.0 (IBM Corp., Armonk, NY, USA).

Results

The sample was made up of 85 female and 142 male patients, and the average age of the cohort was 70.20±4.86 years. An overview of the demographic features of the sample is shown in Table 1. Decreased HGS was observed in 82 patients. CGA consequences were exhibited in Table 2. WBC, NC, and LC were significantly associated with low HGS (r=0.152, p=0.018; r=0.227, p<0.001; r=0.187, p=0.013). Neutrophil-to-lymphocyte ratio, RDW, and PDW were also related to decreased muscle strength (r=0.201, p=0.005; r=0.428, p<0.001; r=0.374, p=0.010). MPV was negatively correlated with HGS (r=-0.469, p=0.010). Inflammation, measured by CRP, was strongly correlated with decreased HGS (r=-0.504, p<0.001). HGS showed no meaningful correlation with MMSE, GDS, or ADL outcomes. The duration of diabetes was positively correlated with decreased muscle strength (r=0.205, p=0.001), whereas glycemic control (HbA1c) was not (p=0.205). The analysis did not reveal any association between HGS and the number of drugs used. Lower Tinetti scores and higher TUG times were associated with decreased HGS (r=-0.198, p=0.046; r=0.204, p=0.009). The associations between HGS and inflammatory parameters are presented in Table 3, and the associations with CGA results are shown in Table 4.

Table 1. Demographic features of participants

Parameters (n=227)	
Age (mean ± SD)	70.20±4.86 (65-88)
M/F (%)	40.6/59.4
Mean value of daily used medication	5.08±2.93 (0-15)
Education (%)	
Illiterate	51.7%
Primary school graduate	31.5%
Secondary school graduate	4.9%
High school graduate	8.4%
Graduated from university	3.5%
Place of residence (%)	
Lives alone	10.5%
Lives with spouse	76.2%
Lives with relatives	13.3%
Smoking (%)	
Yes	19.6%
No	80.4%
Alcohol (%)	
Yes	4.2%
No	95.8%
Physical activity (%)	
Yes	16.8%
No	83.2%
SD: Standart deviation	

Table 2. Comprehensive geriatric assessment test results in patients with and without decreased handgrip strength

Parameters (n=143)	
Frequency of polypharmacy (n=101) (%)	70.6%
HGS (kg)	21.43±9.92 (5-42)
Frequency of comorbidity (%)	64.3%
HbA1c (%)	9.19±1.63 (7.2-13.4)
Disease duration*	21.74±5.88 (5-42)

Table 2. Continued	
BMI	30.97±5.5 (20.3-52)
ADL	5.6±1.08
IADL	6.24±1.82
MMSE	26.41±3.84
GDS	6.24±4.20
MNA-SF	11.92±2.20
Tinetti	22.32±4.55 (6-28)
TUG (s)	12.47±5.37
Frequency of low HGS (n=82)	57.3%
* Disease duration is the time period in terms of years that has passed from the first diagnosis of T2DM. Continuous variables are expressed as mean ± standard deviation. BMI: Body-mass index, ADL: Activities of daily living, HGS: Handgrip strength, IADL: Instrumental activities of daily living, MMSE: Mini-mental state examination, GDS: Geriatric depression scale, MNA-SF: Mini nutritional assessment-short form, TUG: Timed up and go	

Table 3. Comparison of the inflammatory parameters in patients with low and normal handgrip strength			
	Low HGS (n=82)	**Normal HGS (n=61)**	**p**
WBC (x10³/µL)	8.755±2.096	7.746±2.885	0.018
NC (x10³/µL)	5.406±1.673	4.383±1.645	0.000
LC (x10³/µL)	2.084±748	2.613±1.664	0.013
NLR	2.93±2.15	2.06±1.13	0.005
MPV (fL)	8.22±2.54	9.34±1.75	<0.001
RDW (%)	14.18±1.55	13.27±0.74	<0.001
PDW (%)	13.79±1.54	12.97±2.20	0.010
CRP (mg/L)	4.36±1.85	2.26±1.28	<0.001
HbA1c (%)	9.34±1.69	8.99±1.53	0.205
Descriptive variables are expressed in the form of mean ± standard deviation. CRP: C-reactive protein, HbA1c: Glycated haemoglobin, HGS: Handgrip strength, LC: Lymphocyte count, MPV: Mean platelet volume, NC: Neutrophil count, NLR: Neutrophil/lymphocyte ratio, RDW: Red cell distribution width, PDW: Platelet distribution width, WBC: White blood cell			

Table 4. Comparison of the comprehensive geriatric assessment domains in patients with low and normal handgrip strength			
	Low HGS (n=82)	**Normal HGS (n=61)**	**p**
Drug use	5.24±3.20	4.96±2.73	0.571
Disease duration*	23.12±5.35	19.88±6.09	0.001
BMI (kg/m2)	31.15±5.23	30.77±5.86	0.698
Tinetti	21.62±4.67	23.18±4.29	0.046
TUG	13.53±6.12	11.18±5.95	0.009
MNA-SF	10.67±2.35	12.22±1.97	0.032
MMSE	25.76±4.76	26.97±2.78	0.127
GDS	6.41±4.16	5.38±4.27	0.140
ADL	5.58±1.14	5.63±1.01	0.660
IADL	5.98±1.95	6.59±1.57	0.043
* Disease duration is the time period in terms of years that has passed from the first diagnosis of type 2 diabetes mellitus. Descriptive variables are expressed in the form of mean ± standard deviation. BMI: Body-mass index, ADL: Activities of daily living, IADL: Instrumental activities of daily living, MMT: Mini-mental state examination, GDS: Geriatric depression scale, MNA-SF: Mini nutritional assessment-short form, TUG: Timed up and go test			

Although several hematological parameters demonstrated significant correlations with HGS, binary logistic regression analysis revealed that MPV (independent risk factor) and RDW (protective factor) were the strongest predictors of decreased HGS (Nagelkerke R^2=0.516, p<0.001). Specifically, MPV (OR=2.956, 95% CI=1.630-5.350, p<0.001) and RDW (OR=0.549,

95% CI=0.360-0.850, p=0.007) emerged as robust predictors of low HGS, while NC (OR=1.003, 95% CI ≈ 1.001-1.005, p=0.003), LC (OR=1.002, 95% CI ≈ 1.000-1.004, p=0.046), and CRP (OR=1.002, 95% CI ≈ 1.000-1.004, p=0.046) also reached statistical significance. Accordingly, MPV can be considered a strong independent risk factor for reduced HGS, whereas RDW demonstrated a relatively strong protective effect. In contrast, NC, LC, and CRP were significant but clinically weaker risk factors compared with MPV and RDW. Logistic regression observations were demonstrated in Table 5.

Table 5. Binary logistic regression analysis of factors associated with low handgrip strength

Variable	B	SE	OR [Exp(B)]	95% CI for OR	p-value
LC (x10³/μL)	0.002	0.001	1.002	1.000-1.004	0.046
NC (x10³/μL)	0.003	0.001	1.003	1.001-1.005	0.003
CRP (mg/L)	0.002	0.001	1.002	1.000-1.004	0.046
RDW (%)	-0.599	0.221	0.549	0.360-0.850	0.007
MPV (fL)	1.084	0.303	2.956	1.630-5.350	<0.001
NLR	-0.466	0.323	0.627	0.330-1.190	0.155
PDW (%)	-0.157	0.145	0.855	0.640-1.140	0.270

LC: Lymphocyte count, MPV: Mean platelet volume, NC: Neutrophil count, NLR: Neutrophil/lymphocyte ratio, RDW: Red cell distribution width, PDW: Platelet distribution width

Discussion

Our current analysis demonstrated that decreased HGS was associated with several inflammatory markers, including WBC, NC, LC, NLR, RDW, PDW, and CRP. Measures of mobility and functional status, such as Tinetti and TUG scores, were also related to reduced muscle strength, whereas depressive symptoms, activities of daily living, and medication use were not. These findings suggest that systemic inflammation may be an important underlying factor in muscle weakness among older adults with T2DM, and that anti-inflammatory interventions could potentially improve muscle function. Furthermore, testing mobility and functional capacity can be valuable in determining individuals likely to develop muscle weakness.

The biological mechanisms linking inflammation to reduced muscle strength remain incompletely understood. Proposed pathways include muscle fiber atrophy, oxidative stress, mitochondrial dysfunction, and impaired protein synthesis (27). Complications of diabetes, particularly neuropathy and nephropathy, are strongly influenced by inflammation, which may also play a role in the deterioration of muscle function in this population (28,29). The concept of “inflamm-aging” describes the chronic, low-grade inflammatory state that accompanies aging (30). This process, mediated by cytokines like IL-6 and TNF-α, reactive oxygen species, and mitochondrial dysfunction, contributes to muscle breakdown and functional deterioration (31,32). Comorbidities including diabetes, metabolic syndrome, and cardiovascular disease exacerbate this process (33).

Consistent with our findings, several studies have confirmed the link between inflammatory markers and muscle strength. For instance, elevated high-sensitivity CRP levels have been associated with a greater probability of reduced HGS in older women (12). Although CRP exhibited a strong negative correlation with HGS in our study, it did not remain a robust independent predictor in logistic regression analysis, most likely due to multicollinearity with other hematological parameters. By contrast, MPV emerged as a significant risk factor, while RDW acted as a protective factor. Similarly, NLR has been associated with both systemic inflammation and nutritional status, serving as an easily accessible biomarker from routine blood counts (34). In research conducted among older adults with primary sarcopenia, significant associations were observed with novel inflammatory markers such as the Systemic Inflammatory Response Index and the monocyte-to-HDL ratio, whereas platelet indices showed no correlation (35). These data highlight the potential role of different inflammatory pathways in sarcopenia and muscle dysfunction.

Functional and mobility assessments also remain essential in evaluating muscle strength. Lower TUG scores have been linked with decreased grip strength (36), and impaired functional status has been correlated with reduced muscle strength across several geriatric populations (37). Diabetes itself, particularly its longer duration, is a major risk factor for sarcopenia, further emphasizing the need to understand the inflammatory contribution to muscle dysfunction in this setting (38,39).

The limitations of this study include its cross-sectional design, which precludes causal inference, and a relatively modest sample size. Another limitation is the absence of sarcopenia assessment, which would require measurements of muscle mass such as dual-energy X-ray absorptiometry or bioelectrical impedance analysis. Despite these limitations, the study provides important evidence on the relationship between

inflammation and muscle strength in older adults with T2DM, and underscores the importance of CGA approaches that integrate both biological and functional factors.

Conclusion

The study findings provide important insights into the factors contributing to decreased muscle strength in diabetic older adults. The relationship between inflammation and muscle strength is likely complex and multifactorial, and further research is needed to fully elucidate the underlying mechanisms. Nevertheless, the results suggest that reducing inflammation and assessing mobility and functional status may be valuable approaches for improving muscle function in diabetic older adults.

Ethical Approval: *This study was approved by the Non-Interventional Clinical Research Ethics Committee of Gaziantep Islam Science and Technology University (approval no: 650.48.24, date: June 18, 2025).*

Author Contributions:

Concept: İ.H.T.

Literature Review: S.Ö., A.E.

Design: İ.H.T., M.G.

Data acquisition: A.E., A.F.Ö.

Analysis and interpretation: M.G., A.F.Ö.

Writing manuscript: G.Ç., İ.H.T.

Critical revision of manuscript: A.E., A.F.Ö.

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

Financial Disclosure: *Authors declared no financial support.*

References

1. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119.
2. Bezerra CB, Pinho C, Saintrain MVL, Sodre A, Silva C, Doucet J. Characteristics of the clinical treatment of Brazilian and French older adults with diabetes. Diabetes Res Clin Pract. 2021;181:109088.
3. Forbes JM, Cooper ME. Mechanisms of diabetic complications. Physiol Rev. 2013;93(1):137-188.
4. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyere O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31.
5. Zhong P, Yang S, Liu R, Zhu Z, Zhang Y, Cheng W, et al. Handgrip strength and risks of diabetic vascular complications: Evidence from Guangzhou Diabetic Eye Study and UK cohorts. Br J Ophthalmol. 2024;109(1):157-164.
6. Wu H, Gu Y, Wang X, Meng G, Rayamajhi S, Thapa A, et al. Association Between Handgrip Strength and Type 2 Diabetes: A Prospective Cohort Study and Systematic Review With Meta-analysis. J Gerontol A Biol Sci Med Sci. 2023;78(8):1383-1391.
7. Jung YE, Kang KY. Elevated hs-CRP level is associated with depression in younger adults: Results from the Korean National Health and Nutrition Examination Survey (KNHANES 2016). Psychoneuroendocrinology. 2019;109:104397.
8. Salvatore T, Galiero R, Caturano A, Rinaldi L, Criscuolo L, Di Martino A, et al. Current Knowledge on the Pathophysiology of Lean/Normal-Weight Type 2 Diabetes. Int J Mol Sci. 2022;24(1):658.
9. Gasparyan AY, Sandoo A, Stavropoulos-Kalinoglou A, Kitas GD. Mean platelet volume in patients with rheumatoid arthritis: the effect of anti-TNF-alpha therapy. Rheumatol Int. 2010;30(8):1125-1129.
10. Reddy SK, Shetty R, Marupuru S, Yedavalli N, Shetty K. Significance of Platelet Volume Indices in STEMI Patients: A Case-Control Study. J Clin Diagn Res. 2017;11(4):LC05-LC07.
11. Sarkar S, Kannan S, Khanna P, Singh AK. Role of red blood cell distribution width, as a prognostic indicator in COVID-19: A systematic review and meta-analysis. Rev Med Virol. 2022;32(2):e2264.
12. Son DH, Song SA, Lee YJ. Association Between C-Reactive Protein and Relative Handgrip Strength in Postmenopausal Korean Women Aged 45-80 Years: A Cross-Sectional Study. Clin Interv Aging. 2022;17:971-978.
13. Alcohol Research: Current Reviews Editorial Staff. Drinking Patterns and Their Definitions. Alcohol Res. 2018;39(1):17-18.
14. Piercy KL, Polster M, Macias B, Vaux-Bjerke A. Physical Activity in Older Adults: What Every Internist Needs to Know. Am J Lifestyle Med. 2025;19(1):12-22.
15. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189-198.
16. Santangelo I, Ahmad S, Liu S, Southerland LT, Carpenter C, Hwang U, et al. Examination of geriatric care processes implemented in level 1 and level 2 geriatric emergency departments. J Geriatr Emerg Med. 2022;3(4):[article ID].
17. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9(3):179-186.
18. Wen J, Fu CHY, Tosun D, Veturi Y, Yang Z, Abdulkadir A, et al. Characterizing Heterogeneity in Neuroimaging, Cognition, Clinical Symptoms, and Genetics Among Patients With Late-Life Depression. JAMA Psychiatry. 2022;79(5):464-474.
19. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev. 1996;54(1 Pt 2):S59-S65.
20. Köroğlu Ç. Alzheimer hastalarında yürüme ve denge değerlendirmesi: Karşılaştırmalı bir çalışma [Master's thesis]. Pamukkale University; 2014.
21. Hendriks S, Huisman MG, Ghignone F, Vigano A, de Liguori Carino N, Farinella E, et al. Timed up and go test and long-term survival in older adults after oncologic surgery. BMC Geriatr. 2022;22:934.
22. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age Ageing. 2011;40(4):423-429.

23. Little MO. Updates in nutrition and polypharmacy. Curr Opin Clin Nutr Metab Care. 2018;21(1):4-9.
24. Cumhur Cure M, Cure E, Yuce S, Yazici T, Karakoyun I, Efe H. Mean platelet volume and vitamin D level. Ann Lab Med. 2014;34(2):98-103.
25. Morioka K, Sato H, Kuboyama M, Yanagida A, Shoji A. Quantification of CRP in human serum using a handheld fluorescence detection system for capillary-based ELISA. Talanta. 2021;224:121725.
26. Parrinello CM, Selvin E. Beyond HbA1c and glucose: the role of nontraditional glycemic markers in diabetes diagnosis, prognosis, and management. Curr Diab Rep. 2014;14(11):548.
27. Marzetti E, Calvani R, Cesari M, Buford TW, Lorenzi M, Behnke BJ, et al. Mitochondrial dysfunction and sarcopenia of aging: from signaling pathways to clinical trials. Int J Biochem Cell Biol. 2013;45(10):2288-2301.
28. Pan HZ, Zhang L, Guo MY, Sui H, Li H, Wu WH, et al. The oxidative stress status in diabetes mellitus and diabetic nephropathy. Acta Diabetol. 2010;47 Suppl 1:71-76.
29. Li CW, Yu K, Shyh-Chang N, Jiang Z, Liu T, Ma S, et al. Pathogenesis of sarcopenia and the relationship with fat mass: descriptive review. J Cachexia Sarcopenia Muscle. 2022;13(2):781-794.
30. Franceschi C, Bonafè M, Valensin S, Olivieri F, De Luca M, Ottaviani E, et al. Inflamm-aging. An evolutionary perspective on immunosenescence. Ann N Y Acad Sci. 2000;908:244-254.
31. Broderick L, Hoffman HM. IL-1 and autoinflammatory disease: biology, pathogenesis and therapeutic targeting. Nat Rev Rheumatol. 2022;18(8):448-463.
32. Dupont J, Antonio L, Dedeyne L, O'Neill TW, Vanderschueren D, Rastrelli G, et al. Inflammatory markers are associated with quality of life, physical activity, and gait speed but not sarcopenia in aged men (40-79 years). J Cachexia Sarcopenia Muscle. 2021;12(6):1818-1831.
33. Beaudart C, Rolland Y, Cruz-Jentoft AJ, Bauer JM, Sieber C, Cooper C, et al. Assessment of Muscle Function and Physical Performance in Daily Clinical Practice: A position paper endorsed by the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO). Calcif Tissue Int. 2019;105(1):1-14.
34. Borda MG, Lafuente-Sanchis P, Patricio Baldera J, Tarazona-Santabalbina FJ, Chavarro-Carvajal DA, Salazar-Londono S, et al. Assessing Neutrophil-to-Lymphocyte Ratio as a Nutritional Indicator in Community-Dwelling Older Adults. Arch Med Res. 2024;55(4):103003.
35. Bektan Kanat B, Suzan V, Ulugerger Avci G, Unal D, Emiroglu Gedik T, Suna Erdincler D, et al. Systemic inflammatory response index and monocyte-to-high density lipoprotein ratio — new biomarkers remarking the inflammation in primary sarcopenia: The SIMPS study. Bratisl Lek Listy. 2024;125(5):331-336.
36. Bohannon RW, Larkin PA, Cook AC, Gear J, Singer J. Decrease in timed balance test scores with aging. Phys Ther. 1984;64(7):1067-1070.
37. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010;39(4):412-423.
38. Izzo A, Massimino E, Riccardi G, Della Pepa G. A Narrative Review on Sarcopenia in Type 2 Diabetes Mellitus: Prevalence and Associated Factors. Nutrients. 2021;13(1):183.
39. Giha HA, Alamin OAO, Sater MS. Diabetic sarcopenia: metabolic and molecular appraisal. Acta Diabetol. 2022;59(8):989-1000.