Ulusal ROMATOLOJİ Dergisi
Journal of Turkish Society for Rheumatology www.romatolojidergisi.org

Original Article / Orijinal Araştırma

DOI: 10.4274/raed.galenos.2026.87004
J Turk Soc Rheumatol

Prevalence and factors associated with left ventricular diastolic dysfunction in patients with rheumatoid arthritis: A cross-sectional study

Romatoid artrit hastalarında sol ventrikül diyastolik disfonksiyonunun sıklığı ve ilişkili faktörler: Kesitsel bir çalışma

Cansu Akleylek[1], Mehtap Üçer[2], Betül Cengiz Elçioğlu[3], Şükrü Taylan Şahin[3], Neslihan Yılmaz[1]

[1]Demiroğlu Bilim University Faculty of Medicine, Department of Rheumatology, İstanbul, Türkiye
[2]Demiroğlu Bilim University Faculty of Medicine, Department of Internal Medicine, İstanbul, Türkiye
[3]Demiroğlu Bilim University Faculty of Medicine, Department of Cardiology, İstanbul, Türkiye

Abstract

Objective: Rheumatoid arthritis (RA) confers an increased risk of cardiovascular morbidity and mortality compared with the general population. Left ventricular diastolic dysfunction (LVDD) may represent an early manifestation of cardiac involvement. This study aimed to determine the frequency of LVDD in patients with RA and to identify factors associated with LVDD.

Methods: In this cross-sectional study, 83 patients with RA were included. The control group consisted of 41 patients with spondyloarthritis (SpA) and 39 healthy volunteers. LVDD was assessed using transthoracic echocardiography.

Results: Among the 83 patients with RA included in the study, the mean age was 47.7±12.3 years, and the median disease duration was 69 months (interquartile range: 42-144). There were no significant differences among the RA, SpA, and healthy control groups regarding age, hypertension, dyslipidemia, or obesity (all p>0.05). Echocardiographic assessment revealed LVDD in 32.5% (n=27) of patients with RA, 21.9% (n=9) of patients with SpA, and 23.1% (n=9) of healthy controls, with no statistically significant difference among the groups (p>0.05). In the RA cohort, multivariate logistic regression analysis showed that increasing age (p<0.01) and history of smoking (p=0.04) were independently associated with LVDD.

Conclusion: In this study, older age and a history of smoking were independently associated with LVDD among patients with RA. Although the frequency of LVDD was numerically higher in the RA group compared with patients with SpA and healthy controls, this difference did not reach statistical significance. Given the relatively modest sample size, larger prospective studies are warranted to better elucidate the relationship between RA and subclinical diastolic dysfunction.

Keywords: Diastolic dysfunction, echocardiography, rheumatoid arthritis

Özet

Amaç: Romatoid artrit (RA) hastalarında, kardiyovasküler morbidite ve mortalitenin genel popülasyona göre arttığı bilinmektedir. Sol ventrikül diyastolik disfonksiyonu (LVDD) ise kardiyak tutulumun erken bir bulgusu olarak görülebilmektedir. Çalışmamızın amacı RA hastalarında LVDD sıklığını ve buna etki eden faktörleri ortaya koymaktır.

Yöntem: Kesitsel olarak dizayn edilen çalışmaya, RA tanısı almış 83 hasta, kontrol grubu olarak ise spondiloartrit (SpA) tanısı alan 41 hasta ve 39 sağlıklı gönüllü dahil edilmiştir. LVDD, transtorasik ekokardiyografik ölçümler ile değerlendirilmiştir.

Bulgular: Çalışmaya dahil edilen 83 RA hastasının yaş ortalaması 47,7±12,3 yıl, hastalık süresi 69 (çeyrekler arası açıklık: 42-144) ay idi. Gruplar arasında yaş, hipertansiyon, dislipidemi ve obezite varlığı açısından fark saptanmadı (p>0,05). Ekokardiyografik değerlendirmede LVDD; RA hastalarında %32,5 (n=27), SpA ve sağlıklı kontrol gruplarında ise %21,9 (n=9) ve %23,1 (n=9) oranında saptandı (p>0,05). RA hastalarında diyastolik disfonksiyon varlığını etkileyen değişkenlerin analizinde; ileri yaş (p<0,01) ve sigara kullanımının (p=0,04) LVDD ile bağımsız olarak ilişkili olduğu tespit edildi.

Sonuç: Çalışmamızda RA hastalarında ileri yaş ve sigara kullanımı öyküsünün LVDD ile bağımsız ilişkili olduğu saptanmıştı. Öte yandan RA hastalarının SpA ve sağlıklı kontrol gruplarından, istatistiksel anlamlılık görülmemekle birlikte, daha yüksek LVDD oranlarına sahip olduğu saptanmıştır. Ancak çalışmamızdaki sınırlı hasta sayısı göz önüne alındığında, RA ile subklinik diyastolik disfonksiyon arasındaki ilişkinin daha iyi aydınlatılabilmesi için daha geniş ölçekli, prospektif çalışmalara ihtiyaç olduğu düşünülmektedir.

Anahtar Kelimeler: Diyastolik disfonksiyon, ekokardiyografi, romatoid artrit

Correspondence / İletişim: Cansu Akleylek MD,
Demiroğlu Bilim University Faculty of Medicine, Department of Rheumatology, İstanbul, Türkiye
E-mail: cansuakleylek@gmail.com **ORCID ID:** orcid.org/0000-0002-4703-6903
Received / Geliş Tarihi: 11.03.2026 **Accepted / Kabul Tarihi:** 06.11.2026 **Epub:** 10.11.2026

Cite this article as / Atıf: Akleylek C, Üçer M, Cengiz Elçioğlu B, Şahin ŞT, Yılmaz N. Prevalence and factors associated with left ventricular diastolic dysfunction in patients with rheumatoid arthritis: a cross-sectional study. J Turk Soc Rheumatol. [Epub Ahead of Print]

Copyright© 2026 The Author(s). Published by Galenos Publishing House on behalf of Turkish Society for Rheumatology.
This is an open access article under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

Introduction

Rheumatoid arthritis (RA) is a chronic, systemic inflammatory disease that primarily affects the joints but may also involve multiple extra-articular organs. Accumulating evidence indicates that patients with RA face a markedly elevated risk of cardiovascular morbidity and premature mortality compared with the general population. This excess cardiovascular burden cannot be fully explained by traditional risk factors alone and is increasingly attributed to persistent systemic inflammation, endothelial dysfunction, microvascular impairment, and immune-mediated myocardial remodeling.[1-4]

Left ventricular diastolic dysfunction (LVDD) represents an early manifestation of myocardial involvement and may precede the development of clinically overt heart failure. In the general population, LVDD is independently associated with an increased risk of heart failure and adverse cardiovascular outcomes.[5,6] In patients with RA, several echocardiographic (ECHO) studies have demonstrated subclinical diastolic abnormalities even in the absence of clinically apparent cardiovascular disease.[7,8] Nevertheless, the reported prevalence of LVDD in RA varies substantially across studies, likely reflecting heterogeneity in study populations, disease duration, inflammatory burden, and ECHO criteria. Moreover, the relationship between RA-related disease characteristics and diastolic dysfunction remains incompletely defined.

Early identification of LVDD in asymptomatic patients with inflammatory arthritis may be clinically relevant, as myocardial involvement at this stage may be amenable to modification through control of systemic inflammation and optimization of cardiovascular risk management. Furthermore, understanding the determinants of LVDD within the RA population may facilitate risk stratification and enable targeted cardiovascular surveillance strategies.

Accordingly, this cross-sectional study aimed to determine the frequency of LVDD in patients with RA and compare it with that in patients with another chronic inflammatory condition, spondyloarthritis (SpA), as well as in healthy controls. We performed a multivariable analysis to identify independent factors associated with LVDD in the RA population.

Materials and Methods

Study Design and Population

This cross-sectional study was conducted at the rheumatology outpatient clinic of our institution over a one-year period. A total of 146 consecutive patients with RA fulfilling the 2010 American College of Rheumatology/European League Against Rheumatism classification criteria, and 52 consecutive patients with SpA meeting the 2009 Assessment of SpondyloArthritis International Society criteria, were initially screened for eligibility.[9,10] In addition, age- and sex-matched healthy individuals without a history of inflammatory rheumatic or cardiovascular disease were recruited from hospital staff and the general community.

Exclusion criteria were advanced age (≥70 years), severe obesity (body mass index ≥35 kg/m^2), diabetes mellitus (DM), coronary artery disease (CAD), cerebrovascular disease, uncontrolled hypertension, and clinically significant valvular heart disease. Following application of these criteria, 31 RA patients were excluded for type 2 DM, 11 for CAD, 1 for cerebrovascular disease, and 20 for advanced age. Among SpA patients, 8 were excluded due to type 2 DM, 2 due to CAD, and 1 due to advanced age. After these exclusions, 83 patients with RA and 41 patients with SpA (27 ankylosing spondylitis, 12 psoriatic arthritis, 2 inflammatory bowel disease-associated arthritis) remained eligible and were included in the final analysis, along with 39 healthy controls.

Ethical approval was obtained from the İstanbul Bilim University Clinical Research Ethics Committee (approval number: 19.01.2016/44-319, date: 21.01.2016). The study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent.

ECHO Assessment

Transthoracic echocardiography was performed on all participants in the left lateral decubitus position using a General Electric Vivid S6 system, equipped with a 2.5-4 MHz transducer. Simultaneous electrocardiographic monitoring was performed throughout to ensure cardiac rhythm tracking. Standard two-dimensional images were obtained from the parasternal long- and short-axis views and the apical two- and four-chamber views. An experienced cardiologist blinded to the clinical diagnosis performed the examinations, and standard two-dimensional, M-mode, pulsed-wave Doppler, and tissue Doppler imaging techniques were applied in accordance with current ECHO guideline recommendations.

LVDD was assessed using a multiparametric ECHO approach based on the transmitral inflow and tissue Doppler measurements available at the time of the study. The assessment included early (E) and late (A) transmitral flow velocities, E/A ratio, E-wave deceleration time (DT), early diastolic mitral annular velocity (E′), E/E′ ratio, and isovolumic relaxation time (IVRT). Reduced E′ velocity (≤6.5 cm/s), E/A ratio <0.8, DT >200 ms, and IVRT >100 ms were considered ECHO findings consistent with impaired relaxation. The presence of LVDD was determined by the evaluating cardiologists' integrated interpretation of these ECHO parameters rather than by a single parameter or a prespecified number of abnormal parameters. Left atrial volume index and left atrial reservoir strain were not available because data collection preceded the publication of the 2025 American

Society of Echocardiography (ASE) recommendations; therefore, the contemporary 2025 ASE multiparametric algorithm was not applied retrospectively.[11]

Statistical Analysis

Statistical analyses were conducted using IBM Statistical Package for the Social Sciences (SPSS) version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median [interquartile range (IQR)], whereas categorical variables were presented as counts and percentages. Normally distributed continuous variables were analyzed using the Independent Samples t-test or One-Way analysis of variance, while non-normally distributed variables were evaluated with the Mann-Whitney U and the Kruskal-Wallis tests. When the Kruskal-Wallis test indicated significant differences, pairwise comparisons were conducted using the Mann-Whitney U test with Bonferroni correction. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Factors associated with the presence of LVDD in RA patients were analyzed using multivariable logistic regression. Variables that were clinically relevant or that had a p-value <0.05 in the univariable analysis were selected for inclusion in the multivariable logistic regression model. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated, and a two-sided p-value <0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics

A total of 83 patients with RA, 41 patients with SpA, and 39 healthy controls were included in the final analysis. The mean age of the RA group was 47.7±12.3 years, and the median disease duration in RA patients was 69 months (IQR: 42-144). There were no statistically significant differences among the three groups with respect to age, sex distribution, or the prevalence of hypertension, dyslipidemia, and obesity (p>0.05). As expected, C-reactive protein (CRP) levels were significantly higher in both RA and SpA groups than in healthy controls (p=0.001 and p=0.008, respectively), and no significant difference was observed between the two disease groups (p=0.79). The demographic and clinical characteristics of the study groups are summarized in Table 1.

Within the RA cohort, 67.4% were seropositive, 21 patients (25.3%) were receiving biological disease-modifying antirheumatic drugs (bDMARDs), and the mean Disease Activity Score in 28 joints (DAS28) score was 3.36±1.2. In the SpA group, 41.4% of patients were receiving bDMARDs, and the mean Bath Ankylosing Spondylitis Disease Activity Index score was 2.75±2.04.

ECHO Findings

Transmitral inflow and tissue Doppler parameters were assessed in all participants, revealing similar diastolic function profiles across the three groups. No statistically significant differences were observed among the RA, SpA, and healthy control groups with respect to E wave, A wave, E/A ratio, E′ velocity, E/E′ ratio, IVRT, and DT (p>0.05) (Table 2). LVDD was observed in 27 patients with RA (32.5%), 9 patients with SpA (21.9%), and 9 healthy controls (23.1%). The prevalence of LVDD did not differ significantly among the three groups (p>0.05).

Factors Associated with LVDD in RA Patients

Logistic regression analysis was performed to identify independent predictors of LVDD in RA patients. Older age (p<0.01) and ever smoking (p=0.04) were associated with LVDD, whereas obesity, hypertension, dyslipidemia, disease duration, DAS28 score, CRP level, seropositivity, and bDMARD use were not significantly associated with LVDD in the univariable analysis. Based on clinical relevance, dyslipidemia, disease duration, and DAS28 score were included in the multivariable model. In the

Table 1. Demographic and clinical characteristics of the study groups

	RA (n=83)	SpA (n=41)	HC (n=39)	p
Gender, female/male	68/15	30/11	34/5	0.26
Age, years (mean±SD)	47.7±12.3	45.5±10.4	46.3±7	0.53
Disease duration, months [median (IQR)]	69 (42-144)	64 (36-123)		
BMI, kg/m² (mean±SD)	25.9±4.03	27.3±4.29	26.4±3.69	0.2
Obesity, n (%)	15 (18.07)	13 (31.7)	8 (20.5)	0.21
Hypertension, n (%)	25 (30.1)	10 (24.3)	5 (12.8)	0.11
Antihypertensive therapy, n (%)	18 (21.6)	7 (17)	4 (10.2)	0.3
Dyslipidemia, n (%)	10 (12.04)	5 (12.19)	1 (2.5)	0.21
Lipid-lowering treatment, n (%)	7 (8.4)	4 (9.7)	1 (2.5)	0.4
Smoking (ever), n (%)	33 (39.7)	22 (53.6)	14 (35.8)	0.21
C-reactive protein (mg/dL) [median (IQR)]	0.33 (0.14-0.69)	0.34 (0.1-0.83)	0.13 (0.07-0.28)	**0.003***

BMI: Body mass index, HC: Healthy controls, RA: Rheumatoid arthritis, SpA: Spondyloarthritis
*Post-hoc analysis p=0.003 Kruskal-Wallis test (RA vs. SpA p=0.79, RA vs. HC p=0.001, SpA vs. HC p=0.008, Mann-Whitney U test)

multivariable analysis, increasing age [OR: 1.11 (95% CI: 1.05-1.18), p<0.01] and a history of smoking [OR: 3.08 (95% CI: 1.01-9.33), p=0.04] emerged as independent predictors of LVDD, whereas dyslipidemia, disease duration, and DAS28 score were not independently associated with LVDD (Table 3).

Discussion

Cardiovascular involvement in RA is well recognized, and several ECHO studies have reported subclinical diastolic abnormalities even in patients without overt cardiovascular disease. The reported prevalence of LVDD in RA varies widely in the literature, ranging from approximately 26% to 75%, likely reflecting heterogeneity in study populations, as well as differences in ECHO techniques or in the criteria used to define diastolic dysfunction.[7,8,12-16] Consistent with this variability, previous studies have yielded conflicting results regarding whether diastolic dysfunction is significantly increased in RA patients compared with healthy controls.[7,8,15,17] Given this wide range and the lack of consistent data, we designed the present study to evaluate the frequency of LVDD in our RA cohort, where it was detected in 32.5% of patients. Although this frequency falls within the previously reported range, it was numerically higher than in the SpA (21.9%) and healthy control (23.1%) groups; the difference did not reach statistical significance.

Several factors are known to influence myocardial dysfunction, including increased systemic inflammation. Some studies have reported associations between higher disease activity[14,18] and longer disease duration[7,17,19] with diastolic dysfunction. Stepniak et al. reported that the prevalence of diastolic dysfunction in RA patients with sustained low disease activity was comparable to that of healthy controls.[7] In our cohort, disease activity in the RA group was predominantly low- to- moderate (mean DAS28=3.36). Therefore, the relatively well-controlled inflammatory status of our patients may have attenuated potential differences in LVDD between the study groups, consistent with the observed absence of significant differences in LVDD and other ECHO parameters in our study.

In our study, despite excluding major cardiovascular risk factors including advanced age, severe obesity, DM, established cardiovascular disease, and uncontrolled hypertension, LVDD was still detected in nearly one-third of RA patients. This finding is clinically relevant given the well-recognized association between diastolic dysfunction and unfavorable cardiovascular outcomes. Early detection of LVDD is therefore important for identifying and managing modifiable cardiovascular risk factors and for initiating timely therapeutic interventions.

Multivariable analysis revealed that increasing age and ever smoking were independent predictors of LVDD. Several previous

Table 2. Echocardiographic parameters of patients with RA, SpA and healthy controls

	RA (n=83)	SpA (n=41)	HC (n=39)	p
E m/s (mean±SD)	0.77±0.14	0.79±0.18	0.82±0.17	0.25
A m/s (mean±SD)	0.73±0.15	0.71±0.16	0.71±0.15	0.71
E/A ratio [median (IQR)]	1.05 (0.82-1.28)	1.12 (0.9-1.4)	1.15 (0.93-1.32)	0.24
E' m/s [median (IQR)]	0.12 (0.10-0.15)	0.12 (0.1-0.14)	0.13 (0.09-0.15)	0.83
E/E' ratio [median (IQR)]	5.59 (4.53-7)	5.92 (4.62-7.52)	6.11 (5.15-7.64)	0.23
DT ms [median (IQR)]	194 (178-232)	205 (177-238.5)	183 (168-206)	0.07
IVRT ms [median (IQR)]	94 (87-104)	94 (88-98)	92 (88-94)	0.12

A: Late diastolic flow velocity, DT: Deceleration time, E: Early diastolic flow velocity, E': Early diastolic mitral annular velocity, HC: Healthy controls, IVRT: Isovolumic relaxation time, RA: Rheumatoid arthritis, SpA: Spondyloarthritis

Table 3. Factors associated with left ventricular diastolic dysfunction in patients with rheumatoid arthritis

	Univariable analysis		Multivariable analysis	
	Odds ratio (95% CI)	p	Odds ratio (95% CI)	p
Age	1.08 (1.03-1.13)	**<0.01**	1.11 (1.05-1.18)	**<0.01**
Hypertension	0.92 (0.35-2.63)	0.9	-	
Dyslipidemia	3.71 (0.95-14.5)	0.06	1.86 (0.38-9.10)	0.44
Smoking (ever)	3.42 (1.08-10.7)	**0.04**	3.08 (1.01-9.33)	**0.04**
Obesity	0.71 (0.2-2.48)	0.59	-	
Disease activity score (DAS28)	1.13 (0.35-2.63)	0.52	1.09 (0.70-1.71)	0.68
Disease duration	1.005 (0.99-1.01)	0.12	1.005 (0.99-1.01)	0.15
bDMARD use	1.76 (0.56-5.45)	0.32	-	
Seropositivity	0.52 (0.15-1.76)	0.29	-	

bDMARD: Biological disease-modifying antirheumatic drug

RA studies have similarly reported age as an important predictor of diastolic dysfunction.[7,15,18] The independent association with smoking is also clinically meaningful, as smoking promotes endothelial dysfunction, oxidative stress, and myocardial remodeling, all of which may contribute to impaired diastolic function.[4,16] In contrast, RA-related variables such as DAS28, disease duration, and bDMARD use were not associated with LVDD in our cohort; however, disease activity was generally low to moderate, and disease duration was relatively short. These results suggest that, in well-controlled RA populations, traditional cardiovascular risk factors, particularly age and smoking history may play a more prominent role than RA-related variables in the development of diastolic dysfunction.

Study Limitations

This study has several limitations. First, given the cross-sectional design, a causal relationship between inflammatory rheumatic diseases and LVDD cannot be established, therfore the findings should be interpreted as associations. In addition, our assessment of inflammatory burden was limited to cross-sectional measures of disease activity, and data on cumulative glucocorticoid exposure were unavailable. Therefore, the potential contribution of cumulative inflammatory burden and glucocorticoid exposure to LVDD cannot be excluded. Although smoking was independently associated with LVDD, detailed smoking exposure data, including pack-years and smoking duration, were not available; therefore, the effect of cumulative smoking exposure could not be assessed. Second, although patients with known cardiovascular diseases were excluded, the presence of subclinical cardiac conditions cannot be entirely ruled out. In addition, ECHO measurements were obtained at a single time point, precluding evaluation of changes in diastolic function over time. Third, the sample size was determined by the number of consecutive patients meeting the predefined eligibility criteria during the study period rather than by a priori sample size calculation. Therefore, the relatively small sample size, particularly in the SpA and healthy control groups, may have limited the statistical power to detect between-group differences, and the possibility of a type II error cannot be excluded. Given the limited number of LVDD events, the multivariable findings should also be interpreted with caution. Finally, given that our cohort predominantly consisted of patients with low to moderate disease activity and relatively well-controlled RA, the results may differ in populations with more severe disease or higher cumulative inflammatory burden.

Conclusion

In this cross-sectional study, the frequency of LVDD was numerically higher in patients with RA compared with patients with SpA and healthy controls; however, this difference did not reach statistical significance. Among patients with RA, increasing age and a history of smoking emerged as independent predictors of LVDD, whereas disease activity, disease duration, and bDMARDs use were not significantly associated with LVDD. These findings suggest that traditional cardiovascular risk factors may play a more prominent role in the development of diastolic dysfunction among patients with RA than the disease-related variables evaluated in this study. However, given the cross-sectional design of the study, these findings should be interpreted with caution. Further large-scale prospective studies are warranted to clarify these relationships and better define the long-term cardiac outcomes associated with inflammatory rheumatic diseases.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the İstanbul Bilim University Clinical Research Ethics Committee (approval number: 19.01.2016/44-319, date: 21.01.2016).

Informed Consent: All participants provided written informed consent.

Footnotes

This study was accepted as a poster at the 22nd National Congress of Rheumatology. Akleylek C, Üçer M, Elçioğlu Cengiz B, Şahin T, Yılmaz N. Romatoid artrit hastalarında sol ventrikül diyastolik disfonksiyonunu belirleyen faktörler. Ulusal Romatoloji Dergisi. 2022;14(Ek Sayı 1):61.

Authorship Contributions

Concept: C.A., B.C.E., Ş.T.Ş., N.Y., Design: C.A., B.C.E., Ş.T.Ş., N.Y., Data Collection and Processing: C.A., M.Ü., B.C.E., Ş.T.Ş., N.Y., Analysis or Interpretation: C.A., M.Ü., B.C.E., Ş.T.Ş., N.Y., Literature Search: C.A., Ş.T.Ş., N.Y., Writing: C.A., N.Y.

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

Financial Disclosure: The authors declare that they have no relevant financial disclosures.

References

1. Avina-Zubieta JA, Thomas J, Sadatsafavi M, Lehman AJ, Lacaille D. Risk of incident cardiovascular events in patients with rheumatoid arthritis: a meta-analysis of observational studies. Ann Rheum Dis. 2012;71:1524-9.
2. Aviña-Zubieta JA, Choi HK, Sadatsafavi M, Etminan M, Esdaile JM, Lacaille D. Risk of cardiovascular mortality in patients with rheumatoid arthritis: a meta-analysis of observational studies. Arthritis Rheum. 2008;59:1690-7
3. Mutru O, Laakso M, Isomäki H, Koota K. Cardiovascular mortality in patients with rheumatoid arthritis. Cardiology. 1989;76:71-7.
4. Qian Y, Zhang B, Nian F. The association between rheumatoid arthritis and left ventricular diastolic dysfunction: pathogenesis, predictors and managements. Clin Exp Rheumatol. 2025;43:135-44.

5. Redfield MM, Jacobsen SJ, Burnett JC Jr, Mahoney DW, Bailey KR, Rodeheffer RJ. Burden of systolic and diastolic ventricular dysfunction in the community: appreciating the scope of the heart failure epidemic. JAMA. 2003;289:194-202.

6. Kane GC, Karon BL, Mahoney DW, et al. Progression of left ventricular diastolic dysfunction and risk of heart failure. JAMA. 2011;306:856-63.

7. Targońska-Stępniak B, Biskup M, Biskup W, Majdan M. Diastolic dysfunction in rheumatoid arthritis patients with low disease activity. Clin Rheumatol. 2019;38:1131-7.

8. Abdul Muizz AM, Mohd Shahrir MS, Sazliyana S, Oteh M, Shamsul AS, Hussein H. A cross-sectional study of diastolic dysfunction in rheumatoid arthritis and its association with disease activity. Int J Rheum Dis. 2011;14:18-30.

9. Aletaha D, Neogi T, Silman AJ, et al. 2010 Rheumatoid arthritis classification criteria: an American College of Rheumatology/European League Against Rheumatism collaborative initiative. Arthritis Rheum. 2010;62:2569-81.

10. Rudwaleit M, van der Heijde D, Landewé R, et al. The development of Assessment of SpondyloArthritis international Society classification criteria for axial spondyloarthritis (part II): validation and final selection. Ann Rheum Dis. 2009;68:777-83.

11. Nagueh SF, Sanborn DY, Oh JK, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography and for heart failure with preserved ejection fraction diagnosis: an update from the American Society of Echocardiography. J Am Soc Echocardiogr. 2025;38:537-69.

12. Heslinga SC, Van Dongen CJ, Konings TC, et al. Diastolic left ventricular dysfunction in ankylosing spondylitis--a systematic review and meta-analysis. Semin Arthritis Rheum. 2014;44:14-9.

13. Romand X, Adeline F, Dalecky M, et al. Systematic assessment of heart valves and cardiac function by echocardiography in axial spondyloarthritis: A systematic review and meta-analysis. Joint Bone Spine. 2022;89:105375.

14. Alpaydın S, Buyukterzi Z, Akkurt HE, Yılmaz H. Impaired left ventricular diastolic functions and thickened epicardial adipose tissue in rheumatoid arthritis patients is correlated with DAS-28 score. Acta Cardiol Sin. 2017;33:182-7.

15. Yazici D, Tokay S, Aydin S, et al. Echocardiographic evaluation of cardiac diastolic function in patients with rheumatoid arthritis: 5 years of follow-up. Clin Rheumatol. 2008;27:647-50.

16. Schau T, Gottwald M, Arbach O, et al. Increased prevalence of diastolic heart failure in patients with rheumatoid arthritis correlates with active disease, but not with treatment type. J Rheumatol. 2015;42:2029-37.

17. Udayakumar N, Venkatesan S, Rajendiran C. Diastolic function abnormalities in rheumatoid arthritis: relation with duration of disease. Singapore Med J. 2007;48:537-42.

18. Park E, Ito K, Iqbal R, et al. Prospective changes in diastolic function in patients with rheumatoid arthritis. Arthritis Res Ther. 2022;24:184.

19. Liang KP, Myasoedova E, Crowson CS, et al. Increased prevalence of diastolic dysfunction in rheumatoid arthritis. Ann Rheum Dis. 2010;69:1665-70.