J Rheum Dis 2024;31(4):193-199
https://doi.org/10.4078/jrd.2024.0077
pISSN: 2093-940X, eISSN: 2233-4718

Review Article

Application of disease activity index in rheumatoid arthritis management in Korea

Se Rim Choi, M.D., M.S.[1,2], Soo-Kyung Cho, M.D., Ph.D.[1,2], Yoon-Kyoung Sung, M.D., Ph.D., M.P.H.[1,2]

[1]Department of Rheumatology, Hanyang University Hospital for Rheumatic Diseases, [2]Hanyang University Institute for Rheumatology Research, Seoul, Korea

Effective management of rheumatoid arthritis (RA) necessitates the accurate measurement of disease activity using a treat-to-target strategy established as a cornerstone approach. Disease activity assessment tools such as the Disease Activity Score in 28 joints (DAS28), Simplified Disease Activity Index, Clinical Disease Activity Index, and Routine Assessment of Patient Index Data 3 have been internationally validated and recognised. In Korea, the government initiated a quality assessment program mandating routine measurement of DAS28 to ensure high-quality RA management. However, whether the DAS28 is the most suitable disease activity measurement tool in the Korean clinical environment is a topic worth considering. In this review, we comprehensively examined disease activity measurement tools and their performance in the Korean context. We also propose a new strategy for measuring RA disease activity, tailored to the different situations encountered by physicians in routine clinical practice. This review may contribute to the improvement of the quality of care for patients with RA in Korea.

Keywords: Rheumatoid arthritis, Severity of illness index, Outcome assessment, Korea

INTRODUCTION

Rheumatoid arthritis (RA) is the most common inflammatory polyarthritis characterised by symmetrical involvement of the peripheral joints, which causes joint deformity and progressive physical disability [1]. Its global prevalence is approximately 0.5%, although it varies considerably among populations [2]. In Korea, the estimated prevalence of RA ranges from 0.27% to 1.85% [3], and the incidence rate is approximately 28.5~42.0 per 100,000 person-years [4,5]. The degree of functional impairment in RA affects both the health-related quality of life (HRQoL) and economic burden of the illness [6]. RA contributes the most to the total direct medical cost of autoimmune inflammatory rheumatic diseases in Korea and has been rapidly increasing over time [7].

The primary goals of RA management are to achieve long-term HRQoL through symptom control, prevention of structural damage, and normalisation of function [8]. To achieve this goal, the treat-to-target (T2T) strategy was introduced in 2010 [9]. The basic concept of the T2T strategy is to intensify treatment until the target is reached, which is defined as remission or low disease activity (LDA) [9]. Adherence to the T2T strategy is superior to conventional therapeutic approaches for RA in improving functional disabilities and structural damages [10]. The official guidelines for RA management from the European Alliance of Associations for Rheumatology (EULAR) and the American College of Rheumatology (ACR) have endorsed the T2T strategy since the concept was first presented in 2010 [11,12] and remain valid in their latest versions [13,14].

To adhere to the T2T strategy, the International Task Force

Received June 24, 2024; **Revised** July 8, 2024; **Accepted** July 8, 2024, **Published online** August 2, 2024

Corresponding author: Yoon-Kyoung Sung, https://orcid.org/0000-0001-6691-8939
Department of Rheumatology, Hanyang University Hospital for Rheumatic Diseases, 222-1 Wangsimni-ro, Seongdong-gu, Seoul 04763, Korea. **E-mail:** sungyk@hanyang.ac.kr

recommends that quantitative measures of disease activity be obtained and documented regularly in routine clinical practice [8]. The routine use of disease activity measures may be required by payers or governments to demonstrate good quality of care [15]. Because of the efforts of the Korean College of Rheumatology and rheumatologists in Korea, the Disease Activity Score in 28 joints (DAS28) became reimbursable from October 2023 onwards, laying the foundation for implementing the T2T strategy in clinical practice. In line with the DAS28 reimbursement, the Health Insurance Review and Assistance (HIRA), a Korean government agency, began quality assessments for RA management in April 2024 to provide effective medical services to Korean patients with RA. The indicators included early prescription of disease-modifying antirheumatic drugs (DMARDs), regular monitoring of laboratory tests, uninterrupted prescription of DMARDs, regular measurement of disease activity, and the proportion of patients achieving remission or LDA. The DAS28 method was selected for measuring disease activity and determining remission or LDA.

This study aimed to review the performance of RA disease activity measurements in the Korean population and evaluate the strengths and weaknesses of each tool in the Korean healthcare environment. Additionally, we aimed to anticipate the advantages and disadvantages of RA disease evaluation based on the DAS28 and discuss how the utilisation of disease assessment tools should be expanded in various contexts.

MAIN SUBJECTS

Performance of disease activity measures in patients with rheumatoid arthritis

Since the first composite disease activity measurement tool for RA was developed in the 1950s [16], RA disease activity monitoring has been improved. Amid this proliferation of measurement tools, the ACR committee has provided guidelines indicating which RA disease activity measures are best suited for regular use [17,18]. The initial 2012 recommendations included six RA disease activity measures as follows: Clinical Disease Activity Index (CDAI), DAS28, Patient Activity Scale (PAS), Patient Activity Scale-II (PAS-II), Routine Assessment of Patient Index Data 3 (RAPID3), and Simplified Disease Activity Index (SDAI) [17]. The recommendations updated in 2019 [18] were largely unchanged from those previously recommended, although the PAS was not recommended for preferred use in the updated recommendations.

The following section summarises the reliability of disease activity measurement tools for patients with RA, with a particular focus on the Korean population. PAS and PAS-II, which are not commonly used in the Korean population, were excluded.

1) DAS28 with erythrocyte sedimentation rate or C-reactive protein

The DAS28 based on erythrocyte sedimentation rate (DAS28-ESR) is one of the most historic and widely used measures that have been extensively validated in western populations for its use in clinical trials and practice [19-24]. In the Korean population, a lower DAS28-ESR score was associated with better HRQoL and less functional disability in patients with RA [25]. RA management using the T2T strategy targeting remission or LDA based on the DAS28-ESR significantly improved functional outcomes compared to usual care in Korean patients [26].

Although the DAS28-ESR inherently possesses characteristics as a reference standard, the performance of DAS28 based on C-reactive protein level (DAS28-CRP) in the Korean population mostly has been compared with that of the DAS28-ESR. The DAS28-CRP levels had a strong linear correlation with DAS28-ESR (correlation coefficient: 0.87~0.93), indicating its validity as a disease activity measure [27-29]. However, the DAS28-CRP levels were lower than the DAS28-ESR within the same study populations [28,29], and the comparison of disease activity categories based on DAS28-ESR and DAS28-CRP levels showed suboptimal agreements (Cohen's κ: 0.40~0.45). Thus, although the DAS28-CRP levels can reliably measure RA disease activity, they may underestimate disease activity compared with DAS28-ESR.

2) Simplified disease activity index and clinical disease activity index

Since the SDAI and CDAI were originally developed and validated in western populations [30], these indices demonstrated excellent correlations with the DAS28 in other populations [31,32]. The SDAI and CDAI also had a strong linear correlation with the DAS28-ESR in Korean patients with RA, with correlation coefficients of 0.85 and 0.84, respectively [27]. However, disease activity categories based on SDAI or CDAI showed discrepancies from those based on DAS28-ESR [27]. In particular, remission as defined by the SDAI or CDAI was more stringent than DAS28 remission. For example, the remission rates in Ko-

rean patients treated with biologic or targeted synthetic (b/ts) DMARDs ranged from 10% to 13% based on the SDAI or CDAI and from 36% to 56% based on the DAS28 [33]. Thus, the SDAI and CDAI are comparable with the DAS28-ESR as indicators of disease activity in Korean patients with RA, although they are more stringent in classifying patients as having achieved remission.

3) Routine assessment of patient index data 3

Several studies in different ethnic populations have demonstrated that RAPID3 provides similar information regarding disease activity as other quantitative disease activity instruments, such as DAS28, CDAI, or SDAI [34-36]. In Korean patients with RA, RAPID3 scores significantly correlated with DAS28 (correlation coefficient: 0.62), SDAI (correlation coefficient: 0.74), and CDAI (correlation coefficient: 0.75) [37]. However, the agreement of disease activity in remission to low-activity status demonstrated a discrepancy. For example, approximately 90% of patients who showed moderate or high disease activity according to the DAS28, CDAI, and SDAI also exhibited moderate or higher disease activity when assessed using the RAPID3 criteria. Meanwhile, only 50% of patients who were classified as having LDA or remission using other methods showed LDA when assessed using the RAPID3. Thus, the RAPID3 reflects disease activity, although it has better agreement with other disease activity tools in patients with higher disease activity than in those with lower disease activity.

Preferred disease activity measures for routine clinical use in Korea

DAS28-ESR, DAS28-CRP, CDAI, SDAI, and RAPID-3 all comparably reflected disease activity in Korean patients with RA, but with slight differences between each index, as described above. To date, rheumatologists have utilised various disease activity assessment tools, as permitted in clinical practice and research. However, owing to recently implemented reimbursement policies and quality indicators, the standardisation of a single measure, DAS28, is likely to have both benefits and drawbacks. Therefore, while not disputing the fact that the DAS28 is a qualified tool for disease activity assessment, how other useful disease activity measurements can be utilised needs to be considered.

1) Critical appraisal of routine measurements of DAS28

The DAS28 method is the most established composite measure for assessing RA disease activity. The DAS28 is familiar to both clinicians and administrators because the Korean National Health Insurance reimbursement criteria for b/tsDMARDs are based on disease activity in the DAS28 [38]. However, the major drawbacks of these methods include discrepancies between DAS28-ESR and DAS28-CRP levels and misclassification of disease activity in patients with certain phenotypes. There are also ongoing international efforts to address the limitations of DAS28 and improve its accuracy in assessing disease activity.

Clinicians may assume that DAS28 assessments based on ESR or CRP levels are interchangeable. The current policy of the HIRA for quality assessment adopts DAS28 as a standard disease activity measure without specifying whether ESR or CRP levels should be used. However, as mentioned earlier, DAS28-CRP levels tend to underestimate disease activity compared with DAS28-ESR in Korean patients with RA. These observations are not limited to Korean patients as these have also been consistently observed in other regions and ethnicities [39-41]. Conversely, DAS28-ESR may overestimate disease activity compared with DAS28-CRP levels, especially in female patients or those with longer disease duration [42]. Therefore, selecting DAS28 as a standard measurement in routine clinical practice without specifying DAS28-ESR or DAS28-CRP may result in a loss of continuity in the comparative assessments of disease activity. In addition, disease activity categories [27,43] and treatment responses [28] are inconsistently classified when DAS28-ESR and DAS28-CRP are used interchangeably.

Moreover, DAS28 may misclassify disease activity in patients with certain RA phenotypes. For example, patients using specific bDMARDs such as tocilizumab showed a discrepancy between disease activity measured by DAS28 and other disease activity indices. Korean patients with RA receiving tocilizumab were 5 to 7 times more frequently to achieve remission based on the DAS28, compared with assessment based on the SDAI or CDAI [33]. A significant proportion of patients treated with tocilizumab had at least two swollen joints when in DAS28 remission [33]. In another example, misjudgement for disease activity was also possible in patients with RA with ankle and foot joint involvement when using the DAS28. Korean patients with RA in DAS28 remission frequently have residual disease activity in the ankle and foot joints [44]. Overall, over 10% of patients in remission, as assessed by DAS28, had swollen joints in the foot

and/or ankle. Considering that a significant proportion of Korean patients with RA have foot and/or ankle involvement [45], their clinical significance should not be ignored.

Finally, DAS28 has faced criticism for not always aligning with the objectively measured degree of inflammation [46]. Among the four components of DAS28, the swollen joint count and the acute inflammation reactants better predicted imaging-confirmed synovitis than the other components–tender joint count and patient global assessment [47,48]. Therefore, some researchers have proposed modified DAS formulas that reweight these components, which have shown stronger associations with radiographic damage [47,48]. While the accuracy of these modifications has yet to be investigated in the Korean population, their potential benefit over the current DAS28 method warrant further study.

2) Disease activity measurements to be additionally used and their contexts in the era of DAS28

(1) Identification of patients with rheumatoid arthritis in remission

Although LDA and remission have similar statuses based on the T2T concept, remission is particularly important for identifying patients with better outcomes [49], who may be suitable for tapering DMARDs [14]. The clinical significance of RA remission is the absence of signs and symptoms of significant inflammatory disease activity [9]. Physicians cannot rely on DAS28 criteria to determine remission because patients in DAS28 remission commonly experience residual joint inflammation [33,44,45]. In one study, up to 50% of patients in DAS28 remission showed active joint inflammation on ultrasonography [50]. Thus, DAS28 is no longer recommended for defining remission in the international guidelines [51].

In 2011, the ACR and EULAR established a new definition of remission using the Boolean approach, ensuring uniform reporting of outcomes [51]. The Boolean definition to attain remission was defined as each of four core variables (tender joint count, swollen joint count, patient global assessment [PtGA] of disease activity on a 0~10 cm, and CRP level in mg/dL) having a value of ≤1. Analysis of pre-existing clinical trial data on patients with RA suggested that the Boolean criteria later predicted good radiographic and functional outcomes, although DAS28-based measures of remission did not [51]. Since then, the requirement of achieving a PtGA score of ≤1 has been criticised to be excessively strict [52,53], and the updated ACR/EULAR remission definition (Boolean criteria 2.0) [54] has increased the threshold for PtGA to 2 cm. Boolean criteria 2.0 maintained its predictive value for radiographic or functional outcomes and improved the agreement between the Boolean criteria and other index-based remission criteria [54].

Therefore, the use of Boolean remission criteria instead of DAS28 in our clinical practice may be worth considering, aligning with updates in international guidelines [14,51]. Further research is needed to confirm whether Boolean remission enhances long-term outcomes in Korean patients.

(2) Adjustment of treatments based on disease activity

If a patient exhibits disease activity that exceeds low levels, disease activity measurements serve to guide treatment adjustments [9]. The T2T approach targeting DAS28 LDA or remission results in superior radiographic and functional outcomes compared with the standard routine care for RA [10]. Interestingly, a recent meta-analysis indirectly has showed that a T2T strategy aimed at SDAI-LDA was superior to one aimed at DAS28-LDA in achieving remission according to the DAS28, SDAI, or Boolean criteria [55]. Nonetheless, no significant differences in HRQoL or radiographic progression were observed between the two strategies [55]. Therefore, a systematic study is required to determine the optimal criteria for treatment modification in Korean patients with RA. Currently, various disease activity assessment tools can be used; nevertheless, consistently using a single method is necessary to track changes in disease activity. In particular, the interchangeable use of DAS28-ESR and DAS28-CRP levels for assessment should be avoided.

(3) Disease activity measurements in the telehealth settings

The first two scenarios assumed face-to-face patient encounters in a clinic, which has been the norm to date. However, the coronavirus disease 2019 pandemic has highlighted the need to care for patients with RA in telehealth settings [56]. Most studies on telemedicine for RA have evaluated disease activity using DAS28 as an outcome after adopting consultation-based telemedicine as an adjuvant for in-person visits [57]. However, studies that remotely assess composite disease activity to make therapeutic decisions via telemedicine have been limited to date [58].

Recently, disease activity indices such as DAS28 and CDAI have been adopted to better accommodate telehealth contexts

by substituting provider joint counts with patient-assessed joint counts and omitting acute-phase reactants [56]. The development and validation of these modified versions are warranted in the forthcoming telemedicine era. Measurements composed of patient-reported items such as RAPID3 are readily available and require minimal adjustments for use in telemedicine settings [56]. Although changes in RAPID-3 over time are not directly proportional to changes in other disease activity indices [59], it is as sensitive as DAS28 and CDAI in distinguishing active from control treatments in clinical trials [60]. Therefore, the feasibility and long-term impact of RAPID3 use in telehealth settings in Korea should be explored. Additionally, studies using advanced cameras and digital devices to accurately assess swelling and tenderness in 28 joints of patients and comparing these results with those of physician assessments need to be conducted.

CONCLUSION

Quantitative measures of disease activity are fundamental to the management of RA. Several disease activity measures, including DAS28-ESR, DAS28-CRP, SDAI, CDAI, and RAPID3 have been validated and compared in Korean patients with RA. Although DAS28-ESR and DAS28-CRP levels are widely used, discrepancies between them require careful consideration. SDAI, CDAI, and RAPID3 also performed excellently in reflecting disease activity and are comparable to DAS28. All indices can be used to optimise treatment based on disease activity; however, consistent use of a single measure is advised to avoid misclassification.

In this review, we summarised realistic expectations and concerns regarding the standardisation of DAS28. In particular, we provided suggestions on how to define remission and the application of disease activity measurements in telehealth settings. With the recent decision to reimburse DAS28 measurement, we anticipate significant improvements in clinical practice and patient outcomes for RA in Korea. This development is expected to enhance the precision of treatment adjustments and overall disease management. We believe that systematic research on these aspects is necessary in the future.

FUNDING

This research was funded by the Korean College of Rheumatology and supported by the Korea Health Technology R&D Project through the Patient-Doctor Shared Decision Making Research center (PDSDM), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI23C1762).

ACKNOWLEDGMENTS

None.

CONFLICT OF INTEREST

S.K.C. has been an editorial board member of the Journal of Rheumatic Diseases since June 2020, but has no role in the decision to publish this article.

AUTHOR CONTRIBUTIONS

Y.K.S. and S.R.C. conceived of and designed the study. Y.K.S., S.K.C., and S.R.C. were responsible for data acquisition, analysis, and interpretation. S.R.C. drafted the manuscript. Y.K.S., S.K.C., and S.R.C. critically reviewed and revised the manuscript. All the authors approved the final version of the manuscript.

ORCID

Se Rim Choi, https://orcid.org/0000-0002-4625-8571
Soo-Kyung Cho, https://orcid.org/0000-0003-4493-8837
Yoon-Kyoung Sung, https://orcid.org/0000-0001-6691-8939

REFERENCES

1. Di Matteo A, Bathon JM, Emery P. Rheumatoid arthritis. Lancet 2023;402:2019-33.
2. Finckh A, Gilbert B, Hodkinson B, Bae SC, Thomas R, Deane KD, et al. Global epidemiology of rheumatoid arthritis. Nat Rev Rheumatol 2022;18:591-602.
3. Kim H, Sung YK. Epidemiology of rheumatoid arthritis in Korea. J Rheum Dis 2021;28:60-7.
4. Sung YK, Cho SK, Choi CB, Bae SC. Prevalence and incidence of rheumatoid arthritis in South Korea. Rheumatol Int 2013;33:1525-32.
5. Won S, Cho SK, Kim D, Han M, Lee J, Jang EJ, et al. Update on the prevalence and incidence of rheumatoid arthritis in Korea and an analysis of medical care and drug utilization. Rheumatol Int 2018;38:649-56.
6. Lee TJ, Park BH, Son HK, Song R, Shin KC, Lee EB, et al. Cost of illness and quality of life of patients with rheumatoid arthritis in South Korea. Value Health 2012;15(1 Suppl):S43-9.

7. Kim H, Cho SK, Kim JW, Jung SY, Jang EJ, Bae SC, et al. An increased disease burden of autoimmune inflammatory rheumatic diseases in Korea. Semin Arthritis Rheum 2020;50:526-33.
8. Smolen JS, Breedveld FC, Burmester GR, Bykerk V, Dougados M, Emery P, et al. Treating rheumatoid arthritis to target: 2014 update of the recommendations of an international task force. Ann Rheum Dis 2016;75:3-15.
9. Smolen JS, Aletaha D, Bijlsma JW, Breedveld FC, Boumpas D, Burmester G, et al.; T2T Expert Committee. Treating rheumatoid arthritis to target: recommendations of an international task force. Ann Rheum Dis 2010;69:631-7.
10. Stoffer MA, Schoels MM, Smolen JS, Aletaha D, Breedveld FC, Burmester G, et al. Evidence for treating rheumatoid arthritis to target: results of a systematic literature search update. Ann Rheum Dis 2016;75:16-22.
11. Smolen JS, Landewé R, Breedveld FC, Dougados M, Emery P, Gaujoux-Viala C, et al. EULAR recommendations for the management of rheumatoid arthritis with synthetic and biological disease-modifying antirheumatic drugs. Ann Rheum Dis 2010;69:964-75.
12. Singh JA, Furst DE, Bharat A, Curtis JR, Kavanaugh AF, Kremer JM, et al. 2012 Update of the 2008 American College of Rheumatology recommendations for the use of disease-modifying antirheumatic drugs and biologic agents in the treatment of rheumatoid arthritis. Arthritis Care Res (Hoboken) 2012;64:625-39.
13. Fraenkel L, Bathon JM, England BR, St Clair EW, Arayssi T, Carandang K, et al. 2021 American College of Rheumatology guideline for the treatment of rheumatoid arthritis. Arthritis Care Res (Hoboken) 2021;73:924-39.
14. Smolen JS, Landewé RBM, Bergstra SA, Kerschbaumer A, Sepriano A, Aletaha D, et al. EULAR recommendations for the management of rheumatoid arthritis with synthetic and biological disease-modifying antirheumatic drugs: 2022 update. Ann Rheum Dis 2023;82:3-18.
15. van Vollenhoven R. Treat-to-target in rheumatoid arthritis - are we there yet? Nat Rev Rheumatol 2019;15:180-6.
16. Lansbury J. Quantitation of the activity of rheumatoid arthritis. 5. A method for summation of the systemic indices of rheumatoid activity. Am J Med Sci 1956;232:300-10.
17. Anderson J, Caplan L, Yazdany J, Robbins ML, Neogi T, Michaud K, et al. Rheumatoid arthritis disease activity measures: American College of Rheumatology recommendations for use in clinical practice. Arthritis Care Res (Hoboken) 2012;64:640-7.
18. England BR, Tiong BK, Bergman MJ, Curtis JR, Kazi S, Mikuls TR, et al. 2019 Update of the American College of Rheumatology recommended rheumatoid arthritis disease activity measures. Arthritis Care Res (Hoboken) 2019;71:1540-55.
19. Prevoo ML, van 't Hof MA, Kuper HH, van Leeuwen MA, van de Putte LB, van Riel PL. Modified disease activity scores that include twenty-eight-joint counts. Development and validation in a prospective longitudinal study of patients with rheumatoid arthritis. Arthritis Rheum 1995;38:44-8.
20. Prevoo ML, van Gestel AM, van T Hof MA, van Rijswijk MH, van de Putte LB, van Riel PL. Remission in a prospective study of patients with rheumatoid arthritis. American Rheumatism Association preliminary remission criteria in relation to the disease activity score. Br J Rheumatol 1996;35:1101-5.
21. van Gestel AM, Haagsma CJ, van Riel PL. Validation of rheumatoid arthritis improvement criteria that include simplified joint counts. Arthritis Rheum 1998;41:1845-50.
22. Smolen JS, Han C, Bala M, Maini RN, Kalden JR, van der Heijde D, et al.; ATTRACT Study Group. Evidence of radiographic benefit of treatment with infliximab plus methotrexate in rheumatoid arthritis patients who had no clinical improvement: a detailed subanalysis of data from the anti-tumor necrosis factor trial in rheumatoid arthritis with concomitant therapy study. Arthritis Rheum 2005;52:1020-30.
23. Vander Cruyssen B, Van Looy S, Wyns B, Westhovens R, Durez P, Van den Bosch F, et al. DAS28 best reflects the physician's clinical judgment of response to infliximab therapy in rheumatoid arthritis patients: validation of the DAS28 score in patients under infliximab treatment. Arthritis Res Ther 2005;7:R1063-71.
24. Weinblatt ME, Keystone EC, Furst DE, Kavanaugh AF, Chartash EK, Segurado OG. Long term efficacy and safety of adalimumab plus methotrexate in patients with rheumatoid arthritis: ARMADA 4 year extended study. Ann Rheum Dis 2006;65:753-9.
25. Bae SC, Cho SK, Won S, Lee HS, Lee SH, Kang YM, et al. Factors associated with quality of life and functional disability among rheumatoid arthritis patients treated with disease-modifying anti-rheumatic drugs for at least 6 months. Int J Rheum Dis 2018;21:1001-9.
26. Song JJ, Song YW, Bae SC, Cha HS, Choe JY, Choi SJ, et al. Treat-to-target strategy for Asian patients with early rheumatoid arthritis: result of a multicenter trial in Korea. J Korean Med Sci 2018;33:e346.
27. Park SY, Lee H, Cho SK, Choi CB, Sung YK, Bae SC. Evaluation of disease activity indices in Korean patients with rheumatoid arthritis. Rheumatol Int 2012;32:545-9.
28. Son KM, Kim SY, Lee SH, Yang CM, Seo YI, Kim HA. Comparison of the disease activity score using the erythrocyte sedimentation rate and C-reactive protein levels in Koreans with rheumatoid arthritis. Int J Rheum Dis 2016;19:1278-83.
29. Choi IA. Comparison of the disease activity score-28 based on the erythrocyte sedimentation rate and C-reactive protein in rheumatoid arthritis. J Rheum Dis 2017;24:287-92.
30. Aletaha D, Smolen J. The Simplified Disease Activity Index (SDAI) and the Clinical Disease Activity Index (CDAI): a review of their usefulness and validity in rheumatoid arthritis. Clin Exp Rheumatol 2005;23(5 Suppl 39):S100-8.
31. Slama IB, Allali F, Lakhdar T, El Kabbaj S, Medrare L, Ngeuleu A, et al. Reliability and validity of CDAI and SDAI indices in comparison to DAS-28 index in Moroccan patients with rheumatoid arthritis. BMC Musculoskelet Disord 2015;16:268.
32. Dhaon P, Das SK, Srivastava R, Dhakad U. Performances of Clinical Disease Activity Index (CDAI) and Simplified Disease Activity Index (SDAI) appear to be better than the gold standard Disease Assessment Score (DAS-28-CRP) to assess rheumatoid arthritis patients. Int J Rheum Dis 2018;21:1933-9.
33. Koh JH, Lee Y, Kim HA, Kim J, Shin K. Comparison of remission criteria in patients with rheumatoid arthritis treated with biologic or targeted synthetic disease-modifying anti-rheumatic drugs: results from a nationwide registry. Ther Adv Musculoskelet Dis 2022;14:1759720X221096363.
34. Pincus T, Swearingen CJ, Bergman MJ, Colglazier CL, Kaell AT, Kunath AM, et al. RAPID3 (Routine Assessment of Patient Index Data)

on an MDHAQ (Multidimensional Health Assessment Questionnaire): agreement with DAS28 (Disease Activity Score) and CDAI (Clinical Disease Activity Index) activity categories, scored in five versus more than ninety seconds. Arthritis Care Res (Hoboken) 2010;62:181-9.
35. Bossert M, Prati C, Vidal C, Bongain S, Toussirot E, Wendling D. Evaluation of self-report questionnaires for assessing rheumatoid arthritis activity: a cross-sectional study of RAPID3 and RADAI5 and flare detection in 200 patients. Joint Bone Spine 2012;79:57-62.
36. Singh H, Gupta V, Ray S, Kumar H, Talapatra P, Kaur M, et al. Evaluation of disease activity in rheumatoid arthritis by Routine Assessment of Patient Index Data 3 (RAPID3) and its correlation to Disease Activity Score 28 (DAS28) and Clinical Disease Activity Index (CDAI): an Indian experience. Clin Rheumatol 2012;31:1663-9.
37. Kim SK, Park SH, Bae J, Son JT, Choe JY. Performance of Routine Assessment of Patient Index Data 3 (RAPID3) for assessment of rheumatoid arthritis in clinical practice: differential agreement of RAPID3 according to disease activity categories. Rheumatol Int 2014;34:1311-8.
38. Kim Y, Kim GT, Suh YS, Kim HO, Lee HN, Lee SG. The impact of the amendment of the Korean National Health Insurance reimbursement criteria for anti-tumor necrosis factor-α agents on treatment pattern, clinical response and persistence in patients with rheumatoid arthritis. J Rheum Dis 2020;27:159-67.
39. Matsui T, Kuga Y, Kaneko A, Nishino J, Eto Y, Chiba N, et al. Disease Activity Score 28 (DAS28) using C-reactive protein underestimates disease activity and overestimates EULAR response criteria compared with DAS28 using erythrocyte sedimentation rate in a large observational cohort of rheumatoid arthritis patients in Japan. Ann Rheum Dis 2007;66:1221-6.
40. Fleischmann R, van der Heijde D, Koenig AS, Pedersen R, Szumski A, Marshall L, et al. How much does Disease Activity Score in 28 joints ESR and CRP calculations underestimate disease activity compared with the Simplified Disease Activity Index? Ann Rheum Dis 2015;74:1132-7.
41. Fleischmann RM, van der Heijde D, Gardiner PV, Szumski A, Marshall L, Bananis E. DAS28-CRP and DAS28-ESR cut-offs for high disease activity in rheumatoid arthritis are not interchangeable. RMD Open 2017;3:e000382.
42. Castrejón I, Ortiz AM, García-Vicuña R, Lopez-Bote JP, Humbría A, Carmona L, et al. Are the C-reactive protein values and erythrocyte sedimentation rate equivalent when estimating the 28-joint disease activity score in rheumatoid arthritis? Clin Exp Rheumatol 2008;26:769-75.
43. Inoue E, Yamanaka H, Hara M, Tomatsu T, Kamatani N. Comparison of Disease Activity Score (DAS)28- erythrocyte sedimentation rate and DAS28- C-reactive protein threshold values. Ann Rheum Dis 2007;66:407-9.
44. Son KM, Song SH, Lim SK, Seo YI, Kim HA. Characteristics of patients with rheumatoid arthritis in clinical remission: the many aspects of DAS28 remission. Clin Exp Rheumatol 2012;30:947-50.
45. Lee SW, Kim SY, Chang SH. Prevalence of feet and ankle arthritis and their impact on clinical indices in patients with rheumatoid arthritis: a cross-sectional study. BMC Musculoskelet Disord 2019;20:420.
46. Hensor EMA, Conaghan PG. Time to modify the DAS28 to make it fit for purpose(s) in rheumatoid arthritis? Expert Rev Clin Immunol 2020;16:1-4.
47. Baker JF, Conaghan PG, Smolen JS, Aletaha D, Shults J, Emery P, et al. Development and validation of modified disease activity scores in rheumatoid arthritis: superior correlation with magnetic resonance imaging-detected synovitis and radiographic progression. Arthritis Rheumatol 2014;66:794-802.
48. Hensor EMA, McKeigue P, Ling SF, Colombo M, Barrett JH, Nam JL, et al. Validity of a two-component imaging-derived disease activity score for improved assessment of synovitis in early rheumatoid arthritis. Rheumatology (Oxford) 2019;58:1400-9.
49. Radner H, Smolen JS, Aletaha D. Remission in rheumatoid arthritis: benefit over low disease activity in patient-reported outcomes and costs. Arthritis Res Ther 2014;16:R56.
50. Chung SW, Choi JY, Lee SH, Song R, Yang HI, Hong SJ, et al. Predicting imaging remission in rheumatoid arthritis: a case-control ultrasound study. J Korean Med Sci 2020;35:e260.
51. Felson DT, Smolen JS, Wells G, Zhang B, van Tuyl LH, Funovits J, et al. American College of Rheumatology/European League Against Rheumatism provisional definition of remission in rheumatoid arthritis for clinical trials. Arthritis Rheum 2011;63:573-86.
52. Studenic P, Smolen JS, Aletaha D. Near misses of ACR/EULAR criteria for remission: effects of patient global assessment in Boolean and index-based definitions. Ann Rheum Dis 2012;71:1702-5.
53. Studenic P, Felson D, de Wit M, Alasti F, Stamm TA, Smolen JS, et al. Testing different thresholds for patient global assessment in defining remission for rheumatoid arthritis: are the current ACR/EULAR Boolean criteria optimal? Ann Rheum Dis 2020;79:445-52.
54. Studenic P, Aletaha D, de Wit M, Stamm TA, Alasti F, Lacaille D, et al. American College of Rheumatology/EULAR remission criteria for rheumatoid arthritis: 2022 revision. Arthritis Rheumatol 2023;75:15-22.
55. Messelink MA, den Broeder AA, Marinelli FE, Michgels E, Verschueren P, Aletaha D, et al. What is the best target in a treat-to-target strategy in rheumatoid arthritis? Results from a systematic review and meta-regression analysis. RMD Open 2023;9:e003196.
56. England BR, Barber CEH, Bergman M, Ranganath VK, Suter LG, Michaud K. Adaptation of American College of Rheumatology rheumatoid arthritis disease activity and functional status measures for telehealth visits. Arthritis Care Res (Hoboken) 2021;73:1809-14.
57. Jackson LE, Edgil TA, Hill B, Owensby JK, Smith CH, Singh JA, et al. Telemedicine in rheumatology care: a systematic review. Semin Arthritis Rheum 2022;56:152045.
58. Ferucci ED, Day GM, Choromanski TL, Freeman SL. Outcomes and quality of care in rheumatoid arthritis with or without video telemedicine follow-up visits. Arthritis Care Res (Hoboken) 2022;74:484-92.
59. Boone NW, Sepriano A, van der Kuy PH, Janknegt R, Peeters R, Landewé RBM. Routine Assessment of Patient Index Data 3 (RAPID3) alone is insufficient to monitor disease activity in rheumatoid arthritis in clinical practice. RMD Open 2019;5:e001050.
60. Castrejón I, Pincus T. Patient self-report outcomes to guide a treat-to-target strategy in clinical trials and usual clinical care of rheumatoid arthritis. Clin Exp Rheumatol 2012;30(4 Suppl 73):S50-5.