Pedobarographic Measurements of Rheumatoid Feet Compared with Clinical Parameters

A study was conducted to investigate the relationship between plantar pressure pedobarographic measurements and disease activity, radiological abnormalities, and foot indexes in patients with rheumatoid arthritis (RA).

Methods: Sociodemographics, foot symptoms, anatomical distribution, pain intensity and duration, and podiatry services access data were collected. Disease activity scale of 28 joints (DAS28) was used for the disease activity, and Health Assessment Questionnaire (HAQ) was used for the functional status. Foot function index (FFI) was used to measure the impact of foot pathology on its function. The Modified Larsen scoring was used to assess radiological abnormalities. Pedobarographic measurements were used to analyze foot loading characteristics.

Results: A total of 104 feet of 52 patients with RA was evaluated. DAS28 scores did not correlate with the plantar pressure values (p>0.05). A significant correlation was found between HAQ scores and right medial midfoot loading pressure (r=0.355; p<0.01). FFI scores were positively correlated with left lateral midfoot loading pressure (r=0.302; p<0.05). No relationship was found between Manchester Foot Pain and Disability Index and plantar loading characteristics. The radiological scores were correlated with left lateral hindfoot plantar pressure (r=0.286; p<0.05).

Conclusions: Pedobarographic measurements can be considered as a follow-up evaluation tool for the evaluation of all foot parts (forefoot, midfoot, and hindfoot). Rheumatoid feet investigation showed that foot involvement is independent of the disease duration, whereas midfoot plantar pressures are associated with the body mass index. Additionally, DAS28 may fall short as a marker of disease activity because it neglects foot problems.

Keywords: Rheumatoid arthritis, foot, plantar pressure, pain

ÖZ

Amaç: Çalışmanın amacı romatoid artritli (RA) hastalarda pedobarografik ölçüm ile değerlendirilen plantar basınç değişiklikleri ile hastalık aktivitesi, radyolojik anormallikler ve ayak indeksleri arasındaki ilişkinin araştırılmasıdır.

Yöntemler: Sosyodemografik veriler, ayak semptomları, anatomik dağılım, ağrıın şiddetinin ve süresi bilgileri toplandı. Hastalıktaki aktivite için 28 eklemde hastalık aktivite skoru (DAS28) ve fiziksel aktivite için Sağlık Değerlendirme Anketi (HAQ) ve ayak fonksiyonlarının değerlendirilmesi için ayak fonksiyon indeksi (FFI) uygulandı. Radyolojik anormallikleri değerlendirilirken modifiye Larsen skorlaması kullanıldı. Ayak basınç özellikleri analiz etmek için pedobarografik ölçüm yapıldı.

Bulgular: Elli iki RA hastasının toplam 104 ayağı değerlendirildi. DAS28 skorları plantar basınç değişikleri ile korele edildi (p<0.05). HAQ skorları ile sağ orta ayak orta yokuşta basıncı arasında anlamlı bir ilişki saptandı (r=0.355; p<0.01). FFI skorları, sağ lateral orta ayak yokuşta basıncı ile pozitif korelasyon gösterdi (r=0.302; p<0.05). Manchester Ayak Ağrısı ve Disabiliyet İndeksi ve plantar yokuşta özellikleri arasında bir ilişki saptanmamı. Radyolojik skorlar sol lateral arka ayak plantar basınç ile korele edildi (r=0.286; p<0.05).

Sonuçlar: Pedobarografik ölçüler, ayakın tüm bölümlerinin (ön ayak, orta ayak, arka ayak) değerlendirilirlesmesi için bir takip değerlendirme aracı olarak düşünülebilir. Romatoid ayakların pedobarografik incelenmesi, ayak tutulumunun hastalıktaki süresinden bağışmsız olduğunu, orta ayak plantar basınçlarının vücut kilo indeksi ile ilişkilili olduğunu ve DAS28’ın ayak problemlerini ihmal ettiği için hastalıık aktivitesinin bir belirici olarak yeterli kalabalığığini göstermiştir.

Anahtar kelimeler: Romatoid artrit, ayak, plantar basınç, ağrıın
INTRODUCTION

Rheumatoid arthritis (RA) is a chronic inflammatory disorder that primarily affects the cartilage and bone of small and middle-sized joints. Small joint (hand and feet) involvements typically occur in early disease stages. Foot complaints are a major problem in patients with rheumatic diseases. Three-quarters of patients with RA reported foot pain within 4 years of diagnosis. Shi et al. reported that foot problems were seen in almost all patients within 10 years of the disease. Many studies in the literature focused on the structural and functional changes in the affected foot in RA. Despite advances in RA treatment, foot pain remains a common symptom that affects patients’ quality of life.

Pedobarography is a tool that measures dynamic foot loading characteristics in rheumatoid foot deformities. Plantar pressure measurements can be performed in evaluating the foot in every stage of pathology that leads to deformity. Foot deformities in RA are thought to be caused by increased plantar pressures. The detection of plantar pressure distribution using pedobarography reveals useful information for clinicians. Pedobarography is often applied barefoot due to its ease of application. Dynamic plantar pressure changes in patients with RA by barefoot pedobarographic measurements have been previously investigated. Foot deformities in RA can be detected at an early stage by measuring plantar pressure changes during barefoot walking. Pedobarography should be interpreted together with clinical and radiographic evaluation and should be utilized in the periodical visits of patients with RA.

The incidence of foot problems was high, even when clinical remission is yielded by disease activity measurements. Otter et al. demonstrated that this statement is true for many patients with RA, regardless of disease duration or therapy, and may particularly be evident in those receiving biological therapy.

This study aimed to evaluate the use of pedobarographic measurements for detecting plantar loading characteristic abnormalities and their relation with disease activity, type and frequency of deformities, radiologic foot erosion scores, foot functions, and foot care access in patients with RA.

MATERIALS and METHODS

Design of the Study

This is a cross-sectional observational study that was approved by Istanbul Medeniyet University Goztepe Training and Research Hospital Ethics Committee (decision no: 28/G, date: 27.11.2012) following the Declaration of Helsinki, and written informed consent was obtained from all patients.

Participants

A total of 52 patients with RA who met the American College of Rheumatology criteria were recruited from the rehabilitation and rheumatology outpatient clinics of the university hospital. Inclusion criteria were age over 18 years, self-reported foot pain, and written informed consent. Patients with systemic diseases like diabetes mellitus, impaired neurological function, another concomitant musculoskeletal disorder, or acute lower extremity trauma, lower extremity operations, walking aids, or congenital deformities that affect the plantar pressure distribution were excluded from the study, as well as patients who did not report foot pain and were unable to walk independently. Furthermore, patients who had cooperation problems or did not provide informed consent, or were unable to complete the questionnaires were excluded.

Data Collection

Sociodemographics, disease duration, current pharmacological treatment, intensity, duration, and anatomical distribution of foot pain data were collected using surveys during outpatient follow-ups. Foot deformities were inspected and noted by the same investigator. Disease activity scale of 28 joints (DAS28) and Health Assessment Questionnaire (HAQ) was used for the functional status.

HAQ is a four-level scale that investigates the functioning that consists of 20 questions in eight categories. Turkish adaptation and validation were carried out by Küçükdeveci et al.

Foot function index (FFI) was administered to all patients. The FFI consists of three subscales (foot pain, foot disability, and activity limitation) that consist of 23 items about the impact of foot impairments on function. The Turkish adaptation and validation were carried out by Anaforoğlu Külünkoğlu et al.

An experienced radiologist performed the Modified Larsen scoring to assess radiological abnormalities.

The pedobarographic assessment was used to analyze foot loading characteristics. Plantar pressure measurements were simultaneously collected from three barefoot walking trials using a Tek Scan Mat Scan (TekScan Inc., South Boston, USA) pressure mat following a two-step gait initiation protocol. Each foot is divided
into three parts (forefoot, midfoot, and hindfoot) and plantar pressures are calculated (kPa) for each part.

**Statistical Analysis**

The Statistical Package for the Social Sciences 25.0 package program (IBM, Chicago, IL) was used for the statistical analysis. All descriptive statistics of measurements are presented as mean ± standard deviation. The frequency for categorical variables is shown together with their percentages. The Student’s t-test was used to compare the variables that follow a normal distribution between two groups for the quantitative data analyses. Normal distribution was examined with the Kolmogorov-Smirnov test. The level of correlation between variables was determined using the Spearman rho correlation coefficients since the data were not normally distributed. The effect size of the correlation is determined according to Cohen’s classification: 0.10-0.29 as small; 0.30-0.49 as a medium, and 0.50-1.0 as large correlation. Results were bilaterally evaluated at a 95% confidence interval, with a significance level at p<0.05.

**RESULTS**

A total of 104 rheumatoid feet of 52 patients were evaluated. Demographic and clinical characteristics of patients were demonstrated in Table 1.

Foot deformity frequency was 55.8%. Foot deformities include hallux valgus, pes planus, hallux rigidus, claw toe, bunion, and hammertoe (Table 2).

Of the patients, 92.3% (n=48) were receiving disease-modifying antirheumatic drugs, 3.8% (n=2) anti-tumor necrosis factor (TNF), and 51.9% steroid therapy.

Plantar pressure measurements of the right and left foot were demonstrated in Table 3.

No statistically significant relationship was detected between DAS28 measurements and right and left foot pressure measurements (p>0.05).

No statistically significant difference was found between the body mass indexes (BMI) in the pain locations of patients (p>0.05).

A statistically significant positive correlation was found between the BMI and the midfoot medial pressure measurements of the right foot at 46.9% (r=0.469; p<0.01). A statistically significant positive correlation was found between the BMI and the midfoot lateral pressure measurements of the left foot at 37.1% (r=0.371; p<0.01).

The relationship between the HAQ score and plantar pressure measurements is shown in Table 4. A statistically significant positive correlation was found between the HAQ score and the midfoot medial pressure measurements of the right foot at 35.5% (r=0.355; p<0.01).

**Table 1. Demographic and clinical characteristics of patients.**

| Measured                                | Mean ± SD (min-max) |
|-----------------------------------------|---------------------|
| Age (years)                             | 53.88±11.36 (32-78) |
| Body mass index                         | 29.87±5.55 (18.37-43.70) |
| Duration of the disease (day)           | 116.56±92.06 (2-480) |
| Duration of pain (day)                  | 64.94±87.84 (1-480)  |
| VAS                                     | 5.96±2.60 (0-10)    |

**Table 2. Localization of foot pain and foot deformities of patients.**

| Localization of pain                  | n | %   |
|---------------------------------------|---|-----|
| Forefoot                              | 5 | 9.6 |
| Midfoot                               | 10| 19.2|
| Hindfoot                              | 11| 21.2|
| Global                                | 12| 23.1|
| Midfoot + hindfoot                    | 5 | 9.6 |
| Forefoot + midfoot                    | 9 | 17.3|

| Foot deformity                        | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 23| 44.2|
| No                                    | 29| 55.8|

| Hallux valgus                         | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 39| 75.0|
| No                                    | 13| 25.0|

| Pes planus                            | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 46| 88.5|
| No                                    | 6 | 11.5|

| Hallux rigidus                        | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 52| 100 |
| No                                    | 0 | 0   |

| Claw toe                              | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 48| 92.3|
| No                                    | 4 | 7.7 |

| Bunion                                | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 47| 90.4|
| No                                    | 5 | 9.6 |

| Hammer toe                            | n | %   |
|---------------------------------------|---|-----|
| Yes                                   | 51| 98.1|
| No                                    | 1 | 1.9 |
The relationship between the Larsen score and foot pressure measurements is shown in Table 4. A statistically significant negative correlation was found between the Larsen score and the hindfoot lateral pressure measurements of the left foot at 26.8% (r=0.286; p<0.05).

The relationship between the FFI score and foot pressure measurements is shown in Table 4. A statistically significant positive correlation was found between the FFI score and the midfoot medial pressure measurements of the right foot at 31.7% (r=0.317; p<0.05). A statistically significant positive correlation was found between the FFI score and the midfoot lateral pressure measurements of the right foot at 30.2% (r=0.302; p<0.05).

No statistically significant relationship was found between the disease duration and right and left foot pressure measurements (p>0.05).

No statistically significant relationship was found between the visual analog scale score and right and left foot pressure measurements (p>0.05).

**DISCUSSION**

One of the common manifestations of RA is foot involvement. Forefoot pain and deformities in RA readily show the devastating effects of synovitis. However, foot involvement has received less attention in the literature and more emphasis has been placed on hand involvement. Usage of pedobarography as an objective measure of foot function in RA has increased. This study investigated the associations between foot loading characteristics and clinical symptoms, disease activity, and functional status, as well as radiological damage, and revealed that foot involvement was independent of disease duration, disease activity was detected by DAS28, and midfoot plantar pressures were associated with FFI and BMI.

The DAS28 remission criterion is frequently used to evaluate remission in clinical follow-ups and clinical studies. However, the results of the present study showed

### Table 3. Distribution of patients’ right and left foot pressures.

|                  | Mean | SD   |
|------------------|------|------|
| Forefoot, medial (kPa) |      |      |
| Right            | 318.94 | 148.43 |
| Left             | 301.06 | 133.66 |
| Forefoot, mid (kPa) |      |      |
| Right            | 316.06 | 119.38 |
| Left             | 299.62 | 88.78  |
| Forefoot, lateral (kPa) |     |      |
| Right            | 293.65 | 94.17  |
| Left             | 269.42 | 83.68  |
| Midfoot, medial (kPa) |      |      |
| Right            | 86.83  | 54.49  |
| Left             | 78.65  | 47.15  |
| Midfoot, lateral (kPa) |     |      |
| Right            | 101.69 | 62.20  |
| Left             | 93.94  | 54.58  |
| Hindfoot, medial (kPa) |     |      |
| Right            | 255.48 | 111.17 |
| Left             | 254.71 | 58.31  |
| Hindfoot, lateral (kPa) |     |      |
| Right            | 243.94 | 90.66  |
| Left             | 248.85 | 56.15  |

SD: Standard deviation

### Table 4. Relationship between HAQ, Larsen, FFI scores, and foot pressure measurements.

| Foot pressure measurements | HAQ score | Larsen score | FFI score |
|----------------------------|-----------|--------------|-----------|
|                            | r         | p            | r         | p          | r         | p          |
| Forefoot, medial           |           |              |           |            |           |            |
| Right                      | -0.136    | 0.335        | 0.251     | 0.073      | 0.073     | 0.609      |
| Left                       | -0.063    | 0.658        | -0.050    | 0.724      | -0.074    | 0.604      |
| Forefoot, mid              |           |              |           |            |           |            |
| Right                      | -0.160    | 0.257        | 0.178     | 0.206      | 0.023     | 0.872      |
| Left                       | -0.179    | 0.205        | 0.010     | 0.943      | -0.106    | 0.455      |
| Forefoot, lateral          |           |              |           |            |           |            |
| Right                      | -0.073    | 0.606        | -0.140    | 0.321      | 0.070     | 0.622      |
| Left                       | -0.232    | 0.098        | -0.251    | 0.073      | -0.060    | 0.672      |
| Midfoot, medial            |           |              |           |            |           |            |
| Right                      | 0.355     | 0.010**      | -0.045    | 0.751      | 0.317     | 0.022*     |
| Left                       | 0.072     | 0.612        | 0.056     | 0.691      | 0.070     | 0.621      |
| Midfoot, lateral           |           |              |           |            |           |            |
| Right                      | 0.250     | 0.074        | -0.110    | 0.438      | 0.302     | 0.030*     |
| Left                       | 0.041     | 0.776        | 0.027     | 0.847      | 0.023     | 0.871      |
| Hindfoot, medial           |           |              |           |            |           |            |
| Right                      | 0.073     | 0.605        | 0.205     | 0.145      | 0.002     | 0.986      |
| Left                       | -0.070    | 0.620        | -0.207    | 0.142      | -0.049    | 0.732      |
| Hindfoot, lateral          |           |              |           |            |           |            |
| Right                      | 0.058     | 0.682        | 0.100     | 0.480      | -0.031    | 0.826      |
| Left                       | -0.067    | 0.638        | -0.286    | 0.040*     | -0.031    | 0.825      |

*p<0.05, **p<0.01, r: Spearman correlation coefficient, HAQ: Health Assessment Questionnaire, FFI: Foot function index
no association between plantar pressures and DAS28. van der Leeden et al.\textsuperscript{32} previously suggested that the DAS28 remission criterion for RA neglects patients with foot involvement. However, van der Leeden et al.\textsuperscript{32} also found high correlations between disease activity and foot pain when using the DAS44 criterion.

We could not reveal a relationship between disease duration and plantar pressure measurements. Studies revealed that one-third of patients had foot pain as a presentation symptom\textsuperscript{2}. Clinical involvements were observed in 50-86\% of patients at the time of the study, 90\% had foot pain complaints during the disease course, and approximately 90\% had radiological abnormalities in the feet\textsuperscript{1,33,34}. Similar to the present study, these studies show that foot involvement is independent of the disease duration.

The present study revealed that FFI and HAQ were associated with right foot midfoot pressures. The most common deformity was pes planus in the midfoot\textsuperscript{1}. Midfoot problems were reported to be less common; however, similar to our findings, Jeong et al.\textsuperscript{35} reported that walking difficulty was specifically associated with midfoot involvement and functional status were found to be worse in these patients. Additionally, both right and left midfoot plantar pressures were associated with the BMI. A recent cohort study reported the relationship of BMI with foot pain and foot-related activity limitation; however, the relationship between forefoot plantar pressure (barefoot) and BMI was insignificant\textsuperscript{36}. Thus, midfoot evaluation should not be ignored in plantar pressure measurements in the follow-up of patients with RA.

Plantar pressure measurements in the literature are mostly limited to the forefoot region since it is known as the most affected part of the foot\textsuperscript{8,20}. The evaluation of midfoot and hindfoot, as well as forefoot, is one of the strengths of our study.

The present study revealed no relationship between pain intensity and plantar pressure measurements. Schmiegel et al.\textsuperscript{37} reported that the pain intensity during walking did not reflect the degree of forefoot deformity. Pedography can be useful for an early diagnosis of deformities. However, Schmiegel et al.\textsuperscript{37} reported that even though pedographic measurements might show indications for destructive changes, they cannot provide information about erosion severity. The present study revealed a weak relationship between the Larsen score and hindfoot lateral pressure. Therefore, more studies are needed to reveal this relationship.

The study had some limitations. First, the study involved a relatively small number of patients and a lack of prior sample size calculation. Additionally, the study sample mostly consisted of functionally better patients, thus the number of patients receiving anti-TNF therapy was low. Therefore, evaluating patients who received different treatments would be appropriate in future studies. Moreover, plantar pressure measurements were made barefoot in the present study. Nowadays, making measurements barefoot is recommended, as well as in-shoe and orthosis.

**CONCLUSIONS**

Foot pain and deformities are common in RA; however, they can be overlooked in outpatient follow-up clinics. Foot erosion and deformities can be revealed by plantar pressure changes with pedobarographic examinations, thus more appropriate measures can be taken in the treatment and follow-up.

Published in: Study is presented in Annual European Congress of Rheumatology EULAR 2013 and the abstract has published in Annals of the Rheumatic Diseases 2013 vol. 72, pp.1100.

**Ethics**

**Ethics Committee Approval:** This is a cross-sectional observational study that was approved by Istanbul Medeniyet University Goztepe Training and Research Hospital Ethics Committee (decision no: 28/G, date: 27.11.2012) following the Declaration of Helsinki.

**Informed Consent:** Written informed consent was obtained from all patients.

**Peer-review:** Externally and internally peer-reviewed.

**Author Contributions**

Concept: Y.Y., S.T.T., A.I., E.S., S.M., E.K., B.T., Design: Y.Y., S.T.T., A.I., E.S., S.M., E.K., B.T., Data Collection and/or Processing: Y.Y., B.D.K., A.I., E.S., S.M., E.K., B.T., Analysis and/or Interpretation: Y.Y., B.D.K., E.S., S.M., E.K., B.T., Critical Revision: Y.Y., B.D.K., S.T.T., A.I., E.S., S.M., E.K., B.T., Writing: B.D.K.

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

**Financial Disclosure:** The authors declared that this study has received no financial support.

**REFERENCES**

1. Borman P, Ayhan F, Tuncay F, Sahin M. Foot problems in a group of patients with rheumatoid arthritis: an unmet need for foot care. Open Rheumatol J. 2012;6:290-5.
2. Otter SJ, Lucas K, Springett K, et al. Foot pain in rheumatoid arthritis prevalence, risk factors and management: an epidemiological study. Clin Rheumatol. 2010;29:255-71.

3. Bongi SM, Ravenni G, Ciampi B, Del Rosso A, El Aoufy K. Biomechanical pediatric evaluation in an Italian cohort of patients with systemic sclerosis: A pilot study. Eur J Rheumatol. 2016;3:1169-74.

4. Gokcen H, Sariyildiz D, Coskun Benlidayi I. Static foot posture and its relation to clinical variables in ankylosing spondylitis. Int J Rheum Dis. 2021;24:1168-52.

5. Ali Khan S, Saeed MA, Farman S, Sajid Z, Ahmad N, Alam M. Foot Involvement as the First Manifestation in Rheumatoid Arthritis Patients in Lahore. Cureus. 2021;13:e15347.

6. Otter SJ, Young A, Cryer JR. Biologic agents used to treat rheumatoid arthritis and their relevance to podiatrists: a practice update. Musculoskeletal Care. 2004;2:51-9.

7. Shi K, Tomita T, Hayashida K, Owaki H, Ochi T. Foot deformities in rheumatoid arthritis and relevance of disease severity. J Rheumatol. 2000;27:84-9.

8. Konings-Pijnappels APM, Tenten-Diepenmaat M, Dahmen R, et al. Forefoot pathology in relation to plantar pressure distribution in patients with rheumatoid arthritis: A cross-sectional study in the Amsterdam Foot cohort. Gait Posture. 2019;68:317-22.

9. Jaakkola JI, Mann RA. A review of rheumatoid arthritis affecting the foot and ankle. Foot Ankle Int. 2004;25:866-74.

10. Stolt M, Suhonen R, Leino-Kilpi H. Foot health in patients with rheumatoid arthritis: a scoping review. Rheumatol Int. 2017;37:1413-22.

11. AbdEllah AM, Mahmoud ElSayed A, Habeeb RA, Abrahamman MA, Hamouda RM, Hussein SA. Subclinical entheseal involvement in patients with rheumatoid arthritis. The Egyptian Rheumatologist. 2021;43:281-8.

12. Rosenbaum D, Schmiegel A, Meermeier M, Gaubitz M. Plantar sensitivity, foot loading and walking pain in rheumatoid arthritis. Rheumatology (Oxford). 2006;45:212-4.

13. Razak AH, Zayegh A, Begg RK, Wahab Y. Foot plantar pressure measurement system: a review. Sensors (Basel). 2012;12:9884-912.

14. Chalmers AC, Busby C, Goyert J, Porter B, Schulzer M. Metatarsalgia and rheumatoid arthritis—a randomized, single blind, sequential trial comparing 2 types of foot orthoses and supportive shoes. J Rheumatol. 2000;27:1643-7.

15. Woodburn J, Barker S, Helliwell PS. A randomized controlled trial of foot orthoses in rheumatoid arthritis. J Rheumatol. 2002;29:1377-83.

16. Oeffinger DJ, Pectol RW Jr, Tyłkowski CM. Foot pressure and radiographic outcome measures of lateral column lengthening for pes planovalgus deformity. Gait Posture. 2000;12:189-95.

17. Tuna H, Birtane M, Taştekin N, Kokino S. Pedobarography and its relation to radiologic erosion scores in rheumatoid arthritis. Rheumatol Int. 2005;26:42-7.

18. Stewart S, Carroll M, Brenton-Rule A, et al. Region-specific foot pain and plantar pressure in people with rheumatoid arthritis: A cross-sectional study. Clin Biomech (Bristol, Avon). 2018;55:14-7.

19. Otter SJ, Bowen CJ, Young AK. Forefoot plantar pressures in rheumatoid arthritis. J Am Podiatr Med Assoc. 2004;94:255-60.

20. van der Leeden M, Steultjens M, Dekker JH, Prins AP, Dekker J. Forefoot joint damage, pain and disability in rheumatoid arthritis patients with foot complaints: the role of plantar pressure and gait characteristics. Rheumatology (Oxford). 2006;45:465-9.

21. 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.

22. Wells G, Becker JC, Teng J, et al. Validation of the 28-joint Disease Activity Score (DAS28) and European League Against Rheumatism response criteria based on C-reactive protein against disease progression in patients with rheumatoid arthritis, and comparison with the DAS28 based on erythrocyte sedimentation rate. Ann Rheum Dis. 2009;68:954-60.

23. Bruce B, Fries JF. The Health Assessment Questionnaire (HAQ). Clin Exp Rheumatol. 2005;23(5 Suppt 39):14–8.

24. Küçükdeveci AA, Sahin H, Ataman S, Griffiths B, Tennant A. Issues in cross-cultural validity: example from the adaptation, reliability, and validity testing of a Turkish version of the Stanford Health Assessment Questionnaire. Arthritis Reum. 2004;51:14–9.

25. Budiman-Mak E, Conrad KJ, Roach KE. The Foot Function Index: a measure of foot pain and disability. J Clin Epidemiol. 1991;44:561-70.

26. Anaforoğlu Küllünkoğlu B, Fırat N, Yıldız NT, Alkan A. Reliability and validity of the Turkish version of the Foot Function Index in patients with foot disorders. Turk J Med Sci. 2018;48:476-83.

27. Young-Min SA, Shakhapur S, Marshall N, Griffiths I, Caswton T, Grainger A. Modified Larsen scoring of digitized radiographs in rheumatoid arthritis. J Rheumatol. 2003;30:238-40.

28. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. New York: Routledge; 1988. p. 567.

29. Woodburn J, Helliwell PS. Foot problems in rheumatology. Br J Rheumatol. 1997;36:932-4.

30. El-Serougy EM, Eesa NN, El-Azizi HM, Badawi HA. Power Doppler ultrasound in the evaluation of hand joints in rheumatoid arthritis patients in clinical remission: Association with composite index scores and functional status. The Egyptian Rheumatologist. 2019;41:7-10.

31. Hodge MC, Nathan D, Bach TM. Plantar pressure pain thresholds and touch sensitivity in rheumatoid arthritis. Foot Ankle Int. 2009;30:1-9.

32. van der Leeden M, Steultjens MP, van Schaardenburg D, Dekker J. Forefoot disease activity in rheumatoid arthritis patients in remission: results of a cohort study. Arthritis Res Ther. 2010;12:3.

33. Bouysset M, Huguery P. The rheumatoid foot. Pathomechanics, clinical and radiological features. Therapeutic conditions. In: Foot and ankle in rheumatoid arthritis. Paris: Springer Paris; 2006. p. 9-48.

34. Vainio K. The rheumatoid foot; a clinical study with pathological and roentgenological comments. Ann Chir Gynaecol Fenn Suppl. 1956;45:1-107.

35. Jeong HJ, Sohn IW, Kim D, et al. Impact of midfoot and Hindfoot involvement on functional disability in Korean patients with rheumatoid arthritis. BMC Musculoskeletal Disord. 2017;18:365.

36. Dahmen R, Konings-Pijnappels A, Kerkhof S, et al. Higher body mass index is associated with lower foot health in patients with rheumatoid arthritis. Arthritis Care Res. 2014;66:1345-52.