OPEN ACCESS Freely available online

Rheumatology: Current Research

Research Article

# Gait Characteristics in Rheumatoid Arthritis: A Comparative Study with non-RA Foot Disability Patients

**Koichiro Yano[1,2*], Katsunori Ikari[1], Akira Kutsuwada[2], Ryo Hishinuma[2], Kazuya Kubo[2], Yasushi Kuwahara[2], Ken Okazaki[1]**

*[1]Department of Orthopedic Surgery, Tokyo Women's Medical University, 8-1 Kawada, Shinjuku, Tokyo, 1628666, Japan; [2]Foot Clinic Omotesando, 6-28-6 Jinguumae, Shibuya, Tokyo, 1500001, Japan*

## ABSTRACT

**Objective:** Rheumatoid Arthritis (RA) is a chronic systemic autoimmune disease characterized by persistent joint inflammation, leading to joint destruction, pain, deformities, and impaired physical function. The feet are among the most commonly affected sites, and foot involvement often contributes to significant gait disturbances in patients with RA. Gait impairments can substantially reduce mobility, increase the risk of falls, and negatively impact overall quality of life. Although previous studies have reported gait abnormalities in RA, most have used healthy individuals as controls. Such comparisons may not accurately reflect the challenges faced by RA patients in clinical settings, particularly those with existing foot disabilities. This study aimed to clarify the unique gait characteristics of patients with RA by comparing them with non-RA patients who also have foot disabilities, providing a more meaningful clinical comparison

**Methods:** In this cross-sectional study, 59 female patients aged 50-79 years who attended our institution between August 2021 and June 2024 were enrolled. The study included 22 patients diagnosed with RA and 37 patients with non-RA foot disabilities, such as hallux valgus, flatfoot, and degenerative conditions. Gait assessment was performed using the Zebris treadmill system, which enabled quantitative evaluation of stride length, stride time, cadence, walking velocity, and the proportion of each gait phase. Statistical comparisons between the two groups were conducted using the Mann-Whitney U test and Fisher's exact test.

**Results:** Compared to the non-RA group, RA patients exhibited significantly shorter stride length and time, reduced cadence and velocity, and prolonged stance and double support phases. Additionally, they had increased proportions of the load response and pre-swing phases and a decreased proportion of the mid-terminal stance phase. These findings suggest a cautious, instability-driven gait pattern in RA patients.

**Conclusion:** RA patients demonstrate distinct gait adaptations even when compared to individuals with other foot disabilities. Targeted rehabilitation programs and early therapeutic interventions are essential to preserve gait function and prevent further decline.

**Keywords:** Rheumatoid arthritis; Gait analysis; Foot disability; Cross-sectional study; Walking stability; Fall risk; Rehabilitation; Zebris

## INTRODUCTION

Rheumatoid arthritis (RA) is an autoimmune disease characterized by inflammation that affects multiple joints of the body. This inflammation often leads to synovitis in multiple joints, ultimately resulting in joint destruction, deformity, and functional impairment. Notably, approximately 20% to 44% of RA cases initially manifest in the feet [1,2], and over 90% of patients develop foot involvement during the course of the disease [1,3].

Gait is a complex process that can be altered by joint deformities or muscle weakness [4]. Patients with RA often adopt a gait pattern that minimizes pain, which leads to reduced gait speed, shorter stride length, and prolonged double-limb support compared to healthy individuals [5]. This decline in gait performance correlates with impairments in activities of daily living (ADL) and decreased quality of life (QOL) among patients with RA [6,7]. Additionally, the risk of falls is also increased [8].

While a significant proportion of the general population experiences foot disabilities (e.g., hallux valgus occurs in 23%-36% [9,10], while flatfoot occurs in 11.6%-15.6% [11,12], the specific gait characteristics of patients with RA remain unclear. This study aimed to clarify the unique gait characteristics of patients with RA by comparing them to patients without RA but with foot disabilities.

**Correspondence to:** Koichiro Yano, Department of Orthopedic Surgery, Section of Surgery for Inflammatory Arthritis, Tokyo Women's Medical University, 8-1 Kawada, Shinjuku, Tokyo, 1628666, Japan, E-mail: yano.koichiro0715@gmail.com

**Received:** 30-May-2025, Manuscript No. RCR-25-37507; **Editor assigned:** 02-Jun-2025, PreQC No. RCR-25-37507 (PQ); **Reviewed:** 16-Jun-2025, QC No. RCR-25-37507; **Revised:** 23-Jun-2025, Manuscript No. RCR-25-37507 (R); **Published:** 30-Jun-2025, DOI: 10.35248/2161-1149.25.15.438

**Citation:** Yano K, Ikari K, Kutsuwada A, Hishinuma R, Kubo K, Kuwahara Y, et al. (2025) Gait Characteristics in Rheumatoid Arthritis: A Comparative Study with non-RA Foot Disability Patients. Rheumatology. 15:438.

## METHODS

This study was approved by the Institutional Review Board of Tokyo Women's Medical University (approval number: 2022-0132). Patients who were recommended for gait analysis by their physician or who voluntarily requested gait analysis were included in this study. The study population consisted of 37 patients with RA (RA group) and 74 non-RA patients with foot disabilities (non-RA group) who consented to undergo gait analysis at our institution between August 2021 and June 2024. The target age group was 50-79 years old, which has the highest prevalence of RA in Japan [13]; this was selected to eliminate the influence of age-related factors. Only female patients were included, while those with a history of foot or ankle surgery were excluded. After applying the inclusion criteria, total of 22 and 37 patients in the RA and non-RA groups, respectively, were included in this study (Figure 1).

### Gait analysis

Gait analysis was performed using the Zebris treadmill system (Zebris FDM-T; Inter Reha Co., Ltd., Tokyo, Japan), which measured various parameters including stride length, stance phase, load response phase, mid-terminal stance phase, pre-swing phase, swing phase, double support phase, stride time, cadence, and velocity. Stride length was defined as the linear distance covered by one gait cycle [14].

The gait cycle was divided into phases based on the definition of Pirker, et al. (Figure 2) [14]. Patients walked barefoot without assistive devices on the treadmill for 30 seconds. These parameters were compared between the RA and non-RA groups.

### Statistics analysis

Continuous data were summarized as median (interquartile range; IQR), while categorical data were expressed as counts and percentages. The Mann-Whitney U test was used to compare the results of the gait analysis, while Fisher's exact test was used to compare the categorized data between the two groups. The R software was used for all statistical analyses, with $p<0.05$ indicating statistical significance

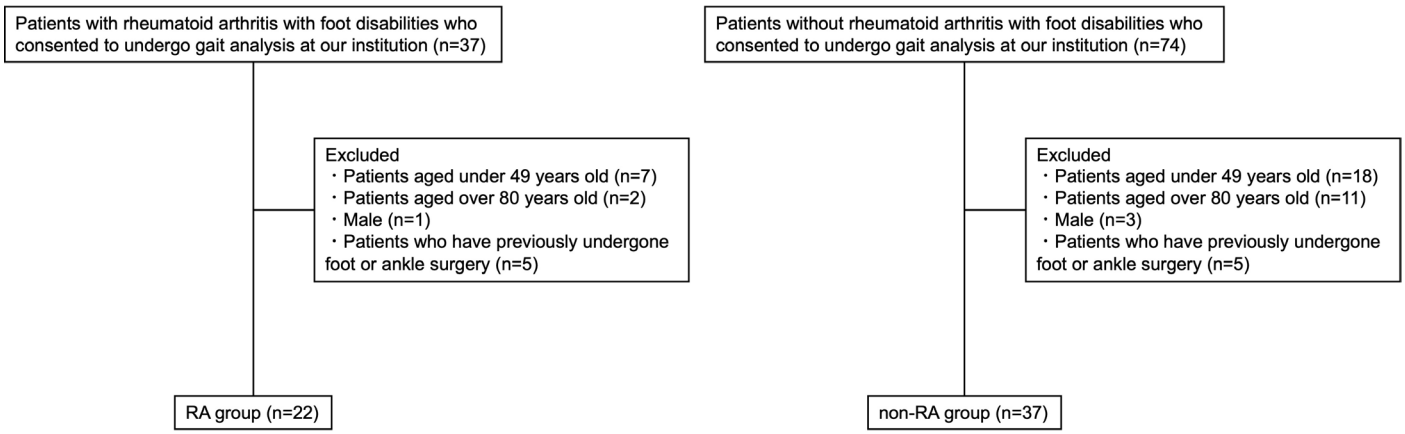


**Figure 1:** Flow diagram showing the enrollment process. The values shown are the number of patients. Note: RA: Rheumatoid Arthritis.

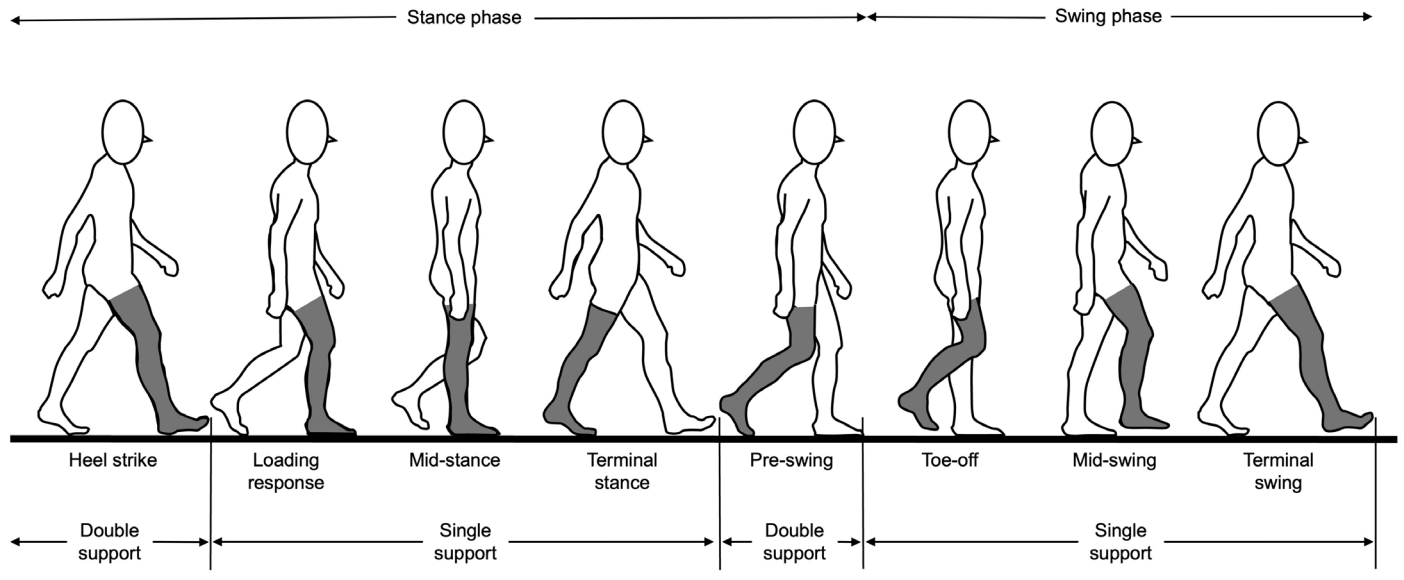


**Figure 2:** Gait cycle. This was divided into each phase based on the definition by Pirker, et al.[14].

## RESULTS

The demographic data is shown in Table 1, with no significant differences observed between the two groups. In both groups, the most common deformity was flatfoot, followed by hallux valgus. The gait analysis revealed that the stride length was significantly shorter in the RA group versus the non-RA group (70.9 (51.0, 94.6)) *vs.* 99.7 (90.5, 107.8) cm, p<0.05; (Figure 3a). Regarding the gait cycle, the stance phase was significantly longer in the RA group versus the non-RA group (left/right, 65.3 (63.8, 65.7)%/66.4 (63.7, 68.6)% *vs.* 62.7 (61.9, 64.2)%/63.1 (62.3, 64.1)%, p<0.05, respectively; Figure 4). Conversely, the swing phase was significantly shorter in the RA group compared to the non-RA group (left/right, 34.7 (34.3, 36.2)%/33.6 (31.4, 36.3)% *vs.* 37.3 (35.8, 38.1)%/36.9 (35.9, 37.7), p<0.05, respectively; Figure 4). A detailed analysis of the stance phase revealed that the proportion of the load response and pre-swing phases was significantly higher in the RA group versus the non-RA group (left/right, load response phase: 14.9 (13.7, 17.7)%/15.8 (14.3, 17.7)% *vs.* 12.6 (12.1, 13.7)%/12.9 (12.5, 14.1)%, p<0.05, respectively; pre-swing phase: 15.7 (14.3, 17.7)%/14.9 (13.7, 17.8)% *vs.* 12.9 (12.5, 14.1)%/12.6 (12.1, 13.7)%, p<0.05, respectively; (Figure 4). Conversely, the proportion of the mid-terminal stance phase was significantly lower in the RA group versus to the non-RA group (33.6 (31.4, 36.3)%/34.7 (34.2, 36.2)% *vs.* 36.9 (35.9, 37.7)%/37.2 (35.8, 38.1)%, p<0.05, respectively; (Figure 4). The double support phase was significantly longer in the RA group versus the non-RA group (30.3 (28.2, 35.4)% *vs.* 26.1 (24.7, 27.6)%, p<0.05; (Figure 3b). Regarding step parameters, stride time was significantly shorter (1.1 (1.0, 1.1) s *vs.* 1.0 (1.0, 1.1) s, p<0.05; (Figure 3c) and cadence was significantly lower 112.5 (105.7, 115.3) *vs.* 117.5 (110.8, 122.8) steps/min, p<0.05; (Figure 3d) in the RA group versus the non-RA group. Lastly, walking velocity was significantly slower in the RA group versus the non-RA group (2.4 (1.8, 3.0) *vs.* 3.4 (3.2, 3.8) km/h, p<0.05; (Figure 3e).

**Table 1:** Patient characteristics

| | RA group (n=22) | non-RA group (n=37) | P |
|---|---|---|---|
| Age, years, median (IQR) | 59.5 (53, 71.5) | 60 (53, 64) | 0.68 |
| **Deformities*** | | | |
| Flatfoot, n (%) | 14 (63.6%) | 26 (70.3%) | 0.77 |
| Hallux valgus, n (%) | 9 (40.9%) | 20 (54.1%) | 0.42 |
| Bunionette, n (%) | 2 (9.1%) | 0 (0%) | 0.14 |
| Splay foot, n (%) | 1 (4.5%) | 0 (0%) | 0.37 |

**Abbreviations:** IQR: Interquartile Range; RA: Rheumatoid Arthritis.

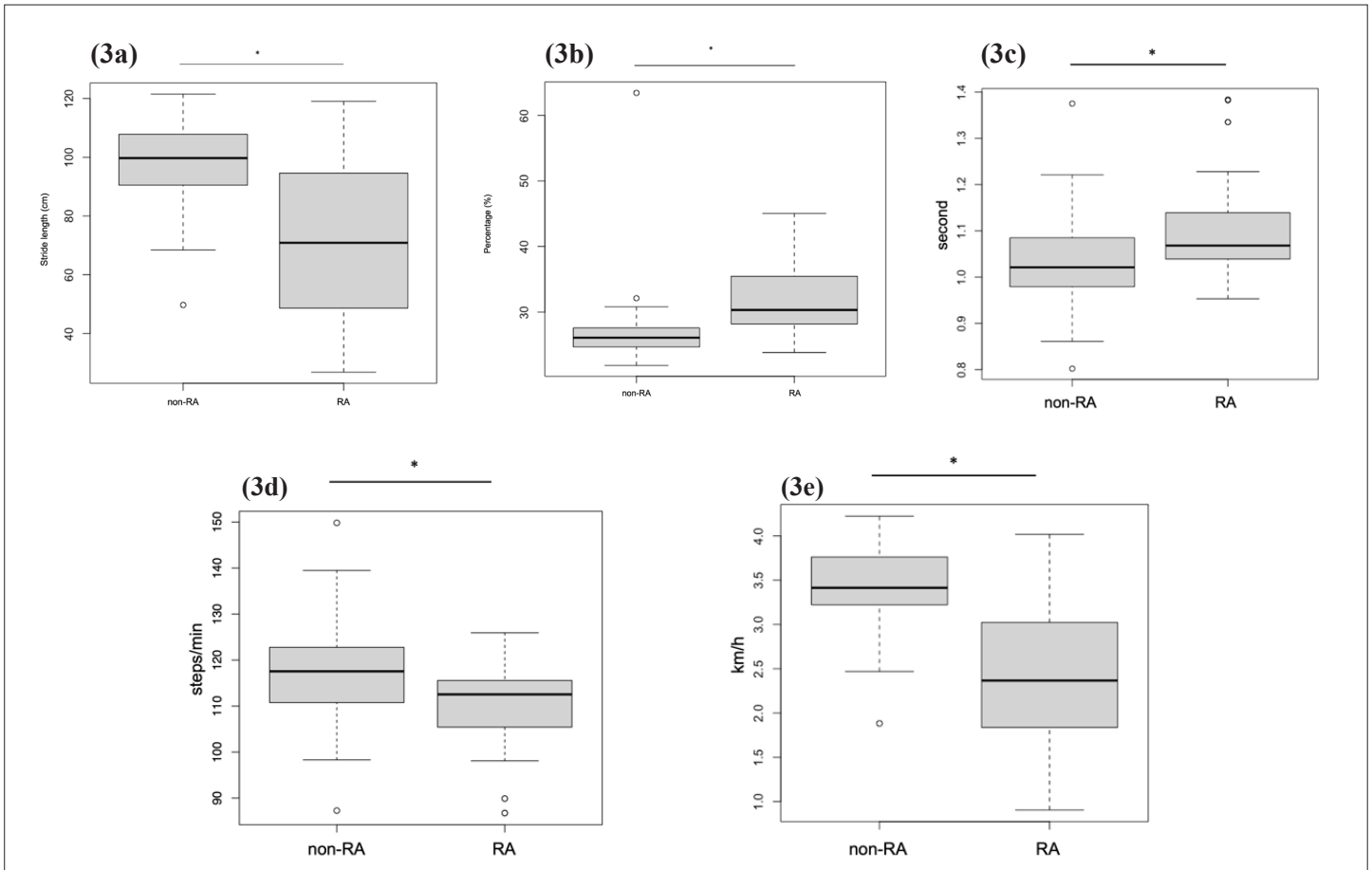


**Figure 3:** Comparison of gait parameters between the RA and non-RA groups. 3a: Stride length; 3b: Proportion of the double support phase; 3c: Stride time; 3d: Cadence; 3e: Walking velocity. **Note:** All values are presented as boxplots. *P<0.05 indicates statistically significant differences between groups.

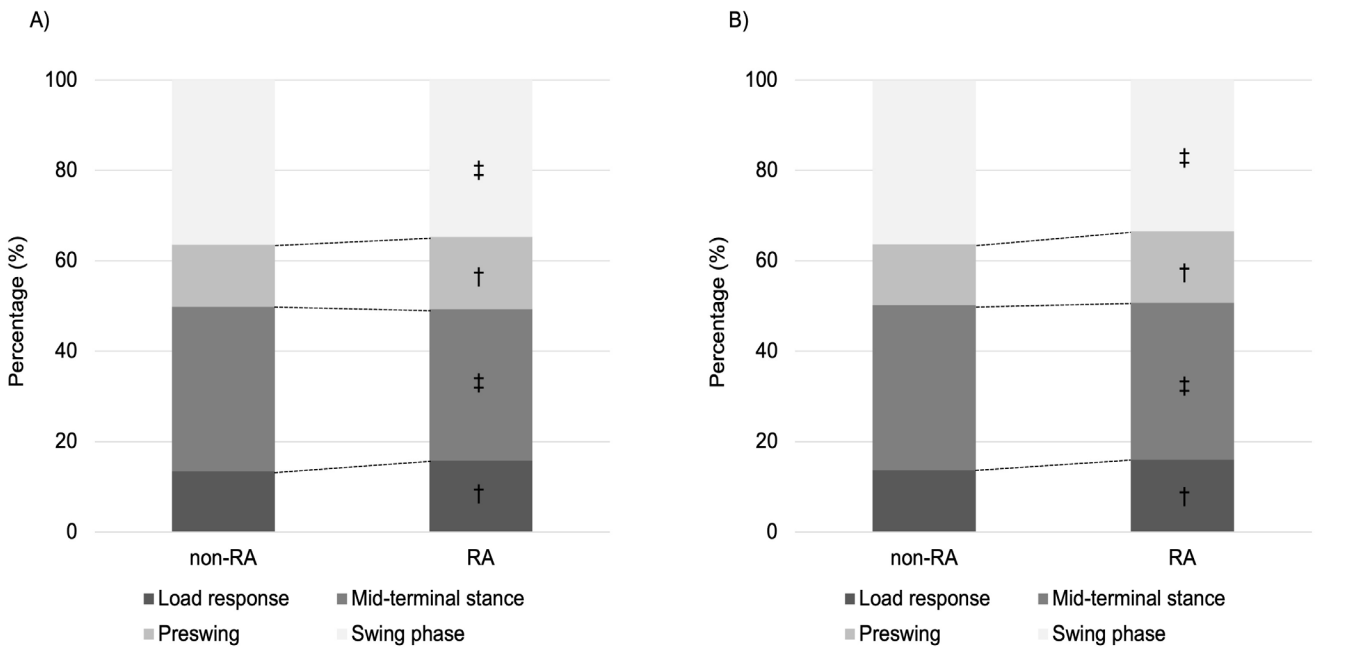


**Figure 4:** Comparison of each phase of the gait cycle. The bar graph represents the mean values, and the error bars indicate the standard deviation. Note: †: indicates a significantly lower proportion in the RA group; ‡: indicates a significantly higher proportion in the RA group. a) Left; b) Right.

## DISCUSSION

In this study, we controlled for the effect of age on gait performance by restricting the age range to 50-79 years, which represents the major population affected by RA in Japan [13]. Additionally, we limited this study to females, who have a high prevalence of RA. In this cohort, the RA group exhibited shorter stride length, longer stance phase, shorter swing phase, longer double support phase, and slower walking speed compared to the non-RA group with foot disabilities.

The gait pattern in RA is characterized by reduced gait speed and stride length [5,15], which have been associated with limitations in ADL and diminished QOL [7,16]. Reduced gait speed and stride length have also been correlated with disease activity and physical function in patients with RA [17-19]. Additionally, a longer double-limb support time has been observed, which suggest that patients adopt a more cautious gait pattern for improved stability [5,15]. Additionally, a decrease in stride length reduces the reaction time available to avoid obstacles, and thus patients are more likely to bump into obstacles [20]. Our findings suggests that patients with RA adopt a more cautious gait pattern than non-RA patients with foot disabilities in order to maintain stability while walking. These findings likely represent compensatory behaviors in response to impaired balance control in patients with RA, as well as avoidance behaviors driven by muscle weakness, restricted range of motion in the lower limb joints, and pain in the lower limb joints and plantar surface. These compensatory strategies may contribute to an increased risk of falls and limitations in ADL, ultimately resulting in decreased QOL.

A decline in gait function can increase the risk of falls. Individuals who have experienced falls tend to have narrower stride widths, shorter double-support phases, shorter swing phases, and reduced knee range of motion [21]. In particular, patients with RA have a high fall risk [22], and their reduced gait function is associated with frailty. Among the diagnostic criteria for frailty, decreased gait speed is most frequently observed indicator [23].

An important strength of this study is its novel comparison between RA patients and non-RA individuals with foot disabilities, rather than with healthy controls, as has been done in most previous studies. This unique design highlights that RA poses a distinct gait disadvantage even among patients who already have foot impairments, underscoring the substantial impact of RA on mobility. In addition, to minimize confounding factors, we specifically focused on women in their 50s to 70s-the demographic with the highest RA prevalence in Japan. This allowed us to control for the influence of both age-related decline in gait performance and sex-based differences in gait and muscle strength. Together, these methodological strengths reinforce the clinical relevance of our findings and emphasize the importance of gait preservation as a key therapeutic target in RA.

This study has several limitations. First, the sample size was small, with a post-hoc power analysis indicating a power of 0.58. Second, the study was restricted to a specific age group and sex, and thus these findings may differ in other patient populations. Third, since patients who were recommended for gait analysis by their physician or voluntarily requested gait analysis were included in this study, there is a possibility of selection bias. Fourth, since this study was conducted at a Foot and Ankle specialty clinic, the information on RA disease activity and the condition of the knee and hip joints was not available.

## CONCLUSION

This study provides a more detailed understanding of the impact of RA on gait characteristics, which may contribute to improvements in the rehabilitation and treatment planning for patients with RA. Patients with rheumatoid arthritis exhibit distinct gait abnormalities, even when compared to non-RA individuals with foot disabilities. The cautious gait pattern seen in RA patients may help maintain stability but can compromise walking efficiency and increase fall risk. Targeted rehabilitation, including balance and strength training, should be emphasized to preserve gait function and enhance quality of life in patients with RA.

## REFERENCES

1. Vainio K. The rheumatoid foot: A clinical study with pathological and roentgenological comments. Ann Chir Gynaecol Fenn Suppl. 1956;45:1-107.
2. Yano K, Ikari K, Inoue E, Sakuma Y, Mochizuki T, et al. Features of patients with rheumatoid arthritis whose debut joint is a foot or ankle joint: A 5,479-case study from the IORRA cohort. PLoS One. 2018;13:e0202427.
3. Michelson J, Easley M, Wigley FM, Hellmann D. Foot and ankle problems in rheumatoid arthritis. Foot Ankle Int. 1994;15:608-613.
4. Eppeland SG, Myklebust G, Hodt-Billington C, Moe-Nilssen R. Gait patterns in subjects with rheumatoid arthritis cannot be explained by reduced speed alone. Gait Posture. 2009;29:499-503.
5. Carroll M, Parmar P, Dalbeth N, Boocock M, Rome K. Gait characteristics associated with the foot and ankle in inflammatory arthritis: A systematic review and meta-analysis. BMC Musculoskelet Disord. 2015;16:1-12.
6. Mendes de Leon CF, Seeman TE, Baker DI, Richardson ED, Tinetti ME. Self-efficacy, physical decline, and change in functioning in community-living elders: A prospective study. J Gerontol B Psychol Sci Soc Sci. 1996;51:S183-190.
7. Jung H, Tanaka S, Iwamoto Y, Yamasaki M, Tanaka R. Relationship between mobility-related activities of daily living and health-related quality of life among healthy older adults: A cross-sectional study using structural equation modeling. Gerontol Geriatr Med. 2021;7:23337214211013166.
8. Promsri A, Cholamjiak P, Federolf P. Walking stability and risk of falls. Bioengineering (Basel). 2023;10:1-12.
9. Nix S, Smith M, Vicenzino B. Prevalence of hallux valgus in the general population: A systematic review and meta-analysis. J Foot Ankle Res. 2010;3:21.
10. Roddy E, Zhang W, Doherty M. Prevalence and associations of hallux valgus in a primary care population. Arthritis Rheum. 2008;59:857-862.
11. Aenumulapalli A, Kulkarni MM, Gandotra AR. Prevalence of flexible flat foot in adults: A cross-sectional study. J Clin Diagn Res. 2017;11:AC17-AC20.
12. Salinas-Torres VM, Salinas-Torres RA, Carranza-Garcia LE, Herrera-Orozco J, Tristan-Rodriguez JL. Prevalence and clinical factors associated with pes planus among children and adults: A population-based synthesis and systematic review. J Foot Ankle Surg. 2023;62:899-903.
13. Nakajima A, Sakai R, Inoue E, Harigai M. Prevalence of patients with rheumatoid arthritis and age-stratified trends in clinical characteristics and treatment, based on the National Database of Health Insurance Claims and Specific Health Checkups of Japan. Int J Rheum Dis. 2020;23:1676-1684.
14. Pirker W, Katzenschlager R. Gait disorders in adults and the elderly: A clinical guide. Wien Klin Wochenschr. 2017;129:81-95.
15. Baan H, Dubbeldam R, Nene AV, van de Laar MA. Gait analysis of the lower limb in patients with rheumatoid arthritis: A systematic review. Semin Arthritis Rheum. 2012;41:768-788.e8.
16. Mochizuki T, Kurata A, Yano K, Ikari K, Okazaki K. Effects of locomotion training on the physical functions and quality of life in patients with rheumatoid arthritis: a pilot clinical trial. Prog Rehabil Med. 2022;7:20220014.
17. Lusa AL, Amigues I, Kramer HR, Dam TT, Giles JT. Indicators of walking speed in rheumatoid arthritis: Relative influence of articular, psychosocial, and body composition characteristics. Arthritis Care Res (Hoboken). 2014;67:21-31.
18. Morita Y, Ito H, Torii M, Hanai A, Furu M, et al. Factors affecting walking ability in female patients with rheumatoid arthritis. PLoS One. 2018;13:e0195059.
19. Yamada M, Aoyama T, Mori S, Nishiguchi S, Okamoto K, et al. Objective assessment of abnormal gait in patients with rheumatoid arthritis using a smartphone. Rheumatol Int. 2012;32:3869-3874.
20. Smulders E, Schreven C, van Lankveld W, Duysens J, Weerdesteyn V. Obstacle avoidance in persons with rheumatoid arthritis walking on a treadmill. Clin Exp Rheumatol. 2009;27:779-785.
21. Smith TO, Clarke C, Wells J, Dainty JR, Watts L, et al. Clinical and biomechanical factors associated with falls and rheumatoid arthritis: Baseline cohort with longitudinal nested case–control study. Rheumatology (Oxford). 2022;61:679-687.
22. Ergul EE, Alkan Melikoglu M. A quantitative assessment of the risk of falls in rheumatoid arthritis patients and determination of the risk factors. Turk J Phys Med Rehabil. 2022;68:271-277.
23. Yoshii I, Kondo M. Clinical characteristics of frailty in Japanese rheumatoid arthritis patients. J Frailty Aging. 2020;9:1-6.