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Whole-body Magnetic Resonance Imaging in Psoriatic Arthritis, Rheumatoid Arthritis, and Healthy Controls: Interscan, Intrareader, and Interreader Agreement and Distribution of Lesions

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ABSTRACT. ***Objective.*** Whole-body MRI (WBMRI) is a promising technique for monitoring patients' global disease activity in inflammatory joint diseases. The validation of WBMRI is limited; no studies have evaluated the test-retest agreement (interscan agreement) and only a few have assessed the intra- and interreader agreement. Therefore, we first examined the interscan agreement of WBMRI in patients with psoriatic arthritis (PsA), rheumatoid arthritis (RA), and healthy controls (HC); and second, we evaluated the intra- and interreader agreement and agreement with conventional hand MRI and determined the distribution of lesions.

Methods. WBMRI was performed twice at a 1-week interval in 14 patients with PsA, 10 with RA, and 16 HC. Images were anonymized and read in pairs with unknown chronological order by experienced readers according to the Outcome Measures in Rheumatology (OMERACT) WBMRI, Canada-Denmark MRI, and the RA MRI scoring system (RAMRIS) and the PsA MRI scoring system (PsAMRIS). Ten image sets were reanonymized for assessment of intra- and interreader agreement. Agreement was calculated on lesion level by percentage exact agreement (PEA) and Cohen κ, and for sum scores by absolute agreement, single-measure intraclass correlation coefficient (ICC).

Results. WBMRI of the spine and peripheral joints and entheses generally showed moderate to almost perfect interscan agreement with PEA ranging from 95% to 100%, κ 0.71–1.00, and ICC 0.95 to 1.00. Intra- and interreader data generally showed moderate to almost perfect agreement. Agreement with conventional MRI varied. More lesions were found in patients than in HC.

Conclusion. WBMRI showed good interscan agreement, implying that repositioning of the patient between examinations does not markedly affect scoring of lesions. Intra- and interreader agreement were moderate to almost perfect.

Key Indexing Terms: magnetic resonance imaging, psoriatic arthritis, rheumatoid arthritis, whole-body imaging

Psoriatic arthritis (PsA) and rheumatoid arthritis (RA) are chronic inflammatory diseases that may affect both axial and peripheral joints. RA is mostly symmetrically distributed and characterized by inflammation of the small joints of the hands and feet, while PsA tends to affect axial and/or peripheral joints in an asymmetrical pattern[1,2]. Modern imaging methods such as magnetic resonance imaging (MRI) and ultrasound allow monitoring of disease activity and progression in clinical trials and practice[3,4]. Conventional MRI allows sensitive visualization of axial and peripheral inflammatory and structural lesions of a limited anatomical area in a single examination. Whole-body MRI (WBMRI) is a relatively new technique, first used for oncologic disease monitoring, which makes it possible to assess both axial and peripheral joints and entheses in 1

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examination[5]. Imaging the entire body in 1 examination within 50 minutes without repositioning the patient makes it a potential future tool for monitoring disease activity in clinical trials and supporting clinical decision making in inflammatory joint diseases[5,6]. WBMRI seems particularly promising in patients with PsA, since PsA presents with varying patterns of axial and peripheral joint and enthesis involvement[6]. WBMRI scoring systems for both the spine and peripheral joints and entheses have been proposed[7,8], but the validation of WBMRI is limited. Studies assessing the intra- and interreader agreement are available[9,10,11,12,13]; however, no studies have evaluated the agreement of test-retest (interscan agreement), which is crucial to assess the significance of observed changes over time and is one of several types of validation that is needed in the verification of outcome measures. The primary aim of this study was to evaluate the interscan agreement of WBMRI. Secondary aims were to examine the intra- and interreader reliability of WBMRI, to compare detection of inflammatory changes in the small joints of the hands by WBMRI and conventional MRI, and to evaluate the distribution of axial and peripheral lesions in patients with PsA and RA as well as healthy controls (HC).

MATERIALS AND METHODS

Patients. Patients with PsA, defined by the CASPAR (Classification for Psoriatic Arthritis) criteria[14], or RA, defined by the American College of Rheumatology/European League Against Rheumatism criteria[15], 18 to 70 years of age, and with clinically active disease were recruited from 2 rheumatological clinics in the Copenhagen area. Further, HC were recruited. For PsA, clinically active disease was defined as ≥ 2 (of 76) swollen joints and ≥ 3 (of 78) painful joints at clinical examination, and involvement of hands defined as swelling of ≥ 1 finger joint [in metacarpophalangeal (MCP) joints 2–5, and proximal interphalangeal (PIP) or distal interphalangeal (DIP) joints 2–5)] and/or ≥ 1 dactylitis. Clinically active disease for RA was defined as ≥ 2 (of 76) swollen joints and ≥ 3 (of 78) painful joints at clinical examination and involvement of hands defined as swelling of ≥ 1 finger joint (MCP 2–5, PIP 2–5, or DIP 2–5).

Exclusion criteria included (1) changes in or initiation of treatment with nonsteroidal antiinflammatory drugs (NSAID), glucocorticoids, and conventional disease-modifying antirheumatic drugs (cDMARD) ≤ 1 month before inclusion and biologic treatment ≤ 3 months before inclusion; (2) pregnancy or breastfeeding; (3) contraindications for MRI, including the use of contrast agents containing gadolinium (Gd); and (4) known recent drug or alcohol abuse. Exclusion criteria for HC were (1) pain in peripheral joints or the spine < 3 months before inclusion, and (2) presence of swollen joints (≥ 1 of 76) and/or tender joints (≥ 1 of 78) at clinical examination.

The study was approved by the local ethics committee, H4-2012-044, and all participants signed informed consent before any study procedures.

Demographics. Background information on age, sex, symptom duration, and diagnosis, as well as treatment status (NSAID, cDMARD, biologic DMARD, and glucocorticoids) for patients and HC was collected.

Clinical examination. For all participants, the following clinical and laboratory variables were collected before the first MRI examination: clinical examination of joints for swelling (76) and tenderness (78) and entheses for tenderness (33); Disease Activity Score in 28 joints, Health Assessment Questionnaire, Bath Ankylosing Spondylitis Disease Activity Index, Bath Ankylosing Spondylitis Functionality Index, and Bath Ankylosing Spondylitis Metrology Index; C-reactive protein; and serum creatinine.

Image acquisition. WBMRI of the entire body (axial and peripheral joints and entheses except for elbows and head) and conventional MRI of the right hand were performed twice for each participant at a 1-week interval.

WBMRI was performed on a Philips 3T Ingenia unit using phased array coils (2 anterior and 1 built-in posterior) with patients in a supine position for the following areas: (1) coronal images of shoulders and anterior chest wall; (2) sagittal images of the cervical, thoracic, and lumbar spine; (3) coronal images of the pelvis and hips; (4) coronal images of hands (positioned behind the buttocks); (5) sagittal images of knees; (6) sagittal images of ankles; and (7) axial images of the ankles/feet. Short-tau inversion recovery (STIR) and pre- and post-Gd (0.1 mmol/kg body weight gadoterate meglumine; Dotarem) T1-weighted spin echo sequences were obtained of all regions, with a slice thickness of 3 mm for hands and ankles/feet, 4 mm for the spine, and 5 mm for shoulders, hips, knees, and ankles.

Conventional MRI of the hand was performed on the same scanner using a dedicated 8 canal hand/wrist for coronal images of the hand and wrist. STIR and pre- and post-Gd T-weighted spin echo sequences were obtained of the right hand and wrist, with a slice thickness of 2.5 mm for STIR sequences and a slice thickness of 0.8 mm for pre- and post-Gd T1-weighted sequences.

The procedure for the MRI sessions was that precontrast WBMRI was performed first, then coils were changed, and then precontrast conventional hand and wrist MRI was done. Contrast was then injected intravenously and the postcontrast conventional MRI was performed, followed by a change of coils and performance of the post-contrast WBMRI.

Further details on the MRI protocol are specified in Supplementary Table 1 (available from authors upon request).

MRI assessment. All WBMRI and conventional MRI images were anonymized and read in pairs, (i.e., the 2 timepoints in continuation of each other), in unknown chronological order, by experienced readers blinded for all clinical and biochemical information. For WBMRI, peripheral joints and entheses were scored according to the Outcome Measures in Rheumatology (OMERACT) WBMRI for peripheral joints and entheses (WIPE) scoring system[7,16] by an experienced musculoskeletal radiologist (I.E.). Using this system, bone marrow edema (BME) and synovitis are scored in all peripheral joints except elbows, and BME and soft tissue inflammation (STI) are scored in 33 entheses (see Krabbe, *et al*[16] for details). Axial joints (spine) were scored according to the Canada-Denmark (CANDEN) MRI scoring system[8] by a second reader, experienced in reading spinal MRI of inflammatory arthritis (S.K.). Using this system, BME, fat lesions, bone erosions, and new bone formation are scored separately at numerous locations in each vertebra (see Krabbe, *et al*[8] for details). Conventional MRI of the wrist, MCP 2–5, and PIP 2–5 were scored according to the RA MRI scoring system (RAMRIS)[17,18,19] and PsA MRI scoring system (PsAMRIS)[20] for synovitis, tenosynovitis, BME, erosions, and periarticular inflammation by a third reader, experienced in reading hand MRI (D.G.). Ten image sets (4 patients with PsA, 3 with RA, and 3 HC) were reanonymized and rescored by the above readers to investigate the intrareader agreement. Further, the same 10 sets were scored according to all the applied scoring methods by an additional reader (M.Ø.), experienced in all 3 scoring methods, to investigate the interreader agreement. All readers calibrated before scoring, as recommended[9].

Statistical analysis. Only patients with complete image sets of WBMRI and conventional MRI were included in the statistical analyses. Scorings at lesion level were assessed using percentage exact agreement (PEA) and Cohen κ, quadratically weighted. For both WBMRI and conventional MRI, PEA and κ were calculated for all joints together, as well as per type of pathology for the different joint regions (peripheral WBMRI: hands, shoulders, hips, knees, ankles/feet; spinal WBMRI: not subdivided; conventional MRI: wrist, MCP and PIP). Scores at the patient level were assessed using a 2-way random effects single measure model of intraclass correlation coefficient (ICC) based on absolute agreement. For WBMRI and conventional MRI, ICC was calculated per type of pathology for the individual joint regions and all joints together. PEA, κ, and ICC for total inflammation

of all inflammatory lesions considered together were calculated both per joint region and for all joints together. Periarticular inflammation was not included in the statistical analyses since it was found only in 2 patients. Intra- and interreader agreement analyses were done on pooled data from the 2 timepoints (i.e., a total of 20 datasets were analyzed). Cohen κ 0–0.20 was considered as no agreement, 0.21–0.39 as slight, 0.40–0.59 as weak, 0.60–0.79 as moderate, 0.80–0.90 as strong, and > 0.90 as almost perfect agreement[21]. ICC values < 0.50 were considered as poor, 0.51–0.75 as moderate, 0.76–0.90 as good, and > 0.91 as excellent reliability[22].

The distribution of lesions in each group (PsA, RA, and HC) was calculated as the percentage of participants with any positive grade of the individual lesion in each specific anatomical area.

The correlation between right hand WBMRI (WBMRI scoring methods) and conventional MRI (RAMRIS/PsAMRIS scoring methods) was assessed using Spearman rho for the sum scores of wrists, MCP 2–5, and PIP 2–5, synovitis, and BME.

Missing data at 1 timepoint were transferred as missing data to the other timepoint. For sum scores, missing data were imputed as zero. All statistical analyses were made in SPSS v. 25 (IBM Corp.) or R v. 3.4.2 (R Foundation for Statistical Computing).

RESULTS

Patients. Forty-three participants were included in the study; 3 were excluded from statistical analyses due to incomplete image sets. Thus, data from 40 participants (14 patients with PsA, 10 with RA, and 16 HC) were analyzed. Demographics and baseline characteristics are shown in Table 1.

Readability and distribution of lesions. The readability of conventional MRI and WBMRI was generally high but in certain areas, mainly the lower sternocostal joints, it was lower. Table 2 shows the readability and the total number of lesions for the anatomical areas for WBMRI and conventional MRI. In general, lesions on WBMRI were more frequent in patients with PsA and RA than HC (Figure 1 and Figure 2).

WBMRI, peripheral joints and entheses. For all of the 4 assessed pathologies (joint BME and synovitis, entheseal BME, and STI), interscan PEA ranged from 95% to 98%, for all joints considered together. For all joints considered together, interscan κ for synovitis and BME were 0.82 and 0.88 (strong), respectively (Table 3), and ICC 0.96 and 0.99 (i.e., excellent). For entheses, interscan κ for soft tissue inflammation and BME were 0.79 and 0.71 (moderate), respectively, and ICC 0.96 and 0.93 (excellent). For all inflammatory lesions considered together, κ was 0.83 (strong) and ICC 0.97 (excellent).

Regarding intrareader data, PEA was ≥ 90%, κ 0.52–0.67 (weak to moderate), with one exception being entheseal BME, and ICC 0.14–0.87 (poor to good), for the various lesion types (Table 4). Interreader data showed PEA ranging from 84% to 97%, κ 0.34–0.72 (slight to moderate), and ICC 0.35–0.93 (poor to excellent) for the various lesion types.

WBMRI, spine. For interscan data, PEA was 100%, κ 0.99–1.00 (almost perfect; Table 3), and ICC ranged from 0.99 to 1.00 (excellent) for the various lesion types. For intrareader lesion level data, PEA was 99–100%, κ was 0.91–1.00 (almost perfect) at lesion level, and ICC ranged from 0.99 to 1.00 (excellent) for the various lesion types (Table 4). For interreader data, PEA ranged from 98% to 100%, κ 0.82–0.93 (strong to almost perfect), with an exception being new bone formation, and ICC ranged from 0.23 to 0.97 (poor to excellent) for the various lesion types.

Conventional MRI. For interscan data, PEA was 98–100%, κ 0.93–1.00 (almost perfect), and ICC was 0.91–1.00 (excellent) across the various lesion types (Table 3). Intrareader data showed PEA ranging from 85% to 99%, κ 0.75–0.95 (moderate to almost perfect), and ICC 0.79–0.99 (moderate

Table 1. Baseline patient characteristics.

	PsA, n = 14	RA, n = 10	HC, n = 16
Age, yrs	48 (31–68)	49 (26–58)	35 (23–54)
Female, n (%)	10 (71)	8 (80)	9 (56)
Symptom duration, yrs	10 (0–24)	7 (3–24)	–
BASDAI (0–100 mm VAS)	36 (2–77)	34 (7–71)	2 (0–14)
BASFI (0–100 mm VAS)	22 (0–54)	15 (0–66)	1 (0–7)
BASMI (0–100)	0 (0–30)	0 (0–0)	0 (0–10)
Axial physician global assessment (0–100 mm VAS)	25 (2–61)	26 (6–57)	0 (0–1)
Axial pain (0–100 mm VAS)	33 (3–83)	32 (4–76)	0 (0–23)
Axial PtGA (0–100 mm VAS)	37 (0–86)	25 (4–76)	0 (0–22)
HAQ (0–100 mm)	0.5 (0–1.5)	0.7 (0.3–1.8)	0 (0–0.1)
Peripheral pain (0–100 mm VAS)	31 (4–78)	33 (0–75)	0 (0–35)
Fatigue (0–100 mm VAS)	37 (0–88)	57 (0–78)	4 (0–40)
Peripheral PtGA (0–100 mm VAS)	47 (0–84)	41 (0–77)	0 (0–36)
No. swollen joints (0–76)	5 (2–12)	6 (3–15)	0 (0–0)
No. tender joints (0–78)	11 (3–24)	8 (3–31)	0 (0–1)
No. tender entheses (0–31)	10 (0–21)	4 (0–14)	0 (0–3)
Serum CRP, mg/dL	5 (1–13)	5 (1–23)	5 (1–14)

Values are median (range). BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; BASMI: Bath Ankylosing Spondylitis Metrology Index; CRP: C-reactive protein; HAQ: Health Assessment Questionnaire; HC: healthy controls; PtGA: patient global assessment; PsA: psoriatic arthritis; RA: rheumatoid arthritis; VAS: visual analog scale.

Table 2. WBMRI and conventional MRI readability and frequency of lesions in patients with PsA and RA and HC.

WBMRI Peripheral Joints

	Readability, %				No. Lesions, % of All Readable Areas[a]											
					Synovitis			JBME			Soft Tissue Inflammation			EBME		
	Syn	STI	JBME	EBME	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC
Shoulders and AC	95	96	96	95	18	10	4	11	6	11	15	6	11	28	14	10
Wrists and 1st CMC	94	–	95	–	29	48	19	5	11	0	–	–	–	–	–	–
Hands, MCP 2–5	96	–	96	–	5	21	1	3	6	0	–	–	–	–	–	–
Hands, PIP 2–5	95	–	94	–	4	8	0	0	0	0	–	–	–	–	–	–
Hands, DIP 2–5	95	–	93	–	13	8	0	1	0	0	–	–	–	–	–	–
SC joint 1	–	94	–	94	–	–	–	–	–	–	2	0	0	0	0	2
SC joint 2	–	93	–	93	–	–	–	–	–	–	0	0	0	4	0	0
SC joints 3–7	–	6	–	5	–	–	–	–	–	–	0	0	0	0	0	0
Pelvis/hip[b]	93	94	93	94	22	19	3	7	6	0	10	12	8	1	0	0
Knees	99	98	98	98	19	13	13	7	0	0	8	4	1	4	1	0
Ankles and TMT	97	95	96	95	17	14	15	11	11	2	20	20	11	19	7	1
Feet, MTP 1–5	91	–	89	–	29	21	20	8	9	0	–	–	–	–	–	–
Feet, PIP 1–5	83	–	83	–	1	1	1	3	2	1	–	–	–	–	–	–
Feet, DIP 1–5	81	–	81	–	0	0	0	0	0	0	–	–	–	–	–	–

WBMRI Spine

	Readability, %				No. of Lesions (% of All Readable Areas)											
					Bone Marrow Edema			Fat			Erosion			New Bone Formation		
	BME	Fat	Ero	NBF	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC
Cervical vertebral bodies	100	100	100	100	0.7	0.9	0.2	0	2	0.8	0	0	0	0.4	0.6	0.8
Cervical posterior parts	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0
Thoracic vertebral bodies	100	100	100	100	2.1	0.8	0.4	0.7	0.7	0.5	0.8	0.7	0	0.3	0.7	0.2
Thoracic posterior parts	100	100	100	100	0.2	0	0	0	0	0	0	0	0	0	0	0
Lumbar vertebral bodies	100	100	100	100	1.5	0.7	0.3	0.5	0.8	0.4	1	0.5	0	0.7	1.2	0.4
Lumbar posterior parts	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0

Conventional MRI

	Readability, %				No. Lesions (% of Readable)											
					Syn			TS			BME			Erosion		
	Syn	TS	BME	Ero	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC	PsA	RA	HC
MCP 2–5	86	86	94	95	42	36	5	19	32	0	1	17	0	8	9	0
PIP 2–5	82	83	91	93	32	25	2	10	18	1	0	11	0	1	1	0
Wrist	86	83	94	95	61	40	23	12	20	3	5	11	0	5	5	0

[a]No. lesions is the total number of lesions for all participants in each group; percentage is the number of observed lesions divided by the total number of possible lesions (i.e., the number of readable areas). [b]Sacroiliac joints not included. AC: acromioclavicular joints; BME: bone marrow edema; CMC: carpometacarpal joint; DIP: distal interphalangeal joint; EBME: entheseal bone marrow edema; Ero: erosion; HC: healthy controls; JBME: joint bone marrow edema; MCP: metacarpophalangeal joint; MRI: magnetic resonance imaging; MTP: metatarsophalangeal joint; NBF: new bone formation; PIP: proximal interphalangeal joint; PsA: psoriatic arthritis; RA: rheumatoid arthritis; SC: sternocostal; STI: soft tissue inflammation; Syn: synovitis; TMT: tarsometatarsal joint; TS: tenosynovitis; WBMRI: whole-body MRI.

to excellent; Table 4). Interreader data showed PEA ranging from 76% to 94%, κ 0.19 to 0.88 (none to strong), and ICC 0.20–0.99 (poor to excellent) for the various lesion types. Periarticular inflammation was seen in 2 patients in both scans. In the analysis of the correlation between WBMRI and conventional MRI of the wrist, MCP, and PIP, the Spearman rho for synovitis were 0.17, 0.51, and 0.28, respectively, and for BME 0.38, 0.82, and not available, respectively (data not shown).

DISCUSSION

This study is, to our knowledge, the first study to assess the interscan agreement (agreement between repeated scans) of WBMRI in inflammatory joint diseases. The overall interscan agreement of WBMRI for both axial and peripheral inflammatory changes in patients with PsA and RA and in HC was good.

WBMRI of the individual areas in the spine and peripheral joints and entheses generally showed good interscan agreement. The overall agreement was comparable for soft tissue and bone changes in joints and entheses. The interscan agreement for the total MRI inflammatory activity (i.e., the sum of joint and entheseal soft tissue and bone inflammation) was good, both for individual regions (ICC > 0.80) and for the entire patient

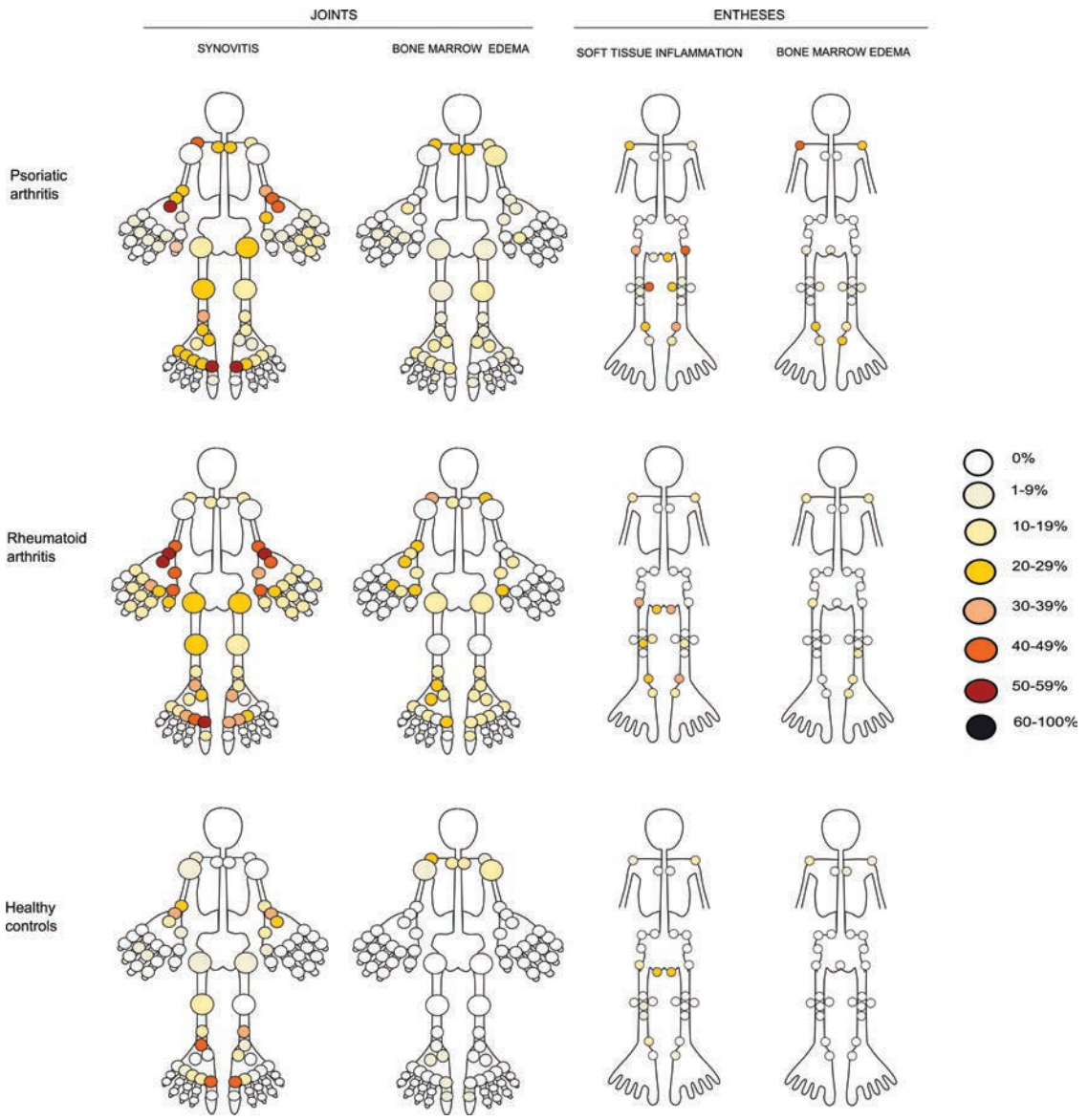

Figure 1. Percentage of participants with lesions found on WBMRI in the examined peripheral joints and entheses. The specific joints and entheses can be seen in Krabbe, *et al*[16]. WBMRI: whole-body magnetic resonance imaging.

(ICC = 0.97). The few exceptions (pelvis/hip and shoulder) showed low κ and ICC, but not a low PEA. This can be explained by only a few patients having lesions, which will lower the κ and ICC. There were no definite patterns of poor agreement for one particular joint or enthesis across evaluated pathologies, nor was there any pathology showing poor agreement for all joints or entheses. For example, poor agreement among the shoulder pathologies was seen only for entheseal STI, whereas for pathologies in the pelvis, poor agreement was seen only for entheseal BME. This indefinite pattern probably results from the low prevalence of lesions and the limited sample size and it is unlikely to represent true differences in agreement between individual sites. Our results imply that repositioning the patient between examinations does not markedly affect the scoring of lesions. This robustness is an important aspect of WBMRI that should be considered when assessing treatment-induced changes over time in clinical trials. This type of validation is rarely done. However, knowing the variability between 2 examinations is very important when evaluating whether a change occurring after a treatment is real or not. It is a limitation that most patients had low disease activity, since we cannot rule out that larger interscan differences may be found in patients with more severe disease.

WBMRI showed good readability of all the assessed areas, except the lower sternocostal joints. Elbows were not included in the protocol since earlier studies have shown poor readability for this area due to its location at the edge of the MRI image (i.e., partly outside the field of view)[13]. Compared to earlier studies[10,11,12] using 3T WBMRI, we found overall similar good readability. In future studies, it is relevant to consider whether scoring of the third to seventh sternocostal joints should be included as part of the WBMRI protocol or omitted from scoring.

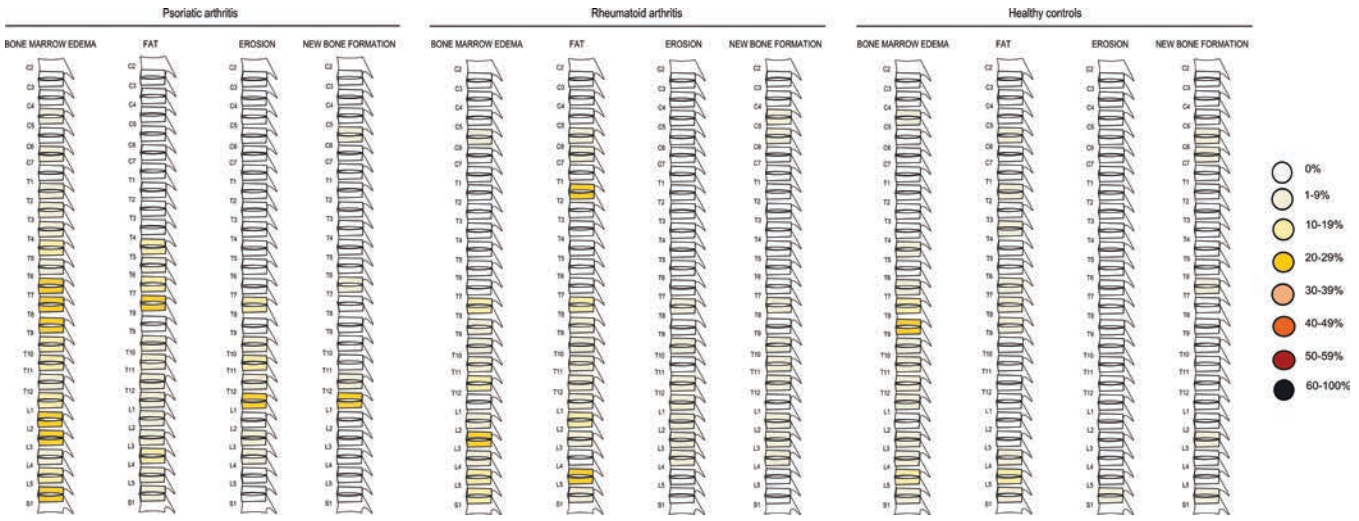

Figure 2. Percentage of participants with lesions in the spine.

The assessment of the distribution of lesions showed more hand lesions in RA than PsA and more involvement of acromioclavicular and sternoclavicular joints and certain entheses in PsA than RA. This is in accordance with the known disease patterns. Overall, patients with RA had more MRI lesions than patients with PsA. This was not explained by clinical differences in the participants, since the RA and PsA groups were similar regarding the number of clinically swollen and tender joints, and symptom duration. In HC, markedly fewer lesions were detected compared to in PsA and RA. However, low-grade inflammatory findings in HC were fairly frequent. It is well known that low-grade inflammation may be seen in HC[23,24]. This may be due to osteoarthritis (OA) or mild inflammation in joints/entheses related to overuse or to the normal physiology of having an active lifestyle. The most frequent finding in HC was synovitis, particularly in the wrist/carpometacarpal joint 1 and MTP 1–5. This may be explained by a relatively low image resolution compared to joint size, which may make the discrimination between normal joint fluid and synovitis difficult, and by the likely presence of subclinical OA. This is in accordance with previous studies that have found low-grade synovitis in small joints of hands and feet in control populations[23,24]. Further, WBMRI assessment is still less certain than optimal conventional MRI, due to poorer image resolution and signal-to-noise ratio.

Intra- and interreader data generally showed moderate to good agreement. Entheseal BME had numerically lower κ and ICC, but similar PEA, compared to the other pathologies. Previously reported ICC for inflammation using the OMERACT WBMRI scoring system[16] was lower (0.67) compared to the ICC (0.93) in this study. In the Krabbe *et al*[8] study, the median interreader ICC for inflammation, fat, erosion, and new bone formation in the spine was 0.78 (range 0.61–0.92) compared to 0.79 (range 0.23–0.97) in the present study (i.e., the interreader ICC was comparable). Other studies[9,10,11,12] have assessed the intra- and interreader agreement for WBMRI using different scoring systems and by this precluding direct comparison. It is likely that the reliability may be further improved by future improvements of the technical quality of WBMRI and the development of standard reference images as proposed by the OMERACT MRI group[16].

The exploratory analysis of the correlation between WBMRI and conventional MRI of the wrist, MCP, and PIP showed the highest values in MCP for both synovitis and BME. The low correlation in wrists may be explained by the different scoring methods. Using the OMERACT WBMRI scoring system, the wrist is scored as 1 joint, whereas in the RAMRIS/PsAMRIS systems, it is scored as several individual joints. Further, the reduced image quality of WBMRI is probably an important factor. Overall, conventional MRI found more lesions than WBMRI of the same joints. Interscan variation for conventional MRI was, as for WBMRI, good to very good. Therefore, repositioning between examinations does not seem to affect the scoring of lesions for either of the 2 approaches.

Strengths of this study were that an extensive MRI protocol including both conventional MRI of 1 wrist/hand and WBMRI of axial and peripheral joints and entheses was repeated within 7 days. This made it possible to assess the interscan agreement. Another strength was that HC were included. Further, the use of the new scoring systems based on international consensus (CANDEN MRI and OMERACT WBMRI WIPE scoring systems) is a strength, since these methods are likely to be used in future studies. The limitations of this study include that the patients generally had low disease activity with few lesions observed. Reading image sets pairwise rather than as individual image sets was chosen as it was expected to allow more reliable detection of changes in lesions between the 2 timepoints, and this is also the convention in clinical trials. The image quality of WBMRI was not optimal, particularly for identifying small structures, but this is gradually improving due to technical advantages.

In conclusion, WBMRI of the spine and peripheral joints and entheses showed good to very good interscan agreement for patients with PsA and RA, and this indicates that repositioning of the patient does not markedly affect the scoring of pathologies between 2 timepoints. Overall, the intra- and interreader agreement was moderate to good.

Table 3. Interscan agreement between two WBMRI examinations performed at a 1-week interval (all participants).

			PEA, %	κ	ICC
WBMRI Peripheral	Synovitis	All	95	0.82	0.96
		Ankles/feet	96	0.83	0.93
		Hands	96	0.84	0.95
		Shoulders	92	0.54	0.60
		Pelvis[a]	97	0.94	0.93
		Knees	87	0.64	0.79
	Joint BME	All	98	0.88	0.99
		Ankles/feet	98	0.84	0.98
		Hands	99	0.87	0.91
		Shoulders	95	0.87	0.91
		Pelvis	99	0.95	1.00
		Knees	100	0.97	1.00
	Entheseal STI	All	97	0.79	0.96
		Ankles/feet	98	0.96	0.98
		Hands	NA	NA	NA
		Shoulders	95	0.27	0.40
		Pelvis	96	0.82	0.93
		Knees	97	0.75	0.95
	Entheseal BME	All	98	0.71	0.93
		Ankles/feet	96	0.59	0.71
		Hands	NA	NA	NA
		Shoulders	96	0.70	0.60
		Pelvis/hip	99	0.40	0.04
		Knees	100	0.87	1.00
	Total inflammation[b]	All	97	0.83	0.97
		Ankles/feet	97	0.83	0.96
		Hands	97	0.85	0.94
		Shoulders	95	0.72	0.80
		Pelvis	98	0.85	0.96
		Knees	98	0.83	0.99
WBMRI Axial	BME	All	100	0.99	0.99
	Fat	All	100	0.99	1.00
	Erosion	All	100	1.00	1.00
	New bone formation	All	100	1.00	1.00
Conv. MRI	Synovitis	All	98	0.97	0.99
		MCP	98	0.97	0.98
		PIP	98	0.95	0.97
		Wrist	98	0.97	0.99
	Tenosynovitis	All	99	0.98	0.99
		MCP	98	0.97	0.99
		PIP	98	0.95	0.91
		Wrist	100	1.00	1.00
	BME	All	100	0.99	1.00
		MCP	99	0.98	0.99
		PIP	100	1.00	1.00
		Wrist	99	0.99	1.00
	Erosion	All	100	0.97	0.98
		MCP	99	0.93	0.92
		PIP	100	1.00	1.00
		Wrist	100	1.00	1.00
	Inflammation	All	99	0.98	1.00
		MCP	99	0.98	0.99
		PIP	99	0.96	0.98
		Wrist	100	0.99	1.00

[a] Pelvis: hip joints; sacroiliac joints not included. [b] Total inflammatory activity; the sum of joint and entheseal soft tissue and bone inflammation. BME: bone marrow edema; Conv.: conventional; ICC: 2-way random effects intraclass correlation coefficient (single measure absolute agreement); κ: Cohen kappa, quadratic weighted; MCP: metacarpophalangeal joints; MRI: magnetic resonance imaging; NA: not applicable; PEA: percentage exact agreement; PIP: proximal interphalangeal joints; STI: soft tissue inflammation; WBMRI: whole-body MRI.

Table 4. Intra- and interreader agreement.

Intrareader				
		PEA, %	κ	ICC
WBMRI peripheral	Synovitis	90	0.58	0.87
	Joint BME	97	0.52	0.45
	Entheseal STI	92	0.67	0.85
	Entheseal BME	97	0.08	0.14
	Total inflammation[a]	94	0.58	0.86
WBMRI axial	BME	100	0.93	0.99
	Fat	99	0.91	0.99
	Erosion	100	1.00	1.00
	New bone formation	100	1.00	1.00
Conv. MRI	Synovitis	85	0.87	0.96
	Tenosynovitis	85	0.75	0.92
	BME	97	0.95	0.99
	Erosion	99	0.83	0.79
	Inflammation	91	0.90	0.99
Interreader				
		PEA, %	κ	ICC
WBMRI peripheral	Synovitis	84	0.41	0.85
	Joint BME	97	0.72	0.91
	Entheseal STI	93	0.41	0.74
	Entheseal BME	97	0.34	0.35
	Total inflammation[a]	92	0.50	0.93
WBMRI axial	BME	100	0.93	0.67
	Fat	99	0.82	0.97
	Erosion	100	0.83	0.91
	New bone formation	98	0.17	0.23
Conv. MRI	Synovitis	76	0.83	0.93
	Tenosynovitis	89	0.68	0.87
	BME	94	0.88	0.99
	Erosion	93	0.19	0.20
	Inflammation	89	0.84	0.99

Values are for 10 participants (psoriatic arthritis, n = 4; rheumatoid arthritis, n = 3; healthy controls, n = 3), and for all anatomical areas considered together. [a]Total inflammatory activity (i.e., the sum of joint and entheseal soft tissue and bone inflammation). BME: bone marrow edema; Conv. MRI: conventional MRI; ICC: 2-way random effects intraclass correlation coefficient, single measure absolute agreement; Kappa: Cohen's Kappa, quadratic weighted; MRI: magnetic resonance imaging; PEA: percentage exact agreement; STI: soft tissue inflammation; WBMRI: whole-body MRI.

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