# The burden of early axial spondyloarthritis

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# Chapter 6

## The impact of illness perceptions and coping on the association between back pain and health outcomes in patients suspected of having axial spondyloarthritis: data from the SPondyloArthritis Caught Early cohort

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## ABSTRACT

**Objective**

To investigate whether illness perceptions and coping influence the relationship between back pain and health outcomes in patients suspected of having axial spondyloarthritis (axSpA).

**Methods**

In the SPondyloArthritis Caught Early cohort, regression models were computed at baseline, with back pain intensity (range 0-10) as the determinant and health-related quality of life, the physical component summary score (PCS) and mental component summary (MCS) of the Short Form 36 (SF-36) health survey, or work productivity loss as outcomes. Subsequently, using Leventhal's Common Sense Model of Self-Regulation, illness perceptions and, thereafter coping were added to the models. Analyses were repeated for patients diagnosed and classified as having axSpA according to the Assessment of SpondyloArthritis international Society axSpA criteria (ASAS axSpA), patients only diagnosed with axSpA (axSpA-diagnosed only), and those with chronic back pain.

**Results**

A total of 424 patients (145 with ASAS axSpA, 81 with only a diagnosis of axSpA, and 198 with chronic back pain); 64% of the total group were female, the mean ± SD age was 30.9 ± 8.1 years, and the mean ± SD symptom duration was 13.3 ± 7.1 months) were studied. In all patients, the strength of the associations between back pain and the PCS, back pain and the MCS score, and back pain and loss of work productivity were decreased by adding illness perceptions to the model, but explained variance improved. Adding coping to these models did not change the results. Comparable results were observed in all subgroups.

**Conclusion**

Illness perception, but not coping, is important in the relationship between back pain and HRQoL and work productivity loss in patients suspected of having axSpA, irrespective of subgroup. This finding suggests that targeting illness perceptions could improve health outcomes in patients suspected of having axSpA.

## INTRODUCTION

The disease burden in patients with axial spondyloarthritis (axSpA) is significant. Treatment aimed at reducing the burden of disease consists of a combination of pharmacologic treatment, education, and exercise.[1] Leventhal's Common-Sense Model of Self-Regulation ('*Common-Sense Model*' (CSM))[2] has been shown to be helpful for understanding patients' responses to various rheumatic diseases and diseases related to axSpA such as psoriasis or inflammatory bowel disease.[3-5] However, the CSM has not yet been studied in patients with axSpA or in patients with chronic back pain who are suspected of having axSpA.[6] The CSM is a theoretical framework used to describe and understand a patient's responses to an illness and its characteristics (e.g. swollen joints, see **Figure 1**).[2] According to the CSM, patients perceive an illness and its characteristics as a health threat and respond to this threat by generating illness perceptions. According to this model, illness perceptions directly influence coping strategies, which in turn influence health outcomes such as health-related quality of life (HRQoL) and loss of work productivity, in order to re-establish a patient's normal health state. Illness perceptions are ideas formulated by patients that help them make sense of their illness, such as perceived personal control over the disease or the experienced negative emotions that they attribute to the disease. In contrast, coping strategies are cognitive and behavioural strategies used to manage stress associated with having to live with the illness (e.g., actively diverting attention from the illness or adapting the level of physical activity).



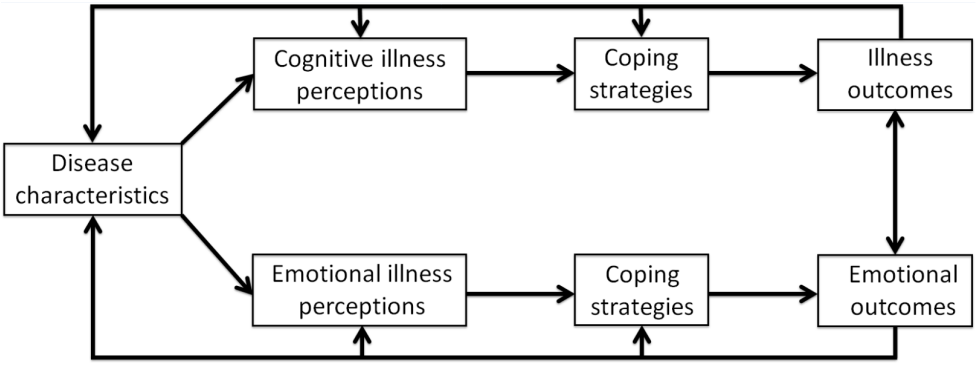


**Figure 1. Flow diagram representing Leventhal's Common-Sense Model of Self-Regulation.**
Adapted by Daleboudt GM (2014)[38]

Relatively little is known about illness perceptions in patients with axSpA, especially those with early axSpA. In a study by Hyphantis and colleagues in patients with longstanding ankylosing spondylitis (AS), '*illness concern*' (i.e., more concerns about the disease) was found to be associated with worse physical HRQoL.[7] Different results concerning illness

perceptions in patients with chronic back pain have been reported. Most studies showed that patients with chronic back pain strongly believe in '*severe consequences*' (e.g. held strong beliefs in severe consequences), strong beliefs that the disease is '*chronic*', and have '*negative emotions*' toward their disease.[8-10]

Two studies in patients with AS showed that avoidant coping styles '*decreasing activities*' and '*pacing*' were associated with more pain and worse physical and mental functioning.[11, 12] These two coping strategies were also strongly related to withdrawal from the workforce.[13] In patients with chronic back pain, maladaptive coping strategies such as '*avoiding physical activity*' were associated with negative health outcomes such as increased pain and disability.[14] However, knowledge about illness perceptions and coping in patients with early axSpA is lacking. Furthermore, little is known about how both illness perceptions and coping impact health outcomes in (early) axSpA.

Exploring use of the CSM in patients with early axSpA and chronic back pain is important, because it may enable health care professionals to identify illness perceptions and coping strategies that are susceptible to additional treatment strategies aimed at decreasing the burden of disease in these patients. In the current study, we first investigated the association between back pain and HRQoL or loss of work productivity, and subsequently, we investigated the influence of illness perceptions and coping on these associations in patients suspected of having axSpA and in subgroups. We used the CSM as the theoretical model. We hypothesized that having severe back pain is associated with lower HRQoL and greater loss of work productivity, and that the strengths of these associations are amplified by negative illness perceptions and maladaptive coping strategies inpatients suspected of having axSpA. We further hypothesized that the relationship between illness perceptions and coping strategies differs across subgroups.

Back pain is a self-reported and subjective symptom that is prevalent among patients with axSpA. Therefore, we thought it would be interesting to additionally investigate the previously mentioned associations, using an objective sign that is typical for axSpA. We considered inflammation on magnetic resonance imaging of the sacroiliac joints (MRI-SI) as measured by the Spondyloarthritis Research Consortium of Canada score for the SI joints (SPARCC-SI) to be a good candidate for being the objective sign. We hypothesized that illness perceptions and coping strategies have little influence on these associations, because a patient is unaware of his or her SPARCC-SI score. Consequently, all analyses were also performed using the SPARCC-SI score instead of backpain as the independent variable in a group of patients who were diagnosed and classified as having axSpA.

## METHODS

Baseline data from the SPondyloArthritis Caught Early (SPACE) cohort of patients who were included between January 2009 and February 2017 were used. Briefly, the SPACE cohort is a prospective inception cohort of patients with chronic back pain (≥ 3 months but ≤ 2 years, and onset before age 45 years).[15] Dutch, Norwegian, and Italian rheumatology outpatient clinics participated in the SPACE study. Approval by local medical ethics committees (Medical Ethics Committee, Leiden University Medical Center [approval no. P08.105]; regional committee for medical and health research ethics in South-East Norway [approval no./ID 2014/426]; and Azienda Ospedaliera di Padova [approval no. 2438P]) was obtained. Informed consent was obtained from all study participants prior to inclusion.

All patients underwent the same diagnostic evaluation at baseline, consisting of medical history, physical examination, questionnaires, laboratory assessments (i.e., HLA–B27), and imaging including plain radiographs of the pelvis and coronal oblique MRI-SI (1.5T, 4-mm slice thickness). Patients were unaware of their diagnosis until the full assessment was performed. Treating rheumatologists provided the diagnosis, using clinical findings and local readings of the images. Patients in whom axSpA was diagnosed were classified according to the Assessment of SpondyloArthritis international Society (ASAS) axSpA criteria[16], based on central reading of images.



Analyses were performed in all patients as well as the following subgroups: patients diagnosed with axSpA and classified according to the ASAS axSpA criteria (ASAS axSpA), patients diagnosed with axSpA only (axSpA-diagnosed only), and patients diagnosed with chronic back pain.

Back pain intensity was assessed by asking patients to report the extent of back pain in the past 7 days on a numeric rating scale (NRS) ranging from 0 (no pain) to 10 (unbearable pain). Inflammation suspected of being axSpA on MRI-SI was quantified by 3 central readers according to the SPARCC-SI scoring method, and the average continuous SPARCC-SI score from 3 readers was calculated. Four quadrants were scored for each SI joint, and additional scores were given to lesions characterized by depth or intensity, resulting in a total score ranging from 0 to 72.[17]

Illness perceptions were assessed with the Revised Illness Perception Questionnaire (IPQ-R), which consists of 3 sections.[18, 19] The first section is the illness identity dimension, in which patients are asked about their experience with particular symptoms (15 items) and the perceived relationship with back pain. The numbers of symptoms with a perceived relationship is summed. The second section of the IPQ-R consists of 7 dimensions:

'*consequences*' (perceived impact of the disease on the patient's life), '*acute/ chronic timeline*' (perceived likeliness of chronicity of the disease), '*personal control*' (perceived personal control over the disease), '*treatment control*' (perceived efficacy of treatment), '*illness coherence*' (extent to which patients feel they understand their disease), '*cyclical timeline*' (the patient's perceptions of variability of her or her disease), and '*emotional representation*' (the patient experienced negative emotions due to the disease). The third section (causal attributions) consists of 18 possible causes that patients may attribute to their disease. Five dimensions were calculated: '*psychological attributions*', '*risk factors*', '*immunity*', '*accident*', and '*chance*'. The subscales of the second and third sections used Likert scales to score all items (1=strongly disagree and 5=strongly agree). Higher scores indicate stronger beliefs in that dimension (second section) or stronger beliefs in a dimension being a cause of the disease (third section).[19]

Coping strategies were assessed with the Coping with Rheumatic Stressors (CORS) questionnaire. The questionnaire is aimed at dealing with the most important stressors in rheumatic diseases: pain, limitations, and dependence.[20, 21] '*Comforting cognitions*' (putting pain in perspective), '*decreasing activities*', and '*diverting attention*' (thinking about/focusing on something else) refer to coping with pain. Coping with limitations is measured by '*optimism*', '*pacing*' (adapting/lowering the level of activity), and '*creative solution seeking*' (searching for creative solutions to cope with the limitations in daily life). The 2 styles of coping with dependence are '*accepting*' (making efforts to accept the level of dependence) and '*showing consideration*' (considering the feelings of others). Higher scores indicate preferential use of a particular coping strategy. The mean scores for each subscale of both the IPQ-R and CORS questionnaires were calculated.

Work productivity was assessed by the Work Productivity and Activity Impairment questionnaire (WPAI: general health, version 1.0). Patients were asked to report, e.g., the number of work hours missed due to their disease, the number of hours that they actually worked, and the impact of their disease on work productivity, scored on an NRS from 0 (health problems had no effect on work) to 10 (health problems completely prevented working) in the past week. The summary measure work productivity loss (i.e., total work impairment due to chronic back pain) on a scale from 0% (no work productivity loss) to 100% (total work productivity loss) was calculated. Greater impairment is indicated by higher percentages.[22]

HRQoL was assessed with the Short Form 36 (SF-36) health survey[23], which consists of 8 subscales. After recoding and recalibration were performed, raw scale scores were transformed into scale scores ranging from 0 (worst health) to 100 (best health). These scores were weighted according to sex- and age-matched scores for patients in each

country.[24, 25] Dutch-weighted scores were used for all Italian patients (n=57; [13%]), because no Italian sex- and age-matched scores were available. Two summary scores, the physical component summary score (PCS) and the mental component summary score (MCS), were calculated and transformed to compare the scores with the general population mean of 50. Higher scores indicate better HRQoL.[26]

**Statistical analysis**

Categorical variables are presented as the number (frequency) and continuous variables as the mean ± SD. Back pain was used in models as an independent variable in analyses of all patients and subgroup analyses, while the SPARCC-SI score was used only in models that included patients with ASAS axSpA. Pearson's correlation coefficients were calculated to determine differences between back pain or SPARCC-SI score, illness perceptions, coping, and outcome measures (PCS, MCS, or work productivity loss) were calculated. All variables that had a significant correlation (P<0.05) with the dependent variables (PCS, MCS, or work productivity loss) were included in a multistep linear regression model for that outcome. Models were adjusted for age and sex, by default. Illness perceptions were added to the basic model with back pain intensity or SPARCC-SI score as an outcome in the first step, and coping strategies were added in the second step. Likelihood ratio tests were used to determine whether the addition of each step independently improved the model. Data analyses were performed using Stata SE version 14.



## RESULTS

Baseline data were available for 550 patients included in the SPACE cohort. Patients were excluded from further analyses when a complete questionnaire (n=39) or scales of the questionnaires (n=87) were missing. For the current analysis, 424 patients were used. Compared with all patients included in the analyses, patients who were excluded from the analyses less often had a diagnosis of axSpA (axSpA diagnosis in 53% of included patients and 39% of excluded patients; P=0.012) and fewer clinical SpA features (2.6 features in included patients and 2.0 features in excluded patients; P=0.002).

In total, 145 of 424 patients were categorized as having ASAS axSpA (diagnosed by the rheumatologist and classified as axSpA), 81 of 424 were categorized as having a diagnosis of axSpA only (diagnosed by a rheumatologist as axSpA only), and 198 of 424 were categorized as having chronic back pain. The mean ± SD age of all patients was 30.9 ± 8.1 years, and the mean ± SD symptom duration was 13.3 ± 7.1 months; these values were comparable with those in the different subgroups (**Table 1**). The majority of patients were female (50% of patients with ASAS axSpA, 65% of patients with axSpA-diagnosed only, and 74% of patients with chronic back pain).

**Table 1. Baseline characteristics and assessment results for 424 patients with chronic back pain in the SPACE cohort, according to subgroups**

| | All patients (n=424) | ASAS axSpA (n=145) | axSpA diagnosis only (n=81) | Chronic back pain (n=198) |
|---|---|---|---|---|
| **Baseline characteristics** | | | | |
| Age at inclusion (years), mean ± SD | 30.9 ± 8.1 | 30.1 ± 7.8 | 32.5 ± 7.8 | 30.8 ± 8.5 |
| Female sex | 272 (64%) | 73 (50%) | 53 (65%) | 146 (74%) |
| Symptom duration (months), mean ± SD | 13.3 ± 7.1 | 13.7 ± 7.2 | 12.2 ± 6.3 | 13.4 ± 7.4 |
| Inflammatory back pain | 295 (70%) | 120 (83%) | 64 (79%) | 111 (56%) |
| Good response to NSAIDs[a] | 190 (45%) | 87 (60%) | 46 (57%) | 57 (29%) |
| Uveitis | 36 (9%) | 26 (18%) | 4 (5%) | 6 (3%) |
| Psoriasis | 51 (12%) | 22 (15%) | 18 (22%) | 11 (6%) |
| Inflammatory bowel disease | 32 (8%) | 7 (5%) | 13 (16%) | 12 (6%) |
| Positive family history | 188 (44%) | 76 (52%) | 33 (41%) | 79 (40%) |
| Enthesitis | 91 (22%) | 34 (24%) | 43 (53%) | 14 (7%) |
| Dactylitis | 28 (7%) | 13 (9%) | 11 (14%) | 4 (2%) |
| Peripheral arthritis | 69 (16%) | 28 (19%) | 24 (30%) | 17 (9%) |
| HLA-B27 positive | 178 (42%) | 130 (90%) | 5 (6%) | 43 (22%) |
| Elevated ESR /CRP level | 177 (42%) | 61 (42%) | 25 (32%) | 31 (16%) |
| X-SI positive | 32 (8%) | 28 (19%) | 0 (0%) | 4 (2%) |
| MRI-SI positive | 64 (15%) | 60 (41%) | 2 (3%) | 2 (1%) |
| Use of NSAIDs | 281 (66%) | 112 (77%) | 54 (67%) | 115 (58%) |
| Number of SpA features[b], mean ± SD | 2.6 ± 1.7 | 3.3 ± 1.6 | 3.5 ± 2.0 | 1.7 ± 1.2 |
| **Assessment results** | | | | |
| Back pain (0-10 scale), mean ± SD | 4.8 ± 2.4 | 4.4 ± 2.3 | 4.4 ± 2.6 | 5.4 ± 2.3 |
| SPARCC-SI (range 0-72), mean ± SD | 1.8 ± 4.9 | 4.8 ± 7.4 | 0.4 ± 1.3 | 0.1 ± 0.6 |
| PCS (range 0-100), mean ± SD | 26.9 ± 14.8 | 28.2 ± 15.0 | 29.1 ± 13.8 | 25.1 ± 14.9 |
| MCS (range 0-100), mean ± SD | 47.2 ± 12.7 | 48.2 ± 13.9 | 44.8 ± 12.2 | 47.5 ± 12.0 |
| WPL (range 0-100), mean ± SD | 42.5 ± 32.1[c] | 37.8 ± 31.5[d] | 35.1 ± 30.4[e] | 49.5 ± 32.0[f] |

Values are presented as number (%) unless specified otherwise. [a] Back pain no longer present or is much better 24-48 hours after administration of a full dose of NSAID. [b] Excluding HLA-B27 testing and imaging.[c] Only 326 patients were evaluated. [d] Only 110 patients were evaluated. [e] Only 65 patients were evaluated. [f] Only 144 patients were evaluated. ASAS, Assessment of SpondyloArthritis international Society; axSpA, axial Spondyloarthritis; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; MCS, mental component summary; MRI-SI, magnetic resonance imaging of sacroiliac (SI) joints, NSAIDs, non-steroidal anti-inflammatory drugs; PCS, Physical Component Summary; SPARCC-SI, Spondyloarthritis Research Consortium of Canada score of the SI-joints; WPL, work productivity loss; X-SI, radiography of SI-joints.

Patients with ASAS axSpA and those with only axSpA diagnosed had more SpA features (excluding HLA-B27 and imaging) (mean 3.3 and mean 3.5 features, respectively) compared with patients with chronic back pain (mean 1.7 features). In patients with chronic back pain, back pain was more severe than that in the ASAS axSpA and the axSpA diagnosed-only group (**Table 1**). A greater percentage of patients in the ASAS axSpA group had inflammation on MRI-SI compared with the percentage in the axSpA-diagnosed only group and the chronic back pain group. The mean PCS was decreased in all groups compared with the general population (mean of 50), but the mean MSC was comparable with that in the general population (**Table 1**). Seventy-seven percent (n=326) of all patients were in the work force at baseline. In 7 patients, loss of work productivity could not be calculated. Work productivity loss was comparable in the ASAS axSpA group and the axSpA-diagnosed only group but was higher in patients with chronic back pain (see **Table 1**). Statistically significant differences in mean scores were observed for the illness perceptions '*personal control*' (mean scores 3.3 in the axSpA group, 3.2 in the axSpA-diagnosed only group, and 3.0 in the group with chronic back pain), '*treatment control*' (mean scores 3.5 in the ASAS axSpA group, 3.3 in the axSpA-diagnosed only group, and 3.3 in the group diagnosed as having chronic back pain), '*illness coherence*' (mean scores 3.3 in the ASAS axSpA group, 3.1 in the axSpA-diagnosed only group, and 2.8 in the group with chronic back pain), '*emotional representation*' (mean scores 2.7 in the ASAS axSpA group, 2.9 in the axSpA-diagnosed only group, and 2.9 in the group with chronic back pain), and '*psychological attributions*' (mean scores 1.9 in the ASAS axSpA group, 2.2 in the axSpA-diagnosed only group, and 2.1 in the group with chronic back pain). No differences in other illness perceptions or coping strategies between the 3 subgroups were observed (data not shown).



**Analysis in all patients**

In the basic model including all patients, the PCS decreased by 3.5 points ($R^2$=0.37, P<0.001), the MCS decreased by 0.9 points ($R^2$=0.03, P<0.001), and work productivity loss increased by 7.7% ($R^2$=0.36, P<0.001) per point increase in the severity of back pain (**Tables 2** and **3**). After adding illness perceptions to the model, the impact of a 1-point increase in back pain on the PCS and work productivity loss became smaller and resulted in a decrease of 2.7 points (P<0.001) and an increase of 6.3% (P<0.001), respectively, and the association between back pain and the MCS was no longer statistically significant (B=-0.1, P=0.838) (**Tables 2** and **3**). The model performance improved by adding illness perceptions: more variance was explained in the PCS ($R^2$=0.47), the MCS ($R^2$=0.32), and work productivity loss ($R^2$=0.40) compared with the basic model, and these differences were statistically significant. After further adding coping strategies to the model, the associations between back pain and the PCS or work productivity loss changed only slightly (-2.3 points (P<0.001) and 5.9% (P<0.001), respectively, per point increase in back pain)

while the association with the MCS score remained the same (-0.01 points per point back pain; P=0.762) compared with the model with illness perceptions only (**Tables 2** and **3**). Explained variance did not further improve statistically significantly (PCS, $R^2$=0.53; MCS, $R^2$=0.32; work productivity loss, $R^2$=0.42) by adding coping strategies.

In the third model, having stronger beliefs in severe consequences (illness perception '*consequences*'; B=-4.7) or chance as a cause for the disease (illness perception '*chance*'; B=-1.0), and more use of the coping strategies '*decreasing activities*' (B=-4.0) and '*pacing*' (B=-3.3) were statistically significantly associated with a lower PCS. The illness perception '*emotional representation*' (having more negative emotions toward the disease) was associated with a better PCS (B=2.2). Attributing more symptoms to the disease (illness perception '*identity*'; B=-0.6), having more negative emotions toward the disease (B=-5.1), and having stronger beliefs in psychological attributions as a cause (illness perception '*psychological attributions*'; B=-4.4) were statistically significant associated with a lower MCS. Having stronger beliefs in severe consequences was statistically significantly associated with more work productivity loss (B=6.4).

**Table 2. Multiple-step linear regression model with back pain, illness perceptions, and coping, explaining HRQoL and work productivity loss among all patients (n=424)**

| | | PCS | | MCS | | WPL[a] | |
|---|---|---|---|---|---|---|---|
| | **Range** | **B** | **95% CI** | **B** | **95% CI** | **B** | **95% CI** |
| **Model 1: Basic model** | | | | | | | |
| Back pain | 0-10 | **-3.5** | **-3.9; -3.0**[b] | **-0.9** | **-1.4; -0.4**[b] | **7.7** | **6.5; 8.9**[b] |
| Age, years | | **0.4** | **0.3; 0.6**[b] | -0.1 | -0.3; 0.04 | -0.1 | -0.5; 0.3 |
| Female | | **2.7** | **0.3; 5.1**[d] | 0.7 | -1.9; 3.3 | 5.7 | -0.3; 11.6 |
| **Model 2: Basic model plus illness perceptions** | | | | | | | |
| Back pain | 0-10 | **-2.7** | **-3.2; -2.2**[b] | -0.1 | -0.5; 0.4 | **6.3** | **5.0; 7.7**[b] |
| Age, years | | **0.5** | **0.4; 0.6**[b] | -0.1 | -0.2; 0.1 | -0.2 | -0.5; 0.2 |
| Female | | **3.5** | **1.2; 5.8**[c] | 1.7 | -0.5; 4.0 | 4.7 | -1.3; 10.7 |
| Identity | 0-15 | -0.3 | -0.8; 0.1 | **-0.6** | **-1.1; -0.2**[c] | 0.3 | -0.9; 1.5 |
| Consequences | 1-5 | **-6.9** | **-8.6; -5.1**[b] | -0.2 | -1.8; 1.5 | **8.6** | **3.9; 13.2**[b] |
| Timeline (acute/chronic) | 1-5 | 0.5 | -1.1; 2.2 | - | - | - | - |
| Personal control | 1-5 | 0.9 | -1.1; 2.8 | 0.8 | -1.0; 2.6 | -2.3 | -7.2; 2.6 |
| Treatment control | 1-5 | 0.7 | -1.7; 3.1 | - | - | - | - |
| Illness coherence | 1-5 | 0.03 | -1.4; 1.5 | 0.1 | -1.3; 1.4 | -2.4 | -6.2; 1.4 |
| Emotional representation | 1-5 | **2.4** | **0.8; 4.1**[c] | **-5.0** | **-6.6; -3.4**[b] | -0.2 | -4.6; 4.2 |

**Table 2. Continued**

| | | PCS | | MCS | | WPL | |
|---|---|---|---|---|---|---|---|
| | **Range** | **B** | **95% CI** | **B** | **95% CI** | **B** | **95% CI** |
| **Model 2: Basic model plus illness perceptions (continued)** | | | | | | | |
| Psychological attributions | 1-5 | 1.4 | -0.3; 3.1 | **-5.4** | **-7.2; -3.7**[b] | -0.4 | -4.3; 3.4 |
| Risk factors | 1-5 | - | - | 2.0 | -0.5; 4.5 | - | - |
| Immunity | 1-5 | -1.3 | -3.3; 0.4 | -1.0 | -2.8; 0.7 | - | - |
| Accident | 1-5 | -0.9 | -2.0; 0.3 | 0.5 | -0.7; 1.7 | - | - |
| Chance | 1-5 | **-1.2** | **-2.1; -0.2**[d] | - | - | - | - |
| **Model 3: Basic model plus illness perceptions and coping** | | | | | | | |
| Back pain | 0-10 | **-2.3** | **-2.8; -1.9**[b] | -0.1 | -0.5; 0.4 | **5.9** | **4.7; 7.2**[b] |
| Age, years | | **0.5** | **0.4; 0.6**[b] | -0.1 | -0.2; 0.1 | -0.2 | -0.6; 0.2 |
| Female | | **3.7** | **1.6; 5.8**[c] | 1.1 | -1.1; 3.3 | 4.3 | -1.4; 10.0 |
| Identity | 0-15 | - | - | **-0.6** | **-1.0; -0.2**[c] | - | - |
| Consequences | 1-5 | **-4.7** | **-6.4; -3.1**[b] | - | - | **6.4** | **2.2; 10.6**[c] |
| Emotional representation | 1-5 | **2.2** | **0.8; 3.6**[c] | **-5.1** | **-6.5; -3.7**[b] | - | - |
| Psychological attributions | 1-5 | - | - | -4.4 | -5.8; -3.1[b] | - | - |
| Chance | 1-5 | **-1.0** | **-1.9; -0.1**[d] | - | - | - | - |
| Comforting cognitions | 1-4 | - | - | 2.1 | -1.0; 5.2 | - | - |
| Decreasing activities | 1-4 | **-4.0** | **-6.7; -1.3**[c] | -0.6 | -2.7; 1.4 | 7.3 | -0.2; 14.8 |
| Diverting attention | 1-4 | - | - | -0.7 | -3.2; 1.9 | - | - |
| Optimism | 1-4 | 1.7 | -0.2; 3.6 | 0.3 | -2.1; 2.8 | - | - |
| Pacing | 1-4 | **-3.3** | **-6.3; -0.3**[d] | - | - | 5.1 | -3.2; 13.5 |
| Creative solution seeking | 1-4 | -1.0 | -3.4; 1.3 | - | - | -0.6 | -7.1; 5.9 |
| Accepting | 1-4 | -0.8 | -2.6; 1.1 | - | - | 0.1 | -5.2; 5.3 |
| Consideration | 1-4 | -1.6 | -3.8; 0.7 | - | - | 1.9 | -3.9; 7.7 |

Statistically significant associations with the outcome are indicated in bold. [a] WPL was assessed in only 319 patients. [b] P<0.001. [c] P<0.01. [d] P<0.05. 95% CI, 95% Confidence Interval; HRQoL, health-related quality of life; MCS, Mental Component Summary; PCS, Physical Component Summary; WPL, work productivity loss.

**Table 3. Adjusted $R^2$ and -2 log likelihood ratios of the multiple-step linear regression model for each group of patients**

| | PCS | | MCS | | WPL | |
|---|---|---|---|---|---|---|
| | adjusted $R^2$ | -2 log likelihood | adjusted $R^2$ | -2 log likelihood | adjusted $R^2$ | -2 log likelihood |
| **All patients** | | | | | | |
| Basic model | 0.37 | -1645.4 | 0.03 | -1672.7 | 0.36 | -1486.3 |
| Basic model + illness perceptions | 0.47 | -1601.3[a] | 0.32 | -1593.1[a] | 0.40 | -1473.4[a] |
| Basic model + illness perceptions + coping | 0.53 | -1578.8 | 0.32 | -1593.3 | 0.42 | -1467.0 |
| **ASAS axSpA patients** | | | | | | |
| Basic model | 0.28 | -573.5 | 0.04 | -581.7 | 0.33 | -511.8 |
| Basic model + illness perceptions | 0.42 | -553.9[a] | 0.36 | -548.3[a] | 0.40 | -503.3[a] |
| Basic model + illness perceptions + coping | 0.45 | -552.7 | 0.38 | -547.0 | 0.43 | -499.9 |
| **AxSpA-diagnosed only** | | | | | | |
| Basic model | 0.37 | -306.6 | 0.02 | -314.5 | 0.29 | -300.8 |
| Basic model + illness perceptions | 0.48 | -296.6[a] | 0.26 | -299.9[a] | 0.35 | -297.0[a] |
| Basic model + illness perceptions + coping | 0.49 | -295.7 | 0.25 | -303.3[b] | 0.36 | -297.1[b] |
| **Chronic back pain** | | | | | | |
| Basic model | 0.42 | -760.8 | 0.03 | -768.6 | 0.37 | -668.6 |
| Basic model + illness perceptions | 0.48 | -747.0[a] | 0.29 | -731.5[a] | 0.39 | -664.3[a] |
| Basic model + illness perceptions + coping | 0.59 | -722.1[a] | 0.29 | -734.1 | 0.47 | -654.3[a] |

[a] Statistically significant (P<0.05) for the model compared with previous model. [b] If no coping dimension could be added to model 2 (basic model + illness perceptions), all nonsignificant illness perceptions were removed from model 3 (basic model + illness perceptions and coping). ASAS, Assessment of SpondyloArthritis international Society; axSpA, axial Spondyloarthritis; HRQoL, health-related quality of life; MCS, Mental Component Summary; PCS, Physical Component Summary; WPL, work productivity loss.

**Subgroup analyses**

Similar results were observed in the ASAS axSpA group (**Tables 3** and **4**), the axSpA-diagnosed only group (**Tables 3** and **5**), and the chronic back pain group (**Tables 3** and **6**) separately. The negative association between back pain and the MCS was observed only in the basic model. The strength of the associations between back pain and the PCS or work productivity loss decreased after adding illness perceptions to all basic models, although the model performance improved. Results did not change when coping strategies were added to illness perceptions. The same illness perceptions and coping strategies that were associated with PCS, MCS, and work productivity loss in all patients were also associated with these outcomes in each subgroup of patients. Only small differences were found (see **Tables 3-6**).

**SPARCC-SI score in patients with ASAS axSpA**

All analyses were repeated using the SPARCC-SI score instead of back pain in patients with ASAS axSpA to investigate whether an objective disease measure would yield results similar to those obtained using back pain intensity. In the basic model, the PCS decreased by 0.8 point (P<0.001), the MCS increased by 0.6 point (P<0.001), and work productivity loss increased by 0.9% (P=0.035) per point increase in the SPARCC-SI score (**Supplementary Table S1**). After illness perceptions and coping strategies were added, the PCS decreased by 0.8 point and 0.7 point, respectively, the MCS increased by 0.5 point and 0.5 point, respectively, and work productivity loss 1.1% and 0.9%, respectively. These results are different from those using models with back pain, because the strength of the associations was not influenced by adding illness perceptions and coping strategies.

**Table 4. Multiple-step linear regression model with back pain, illness perceptions, and coping explaining variance in HRQoL and work productivity loss among ASAS axSpA patients (n=145)**

| | | PCS | | MCS | | WPL[a] | |
|---|---|---|---|---|---|---|---|
| | Range | B | 95% CI | B | 95% CI | B | 95% CI |
| **Model 1: Basic model** | | | | | | | |
| Back pain | 0-10 | **-3.4** | **-4.3; -2.4**[b] | **-1.0** | **-2.0; -0.02**[d] | **7.7** | **5.5; 9.9**[b] |
| Age, years | | **0.4** | **0.1; 0.7**[c] | -0.2 | -0.5; 0.1 | 0.3 | -0.4; 0.9 |
| Female | | 3.3 | -1.0; 7.6 | 4.2 | -0.3; 8.7 | 5.6 | -4.3; 15.5 |
| **Model 2: Basic model plus illness perceptions** | | | | | | | |
| Back pain | 0-10 | **-2.3** | **-3.2; -1.4**[b] | -0.3 | -1.2; 0.6 | **5.7** | **3.3; 8.0**[b] |
| Age, years | | **0.6** | **0.3; 0.8**[b] | -0.1 | -0.4; 0.1 | 0.03 | -0.6; 0.7 |
| Female | | 3.5 | -0.5; 7.6 | 2.9 | -1.0; 6.8 | 2.5 | -7.6; 12.6 |
| Identity | 0-15 | -0.7 | -1.5; 0.1 | -0.4 | -1.2; 0.4 | 1.7 | -0.2; 3.6 |
| Consequences | 1-5 | **-8.4** | **-11.9; -4.9**[b] | 1.6 | -1.8; 4.9 | **9.3** | **0.8; 17.8**[d] |
| Timeline (acute/chronic) | 1-5 | -0.1 | -2.8; 2.7 | - | - | 0.8 | -5.8; 7.5 |
| Personal control | 1-5 | - | - | - | - | -2.9 | -10.4; 4.6 |
| Illness coherence | 1-5 | - | - | -0.5 | -3.0; 2.0 | - | - |
| Emotional representation | 1-5 | 1.6 | -1.3; 4.5 | **-6.8** | **-10.0; -3.7**[b] | 3.5 | -4.0; 11.0 |
| Psychological attributions | 1-5 | - | - | **-7.6** | **-11.1; -4.1**[b] | - | - |
| Risk factors | 1-5 | - | - | 2.9 | -1.7; 7.5 | - | - |
| Immunity | 1-5 | 0.7 | -2.1; 3.5 | -1.0 | -4.2; 2.3 | - | - |
| Accident | 1-5 | -2.0 | -4.0; 0.1 | - | - | - | - |
| **Model 3: Basic model plus illness perceptions and coping** | | | | | | | |
| Back pain | 0-10 | **-2.1** | **-3.0; -1.2**[b] | -0.2 | -1.1; 0.7 | **5.5** | **3.2; 7.8**[b] |
| Age, years | | **0.6** | **0.3; 0.8**[b] | -0.1 | -0.3; 0.2 | 0.1 | -0.5; 0.8 |
| Female | | 2.9 | -1.1; 6.8 | 2.6 | -1.2; 6.4 | 7.6 | -2.3; 17.1 |
| Consequences | 1-5 | **-7.1** | **-10.2; -3.9**[b] | - | - | **8.9** | **1.3; 16.6**[d] |
| Emotional representation | 1-5 | - | - | **-5.6** | **-8.3; -2.8**[b] | - | - |
| Psychological attributions | 1-5 | - | - | **-5.6** | **-8.2; -3.1**[b] | - | - |
| Comforting cognitions | 1-4 | - | - | 3.8 | -1.4; 9.0 | - | - |
| Decreasing activities | 1-4 | -2.7 | -8.4; 3.0 | -2.7 | -6.4; 1.1 | 2.6 | -11.2; 16.4 |
| Optimism | 1-4 | - | - | -1.3 | -5.6; 3.0 | - | - |
| Pacing | 1-4 | -2.8 | -9.0; 3.4 | - | - | 13.4 | -2.2; 28.9 |
| Creative solution seeking | 1-4 | -0.3 | -4.3; 3.8 | - | - | -4.4 | -14.3; 5.5 |
| Accepting | 1-4 | -1.8 | -5.2; 1.6 | 2.6 | -0.6; 5.8 | 5.5 | -2.8; 13.7 |

Statistically significant associations with the outcome are indicated in bold. [a] WPL was assessed in only 110 patients. [b] P<0.001. [c] P<0.01. [d] P<0.05. ASAS, Assessment of SpondyloArthritis international Society; axSpA, axial Spondyloarthritis; HRQoL, health-related quality of life; MCS, Mental Component Summary; PCS, Physical Component Summary; WPL, work productivity loss.

**Table 5. Multiple-step linear regression model with back pain, illness perceptions, and coping, explaining variance in HRQoL and work productivity loss among axSpA-diagnosed only patients (n=81)**

| | | PCS | | MCS | | WPL[a] | |
|---|---|---|---|---|---|---|---|
| | Range | B | 95% CI | B | 95% CI | B | 95%CI |
| **Model 1: Basic model** | | | | | | | |
| Back pain | 0-10 | **-3.2** | **-4.2; -2.3[b]** | -0.6 | -1.7; 0.4 | **6.9** | **4.3; 9.6[b]** |
| Age, years | | 0.2 | -0.1; 0.5 | 0.1 | -0.3; 0.4 | 0.2 | -0.7; 1.1 |
| Female | | **5.5** | **0.3; 10.7[d]** | -4.6 | -10.4; 1.2 | -0.3 | -14.0; 13.4 |
| **Model 2: Basic model plus illness perceptions** | | | | | | | |
| Back pain | 0-10 | **-2.6** | **-3.5; -1.7[b]** | 0.1 | -0.9; 1.1 | **6.2** | **3.5; 8.8[b]** |
| Age, years | | **0.3** | **0.03; 0.6[d]** | 0.1 | -0.2; 0.4 | 0.1 | -0.8; 1.0 |
| Female | | **5.9** | **1.1; 10.6[d]** | -4.0 | -9.3; 1.3 | 3.4 | -10.3; 17.1 |
| Identity | 0-15 | -0.6 | -1.6; 0.5 | -0.8 | -2.0; 0.3 | - | - |
| Consequences | 1-5 | **-5.1** | **-8.2; -2.0[c]** | 1.3 | -2.1; 4.8 | 1.4 | -6.8; 9.7 |
| Illness coherence | 1-5 | - | - | 2.0 | -1.3; 5.2 | **-8.7** | **-17.1; -0.3[d]** |
| Emotional representation | 1-5 | 2.3 | -1.0; 5.6 | **-4.5** | **-8.3; -0.7[d]** | - | - |
| Psychological attributions | 1-5 | - | - | -2.0 | -5.7; 1.8 | - | - |
| Immunity | 1-5 | -2.3 | -5.5; 0.9 | -1.2 | -5.0; 2.6 | - | - |
| **Model 3: Basic model plus illness perceptions and coping** | | | | | | | |
| Back pain | 0-10 | **-2.4** | **-3.4; -1.5[b]** | -0.1 | -1.1; 0.8 | **6.2** | **3.7; 8.9[b]** |
| Age, years | | **0.3** | **0.1; 0.6[d]** | 0.1 | -0.2; 0.4 | 0.1 | -0.7; 1.0 |
| Female | | **6.4** | **1.4; 11.3[d]** | -4.3 | -9.4; 0.8 | 3.8 | -9.6; 17.2 |
| Consequences | 1-5 | **-3.7** | **-7.2; -0.2[d]** | - | - | - | - |
| Illness coherence | 1-5 | - | - | - | - | **-9.5** | **-16.6; -2.4[d]** |
| Emotional representation | 1-5 | - | - | **-6.8** | **-9.6; -4.1[b]** | - | - |
| Decreasing activities | 1-4 | -2.5 | -8.2; 3.2 | - | - | - | - |
| Pacing | 1-4 | -0.9 | -8.3; 6.5 | - | - | - | - |
| Creative solution seeking | 1-4 | -2.0 | -7.2; 3.2 | - | - | - | - |

Statistically significant associations with the outcome are indicated in bold. [a] WPL was assessed in only 65 patients. [b] P<0.001. [c] P<0.01. [d] P<0.05. axSpA, axial Spondyloarthritis; CI, 95% Confidence Interval; HRQoL, health-related quality of life; MCS, Mental Component Summary; PCS, Physical Component Summary; WPL, work productivity loss.

**Table 6. Multiple-step linear regression model with back pain, illness perceptions, and coping, explaining variance in HRQoL and work productivity loss in patients with chronic back pain (n=198)**

| | | PCS | | MCS | | WPL[a] | |
|---|---|---|---|---|---|---|---|
| | **Range** | **B** | **95% CI** | **B** | **95%CI** | **B** | **95% CI** |
| **Model 1: Basic model** | | | | | | | |
| Back pain | 0-10 | **-3.7** | **-4.4; -3.0[b]** | **-1.0** | **-1.8; -0.3[c]** | **7.8** | **5.9; 9.6[b]** |
| Age, years | | **0.5** | **0.3; 0.7[b]** | -0.03 | -0.2; 0.2 | -0.4 | -0.9; 0.1 |
| Female | | 1.0 | -2.7; 4.7 | -0.2 | -4.0; 3.7 | 8.4 | -1.1; 17.9 |
| **Model 2: Basic model plus illness perceptions** | | | | | | | |
| Back pain | 0-10 | **-3.0** | **-3.8; -2.2[b]** | -0.1 | -0.8; 0.7 | **6.5** | **4.5; 8.6[b]** |
| Age, years | | **0.5** | **0.3; 0.7[b]** | -0.01 | -0.2; 0.2 | -0.4 | -0.9; 0.1 |
| Female | | 2.5 | -1.1; 6.1 | 1.0 | -2.4; 4.4 | 7.2 | -2.3; 16.7 |
| Identity | 0-15 | - | - | **-0.6** | **-1.2; -0.01[d]** | - | - |
| Consequences | 1-5 | **-6.4** | **-8.9; -3.9[b]** | -0.8 | -3.2; 1.7 | **10.1** | **2.8; 17.4[c]** |
| Timeline (acute/chronic) | 1-5 | - | - | -1.6 | -4.0; 0.9 | - | - |
| Personal control | 1-5 | 0.5 | -2.6; 3.5 | 1.4 | -1.6; 4.3 | 0.3 | -7.8; 8.4 |
| Treatment control | 1-5 | 1.6 | -1.7; 4.9 | 1.8 | -1.7; 5.2 | - | - |
| Illness coherence | 1-5 | -0.2 | -2.3; 2.0 | 1.0 | -1.1; 3.1 | - | - |
| Emotional representation | 1-5 | **3.0** | **0.7; 5.4[d]** | **-4.1** | **-6.4; -1.8[b]** | -1.1 | -7.2; 5.0 |
| Psychological attributions | 1-5 | - | - | **-4.2** | **-6.7; -1.8[c]** | - | - |
| Immunity | 1-5 | - | - | 0.2 | -2.2; 2.6 | - | - |
| Accident | 1-5 | - | - | 0.2 | -1.6; 1.9 | - | - |
| **Model 3: Basic model plus illness perceptions and coping** | | | | | | | |
| Back pain | 0-10 | **-2.2** | **-2.9; -1.5[b]** | -0.2 | -0.9; 0.5 | **5.1** | **3.2; 7.1[b]** |
| Age, years | | **0.5** | **0.3; 0.7[b]** | -0.04 | -0.2; 0.2 | **-0.5** | **-1.0; -0.03[d]** |
| Female | | **3.6** | **0.4; 6.8[d]** | 0.8 | -2.6; 4.2 | 5.2 | -3.7; 14.2 |
| Identity | 0-15 | - | - | **-0.7** | **-1.3; -0.1[d]** | - | - |
| Consequences | 1-5 | **-3.4** | **-5.7; -1.0[c]** | - | - | 4.8 | -1.6; 11.2 |
| Emotional representation | 1-5 | **2.6** | **0.7; 4.6[c]** | **-5.0** | **-6.9; -3.1[b]** | - | - |
| Psychological attributions | 1-5 | - | - | **-3.4** | **-5.6; -1.3[c]** | - | - |
| Comforting cognitions | 1-4 | - | - | -0.2 | -4.4; 4.0 | - | - |
| Decreasing activities | 1-4 | **-5.9** | **-9.7; -2.2[c]** | -0.5 | -3.6; 2.5 | 10.2 | -1.1; 21.5 |
| Optimism | 1-4 | **2.8** | **0.2; 5.4[d]** | 2.5 | -1.3; 6.4 | - | - |
| Pacing | 1-4 | **-4.5** | **-8.5; -0.5[d]** | - | - | 7.4 | -4.0; 18.8 |
| Creative solution seeking | 1-4 | -2.5 | -5.6; 0.6 | - | - | 7.3 | -1.6; 16.3 |
| Accepting | 1-4 | -1.3 | -4.0; 1.5 | - | - | - | - |

Statistically significant associations with the outcome are indicated in bold. [a] WPL was assessed in only 144 patients. [b] P<0.001. [c] P<0.01. [d] P<0.05. HRQoL, health-related quality of life; MCS, Mental Component Summary; PCS, Physical Component Summary; WPL, work productivity loss.

## DISCUSSION

To our knowledge, this is the first study that used the CSM as a theoretical framework to investigate patients' responses to 1) back pain in patients with chronic back pain referred to a rheumatology outpatient clinic due to a suspicion of axSpA and 2) inflammation on the MRI-SI in patients with ASAS axSpA. As expected, our study demonstrated that an increasing level of self-reported back pain is associated with worsening of the physical HRQoL and loss of work productivity. In addition, we show for the first time that illness perceptions are important in the relationship between back pain and HRQoL and work productivity loss in patients suspected of having axSpA, irrespective of subgroup. However, we observed no effect of coping on HRQoL or work productivity loss in our cohort. As hypothesized, in patients with ASAS axSpA, illness perceptions and coping strategies did not change the association between levels of bone marrow edema in the sacroiliac joints (which was chosen to represent objective levels of inflammation), although the model performance improved. Our study suggests that in order to improve physical HRQoL and work productivity, the focus should also be on targeting negative illness perceptions.



These findings are important for managing patients with axSpA and chronic back pain. Rheumatologists and health care professionals should be aware that illness perceptions play an important role in determining medical outcomes in these patients. Illness perceptions should, therefore, be actively explored and taken into consideration in the management plan. To maximally improve health outcomes in patients with axSpA, psychological support could be given in addition to targeting back pain using drug treatment and physiotherapy. Several studies in other diseases have shown that psychological interventions could potentially change illness perceptions.[27-30]

The main aim of our study was to investigate the clinical question of how rheumatologists and health care professionals can maximally improve health outcomes and whether and which illness perceptions and coping strategies are important for disease management in patients with early onset of axSpA. Therefore, we performed a stepwise regression analysis rather than a mediation analysis. In the regression analysis, the effect of illness perceptions and coping strategies on the relationship between back pain and outcomes can be clearly seen. In a mediation analysis, back pain would be included as a control variable, and therefore this effect would no longer be apparent. The advantage of a mediation analysis would be that all direct and indirect effects of illness perceptions and coping could be evaluated, but the clinical interpretation of the various coefficients in the model is unclear.

In patients with chronic back pain, no associations between illness perceptions and HRQoL or work productivity loss have been investigated, as far as we know. Only one previous

study investigated the association between illness perceptions and HRQoL in patients with longstanding AS. In that study, the Brief Illness Perception Questionnaire[31] was used and showed that higher scores on the illness perception '*concern*', part of the '*emotional representation*' of the disease, were associated with worse physical HRQoL.[7] Those findings contrast with the findings in our cohort, in which it was shown that '*consequences*' and '*chance*' were associated with decreased physical HRQoL, and that '*identity*', '*emotional representation*', and '*psychological attributions*' were associated with decreased mental HRQoL. '*Consequences*' was also associated with increased loss of work productivity. Differences between our study and the study including AS patients might be explained by the use of different questionnaires (Brief IPQ versus IPQ-R in our cohort) and different patient populations (longstanding AS versus early axSpA or suspected axSpA in our cohort). It is possible that other illness perceptions become more important when the disease is longstanding.

Further, several studies showed that the maladaptive coping strategies '*decreasing activities*' and '*pacing*' were associated with worse HRQoL and withdrawal from the workforce in patients with AS[11-13], and that '*avoiding physical activity*' was associated with increased pain and disability in patients with chronic back pain.[14] In our study, increased use of the '*decreasing activities*' and '*pacing*' strategies were associated with lower physical HRQoL. These coping strategies were not related to work productivity loss, which could be explained by the fact that work productivity loss and withdrawal from the work force are different concepts. Moreover, this difference could also reflect the difference between early versus longstanding disease.

In contrast to our expectations, a positive association between illness perception '*emotional representation*' (having more negative emotions toward the disease) and physical HRQoL was observed in our study. When examining correlations between '*emotional representation*' and the PCS, we observed negative associations in all patients and in each subgroup, as expected. Therefore, this effect appears only in the multivariable model, in the context of the other illness perceptions that play a significant role. The context of other illness perceptions might explain why the association between '*emotional representation*' and HRQoL reversed. Additionally, in our study coping strategies did not have an additional influence over illness perceptions for the association between back pain and HRQoL or work productivity loss, in contrast to our hypothesis. These unexpected findings could be explained by the CSM itself, because the CSM is a self-regulatory model. The CSM implies that individuals use coping strategies based on his or her illness perceptions, and illness perceptions are adapted based on coping strategies by a feedback loop from HRQoL to these factors. Using maladaptive coping strategies decreases HRQoL, and according to the CSM, illness perceptions will be adapted in a manner such that

worsening in HRQoL is reduced. Furthermore, the effect of illness perceptions may be balanced by coping strategies. Having more negative emotions associated with a disease could lead to a change in coping strategies from maladaptive toward adaptive in order to decrease worsening of HRQoL. Future studies are needed to investigate this notion further. The effect of coping strategies could have been disadvantaged or changed or different due to the fact that coping strategies cannot be added to the model before illness perceptions are added. However, testing the coping strategies first would violate the CSM.

Our main analysis was performed in all patients suspected of having axSpA. Remarkably, comparable results were observed in all analyses in all subgroups. This finding may be explained by the fact that patients were unaware of the results of laboratory and imaging tests and diagnosis when they filled out the questionnaires. Therefore, it would be interesting to study the impact of receiving a diagnosis on illness perceptions and coping. Unfortunately, in our cohort we currently have no data on this subject.



Our results suggest that HRQoL and work productivity can be further improved by interventions targeting patients' cognitions and behaviour along with treatment that suppresses pain and inflammation. Targeting patients' cognitions and behaviour along with treatment that suppresses pain is more established not only in studies but also in treatment strategies for patients with back pain compared to SpA.[1, 32, 33] These interventions could be used for the patients with chronic back pain who were not diagnosed with axSpA in the SPACE cohort, because nonspecific back pain is the most common diagnosis.[34] Illness perceptions and coping strategies are potentially modifiable factors, and several studies have already shown that in various diseases cognitive behavioural interventions based on the CSM were able to change illness perceptions and coping strategies, leading to a decreased disease burden.[35, 36] The results of our study suggest that the illness perceptions '*consequences*' and '*chance*' should be targeted in order to improve physical HRQoL, '*emotional representation*' should be targeted for improving mental HRQoL, and '*consequences*' should be targeted to decrease work productivity loss. For example, health care specialists could discuss with patients how consequences can be minimized, explain the causal attributions to patients, and pay attention to the emotions of patients. Additionally, aiming for positive illness perceptions, having social support, and belief in self-efficacy may also help to improve health outcomes.[37] Furthermore, the use of '*decreasing activities*' and '*pacing*' as coping strategies should be discouraged in order to improve physical HRQoL.

One of the limitations of this study is that no causal relationship could be investigated, because of the cross-sectional character of the study. Only longitudinal studies enable the investigation of causality. Another limitation is that the CORS questionnaire, which was

used in our study, is designed to measure coping strategies directed at the stressors of inflammatory rheumatic diseases.[20, 21] In our cohort, patients with chronic back pain also filled out this questionnaire. However, all patients were unaware of their diagnosis at the time they filled out the questionnaires. A statistical limitation that should be mentioned is that we used $R^2$ values to justify certain variable choices in the models. These values may be spuriously inflated because of covariance of components of the HRQoL and illness perceptions. Therefore, absolute $R^2$ values should be interpreted with caution. This limitation will, however, not jeopardize the main finding of this study, namely, that illness perceptions influence the relationship between backpain and HRQoL.

In conclusion, in patients suspected of having axSpA, high intensity of back pain is associated with worsening of physical HRQoL and increasing loss of work productivity. Our results suggest that, in addition to treating back pain, targeting negative illness perceptions could improve HRQoL and work productivity. Our study supports the development of interventions targeting patients' cognitions in addition to use of existing treatment options to decrease the burden of disease in patients suspected of having axSpA. Future research is needed to investigate whether the impact of illness perceptions and coping strategies vary over time, the differences between these factors in early and longstanding disease, as well as the impact of targeting illness perceptions on back pain and physical HRQoL.

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## SUPPLEMENTARY MATERIALS

**Supplementary Table S1. Multiple step linear regression model with inflammation on the MRI-SI, illness perceptions, and coping, explaining variance in health-related quality of life and work productivity loss among ASAS axSpA patients (n=145)**

| | | PCS | | MCS | | WPL (n=110) | |
|---|---|---|---|---|---|---|---|
| | Range | B | 95%CI | B | 95%CI | B | 95%CI |
| **Model 1: Basic model** | | | | | | | |
| SPARCC-SI | 0-72 | **-0.8** | **-1.1;-0.5**[a] | **0.6** | **0.3; 0.9**[a] | **0.9** | **0.1; 1.7**[c] |
| Age, years | | 0.3 | -0.002; 0.6 | -0.2 | -0.5; 0.1 | 0.7 | -0.1; 1.5 |
| Female | | -2.7 | -7.5; 2.0 | **5.6** | **1.1; 10.1**[c] | **14.1** | **2.0; 26.2**[a] |
| **Model 2: Basic model plus illness perceptions** | | | | | | | |
| SPARCC-SI | 0-72 | **-0.8** | **-1.0; -0.5**[a] | **0.5** | **0.2; 0.7**[a] | **1.1** | **0.3; 1.8**[b] |
| Age, years | | **0.5** | **0.3; 0.8**[a] | -0.1 | -0.3; 0.1 | 0.2 | -0.5; 1.0 |
| Female | | 0.1 | -4.0; 4.1 | **4.8** | **0.9; 8.6**[c] | 6.9 | -4.2; 18.0 |
| Identity | 0-15 | **-1.3** | **-2.1; -0.6**[b] | -0.4 | -1.1; 0.3 | **2.9** | **0.9; 4.9**[b] |
| Consequences | 1-5 | **-9.4** | **-12.8; -6.0**[a] | 0.1 | -3.0; 3.3 | **14.9** | **6.2; 23.6**[b] |
| Timeline (acute/chronic) | 1-5 | -0.3 | -3.0; 2.4 | - | - | 2.1 | -4.9; 9.2 |
| Personal control | 1-5 | - | - | - | - | -6.0 | -13.9; 1.8 |
| Treatment control | 1-5 | - | - | - | - | - | - |
| Illness coherence | 1-5 | - | - | -0.03 | -2.4; 2.3 | - | - |
| Emotional representation | 1-5 | 1.2 | -1.7; 4.1 | **-6.4** | **-9.4; -3.4**[a] | 3.2 | -4.8; 11.2 |
| Psychological attributions | 1-5 | - | - | **-7.3** | **-10.6; -4.0**[a] | - | - |
| Risk factors | 1-5 | | | 3.6 | -0.8; 8.0 | - | - |
| Immunity | 1-5 | -0.9 | -3.8; 1.9 | -0.5 | -3.5; 2.7 | - | - |
| Accident | 1-5 | -0.7 | -2.8; 1.3 | - | - | - | - |
| **Model 3: Basic model plus illness perceptions and coping** | | | | | | | |
| SPARCC-SI | 0-72 | **-0.7** | **-1.0; -0.5**[a] | **0.5** | **0.3; 0.8**[a] | **0.9** | **0.2; 1.6**[c] |
| Age, years | | **0.5** | **0.3; 0.7**[a] | -0.1 | -0.3; 0.2 | 0.2 | -0.4; 0.9 |
| Female | | -0.5 | -4.3; 3.4 | **4.6** | **0.9; 8.3**[c] | **12.1** | **1.8; 22.5**[c] |
| Identity | 0-15 | **-1.3** | **-2.0; -0.6**[b] | - | - | **2.8** | **0.9; 4.6**[b] |
| Consequences | 1-5 | **-7.2** | **-10.2; -4.3**[a] | - | - | **11.7** | **3.8; 19.5**[b] |
| Emotional representation | 1-5 | - | - | **-5.7** | **-8.2; -3.1**[a] | - | - |
| Psychological attributions | 1-5 | - | - | **-4.9** | **-7.3; -2.5**[a] | - | - |

**Supplementary Table S1. Continued**

| | | PCS | | MCS | | WPL (n=110) | |
|---|---|---|---|---|---|---|---|
| | **Range** | **B** | **95%CI** | **B** | **95%CI** | **B** | **95%CI** |
| **Model 3: Basic model plus illness perceptions and coping (continued)** | | | | | | | |
| Comforting cognitions | 1-4 | - | - | 4.2 | -0.8; 9.1 | - | - |
| Decreasing activities | 1-4 | **-5.6** | **-10.8; 0.4**[c] | **-3.8** | **-7.1; -0.4**[c] | 10.5 | -3.3; 24.4 |
| Optimism | 1-4 | - | - | -1.6 | -5.6; 2.4 | - | - |
| Pacing | 1-4 | -0.5 | -6.4; 5.4 | - | - | 8.6 | -7.7; 24.8 |
| Creative solution seeking | 1-4 | 0.5 | -3.4; 4.4 | - | - | -5.7 | -16.1; 4.8 |
| Accepting | 1-4 | -3.2 | -6.4; 0.03 | 2.7 | -0.3; 5.7 | 8.0 | -0.6; 16.5 |
| | | **adj. $R^2$** | **-2 log likelihood** | **adj. $R^2$** | **-2 log likelihood** | **adj. $R^2$** | **-2 log likelihood** |
| Basic model | | 0.15 | -585.0 | 0.10 | -577.4 | 0.06 | -530.5 |
| Basic model + illness perceptions | | 0.44 | -551.1[d] | 0.42 | -541.8[d] | 0.31 | -510.2[d] |
| Basic model + illness perceptions + coping | | 0.50 | -543.9 | 0.46 | -538.9 | 0.39 | -503.4[d] |

Statistically significant associations are indicated in bold. [a] P<0.001. [b] P<0.01. [c] P<0.05.[d] Likelihood ratio test is statistically significant (p<0.05) for the model compared to the previous model. ASAS, Assessment of SpondyloArthritis international Society; axSpA, axial Spondyloarthritis; CI, Confidence Interval; MCS, Mental Component Summary; MRI-SI; Magnetic Resonance Imaging of the sacroiliac joints; PCS, Physical Component Summary; SPARCC-SI, Spondyloarthritis Research Consortium of Canada Score of the sacroiliac joints; WPL, work productivity loss.