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Spinopelvic changes based on the simplified SRS-Schwab adult spinal deformity classification: relationships with disability and health-related quality of life in adult patients with prolonged degenerative spinal disorders

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Abstract

Study Design: Cross-sectional, observational study.

Objective: To study the occurrence of sagittal malalignment, the adaptability of a simplified sagittal modifiers grading of the Scoliosis Research Society (SRS)-Schwab adult spinal deformity classification (ASD), and the deformity-specific SRS questionnaire version 30 (SRS-30) in an unselected adult cohort with symptomatic degenerative spinal disorders.

Summary of Background Data: The sagittal modifiers of the SRS-Schwab ASD classification correlate with health-related quality of life (HRQoL) measures in patients with ASD. The deformities and disabilities caused by sagittal malalignment in patients with common degenerative spinal disorders of multiple etiologies are rarely studied. A simplified and categorizing version of the SRS-Schwab ASD classification in relation to the Oswestry Disability Index (ODI) and the SRS-30 outcomes has not yet been developed.

Methods: We recruited 874 consecutive patients with degenerative spinal disorders between March 2013 and February 2014. Full spine radiographs were taken and the patients divided into sagittal deformity severity groups: mild or none, moderate, and marked deformity. Participants completed the ODI, SRS-30, and a general health questionnaire.

Results: We included 637 patients in the analysis. The severity of sagittal deformity was mild or none in 407 (63.9%) patients, moderate in 159 (25.0%), and marked in 71 (11.1%). Linearity across the modifier grades and deformity classes was found for ODI total score (p=0.033), and the function/activity (p=0.004) and self-image/appearance (p=0.030) domains of the SRS-30. Age, body mass index, duration of symptoms, and the use of painkillers increased while physical activity, working, and educational status decreased significantly with deformity severity.

Conclusions: Sagittal spinopelvic malalignment is significantly related to deterioration of the ODI and the SRS-30 in symptomatic adults with degenerative spinal disorders. The SRS-Schwab classification sagittal modifiers categorized into 3 groups is a practical tool to detect various clinically significant grades of deformity in a cohort with no recognized ASD.

Introduction

Adult spinal deformity (ASD) has multiple etiologies[1, 2] and it can develop gradually over many years. Not all elderly people lose their sagittal spinal balance due to advancing age[3-5]. The typical radiographic findings of deteriorating sagittal alignment are a mismatch between the lumbar lordosis (LL) and pelvic incidence (PI), PI-related retroversion of the pelvis i.e. pelvic tilt (PT), anteriorizing sagittal vertical axis (SVA), widening T1 pelvic angle (TPA)[6], a loss of kyphosis in the lower thoracic spine, and changes in the cervical spine[7, 8]. Many studies have reported how the loss of spinal balance and alignment affects health-related quality of life (HRQoL) and disability[9-11]. With surgical correction of the spinal alignment, this can be improved, although there is a considerable risk of deformity from the surgery[12, 13]. Previous study cohorts have either involved adult scoliosis patients or those with marked deformity, or asymptomatic age-matched normative controls[14, 15]. There is a lack of research, and therefore knowledge, about sagittal disorders, disability, and the quality of life of patients with symptomatic degenerative spinal conditions that precede the development of ASD. It is most likely that patients with moderate spinal deformity will end up undergoing lower back surgery without imaging of the spinal alignment, despite the fact that evaluation of the whole spine could benefit in the technical planning of the surgery[12, 16, 17].

The Scoliosis Research Society (SRS)-Schwab ASD classification consists of coronal and sagittal modifiers. The sagittal spinopelvic modifiers have been proven to correlate with HRQoL and the classification is valid for evaluating ASD. Changes in individual modifiers have been described in previous studies of patients with ASD[18-20]. **No study has evaluated the application of the classification for an unselected consecutive cohort of patients with degenerative spinal disorders without precognition of any marked deformities,** including a simplification of the classification by combining the sagittal modifiers into three categories of sagittal deformity severity and correlation of the categories with HRQoL measures.

Our aim was to study the occurrence of sagittal malalignment and the adaptability of a simplified sagittal modifiers grouping of the SRS-Schwab adult deformity classification and the deformity specific SRS

questionnaire version 30 (SRS-30) in an unselected adult cohort with symptomatic degenerative spinal disorders.

Material and Methods

A total of 874 consecutive adult patients with prolonged degenerative thoracolumbar disorders were referred from primary health care over the course of one year to Jyväskylä Central Hospital, which is the only tertiary care spine clinic in Jyväskylä, serving a population of 255,000. All referred patients were recruited to the study. **643 patients volunteered the study and signed written consent to participate the study.** Exclusion criteria were age <18 years, missing or non-diagnostic radiographs, malignancy, neuromuscular disease, or acute fracture. This study was approved by the Research Ethics Committee of the Central Finland Health Care District. Full spine radiographs were obtained to measure the SRS-Schwab sagittal modifiers[18, 19]: PI-LL, sagittal vertical axis (SVA), and PT. Utilizing these sagittal modifiers, groups were formed according to the severity of the deformity: mild or none, 0 or 1+; moderate, 2-3+; and marked, 4-6+ modifiers. Disability and HRQoL related to severity of the sagittal deformity was measured with the validated Finnish version of the condition specific outcome measure for spinal disorders, the Oswestry Disability Index (ODI2.0)[21] and the deformity-specific HRQoL measure, the Scoliosis Research Society Questionnaire 30 (SRS-30)[22], and a general health questionnaire including visual analogue scales (VAS). The ODI consists of 10 questions with total scores ranging from 0 (no disability) to 100 (worst disability) and a total score of 40 or more indicates severe disability. The SRS-30 contains 23 questions in the subscore for all patients and 7 additional questions for patients after surgical treatment. Each question is answered on a scale of 1 to 5. The SRS-30 is divided into 5 domains and provides a subscore for each domain. Information on current leisure time physical activity levels was obtained using the Frequency Intensity Time (FIT) index developed by Kasari[23], which asks about frequency of exercise per week, the type of activity, and the duration of the exercise. Scores range from 1 to 100 points indicating low (<36), moderate (36-63), or high (>63) physical activity levels. Clinical data was obtained from the patient records.

The data is presented as means with standard deviations (SD), as medians with interquartile range (IOR), or as counts with percentage. Statistical significance for the hypothesis of linearity across the modifier grades and deformity classes were evaluated using an analysis of variance, the Cuzick test, and the Cochran-Armitage test. In the case of violation of the assumptions (e.g. non-normality), a bootstrap-type test was used. No adjustment for multiplicity was made. The α-level was set at $p < 0.05$ and all analyses were performed using STATA 14.0 (StataCorp LP, College Station, TX, USA).

Results

A total of 637 patients with complete data and signed informed consent (mean (SD) age 54.8 (15.3) years, 56.2% female) were included in the final analysis. The characteristics of the deformity classes are presented in Table 1. Age, body mass index (BMI), duration of symptoms, and the use of painkillers increased significantly while physical activity, working, and educational status decreased significantly with deformity severity.

The ODI mean score in the severe group was 47, which represented severe disability. The ODI total score (p=0.033), SRS-30 function/activity (p=0.004), and self-image/appearance (p=0.030) domains deteriorated significantly with the severity of the deformity (Table 2). The mean modifier values in the deformity severity groups are presented in Table 3.

The lowest percentage of 0 grades (57%) was detected in PT, while the proportions in SVA and PI-LL were 65% and 71%, respectively (Figure 1). The paramount cause of disability measured by the ODI was **SVA >9.5 cm** (++) (p=0.002) (Figure 2).

Discussion

This study cohort represented an unselected population of patients with symptomatic prolonged degenerative spinal conditions referred to a tertiary spine clinic. One-third of the study population had moderate or severe sagittal disorders without previously diagnosed spinal deformity. The ODI total score deteriorated along with the severity of the deformity. **The low baseline physical activity level was related to the prolonged pain and dysfunction of the patients in all groups. Differences in pain**

levels and socio-demographic background of the patients did not explain the linear deterioration of the FIT index between the deformity severity groups. Thus the authors concluded that the deformity is an independent factor, which inhibits the physical activity.

Surprisingly, current pain levels on the SRS-30 did not differ between the groups as expected. **However, we found that the duration of pain and the need for painkillers increased with the severity of the deformity indicating more regular demand of pain medication in patients with severe deformities than in the other groups.**

Patients with an **increasing radiographic deformity** were significantly older and more overweight. Araujo et al. found that being overweight or obese can turn sagittal balance positive[24], but the loss of skeletal sagittal alignment does not automatically increase with advancing age[4,5] and should be considered an abnormal condition, a possible source of symptoms, and a target for treatment.

The association between lower educational status and severe deformity in our study may be biased by the limited educational options for the older generations and the true correlation is between severe deformity and increased age.

Maintaining an erect position with increasing sagittal malalignment causes fatigue and pain in the buttocks, spine, and thighs[25] and the non-operative treatment should cover both compensatory mechanisms and treatment for loss of sagittal inclination. **Mild and moderate disorders of the sagittal alignment were common in our cohort and individual physical rehabilitation programs focused on exercise and diet should be targeted on them.**

However, only a fewphysical rehabilitation protocols for spinal deformity are described[26,27]and non-operative treatment is often a collection of physical therapies, injections, medication, and observation[28].

Pelvic tilt was the first modifier to indicate sagittal disorders in our study, and this finding is consistent with previous reports[8,9]. Increased PT appears before SVA is anteriorized[29]. Buckland et al. found that compensation for neural compression can increase SVA positivity while PT remains normal in mild and

moderate spinal deformities. In moderate and severe deformities, the desire to maintain an upright position overrides the need for neural decompression and the compensatory mechanisms are activated[30]. This phenomenon of the anteriorized SVA and normal PT was seen in patients with diagnosed symptomatic neural compression in our study but it was independent of the PI value and not statistically significant in this material (unpublished data).

The PI-LL mismatch is one of the main drivers of the loss of sagittal alignment[9]. Kim et al. stated that PI-LL mismatch is associated with pathologic degenerative changes, not the normal aging process[31]. This is supported by our study with symptomatic patients, since the proportion of **PI-LL mismatches increased with the severity of the deformity and the disability and was not induced by pain or neural compression.**

The range of values of the sagittal modifiers in our study matches that in the Schwab et al.[18] validation study of the classification, where the cases were selected to represent a distribution of the classification grades. They found the radiographic parameter thresholds predictive of an ODI score of 40 to be 11° for PI-LL, 22° for PT, and 46 mm for SVA[18]. In our study, both the moderate and severe groups matched these values, indicating that the classification is valid even in its simplified form with 3 groups of sagittal modifiers.

The groups were significantly different in the SRS-30 function/physical activity and self-image/appearance domains. The severity of the deformity did not correlate with self-reported pain or mental health. This may result from the variety of etiologies in our cohort where the deformity was not the only source of pain and discomfort.

Both ODI and SRS-30 were sensitive to the loss of function. Disease-specific SRS-30 has increased value when the deformity is severe since the other outcome measures do not include questions about self-image and appearance.

The strength of this study was that our institution is the only tertiary spine clinic to serve the district population and it has standardized referral guidelines. The study cohort represented the majority of the district patients with prolonged degenerative thoracolumbar disorders and therefore the results can be generalized. One limitation was that only the sagittal parameters of the SRS-Schwab classification were

included and comparison of groups with the other spinopelvic parameters was not performed. The influence of the different diagnoses on the deformity could not be evaluated since some categories had too few patients.

Conclusions

In conclusion, sagittal imbalance and compensatory mechanisms are common and strongly related to deterioration of physical and social functioning outcomes and HRQoL measures in symptomatic adult patients with general degenerative spinal disorders and no pre-known ASD. For them, the sagittal modifiers of the SRS-Schwab adult spinal deformity classification, categorized into 3 groups, is a useful and a practical tool to detect various grades of deformity. Analysis of sagittal alignment in the early phases of degenerative spinal disorders can orientate the physicians to more individualized physical rehabilitation programs and severe cases can be referred for surgical consultation for diagnosis of the deformity.

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Figure 1. Distribution of patients according to the severity of the sagittal deformity with the original sagittal modifier grades and the modified grades. Deformity severity groups: mild or no deformity (0 or 1+ modifiers), moderate (2-3+ modifiers), and marked (4-6+ modifiers).

SRS, Scoliosis Research Society; PI-LL, pelvic incidence-lumbar lordosis; PT, pelvic tilt; SVA, sagittal vertical axis; ODI, Oswestry Disability Index
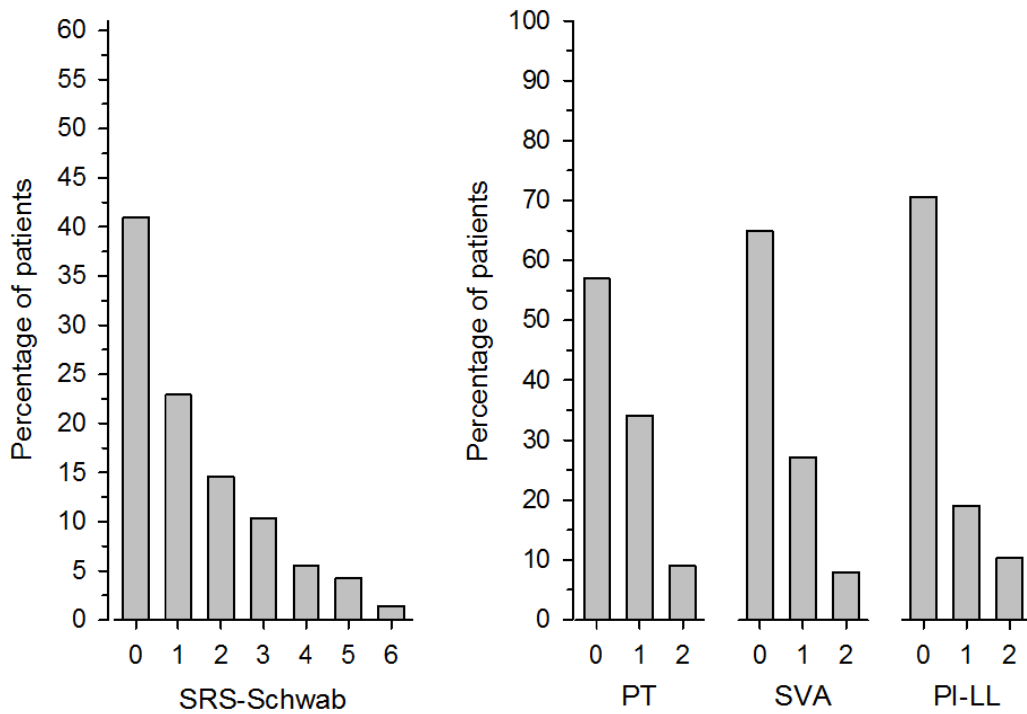
Figure 2. Individual sagittal modifiers in relation to the Oswestry Disability Index total score and Scoliosis Research Society-30 subtotal score

Severity: 0 mild or none, + moderate, ++ marked

PI-LL, pelvic incidence-lumbar lordosis; PT, pelvic tilt; SVA, sagittal vertical axis; ODI, Oswestry Disability Index
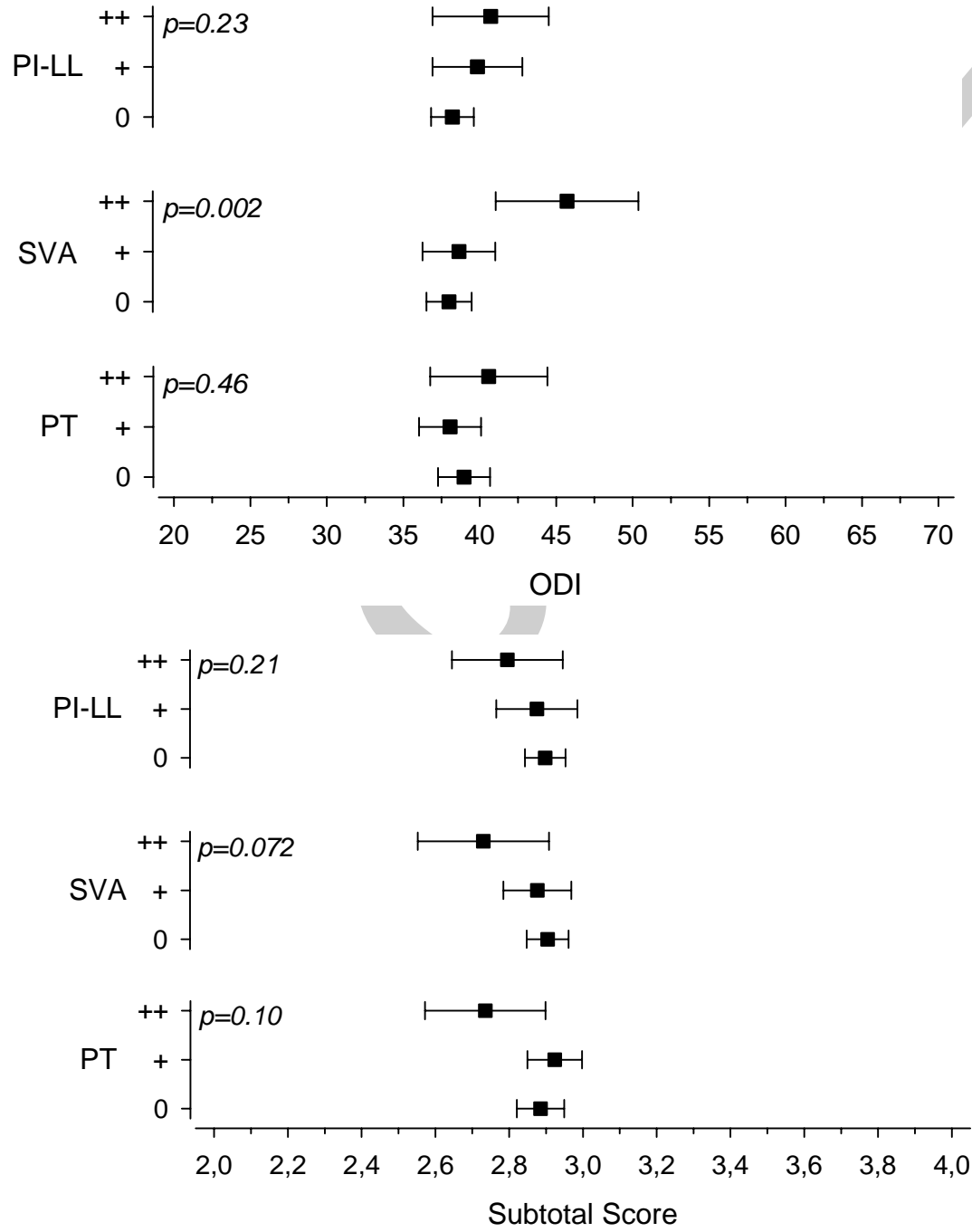
*statistically significant

Table 1. The characteristics of the study cohort classified with the simplified categorization of the Scoliosis Research Society-Schwab adult spine deformity classification sagittal modifiers

Characteristic	Sagittal deformity severity group			
Total n=637	Mild or none n= 407	Moderate n=159	Severe n=71	p-value
Female, n (%)	222 (54)	87 (55)	49 (69)	0.066
Age (years), mean (SD)	51 (15)	59 (13)	66 (13)	<0.001*
BMI (kg/m^2), mean (SD)	27.1 (4.9)	28.1 (4.5)	29.1 (5.0)	<0.001*
Marriage or common-law marriage n (%)	305 (75)	109 (69)	37 (52)	<0.001*
Years of education, mean (SD)	13 (4)	11 (4)	11 (3)	<0.001*
Available for work, n (%)	283 (70)	81 (51)	14 (20)	0.001*
Smokers, n (%)	101 (25)	39 (24)	12 (17)	0.23
Physical activity (Kasari-FIT-index)	35 (22)	33 (22)	22 (18)	0.001*
Daily use of painkillers, n (%)	207 (51)	83 (52)	49 (69)	0.016*
Back pain VAS, mean (SD)	58 (29)	62 (27)	60 (29)	0.69
Leg pain VAS, mean (SD)	53 (31)	56 (33)	59 (29)	0.14
Duration of current back pain in months, median (IQR)	18 (6,48)	25 (10,68)	24 (9,102)	0.002*
Diagnoses, n (%)				
Scoliosis	9 (2)	12 (8)	13 (18)	<0.001*
Spondylolisthesis	57 (14)	35 (22)	6 (9)	0.91
Neural compression	201 (49)	69 (43)	37 (52)	0.81
Degenerative spine without neural compression**	140 (34)	43 (27)	15 (21)	0.01*
Previous spine surgery, n (%)	19 (5)	8 (5)	7 (10)	0.095

*Statistically significant for the hypothesis of linearity across the deformity classes evaluated by analysis of variance, Cuzick test, Cochran-Armitage test, adjusted for age, sex, BMI, and years of education.

Degenerative spine includes spondylosis, disc degeneration, facet joint arthrosis and other degenerative conditions without neural compression.

BMI, body mass index; SD, standard deviation; FIT, frequency intensity time; VAS, visual analog scale

Table 2. The outcome measures of the Oswestry Disability Index and the SRS-30 in the deformity severity groups

Outcome measures	Deformity severity group			
	Mild or none n=407	Moderate n=159	Severe n=71	p-value
Oswestry Disability Index	37 (16)	40 (16)	47 (16)	0.033[*]
SRS-30				
Function/activity	2.89 (0.77)	2.77 (0.70)	2.48 (0.64)	0.004[*]
Pain	2.40 (0.76)	2.39 (0.71)	2.45 (0.88)	0.77
Self-image/appearance	2.93 (0.67)	2.83 (0.62)	2.53 (0.65)	0.03[*]
Mental health	3.43 (0.87)	3.44 (0.89)	3.26 (0.86)	0.29
Sub total	2.92 (0.62)	2.86 (0.57)	2.68 (0.62)	0.088
Satisfaction with management[**]	3.10 (0.78)	3.17 (0.71)	3.13 (0.65)	0.87
Total score[**]	2.91 (0.57)	2.89 (0.53)	2.73 (0.55)	0.17

* Statistical significance on the bootstrapped type analysis of variance with age, sex, BMI, and years of education as covariates.

** Total n=588

SRS-30, Scoliosis Research Society (version 30)

Table 3. The SRS-Schwab classification sagittal modifiers in the deformity severity groups

Sagittal modifiers of the SRS-Schwab ASD with classification threshold values		Mild or none (n=407)	Moderate (n=159)	Severe (n=71)
		Mean (SD) min-max		
PI-LL	*0: up to 10°* *+: moderate 10-20°* *++: marked > 20°*	-3.7 (8.0) -29 – 17	11.0 (8.8) -18 – 37	27.7 (9.5) 10 – 50
PT	*0: < 20°* *+: 20-30°* *++: > 30°*	15.1 (6.0) -3 – 30	23.4 (7.0) -12 – 41	30.8 (8.4) 13 – 71
SVA	*0: < 4 cm* *+: 4-9.5 cm* *++: > 9.5 cm*	16.8 (25.1) -58 – 89	50.6 (37.1) -21 – 236	98.4 (46.2) -31 – 231

Severity: 0 mild or none, + moderate, ++ marked

SRS, Scoliosis Research Society; ASD, adult spine deformity; SD, standard deviation; PI-LL, pelvic incidence – lumbar lordosis; PT, pelvic tilt; SVA, sagittal vertical axis