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ORIGINAL ARTICLE

How back pain intensity relates to clinical and psychosocial factors in patients with idiopathic scoliosis

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Abstract

Objective A pain intensity of 3 can reliably distinguish idiopathic scoliosis (IS) patients with acceptable pain or not. This research aims to analyze psychosocial, family and quality of life differences in patients according to their pain status.

Material and methods Patients with IS, without previous surgery, Cobb ≥ 30° and age (12–40) were included in the study. They completed the questionnaires Numerical Rate Scale (NRS), Tampa Scale for Kinesiophobia (TSK)-11, SRS22r, Hospital Anxiety-Depression Scale (HADS), COMI item 7 (work/school absenteeism) and family APGAR. Comorbidities and family health history were collected. Analysis of covariance was performed to compare means between the PAIN (NRS > 3), (NRS < = 3) groups controlling for the effect of age and the magnitude of the curve.

Results In total, 272 patients were included. 37.1% belonged to the PAIN group (PG). The PG showed a significantly higher Cobb grade and age than the NO-PAIN group. After controlling for these variables, the PG had worse pain, mental health and SRS22-subtotal values. However, they did not differ in function or self-image. PG showed higher levels of kinesiophobia, anxiety, depression, absenteeism from work/school and impact on social/family environment. PG patients reported a higher prevalence of comorbidities and family history of nonspecific spinal pain.

Conclusions Patients with IS and unacceptable pain constitute a group with a different incidence of psychological, social, family and comorbidities factors than those with acceptable pain. In contrast, the severity of IS was not substantially different between the groups. This profile is similar to that observed in patients with nonspecific spinal pain.

Keywords Pain · Idiopathic scoliosis · Psychosocial factors · Quality of life

Introduction

The presence of back pain in patients with idiopathic scoliosis (IS) has stimulated the interest of researchers. However, the literature is full of controversies, as there is much heterogeneity in the concept itself, leading to conflicting conclusions depending on how results are evaluated and analyzed. Some authors label patients who simply answer "yes" to a question about the presence of pain as being affected by pain [1, 2]. Nevertheless, the usual practice is to record pain intensity on a numerical rating scale (NRS) from 0 to 10. Using this scale, some authors classify any intensity greater than 0 as pain [3–5], although this appears to overestimate the prevalence of pain. Theroux et al. [4] analyzed a cohort of patients with mild-to-moderate adolescent IS and found a 68% prevalence of pain, with a mean pain intensity of 1.63 on the NRS. Wong et al. [5] analyzed another cohort of patients with mild adolescent IS and found a prevalence of current pain of 18%, with a mean intensity of 2.5. Considering that the estimated minimum detectable change on the NRS is 2 [6], these above-mentioned studies indicate that the average pain in these patients is clinically not highly significant.

Therefore, it is evident that there is a need to categorize IS patients according to pain intensity on the NRS and to set a common clinical threshold to what can be regarded as pain clinically affecting a patient's life. Hence, some authors decided to intuitively use a threshold value to include patients within the "pain group" [7–9]. Recently,

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Mannion et al. [10] determined the NRS value that identifies a patient as being in an acceptable symptomatic state in a large cohort of patients of > = 18 years old from an adult scoliosis registry. They conducted the study using receiver operating characteristic (ROC) curve analysis and found that a threshold value of < = 3 separated patients in an acceptable state from those who were not, reaching a high predictive value (the area under the curve [AUC] was 0.8).

Several factors have been related to pain intensity in IS patients: age; curve magnitude; and diverse psychosocial conditions, such as sleep disorders, depression, anxiety, or kinesiophobia [1, 4, 5, 7–9, 11–13]. However, the differences between groups of patients with and without pain have not been examined when the allocation to these groups is based on a robust and evidence-based cutoff point. The aim of this project was to further validate the cutoff value of < = 3 to divide patients into high or low pain intensity groups in a large enough cohort of adolescent and young adult patients with IS. The hypothesis to be confirmed was that the two groups would differ in several psychosocial characteristics. The specific objectives are to analyze the differences between the two groups in age, curve magnitude, comorbidities, family and social environment, quality of life, kinesiophobia and mental health.

Materials and methods

Study design

This is an IRB-approved, prospective, multicenter and cross-sectional study. Sample size was calculated to detect an R-squared of 0.02 attributed to one independent variable using an F-test with a significance level (alpha) of 0.05 after adjusting for three additional variables with an R-squared of 0.35. A total of 250 patients were deemed necessary to achieve a 80% power.

Patients were recruited consecutively in the outpatient scoliosis clinic of the three participating centers. The inclusion criteria were as follows: diagnosis of IS; radiological magnitude of the major curve in the coronal plane, as measured by the Cobb angle, greater than or equal to 30º; no surgical treatment; and an age between 12 and 40 years. Patients with congenital, neuromuscular or syndromic scoliosis were excluded. Parents/patients who consented to participate in the study underwent an extensive interview to gather information on past and present comorbidities and family health history (serious diseases, scoliosis or other spine disorders). In addition, a complete physical and neurological examination and a PA full-spine X-rays were performed. Regarding current work/school activity, the patients were classified as active if they had normal activity and as nonactive if they were unemployed, on sick leave or disabled. In addition, information about age, sex, curve magnitude and type of treatment was recorded.

Outcomes

As outcome measures the following questionnaires were distributed among the patients for further analysis:

Refined **Scoliosis Research Society-22** (SRS-22r). The questionnaire consists of 20 nonmanagement items belonging to 4 dimensions: Function/Activity, Pain, Self-Image and Mental Health. Each domain has five questions and each question is answered using a five-point Likert scale ranging from 1 (worst) to 5 (best). Results are presented as the mean of each scale (sum of 5 questions/5) and the mean subtotal score (sum of 20 questions/20); hence, ranking ranges are from 1 to 5 [14].

The **Core Outcome Measurement Index** (COMI) item 7 that assesses work/school absenteeism because of the pain was used [15] *During the past four weeks, how many days did your back problem keep you from going to work (job, school, housework).* Answers options are: none (score 0); between 1 and 7 days (score 1); between 8 and 14 days (score 2); between 15 and 21 days (score 3) and more than 21 days (score 4).

Self-reported pain intensity was assessed using the **Numerical Rating Scale** (NRS 0–10), where 0 indicates no pain and 10 indicates the worst pain imaginable. Patients were asked to rate the average pain they had experienced in the last month. Patients were assigned to PAIN group when score was > 3 and to NO-PAIN group when < = 3.

Hospital Anxiety and Depression Scale (HADS) questionnaire [16] was used to determine the levels of anxiety or depression that the person was experiencing. The instrument comprises two 7-item scales designed to rate depression (HADS−D) and anxiety (HADS−A). Ratings for each question may range from 0 (best) to 3 (worst). In both the subscales, the scores are interpreted with the following criteria: 0–7 = Normal; 8–10 = Borderline abnormal and 11–21 = Abnormal.

The Spanish version of the **Tampa Scale of Kinesiophobia** (TSK) [17] is an 11-item measure; patients rate each item on a 4-point Likert scale with scoring alternatives ranging from strongly disagree (1 point) to strongly agree (4 points) with higher scores indicating higher kinesiophobia levels.

The **family APGAR** [18] is a 5-item questionnaire, with each item rated on a 3-point scale (score range 0 (worst) – 10 (best)). A total score of 8 to 10 indicates a highly functional family, a score of 4 to 7 a moderately dysfunctional family and score of 0 to 3 a dysfunctional family.

To assess the influence of the social and family environment, a battery of five questions was developed. The patients were asked, "Do you think that any of these problems could be affecting your quality of life:

- The relationship with my teachers or bosses,
- My academic scores or my achievements at work,
- The relationship with my peers,
- Lack of leisure time, and
- The relationship with my family?

The answer to each of these questions was a binary "yes" or "no."

Statistical analysis

Descriptive statistics included the mean, range, standard deviation or 95% confidence interval, as required. In a first step, a Student's *t* test was used to compare means of age and curve magnitude between groups. Since the groups were found to differ in these variables, the comparison of the means was further performed with an analysis of covariance (ANCOVA). Analysis of covariance is used to test the main and interaction effects of categorical variables on a continuous dependent variable, controlling for the effects of selected other continuous variables. In observational designs, this type of analysis allows to remove the effects of variables which modify the relationship of the categorical independents to the interval dependent. The comparison of proportions between the two groups was done with the Chi-square test and Fisher's exact test. SPSS version 25 software was used for the statistical analysis.

Results

From July 2018 to December 2019, 272 patients were included. The mean age was 18.1 years (range 12 to 40 years), 83.5% of the patients were females, and the average largest curve Cobb angle was 46.1° (range 30° to 96°). Regarding treatment, one hundred forty-eight patients were under observation (no active treatment or proposed for surgery), 81 were wearing a brace, and 43 were scheduled for surgery. There were 195 adolescents (age range 12 to 17 years) and 77 young adults (age range 18 to 40 years).

The average pain intensity was 2.70 (SD = 2.34, 95% CI [2.42, 2.98]). The sample was divided into two groups: The PAIN group with an NRS > 3 consisted of 101 patients (37.1%, 95% CI[31.4, 43.2]) and had an average NRS of 5.3. The NO-PAIN group with an NRS < = 3 consisted of 171 patients (62.9%) and had an average NRS of 1.1. The PAIN group showed a higher largest Cobb angle (48.6° vs. 44.6°, $p = 0.025$) and age (20.9 vs. 16.5 years, $p = 0.0001$) than the NO-PAIN group. According to this result, for the remaining variables, the comparison between the means of the two groups was conducted using a covariance analysis.

Table 1 shows the average scores of the SRS-22 subtotal and subscales for the two groups. Compared with the NO-PAIN group, PAIN group had a significantly lower subtotal score, as well as lower pain and mental health domain scores. The groups did not differ in function or body image.

Table 1 Mean SRS-22 subtotal and subscales scores for PAIN and NO-PAIN groups

	PAIN	NO-PAIN	*p*
SRS-22 subtotal	3.28	3.56	.02
SRS-22 function	3.64	3.83	.1
SRS-22 pain	3.13	3.58	.002
SRS-22 image	3.11	3.23	.3
SRS-22 mental health	3.24	3.62	.0001

*p statistical significance from ANCOVA test

Table 2 Mean scores of other outcome instruments for the PAIN and NON-PAIN groups

	PAIN	NO-PAIN	*p**
TSK	23.6	21.7	.023
HADS anxiety	7.2	4.9	.0001
HADS depression	3.3	1.9	.0001
COMI#7	1.34	1.08	.001
Family APGAR	8.58	8.80	.38

*p statistical significance from ANCOVA test

The patients in the PAIN group showed a higher level of kinesiophobia, anxiety, depression and work/school absenteeism than the patients in the NO-PAIN. However, family functionality was similar in both groups. Regarding the HADS depression scale categories, 100% of the patients with an abnormal score belonged to the group PAIN in contrast to only 35.9% of the patients with a normal score ($p = 0.03$). Concerning the HADS anxiety scale, 66.7% of the patients with an abnormal score belonged to the PAIN group, compared with 27% of the patients with a normal score ($p = 0.0001$) (Table 2).

The percentage of patients in the PAIN and NO-PAIN groups and the risk associated with the occurrence of different clinical, social and occupational characteristics are detailed in Table 3a and b. The percentage of females was higher in the PAIN group than in the NO-PAIN group (89.1% vs. 80.1%), but this difference did not reach statistical significance.

The percentage of patients wearing a brace in the No-PAIN group was significantly higher than that observed in the PAIN group (36.8% vs.17.8%) ($p = 0.01$). These data indicate that patients under brace have a lower risk of falling into the PAIN group ($OR = 0.37$).

There was a higher percentage of nonactive individuals in the PAIN group (6.9% vs. 1.8%, $p = 0.04$). With regard to the comorbidity profile, 44 out of 272 patients (16.7%)

Table 3 Percentage of cases in the PAIN and NON-PAIN groups presenting different (a) clinical features and (b) social and family

	PAIN %	NO-PAIN %	*p*	*OR* [95% CI]
a				
Sex				
Females	89.1%	80.1%	.06	.49 [.23, 1.02]
Type of treatment				
Brace	17.8%	36.8%	.001	.37 [.2, .67]
Daily activity				
Nonactive	6.9%	1.8%	.04	4.17 [1.05, 16.5]
Current comorbidities	23.8%	10.6%	.005	.38 [.19, .74]
Past comorbidities	17.8%	6.5%	.004	.31 [.14, .7]
Family history of scoliosis	41.6%	33.5%	.1	.7 [.42, 1.17]
Other spine diseases in the family	24%	13.6%	.04	.49 [.26, .94]
Other severe diseases in the family	18.2%	20%	.7	1.12 [.59, 2.12]
b				
Relationship with teachers/bosses	11%	2.4%	.005	5.09 [1.57, 16.4]
Academic/work success	31%	13.6%	.001	2.85 [1.54, 5.25]
Relationship with peers	17%	7.7%	.02	2.45 [1.13, 5.3]
Lack of leisure time	30%	10.7%	.0001	3.59 [1.87, 6.88]
Family relationships	16%	4%	.001	4.4 [1.74, 11.1]

* *p* and *OR* from χ^2 test

reported some type of current comorbidity and 26 out of 272 (9.5%) reported a past comorbidity. In the vast majority of cases, comorbidities refer to respiratory (asthma), cardiac (nonsevere valvular anomalies) or mental (anxiety, depression, ADHD) problems. A case of isthmic spondylolisthesis was found in an 18-year-old girl with a right thoracic scoliosis who complained of pain in the gibbosity area. The PAIN group included a higher proportion of patients with past and current comorbidities and a family history of spine disorders other than scoliosis. However, the percentage of patients with a family history of scoliosis or a severe disease in the family was similar in both groups (Table 3a).

In the PAIN group, there was a higher proportion of patients who reported problems in their relationship with teachers or bosses, academic or work success, relationship with peers, lack of leisure time or relationship with family (Table 3b).

Discussion

There is extensive evidence that several factors other than spinal deformity can influence the development of back pain in adolescents and young adults with IS. Diverse psychosocial variables have been associated with the appearance of pain in a similar way to what happens in nonspecific low-back pain [4, 5, 7–9, 11–13]. However, analyzing which factors influence pain is difficult if a patient is considered to have pain when he or she answers "yes" to the question of whether the back is painful or when he or she scores the pain intensity as greater than 0. Mannion et al. [10] determined that an $NRS <= 3$ reliably differentiates patients who are in an acceptable symptomatic state from those who are not ($AUC = 0.8$). Consequently, we decided to divide our cohort of adolescent and young adult scoliosis patients into two groups according to pain intensity and analyze the differences between them. The hypothesis was that patients in the PAIN group would have a worse psychological, social, health and family profile than those in the NO-PAIN group. In our cohort, the prevalence of > 3 pain was 37.1%. Other authors have categorized patients using an intuitively established NRS cutoff value. Makino et al. [8] reported a prevalence of >= 3 pain of 16.2% in a cohort of female adolescents with IS who were no candidates for surgery. Smorgick et al. [7] found a pain prevalence of 48% using a threshold value of >= 5 in a cohort of adolescent IS patients scheduled for surgery. Fekete et al. [9] analyzed pain prevalence in a registry of IS patients (both adolescents and young adults) scheduled for surgical treatment; using a threshold value of >= 4, they found a prevalence of 52% in young adults and 38% in adolescents. Unlike these series, our cohort included both women and men, several treatment options and both adolescents and young adults.

Patients in the PAIN group were older than those in the NO-PAIN group (20.9 vs. 16.5 years, $p = 0.0001$). A significant correlation between age and pain in IS has been a common finding [1, 4, 5, 7, 9]. A larger scoliosis was also observed in the PAIN group than in the NO-PAIN group (48.6º vs. 44.6º, $p = 0.025$). Some authors have reported a higher frequency and intensity of pain depending on the magnitude of the curve [4,

5, 7], while others have failed to find any difference [1, 3, 8, 9, 11]. These divergences, added to the small difference observed, contribute to the overall impression that the magnitude of the curve is not a crucial determinant of pain intensity. Despite these slight differences, we decided to control for these two variables to avoid confounding in the analysis.

The average pain intensity in the group of patients with a brace was lower (*NRS* = 1.7) than the pain of patients under observation (*NRS* = 3.0) or waiting for surgery (*NRS* = 3.3) and patients under brace have a lower risk of falling into the PAIN group (OR = 0.37). Previously, Smorgick et al. [7] and Theroux et al. [4] had reported similar findings in adolescent IS patients. Both studies found that brace treatment was independently related to pain intensity. This effect of brace has been poorly studied in the literature and would merit further analysis.

Compared with the NO-PAIN group, the PAIN group had a significantly lower SRS-22r scores of the pain and subtotal domains, but the groups did not differ in function and body image. Makino et al. [8] also found lower SRS-22 scores in pain and no difference in body image perception. Nevertheless, they found a significantly lower score in the function domain in the pain group. In addition, using a specific instrument to assess the quality of life associated with back pain, they found a lower social function and walking ability in the pain group. Probably, these findings could be related to the high level of work/school absenteeism we found in this group using COMI question #7. This measure had not been previously used in patients with IS. In general, these data indicate that patients in the pain group have decreased daily activity, and this situation increases the risk of being part of the pain group. In our PAIN group, 6.9% of the patients were nonactive (they were unemployed, on sick leave, or disabled), compared with 1.8% in the NO-PAIN group (*OR* = 4.17). At this point, we cannot establish a cause-and-effect relationship in these findings.

Compared with those in the NO-PAIN group, patients in the PAIN group had worse SRS-22 mental health scores; similar findings were reported by Makino et al. [8] and Djurasovic et al. [11]. In addition, patients in the PAIN group showed higher levels of anxiety and depression. All patients (100%) with an abnormal HADS depression score pertained to the PAIN group, in contrast to 35.9% of the patients with a normal score. In relation to the HADS anxiety scale, 66.7% of the patients with an abnormal score, compared with 27% of the patients with a normal score, belonged to the PAIN group. Wong et al. [11] identified anxiety and depression, along with sleep disorders, as determining factors for the intensity of pain in patients with IS.

The patients in the PAIN group presented higher levels of kinesiophobia than those in the NO-PAIN group. Fear of movement is significantly associated with pain in patients with nonspecific low-back pain [19], but this has been poorly studied in IS [12, 13]. Family functionality, as assessed with the family APGAR scale, was similar in both groups, and the mean scores corresponded to highly functional families [18]. However, a higher percentage of patients in the PAIN group reported problems in family relationships (16% vs. 4%), and this feature represents a high risk of belonging to this group (*OR* = 4.4).

It is also noteworthy that 24% of the patients in the PAIN group, compared with 13.6% of the patients in the NO-PAIN group, reported a family history of spine disorders other than scoliosis, while the prevalence of scoliosis or other serious diseases in the family was similar in both groups (Table 3). When analyzing what this family history of spinal diseases consisted of, we found that almost all the cases involved herniated discs, cervical pain, or lumbar pain. That is, children with scoliosis whose parents have nonspecific spinal pain are at increased risk of suffering from unacceptable pain. These findings highlight the parents' relevance for the symptoms and functioning of children with chronic pain. Poppert-Cordts et al. [20] analyzed the relationships between parents' pain characteristics and physical and psychological functioning and children's pain in a cohort of children attending a tertiary pain clinic. They found a significant correlation between children's pain intensity and parents' pain features, physical functioning and psychological factors. Siemer et al. [21] conducted a longitudinal study on a cohort of adolescent IS patients scheduled for surgery and found a remarkable influence (20% of the variance) of different parental factors on children's long-term postoperative pain-related symptoms.

It is interesting to note the higher prevalence of patients with current (23.8% vs. 10.6%) or past comorbidities (17.8% vs. 6.5%) within the PAIN group as compared with the NO-PAIN group. The most frequently reported comorbidities were respiratory comorbidities (asthma, pneumonia), followed by cardiac comorbidities (congenital anomalies) and psychological comorbidities (depression, anxiety, anorexia). We could affirm that, in general, these are not "painful" diseases, so their mere presence would not explain the worse pain suffered by these patients. The association between comorbidities and pain has already been reported in patients with low-back pain [22] or chronic spinal pain [23] but had not previously been reported in young patients with IS.

A higher percentage of patients in the PAIN group than in the NO-PAIN group admitted having problems with their teachers/bosses or peers and with achieving success at school/work. It is difficult to understand the relationship between these traits and back pain. These characteristics seem to indicate the existence of a certain degree of social inhibition. D'Agata et al. [24] observed that introversion (or social inhibition) was the dominant personality trait in an adolescent IS cohort. On the other hand, "normal" introversion can be negatively affected by a state of anxiety/depression [25]. This association between pain, anxiety/depression and social inhibition could explain our findings.

When examining the characteristics of the PAIN group, we can observe remarkable similarities with those found in patients with nonspecific spinal pain, in which often no

relationship is found between pain and the results of imaging tests (Rx, CT, or MRI). In these patients, pain intensity and disability have been found to be related to psychological factors such as depression, anxiety, fear avoidance behavior, family circumstances and social/work factors [26, 27]. In healthy adolescents, it has also been observed that the presence of significant spinal pain is related to school problems, family problems and states of anxiety and/or depression [28]. The main strength of the current study is the large sample, with patients of different ages, different treatments and a wide range of scoliosis magnitudes. To assess clinical variables, we used validated instruments. Patients were allocated to study groups using a robust and evidence-based cutoff point. However, we should note as a weakness that the cutoff point used was calculated in patients over 18 years old [10]. We can argue that in this study, the vast majority of patients diagnosed with IS were young adults (< 40 years old). A second criticism may regard the study's methodology, since we turned a continuous variable (pain intensity) into a categorical variable (pain groups). The preparation of a multivariate analysis seems to be a difficult task as some application conditions may not be achieved. Moreover, we were more interested in describing and comparing the characteristics of patients with high and low levels of pain rather than getting a formula to predict pain intensity. Finally, the cross-sectional design of the study limits the conclusions that can be drawn for a group of individuals who are undergoing dramatic physical and psychosocial changes. Despite these limitations, our findings provide guidance for future lines of research. In patients who are going to have an operation, preoperative pain intensity will influence postoperative pain, total analgesic dose and even pain intensity one year after surgery [29]. Some factors related to pain intensity, such as depression, anxiety or fear of movement, could be treated beforehand to decrease the pain intensity in the postoperative period, leading to a decrease in pain intensity in the perioperative period. Monticone et al. [30] reported significant pain improvement using cognitive behavioral therapy in adult IS patients. In this regard, it would be of special interest to analyze the effect of braces on pain intensity. Many questions come to mind: Could a brace reduce pain intensity in highly symptomatic patients? In highly symptomatic patients scheduled for surgery, could bracing improve perioperative pain control?

In conclusion, patients with IS and high level of pain constitute a group characterized by psychological, social, work/school and familial factors. In addition, they report a higher prevalence of comorbidities and a family history of nonspecific spinal pain and clearly distinguishable from the low-level pain group. In contrast, IS severity was not substantially different between the groups. Overall, this profile is remarkably similar to that observed in patients with nonspecific spinal pain. Lastly, the effect of bracing on pain intensity requires further study.

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Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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