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ORIGINAL ARTICLE

Impact of mental health components on the development of back pain in young adults with adolescent idiopathic scoliosis

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Abstract

Background Back pain occurs commonly in adults and is multifactorial in nature. This study aimed to assess the prevalence and intensity of back pain during young adulthood in subjects with adolescent idiopathic scoliosis (AIS), as well as factors that may be associated with its prognosis.

Methods Subjects with AIS aged 20–39 treated conservatively were included in this study. Patient-reported outcome measures in adulthood involved episodes of back pain, and scales of self-image, depression, anxiety, and stress. Additionally, pain, self-image, and mental health scores were retrieved at the first clinic consultation. Occurrence of back pain was defined as a numeric pain rating scale ≥ 6.

Results 101 participants were enrolled. The prevalence of back pain in the lifetime, past 12 months, past 6 months, past 1 month, past 7 days, and past 24 h were 37%, 35%, 31%, 27%, 23%, and 20%, respectively. Male, self-image, and depression were significant associated factors for the development of back pain at all time points. Furthermore, the analyses of the initial presentation of participants have shown that participants with back pain in adulthood were characterised by poor self-image and mental health during their adolescence.

Conclusion The present study addressed the natural history of back pain in young adults with conservatively treated AIS. Psychological makeup has been shown to constitute the development of back pain and is strongly hinted as an early sign of having back pain in adulthood among subjects with AIS.

Keywords Adolescent idiopathic scoliosis · Back pain · Conservative treatment · Young adulthood · Psychological factors · Mental health · Self-image · Depression

Introduction

Adolescent idiopathic scoliosis (AIS) is the most common spine deformity worldwide [1], and scoliotic individuals may complain of back discomfort [2]. Although back pain causes rapidly increased disability-adjusted life years in the global population when compared to other diseases and injuries [3], some researchers have found that the occurrence of back pain was significantly higher in subjects with scoliosis as compared to healthy adolescents [4, 5]. In the literature, the prevalence of back pain among scoliotic participants varied between papers, yet the reason for this variation is unknown [6–9].It has also been shown that back pain in AIS is a risk factor for developing back pain in adulthood [5]. But generally, the research into the prevalence distribution and severity of back pain among young adults is lacking [10–12].

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Nevertheless, the pathomechanism of back pain in AIS is not known [13]. Based on the multifactorial aetiology of back pain [7], it was suggested that spinal morphology is not the only explanation [9]. Several associated factors for back pain in AIS were separately investigated, including age [6, 8], body mass index [5], Cobb angle [6, 8], curve pattern [9], appearance [7], and mental health [7–9]. However, the interplay among these factors is yet to be known. It remains uncertain whether physical and/or psychological factors contribute to the development of back pain.

To assess the burden of scoliosis-related back pain, the patient group without receiving definitive correction for the condition of AIS should be targeted. Accordingly, the information about this young adult group may help clinicians to mitigate their pain and prevent severe back problems. Given the above, the present study aimed to evaluate the prevalence and intensity of back pain among young adults with conservatively treated AIS. This study also aimed to determine the effects of psychological makeup on the perception of pain among participants.

Methods

The manuscript was prepared in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) recommendation [14].

Study design

This prospective cross-sectional study complied with the World Medical Association Declaration of Helsinki [15]. The study protocol obtained approval from the institutional review board of the University of Hong Kong and Hospital Authority Hong Kong West Cluster (reference number: UW 22-257). Informed consent was provided to the participants prior to any study procedures initiate.

Setting

The study site was a territory-wide referral centre in Hong Kong. It is one of the only two designated hospitals specialised in managing spinal deformity, which covers at least half of the local population. Subjects with AIS were screened consecutively from the patient lists of an orthopaedic scoliosis outpatient clinic between 04th January 2021 and 22nd December 2021. All eligible study subjects were included without restrictions on curve severity and curve pattern. Potential candidates were contacted by phone and enquired about their willingness to participate in this study. On top of the baseline assessment, an electronic database stored records of the Scoliosis Research Society patient outcome questionnaire during regular clinic visits was used. Data collected during the initial presentation were retrieved.

Participants

Study subjects aged 20–39 years with a primary diagnosis of AIS were eligible for inclusion, of which this specific age range of young adults was less affected by spinal degeneration [16]. Additionally, only those who attended the clinical appointment at the scoliosis clinic with the available radiological findings were included. The exclusion criteria were listed as follows, (1) spinal trauma, injury, fracture, or tumour, (2) history of spinal surgery, and (3) mental retardation. Electronic medical records were reviewed to confirm the eligibility.

Measurements

The primary outcomes were collected through a self-administered online survey (Qualtrics XM, United States). Particularly, the numeric rating scale (NRS) was adopted to quantify the intensity of back pain [17]. Average pain intensity in the lifetime, past 12 months, past 6 months, past 1 month, past 7 days, and past 24 h, was graded using a 0 (no pain) to 10 (extreme pain requiring emergency care) scale [18]. Other psychological factors were examined via the self-image subscale of the Scoliosis Research Society questionnaire [19], the patient health questionnaire [20], the generalised anxiety disorder scale [21], and the stress subscale of the depression anxiety stress scale [22]. The self-image subscale mapped one's perceived appearance of the back, with a score of 5 being the best and 1 being the worst. The patient health questionnaire, the generalised anxiety disorder scale, and the stress scale estimated the depressive symptoms (0–27 points), anxiety symptoms (0–21 points), and stress levels (0–34 points) of participants, respectively. Smoking habit was affirmed by asking whether the participants have ever smoked, while alcohol consumption was asked by intake of alcoholic beverages or not over the past year. Furthermore, the radiographic assessment was used on the posteroanterior standing view of the whole spine (EOS imaging, France). Since all patients attending the scoliosis clinic would have the imaging taken routinely, no additional X-ray images were required for this study. The picture archiving and communication system (PACS) was utilised for measuring the Cobb angle of the major curve and classifying the curve pattern. Demographic data were extracted from the database of medical records. Alternatively, the pain, self-image, and mental health scores of the Scoliosis Research Society questionnaire collected during the first clinic consultation were also used.

Variables

Apart from the pain intensity, the occurrence of back pain was dichotomised into the study (NRS ≥ 6 points) and control groups (NRS < 6 points) [23]. The pain, self-image and mental health scores were the mean value of the questions answered, whereas the depression, anxiety, and stress scores were the accumulative points of the corresponding answers. Records of smoking and drinking were recognised as smokers and alcohol drinkers. Regarding the condition of AIS, the Cobb angle of the major curve was evaluated and subdivided into three levels of severity [24], namely mild curve as curve magnitude from 10° to 24°, moderate curve as between 25° and 44°, and severe curve as ≥ 45°. In addition, the categorisation of curve patterns (see Appendix) was adapted from the Lenke classification because the lack of bending films in non-surgical patients [25]. All spinal curves ≥ 10° were accounted. The six types of curvature involved, (a) main thoracic curve with a single curvature in the lower thoracic region, (b) double thoracic curves with two curvatures in both upper and lower thoracic regions, (c) double major curves I with two curvatures and the major curve at the thorax, (d) triple major curves with three curvatures over the spine, (e) thoracolumbar or lumbar curve with one curvature in the thoracolumbar or lumbar region, and (f) double major curves II with two curvatures and the major curve at the lower back. Conservative treatment was received for AIS, including observation, physiotherapy, and bracing.

Statistical analysis

All data were analysed by the statistical package for the social sciences software version 28.0 (SPSS Inc., United States). The level of significance was set at 0.05. In light of the primary objective, the independent samples t-test was performed between participants with and without back pain. Subgroup analyses were performed by the Chi-squared test and Kruskal–Wallis test to evaluate participants with different curve severities, curve patterns, and treatments. In order to address the secondary objective, backward stepwise logistic and linear regression were applied to establish the associated factors for back pain. Further, the Mann–Whitney U test was performed between pain and control groups to compare the pain, self-image, and mental health scores measured in adolescence.

Results

Initially, 583 potential study subjects were retrieved and assessed for eligibility. Of them, 457 were excluded since they could not be reached ($n = 243$), declined to participate ($n = 131$), did not meet the inclusion criteria ($n = 36$), or had undergone spinal surgery ($n = 47$). After removing 25 entries due to incompletion of the survey, a total of 101 participants were enrolled in the present study (Fig. 1).

The demographics of participants were shown with mean and standard deviation or proportion in percentage (Table 1), comprising age of 24.5 ± 4.8 years, females rate at 77.2%, 1.6 ± 0.1 m in height, 53.5 ± 9.9 kg in weight, and body

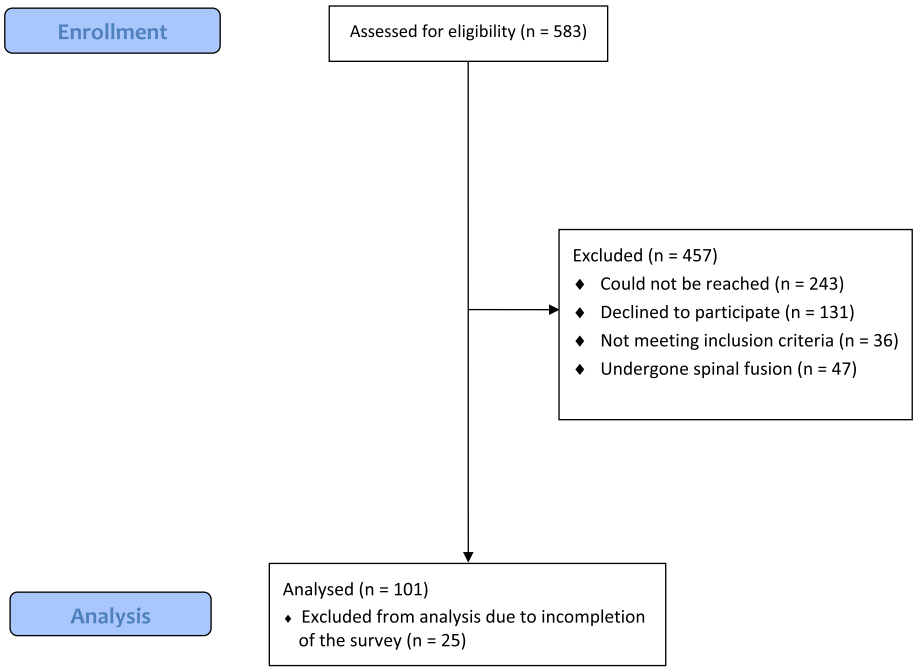

Fig. 1 Flow diagram of participant recruitment

Table 1 Characteristics of participants

	Mean ± standard deviation/proportion in percentage
Demographics	
Age (years)	24.5 ± 4.8
Gender (female)	77.2%
Height (m)	1.6 ± 0.1
Weight (kg)	53.5 ± 9.9
Body mass index (kg/m^2)	19.9 ± 3.1
Smoker (yes)	4.0%
Alcohol drinker (yes)	58.4%
Radiological data	
Cobb angle of the major curve (°)	41.9 ± 13.8
Curve severity of the major curve	
Mild [10°–24°]	11.0%
Moderate [25°–44°]	48.0%
Severe [≥ 45°]	41.0%
Curve pattern	
Main thoracic	8.0%
Double thoracic	4.0%
Double major I	25.0%
Triple major	26.0%
Thoracolumbar/Lumbar	6.0%
Double major II	31.0%
Treatment received	
Observation	24.8%
Bracing	49.5%
Physiotherapy	25.7%
Psychological scores	
Self-image	3.4 ± 0.8
Depression	4.9 ± 5.2
Anxiety	4.5 ± 4.9
Stress	9.0 ± 8.9

mass index of 19.9 ± 3.1. Among them, 4.0% and 58.4% were smokers and alcohol drinkers. In relation to their condition of AIS, the average Cobb angle of the major curve was 41.9° ± 13.8°. Most of them had a moderate (48.0%) or severe curve (41.0%), whereas the distribution of curve patterns mainly encompassed double major I (25.0%), triple major (26.0%), and double major II (31.0%). About half of them received bracing (49.5%).

In general, the prevalence of back pain in the lifetime, past 12 months, past 6 months, past 1 month, past 7 days, and past 24 h were 36.6%, 34.7%, 30.7%, 26.7%, 22.8%, and 19.8%, respectively. With reference to the intensity of back pain, the study group had significantly greater NRS than the control group in all periods (Table 2). The average pain intensity within the study group was denoted as 7.1 ± 1.1 points in the lifetime, 7.2 ± 1.2 points in the past

Table 2 Overall prevalence and intensity of back pain

Back pain	Prevalence (%)	Intensity		
		Pain	Control	Sig.
Lifetime	36.6	7.1 ± 1.1	2.5 ± 1.7	< 0.001*
Past 12 months	34.7	7.2 ± 1.2	2.2 ± 1.7	< 0.001*
Past 6 months	30.7	7.2 ± 1.1	2.2 ± 1.7	< 0.001*
Past 1 month	26.7	7.2 ± 1.2	1.8 ± 1.7	< 0.001*
Past 7 days	22.8	7.1 ± 1.2	1.5 ± 1.7	< 0.001*
Past 24 h	19.8	7.3 ± 1.2	1.1 ± 1.6	< 0.001*

* = significant

12 months, 7.2 ± 1.1 points in the past 6 months, 7.2 ± 1.2 points in the past 1 month, 7.1 ± 1.2 points in the past 7 days, and 7.3 ± 1.2 points in the past 24 h. Subgroup analyses have illustrated that curve severity, curve pattern, and treatment received were not associated with the prevalence and intensity of back pain (Tables 3 and 4).

As for the inputs of regression models, the following parameters were entered at the beginning stage, namely age, gender, body mass index, smoking, alcohol drinking, major Cobb angle, self-image, depression, anxiety, and stress scores.

Logistic regression was performed to ascertain the effects of associated factors on the likelihood that adult participants have back pain (Table 5). Age was associated with the occurrence of back pain in the lifetime ($p = 0.001$), past 12 months ($p = 0.012$), and past 24 h ($p = 0.038$). Males were associated with the occurrence of back pain in past 7 days ($p = 0.034$) and past 24 h ($p = 0.040$). History of smoking was associated with the occurrence of back pain in past 6 months ($p = 0.030$) and past 1 month ($p = 0.023$). History of alcohol drinking was associated with the occurrence of back pain in past 6 months ($p = 0.011$) and past 1 month ($p = 0.034$). Major Cobb angle was associated with the occurrence of back pain in the lifetime ($p = 0.041$), past 6 months ($p = 0.028$), and past 24 h ($p = 0.025$). Stress symptoms were associated with the occurrence of back pain in the lifetime ($p = 0.032$) and past 1 month ($p = 0.045$). Notably, the self-image score consistently showed associations with the occurrence of back pain at all time points.

Moreover, linear regression was performed to predict the intensity of back pain among participants (Table 6). Age was associated with the pain intensity in the lifetime ($p = 0.001$), past 12 months ($p = 0.040$), past 6 months ($p = 0.019$), and past 24 h ($p = 0.020$). Body mass index was associated with the pain intensity in past 7 days ($p = 0.044$). History of alcohol drinking was associated with the pain intensity in the lifetime ($p = 0.048$), past 12 months ($p = 0.020$), and past 6 months ($p = 0.012$). Anxiety symptoms were associated with the pain intensity in the lifetime ($p = 0.005$). More importantly, males, self-image score, and depressive

Table 3 Subgroup analyses of the prevalence of back pain

	Lifetime prevalence	12-month prevalence	6-month prevalence	1-month prevalence	7-day prevalence	24-h prevalence
Curve severity						
Mild	36.4%	27.3%	27.3%	9.1%	9.1%	9.1%
Moderate	35.4%	35.4%	29.2%	25.0%	16.7%	16.7%
Severe	39.0%	36.6%	34.1%	34.1%	34.1%	26.8%
Sig.	0.939	0.845	0.845	0.229	0.076	0.309
Curve pattern						
Main thoracic	25.0%	25.0%	25.0%	25.0%	25.0%	12.5%
Double thoracic	25.0%	50.0%	50.0%	50.0%	25.0%	25.0%
Double major I	32.0%	24.0%	20.0%	20.0%	20.0%	20.0%
Triple major	34.6%	42.3%	34.6%	26.9%	23.1%	15.4%
Thoracolumbar/Lumbar	66.7%	66.7%	66.7%	50.0%	50.0%	50.0%
Double major II	41.9%	32.3%	29.0%	25.8%	19.4%	19.4%
Sig.	0.599	0.365	0.306	0.647	0.722	0.539
Treatment received						
Observation	32.0%	24.0%	24.0%	16.0%	12.0%	16.0%
Physiotherapy	34.6%	38.5%	26.9%	26.9%	23.1%	23.1%
Bracing	40.0%	38.0%	36.0%	32.0%	28.0%	20.0%
Sig.	0.771	0.435	0.506	0.336	0.297	0.817

Table 4 Subgroup analyses of the intensity of back pain

	Lifetime pain intensity	12-month pain intensity	6-month pain intensity	1-month pain intensity	7-day pain intensity	24-h pain intensity
Curve severity						
Mild	6.3 ± 0.5	6.3 ± 0.6	6.3 ± 0.6	6.0 ± 0.0	6.0 ± 0.0	6.0 ± 0.0
Moderate	7.3 ± 1.3	7.4 ± 1.2	7.3 ± 0.8	7.1 ± 0.8	7.0 ± 0.9	6.9 ± 0.8
Severe	7.1 ± 1.1	7.1 ± 1.2	7.4 ± 1.3	7.4 ± 1.4	7.2 ± 1.4	7.6 ± 1.3
Sig.	0.689	0.601	0.743	0.119	0.084	0.116
Curve pattern						
Main thoracic	7.0 ± 1.4	6.5 ± 0.7	7.0 ± 1.4	7.0 ± 1.4	6.5 ± 0.7	7.0 ± 0.0
Double thoracic	8.0 ± 0.0	6.5 ± 0.7	6.5 ± 0.7	6.5 ± 0.7	7.0 ± 0.0	7.0 ± 0.0
Double major I	7.1 ± 1.2	7.3 ± 1.4	7.4 ± 1.5	7.6 ± 1.8	7.4 ± 1.9	7.4 ± 1.9
Triple Major	6.9 ± 0.8	6.9 ± 1.1	7.3 ± 1.3	7.4 ± 1.4	7.5 ± 1.2	7.8 ± 1.0
Thoracolumbar/Lumbar	7.0 ± 1.4	7.5 ± 1.9	7.0 ± 1.2	6.7 ± 0.6	6.7 ± 1.2	6.7 ± 1.2
Double major II	7.2 ± 1.3	7.5 ± 1.1	7.3 ± 0.7	7.1 ± 0.8	6.8 ± 0.8	7.2 ± 0.8
Sig.	0.849	0.674	0.592	0.482	0.262	0.431
Treatment received						
Observation	6.3 ± 0.5	6.3 ± 0.5	6.3 ± 0.5	6.5 ± 0.6	6.3 ± 0.6	6.3 ± 0.5
Physiotherapy	7.8 ± 1.5	7.7 ± 1.3	7.7 ± 0.8	7.3 ± 0.8	7.3 ± 0.8	7.2 ± 0.8
Bracing	7.1 ± 1.0	7.2 ± 1.2	7.3 ± 1.2	7.3 ± 1.4	7.1 ± 1.4	7.7 ± 1.3
Sig.	0.493	0.604	0.479	0.381	0.436	0.580

*=significant

symptoms constantly associated with the pain intensity at all times.

Accordingly, the retrospective analyses were implemented on the pain and psychological scores during the first presentation of participants (Table 7). Their mean age was 15.8 ± 4.7 years old, and the mean duration of follow-ups was 9.8 ± 4.2 years. Lower self-image scores were characterised by participants with back pain in past 12 months ($p = 0.018$), past 6 months ($p = 0.012$), past 7 days ($p = 0.002$), and past 24 h ($p = 0.006$) compared to

Table 5 Logistic regression models for the development of back pain

	Lifetime occurrence		12-month occurrence		6-month occurrence		1-month occurrence		7-day occurrence		24-h occurrence	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
Age	0.136	0.001*	0.081	0.012*	0.093	0.054	–	–	–	–	0.124	0.038*
Male	–	–	–	–	–	–	–	–	2.377	0.034*	2.367	0.040*
Smoking	–	–	–	–	3.702	0.030*	2.907	0.023*	2.359	0.060	4.101	0.071
Alcohol drinking	−1.000	0.053	−0.942	0.063	−1.428	0.011*	−1.318	0.034*	–	–	–	–
Major Cobb angle	−0.034	0.041*	–	–	−0.045	0.028*	–	–	–	–	−0.058	0.025*
Self-image	−0.782	<0.001*	−0.812	<0.001*	−1.307	<0.001*	−1.221	<0.001*	−1.171	0.001*	−1.825	<0.001*
Stress	0.055	0.032*	0.048	0.053	–	–	0.057	0.045*	0.057	0.072	–	–

B = unstandardised coefficient

* = significant

Table 6 Linear regression models for the intensity of back pain

	Lifetime pain intensity		12-month pain intensity		6-month pain intensity		1-month pain intensity		7-day pain intensity		24-h pain intensity	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
Age	0.138	0.001*	0.088	0.040*	0.099	0.019*	0.077	0.068	–	–	0.099	0.020*
Male	1.224	0.025*	1.339	0.014*	1.128	0.034*	1.404	0.010*	1.597	0.002*	1.524	0.005*
Body mass index	–	–	–	–	–	–	–	–	0.118	0.044*	–	–
Alcohol drinking	0.930	0.048*	1.173	0.020*	1.252	0.012*	0.865	0.083	–	–	–	–
Major Cobb angle	−0.030	0.076	–	–	–	–	–	–	–	–	–	–
Self-image	−0.468	0.042*	−0.617	0.010*	−0.653	0.006*	−0.777	0.001*	−0.980	<0.001*	−1.048	<0.001*
Depression	0.275	0.003*	0.161	0.002*	0.157	0.002*	0.185	<0.001*	0.174	<0.001*	0.135	0.008*
Anxiety	−0.282	0.005*	–	–	–	–	–	–	–	–	–	–
Stress	0.090	0.054	–	–	–	–	–	–	–	–	–	–

B = unstandardised coefficient

* = significant

those without pain. Likewise, participants with back pain in past 7 days and 24 h had significantly poorer mental health scores than individuals with no pain ($p = 0.002$, $p = 0.017$). Essentially, all participants with pain in adulthood demonstrated inferior self-image and mental health scores during adolescence compared to the control group. Pain scores were similar between groups at all time points.

Discussion

The present study identified for the first time that participants aged 20 to 39 with back pain possessed lower self-image and mental health during adolescence as compared to their counterparts. It also shows relationships between the occurrence and intensity of back pain with self-image and depression in adulthood.

The current results entailed that the current back pain in young adults with conservatively treated AIS was 20%. Despite direct comparisons that could not be made, this prevalence seems to be in line with other studies of scoliotic subjects. It has been observed that the prevalence of back pain was 18% during adolescence [8]. While back pain in the above 40 years of age has increased to 69% [11], there were 77% of elderlies experienced back pain [10]. The results of the present study fit into the above figures.

Meanwhile, other periods of back pain also implied increasing trends from adolescence to young adulthood. For instance, the 7-day prevalence was from 21% in adolescents to 23% as documented in this study [8], as well as the prevalence of 1-month, 6-month, and 12-month consistently evidenced the same progression (i.e., from 25 [8] to 27%, from 26 [7] to 31%, and from 30 [8] to 35%, respectively). Collectively, the prevalence of back pain in AIS has been showing an increment along with age. This was also confirmed by the regression models in the present study that increasing age was a significant associated factor.

Table 7 SRS-22r scores during participants' first clinic visit

	Pain	Control	Sig.
Pain score at presentation			
Past 12 months	4.4 ± 0.4	4.6 ± 0.5	0.056
Past 6 months	4.4 ± 0.4	4.5 ± 0.5	0.370
Past 1 month	4.4 ± 0.4	4.5 ± 0.5	0.203
Past 7 days	4.3 ± 0.4	4.5 ± 0.5	0.076
Past 24 h	4.4 ± 0.4	4.5 ± 0.5	0.211
Self-image score at presentation			
Past 12 months	3.5 ± 0.7	3.9 ± 0.5	0.018*
Past 6 months	3.5 ± 0.7	3.9 ± 0.5	0.012*
Past 1 month	3.5 ± 0.7	3.7 ± 0.6	0.095
Past 7 days	3.4 ± 0.7	3.8 ± 0.6	0.002*
Past 24 h	3.4 ± 0.6	3.8 ± 0.6	0.006*
Mental health score at presentation			
Past 12 months	4.1 ± 0.6	4.3 ± 0.5	0.067
Past 6 months	4.1 ± 0.6	4.3 ± 0.5	0.125
Past 1 month	4.0 ± 0.6	4.3 ± 0.5	0.091
Past 7 days	4.0 ± 0.6	4.3 ± 0.5	0.002*
Past 24 h	4.0 ± 0.6	4.3 ± 0.5	0.017*

* = significant

Interestingly, the psychological makeup was substantiated as an important risk factor for back pain. The poor self-image is a sequela of scoliosis, and the current results have shown that the self-image was independently associated with back pain. Comparably, Makino et al. [7] described a significant odds ratio of 0.30 in self-image for predicting back pain. In the meantime, the topic of depression is still an unsolved puzzle in AIS [26, 27]. While Weinstein et al. [10] declared that the difference in depressive symptoms between older patients and healthy controls was insignificant, Matamalas et al. [28] presented a significant difference in depressive scores between patients with and without back pain. These findings together have insinuated the independent relationship between depression and back pain, which has been studied in academia recently [29, 30].

Consequently, the retrospective analyses of the initial psychological data provided new insights into the existing knowledge. Participants with back pain in adulthood had diminished self-image and mental health during their adolescence. Based on this finding, it could be inferred that the defective psychological factors were not coming after the development of back pain. This vicious cycle of back pain was likely to be aggravated by the worsening mental health at the beginning, and then the magnified severity of pain also contributed to the reduced mental health. Thus, the psychological makeup constituted the prognosis of back pain in subjects with AIS throughout their age development.

As noted, there was a proportion of scoliotic subjects with back pain in their young adulthood. With reference to the current findings, self-image and depression were potentially modifiable associated factors for back pain. Clinicians should try to manage patients' psychological distress through physical (e.g., physiotherapeutic scoliosis-specific exercises for the correction of spinal alignment) and mental health interventions (e.g., early referral to clinical psychologist). In the hope that, though controlling the occurrence and intensity of back pain, future severe back problems and their associated consequences can be prevented.

Future studies should have a more precise definition of back pain. Given the evidence of impaired pain modulation in patients with back pain [31], a cut-off value of either NRS or visual analogue scale for determining the pain of interest is required. Further validation with the pressure pain threshold in the AIS population may be exploited [32]. Subsequently, the current results suggested inadequate intervention in self-image. Surgical intervention is deliberated as beneficial to the improvement of the self-image [33], but not the bracing [34]. As a result, scoliotic adolescents with mild and moderate curves are disadvantaged by the situation. Future research should be targeted this particular group with psychological intervention. For the relationship between back pain and depression, treatment direction may also focus on the changes in depressive symptoms on the prognosis of back pain in AIS. Lastly, the absence of curve conditions in the development of back pain is poorly understood. Although a few studies have exhibited the effects of severe curves among teenagers with back pain [6, 8, 9], there is no study that investigated the progression of pain into young and middle adulthood.

Several limitations are noted in this study. A drawback was the incomplete profile of back pain estimated. The pain was not characterised by curve location or convexity of the major curve. A few more confounding factors of back pain were not reviewed [13], for example, coronal balance, sagittal alignment, and vertebral rotation. Besides, it remains uncertain whether spinal degeneration exists. The records of back pain in the present study were due to the spinal curve or other problems like nerve issues are also unclear. Notwithstanding the four psychological variables addressed, the exploration of psychological distress in subjects with back pain may not be comprehensively outlined. The present study has already incorporated the commonest psychological factors in AIS [35]. In view of the subgroup analyses being underpowered (insufficient samples in particular subgroups), some results should be interpreted with caution. Lastly, there was a 19.8% of drop-out rate as noted in the present study. This may slightly affect the quality of the current results.

Conclusion

The present study described the prevalence distribution and severity of back pain in young adults with conservatively treated AIS. Importantly, the current results revealed that psychological makeup predominantly constituted the development of back pain. The results have also elucidated that there was a relationship between back pain in adulthood and self-image and mental health during adolescence. It is strongly hinted that reduced psychological factors may not be the consequence but aggravating factors for back pain. The proposed knowledge gaps generated from this study, inclusive of the relationship between back pain and psychological distress, should be clarified in future studies.

Appendix: Adapted classification system for adolescent idiopathic scoliosis

Curve pattern	Apical level		
	Proximal thoracic [Apex at T3–T5]	Main thoracic [Apex at T6–T11]	Thoracolumbar/Lumbar [Apex at T12–L4]
Main thoracic		✓ (major)	
Double thoracic	✓	✓ (major)	
Double major I		✓ (major)	✓
Triple major	✓	✓	✓
Thoracolumbar/lumbar			✓ (major)
Double major II		✓	✓ (major)

All curves with Cobb angle of more than 10° were counted

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Declarations

Conflict of interest None of the authors has any potential conflict of interest.

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