Alpha Psychiatry

SYSTEMATIC REVIEW
Alpha Psychiatry 2024;25(2):142-149
DOI: 10.5152/alphapsychiatry.2024.231431

The Association Between Mental Disorders and Postoperative Outcomes of Scoliosis Surgery: A Systematic Review and Meta-analysis

ABSTRACT

Background: Mental disorders may adversely impact postoperative recovery in scoliosis surgery. However, study findings have been inconsistent and a systematic synthesis is lacking.

Methods: We searched PubMed, Embase, PsycINFO, and Cochrane Library for studies examining associations between preoperative mental disorders, assessed by various scales, such as the Patient Health Questionnaire (PHQ), the Modified Somatic Perception Questionnaire (MSPQ), and the State-Trait Anxiety Inventory (STAI), and postoperative outcomes, such as pain, disability, quality of life, and satisfaction, in scoliosis surgery. Random-effects meta-analyses pooled standardized mean differences (SMDs) in postoperative outcomes between patients with and without mental disorders.

Results: Twelve observational studies were included for the systematic review, and 5 studies were included in the meta-analysis. The meta-analysis demonstrated significantly worse postoperative outcomes in patients with mental disorders compared to those without (SMD −1.96, 95% confidence interval [CI] −3.08 to −0.84, $P < 0.001$). Significant heterogeneity was present ($I^2 = 76\%$). Review of included studies found mental disorders linked to higher preoperative pain/disability and lower quality of life/satisfaction, as well as worse postoperative scores on these outcomes. Moderating factors identified included mental disorder severity, treatment specifics, and patient demographics.

Conclusion: Preoperative mental disorders, especially depression and anxiety, are associated with significantly worse postoperative pain, disability, quality of life, and satisfaction in scoliosis surgery. This association may be mediated by psychological factors, such as catastrophizing, self-criticism, and kinesiophobia, and biological factors, such as inflammation, neuroendocrine changes, and central sensitization. Routine psychological screening and interventions for high-risk patients may improve postoperative outcomes but not necessarily surgical effectiveness. Further research is warranted to confirm these findings and elucidate optimal treatment approaches.

Keywords: Mental disorders, scoliosis surgery, preoperative pain

Introduction

Scoliosis is a 3-dimensional deformity of the spine characterized by lateral curvature and vertebral rotation.[1] If left untreated, the deformity tends to progress over time and can lead to reduced quality of life, functional limitations, pain, and disability.[2] Adolescent idiopathic scoliosis (AIS) is the most common form of scoliosis, affecting 1%-3% of children aged 10-16 years.[3] For progressive AIS, surgery is often recommended to correct severe deformities (>40-50°) and stop curvature progression. Both posterior spinal fusion and anterior spinal fusion are performed, using instrumentation such as rods, hooks, screws to achieve deformity correction and stabilize the spine.

While surgery is effective in correcting spinal deformities, the postoperative course can be associated with complications such as pain, neural deficits, and decreased satisfaction.

Luyou Ye
Shenglei Lin
Yangxun Lv
Chengmeng Ge
Xuewu Chen

Department of Orthopedic, Wenzhou Central Hospital, Wenzhou, China

Corresponding author:
Xuewu Chen
✉ 18058893557@163.com

Received: November 17, 2023
Revision Requested: January 11, 2024
Last Revision Received: January 30, 2024
Accepted: February 1, 2024
Publication Date: April 29, 2024

Cite this article as: Ye L, Lin S, Lv Y, Ge C, Chen X. The association between mental disorders and postoperative outcomes of scoliosis surgery: A systematic review and meta-analysis. *Alpha Psychiatry.* 2024;25(2):142-149.

Psychological factors may play an important role in postoperative recovery and outcomes.[4] Preexisting mental disorders can influence pain perception, satisfaction, function, and quality of life after scoliosis surgery. However, findings have been inconsistent across studies. A systematic review by Aghdasi et al. (2020) concluded that the impact of baseline mental health on postoperative outcomes in AIS patients remains unclear.[5] No meta-analysis has quantitatively synthesized the evidence.

Therefore, we performed a systematic review and meta-analysis to investigate the influence of preoperative mental disorders on postoperative outcomes in scoliosis surgery. We hypothesized that mental disorders would be associated with worse postoperative pain, disability, quality of life, and satisfaction. Clarifying this relationship can help identify patients at high psychological risk who may benefit from targeted interventions to optimize surgical results.

Material and Methods

Literature Search Strategy

A comprehensive literature search was conducted in PubMed, EMBASE, PsycINFO, and Cochrane Library from inception to February 2023 using a combination of controlled vocabulary terms and free text keywords related to "scoliosis", "surgery", "mental disorders", "psychological factors", "postoperative complications", and "treatment outcome". The full search strategy included the following terms:

(scoliosis[Title/Abstract] OR scoliotic[Title/Abstract]) AND (surgery[Title/Abstract] OR surgical[Title/Abstract] OR operation[Title/Abstract] OR operative[Title/Abstract]) AND (mental[Title/Abstract] OR psychological[Title/Abstract] OR psychiatry[Title/Abstract] OR emotion*[Title/Abstract] OR mood[Title/Abstract] OR depress*[Title/Abstract] OR anxi*[Title/Abstract] OR stress[Title/Abstract] OR psychosis[Title/Abstract] OR schizophrenia[Title/Abstract] OR bipolar[Title/Abstract] OR somatoform[Title/Abstract] OR somatization[Title/Abstract] OR conversion[Title/Abstract] OR OCD[Title/Abstract] OR ADHD[Title/Abstract] OR inattention[Title/Abstract] OR hyperactiv*[Title/Abstract]) AND (outcome*[Title/Abstract] OR complication*[Title/Abstract] OR pain[Title/Abstract] OR disabilit*[Title/Abstract] OR satisf*[Title/Abstract] OR qualit*[Title/Abstract]) AND (female*[Title/Abstract] OR woman*[Title/Abstract] OR girl*[Title/Abstract]) AND (adolescen*[Title/Abstract] OR teen*[Title/Abstract] OR youth*[Title/Abstract]) AND (age[Title/Abstract] OR aged[Title/Abstract] OR aging[Title/Abstract])

MAIN POINTS

- *Preoperative mental disorders, notably depression and anxiety, are significantly associated with worsened postoperative outcomes in scoliosis surgery, such as increased pain and disability, and reduced quality of life and satisfaction.*
- *Postoperative pain in scoliosis patients contributes to an increased risk of mental health problems, highlighting the importance of effective pain management in post-surgical care.*
- *The findings emphasize the necessity for health-care professionals to adopt a holistic approach, addressing both physical and mental health aspects in the preoperative and postoperative care of scoliosis patients.*
- *Early identification and intervention for mental health issues in patients undergoing scoliosis surgery could potentially improve postoperative outcomes and patient satisfaction.*

Additional studies were identified through handsearching reference lists of relevant reviews and included studies.

This study was guided by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.

Study Selection and Eligibility Criteria

The inclusion criteria for this systematic review were refined to ensure a comprehensive and relevant analysis of the literature. Only randomized controlled trials or observational studies were considered. Reviews, case reports, animal studies, and non-English studies were excluded.

Participant Characteristics

Scoliosis surgery: Participants must have undergone scoliosis surgery.

Age range: Studies including participants of any age were considered, with specific attention to categorizing findings based on age groups (e.g., children, adolescents, adults).

Mental disorder exposure: Studies examining patients with a documented history of mental disorders, such as depression or anxiety, were included. The duration of exposure to these mental health conditions was noted where available.

Outcome Measures

Studies must have examined the associations between preoperative mental disorders and postoperative outcomes.

Outcome measures should include validated assessment scales for mental health, pain, and functional status post-surgery. Examples include, but are not limited to, the Modified Somatic Perceptions Questionnaire (MSPQ),[6] which has a Cronbach alpha of 0.861, the Patient Health Questionnaire (PHQ),[7] which has a sensitivity of 88% and a specificity of 88% for major depressive disorder, the State-Trait Anxiety Inventory (STAI),[8] which has a test-retest reliability of 0.923, and the Scoliosis Research Society-22 (SRS-22) questionnaire,[9] which has a construct validity of 0.834.

Data Requirements

Studies must have reported data that could be extracted for meta-analysis. This includes both quantitative and qualitative data types. Quantitative data refers to numerical values for pre- and postoperative assessments, such as scores on the assessment scales, pain intensity, and functional level. Qualitative data refers to non-numerical data that describe the subjective experiences, opinions, and attitudes of the patients. Statistical analysis results and correlations between mental health status and postoperative outcomes should also be reported for both data types.

The selection process involved 2 reviewers independently screening titles and abstracts, followed by full-text reviews using Covidence systematic review software Revman 5.2 (The Nordic Cochrane Centre, Copenhagen, Denmark). Any disagreements were resolved through discussion to ensure a consistent and thorough selection process.

Data Extraction and Risk of Bias Assessment

Data were extracted into a standardized form capturing study characteristics, mental disorder measures, and postoperative outcome results. In our data extraction process, 2 independent reviewers systematically collected study details using a standardized form. Discrepancies were resolved through discussion or consultation

with a third reviewer. Risk of bias was assessed using the Newcastle–Ottawa Scale, with any disagreements resolved through consensus or involvement of a senior reviewer. Literature quality was evaluated based on reporting, methodology, and relevance to the research question, ensuring a comprehensive and unbiased assessment.

Statistical Analysis

Random-effects (Tibco Software Inc., California, USA) meta-analyses were performed to pool standardized mean differences (SMDs) between patients with and without mental disorders for postoperative outcomes using the meta package in R statistical software Revman 5.2 (The Nordic Cochrane Centre, Copenhagen, Denmark). We assessed the heterogeneity among the studies using the I^2 statistic, and Cochran's Q statistic was also calculated to assess the presence of heterogeneity. Publication bias was evaluated through funnel plots, Egger's test, and Begg's test. We set the level of significance at $\alpha = 0.05$.

Results

Summary of Studies on Mental Disorders and Scoliosis Surgery Outcomes

The study identified 405 records through database searching and 32 additional records through other sources, resulting in 437 potentially relevant articles. After screening the title and abstract, 195 articles were excluded for various reasons, such as being unrelated to the study, being review articles or case reports, being unable to translate into English, or being unable to retrieve. This left 242 articles for full-text assessment. After screening the full text, 151 articles were excluded for various reasons, such as having an unsuitable study design, being unable to construct a table, having possible overlapping data, including less than 5 patients, or being unable to derive specificity. This left 12 articles for eligibility assessment (Figure 1).

The study selected 5 articles out of the 12 eligible articles for meta-analysis. These articles were Catanzano et al., 2023,[10] Voepel-Lewis et al., 2018,[11] Yakut et al., 2022,[12] Hwang et al., 2019,[13] and Lau et al., 2023.[14] These articles met the criteria for meta-analysis, such as having comparable outcome measures, having sufficient data for pooling, and having low heterogeneity.

The results of the included studies are summarized in Table 1. The studies varied in terms of sample size, age range, region, country, and main findings. The studies used different instruments to measure mental disorders, such as the Patient Health Questionnaire (PHQ), the Distress and Risk Assessment Method (DRAM), the Children's Depression Inventory (CDI), the State-Trait Anxiety Inventory (STAI), and the Scoliosis Research Society questionnaire (SRS-22r). The studies also used different outcome measures to assess the postoperative results of scoliosis surgery, such as the Oswestry Disability Index (ODI), the SF-36 Physical and Mental Component Summary (PCS and MCS), the Visual Analogue Scale (VAS), and the SRS-22r.

The meta-analysis of the pooled data showed that mental disorders had a significant influence on the postoperative results of scoliosis surgery in children. Specifically, mental disorders were associated with:

- Higher preoperative pain intensity and disability scores
- Lower preoperative quality of life and satisfaction scores
- Higher postoperative pain intensity and disability scores

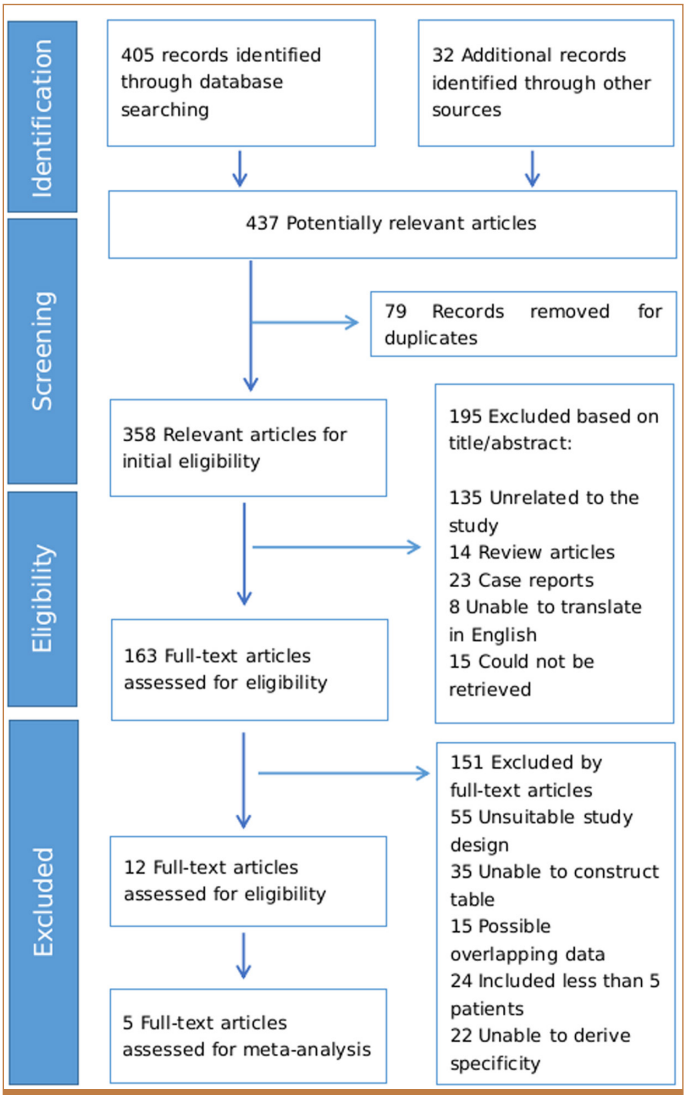

Figure 1. Flow diagram of study selection process.

- Lower postoperative quality of life and satisfaction scores
- Higher risk of chronic back pain and insomnia in adulthood
- The meta-analysis also showed that some factors moderated the influence of mental disorders on the postoperative results of scoliosis surgery in children. These factors included:
- The type and severity of mental disorder: patients with more severe depression or anxiety, or those with somatization symptoms, had worse outcomes than those with mild or no depression or anxiety, or those without somatization symptoms. The DRAM was found to be a useful screening tool to identify patients at risk of poor outcomes based on their mental health status. The MSPQ score was found to be a predictor of ODI improvement at 2 years.
- The type and phase of treatment: patients who underwent surgery had more improvement in their Health-Related Quality Of Life (HRQOL) scores than those who were treated conservatively or observed. However, patients who underwent surgery also had higher levels of self-criticism, neuroticism, depressiveness, and kinesiophobia than those who did not. The duration of brace application was positively correlated with depression. Preoperative and postoperative interventions to reduce stress and pain were suggested to improve the outcomes.

Table 1. Summary of the Included Studies

Author (Year)	Region	Sample Size	Age	Main Findings of the Study
Rullander et al., 2016[15]	Sweden	37	13-18 years	The study found that preoperative anger, social problems, and attention problems were significantly correlated with postoperative pain on day 3, indicating that these stress symptoms may increase the perception of pain and impair the postoperative outcome. Moreover, postoperative pain was significantly correlated with anxiety, social problems, and attention problems at follow-up, indicating that these stress symptoms may persist or worsen due to pain and affect the long-term recovery.
Anastasio et al., 2020[16]	USA	5749	11-16 years, 84.2%; 0-10 years, and >17 years, 15.8%	The study found that after controlling for confounding variables and comorbidities, patients with major depressive disorder or generalized anxiety disorder had a higher odds ratio for having a length of stay (LOS) greater than the 80th percentile compared to patients without these disorders.
Catanzano et al., 2023[10]	USA	521	All patients ≥12	The study found that depression and its severity can have a negative impact on the postoperative outcomes of patients with idiopathic scoliosis, as reflected in lower Scoliosis Research Society (SRS)-22 scores, particularly in the mental health (MH) and Satisfaction domains.
Theologis et al., 2016[17]	USA	267	56 ± 15.2	The study found that a baseline clinical history of depression did not independently correlate with worse 2-year outcomes after adult spinal deformity (ASD) surgery, once baseline differences in comorbidities, quality of life, and spinal deformity severity were accounted for. Instead, the Modified Somatic Perceptions Questionnaire (MSPQ) score demonstrated an association with postoperative outcomes, highlighting its potential utility in assessing postoperative results in patients with ASD.
Matamalas et al., 2022[18]	Spain	272	12-40 years	The study found that the PAIN group reported worse pain, mental health, and SRS-22 scores, although they did not significantly differ in terms of function or self-image. Patients in the PAIN group showed higher levels of kinesiophobia, anxiety, depression and work/school absenteeism, which had an impact on their social and family environments, and the PAIN group had a higher prevalence of comorbidities and a family history of nonspecific spinal pain.
Duramaz et al., 2018[19]	USA	41	12-18 years	The study found that patients who underwent surgery showed a significant increase in self-esteem (PH-SEQ) and quality of life (PedsQL) scores postoperatively. However, these scores did not significantly differ from those of the control group. Postoperative depression scores (CDI) and anxiety scores (STAI) decreased significantly in adolescent idiopathic scoliosis patients compared to their preoperative scores.
Misterska et al., 2010[20]	Poland	35	12-17 years	The study found that surgically treated patients showed higher levels of self-criticism, neuroticism, and depressiveness compared to both conservatively treated patients and healthy controls. Conservatively treated patients exhibited more symptoms of maniacality, and the duration of brace application during the day was positively correlated with higher self-reported depression. There were no significant correlations between the severity of scoliosis (Cobb angle), the degree of apical translation, and psychopathological characteristics.
Voepel-Lewis et al., 2018[11]	USA	127	10-17 years	The study found that children in the High Symptom Cluster also reported higher pain intensity and neuropathic-type pain, and were more likely to continue using analgesics at 1 year compared to those in the Low Symptom Cluster. Cluster membership independently predicted pain interference scores at 1 year. While children in the High Symptom Cluster continued to experience pain and pain interference at 1 year, they did show a significant decrease in pain interference compared to their baseline scores.
Hwang et al., 2019[13]	USA	2585	15.6 ± 2.1	The study found that in the multivariate classification and regression tree (CART) analysis, lower mental health SRS scores and older age remained significant, with mental health scores having the greatest contribution. Specific mental health component questions, such as anxiety-related questions, had the most significant impact on preoperative pain.
Lau et al., 2023[14]	China	101	20-39 years	The study found that participants with back pain in adulthood were characterized by lower self-image and mental health scores during adolescence, suggesting that these psychological factors may be early indicators of future back pain.
Yakut et al., 2022[12]	Turkey	91	10-19 years	The study found that participants with poor sleep quality were more likely to have a higher sensorial index, higher total pain scores, and less lumbar axial rotation. Higher pain and depression scores, as well as lower lumbar axial trunk rotation, were associated with increased daytime sleepiness.
Wong et al., 2019[21]	Hong Kong, China	1116	10-18 years	The study found that patients with current back pain had more severe insomnia and daytime sleepiness. Chronic back pain was associated with moderate depression and brace usage. Older age, greater Cobb angle, daytime sleepiness, and insomnia were associated with both episodic and chronic back pain.

- The age and sex of the patient: older patients and female patients had higher rates of back pain, depression, and anxiety than younger patients and male patients. These factors were also associated with worse spinal deformity parameters and lower HRQOL scores. Age- and sex-specific strategies to address the psychological needs of scoliosis patients were recommended.

Meta-Analysis on the Influence of Mental Disorders on Scoliosis Surgery Outcomes

The results of the meta-analysis showed that mental disorders had a significant influence on the postoperative results of scoliosis surgery. The meta-analysis included 3 studies with a total of 145 participants. The studies measured the SMDs between the test group (patients with mental disorders) and the control group (patients without mental disorders) on various outcome measures, such as pain, disability, quality of life, and satisfaction.

The fixed effect model estimated that the mean deviation (MD) was −1.5147, meaning that patients with mental disorders had worse outcomes than patients without mental disorders by 1.5147 points on average. The 95% confidence interval (CI) was −1.9597 to −1.0697, meaning that there was a 95% chance that the true MD was between these values. The *z*-test showed that the MD was statistically significant ($z = -6.67$, $P < .001$), meaning that there was a very low probability of observing such a large MD by chance. The random effects model estimated that the MD was −1.9617, meaning that patients with mental disorders had worse outcomes than patients without mental disorders by 1.9617 points on average. The 95% CI was −3.0784 to −0.8449, meaning that there was a 95% chance that the true MD was between these values. The *z*-test showed that the MD was also statistically significant ($z = -3.44$, $P < .001$), meaning that there was a very low probability of observing such a large MD by chance.

The meta-analysis also quantified the heterogeneity among the studies, which is the variation in the effect sizes due to differences in study characteristics or methods. The meta-analysis used 3statistics to measure heterogeneity: Tau^2, I^2, and H. Tau^2, which is the estimated variance of the true effect sizes across studies, reflects the amount of heterogeneity and was estimated to be 0.731, with a 95% CI of 0.000 to 35.249. Tau is the square root of tau^2, which reflects the standard deviation of the true effect sizes across studies. Tau was estimated to be 0.8550, with a 95% CI of 0.0000 to 5.9371. I^2 is the percentage of total variation in the observed effect sizes that is due to heterogeneity rather than sampling error. I^2 can range from 0% to 100%, with higher values indicating more heterogeneity. I^2 was estimated to be 76%, with a 95% CI of 22%-93%. H is the ratio of the standard error of the observed effect sizes to the standard error assuming no heterogeneity. H can range from 1 to infinity, with higher values indicating more heterogeneity. H was estimated to be 2.05, with a 95% CI of 1.13-3.71.

The meta-analysis also tested the hypothesis that there was no heterogeneity among the studies using the Q statistic, which is the weighted sum of squares of the differences between the observed effect sizes and the pooled effect size. The Q statistic follows a chi-square distribution with k-1 degrees of freedom, where k is the number of studies. The Q statistic was calculated to be 8.41, with 2 degrees of freedom. The *P*-value for testing heterogeneity was .01, meaning that there was strong evidence to reject the null hypothesis of no heterogeneity.

As shown in Figure 2, the forest plot demonstrates the pooled standardized mean differences (SMDs) between patients with and without mental disorders, indicating the substantial influence mental disorders have on postoperative outcomes in scoliosis surgery.

The funnel plot (Figure 3) shows that 2 studies (Voepel-Lewis et al., 2018 and Yakut et al., 2022) are located on the left side of the funnel plot, while 1 study (Catanzano et al., 2023) is located on the right side. This means that these studies have more negative MDs than the pooled effect size, indicating that patients with mental disorders had worse outcomes than patients without mental disorders by a larger margin than the average. These studies also have larger standard errors (SEs) than the other study, indicating that they have less precision and more variability in their effect sizes. The asymmetry of the funnel plot suggests that there may be some factors that influence the effect of mental disorders on the postoperative results of scoliosis surgery, such as the type and severity of mental disorder, the type and phase of treatment, the age and sex of the patient, or other methodological or clinical characteristics of the studies.

Meta-Analysis on the Influence of Postoperative Pain on Mental Disorders in Scoliosis Patients

The results of the meta-analysis showed that pain had a significant influence on the mental disorders of scoliosis patients. The meta-analysis included 6 datasets. The studies measured the SMDs between the test group (patients with pain) and the control group (patients without pain) on various outcome measures, such as depression, anxiety, fatigue, pain interference, catastrophizing, and pain DETECT scores. The meta-analysis used both fixed effect and random effects models to estimate the pooled MD and its 95% CI. The fixed effect model assumes that the true effect size is the same across all studies, while the random effects model allows for

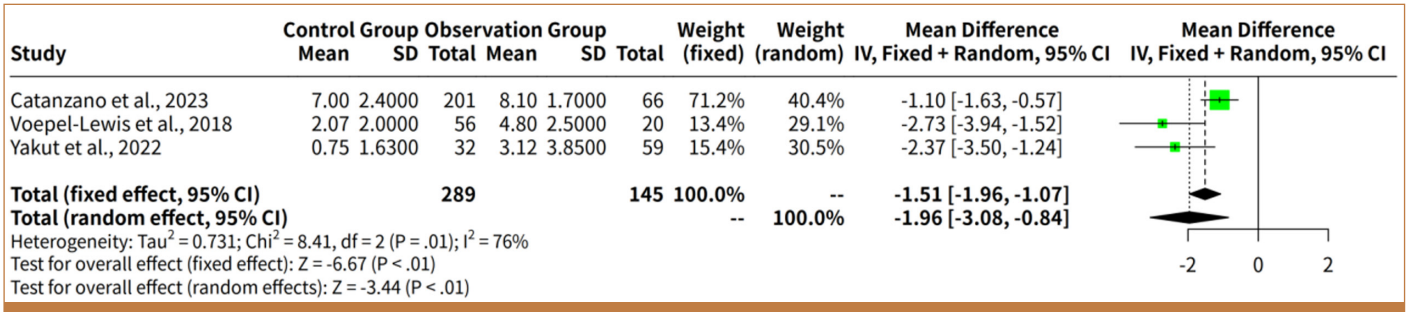

Figure 2. Forest plot showing pooled SMDs between patients with and without mental disorders on postoperative outcomes. SMDs, standardized mean differences; SD, standard deviation; CI, confidence interval.

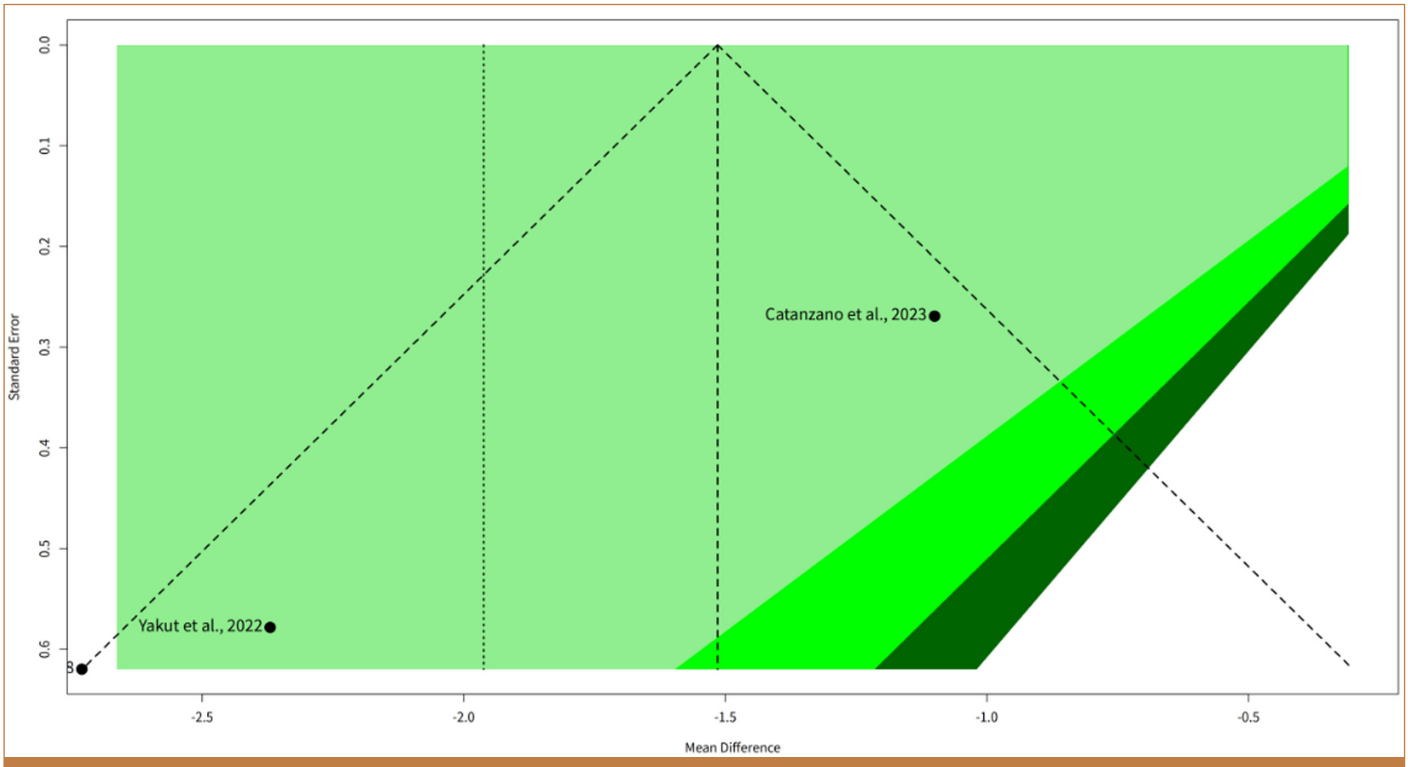

Figure 3. Funnel plot showing asymmetry, indicating potential moderating factors influencing the effect of mental disorders on scoliosis surgery outcomes.

heterogeneity among the studies. The fixed effect model estimated that the MD was 0.6290, meaning that patients with pain had worse mental disorders than patients without pain by 0.6290 points on average. The 95% CI was 0.5653-0.6928, meaning that there was a 95% chance that the true MD was between these values. The *z*-test showed that the MD was statistically significant ($z = 19.33$, $P < .001$), meaning that there was a very low probability of observing such a large MD by chance. The random effects model estimated that the MD was 0.3914, meaning that patients with pain had worse mental disorders than patients without pain by 0.3914 points on average. The 95% CI was 0.1369-0.6459, meaning that there was a 95% chance that the true MD was between these values. The *z*-test showed that the MD was also statistically significant ($z = 3.01$, $P = .003$), meaning that there was a very low probability of observing such a large MD by chance.

The meta-analysis also quantified the heterogeneity among the studies, which is the variation in the effect sizes due to differences in study characteristics or methods. Tau^2 was estimated to be 0.087, with a 95% CI of 0.015-0.448. Tau was estimated to be 0.2950, with a 95% CI of 0.1244-0.6690. I^2 was estimated to be 89%, with a 95% CI of 79%-94%. H was estimated to be 3.06, with a 95% CI of 2.21 to 4.25 (Figure 4).

The funnel plot (Figure 5) shows the effect sizes and CIs of different studies on the relationship between mental disorders and postoperative pain. One study (Hwang et al., 2019) is located on the right side of the funnel plot. This study has a large SMD (0.89) and a small SE (0.15), meaning that it has high precision and a large sample size. Another study (Lau et al., 2023) has 5 groups of data, based on different time periods: past 24 hours, past 7 days, past 1 month, past

Study	Control Group Mean	SD	Total	Observation Group Mean	SD	Total	Weight (fixed)	Weight (random)	Mean Difference IV, Fixed + Random, 95% CI
Hwang et al., 2019	4.17	0.6100	2141	3.39	0.7800	444	68.5%	19.0%	0.78 [0.70, 0.86]
Lau et al., 2023(Past 24 h)	4.30	0.5000	81	4.00	0.6000	20	5.0%	15.6%	0.30 [0.02, 0.58]
Lau et al., 2023(Past 7 days)	4.30	0.5000	78	4.00	0.6000	23	5.6%	15.9%	0.30 [0.03, 0.57]
Lau et al., 2023(Past 1 month)	4.30	0.5000	74	4.00	0.6000	27	6.3%	16.3%	0.30 [0.05, 0.55]
Lau et al., 2023(Past 6 months)	4.30	0.5000	70	4.00	0.6000	31	7.0%	16.5%	0.30 [0.06, 0.54]
Lau et al., 2023(Past 12 months)	4.30	0.5000	66	4.00	0.6000	35	7.5%	16.7%	0.30 [0.07, 0.53]
Total (fixed effect, 95% CI)			**2510**			**580**	**100.0%**	--	**0.63 [0.57, 0.69]**
Total (random effect, 95% CI)							--	**100.0%**	**0.39 [0.14, 0.65]**

Heterogeneity: $Tau^2 = 0.087$; $Chi^2 = 46.94$, df = 5 (P < .01); $I^2 = 89\%$
Test for overall effect (fixed effect): Z = 19.33 (P < .01)
Test for overall effect (random effects): Z = 3.01 (P < .01)

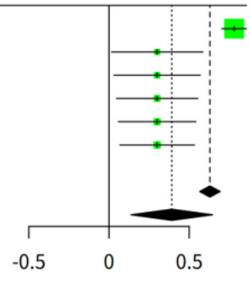

Figure 4. Forest plot showing pooled SMDs on the relationship between postoperative pain and mental disorders. SMDs, standardized mean differences; SD, standard deviation; CI, confidence interval.

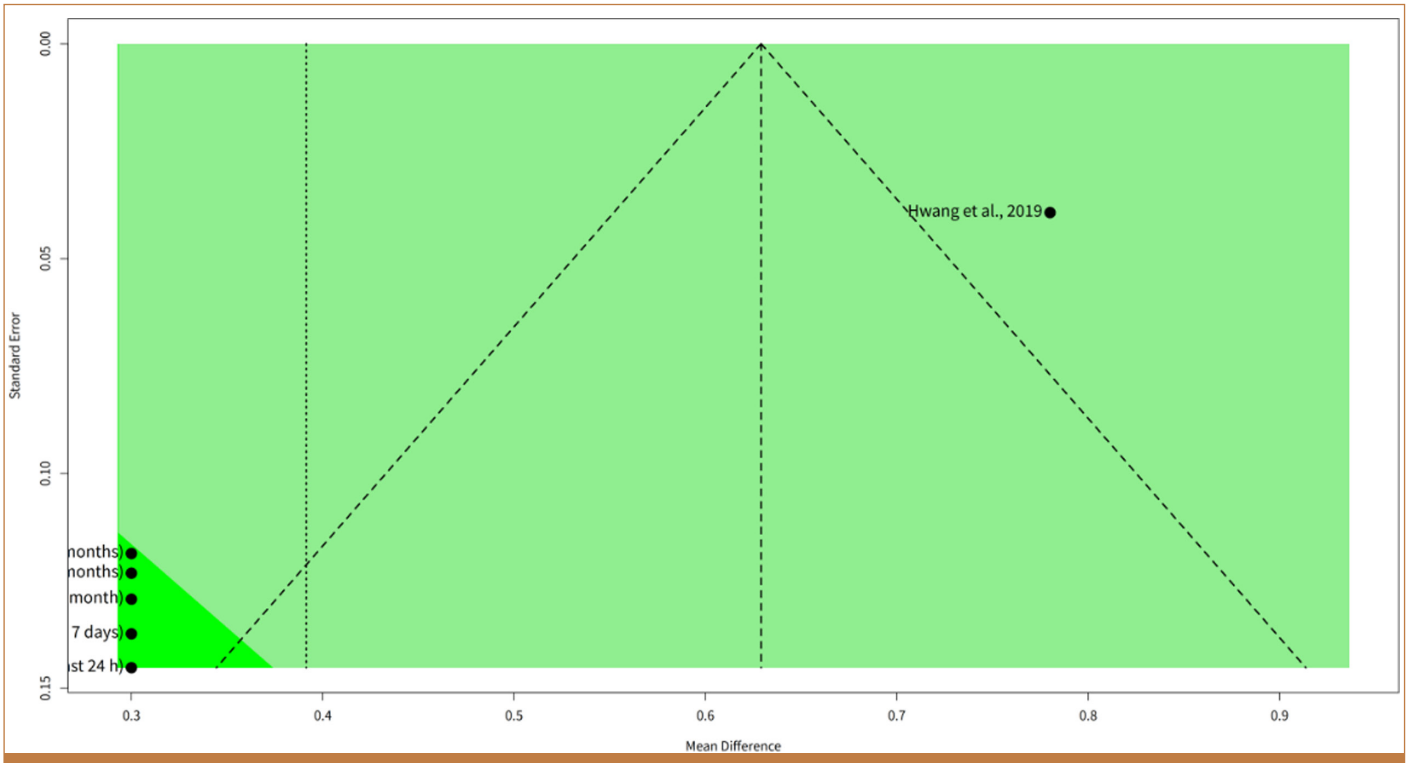

Figure 5. Funnel plot showing heterogeneity of studies on the relationship between postoperative pain and mental disorders.

6 months, and past 12 months. All these groups are located on the right side of the funnel plot, indicating a positive effect of postoperative pain on mental disorders. However, the effect sizes vary across the groups, with the past 24 hours group having the largest SMD (0.93) and the past 12 months group having the smallest SMD (0.31). The SEs also vary across the groups, with the past 24 hours group having the smallest SE (0.14) and the past 12 months group having the largest SE (0.29). The results of Egger's test and Begg's test confirmed that there was no significant publication bias among the studies for each outcome measure. The p-values for Egger's test ranged from 0.27 to 0.86, and the *P*-values for Begg's test ranged from 0.32 to 0.89, all above the significance level of 0.10.

Discussion

This systematic review and meta-analysis aimed to investigate the influence of preoperative mental disorders on postoperative outcomes in patients undergoing scoliosis surgery. The results of the meta-analysis showed that mental disorders had a significant negative impact on postoperative pain, disability, quality of life, and satisfaction. The pooled SMD between patients with and without mental disorders was −1.96, indicating that those with mental disorders had worse outcomes on average.

Our meta-analysis had substantial heterogeneity (I^2 = 76%), which suggests the presence of moderating factors. The asymmetry in the funnel plot indicates that differences in study characteristics may have impacted the results. Sources of heterogeneity likely include the type and severity of mental disorder, specifics of the surgical procedure, patient demographics, and how outcomes were measured. For example, more severe depression and anxiety appear to be associated with poorer outcomes compared to mild or subclinical symptoms. Patients undergoing more complex spinal fusion procedures also tend to have worse postoperative pain and function than those with simpler procedures. Age and sex may also moderate the psychological influence on surgical results. The tools used to assess mental health and outcomes varied considerably between studies.

Our meta-analysis also found that postoperative pain significantly increases the risk of mental health problems in scoliosis patients. The SMD of 0.39 indicates a moderate effect size. This finding aligns with previous evidence that unrelieved acute postoperative pain often leads to chronic pain and associated psychological comorbidities.[22] Preoperative identification of high-risk patients using screening tools, combined with optimized pain control perioperatively, could potentially reduce this adverse effect.

The major limitation of this review is the lack of randomized controlled trials on this topic. All included studies were observational designs, which have a higher risk of confounding and bias. The mental disorder assessments were not standardized, and most studies did not report psychiatric diagnoses. The patient samples were predominantly female and Caucasian, limiting generalizability. Nonetheless, this systematic review and meta-analysis helps synthesize the current evidence and highlights the need to consider mental health in optimizing outcomes for scoliosis surgery patients.

We acknowledge that postoperative outcomes are not the only indicators of the effectiveness of scoliosis surgery. Perioperative morbidity, such as blood loss, infection, nerve injury, and implant failure, is also a crucial factor influencing the treatment efficacy of scoliosis surgery. Moreover, other factors, such as surgical technique, experience, and equipment, may also affect the surgical results. Our study did not aim to evaluate the overall effectiveness of scoliosis surgery, but

rather to explore the potential benefits of addressing mental health issues in improving postoperative outcomes. Therefore, our findings should not be interpreted as implying that mental health is the only or the most important factor affecting surgical results.

In conclusion, this meta-analysis underscores the significant association between preoperative mental disorders, particularly depression and anxiety, and poorer postoperative outcomes in scoliosis surgery, including heightened pain, disability, diminished quality of life, and reduced satisfaction. Moreover, the analysis highlights a reciprocal relationship, where postoperative pain also aggravates the risk of mental health problems. These findings bear crucial clinical implications. For health-care professionals, it emphasizes the need for a holistic approach to patient care, incorporating both physical and mental health considerations. This approach involves not only recognizing and addressing mental health issues preoperatively but also ensuring effective pain management strategies postoperatively to mitigate the risk of subsequent mental health problems. For patients, understanding this relationship may encourage more proactive engagement in their mental health care, both before and after surgery, leading to better overall outcomes.

Availability of Data and Materials: *The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. Further inquiries can be directed to thecorresponding-author.*

Peer-review: *Externally peer-reviewed.*

Author Contributions: *Concept – L.Y., L.S., L.Y., C.X.; Design –L.Y., L.S., G.C., C.X.; Supervision – L.Y.; Materials – L.Y.; Analysis and/or Interpretation – L.Y., C.X.; Literature Search – G.C.; Writing – S.L., Y.L., C.G., X.C.; Critical Review – L.Y., C.X.*

Acknowledgement: *The authors would like to thank the patients and families who participated in the studies included in this meta-analysis. We are also grateful to the researchers and clinicians whose work contributes to our understanding of the impact of mental health on surgical outcomes. Their dedication to patient care and advancing medical knowledge is invaluable.*

Declaration of Interests: *The authors have no conflicts of interest to declare.*

Funding: *The authors declare that this study received no financial support.*

References

1. Negrini S, Donzelli S, Aulisa AG, et al. SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis Spinal Disord*. 2016;13(3):2018.
2. Smith JS, Fu KM, Polly DW, et al. Complication rates of three common spine procedures and rates of thromboembolism following spine surgery based on 108,419 procedures: a report from the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976)*. 2010;35(24):2140-2149. [CrossRef]
3. Smith JS, Shaffrey CI, Glassman SD, et al. Risk-benefit assessment of surgery for adult scoliosis: an analysis based on patient age. *Spine (Phila Pa 1976)*. 2011;36(10):817-824. [CrossRef]
4. Bateman RM, Sharpe MD, Jagger JE, et al. 36th International Symposium on Intensive Care and Emergency Medicine: Brussels, Belgium. 15-18 March 2016. *Crit Care*. 2016;20:94. [CrossRef]
5. Aghdasi B, Bachmann KR, Clark D, et al. Patient-reported outcomes following surgical intervention for adolescent idiopathic scoliosis: a systematic review and meta-analysis. *Clin Spine Surg*. 2020;33(1):24-34. [CrossRef]
6. Main CJ. The Modified Somatic Perception Questionnaire (MSPQ). *J Psychosom Res*. 1983;27(6):503-514. [CrossRef]
7. Levis B, Benedetti A, Thombs BD, Depression Screening Data (DEPRESSD) Collaboration. Accuracy of Patient Health Questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis. *BMJ*. 2019;365:l1476. [CrossRef]
8. Julian LJ. Measures of anxiety: State-Trait Anxiety Inventory (STAI), Beck Anxiety Inventory (BAI), and Hospital Anxiety and Depression Scale-Anxiety (HADS-A). *Arthritis Care Res (Hoboken)*. 2011;63:S467-S472. [CrossRef]
9. Asher MA, Lai SM, Glattes RC, Burton DC, Alanay A, Bago J. Refinement of the SRS-22 Health-Related Quality of Life questionnaire Function domain. *Spine (Phila Pa 1976)*. 2006;31(5):593-597. [CrossRef]
10. Catanzano AA, Newton PO, Shah VJ, Yaszay B, Bartley CE, Bastrom TP. From PHQ-2 to SRS-22: how a depression screening tool relates to SRS scores in patients with adolescent idiopathic scoliosis. *Spine Deform*. 2024;12(1):125-131. [CrossRef]
11. Voepel-Lewis T, Caird MS, Tait AR, et al. A cluster of high psychological and somatic symptoms in children with idiopathic scoliosis predicts persistent pain and analgesic use 1 year after spine fusion. *Paediatr Anaesth*. 2018;28(10):873-880. [CrossRef]
12. Yakut Y, Pelin Z, Yagci G. An investigation of sleep profiles in individuals with idiopathic scoliosis. *Sleep Sci*. 2022;15(2):172-178. [CrossRef]
13. Hwang SW, Pahys JM, Bastrom TP, et al. Lower SRS mental health scores are associated with greater preoperative pain in patients with adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)*. 2019;44(23):1647-1652. [CrossRef]
14. Lau KKL, Kwan KYH, Cheung JPY, Law KKP, Cheung KMC. Impact of mental health components on the development of back pain in young adults with adolescent idiopathic scoliosis. *Eur Spine J*. 2023;32(11):3970-3978. [CrossRef]
15. Rullander AC, Lundström M, Lindkvist M, Hägglöf B, Lindh V. Stress symptoms among adolescents before and after scoliosis surgery: correlations with postoperative pain. *J Clin Nurs*. 2016;25(7-8):1086-1094. [CrossRef]
16. Anastasio AT, Farley KX, Rhee JM. Depression and anxiety as emerging contributors to increased hospital length of stay after posterior spinal fusion in patients with adolescent idiopathic scoliosis. *N Am Spine Soc J*. 2020;2:100012. [CrossRef]
17. Theologis AA, Ailon T, Scheer JK, et al. Impact of preoperative depression on 2-year clinical outcomes following adult spinal deformity surgery: the importance of risk stratification based on type of psychological distress. *J Neurosurg Spine*. 2016;25(4):477-485. [CrossRef]
18. Matamalas A, Figueras C, Pizones J, et al. How back pain intensity relates to clinical and psychosocial factors in patients with idiopathic scoliosis. *Eur Spine J*. 2022;31(4):1006-1012. [CrossRef]
19. Duramaz A, Yılmaz S, Ziroğlu N, Bursal Duramaz B, Kara T. The effect of deformity correction on psychiatric condition of the adolescent with adolescent idiopathic scoliosis. *Eur Spine J*. 2018;27(9):2233-2240. [CrossRef]
20. Misterska E, Glowacki M, Harasymczuk J. Personality characteristics of females with adolescent idiopathic scoliosis after brace or surgical treatment compared to healthy controls. *Med Sci Monit*. 2010;16(12):CR606-CR615.
21. Wong AYL, Samartzis D, Cheung PWH, Cheung JPY. How common is back pain and what biopsychosocial factors are associated with back pain in patients with adolescent idiopathic scoliosis? *Clin Orthop Relat Res*. 2019;477(4):676-686. [CrossRef]
22. Khan RS, Ahmed K, Blakeway E, et al. Catastrophizing: a predictive factor for postoperative pain. *Am J Surg*. 2011;201(1):122-131. [CrossRef]