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Is physical activity contraindicated for individuals with scoliosis? A systematic literature review ☆,☆☆,★

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Objective: The purpose of this study was to perform a systematic review of the literature and other authoritative sources for recommendations regarding the appropriateness of physical and sporting activity for those with scoliosis.

Methods: The literature was systematically searched in PubMed, the Cumulative Index to Nursing and Allied Health Literature, the Index to Chiropractic Literature, and the National Guidelines Clearinghouse from the earliest date of each database through July 2008. All languages and research designs were included. Web sites of respected organizations were searched for position/white papers on scoliosis and physical activity. Included articles were rated using the Oxford Centre for Evidence-Based Medicine criteria, and recommendations for physical activity were made using the Oxford Centre's criteria for grades of recommendation.

Results: Of 42 articles retrieved, 11 met the inclusion criteria. The Internet review of 18 organizations yielded no previous guidelines or position papers for physical activity and scoliosis. Recommendations were made from 3 level 3b studies and 8 level 5 studies; they

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include the following: (1) brace-treated and surgically treated scoliosis patients have demonstrated that they can physically participate in physical activities at the same level as nonsurgical patients (grade C recommendation); (2) nonsurgically treated patients are encouraged to participate in sports and physical activity and (3) scoliosis is not a contraindication to participation in most sports (grade D recommendation); (4) brace-treated scoliosis patients are encouraged to exercise with their brace on; however, exercise may also be done outside of the brace (grade D recommendation); and (5) physical activity may be commenced after surgery for scoliosis; however, no high-quality evidence exists that guides the timing of return to physical activity (grade D recommendation). A potential association between elite-level competition in specific sports at an early age and an increased prevalence of scoliosis has been reported (grade C recommendation).

Conclusion: This article offers evidence-based guidance to health care providers and to patients with scoliosis when making decisions to participate in physical and sporting activities. © 2009 National University of Health Sciences.

Introduction

Scoliosis is commonly defined as a lateral spinal curvature of at least 10° (Fig 1) when measured with Cobb's method¹ and often results in a visible rib hump when the patient bends forward at the waist. Primary care providers and spine specialists often see patients with this condition. For those 16 years and younger, scoliosis has a prevalence of 2% to 3%,¹ with a lower prevalence of 0.3% to 0.5% noted for curves larger than 20° .² Scoliosis is present equally in males and females for curves of approximately 10° ; but with larger curves, the prevalence for scoliosis is greater in females.¹ In the United States, approximately 500 000 adults have scoliosis.³ Potential complications of scoliosis include back pain,^{1,4} curve progression,¹ psychosocial effects,^{1,5} and, in severe cases, pulmonary symptoms.^{1,6,7} Although some cases of scoliosis are due to an underlying congenital anomaly or pathology, such as neurofibromatosis, connective tissue disorders, or spinal cord abnormalities,⁴ most (65%) of the curves are idiopathic.³

According to the literature, conventional management options for patients with scoliosis are 3-fold: observation, bracing, and surgery.^{8,9} During observation, for curves less than 25° in skeletally immature patients^{8,9} and less than 45° in skeletally mature patients,⁹ assessment is made over time via radiography to observe for progression of the scoliotic curve and any potentially related symptoms. When the curve progresses to 25° , patients are often treated with one of numerous braces available on the market in an effort to halt progression of the scoliosis.⁸ Spinal fusion is the final option for patients with progressing scoliotic curves⁸ greater than 40° to 50° .¹⁰ Therapeutic

exercises,^{10,11} lateral electrical stimulation,¹² manual therapy,¹³ a combination of manual therapy and rehabilitation exercises,¹⁴ traction,¹⁵ and acupuncture¹⁶ are additional scoliosis interventions noted in the literature; however, insufficient evidence currently suggests the efficacy of these procedures in halting curve progression or restoring a normal curve, although some may aid in reducing pain associated with scoliosis.

Despite the many studies regarding scoliosis treatment or the management of associated pain, previous authors^{4,10,17} have pointed out that little objective information is available to guide patients with scoliosis—or parents of young patients—about acceptable physical activities or if participation in sporting activities is prudent. Historically, in the United States, there are recommendations in the literature that people with scoliosis should not participate in exercise.^{11,18,19} One of the earliest studies on scoliosis and treatment was a 1941 study published by the American Orthopaedic Association.¹⁸ This group suggested that the use of exercise would worsen lateral curvatures for patients with idiopathic scoliosis. In 185 cases treated with exercise alone, approximately 60% of the patients experienced a worsening of the curve; and the curve remained unchanged in the remaining 40%. This article concluded that bracing and surgical fusion were the treatments of choice. The determinations made in this study eventually led to widespread recommendations for scoliosis patients to avoid sporting and exercise activities.^{11,19} This may explain the scarcity in the literature concerning the appropriateness of exercise and sporting activities for patients with scoliosis.

At present, no published recommendations are found regarding the suitability of physical activity for those



Fig 1. A young patient with scoliosis.

with scoliosis. A new emphasis is being placed on exercise to combat the epidemic of obesity in the United States²⁰; people with scoliosis often desire to remain active,^{4,19} and a rise in female participation in sports has been noted over the past couple of decades.²¹ Therefore, investigation into the appropriateness of physical activity for people with scoliosis is needed.

The focus of this study is (1) to systematically and critically review the literature to evaluate if physical activity is considered a contraindication for individuals with scoliosis and (2) to synthesize this literature and offer recommendations for participation in physical activities for patients with scoliosis.

Methods

Search strategy

PubMed and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) were searched using EBSCOhost Web; the Index to Chiropractic Literature (ICL) was searched directly at its site (www.chiroindex.org). Searches for all databases were from their starting dates through July 2008, and they were conducted during the month of August 2008. The initial search strategy combined the term *scoliosis* with a variety of terms relevant to the topic of study (Table 1). When that search was completed, CINAHL was searched using the same strategy. Relevant hits were verified against the previously recorded relevant data from the PubMed search and were noted as “new hits” in Table 1. This same procedure was used for the ICL search, verifying results from the ICL against both PubMed and CINAHL results. We sought out additional articles referenced in the articles retrieved.

The National Guidelines Clearinghouse was searched for existing guidelines pertinent to physical activity participation for people with scoliosis. *Scoliosis* was the only search term, and all available guidelines were reviewed for relevance. We also investigated Web sites of organizations/agencies with a potential interest in scoliosis. These Web sites were selected by searching an Internet browser using the term *scoliosis*. All organizations returned by the search were searched for position/white papers about scoliosis and physical activity (Table 2).

Inclusion/exclusion criteria

Articles (all languages and all research designs) assessing or discussing the appropriateness of physical activity for people with all types of scoliosis were included. Articles published in languages other than English were translated to English using a software translator (Google Language Tools; Google Inc, Mountain View, CA). Only studies from peer-reviewed scholarly journals were included. Articles

Table 1 Search terms and results

Search Terms	MEDLINE		CINAHL		ICL	
	Total Hits	Potentially Relevant New Hits	Total Hits	Potentially Relevant New Hits	Total Hits	Potentially Relevant New Hits
<i>Scoliosis + sport</i>	137	37	3	0	83	0
<i>Scoliosis + sports</i>	157	8	17	0	0	0
<i>Scoliosis + athletic injuries</i>	30	1	9	1	3	0
<i>Scoliosis + athletic participation</i>	6	0	0	0	0	0
<i>Scoliosis + sport performance</i>	5	0	1	0	0	0
<i>Scoliosis + public health</i>	27	9	2	0	6	0
<i>Scoliosis + exercise</i>	319	6	90	3	3	0
Total	681	61	122	4	95	0

from trade magazines and nonscholarly sources were excluded, as were letters to the editor and articles not specific to the use or recommendations of physical activity participation for people with scoliosis. Reports of therapeutic exercises (eg, stretching, strengthening) used as a treatment to correct the curvature of scoliosis were excluded because of their intentional use as a therapeutic intervention, rather than as a means to merely exercise or maintain physical activity. Reports without abstracts but appearing potentially relevant were obtained when available, although the few articles that fit this category were usually more than 10 years old and in a foreign language. Abstracts of conference proceedings were not included because of

the high rate of conference presentations that are never published.^{22,23} Web sites of private health care practitioners, private individuals, and group practices were excluded.

Methods of review

The primary author conducted the search; secondary authors were asked to contribute additional citations felt to be missing from the list. Abstracts of the citations that obviously met the review criteria, or possibly met the criteria, were saved. Full articles of each abstract were then retrieved. All authors independently reviewed each of the full articles to verify that they

Table 2 Organization websites included in search for organization position statements regarding physical activity and scoliosis

Organization	Web Site URL
American Academy of Family Physicians	www.aafp.org
American Academy of Orthopedic Surgeons	www.aaos.org
American Academy of Pediatrics	www.ap.org
American Chiropractic Association	www.amerchiro.org
American College of Sports Medicine	www.acsm.org
American Physical Therapy Association	www.apta.org
ARISE—The Scoliosis Research Trust	http://scoliosisresearchtrust.org.uk/
International Chiropractic Association	www.chiropractic.org
International Chiropractic Pediatric Association	www.icpa4kids.org
International Society on Spinal Orthopaedic and Rehabilitation Treatment—SOSORT	www.sosort.org
National Athletic Trainers' Association	www.nata.org
National Institute of Arthritis and Musculoskeletal and Skin Diseases	www.niams.nih.gov
National Scoliosis Foundation	www.scoliosis.org
North American Spine Society	www.spine.org
Scoliosis Association	www.scoliosis-assoc.org
Scoliosis Care Foundation	www.scoliosiscare.org
Scoliosis Research Society	www.srs.org
Spine Society of Australia	www.scoliosis-australia.org

Table 3 The Oxford Centre for Evidence-Based Medicine levels of evidence rating scheme

Level	Study(ies)
1a	Systematic review with homogeneity of randomized clinical trials
1b	Individual randomized clinical trial with narrow confidence interval
1c	All or none studies
2a	Systematic review with homogeneity of cohort studies
2b	Individual cohort study (including low-quality randomized clinical trial)
2c	Outcomes research; ecological studies
3a	Systematic review with homogeneity of case-control studies
3b	Individual case-control study
4	Case series and poor-quality cohort and case-control studies
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research, or “first principles”

had met the inclusion criteria. Articles that did not meet the criteria were discarded, and a note was made as to why they were excluded. Once an article was included, the citation, study design, principal findings, and other pertinent notes were logged in a summary table. Differences in opinions of the authors regarding the particular inclusion or exclusion of any articles were settled by discussion and e-mail correspondence until consensus was achieved.

Quality scoring

The Oxford Centre for Evidence-Based Medicine levels of evidence rating scheme²⁴ was used. In this system, evidence is rated for quality from levels 1 (best quality) to 5 (lowest quality), primarily on the research design. The levels of evidence for therapy, prevention, etiology, or harm studies are presented in Table 3. Included articles were rated using this scheme. This scheme is primarily based on the level of evidence inherently provided by the research design that a study team selects for their research. Thus, to rate an article, one must essentially identify the research design used by the research team. The authors did not have any disagreements pertaining to the identification of research designs or ranking. Information from the reviewed studies pertaining to physical activity and scoliosis was tracked in a spreadsheet and analyzed for similarity or contradictions. Recommendations for physical activity participation for those

with scoliosis were made based upon areas of congruence between articles reviewed. The Oxford Centre for Evidence-Based Medicine grades of recommendation²⁴ were used. This grading system is used in conjunction with the levels of evidence scheme described above. The strength of recommendations is made by considering the quality of the evidence obtained. The scale of strength of recommendations is presented in Table 4.

Results

Quantity of studies

Eight hundred ninety-eight initial citations were found during the literature search. After applying the exclusion criteria, 65 potential studies were identified (Table 1); and 27 of these were discarded after a review of the abstracts made it apparent that the studies were not about scoliosis and physical activity. After each of the remaining 38 articles were read, 4 additional articles were retrieved after considering the articles cited in the references of the articles read. Consensus for inclusion of articles deemed 11 articles^{4,8,10,17,19,25-30} acceptable for review, thereby culling 31 articles. All 31 articles^{1,5-7,9,11,21,31-53} were excluded because they made no recommendations pertaining to physical activity and scoliosis. Four of the articles^{11,49,52,53} were also excluded because they focused on therapeutic exercises as a treatment of scoliosis curvature rather than reporting physical activity for people with scoliosis. All 3 potentially relevant guidelines found in the National Guidelines Clearinghouse^{3,54,55} were excluded from review because they did not address athletic participation for people with scoliosis. None of the 18 organization Web sites reviewed contained a position statement regarding the appropriateness of physical activity for people with scoliosis.

Table 4 The Oxford Centre for Evidence-Based Medicine grades of recommendation

Grade	Quality of Evidence
A	Consistent level 1 studies
B	Consistent level 2 or 3 studies or extrapolations from level 1 studies
C	Level 4 studies or extrapolations from level 2 or 3 studies
D	Level 5 evidence or troublingly inconsistent or inconclusive studies of any level

Table 5 Summary table of studies included in this review

Level of Evidence	Design	Author	Summary
3b	Case control	Parsch (2002)	Scoliosis patients experienced more impairment to their sporting activities than did age-matched controls. Sport activity was not more restricted after extended spinal fusion than it was after nonoperative treatment. The primary reasons people with scoliosis reduced their activities were functional limitations and back pain; but they participated in sports equally as strenuous as age-matched controls, regardless of fusion or the number of fused segments.
3b	Case control	Danielsson (2006)	Brace-treated and fusion-treated patients had less spinal mobility and muscle endurance at 20-y follow-up compared with healthy subjects. Physical function was not severely restricted for scoliosis subjects, however.
3b	Case control	Meyer (2007)	In comparing exercise/sporting activity between teens with and without scoliosis, those with a double major scoliosis exercised more than single major curve patients and controls. The authors recommended regular and nonintensive physical/sport activity for scoliosis patients but to avoid spinal trauma, which the authors suggest may occur with judo, triple jump, long jump, butterfly swimming, weight lifting, and off-road cycling.
5	Narrative review	Von Stempel (1993)	With scoliosis less than 20°: recommended no restrictions to physical activity; 20°-30°: restricted from performance sport, but school sports and competitive sports allowed; 30°-50° or 20°-30° with progression of 5° in 6 mo: school sports allowable with brace, nonschool sports allowable (horseback riding, tennis, table tennis). Performance sport contraindicated, competitive sport at "club level" contraindicated but may be allowable at school with watchful eye of a teacher. Curves of 50° or more: recommended endurance sports (cycling, swimming, hiking, jogging). Postoperative patients: no sport for 1 y, including cycling and table tennis; no competition sports in second year; return to sports in third year if fusion mass is stable; no performance sport postoperatively even in year 3. Sports with axial and rotational load not recommended after surgery (ball games, tennis, alpine skiing, trampoline, technical athletics, rhythmic gymnastics, contact sports). Performance sport and competitive sport at mass sport not recommended.
5	Narrative review	Omey (2000)	Scoliosis is not a contraindication to participation in sports. Unless scoliosis is severe, it does not reduce physical function. If pain accompanies scoliosis, examination for underlying pathology (eg, syringomyelia, disk herniation, degenerative spinal disease) should be performed. Active strengthening and flexibility encouraged during brace wearing. Sports may be played while athlete is not wearing a brace. Swimming is not contraindicated, although some previous researchers felt that it increased scoliosis. Aquatic activity may help maintain flexibility, strength, and endurance. Professional volleyball should be avoided because of facet stressing, but recreational/amateur volleyball is acceptable. Postoperative patients: contact sports, gymnastics, and diving should not be performed.

Table 5 (continued)

Level of Evidence	Design	Author	Summary
5	Narrative review	Wood (2002)	Nonsurgically treated scoliosis is not a contraindication to participation in most sports. "There is no objective evidence in the literature to suggest that active participation in any sport is directly associated with worsening of scoliotic curvatures beyond that of the natural history of the disorder." Active exercise was recommended for those who wear braces (eg, Milwaukee brace, Boston brace) for their scoliosis, and brace wearing during exercise was encouraged. According to this author, no study exists showing any negative effects of contact sports on the curve of a braced individual. Encouraged any and all athletic participation during hours out of a brace, not only for physical benefit, but for psychologic and social well-being. For postoperative scoliosis, the following recommendations were made: 2 mo = recreational swimming, cycling, hiking; 4 mo = light physical activity (tennis, catch, shooting basketballs); 6 mo = all activities, including contact (if fusion is solid, instrumentation is stable, and there is no pain). An exception was long fusions below L3, as the author cautioned against heavy twisting or contact sports.
5	Narrative review	Baker (2004)	Scoliosis alone is not a criterion for disqualification from sports. People with braces may require sports participation limitations while in the brace. No evidence that exercise can increase or decrease curvature.
5	Narrative review	Liljenqvist (2006)	Sporting activity should be encouraged for physical and psychologic well-being. Sports are allowable for those in a brace. Encouraged endurance sports without impact (cycling, swimming, walking, in-line skating, dance, step aerobics, yoga, horseback riding). Volleyball and high-impact sports not recommended. Postoperative patients: cycling allowable at 6 mo; swimming allowable; contact/collision not allowable. Sports with risk for falling should be avoided.
5	Narrative review	Schiller (2008)	Author pointed out that a scarcity in the literature exists that documents appropriate guidelines for athletic participation after nonoperative and operative treatment. Recommended flexibility training. Stated that patients with scoliosis treated nonoperatively can participate in all sporting activities. Sport participation while wearing a brace is allowed, not protective, and should be advocated. Sport participation out of a brace is also possible. Conditioning should focus on flexibility of the spine and core strengthening. Addition of plyometrics and power lifting after appropriate conditioning is allowed. Athletes with scoliosis should be encouraged to participate in sport. Postoperative participation in sport should be at the discretion of the surgeon. Author did not recommend against torque sports (gymnastics, ballet, swimming, wrestling, javelin).
5	Survey	Rubery (2002)	Postoperative patients: among physicians surveyed, most popular time to allow low-impact, noncontact sports = 6 mo. Contact sport allowed between 6 and 12 mo. 13% felt no contact should ever be allowed in postoperative patients. No collision sports recommended by 60% of respondents; but for those who did allow it, it was after 12 mo. Gym class resumed at 6-12 mo. No catastrophic neurologic complications were identified by respondents as being related to postoperative sports participation.
5	Case report	Fuchs (2001)	A patient with a previous posterior T2-L1 fusion for scoliosis sustained a cervical dislocation during a fall on her head/neck during cheer-leading. The authors therefore recommended against collision sport and sports requiring excessive spinal mobility, such as cheer-leading and gymnastics, in postoperative scoliosis patients.

Summary of included studies

The summary table for the included studies is presented in Table 5. No systematic reviews (levels 1a, 2a, 3a), randomized clinical trials (levels 1b, 2b), all or none studies (level 1c), cohort studies (level 2b), ecological studies (level 2c), or case series (level 4) were identified that met the inclusion criteria and addressed the purpose of this study.

The strongest evidence (level 3b) found pertaining to the appropriateness of physical activity for those with scoliosis were 3 case-control studies.²⁵⁻²⁷ Parsch et al²⁵ assessed the sports activities of 2 groups of patients with idiopathic scoliosis. In 1 group, the scoliosis was treated operatively; and in the other group, the scoliosis was treated nonoperatively. Each was compared with age-matched controls. The authors found that scoliosis patients experienced more impairment to their sporting activities in the long term than did age-matched controls. Sport activity was not more restricted after extended spinal fusion than it was after nonoperative treatment. The primary reasons people with scoliosis reduced their physical activities were functional limitations and back pain; but they participated in sports equally as strenuous as age-matched controls, regardless of fusion or the number of fused segments. The authors concluded that a patient with idiopathic scoliosis who is considering surgical stabilization may have a comparable level of long-term sporting activity with that of a nonoperatively managed patient with the same magnitude of spinal curve. Danielsson et al²⁷ assessed several physical and quality-of-life parameters of surgically treated and brace-treated scoliosis patients 20 years after their therapy was concluded and compared these outcomes with 100 age- and sex-matched controls. They found that, compared with the controls, patients who had brace-treated and surgically treated scoliosis had less spinal mobility and muscle endurance at 20-year follow-up. However, physical function was not severely restricted for the scoliosis patients. Meyer et al²⁶ assessed associations between exercise and sporting activities and idiopathic scoliosis in 74 girls with 2 lateral curvatures (double major curves) and 95 girls with a single major curve who were age-matched to 100 control girls. Girls with a double major scoliosis exercised more frequently than single major curve patients and controls. The authors recommended regular and nonintensive physical/sport activity for scoliosis patients; but the patients were told to avoid spinal trauma, which the authors suggested may occur with judo, triple jump, long jump, butterfly swimming, weight lifting, and off-road cycling. How-

ever, these suggestions were not based upon data and were only the authors' opinions.

The bulk of the literature pertaining to the appropriateness of physical activity for those with scoliosis is level 5 evidence, consisting of 6 nonsystematic reviews of the literature (narrative overviews),^{4,8,10,19,28,29} 1 survey,¹⁷ and 1 case report.³⁰ Von Stempel et al²⁹ published the earliest article found on the topic of physical activity and scoliosis. Based upon their experience in operatively and nonoperatively treated scoliosis patients, they made several recommendations regarding the appropriateness of physical activity for their patients. For scoliosis with a Cobb angle less than 20°, they suggested no restrictions on activity. For curves of 20° to 30°, they recommended restriction from what they termed *performance sport*; but school sports and *competitive sports* were allowed. For curves of 30° to 50° or 20° to 30° with progression of 5° in 6 months, they allowed school sports with patients wearing a brace and also allowed some nonschool sports (eg, horseback riding, tennis, table tennis) but did not recommend performance sport or competitive sports at club level. They would allow competitive sports, however, if performed at school; it should be under the watchful eye of a teacher. For curves of 50° or more, von Stempel et al recommended endurance sports (eg, cycling, swimming, hiking, jogging). For postoperative patients, they allowed no sport for 1 year, including cycling and table tennis, and no competitive sports in the second postoperative year; but they would allow the return to sports in the third year if the fusion mass was fully consolidated. The authors did not report by what means they determined full fusion. They would not allow a return to performance sport for postoperative patients at all, and sports with axial and rotational loads (inclusive of ball games, tennis, alpine skiing, trampoline, technical athletics, rhythmic gymnastics, contact sports) were not recommended after surgery.

Omey et al⁸ suggested that scoliosis is not a contraindication to participation in sports and asserted that, unless a scoliosis was severe, it would not reduce physical function. According to Omey et al,⁸ "Scoliosis is not a contraindication to participation in sports by the young athlete"; and they recommended examination for underlying pathology (eg, syringomyelia, disk herniation, degenerative spinal disease) if pain accompanied scoliosis. They also encouraged active strengthening and flexibility exercises for the spine during brace wearing and maintained that sports may be played while the athlete was not wearing a brace. Omey et al specifically asserted that aquatic activity may be helpful to maintain flexibility, strength,

and endurance. They stated that professional volleyball should be avoided because of facet stressing, but felt that recreational/amateur volleyball is acceptable. For postoperative patients, they deemed that contact sports, gymnastics, and diving should not be performed. Similar to Omev et al, Wood¹⁹ declared that nonsurgically treated scoliosis is not a contraindication to participation in most sports. Wood was very direct in his opinion, stating that “There is no objective evidence in the literature to suggest that active participation in any sport is directly associated with worsening of scoliotic curvatures beyond that of the natural history of the disorder.” He recommended active exercise for those who wear braces (eg, Milwaukee brace, Boston brace) for their scoliosis, and brace wearing during exercise was encouraged. Wood also claimed that no study exists showing negative effects of contact sports on the curve of a braced individual. He encouraged any and all athletic participation during hours out of a brace, not only for physical benefit, but for psychologic and social well-being. For postoperative scoliosis patients, at 2 months, recreational swimming, cycling, and hiking were allowed; at 4 months, light physical activity (tennis, catch, shooting basketballs) was allowed; at 6 months, all activities, including contact sport, were allowed if the fusion was solid, instrumentation was stable, and the patient had no pain. An exception was long fusion below L3, as the author cautioned against heavy twisting or contact sports.

In 2004, Baker and Patel²⁸ reiterated the belief that scoliosis alone is not a criterion for disqualification from sports. They stated that people with braces may require sports participation limitations while the athlete is in the brace and echoed Wood’s¹⁹ position that there is no evidence that exercise can increase or decrease a scoliosis curvature. Liljenqvist et al¹⁰ also encouraged sporting activity for physical and psychologic well-being, including for those patients wearing a brace. They encouraged endurance sports without impact, including cycling, swimming, walking, in-line skating, dance, step aerobics, yoga, and horseback riding, but did not recommend volleyball and other high-impact sports. For postoperative patients, they stated that cycling and swimming were allowable at 6 months, but that contact/collision sports were not allowable; and they felt that sports with a risk for falling should be avoided. A most recent review (2008) by Schiller and Ebersson⁴ recommended flexibility training and indicated that patients with scoliosis treated nonoperatively can participate in all sporting activities. They held that sport participation while wearing a brace was allowed,

albeit not as a protective device, and that sport participation out of a brace was also possible. The authors claimed that conditioning should focus on flexibility of the spine and core strengthening and felt that the addition of plyometrics and power lifting after appropriate conditioning was acceptable. Specifically, they felt that athletes with scoliosis should be encouraged to participate in sport. For postoperative patients, they maintained that sports participation should be at the discretion of the surgeon. They did not recommend against torque sports for postoperative patients (eg, gymnastics, ballet, swimming, wrestling, javelin), as had previous authors.

Rubery and Bradford¹⁷ surveyed the membership of the Scoliosis Research Society regarding their opinions of return to athletic activity after spinal surgery. Among the physicians surveyed (n = 316, 44% response rate), the most popular time to allow low-impact, noncontact sports was 6 months after surgery. Physicians allowed contact sports between 6 and 12 months after surgery. Thirteen percent felt that no contact sport should ever be allowed in postoperative patients. No collision sport was allowed by 60% of respondents; but for those that did allow it, participation was after 12 months. Gym class was commonly allowed to resume at 6 to 12 months. No catastrophic neurologic complications were identified by respondents as being related to postoperative sports participation.

Fuchs et al³⁰ reported a case of a patient with a previous posterior T2-L1 fusion for scoliosis who sustained a cervical dislocation during a fall on her head/neck during a cheer-leading exercise. The authors therefore recommended against collision sport and sports requiring excessive spinal mobility, such as cheer-leading and gymnastics, in postoperative scoliosis patients.

Scoliosis may be more common in participants of various sports; the topic was broached in 7 articles^{8,10,19,28,32,35,36} among the 42 retrieved for this review, and 4 of these were included in the literature synthesis.^{8,10,19,28} Summarily, authors have reported scoliosis more commonly in the sports of dancing,^{8,19,28} ballet,¹⁹ swimming,^{8,19,28,36} javelin,^{8,19,36} table tennis,¹⁹ tennis,^{10,19} hurling,¹⁹ gymnastics,^{28,35} and rhythmic gymnastics.^{10,32} However, no clear causal relationship is established that demonstrates that a particular sport causes or contributes to scoliosis.

Quality scores

Because the 3 usual and customary categories for treating the curvature associated with scoliosis are

observation, bracing, and surgery, the recommendations in this study follow this classification.

- Brace-treated and surgically treated scoliosis patients have demonstrated that they can physically participate in sports activities at the same level as controls (grade C recommendation [2 level 3b studies^{25,27}]).
- Brace-treated or observation-only scoliosis patients are encouraged to participate in sports and physical activity (grade D recommendation [1 level 3b study²⁶; 5 level 5 studies^{4,8,19,28,29}]).
- Nonsurgically treated scoliosis is not a contraindication to sports participation (grade D recommendation [3 level 5 studies^{8,19,28}]).
- Brace-treated scoliosis patients are encouraged to exercise with their braces on; however, exercise may also be done outside of the brace (grade D recommendation [4 level 5 studies^{4,8,19,29}]).
- Sports and exercise may be commenced in the months after surgery for scoliosis correction; however, there is no high-quality evidence guiding return to sport activity. Currently, return to activity is based upon the opinion of the attending surgeon (grade D recommendation [2 level 5 studies^{17,28}]) and expert opinions without explicit critical appraisal (grade D recommendation [5 level 5 studies^{8,19,28-30}]). No clear evidence or guideline is offered regarding contact and/or collision sports after surgery.
- A potential association between elite-level competition in particular sports at an early age and an increased prevalence of scoliosis has been reported (grade C recommendation [1 level 3b study³²; 1 level 4 study³⁵; 5 level 5 studies^{8,10,19,28,36}]).

Discussion

The primary finding from this review is that most studies support physical activity for patients with scoliosis. Exercise is encouraged in the available literature and not absolutely contraindicated, even for those who have had spinal surgery. This conclusion has application for those in clinical practice who can reassure their patients that they may continue to enjoy an active lifestyle. The information is also of use for clinicians to encourage individuals with scoliosis and to let them know that scoliosis is not a reason to avoid exercise. Furthermore, it demonstrates that little to no obvious harm is associated with physical activity and scoliosis. It would seem feasible that clinical trials

could be conducted to determine which types of activity lead to better physical or quality of life outcomes for both operatively treated and nonoperatively treated patients.

We found 2 case-control studies^{25,27} of reasonable quality showing that brace-treated and surgically treated scoliosis patients can physically participate in sports activities at the same level as controls. However, the literature included in this review also contains several articles^{8,17,19,28-30} of lower quality wherein the authors advise against participating in the athletic activities of healthy subjects. There may be several explanations for this phenomenon. First, although physicians may tell patients not to engage in a particular activity, patients may not comply with the recommendation. Second, there may be a discord between what physicians think their patients can do and what the patients are actually capable of doing. Third, the potential of litigation for telling a postoperative patient to return to collision or contact sport might drive physician decision making. Fourth, it is possible that some physicians are not aware of published studies demonstrating that surgically treated patients are as active as nonsurgically treated ones. The gap between what physicians feel is appropriate for patients and what patients actually do is a fertile area for further study.

Another interesting finding is that the literature pertaining to physical activity for patients being treated with bracing is essentially anecdotal. We had hoped there would be more substantial data available to aid in clinical decision making when providers make physical activity recommendations to brace-treated patients. More research is needed in this area, particularly in focusing on physical activity risk factors associated with scoliosis progression and any risk of injury with sports participation.

Despite surgery being a therapeutic option for scoliosis patients, the scarcity of the body of evidence to guide the physician in helping patients regain healthy and active lifestyles after surgery is remarkable. We found no guidelines or position statements that could serve as a standard of care in the area of safety of exercise for postsurgical patients. Rubery and Bradford¹⁷ confirmed our suspicion, "... the nature and timing of postoperative return to sports has remained largely based on anecdote and traditional teaching"; they undertook a bold study to query the membership of the Scoliosis Research Society regarding their opinions of return to exercise after surgical correction of scoliosis. They found from this study that there was no consensus regarding return to activity. Twenty-four percent of physicians restricted postsurgical scoliosis

patients from collision sports forever, 36% advised against, and 39% allowed this activity by 2 years after surgery. All responding physicians eventually allowed patients to return to low-impact, noncontact sports (eg, swimming and cross-country skiing); however, the waiting period ranged from immediately after surgery to 2 years. We acknowledge that every patient case must be given due consideration and that a guideline cannot possibly fit every unique situation; however, we do suggest that return to physical activity guidelines are needed for postsurgical scoliosis patients, such as programs designed for postoperative total hip arthroplasty patients.⁵⁶

Although conjecture is found in the literature regarding concerns that physical activity may worsen a scoliotic curve or may increase the prevalence of scoliosis, little data support such hypotheses. Thus far, the number of epidemiology studies conducted is small; and we feel the quality could be improved. For example, the purpose of the study of Meyer et al²⁶ was to determine the relationship between scoliosis curve type (outcome) and the type of physical activity (exposure) practiced by the subjects; however, no odds ratios were reported. A similar situation is found in the article of Tanchev et al³² wherein the term *incidence* is used in providing prevalence data; this is erroneous because *incidence rate* is used to describe the number of new cases in a population over a given period and *prevalence* simply means the number of cases present in the population.⁵⁷ Most importantly, a causal association between participation in a specific sport and an increase in the prevalence of scoliosis in that sport should not be made without substantial investigation using prospective research designs, such as cohort studies. It is interesting to note that no cohort studies have been conducted to provide a closer causal association between various sports and scoliosis and to allow one to establish relative risks associated with such sporting activities. Cohort studies are generally used to examine rare exposures⁵⁸; and although difficult to carry out, they would be a reasonable research design to make more definitive statements regarding the association of particular sports and their potential casual association with scoliosis. This is an area in the scoliosis literature in need of additional and more rigorous research.

Limitations

Although the present study is a stronger form of evidence than the many narrative overviews available on this topic, it does have some limitations. This study

focused on idiopathic scoliosis; and the results may not be generalizable to those patients who have scoliosis resulting from another disorder, such as neurofibromatosis, spinal degeneration, or joint hypermobility syndrome. The degree to which our findings may be generalized to scoliosis patients with back pain is not known. Furthermore, our recommendations may not be generalizable to those who have had multiple surgical procedures to correct spinal deformity or have other comorbidities that preclude exercise or sport. A potential drawback is that the literature pertaining to therapeutic exercise for the treatment of scoliosis curvature was not taken into consideration; it is possible that some evidence from the treatment literature may have provided further evidence of the safety of exercises for scoliosis patients and should be studied further. No level 1 or level 2 studies that applied to the study question were identified. The levels of evidence pertaining to physical activity safety and scoliosis are low; thus, the quality scores and recommendations are supported more by observational studies and expert opinion than by rigorous controlled studies.

Conclusion

Relatively low levels of evidence and recommendations (grades C and D) demonstrate that little objective evidence exists to inform patients, policy makers, or providers regarding the safety of physical activity for individuals with scoliosis. There is no evidence that sporting or physical activity is harmful to patients with scoliosis, with the possible exception of some cases immediately after surgery or instances of other underlying pathology. The principal findings of this review are as follows: (1) brace-treated and surgically treated scoliosis patients have demonstrated that they can physically participate in sports activities at the same level as controls; (2) nonsurgically treated patients are encouraged to participate in sports and physical activity, and scoliosis is not a contraindication to participation in most sports; (3) brace-treated scoliosis patients are encouraged to exercise with their brace on; however, exercise may also be done outside of the brace; (4) physical activity may commence after surgery for scoliosis; however, there is no high-quality evidence guiding return to sport activity; and (5) the potential association between elite-level competition in particular sports at an early age and an increased prevalence of scoliosis has been reported.

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