European Journal of Physical and Rehabilitation Medicine 2023 April;59(2):222-7
DOI: 10.23736/S1973-9087.23.07489-0

ORIGINAL ARTICLE

Sports participation reduces the progression of idiopathic scoliosis and the need for bracing

An observational study of 511 adolescents with Risser 0-2 maturation stage

Alessandra NEGRINI [1] *, Sabrina DONZELLI [1], Massimiliano VANOSSI [1], Martina POGGIO [1], Claudio CORDANI [2], Fabio ZAINA [1], Stefano NEGRINI [3, 4]

[1]Italian Scientific Spine Institute (ISICO), Milan, Italy; [2]Laboratory of Evidence-based Rehabilitation, IRCCS Istituto Ortopedico Galeazzi, Milan, Italy; [3]Department of Biomedical, Surgical and Dental Sciences, University "La Statale" , Milan, Italy; [4]IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

*Corresponding author: Alessandra Negrini, Italian Scientific Spine Institute (ISICO), Via Roberto Bellarmino, 20141 Milan, Italy.
E-mail: alessandra.negrini@isico.it

ABSTRACT

BACKGROUND: In clinics and the literature, there are doubts about the indications and contraindications of sports to support rehabilitation treatment for adolescents with idiopathic scoliosis (IS).
AIM: The aim of the study is to assess sports activities' effect and frequency in a large population of adolescents with idiopathic scoliosis (IS).
DESIGN: Retrospective observational cohort study.
SETTING: Tertiary referral institute specialized in the conservative treatment of scoliosis.
POPULATION: consecutive patients in a clinical database of age ≥10, with juvenile or adolescent IS diagnosis, 11-25° Cobb curve, Risser Bone Maturity Score 0-2, no brace prescription, radiographic follow-up radiographs at 12±3 months.
METHODS: At 12-month follow-up, radiograph, we considered progression an increase of scoliosis curve ≥5° Cobb and failure an increase to ≥25° Cobb – need of a brace. We calculated the Relative risk (RR) to compare the outcome of participants performing sports (SPORTS) or not (NO-SPORTS). We run a logistic regression with covariate adjustment to assess the effect of sports participation frequency on the outcome.
RESULTS: We included 511 patients (mean age 11.9±1.2, 415 females). Participants in the NO-SPORTS group showed a higher risk of progression (RR=1.57, 95% CI: 1.16-2.12, P=0.004) and failure (RR=1.85, 95% CI: 1.19-2.86, P=0.007) than participants in SPORTS. Logistic regression confirmed that the more frequent the sports activities, the less probable progression (P=0.0004) and failure (P=0.004) were.
CONCLUSIONS: This study shows that sports activities have a protective role against progression at 12-month follow-up in adolescents with milder forms of IS. Excluding high-level sports activities, the risks of progression and failure decrease with the increase in sports frequency per week.
CLINICAL REHABILITATION IMPACT: Albeit non-specific, sports can help in the rehabilitation of patients with idiopathic scoliosis and reduce brace prescription.

(*Cite this article as:* Negrini A, Donzelli S, Vanossi M, Poggio M, Cordani C, Zaina F, *et al*. Sports participation reduces the progression of idiopathic scoliosis and the need for bracing. An observational study of 511 adolescents with Risser 0-2 maturation stage. Eur J Phys Rehabil Med 2023;59:222-7. DOI: 10.23736/S1973-9087.23.07489-0)

KEY WORDS: Scoliosis; Sports; Adolescent; Exercise.

Scoliosis is a general term comprising a heterogeneous group of conditions consisting of changes in the shape and position of the spine, thorax and trunk. By definition, idiopathic scoliosis (IS) is of unknown origin and is probably due to several causes.[1] The Scoliosis Research Society (SRS) suggests that the diagnosis is confirmed with a Cobb angle of 10° or higher and axial rotation. Juvenile idiopathic scoliosis (JIS) is diagnosed between 4 and 9 years of age, whereas adolescent idiopathic scoliosis occurs from age 10.

According to current evidence, AIS non-operative treatments include Physiotherapeutic Scoliosis Specific Exercises (PSSE)[2, 3] and/or bracing:[4, 5] these are chosen according to curve severity.[1] The International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) guidelines for the conservative treatment of scoliosis propose the benefits of sports practice as an adjunct to these treatments. Sports activities aim to improve overall fitness and wellness,[1] and systematic exercising is probably not associated with the development of IS.[6]

The association between sports and spine deformities is still controversial, with some studies reporting an association with the prevalence of scoliosis and/or trunk asymmetries[7-13] and others showing similar trunk asymmetries and IS prevalence in athletes and non-athletes.[6, 14-16] All around the world, some physicians advise in favor of and others against sports. Patients and parents are puzzled between these two extremes and often ask for advice on choosing the best sports to prevent scoliosis onset or its progression. To our knowledge, the association between sports activities, their frequency, and IS still needs to be defined in adolescents conservatively treated for IS.

The primary aim of this study was to assess the effect of sports activities on a large population of adolescents with IS during one year of conservative treatment. The secondary aim was to investigate which factors influence scoliosis progression most: sports performance and practice per week, and individual physical characteristics, namely age, Cobb degrees, Risser sign, angle of trunk rotation (ATR) and Body Mass Index (BMI).

Materials and methods

Design and setting

We designed a retrospective observational cohort study, with a 12-month follow-up period, embedded in a prospective clinical database of a tertiary referral Institute specialized in spinal disorders conservative treatment. The local ethics committee approved the study (Milan Area B Ethical Committee - n. 506_2019bis, 22-05-2019). All patients and their parents gave informed consent for research purposes.

Participants

We assessed all 23,162 consecutive patients included in the database for eligibility. Inclusion criteria were: age ≥10, with juvenile or adolescent IS diagnosis, Cobb angle between 11° and 25°, Risser score between 0 and 2, follow-up visits at 6 and 12 months, and follow-up radiograph at 12±3 months. We decided to include the patients who had a diagnosis of scoliosis before entering our study to enlarge the available sample. We previously showed no difference between the two populations.[17] To be consistent with other studies, we also decided to follow the SOSORT-SRS criteria[18] including patients with Risser 0-2 score. Exclusion criteria were brace prescription, back pain, and other associated neurological and congenital pathologies.

Groups

In Italy, many adolescents engage in extra-curricular sports activities. Physicians collected data about this out-of-school sports participation and frequency per week at each scheduled follow-up visit every six months.

Outcomes

The main outcome measures at the 12-month follow-up were radiographic. We considered as "progression" an increase of Cobb angle of at-least 5° and as "failure" a curve exceeding 25° – presumed need of a brace.

Statistical analysis

Descriptive statistics included mean values and standard deviation for normally distributed parameters and median and interquartile range for abnormally distributed continuous variables. We drew histograms to check the distribution of continuous parameters. We checked the mean and standard deviation of continuous variables to check the assumption of equal variance. The assumptions for applying a parametric test for continuous variables were not fully respected. Therefore, we applied the Wilcoxon rank-sum test for continuous variables difference in the two groups. To check the differences in proportion between the two groups, we used chi-square test. Binary logistic regression provided the relative risk (RR) of needing a brace and worsening more than 5 Cobb degrees. The binary logistic regression models included the following explanatory variables: sex, juvenile IS diagnosis, baseline age, Cobb degrees, Risser sign, ATR,

and BMI. For selecting explanatory variables, we checked the effect of single variables in univariate analysis to predict the need for a brace or the worsening of more than 5 Cobb degrees. We finally ran the multivariate analysis, including the predictors that resulted significant in the univariate models. We ran a logistic regression with covariate adjustment to assess if the frequency of the sports per week influenced the outcome measures. Stratification was applied to control covariates. For the subgroup analysis, we selected patients practising sports activities 1 to 4 times a week and checked the odds of failure or progression from those not practising sports. In this subgroup, we run a multivariate analysis including clinically relevant predictors: age, Risser, gender and sports activities. We set the alpha level at 0.05 and CI at 95%. We conducted all statistical analyses using the Stata statistical package v. 14.

Results

We included 511 patients (mean age 11.9±1.2, 415 females). Table I reports the baseline characteristics and treatments performed during observation. During the 12-month follow-up period, 318 patients regularly performed sports (Table II).

Patients in NO-SPORTS showed a higher risk of progression (RR=1.57; 95% CI: 1.16-2.12, P=0.004) and failure (RR=1.85; 95% CI: 1.19-2.86, P=0.007) than patients in SPORTS. As juvenile IS was more frequent in SPORTS, we checked and found no differences with adolescent IS for progression (RR=0.99; 95% CI: 0.68-1.45, P=0.9) and failure (RR=0.95; 95% CI: 0.54-1.68, P=0.8).

We ran a logistic regression for the subgroup practicing sports with a frequency of one to four times per week (399, mean age 11.8±1.4, 322 females): the odds of progression and failure in those not practicing sports were 46% and 47% higher, respectively (Table III and IV). As the sports practice increased by one occurrence per week, the risk of progression and failure decreased by 0.1 (95% CI: 0.05-0.15, P=0.000) and 0.06 (95% CI: 0.02-0.09, P=0.001), respectively. Males were more represented than females in the sub-groups practicing SPORTS three and four times per week, while females were more represented in the subgroup practicing sports once per week. The stratification by sex did not change results.

TABLE II.—*The number of patients performing the different sports activities.*

Sports	N.	Sports	N.
Mixed *	75	Horse riding	4
Volleyball	56	Rowing	3
Dance	47	Gym	3
Swimming	29	Hockey	1
Football	23	Table tennis	1
Basketball	16	Acrogym	1
Martial arts	12	Synchronized swimming	1
Athletics	10	Skiing	1
Artistic gymnastics	8	Water polo	1
Tennis	8	Badminton	1
Rhythmic gymnastics	6	Cycling	1
Skating	5	Modern gymnastics	1
Fencing	4		
		Total	318

*Patients performing multiple sports over the 12-month follow-up.

Discussion

The present study shows that regular non-competitive sports activities increase the short-term probability of adolescents with IS not having a progression of the curve and requiring bracing. To our knowledge, this is the first extensive prospective study to check the effect of sports activities on this population. According to these results, regular sports activities should be recommended.

TABLE I.—*Descriptive statistics of the participants and of the SPORTS and NO-SPORTS groups.*

Parameters	Total (N.=511)	SPORTS group (N.=318)	NO-SPORTS group (N.=193)	P value
Females	415 (81.2%)	251 (78.9%)	164 (84.9%)	0.09
Age	11.08 (11.7-11.9)	11.8 (11.6-11.9)	11.9 (11.8-12)	0.053
Cobb degrees	15.8 (15.4-16.1)	15.6 (15.2-16)	15.8 (15.5-16.1)	0.36
Risser sign 0	448 (87.6%)	280 (88%)	168 (87%)	0.31
Risser sign 1	57 (11.1%)	33 (10.3%)	24 (12.4%)	
Risser sign 2	3 (0.5%)	3 (0.9%)	0 (0%)	
ATR	6.1 (5.8-6.3)	6 (5.7-6.3)	6.1 (5.8-6.3)	0.36
BMI	17.7 (17.5-17.9)	17.5 (16.1-18.9)	17.4 (16.1-19.1)	0.3
JIS	101 (19.7%)	72 (22.6%)	29 (15%)	0.03*
PSSE**	376 (73.5%)	243 (76%)	133 (68%)	0.06

Data are reported as the number (ratio) or mean (95% CI).
*P<0.05; **PSSE during all 12 months of the follow-up.

TABLE III.—*Odds ratios (OR) of progression more than 5 Cobb degrees in a multivariate logistic model. An ascending logistic regression was used. The analysis included: sports 1-4 times per week, age, gender and Risser sign. R2 = 0.06. *Level of significance P<0.05.*

Parameters	Adjusted OR	P value	95% CI
Sports 1-4 times per week	0.54	0.000*	0.40-0.74
Age	1.15	0.240	0.91-1.46
Gender	0.66	0.234	0.33-1.31
Risser	0.38	0.052	0.14-1.00

An ascending logistic regression was used. The analysis included: sports 1-4 times per week, age, gender and Risser sign.
R^2=0.06.
*P<0.05.

TABLE IV.—*Odds ratios (OR) of progression until the need of a brace in a multivariate logistic model.*

Parameters	Adjusted OR	P value	95% CI
Sports 1-4 times per week	0.53	0.005*	0.34-0.82
Age	1.07	0.657	0.78-1.47
Gender	0.43	0.157	0.13-1.37
Risser	0.54	0.264	0.18-1.58

An ascending logistic regression was used. The analysis included: sports 1-4 times per week, age, gender and Risser sign.
R^2=0.14.
*P<0.05.

Previous studies focused on various sports, mainly investigating the prevalence of scoliosis or trunk asymmetries in athletes performing specific sports such as swimming,[7, 8] tennis,[14, 19] ballet,[9, 12] volleyball,[10, 11] rhythmic[13] or artistic gymnastics,[19, 20] wrestling,[19] and soccer,[19] and comparing them with data from normal controls. The results on the relationship between specific sports and spine deformities or trunk asymmetries are controversial. Some studies found an association between swimming and trunk asymmetries,[7, 8] and others did not.[16, 21] MacMaster[22] found that participants who never performed gymnastics had 5.1 times the odds of having adolescent IS compared with those who participated in these activities. Conversely, Hellstrom[19] and Trexler[20] found a higher prevalence of scoliosis in gymnasts. Most of these studies have a cross-sectional design which does not allow to identify a causal-effect relationship. Therefore, their results should be interpreted with caution. The current study is characterised by an observational longitudinal design, with a 12 months follow-up. Therefore, the results provide a more reliable association between sports and scoliosis progression.

High-intensity training shows different results with a common trend in the literature. In most studies, agonistic athletes or professional dancers more frequently presented trunk asymmetries and scoliosis than controls.[7-9, 13, 19, 20] Athletes performing low-intensity sports activities showed the opposite.[14, 16, 21] These data are coherent with the results of our study, showing a tendency of non-agonistic sports activities toward a protective role from scoliosis progression.

We found that while the sports activity level remains moderate, the increase in the weekly frequency directly correlates with better outcomes, thus endorsing the hypothesis that sports activities positively impact adolescents with IS. This result also corresponds to the typical trend found for the relationship between sports activities and pain in adolescents.[23, 24] Back pain is more frequent in inactive adolescents and high-level competitive athletes.

The AVON study prospectively studied 4640 children and identified an inverse association between physical ability at 18 months and scoliosis onset between ages 10 and 15. They also found similar associations for lower self-reported physical activities at age ten and lower objectively measured physical activities at age 11.[25] Different hypotheses could explain these findings: 1) a reduced physical function in children is a risk factor for IS initiation; 2) lower physical activities could be an early manifestation of the same underlying abnormality that eventually results in IS; 3) adolescents with progressive IS are less likely to engage in physical activities. The latter hypothesis could also explain our results because a prospective association does not allow drawing cause/effect relationships: future experimental trials could check this alternative hypothesis. Nevertheless, our results align with RCTs' results on PSSE, clinical guidelines expert consensus, and clinical observations: all these data drive the assumption that sports can have a protective effect on adolescents with IS.

Strengths and limitations of the study

One of the main limitations of the current study is that we collected data about sports participation and practice per week during clinical consultations, and we cannot exclude a recall bias. In addition, the physicians interviewed patients only about the type of sports they played and weekly frequency, but they did not ask about the number of hours dedicated to each session.

We could not check for the combined effect of sports and PSSE. The last has shown efficacy in randomised controlled trials (RCTs),[2] but with a relatively small effect size. Similarly, this study on sports activities also shows a positive but low effect size. An end-of-growth study of 327 Risser 0-2 AIS patients showed an RR of failure (bracing)

for PSSE of 1.72,[26] *versus* the 1.57 of sports in this study. To check the experts' prevailing hypothesis that the two have additive effects[1] it would be necessary to perform a study with many participants. Currently, RCTs show PSSE efficacy, while sports are effective according to observational data only: treatments should consider either PSSE alone or (probably better) in combination with sports. In case PSSE treatment is unavailable locally, sports can be safely suggested.

Another limitation of this study is the impossibility of checking single sports as most patients performed multiple sports throughout the follow-up (*i.e.*, tennis twice a week and swimming once a week) or changed the sports they performed during the follow-up. In addition, we had poor representation of many sports (*i.e.*, water polo, ice hockey, fencing). In the future, other study designs could explore these aspects in greater depth.

The strengths of the present study include the prospective data collection, including all consecutive patients corresponding to the inclusion criteria, the large sample size, the focus on a specific high-risk population with meaningful clinical outcome criteria, and the 12-month follow-up. All this provides good reliability and generalizability of results, decreasing the risk of type I error (increasing the power of the study).

Conclusions

This study shows that sports activities protect against IS progression in adolescents with milder forms of IS at 12-month follow-up. According to the present results, regular sports activities should be recommended by physicians, thus confirming the recommendation of the guidelines on scoliosis conservative treatment.[1] Excluding high-level sports activities, the risks of progression or failure decrease as the weekly frequency of the sports increases from one to four times per week. The well-known positive effects on health, well-being and growth of non-agonistic sports are confirmed, and clinicians should not prohibit them to adolescents with IS. Future studies with different designs should check individual sports and the combined effect of PSSE and sports activities.

References

1. Negrini S, Donzelli S, Aulisa AG, Czaprowski D, Schreiber S, de Mauroy JC, *et al.* 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis Spinal Disord 2018;13:3.

2. Monticone M, Ambrosini E, Cazzaniga D, Rocca B, Ferrante S. Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial. Eur Spine J 2014;23:1204–14.

3. Romano M, Minozzi S, Zaina F, Saltikov JB, Chockalingam N, Kotwicki T, *et al.* Exercises for adolescent idiopathic scoliosis: a Cochrane systematic review. Spine 2013;38:E883–93.

4. Weinstein SL, Dolan LA, Wright JG, Dobbs MB. Effects of bracing in adolescents with idiopathic scoliosis. N Engl J Med 2013;369:1512–21.

5. Negrini S, Minozzi S, Bettany-Saltikov J, Chockalingam N, Grivas TB, Kotwicki T, *et al.* Braces for idiopathic scoliosis in adolescents. Cochrane Database Syst Rev 2015;6:CD006850.

6. Kenanidis E, Potoupnis ME, Papavasiliou KA, Sayegh FE, Kapetanos GA. Adolescent idiopathic scoliosis and exercising: is there truly a liaison? Spine 2008;33:2160–5.

7. Becker TJ. Scoliosis in swimmers. Clin Sports Med 1986;5:149–58.

8. Zaina F, Donzelli S, Lusini M, Minnella S, Negrini S. Swimming and spinal deformities: a cross-sectional study. J Pediatr 2015;166:163–7.

9. Warren MP, Brooks-Gunn J, Hamilton LH, Warren LF, Hamilton WG. Scoliosis and fractures in young ballet dancers. Relation to delayed menarche and secondary amenorrhea. N Engl J Med 1986;314:1348–53.

10. Modi H, Srinivasalu S, Smehta S, Yang JH, Song HR, Suh SW. Muscle imbalance in volleyball players initiates scoliosis in immature spines: a screening analysis. Asian Spine J 2008;2:38–43.

11. Grabara M. Comparison of posture among adolescent male volleyball players and non-athletes. Biol Sport 2015;32:79–85.

12. Longworth B, Fary R, Hopper D. Prevalence and predictors of adolescent idiopathic scoliosis in adolescent ballet dancers. Arch Phys Med Rehabil 2014;95:1725–30.

13. Tanchev PI, Dzherov AD, Parushev AD, Dikov DM, Todorov MB. Scoliosis in rhythmic gymnasts. Spine 2000;25:1367–72.

14. Zaina F, Donzelli S, Lusini M, Fusco C, Minnella S, Negrini S. Tennis is not dangerous for the spine during growth: results of a cross-sectional study. Eur Spine J 2016;25:2938–44.

15. Watanabe K, Michikawa T, Yonezawa I, Takaso M, Minami S, Soshi S, *et al.* Physical Activities and Lifestyle Factors Related to Adolescent Idiopathic Scoliosis. J Bone Joint Surg Am 2017;99:284–94.

16. Bielec G, Peczak-Graczyk A, Waade B. Do swimming exercises induce anthropometric changes in adolescents? Issues Compr Pediatr Nurs 2013;36:37–47.

17. Donzelli S, Zaina F, Lusini M, Minnella S, Negrini S. In favour of the definition "adolescents with idiopathic scoliosis": juvenile and adolescent idiopathic scoliosis braced after ten years of age, do not show different end results. SOSORT award winner 2014. Scoliosis 2014;9:7.

18. Negrini S, Hresko TM, O'Brien JP, Price N; SOSORT Boards; SRS Non-Operative Committee. Recommendations for research studies on treatment of idiopathic scoliosis: Consensus 2014 between SOSORT and SRS non-operative management committee. Scoliosis 2015;10:8.

19. Hellström M, Jacobsson B, Swärd L, Peterson L. Radiologic abnormalities of the thoraco-lumbar spine in athletes. Acta Radiol 1990;31:127–32.

20. Trexler ET, Smith-Ryan AE, Roelofs EJ, Hirsch KR. Body Composition, Muscle Quality and Scoliosis in Female Collegiate Gymnasts: A Pilot Study. Int J Sports Med 2015;36:1087–92.

21. Boldori L, Da Soldà M, Marelli A. [Anomalies of the trunk. An analysis of their prevalence in young athletes]. Minerva Pediatr 1999;51:259–64. [Italian].

22. McMaster ME, Lee AJ, Burwell RG. Physical activities of Patients with adolescent idiopathic scoliosis (AIS): preliminary longitudinal case-control study historical evaluation of possible risk factors. Scoliosis 2015;10:6.

23. Balagué F, Troussier B, Salminen JJ. Non-specific low back pain in children and adolescents: risk factors. Eur Spine J 1999;8:429–38.

24. Balagué F, Dudler J, Nordin M. Low-back pain in children. Lancet 2003;361:1403–4.

25. Tobias JH, Fairbank J, Harding I, Taylor HJ, Clark EM. Association between physical activity and scoliosis: a prospective cohort study. Int J Epidemiol 2019;48:1152–60.

26. Negrini S, Donzelli S, Negrini A, Parzini S, Romano M, Zaina F. Specific exercises reduce the need for bracing in adolescents with idiopathic scoliosis: A practical clinical trial. Ann Phys Rehabil Med 2019;62:69–76.

Conflicts of interest.—Stefano Negrini and Alessandra Negrini own stocks of the Italian Scientific Spine Institute (ISICO). All other authors have no conflicts of interest.

Funding.—This study was supported and funded by the Italian Ministry of Health - Ricerca corrente (2022).

Authors' contributions.—Alessandra Negrini, Sabrina Donzelli, Massimiliano Vanossi, Martina Poggio, and Stefano Negrini conceived research design. Alessandra Negrini, Sabrina Donzelli, Massimiliano Vanossi, Martina Poggio, Claudio Cordani, Fabio Zaina, and Stefano Negrini have given substantial contribution to the acquisition of data and data interpretation. MP and Alessandra Negrini drafted the manuscript, Stefano Negrini, Sabrina Donzelli, and Fabio Zaina revised it critically. All authors read and approved the final version of the manuscript.

History.—Article first published online: March 9, 2023. - Manuscript accepted: February 9, 2023. - Manuscript revised: January 26, 2023. - Manuscript received: February 22, 2022.