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# Why do idiopathic scoliosis patients participate more in gymnastics?

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**The influence of physical and sporting activities (PSA) on idiopathic scoliosis (IS) is still obscure. The aim of this study was to investigate whether such an influence exists and if so, to determine its characteristics. Two hundred and one teenagers with IS and a control group of 192 adolescents completed an epidemiological questionnaire. Those practising gymnastics were more numerous in the IS group than in the control group. Moreover, the practice of gymnastics was chosen before IS was diagnosed. As gymnastic activities are considered neither as a therapy nor as a precursor of IS, the distribution observed could be linked to a common factor that both increases the likelihood of IS and favors the practice of gymnastics. Joint laxity (JL) may be such a common factor, and was therefore tested (wrist and middle finger) on 42 girls with IS and 21 girls of a control group. IS patients, practising gymnastics or not, showed a higher JL than the control group practising gymnastics or not. Furthermore, the groups practising gymnastic activities did not show higher JL levels than the other groups. Children with a high JL could be drawn toward gymnastics because of their ability to adapt to the constraints of this sport. Girls with a high JL may therefore be prone to developing IS. The fact that most teenagers with IS practise gymnastics could be related to a higher JL.**

Idiopathic scoliosis (IS) is a spinal deformity consisting in a relative displacement of the vertebrae, occurring in the three spatial planes with no significant osteo-articular loss and developing on all or part of the spinal column, which is essentially progressive during the period of growth (Hagglund et al., 1992). Research has focused on primary abnormalities of the genetics, growth, structure and biomechanics of the discs and muscle, and on the central nervous system; none of these hypotheses has definitely been proved and their involvement is probably multifactorial (Sahlstrand & Lidstrom, 1989; Hagglund et al., 1992; Lonstein, 1994; Gauchard et al., 2001).

IS is one of the most common childhood spinal deformities. The incidence of this deformation varies from 0.4% to 13%, depending on how it is defined and depending on the slope of the curve (Brooks et al., 1975; Bunnell, 1986; Goldberg et al., 1995). The type of curvature can be double or single (lumbar, thoraco-lumbar or thoracic location). Several studies have shown that the incidence of IS can increase with physical and sporting activity (PSA) (Becker, 1986; Hellstrom et al., 1990), but no study has highlighted the influence of practicing PSA practice on IS. However, the frequency of the lesions and back pain is high among young sportswomen. Girls practising sports such as gymnastics (Micheli, 1985) and dancing (Micheli, 1983; Ireland & Micheli, 1987) run a higher risk of IS. Bone deformation is usual during the period of growth because of vertebral body weakness and mechanical constraints exceeding its natural resistance. Thus, muscular activity could impair IS. IS has been observed among 10% of tennis players (Hellstrom et al., 1990), 16% of young swimmers (Becker, 1986) and 24% in professional ballet companies (Warren et al., 1986). Dieting, weight loss and physical training can cause a drop in the estrogen level. A high frequency of delayed menarche, secondary amenorrhea and irregular menstrual cycles are often observed among young ballet dancers (Warren et al., 1986). Restrictive diets, necessary to conform to a thin body image (Benson et al., 1990), supplemented by early physical practice, are known to delay menarche. Moreover, teenagers could be more vulnerable to spine lesions during the peak of puberty because of the imbalance of muscular forces as well as joint flexibility (Strong et al., 1989). This phenomenon is similar among girls who practise eurhythmics. The latter show a delay of maturity and growth probably caused by their thinness and joint flexibility (Tanchev et al., 2000).

However, these studies focused on high-intensity practices, more than 20 h training per week. Adolescents must avoid intensive PSA, which can deteriorate the development of the musculo-skeletal system during growth (Burwell et al., 1983). The intensity of PSA practice of the majority of teenagers is low, hence the interest in observing the relationship between spine deviations and moderate PSA practice.

The authors agree on the fact that regular non-intensive physical activity has a positive effect on the adolescent with IS (Omey et al., 2000), which would seem to have a beneficial effect on many parameters (Fayada et al., 1999), especially on the respiratory and muscular systems (Von Strempel et al., 1993) and on the psychological level (Freidel et al., 2002). Once a PSA has been well understood and practised, it becomes an essential complement of rehabilitation, muscular reinforcement and dynamization for the teenager (Perrin, 1996).

Traditionally, stretching sports such as basketball and volleyball are recommended (Fayada et al., 1999) because they involve keeping the spine straight. However, sporting activity is not limited to these practices, all the more so as IS remains moderate. Thus, many sports can be practised, including judo (Brondani, 1998), swimming (Becker, 1986), riding (Auvinet, 1998) and dancing (Omey et al., 2000). Lastly, the young child ought to practise several PSA (Parsch et al., 2002), using various resources. However, a consensus between the specialist in pediatric orthopedics and the sport physician is needed in order to advise the child properly.

Within this context, this study aimed to investigate the influence of the practice of PSA on IS and, if such an influence exists, to determine its characteristics.

## Materials and methods

### Subjects

Two hundred and one adolescent patients with progressive IS (174 girls, 27 boys; age range 9–18 years, mean 14.5, SD = 2.1) took part in this epidemiological study. All the children and their parents gave written consent before data collection. These participants were recruited from among patients with severe IS scheduled for surgery with Cotrel–Dubousset instrumentation and arthrodesis at the University Hospital of Nancy, and from among children because of being set in plaster or an orthopedic corset with a follow-up at the Office d'Hygiène Sociale (Meurthe-et-Moselle, East of France). One hundred and fifty-one adolescents were treated with a brace (Cobb angle: 20°–40°), and except for one subject submitted to surgery (Cobb angle greater than 40°), the rest of the group (49 patients) had only a medical follow-up (Cobb angle: 10°–20°). The majority of these adolescents at time of evaluation reached the end of growth and Risser iliac apophysis staging was close to five. The distribution according to the location of IS was as follows: double major curve, $n = 82$; lumbar curve, $n = 59$; thoraco-lumbar curve, $n = 26$; and thoracic curve, $n = 34$.

The group with IS was compared with 192 control adolescents from secondary schools, aged from 12 to 18 (average age: 15.3 ± 1.9 years, 171 girls), so that if an IS were to appear it was already there.

Among the IS adolescent population, joint laxity (JL) was measured in 42 IS adolescents aged from 11 to 18 (mean age: 15.5 ± 2.4 years). A form requiring the consent of the subject and parents was signed before each data acquisition. A control group (C) was composed of 21 girls without IS aged from 14 to 18 (mean age: 16.4 ± 1.8 years). Both groups were partitioned according to the practice (IS-G and C-G) or not of gymnastic activity (IS-NG and C-NG).

### Methods

A cross-sectional epidemiological study was carried out to highlight the relationships between the practice of PSA and IS. The first part of the questionnaire was based on the life style of the adolescent and more particularly biometric status, pain, curricular and extra-curricular PSA before diagnosis of spine deformation, and on the psychological aspect, training courses and holidays, and was filled in by the patient. The second part, concerning the type of IS and its evolution, was filled in by the orthopedic surgeon or the rehabilitation physician.

JL, in order to reduce the effect that sport has on laxity, may be evaluated at the peripheral level of the subjects, i.e. wrists and fingers. The mean of the right and left values was noted for each of the two measurements made using a goniometer strapped to the subject's forearm.

This wrist test consisted in measuring the angle formed between the forearm and the dorsal face of the hand (metacarpus). The forearm was laid flat on a flat surface, the palm of the hand resting flat on the surface and the subject, with the help of the examiner, carried out a passive hyperextension of the wrist (Fairbank et al., 1984).

The middle finger test consisted in placing the forearm on a plane surface, the palm of the hand vis-à-vis the plane. The subject carried out a passive hyperextension of the middle finger by putting pressure on the proximal joint of the finger. The examiner measured the angle between the metacarpus and the first phalange of the middle finger (Fairbank et al., 1984).

### Statistics

Comparisons were made using nonparametric statistical tests (Statview Software, Abacus, Berkeley, California). The comparisons of distribution were carried out with the chi-square test. In the JL test, in accordance with the sample size associated to the graphic examination of the normality of the distributions, parametric statistical tests were used: ANOVA (variance analyses) for the study of the effects of the various factors and Fisher's PLSD test for pairwise comparisons. Statistical significance was accepted for $P$-values lower than 0.05.

## Results

The IS group presented a heterogeneity of distribution according to the type of PSA, compared with a theoretical distribution, because of the presence of a

Table 1. Comparison between the adolescent group with IS and the control group concerning distribution into eight PSA groups with OR and 95% CI

| | IS group, $n = 201$ % (*n*) | Control group, $n = 192$ % (*n*) | OR | CI |
|---|---|---|---|---|
| *No PSA* | 31.3 (63) | 30.7 (59) | | |
| *PSA* | 68.7 (138) | 69.3 (133) | 0.97 | 0.67–1.49 |
| Gymnastics | 36.3 (73)*** | 15.6 (30) | 3.08 | 1.90–4.98 |
| OPA | 7.4 (15)* | 13.5 (26) | 0.51 | 0.26–0.99 |
| Team sports | 6.0 (12)*** | 17.7 (34) | 0.29 | 0.15–0.58 |
| Aquatic sports | 6.0 (12) | 5.7 (11) | 1.04 | 0.45–2.38 |
| Dual sports | 5.0 (10) | 3.6 (7) | 1.38 | 0.53–3.59 |
| Fighting sports | 4.5 (9)* | 9.9 (19) | 0.42 | 0.19–0.95 |
| Athletics | 2.5 (5) | 3.1 (6) | 0.79 | 0.25–2.48 |
| Extreme sports | 1.0 (2) | 0.0 (0) | – | – |

Statistical significance is indicated as follows: *$P<0.05$, ***$P<0.001$.
OPA, outdoor physical activity; IS, idiopathic scoliosis; PSA, physical and sporting activity; OR, odds ratios; CI, confidence intervals.

predominant practice, namely gymnastics activity ($\chi^2_{df2} = 57.9$, $P<0.0001$). A similar distribution was noted in the control group explained by three important practices (gymnastics, outdoor physical activity and team sports) and three practices with few participants (dual sport, athletics and extreme sport) ($\chi^2_{df2} = 37.4$, $P<0.0001$). However, Table 1 shows that 68% of the adolescents with IS practised PSA, and that a similar rate of PSA practice (69.3%) was observed in the control group, revealing a homogeneity between these groups concerning PSA participants ($\chi^2_{df2} = 0.017$, $P>0.8$; odds ratios (ORs) = 0.97; confidence intervals (CIs) = 0.63–1.49). All the other activities combined, it seemed that patients with IS turned more to gymnastic activities than the control individuals ($\chi^2_{df2} = 26.5$, $P = 0.0001$; ORs = 3.08; CIs = 1.90 – 4.98).

No significant difference was noted between the teenagers with double-major curve ($n = 35$) and teenagers with a simple curve ($n = 28$) in the group of children practising gymnastic activities.

The intensity of extra-curricular PSA practice was 1.6 sessions per week (Table 2). The duration of each session was on average 1 h and 30 min, meaning that the duration of weekly practice was approximately 2 h. Only 34% of these practising teenagers took part in 1–3 competitions during the year of practice. Moreover, 87.7% of the teenagers stopped their main practice during the holidays and preferred it to other activities like swimming in 65.5% of the cases. About 56.6% of the teenagers practised sport in order to be in good health, with no intention of competing and excelling themselves.

More than 80% of the adolescents with IS did not report any back pain in relation with their spinal deformity. This observation is confirmed by the fact that 86% of these teenagers did not change their practice habit before the evaluation by the pediatric orthopedics consultant.

Table 2. Teenagers with idiopathic scoliosis practising sport

| Extra-curricular activities | % (*n*) | Age (years) | BMI (kg/m$^2$) | Training per week (*n*) |
|---|---|---|---|---|
| Gymnastics | 52.9 (73) | 14.5 | 18.3 | 1.5 |
| OPA | 10.9 (15) | 14.1 | 17.1 | 2.3 |
| Dual sports | 7.2 (10) | 15.1 | 18.5 | 1.6 |
| Team sports | 8.7 (12) | 11.8 | 18.1 | 1.7 |
| Aquatic sports | 8.7 (12) | 14.1 | 18.8 | 1.4 |
| Fighting sports | 6.5 (9) | 14.4 | 18.8 | 1.3 |
| Extreme Sports | 1.5 (2) | 16.1 | 20.0 | 2.0 |
| Athletics | 3.6 (5) | 17.0 | 18.0 | 1.0 |
| *Sporting* | 100 (138) | 14.5 | 18.2 | 1.6 |

Characterization of the various groups according to sport practiced, age, BMI and number of sessions per week.
OPA, outdoor physical activity; BMI, body mass index.

A significant difference was determined between the body mass index (BMI), reflecting individual morphotype, for the girls with IS, which was 18.29 ($\pm$ 2.21), whereas it was 19.29 for the control group of the same age ($P<0.0001$). A low BMI is typical of tall and light subjects.

Table 3 shows significant differences in the analysis of the wrist variance test ($F = 5.1$; $P<0.003$). The IS group practising gymnastics (IS-G) showed higher amplitudes in the measurement of the articular flexibility of the wrist than the other groups, where the amplitudes were low (IS-G = 99.3 ± 8.6°; IS-NG = 96.5 ± 8.2°; C-G = 88.5 ± 4.7°; C-NG = 88.2 ± 12.5°). Thus, despite an absence of significance between the IS-G vs IS-NG and the C-G vs C-NG groups, in terms of PSA comparison, the following hierarchy from the lowest to the highest JL was observed: C-NG, C-G, IS-NG and IS-G. However, differences were noted between the IS-G vs C-NG ($P<0.001$), IS-G vs C-G ($P<0.01$), IS-NG vs C-NG ($P<0.01$) and IS-NG vs C-G ($P<0.06$) groups. The group of adolescents with IS (97.9°), whether practising gymnastics or not, displayed a higher JL than the teenagers of the control group (88.7°), whether practising gymnastics or not ($P<0.0003$). In terms of distribution, wrist flexibility that exceeds the normal value ± 2 SD was 4.7% (one per 21) in the control group and 11.9% (five per 42) in the IS group.

A similar distribution was observed with the major test (Table 3), i.e. IS-G = 75.8 ± 11.9°; IS-NG = 72.1 ± 10.3°; C-G = 70 ± 10.6°; and C-NG = 67.9 ± 13.7°. A difference was observed between the IS-G and C-NG ($P<0.05$) groups.

## Discussion

This study showed that the teenagers with IS practised as much PSA as the control individuals, but

Table 3. Analysis of variance of the C-NG, the C-G, the IS-NG and the IS-G for the wrist and middle finger tests

| | Groups (*M*) | | | | ANOVA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | C-NG ($n = 13$) | C-G ($n = 8$) | IS-NG ($n = 20$) | IS-G ($n = 22$) | *F* test: *F* values (*P*) | Fisher's PLSD (*P*) | | | | | |
| | | | | | | IS-G vs IS-NG | IS-G vs C-G | IS-G vs C-NG | IS-NG vs C-G | IS-NG vs C-NG | C-G vs C-NG |
| Wrist (deg.) | 88.2 | 88.5 | 96.5 | 99.3 | 5.1 (0.003) | NS | 0.01 | 0.001 | 0.06 | 0.01 | NS |
| Middle finger (deg.) | 67.9 | 70 | 72.1 | 75.8 | 1.3 (NS) | NS | NS | 0.05 | NS | NS | NS |

C-NG, control group not practising gymnastics; C-G, control group practising gymnastics; IS-NG, IS group not practising gymnastics; IS-G, IS group practising gymnastics.

that they were more frequently involved in gymnastic activities, whereas the controls practised team sports more often. The intensity of practice of the teenagers with IS was low (2 h training per week).

The low intensity of practice cannot explain a delay in the growth and an asymmetrical overload on the spine. Thus, a low intensity of practice of gymnastic activities cannot increase the development of IS and cannot be at the origin of IS (Omey et al., 2000). Moreover, teenagers with IS chose the practice of PSA before IS diagnosis, which did not lead to the adolescent practising a gymnastic activity.

As a general rule, IS in the pediatric population is not painful (Ramirez et al., 1997). On the other hand, several studies have reported generalized back pain in as many as 75% of young athletes (Sward et al., 1990). In our study, in spite of the high frequency in gymnastic practice, few adolescents with IS reported pain associated with spinal deformity. A low intensity of practice, in order to be in good health, could explain this low painful frequency and no complaint of fatigue in our population. This absence of back pain allowed them to begin or to continue a PSA like gymnastics practice.

The BMI was lower among the teenagers with IS than in the control population. Warren et al. (1986) noted that the young ballet dancers with IS were taller than those without IS, and Carr et al. (1993) noted that the teenagers with IS were taller during growth than the adolescents without IS. This can be explained by the fact that children with IS display a longer period of puberty and not by the actual practice of sport (Lonstein, 1994). There is also a relation between an image of a disturbed body and a food disorder among teenagers with IS, that is confirmed by the fact that the diagnosis of this deformation is often associated with a low weight (Smith et al., 2002). The low BMI of the girls with IS in this study shows that they are both tall and light, a characteristic which is common to girls practising gymnastic activities. There is a link between the morphotype of the teenager with IS and of teenagers practising gymnastic activities. Thus, young adolescents with a tall and slim morphotype would be more attracted to a practice requiring this characteristic as IS adolescents.

As IS did not lead the subjects to practise gymnastic activities and because the practice of gymnastics was not at the origin of IS, a common factor could explain these results. This factor would explain the high proportion of subjects practising gymnastic activities in the population of adolescents with IS.

Because IS and gymnastic activities concerned mainly girls, this common factor could be JL, all the more so in that it is a very important element in practices such as gymnastic activities, it is more frequent among girls (Bulbena et al., 1992; Decoster et al., 1997) and decreases with age (Larsson et al., 1987; Gedalia & Press, 1991).

The JL of the adolescents with IS, practising gymnastics or not, was higher than that of the control group, practising gymnastics or not. JL is likely in relation to the variation in collagen structures and conjonctive tissue organization (Kirk et al., 1967). Higher JL was present before the diagnosis of IS. Moreover, the practice of PSA was chosen before the diagnosis of IS was made. Teenagers with a high level of articular flexibility are naturally directed toward PSA practices requiring this characteristic. Gymnastic activities, more precisely gymnastics, eurhythmics and dancing, are practices requiring a constitutionally increased JL (Gannon & Bird, 1999; Tanchev et al., 2000). Adolescents with IS, who have a higher JL level, are more likely to choose gymnastic activities.

The level of practice of gymnastic activities has no influence on the teenagers' JL. As JL cannot be acquired by the sporting practice, adolescents having this natural specificity are more fitted to continue a practice that requires a great laxity (Klemp & Chalton, 1989). Thus, adolescents with IS who have a high level of articular laxity are more likely to continue gymnastics.

The frequency of JL (Bulbena et al., 1992; Decoster et al., 1997) in adolescents with IS is higher among girls. This distribution is even higher in the number of girls who practise gymnastics, according to the work of Tanchev et al. (2000), who considered that JL, growth retardation and asymmetrical overload on the spine are linked.

IS and joint hyperlaxity are very often connected as far as the syndromes of Marfan and Ehlers-Danlos (Giampietro et al., 2002; Jones et al., 2002) are concerned, the latter lending itself to performing gymnastic postures such as those of contortionists in circus arts. Thus, these syndromes are also related to the presence of IS, JL and the practice of a PSA requiring a high degree of joint flexibility.

## Perspectives

This study has shown that IS is associated with higher JL, but that it is not directly related to the practice of PSA. The practice of gymnastics does not have an influence on IS; however, adolescents with IS, by their high important JL, would seem to choose and prefer to continue the practice of gymnastic activities. This practice does not generate IS and its low intensity does not make spine deformation worse. This absence of IS aggravation by the practice of gymnastic activities shows that the exclusion of the latter is unjustified. The regular practice of gymnastic activities reinforces the deep muscles of the spine and consists in a proprioceptive work. Physicians must encourage adolescents diagnosed as having IS to begin or continue to practise PSA in a regular and non-intensive way without excluding the practice of gymnastic activities. This practice will allow them to exercise and to complete their rehabilitation in a relaxing and playful way.

**Key words:** idiopathic scoliosis, physical and sporting activities, joint laxity, teenagers.

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