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ORIGINAL ARTICLE

Tennis is not dangerous for the spine during growth: results of a cross-sectional study

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Abstract
Purpose Tennis is widely practiced by adolescents in many countries. Many spinal deformity experts consider this activity, together with other asymmetrical sports, as risk factors for scoliosis development even though scientific data are missing. The aim of the present study was to verify the prevalence of spinal deformities and LBP in adolescent competitive tennis players compared to healthy controls.
Methods We designed a cross-sectional study. A convenience sample of 102 adolescent tennis players (52 girls) was compared to 203 scholars (102 girls) of the same age (12 years). We used a questionnaire to collect data on LBP and we measured the ATR to screen for spinal deformities and the plumb line distances for kyphosis (C7 and C7 + L3) and lordosis (L3).
Results We found similar spinal deformities in both groups: ATR female: 3.2° ± 1° (tennis) versus 2.8° ± 1° (school), NS; ATR males: 2.8° ± 1° (tennis) versus 2.6° ± 1° (school), $p < 0.05$. No differences were found for kyphosis and lordosis. Low back pain prevalence was similar for both groups, but a significant difference was found for limitation of usual activity, which was higher for tennis players than controls.
Conclusion The correlation between tennis, an asymmetric sport, and spinal deformities that has been postulated by many experts was not confirmed by our data. There was no correlation between tennis and LBP, even if there were some differences among groups for limitations of the daily activities. Adolescent competitive tennis showed to be a safe sport without an increased risk of spinal deformities and LBP.

Keywords Scoliosis · Iperkyphosis · Low back pain · Tennis · Sport

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Introduction

Recently, some papers explored the possible connection between sport, spinal deformities and low back pain (LBP), and new perspectives arose. Swimming, traditionally considered a first level treatment for spinal diseases, such as spinal deformities, poor posture, hyperkyphosis and scoliosis, showed to be a risk factor for such problems if performed at a competitive level [1, 2]. Ballet dance was found to be associated with eating disorders and scoliosis in professional young female dancers [3]. Recently a similar effect has been found also in adolescents [4]. Despite the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) guidelines for the conservative treatment of scoliosis highlighting the benefits of sports practice (but clearly stating that sports cannot be considered a treatment [5]), the relationship between sports and scoliosis is still debated. This is due to the fact that only some sports have been investigated so far [6]. The case of asymmetric sports is paradigmatic: traditionally considered a risk factor for progression of scoliosis even if, at the best of our knowledge, no data are available to support this hypothesis.

Regarding the correlation between sports and low back pain during adolescence, there is conflicting evidence: some studies found a higher prevalence of LBP in swimmers [7], while others reported swimming to be protective for this kind of problem [8]. LBP has been related to jogging, handball playing and gymnastics, while soccer has been found to be protective [8]. But, generally speaking, there seems to be a *U*-shaped correlation between the hours of sports per week and LBP, with moderate activity being protective whereas intense activity is a risk factor [9].

Tennis is the fifth most diffuse sport in Italy, the first among asymmetric ones [10], and it is frequently condemned as a possible risk factor for spinal deformities and back pain. Nevertheless, this idea is not supported by any data, since no study has been conducted yet. Therefore, the aim of the present study is to verify the prevalence of spinal asymmetries, deformities and LBP in adolescent competitive tennis players compared to healthy controls.

Methods

To verify the prevalence of spinal deformities and LBP in adolescent competitive tennis players compared to healthy controls we used the same methodology adopted in a previous paper about swimming and spinal diseases, and we report the main details here [2].

Study design

We designed a cross-sectional study.

Setting

A public school and private competitive tennis societies.

Participants

We used a convenience sample in the area of Monza, which is a densely populated area in the north of Italy close to Milan, and can be considered representative of an urban population. Several tennis societies from the same area were approached for the recruitment of the Competitive Tennis Group (TG), while controls were recruited from local schools (Control Group, CG). No restrictions were considered for sports practice in the latter group, since we wanted to compare competitive tennis players with the general population. In addition, we did not exclude subjects with a previous diagnosis of scoliosis since we wanted a representative population. We could not calculate the sample size since, to our knowledge, no other study like this has been performed before. We tried to recruit as many subjects as possible from tennis clubs, and tried to recruit about twice that number as controls from schools.

Both groups were clinically evaluated by the same operator to detect spinal deformities via the angle of trunk rotation (ATR), measured using a Bunnell scoliometer at thoracic, thoraco-lumbar and lumbar level. The plumb line distances at C7 and L3 were measured to determine kyphosis and lordosis [11, 12]. The resulting data were analyzed for mean values with the use of a definite clinical cut-off. For Bunnell degrees, we set the cut-off at 5° and 7°. These values are considered as the most significant for screening: 5° is a significant cut-off for subjects who could benefit from a specific exercise program, while 7° is the cut-off for patients needing a brace [13–16]. For the plumb line distances, we set a different clinical cut-off: 50 mm for C7 and 60 mm for L3 according to our normative data [12]. We also considered the sagittal index, which consists of the sum of C7 and L3: a value larger than 90 mm is considered to be correlated with increased kyphosis [17].

To evaluate the prevalence of LBP, we administered a questionnaire previously validated including questions about both present and past LBP and sciatica, the use of drugs, the need for medical visits, and eventual diagnostic exams [18].

Statistical analysis

A *t* test and a Chi square test were used; odds ratios (OR) and 95 % confidence intervals (95 CI) were calculated. Alpha was set at 0.05.

Results

A total of 305 adolescents out of 305 who were invited to participate were included and divided into two groups according to their sporting habits: the first (Tennis Group, TG) was comprised of 102 adolescent competitive tennis players (52 females, mean age 12.0 ± 0.8 years; 50 males, mean age 12.0 ± 1.0 years). These subjects trained usually three times a week for an average of 1.30 h per session. We did not collect data about the age when they started playing tennis. The second (Control Group, CG) was comprised of 203 school pupils (102 females, mean age 12.3 ± 0.9 years; 101 males 12.4 ± 1.0 years). All the subjects completed the clinical evaluation and the questionnaire. We had no missing data.

As shown in Tables 1 and 2, the average ATR did not differ between groups in both males and females. When the 7° ATR threshold was considered, this being significant for scoliosis detection, female tennis players had an odds ratio of 0.62 (95 % CI 0.19–2.04) while it was not possible to calculate this number for males since none from the CG had such a value. Table 3 shows a comparison with the available studies reporting data about scoliosis and spinal deformities.

When considering the sagittal plane, there were slight differences between the TG and CG for males, with tennis

Table 1 Females group comparison

Females	Tennis	School	*t* test/Chi square
Age (years)	12.0 ± 0.8	12.3 ± 0.9	$p = 0.04$
Height (cm)	156.5	154.7	NS
Weight (kg)	48.0	49.3	NS
ATR (Bunnell degrees)	3.2 ± 2.1	2.8 ± 1.7	NS
ATR > 5° (%)	15	20	NS
ATR > 7° (%)	4	12	NS
C7 (mm)	19.2 ± 1.1	22.6 ± 1.1	NS
L3 (mm)	40.3 ± 1.7	44.0 ± 1.2	NS
Sagittal index (C7 + L3)	59.4 ± 18.1	66.6 ± 17.8	$p = 0.021$
Sagittal index (C7 + L3) > 90 mm	0	7 (7 %)	$p = 0.015$

Table 2 Males group comparison

Males	Tennis	School	*t* test/Chi square
Age (years)	12.0 ± 1.0	12.4 ± 1.0	$p = 0.04$
Height (cm)	157.0	158	NS
Weight (kg)	50.2	52.3	NS
ATR (Bunnell degrees)	2.8 ± 1.5	2.5 ± 1.4	NS
ATR > 5° (%)	13	18	NS
ATR > 7° (%)	2	0	NS
C7 (mm)	18.0 ± 1.4	22.7 ± 2.6	$p = 0.007$
L3 (mm)	38.4 ± 1.4	65.3.5 ± 13.6	$p = 0.02$
Sagittal Index (C7 + L3)	56.5 ± 17.0	66.6 ± 1.8	$p = 0.002$
Sagittal Index (C7 + L3) > 90 mm	0	2 (2 %)	NS

players presenting less marked kyphosis and lordosis, even if in the range of normality.

Regarding LBP, females showed a higher prevalence than males, but there were no differences between the TG and CG when divided by gender (Table 4). Information about the need for medical assessment, imaging and therapy for back pain were collected, but no significant difference among groups was found (Table 5). The only significant finding has been the absence from sport practice in the female TG (OR 3.06; 95 % CI 1.06–8.80). In the tennis group none underwent a radiological evaluation for back pain; only one male reported chronic low back pain and needed some kind of treatment (drugs, exercise and physical therapy were reported altogether in the questionnaire) but these differences were not significant.

Discussion

Tennis, the most practiced asymmetric sport [10], has traditionally been considered a prototype of sports that can damage the spine and increase the risk of spinal deformity progression. Our data rejects this idea, showing a similar prevalence of trunk asymmetry in both tennis and control groups. Even if we did not have the opportunity to perform radiographs to confirm the diagnosis of scoliosis, the ATR measure is a useful screening tool for identifying individuals with scoliosis and referring them for radiographs and expert evaluation [19]. This protocol was used in previous studies [2, 4]. In this study, we have been more selective than Longworth et al. [4] since we set the ATR cut-off at 7° according to Bunnell findings to reduce the risk of rotational trunk asymmetries, which have no pathological meaning [13, 15, 16]. This cut-off value was also proposed recently for a more appropriate referral during pediatric evaluation [20]. Comparing the available literature data about the relation between sport and spinal deformities, we can find that the prevalence of subjects with at least 5° Bunnell is quite similar in dancing and tennis, but much larger in swimming (Table 3). A possible explanation of these findings could be represented by the daily hours of practice, with swimmers used to train much more than dancers and tennis players. This interpretation would give reason also for the high prevalence of scoliosis reported in rhythmic gymnastics, who train 28 h a week on average [6]. These differences among competitive athletes' training hours are not surprising, since timing for specialization varies for different sports: gymnastic requires this very early, at about 5–6 years of age, while for other sports it's achieved much later, during late adolescence, like

Table 3 Prevalence of spinal deformities and scoliosis according to available literature

Sport	Study group (n° participants)	Sex	OR (95 % CI)	Age	h/week	ATR $\geq$ 5°	ATR $\geq$ 7°	Clinical suspect	Radiography (>10° Cobb)	References
Tennis	52	F	0.62 (0.19 –2.04)	12.0 ± 1.0	4–6	26 %	4 %		NA	Zaina et al. #
	50	M	–	12.0 ± 0.8	4–6	28 %	8 %		NA	
	102	M + F	0.99 (0.36–2.72)	12.0 ± 0.9	4–6	27 %	6 %		NA	
Swimming	62	F	2.50 (1.20–5.20)	12.5 ± 0.9	10–15	58 %	34 %		NA	Zaina et al. [5]
	50	M	1.21 (0.51–2.83)	12.5 ± 1.0	10–15	56 %	20 %		NA	
	112	M + F	1.86 (1.08–3.20)	12.5 ± 1.0	10–15	57 %	28 %		NA	
Ballet dance	30	F	12.44 (1.46–105.74)	12.00 ± 2.60	6.13 ± 2.0	30 %	NA		NA	Longworth et al. [5]
Rythmic gymnastics	100	F	12.2 (6.3–23.6)	12.44 ± 1.65	28.4 ± 12.16	NA	NA	16 %	12 %	Tanchev et al. [6]

OR odds ratio, *95 % CI* 95 % confidence interval

Data from current study

swimming first and tennis even later [21]. We could consider 8–10 h per week as a possible cut off, where a more frequent practice could be a risk factor for spinal deformities, but we do not think it's just a matter of training duration and the kind of activity is relevant too. The general consideration based on the different articles published so far is that sports that intensively mobilize the spine are at risk for trunk asymmetry development and/or progression, eventually leading to scoliosis progression [6]. Sports such as rhythmic gymnastics can enhance the progression of scoliosis for this reason, while swimming and dancing are associated with a higher prevalence of trunk asymmetries [2, 4]. It's well known that joint hypermobility is a feature common to scoliosis patients [22], and could explain the association with some sports. Nevertheless we must also remember that there could be a self-selection since subjects with joint hypermobility would better perform in such sports like rhythmic gymnastics, dance and swimming.

In every attempt to interpret these data, we must be aware that all of these are cross-sectional studies, so unable to find out a cause-effect ratio, but simply a correlation. For this reason we are only trying to interpret in an homogenous way these scant data waiting for further studies. Furthermore, it's impossible at this stage to investigate whether problems connected to intensive sport training like muscle fatigue, overuse syndrome, stretching secondary stabilizers, muscle development lagging growth spurt that for sure have a role in the genesis of low back pain can be among the mechanisms promoting or even originating scoliosis since this latter is mainly idiopathic, with unknown cause in the largest part of cases.

Nevertheless, these new insights about the effects of sports on the spine follow another significant recent discovery: swimming, traditionally considered not only safe but even protective for spinal diseases, showed not to be helpful and safe for spinal deformities, posture and LBP [2]. It is still common to find parents that force their children to go swimming and prevent them from practicing tennis or other asymmetric sports with the hope of preventing spinal diseases; even worse, physicians are still giving such advice. Our study should inform about the real impact of these sports, thus being relevant for spinal disease experts but also for pediatricians who are frequently asked about the impact.

When considering the sagittal profile of the spine, there were no pathological alterations nor a negative postural effect, even if some differences were found in the male population, with schoolchildren showing a larger lordosis. This is probably a benefit of the tennis training that increases the muscular tone. In previous studies about swimming and soccer, an increase of kyphosis was found [2, 23]. This was probably due to a postural collapse in

Table 4 Frequency of back pain episodes in females

Gender	Group	Low back pain episodes				
		Never (%)	Once (%)	Sometimes (%)	Frequent (%)	Persistent (%)
Females	School	50	12	32	6	0
	Tennis	31	19	42	5	3
Males	School	77	11	11	0	1
	Tennis	66	16	14	2	2

The differences were tested with a Chi square test separated for gender (NS)

Table 5 Back pain in tennis players compared to school students

Event	Gender	OR	95 % CI
Back pain now	Males	3.06	0.25–36.87
	Females	0.13	0.1–1.13
	Total	0.36	0.97–1.35
Chronic back pain	Males	1.4	0.02–74.00
	Females	0.42	0.02–7.03
	Total	0.96	0.84–10–93
School absence for back pain	Males	1.5	0.24–9.30
	Females	0.54	0.15–1.94
	Total	0.78	0.27–2.21
Sport absence for back pain	Males	0.69	0.18–2.62
	Females	3.06*	1.06–8.8
	Total	1.58	0.72–3.44
Medical evaluation for back pain	Males	0.93	0.13–6.30
	Females	0.96	0.29–3.14
	Total	0.54	0.02–1.50
Radiological evaluation for back pain (radiograph)	Males	0.44	0.01–11.65
	Females	0.15	0.01–2.89
	Total	0.13	0.01–2.43
Low back pain treatment (drugs–exercise–physical therapy)	Males	0.18	0.02–1.72
	Females	0.18	0.01–3.55
	Total	0.15	0.02–1.23

OR odds ratio, *95 % CI* 95 % confidence interval

* $p < 0.05$

swimming, where the problem was more evident, and to the need to look at the ball on the ground in soccer, where the increase was small.

Regarding LBP, females, as previously documented [24], showed a higher prevalence when compared with males, but there was not a clear role of tennis practice in preventing nor causing back pain. This is probably due to the amount of weekly practice, which was, on average, 4–5 h, which is not enough to create problems that have been documented in other studies. Some authors tried to study the dynamic of the technical movements of tennis that could be harmful for the spine [25, 26]. Another study reported the most common injuries in adolescent tennis players among whom LBP was also reported, but no comparison with the general population was made [27]. Other sports showed to contribute to LBP; some research found an association between swimming and aerobics and LBP in adolescence [7], while others reported an increased risk of LBP in adolescents who practiced sports for more than 6 h per week and in girls who spent too much time sitting. It is not always easy to assess the contribution of each single sport as a risk factor for LBP since many young persons practice more than one sport [17, 18]. With this regard, it is also interesting to notice that, practicing different sports seemed to protect from the harmful effects of a single sport, probably because of a less intense practice of the same activity with respect to single sport competitive athletes [28]. Every sport shows specific traumatological issues: knee distortions and lower limbs trauma are very frequent in soccer [29], ankle sprains in basketball and volleyball [30], shoulder injuries in swimming [31]. The risk relies on specific repeated movements or on the probability of specific trauma. For LBP the mechanism is not so clear and it's really hard to find its origin, sometimes even impossible, being too many the possible pain generators in the spine [32]. Ligaments, discs and muscles can be injured and so involved in the genesis of pain. For this reason we can make different hypothesis on its origin, but we really cannot solve this problem at least according to current knowledge, being the sport frequency, repeated spinal movement and sport specialization the only relevant factors so far documented [21]. In the lack of a specific knowledge of the genesis of LBP, its also difficult to give robust indications, even if we can state that a moderate activity of 1 h a day could be protective, mainly if based on more than one sport.

The main limitation of this study is the lack of a radiographic exam to confirm the presence of clinically detected scoliosis. Nevertheless, the ATR values are similar in both groups, so we feel confident when we state that tennis has no significant association with trunk asymmetries suggestive for scoliosis. The ATR is a worldwide diffuse screening tool for scoliosis, and both groups have the same risk of false positives. Studies about Bunnell scoliometer showed a good reliability both intra ($r = 0.86$–0.97) and interrater ($r = 0.88$–0.96), with better performance for thoracic curves [33]. A cut-off of 7° has a positive predictive value of 0.71 for curves of 10° Cobb and 0.66 for 20°; the negative predictive value is respectively 0.66 both for 10° and 20° Cobb [34]. Other non-invasive evaluation methods exists, like the Moiré topography, which is a photography based technique, the raster stereography and computerized surface mapping systems such as Integrated Shape Imaging Systems (ISIS), but they are too expensive and time consuming [19, 35, 36]. For this reason, the best tool for screening purpose is the scoliometer [37].

Also, the sample size was a bit small for a pathology, whose prevalence is about 2–3 % [38], and could, thus, explain the not significant OR. We tried to recruit as many tennis players as possible, but it was difficult to reach about one hundred subjects; a future study involving the Italian Tennis Federation could try to recruit more subjects. For LBP assessment, we only used a validated questionnaire with no clinical visit of the subjects, meaning that we lacked some information; recall bias was possible, but this was the same in both groups.

Conclusions

The correlation between tennis, an asymmetric sport, and spinal deformities that has been postulated by many experts was not confirmed by our data. This is a new finding since, until now, literature was lacking on this topic. There was no correlation between tennis and LBP; thus, its practice should not be forbidden by families and physicians to prevent spinal diseases in children and adolescents who are willing to play. Personal preferences make sports more pleasant and practice more recreational.

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Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to disclose. No funding was provided for this study.

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