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Spondylolysis In Adolescent Athletes: Differences Based on Sex and Timing of Presentation

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ABSTRACT

Background: Spondylolysis is a common cause of spine pain in adolescent athletes, but little is known about possible differences in cases of this process based on sex of the patient or timing of presentation. This descriptive study aims to determine whether significant differences exist.

Methods: Retrospective chart review of all patients ages 10-20 years diagnosed with spondylolysis over a 17-year period. Demographic, injury history, physical exam findings, diagnostic imaging findings, treatments, return to sport vs. surgical consultation and duration of care information was collected and analyzed.

Results: Females and early presenters (presentation ≤90 days) with spondylolysis are significantly younger and are more likely to report pain with spine range of motion compared to males and late presenters (presentation >90 days). Males are more likely to report an acute onset of pain and leg weakness. Stork testing has a higher sensitivity in females. Late presenters show more x-ray findings than early presenters and females are more likely to demonstrate spina bifida occulta on x-ray. Magnetic resonance imaging has low sensitivity in both sexes. All subgroups show shortened duration of care if treated without formal physical therapy or lumbar bracing. Late presenters show a longer duration of care and are more likely to be referred for surgical consultation than early presenters.

Conclusions: Several statistically significant differences in presentation, exam findings, diagnostic imaging findings, and duration of care in patients with spondylolysis exist based on patient sex and timing of presentation.

Introduction

Differences in sport injury characteristics based on gender is an area of interest to sport medicine physicians. It is well documented that anterior cruciate ligament injuries,[1] bone stress injuries (BSI),[2] and concussion[3] are more common in females than males participating in the same sport. Women tend to take longer to return to sport after BSI[4] and show a longer time to symptom recovery after concussion compared to males.[5] Achilles tendon ruptures,[6] ulnar collateral ligament (UCL) injuries,[7] and pelvic avulsion fractures[8] are more common in males. Significant gender differences regarding injury onset and timing of presentation (ToP), grade of injury and tear location of UCL injuries have been reported.[7]

Improved injury outcomes are expected if accurate diagnosis and initiation of treatment occurs early. Delay in diagnosis of sport injuries may be due to failure of the clinician to recognize the injury, or failure in or delay of ordering appropriate testing. A common reason is delay in the patient seeking care. Diagnosis of slipped capital femoral epiphysis is commonly delayed for several months,[9] and delays often lead to higher grades of slip prior to treatment and worse outcomes.[10] Even a brief delay in diagnosis, as with scaphoid fracture, may lead to poor outcome.[11]

Back pain is a common complaint in the adolescent athlete population. Prevalence of back pain in this age group increases with age,[12] and incidence increases with pubertal development and linear growth.[13] Females are more likely to experience back pain than males.[14] Pain due to stress fracture of the pars interarticularis, spondylolysis, is a common identifiable cause of back pain in adolescent athletes,[15,16,17,18,19] and is more common in males. [12,14,16,18,19,20,21,22,23,24,25,26,27,28,29,30] Differences between the sexes in the inciting sport activity[12,18,19,20] and age[18,20] at ToP for spondylolysis have been reported, but additional differences are seldom mentioned; only one study has carried out a more in-depth analysis of differences based on sex.[20] Time from onset of back pain to diagnosis may vary widely from patient to patient, but differences in presentation, exam findings, diagnosis and treatment outcomes based on ToP has not been investigated previously.

The purpose of this descriptive study is to analyze an existing database of spondylolysis cases in adolescent athletes to compare for potential differences in common presenting complaints, physical exam findings, imaging findings, treatments and outcomes based on sex and ToP.

Methods

Institutional review board approval was obtained to analyze existing data of a cohort of 533 cases of spondylolysis which were evaluated and treated at a single, community-based sports medicine practice.[18] The 533 cases were identified after reviewing all charts of patients presenting with a back pain complaint between January 1, 2005 and December 31, 2022.

Cases were excluded if the patient was aged less than 10 years or greater than 20 years at time of diagnosis, the diagnosis of a pars interarticularis injury was not confirmed by imaging (x-ray, bone scan with single photon emission computerized tomography [SPECT], magnetic resonance imaging [MRI], or computed tomography [CT] scan), or treatment was not completed prior to conclusion of the study period (completion of treatment defined as released to return to sport, referred to orthopedic surgeon for possible operative intervention, or lost to follow-up).

Medical records were reviewed for demographic data including patient age at time of presentation, gender, and primary sport at time of presentation. History data collected included patient (and/or parent) responses to questions of duration of symptoms prior to presentation, acute vs. insidious pain onset, pain with activities, pain at rest, painful range of motion (ROM), decreased ROM, radiating leg pain, lower extremity weakness and lower extremity numbness and/or tingling. Examination findings recorded included tenderness to palpation, pain reported with active and/or passive ROM, decreased ROM, decreased lower extremity sensation to light touch, decreased lower extremity strength, and findings on Trendelenburg, straight leg raise and stork tests. Stork test was considered a true positive only if the test was painful on the same side of a diagnosed stress fracture, and truly negative if the test was pain-free when no stress fracture was diagnosed on that side. Information regarding orthopedic surgery consultation, surgical intervention, or other complications was also reviewed if available. X-ray findings were recorded if there were suspicious changes at the pars interarticularis (frank fracture, sclerosis, pars elongation) or if spina bifida occulta (SBO) was noted. If advanced tests were performed (bone scan with SPECT, MRI and/or CT scans), these findings were recorded. Side and level of injury data were collected.

Management of each patient was made on a case-by-case basis and was directed by the treating physician. There was no set treatment protocol. Several treatments were utilized in nearly all cases including rest from inciting activities, use of ice or heat for comfort, and the use of oral acetaminophen or non-steroidal anti-inflammatory drugs as needed for pain control, therefore these treatment components were not analyzed. The treatments utilized with the greatest variability were the use of formal physical therapy (PT) vs. home exercise program (HEP), and the use of lumbar bracing vs. no bracing; these treatment variables were analyzed in greater detail. Decision for medical release for return to athletics was based on subjective report of pain-free daily and rehabilitation activities, and a pain-free examination which revealed full spine ROM, and normal neurologic examination. Patients were instructed on a gradual, pain-free activity advancement program and advised to take 4-6 weeks to advance toward full participation. Duration of care (DoC, defined as start day of treatment to the day of patient clearance to return to play [RTP] advancement) was recorded. Information regarding orthopedic surgery consultation, surgical intervention, or other complications was also reviewed if available. Orthopedic surgery consultation was obtained for non-response to non-operative treatment, presentation consistent with a chronic non-union, or patient/parental.

Statistical Analysis

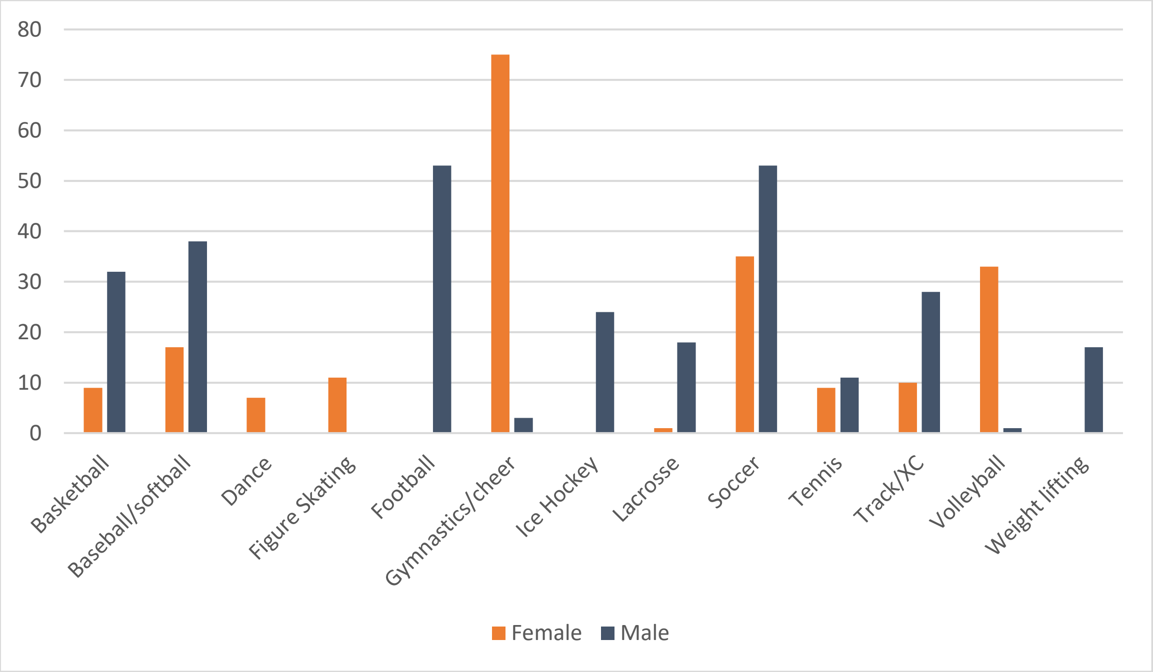
Collected data was analyzed comparing females vs. males, and then separately comparing those who presented ≤90days from onset of pain (early presenters, EPs) v. those presenting >90days from onset of pain (late presenters, LPs). All continuous data were described using medians and interquartile range (IQR); categorical data were described using counts and percentages. Kruskal-Wallis tests were performed for comparison of continuous data and Chi-square tests were used to compare categorical data. Pairwise comparisons with a Benjamini-Hochberg adjustment were used for significant variables with more than 2 categories for categorical variables and Dwass, Steel, Critchlow-Fligner multiple comparison analysis for numeric variables. Statistical significance was set at $p<0.05$. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Of the 533 cases of spondylolysis previously reported, 382 presented ≤90 days from the onset of pain, while 151 presented >90 days after the onset of pain. Females presented slightly earlier than males (35 days [IQR 21, 120] vs. 42 days [IQR 21, 180] respectively) but this difference was not statistically significant. Median time to presentation in EPs was 30 days (IQR 16, 60) vs. 365 days (IQR 180, 455) for LPs, which was statistically significant ($p<0.01$).

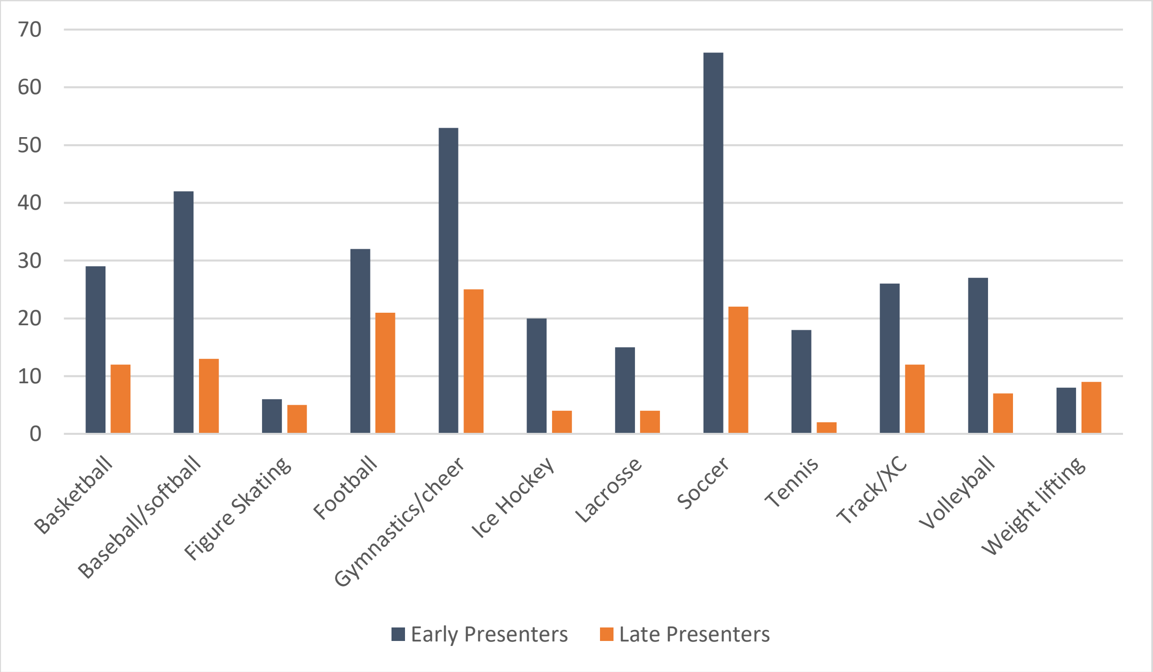
Females comprised 40.5% of the total cohort (41.6% of EP and 37.7% LP). Median age at presentation for females was 14.9 years (IQR 14, 16.1) vs. 15.3 years (IQR 14.4, 16.3) for males, which was statistically significant ($p=0.02$). EPs presented at an earlier age than LPs (15.1 years [IQR 14.0, 16.1] vs. 15.6 years [IQR 14.6, 16.7] respectively, p<0.01). Sport activities reported to be associated with the onset of back pain has been reported for this group previously [18]. The top sports for each sex and EPs vs. LPs are presented in figures 1 and 2 respectively.

Figure 1. Top sports associated with spondylolysis based on sex.



XC = Cross country running

Figure 2. Top sports associated with spondylolysis by number of cases based on timing of presentation.



XC = Cross country running

Review of history reporting revealed an insidious onset of pain 78.9% of the time, which was similar in both the EP and LP groups. Males were significantly more likely to report an acute onset of pain vs. females (24.2% v. 16.7% respectively, p=0.04). Females were more likely to report pain at rest vs. males (20.0% vs. 13.7% respectively, p=0.06) but this difference did not meet statistical significance. Report of pain at rest was similar in both EPs and LPs. Females were significantly more likely to report painful ROM vs. males (74.4% vs. 66.0% respectively, p=0.04) and were significantly more likely to report radiating pain down one or both legs (18.1% vs. 7.9% in males, p<0.01). Males were more likely to report lower extremity weakness (6.7% vs. 2.8% in females, p=0.05). History differences are reported in table 1.

Table 1. History differences in patients diagnosed with spondylolysis.

	Female	Male		EP	LP
Age (y)	14.9*	15.3		15.1**	15.6
Time to presentation (d)	35	42		30**	365
Acute pain onset	16.7%	24.2%^		22.9%	16.7%
Pain at rest	20.0%	13.7%		16.6%	15.3%
Pain with ROM	74.4%^^	66.0%		70.5%	66.7%
Decreased ROM	23.3%	17.5%		20.0%	19.3%
Radiating leg pain	18.1%$^{+}$	7.9%		12.6%	10.7%
LE weakness	2.8%	6.7%$^{\#}$		5.8%	3.3%

EP=early presenters, LP=late presenters, ROM=range of motion, LE=lower extremity
*= statistical significance of p=0.02 compared to males
**= statistical significance of p<0.01 compared to LPs
^= statistical significance of p=0.04 compared to females
^^= statistical significance of p=0.04 compared to males
$^{+}$= statistical significance of p<0.01 compared to males
$^{\#}$= statistical significance of p=0.05 compared females

On physical examination, males were significantly more likely to experience right sided pain, and females significantly more likely to report bilateral/midline pain on palpation. There were no differences in pain with ROM or decreased ROM on exam in females v. males, while EPs had more pain with ROM (78.5% vs. 70.2% in LPs, p=0.05) and decreased ROM (29.3% vs. 20.5% in LPs, p=0.05) compared to LPs. Females were significantly more likely to demonstrate a positive Trendelenburg test vs. males (13.7% vs. 7.3% respectively, p=0.02). Straight leg raise was positive in 6.0% overall, with no differences when comparing females vs. males, or EPs vs. LPs. Differences in examination findings are reported in table 2.

Table 2. Physical exam differences in patients diagnosed with spondylolysis.

	Female	Male		EP	LP
Pain on palpation	46.5%	38.5%		40.9%	43.7%
Pain with ROM	77.2%	75.4%		78.5%*	70.2%
Decreased ROM	27.6%	26.3%		29.3%*	20.5%
Trendelenburg positive	13.7%**	7.3%		9.2%	11.4%
SLR positive	3.8%	7.6%		5.8%	6.6%
Stork pain	82.1%^	65.3%		73.9%	67.1%

EP=early presenters, LP=late presenters, ROM=range of motion, SLR=straight leg raise

*= statistical significance of p=0.05 compared to LPs

**= statistical significance of p=0.02 compared to males

^= statistical significance of p<0.01 compared to males

Stork testing was painful in 72.0% of patients with no statistical difference in the presence of pain on stork testing in EPs vs. LPs (73.9% vs. 67.1% respectively, p=0.13), but there was a statistically significant difference in females vs. males (82.1% vs. 65.3% respectively, p<0.01). Stork test sensitivity (SN) was significantly greater in females v. males (68.6% v. 52.0%, p<0.01), as well as EPs compared to LPs (61.1% v. 52.8%, p=0.03). Specificity was significantly lower in females vs. males (59% v. 73.5% respectively, p=0.01). Specificity was similar based on presentation timing (LPs 65.1% vs. EPs 68.5%, p=0.80). A full comparison of stork testing results is presented in table 3.

Table 3. Stork Test Statistics

		SN	SP	PPV	NPV	Accuracy
Females	Total	68.6*	59.0	83.4	38.5	66.2
	EPs	69.7	56.8	82.1	39.7	66.3
	LPs	65.5	66.7	87.3	35.6	65.7
Males	Total	52	73.5^	85.7	33.4	57.3
	EPs	54.9	76.7	86.8	37.9	60.7
	LPs	45.6	64.1	82.9	23.6	49.5
All	Total	58.6	67.7	84.6	35.1	60.9
	EPs	61.1#	68.5	84.5	38.5	63.0
	LPs	52.8	65.1	84.3	27.2	55.4

SN=Sensitivity; SP=Specificity; PPV=Positive predictive value; NPV=Negative predictive value; EPs=Early presenters; LPs=Late presenters

*= statistical significance of p<0.01 compared to total males

^= statistical significance of p=0.01 compared to total females

#= statistical significance of p=0.03 compared to total LPs

Late presenters were significantly more likely to exhibit x-ray changes compared to EPs (46.2% v. 26.6%, p<0.01). There was no difference in the presence of x-ray findings in the pars interarticularis region between females and males. Spina bifida occulta was more common in females v. males (29.8% v. 21.1% respectively; p=0.09) and in LPs v. EPs (27.1% v. 23.5% respectively, p=0.48) without reaching statistical significance. Sensitivity of MRI (as determined by a negative MRI for spondylolysis with subsequent positive bone scan with SPECT or CT) was slightly higher in females vs. males (54.2% vs. 53.8% respectively, p=0.98).

There were no differences in laterality of injury when comparing females to males, or EPs to LPs. Injury level in males was most common at L5 and decreased with each successive lumbar level (L5 68.7%, L4 19%, L3 11.4%, L2 0.9%). Injuries in females deviated slightly from this pattern (L5 57.3%, L4 22.5%, L3 12.7%, L2 2.8%, L1 3.3%) and 1.4% of injuries in females were noted in the lower thoracic spine. Level of injury in EPs were also most common at L5 with decreasing frequency with each ascending spinal level. In LPs, L3 injuries were slightly more common than L4 injuries (16.0% v. 15.3% respectively). Males were more likely to experience L5 fractures (68.7% v. 57% in females), while only females demonstrated fractures at L2 or higher (7.5%).

For most of the study period, two practitioners provided care for patients with no specific, single treatment protocol utilized. The main areas of comparison of treatment in this study were in the use formal PT vs. HEP (some started with HEP and transitioned later to PT) and lumbar bracing vs. non-bracing (some started without bracing and added bracing later). Early presenters were significantly more likely to complete their treatment with HEP only compared to LPs (38% vs. 27.4% respectively, p=0.04). Physical therapy was more likely to be added after a period of HEP in females vs. males (10.3% vs. 4.2% respectively, p=0.02). Patients were treated without the use of a brace 77.8% of the time. There were no differences in the use of bracing or non-bracing based on sex or presentation timing.

Median DoC was significantly longer for females vs. males (91 days [IQR 63, 131] vs. 77 days [IQR 58, 100] respectively, p<0.01) and for LPs vs. EPs (92 days [IQR 60, 135] vs. 78.5 days [IQR 61, 105] respectively, p<0.01). LPs were significantly more likely to be referred for orthopaedic consultation vs. EPs (15.1% vs. 4.3%, p<0.01), likelihood of orthopaedic consultation was no different based on sex.

Comparing patients treated with HEP vs. PT, DoC was significantly shorter for females treated exclusively with HEP (HEP 65.5 days vs. PT 115.5 days, p<0.01); this was also the case in males (HEP 62.4 days vs. PT 92 days, p<0.01), EPs (HEP 64 days vs. PT 91 days, p<0.01) and LPs (HEP 59 days vs. PT 98 days, p<0.01). Comparing non-bracing vs. bracing, shorter DoC was seen in the non-brace group in females (no-brace 90 days vs. brace 121.1 days, p<0.01), males (no-brace 76.4 days vs. brace 114.5 days, p<0.01), EPs (no-brace 72 days vs. brace 97 days, p<0.01) and LPs (no-brace 75 days vs. brace 98 days, p<0.01).

Median total time from onset of pain to clearance to begin RTP activities was significantly longer in LPs compared to EPs (410 days [IQR 264, 550] vs. 112 days [IQR 88, 150] respectively, p<0.01). There was no statistical difference in median time from onset of pain to clearance to begin RTP activities in females vs. males (145 days [IQR 100, 255] vs. 129.5 days [IQR 94.5, 216] respectively, p=0.17).

Discussion

Spondylolysis is a common cause of low back pain in adolescent athletes and is more commonly reported in males. [12,14,16,18,19,20,21,22,23,24,25,26,27,28,29,30] In this cohort, males made up most cases both in EPs and LPs (58.4% and 62.3%, respectively); no prior studies comparing EPs to LPs were discovered for comparison. Females were diagnosed at a younger age than males (median age 14.9y vs. 15.3y), Asai, et.al. did not report an age difference based on sex.[20]

One prior report demonstrated males diagnosed with spondylolysis are more likely to endorse a traumatic onset of pain compared to females (18.7% v.s 6.1% respectively)[12] which is consistent with the current findings. Sairyo et.al. reported a 17% likelihood of radiculopathy in adolescent patients with spondylolysis without listhesis. They propose the radiculopathy to come from extra-osseous hematoma and edema at the site of the stress fracture.[31] No prior studies comparing radiculopathy symptoms in females vs. males associated with spondylolysis were found. While radiculopathy in cases of spondylolysis was less common in the current population (12.1%), it was significantly more common in females v. males (18.1% vs. 7.9%, respectively).

Stork test SN rates of 52.8-79% and SP rates of 9-63.8% have been reported.[15,18,27,32] No prior studies comparing stork test results between the sexes or EPs vs. LPs were discovered. Stork SN was similar in this group compared to prior studies, while males (73.5%), EPs (68.5%) and LPs (65.1%) all showed higher SP on stork testing compared to prior reports.[15,18,27,32] Females were significantly more likely to have pain on stork testing vs. males, and SN was significantly higher in females (68.8% vs. 52.0% in males; $p<0.01$) and EPs (61.1% vs. 52.8% in LPs; $p=0.03$). Stork SP was significantly higher in males vs. females (73.5% vs. 59% respectively, $p=0.01$).

Using CT scans to screen an adult population of patients presenting for non-back pain related problems, Sakai et.al[26] showed SBO to be present in 7.7% of subjects, and in patients with SBO, 16.2% also had findings of spondylolysis; this was a 3.7x increased association compared to those without SBO. Spina bifida occulta was more commonly noted in all subdivisions of this study group, but all the patients here presented for back pain, and only those with diagnosed spondylolysis were analyzed. Prior studies of patients with spondylolysis show an even higher prevalence of SBO in general, and specifically, males have a higher prevalence than females.[20,33,34] Prevalence of SBO in males with spondylolysis has been reported as high as 65-70.9% in males and 44-47% in females.[20,33] This study group showed SBO much less frequently, and more common in females.

MRI is commonly the preferred advanced radiology test to confirm the presence of spondylolysis due in part to its lack of radiation exposure. Sensitivity of MRI for diagnosis of spondylolysis has been reported from 59.1-80%[18,32,35] but these studies did not investigate for differences based on sex. In this group, spondylolysis in females was confirmed by MRI in 15 cases with an additional 9 cases confirmed with subsequent bone scan with SPECT or CT scan (SN = 62.5%). Spondylolysis was confirmed by MRI in males in 24 of 39 cases (SN = 61.5%).

L5 is the most common level for spondylolysis[18,20,22,23,25,27,28,30] and most studies show the incidence decreasing with each ascending spinal level.[18,19,20,21,22,23,25,27,30] Asai, et.al. showed that both males and females demonstrated this pattern and noted no injuries in females above L3.[20] This study shows L1 injuries to be slightly more common than L2 injuries in females and 7.5% of injuries in females are above the L3 level. EPs followed the same pattern as the general cohort, though LPs did show slightly more L3 injuries than L4.

Asai et.al.[20] reported no difference in DoC based on sex (91.5d in females vs. 96d in males; $p=0.18$). Patients in this cohort experienced a significantly shorter DoC if they were males (median 77d vs. 91d for females; $p=0.001$) or EPs (median 78.5d vs. 92d for LPs; $p=0.009$). Females, males, EPs and LPs all experienced shorter DoC if treated exclusively with HEP v. PT or treated exclusively without bracing v. bracing; no prior studies comparing these treatment variables between sexes or based on ToP were discovered. Late presenters were more likely to be referred for surgical consultation. This was most commonly due to a significant duration of symptoms coupled with x-ray changes, which were significantly more common in the LP group.

There are several limitations of this study to acknowledge. History data obtained from patients and their parents is subject to recall bias as well as reporting bias. It is possible that not all patients presenting for back related issues over the study period were identified, so some cases may have been missed. There were 82 patients who never followed through with the recommended workup and were subsequently lost to follow-up, likely leading to loss of a moderate number of additional cases. Duration of care is based on when patients were cleared to begin their return to play advancement. No long-term or phone call follow-up was performed to determine exactly when patients returned to play.

Conclusions

Spondylolysis is a common cause of back pain in adolescent athletes. There are differences in history, physical exam findings, radiology test findings and DoC based on the sex of the patient and the ToP which physicians should be aware of when caring for adolescent athletes presenting with back pain. Treatment with HEP and without bracing may lead to shorter DoC than formal PT and bracing regardless of sex or presentation timing. Awareness of these differences will aid physicians in the diagnosis and treatment of adolescent athletes with spondylolysis.

Conflict of Interest:

The author declares no conflicts of interest.

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