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Lumbar Spondylolysis in Female Indoor Volleyball Athletes: A Descriptive Study of 33 Cases

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ABSTRACT

Background: Spondylolysis is a common cause of back pain in adolescent athletes, though little is known about spondylolysis in volleyball. This descriptive study aims to compare historical, physical examination, imaging and treatment outcome differences between female volleyball athletes and female athletes from other sports

Methods: Retrospective chart review of female athletes aged 10-20 years diagnosed with spondylolysis over a 17-year period divided between volleyball and non-volleyball athletes was performed. Demographic, injury history, physical exam findings, diagnostic imaging findings, treatments, return to sport and duration of care information was collected and analyzed.

Results: Volleyballers with spondylolysis are significantly older than non-volleyballers (16.0 vs. 14.75 years, respectively; $p<0.001$). Responses to history questions are similar between groups with exception of the report of lower extremity weakness. Physical exam findings were also similar between the groups except for pain with active and/or passive range of motion, which was present in 97% of volleyball athletes (vs. 73.8 of other sports; $p<0.001$). Stork testing showed a significantly greater negative predictive value in volleyball athletes. Athletes playing the outside hitter position were significantly more likely to be affected, and more likely to suffer a unilateral left-side injury compared to other positions, and all injuries were in front row players. Duration of care was significantly shorter for volleyball players who were treated exclusively with home exercises compared to formal physical therapy and with non-bracing compared to bracing. There were no differences in duration of care between volleyballers and non-volleyballers.

Conclusions: Several statistically significant differences exist between female volleyball athletes with spondylolysis and female athletes from other sports. Athletes may be cleared to return to sport sooner if treated exclusively with home exercises and/or non-bracing instead of formal physical therapy and/or bracing. Outside hitters are at greatest risk for spondylolysis and are much more likely to have left-side injuries.

Introduction

The sport of volleyball originated in the United States (US) around 1895. Originally called mintonette, volleyball was developed as a hybrid of basketball, baseball, tennis and handball.[1] Women's and men's volleyball debuted as an Olympic sport at the 1964 Tokyo Games. The popularity of the sport has grown steadily through the years, from 200 million worldwide participants in 1994[2] to an estimated 800 million people today.[3] In Europe, youth volleyball participation increases with age. While there is a slight decrease in participation in females between the 12/13-year-old age group to the 14/15-year-olds, participation numbers recover in 16/17-year-olds. Female participation outpaces males at all youth ages in Europe, one of only two sports to have a higher percentage of female participation. Volleyball participation ranks behind basketball, football (soccer) and athletics (track and field) for European females,[4] unlike in the US where volleyball participation numbers rank only behind track and field for females.[5]

With increased participation comes increased risk of injury, the numbers rise even higher in athletes who specialize (≥8 months/year) in a specific sport.[6,7] Both acute and overuse injuries are common in volleyball and may include lower and upper extremity injuries as well as acute head injuries. Injuries to the ankle and knee are reported most often.[8-15] Concussion was the most common injury reported at the Canadian Youth Volleyball National Championships in 2018, accounting for over 25% of all injuries at that multi-age group, 7-day tournament.[16] Back pain/injury is often listed in volleyball related studies, accounting for 6.0-17.4% of all injuries.[8-10,12,13,15,17] Muscle strains are typically reported as the most common back injury,[8,10,17] though other spine pathologies have been reported.[18-22] Many studies do not go into detail regarding the nature of volleyball related spine problems.[9,12,13,15]

Spondylolysis, stress fracture of the pars interarticularis, is considered the most common identifiable cause of low back pain in adolescent athletes.[23] Caused by repetitive spine hyperextension and rotational activities, most sports can produce the forces necessary which lead to spondylolysis. Reports of spine stress fracture[18-21] and specifically spondylolysis[18-20,22] are less common in volleyball. This descriptive study analyzed data collected from adolescent volleyball players diagnosed with lumbar spondylolysis at a community-based sports medicine practice over a 17-year period. Variables assessed included patient demographics, history and physical examination findings at initial presentation, diagnostic imaging, fracture characteristics, treatments used, duration of treatment, and outcomes. The purpose of this study is to determine if there are differences in the history, examination and duration of treatment based on physical therapy vs. home exercise program or bracing vs. non-bracing in female volleyball vs. non-volleyball athletes.

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[20] which was later broken down by sex.[24] 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 at a single, community-based sports medicine practice. Inclusion criteria for this study included female patients aged ≥10 years and ≤20 years at time of diagnosis, the diagnosis of a pars interarticularis injury confirmed by imaging (x-ray, bone scan with single photon emission computerized tomography [SPECT], magnetic resonance imaging [MRI], or computed tomography [CT] scan), treatment 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), and indoor volleyball reported as the primary sport at the time of injury. Female volleyball data was extracted from the full female athlete cohort for comparison of female volleyball athletes vs. female athletes of other sports. Other sports included athletics (track and field), basketball, dance, figure skating, field hockey, football (soccer), general training, gymnastics/cheer, lacrosse, softball, swimming/diving and tennis.

Medical records of the female athletes were reviewed for historical data including patient age at time of presentation and patient (and/or parent) responses to questions regarding duration of symptoms prior to presentation, acute vs. insidious pain onset, location of pain (right, left or bilateral/midline), pain with activities, pain at rest, painful range of motion (ROM), decreased ROM, radiating leg pain, lower extremity weakness, lower extremity numbness and/or tingling and presence of additional symptoms including fever, sweats, chills or bowel or bladder control issues. Volleyball athlete histories also included primary position (outside hitter [OH], middle blocker [MB], opposite [OPP; also referred to as "right side"], setter or defensive specialist/libero]) and dominant (serving/hitting) arm.

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. As reported in previous studies of the full cohort,[20,24] 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 region (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 scan), 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 all cases including rest from inciting activities, use of ice and/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 PT vs. 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 request.

Statistical Analysis

All continuous data were described using medians and interquartile range (IQR); categorical data were described using counts and percentages. Unpaired T-tests were used for comparison of continuous data. Fisher exact test for count data was utilized to compare the association of categorical data. Chi square tests were used compare observed frequencies in categorical data. Statistical significance was set at $p<0.05$. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

After applying inclusion criteria to the original study cohort,[20] 33 cases of spondylolysis in female indoor volleyball athletes were identified for inclusion in the study; 183 cases in non-volleyball female athletes were used for comparison. Median age at time of presentation was 16 years old (IQR 15.2, 16.9) in volleyball vs. 14.75 years (IQR 13.83, 16.0) in non-volleyball; this difference was statistically significant ($p<0.001$). Median time from onset of pain to presentation between the groups was not statistically significant (42 days [IQR 26, 90] in volleyball vs. 35 days [IQR 21, 120] in other sports; $p=0.44$).

Most cases (72.7%; 24/33) occurred in OHs. Middle blockers made up 6/33 cases (18.2%), there were two OPPs (6.1%), one setter (3%) and no defensive specialists/liberos were represented. Nearly all the athletes were right hand dominant (93.9%; 31/33). The two left hand dominant athletes both played the OPP position.

Historical information revealed 39.4% (13/33) of patients complaining of right-side pain; left-sided pain and bilateral/midline pain history were equally reported (30.3%, 10/33 each); reported side of pain in non-volleyballers was 27.5% right (49/178), 30.4% left (54/178) and 42.1% (75/178) bilateral/midline. A repetitive use mechanism was described by 87.9% vs. 83.1% in other sports, while the remaining athletes related an injury event initiating their onset of pain. All patients in both groups complained of pain with sport activities. Volleyball athletes reported pain at rest 21.2% of the time vs. 19.8% in other sports. Painful ROM was reported in 81.8% compared to only 73.1% in non-volleyball players and decreased ROM was noted in 33.3% vs. 21.4% of volleyballers vs. non-volleyballers, respectively. Report of radiation of pain to the buttocks or into the legs was virtually the same in both groups (18.2% in volleyball vs. 18.1% in other sports). Numbness and/or tingling was reported more commonly in volleyball players (9.1% v. 6.6% in non-volleyball players). Six non-volleyball athletes (3.3%) and no volleyballers reported lower extremity weakness and no athletes reported fevers, sweats, chills, or bowel/bladder disturbances. Comparison of history data compared to female athletes from other sports is listed in table 1.

Table 1. Comparison of history data between female volleyball and non-volleyball athletes.

	Volleyball Athletes	**Non-Volleyball Athletes**	**p-value**
Age at presentation (y)	16.0 (IQR 15.2, 16.9)	14.75 (IQR 13.83, 16.0)	<0.001
Time to presentation (d)	42 (IQR 26, 90)	35 (IQR 21, 120)	0.44
Side of injury Right Left Bilateral/midline	 39.4% (13) 30.3% (10) 30.3% (10)	 27.5% (49) 30.4% (54) 42.1% (75)	0.32
Mechanism of injury (repetitive use vs. trauma)	Repetitive: 87.9% (29/33) Trauma: 12.1% (4/33)	Repetitive: 83.1% (152/183) Trauma: 16.9% (31/183)	0.8
Pain with sport activities	100% (33/33)	100% (183/183)	1.0
Pain at rest	21.2% (7/33)	19.8% (36/182)	0.86
Painful ROM	81.8% (27/33)	73.1% (133/182)	0.25
Decreased ROM	33.3% (11/33)	21.4% (39/182)	0.19
Radiating pain into leg(s)	18.2% (6/33)	18.1% 33/182)	0.99
Extremity numbness and/or tinging	9.1% (3/33)	6.6% (12/182)	0.65
Lower extremity weakness	0	3.3% (6/182)	0.01
Fever/sweats/chills	0	0	
Bowel/bladder changes	0	0	

y = years; IQR = interquartile range; d = days; ROM = range of motion

The most common physical exam finding in volleyball athletes was pain with ROM (97% v. 73.8% in other sports; $p < 0.001$), followed by pain on stork testing (volleyball 81.8% vs. non-volleyball 82.1%), and tenderness to palpation (54.5% volleyball vs. 45.4% in non-volleyball). Positive Trendelenburg was significantly more common in volleyballers (28.1% vs. 10.5% in non-volleyballers; p=0.05). Decreased ROM was less common in volleyball athletes (18.2% vs. 28.9% in other sports), as was a positive straight leg raise test (3% in volleyball players vs. 6.6% in non-volleyball athletes). No patient in either group demonstrated reduced sensation to light touch or lower extremity weakness on manual muscle testing. Comparison of physical exam findings between female volleyball athletes and those from other sports is found in table 2.

Table 2. Comparison of exam findings between female volleyball and non-volleyball athletes.

	Volleyball Athletes	**Non-Volleyball Athletes**	**p-value**
Pain with ROM	97% (32/33)	73.8% (135/183)	<0.001
Tenderness to palpation	54.5% (18/33)	45.4% (83/183)	0.33
Decreased ROM	18.2% (6/33)	28.9% (53/183)	0.16
Pain with Stork testing	81.8% (27/33)	82.1% (147/179)	0.97
Positive Trendelenburg	28.1% (9/32)	10.5% (19/181)	0.05
Positive SLR	3% (1/33)	6.6% (12/181)	0.37
Reduced sensation	0	0	
Lower extremity weakness	0	0	

ROM = range of motion

Stork testing was performed bilaterally on all patients. Sensitivity (SN) of stork test was 71.1% and specificity (SP) was 76.2%, positive predictive value (PPV) 86.5%, negative predictive value (NPV) was 55.2%, and accuracy of 72.3%. While all these finding were greater in volleyball athletes, only NPV of stork testing was statistically greater in volleyballers vs. non-volleyballers (p=0.03). Details of stork testing are reported in table 3.

Table 3. Stork test results and comparison results to other sports

	TP	**TN**	**FP**	**FN**	**SN**	**SP**	**PPV**	**NPV**	**Accuracy**
VB	32	16	5	13	71.1%	76.2%	86.5%	55.2%	72.3%
Other sports	184	46	38	86	68.2%	54.8%	82.9%	34.9%	65.0%
p-value					0.63	0.56	0.54	0.03	

VB=volleyball; TP=true positive; TN=true negative; FP=false positive; FN=false negative; SN=sensitivity; SP=specificity; PPV=positive predictive value; NPV=negative predictive value

X-ray interpretations were recorded in 32 volleyball cases and 165 non-volleyball cases. In volleyballers, suspicious x-ray findings in the pars region were noted in 25%; L5 was the most common level (71.4%), followed by L4 and L3 (14.3% each). Spinal level of x-ray finding was not reported in one case. In other sport athletes, suspicious x-ray findings were noted in 37% of cases, were also most common at L5 (78.7%) and were less likely with each ascending level (11.5% at L4, 8.2% at L3, and 1.6% at L1). Spina bifida occulta was present in 42.3% of volleyball athletes and all cases of SBO were at the S1 level. In other sport athletes, SBO was present in 30.2% with 87.5% of cases at S1 and 12.5% at L5. Bone scan with SPECT was ordered on 28 volleyball patients and confirmed the diagnosis of active lesions in all but one case (a lesion seen on x-ray was inactive on SPECT, considered to be a chronic non-union). In other sports, bone scan with SPECT was ordered as the advanced imaging test of choice and confirmed the diagnosis in 150 cases. Comparison of imaging findings are presented in table 4.

Table 4. Comparison of Imaging Findings

	Volleyball Athletes	**Non-Volleyball Athletes**	**p-value**
Suspicious X-ray Findings	Frequency: 25% (8/32) Spinal level: L5 – 71.4% (5/7) L4 – 14.3% (1/7) L3 – 14.3% (1/7)	Frequency: 37% (61/165) Spinal level: L5 – 78.7% (48/61) L4 – 11.5% (7/61) L3 – 8.2% (5/61) L1 – 1.6% (1/61)	0.19 0.97
SBO	Frequency: 42.3% (11/26) Level: L5 – 100% (11/11)	Frequency: 26.7% (28/106) Level: L5 – 87.5% (21/24) L4 – 12.5% (3/24)	0.16 0.22
MRI	TP: 3 FN: 2 SN: 60%	TP: 15 FN: 15 SN: 50%	0.68
Side of fracture	Right: 7 (21.2%) Left: 13 (39.4%) Bilateral: 13 (39.4%)	Right: 38 (21.0%) Left: 52 (28.7%) Bilateral: 91 (50.3%)	0.42
Level of fracture	L5: 14 L4: 11 L3: 6 L2: 0 L1: 2 T12: 0 T11: 0	L5: 115 L4: 36 L3: 16 L2: 6 L1: 6 T12: 1 T11: 2	0.18

SBO=spina bifida occulta; MRI=magnetic resonance imaging; TP=true positive; FN=false negative; SN=sensitivity

Magnetic resonance imaging was ordered as the initial advanced diagnostic study in five volleyball cases (all were cases in which there was a history of radicular pain and x-rays were read as normal) and confirmed the diagnosis of spondylolysis in three cases; in two cases MRI was normal, and diagnosis was confirmed with subsequent bone scan with SPECT (SN of MRI= 60%). Magnetic resonance imaging was the initial advanced diagnostic test in 30 non-volleyball athletes and confirmed the diagnosis of spondylolysis in 15 cases; in the other 15 cases, MRI was read as normal and diagnosis was confirmed with bone scan with SPECT (13 cases) or CT scan (2 cases) leading to a SN of 50% in this group of athletes. The difference in MRI SN between the groups was not statistically significant (see table 4).

In volleyball athletes, unilateral left-side injuries and bilateral injuries each accounted for 39.4% of cases (13/33), with the remaining 21.2% (7/33) being unilateral right-side injuries. All 13 unilateral left-side injuries and 84.6% (11/13) of the bilateral injuries occurred in OHs, all of whom were right-hand dominant. Middle blockers suffered two bilateral injuries and four unilateral right-side injuries, all MBs were right-hand dominant. Both OPPs in the cohort suffered unilateral right-side injuries, and these were the only left-hand dominant athletes. The right-handed setter also experienced a unilateral right-side injury. Differences in laterality of injury based on player position were statistically significant. Outside hitters were more likely to suffer unilateral left-side injuries compared to all other positions ($p<0.005$) and comparing OHs to MBs and OPPs/setter individually ($p=0.02$ vs. MB; $p=0.009$ vs. OPP/setter). There was no statistical difference comparing laterality of injury between MBs vs. OPPs/setter positions. The most common level of injury was L5 (42.4%), followed by L4 (33.3%), L3 (18.2%) and L1 (6.1%). Side of injury and spinal level of injury comparison to non-volleyball athletes is also in table 4.

For most of the study period, two practitioners provided care for patients with no specific, single treatment protocol utilized. Three of the 33 volleyball athletes were referred to surgery and another three were lost to follow-up, leaving 27 cases for analysis of treatment outcomes. The main areas of comparison of treatment in this study were in the use formal PT vs. HEP and lumbar bracing vs. non-bracing; shared decision-making was utilized to determine PT vs. HEP and bracing vs. non-bracing treatment choices. In the volleyball group, ten patients were treated with HEP only, 17 with PT and two were initially treated with HEP and later converted to PT treatment. Non-bracing treatment was used in 22 patients, four used bracing as initial treatment. Both patients who started with HEP and later converted to PT also started with non-brace treatment and later converted to bracing; interestingly, each eventually were referred for surgical consultation.

Median DoC was 84 days (IQR 58, 98.25) in volleyball athletes, which was shorter than other female athletes (median 91 days [IQR 63, 126]) but this difference was not significant ($p=0.21$). Both volleyball and non-volleyball athletes had shorter DoCs if treated exclusively with home exercises compared to formal therapy. Volleyballers showed a longer DoC than non-volleyballers when treated only with HEP (median 75.5 days vs. 62.5 days, respectively; $p=0.91$), and a shorter DoC when treated solely with PT (median 89 days vs. 105 days, respectively). Comparing bracing treatment

options, shorter DoC was seen in the non-brace group vs. bracing in both the volleyball (median 80.5 days for no bracing vs. 97.5 days for bracing) and non-volleyball athletes (median 86 days for no bracing vs. 108.5 days for bracing). Statistically significant differences included shorter DoC for volleyballers treated with HEP only vs. PT only (p=0.03), non-volleyballers treated with HEP only vs. PT only (p<0.001), and non-volleyballers treated with no bracing vs. bracing (p=0.03). Details of DoC findings appear in table 5.

Table 5. Duration of Care Comparisons

	Volleyball Athletes	**Non-Volleyball Athletes**	**p-value**
Total DoC (days)	84 (IQR 49, 105)	91 (IQR 63, 126)	0.21
DoC (days) HEP vs. PT HEP only PT only	 75.5 (IQR 40, 83)* 89 (IQR 62, 118)	 62.5 (IQR 41.75, 75.25)^ 105 (IQR 79.5, 144.5)	 0.91 0.3
DoC (days) Brace vs. No Brace Brace No Brace	 97.5 (IQR 78, 120) 80.5 (IQR 46.5, 80.5	 108.5 (IQR 92.25, 144.75) 86 (61.75, 120.5)#	 0.54 0.06

DoC = duration of care; IQR = interquartile range; HEP = home exercise program; PT = physical therapy
* - significantly shorter compared to PT in volleyball athletes: p=0.03
^ - significantly shorter compared to PT in non-volleyball athletes: p<0.001
# - significantly shorter compared to bracing in non-volleyball athletes: p=0.03

Discussion

In the original study from which the female volleyball cohort was taken for analysis,[20] there were 33 females and one male volleyball athlete; volleyball was not a popular sport for male participation in the area where the study took place

during the study period, so this difference was not unexpected. For this reason, only female volleyball athletes were studied, and all were indoor volleyball athletes. A higher number of spondylolysis cases in female volleyball athletes vs. males has been shown previously.[19] With exception of age at presentation, gender, sport played and stork test findings, there are very few published reports documenting specifics of multiple components of history and physical exam findings in adolescent athletes with spondylolysis and the current study population is drawn from these prior studies;[20,24] therefore, comparison with prior information is limited. This is the first report looking at specific details surrounding cases of spondylolysis in female volleyball athletes.

The median age at time of injury of 16 years is higher than 14.75 years in other female sports, and the 14.9 years noted in the full cohort of female athletes from which these cases were drawn.[24] This is also older than a majority of studies which show median (or mean) age at presentation of 13.1-15.3 years old[19,20,22,25-30] but these studies included both females and males. One prior study did describe a mean age at time of diagnosis of 17.2 years,[31] one shows females present at a younger age than males[24] while another shows no difference in age at presentation.[19]

With respect to historical data, only age at presentation and report of lower extremity weakness revealed statistically significant differences comparing female volleyball players to female athletes competing in other sports; the low number of athletes reporting lower extremity weakness calls the relevance of this finding into question. Time to presentation in female volleyball athletes of 42 days was the same as a prior report which included males.[20] Timing of presentation of female athletes in non-volleyball sports (35 days) was shorter than the volleyball athletes but the same as a prior report on female athletes from all sports;[24] both groups presented much sooner than 166 days reported by El Rassi, et.al.[26] An acute/traumatic mechanism described by 12.1% of the volleyball group was slightly lower than females from other sports (16.9%) and the 16.7% reported by female athletes from all sports combined as a full group.[24] The report of an acute and/traumatic onset of back pain in both volleyballers and non-volleyballers is higher than a prior investigation which showed a 6.1% traumatic pain onset in females,[32] but far lower than the 40.4% acute onset reported by El Rassi, et.al.[26]

All female athletes with spondylolysis reported pain with sport activities regardless of their primary sport; pain at rest in volleyball (21.2%) and other female sport athletes 19.8% was more common than males (13.7%)[24] and a cohort containing both females and males (16.2%).[20] Painful ROM was more common in volleyball vs. non-volleyball athletes in this study (81.8% vs. 73.1%, respectively) and more common than reports in males (66%)[24] and a combined group of females and males combined (69.4%).[20] The decreased ROM reported by 33.3% of volleyballers was higher than non-volleyballers (21.4%) and both were higher than males alone (17.5%)[24] and the 19.8% reported by the group combining female and males.[20] Reports of radiating leg pain were the same (18.1%) in volleyball and other female athletes and is higher than this symptom reported in males (7.9%).[24] Lower extremity weakness has been reported in 5.1% of all athletes[20] and 2.8% of female athletes[24] eventually diagnosed with spondylolysis and this is consistent with the numbers seen in non-volleyball athletes, but these symptoms were not reported in female volleyball players.

The exam finding of pain with ROM was significantly more common in female volleyball athletes compared to those in other sports and higher than reports in female athletes of all sports (77.2%), males (75.4%),[24] and a combined group of females and males (76.1%).[20] Pain

on stork testing is similar in female athletes regardless of the sport (81.2%) and is found more commonly in females compared to males (65.3).[24] Tenderness to palpation was more common in female volleyball than other female athletes and more common than in males (38.5%).[24] A positive Trendelenburg test in female volleyballers (28.1%) was more common than in non-volleyballers (10.5%), a combined cohort of females and males (9.8%)[20] and males alone (7.3%).[24] Decreased ROM on physical exam was less common in volleyball athletes (18.2%) compared to non-volleyball athletes (28.9%), male athletes (26.3%),[24] and a large group of female and male athletes combined (26.8%).[20]

Stork test SN in volleyball athletes and non-volleyball females was consistent with prior studies which showed SN of 50-79%.[20,30,33,34] Stork SP in earlier studies of 9-67.7% are reported,[20,30,33,34] consistent with the SP in non-volleyball females (54.8%); volleyball athletes showed higher stork SP at 76.2%. Of note, the prior studies of stork test SN and SP included both female and male athletes. Stork test PPV in volleyball and non-volleyball females (86.5% and 82.9%, respectively) are consistent with prior reports in combined gender reports (40.5 - 84.6%)[20,34] and males only (85.7%).[24] Negative predictive value of stork testing is greater in volleyball athletes (55.2%) than non-volleyball athletes in this study (34.9) and prior reports from combined gender cohorts (35.8-46.9%)[20,34] and males alone (33.4%).[24]

As in the initial study from which subjects were drawn,[20] suspicious x-ray findings were noted in about 30% of cases but rarely were considered diagnostic. Spina bifida occulta was present in 42.3% of volleyballers which is consistent with prior reports of 29.8-46.2% in female athletes.[19,22,24]

Spondylolysis was most often diagnosed by bone scan with SPECT. Magnetic resonance imaging was only used as the initial advanced diagnostic test of choice in 35/216 cases in female athletes (5/33 of volleyball athlete cases and 30/183 non-volleyball athlete cases) and only confirmed the diagnosis in 18/35 cases. This overall MRI SN of 51.4% (60% in volleyball and 50% in non-volleyball) is slightly lower than the 54-61.9% reported in some prior studies[20,35] but much lower than the 80% reported by Masci, et.al.[34] The most common spinal level injured in both the volleyball and non-volleyball athlete groups was L5, followed by L4, then L3; this pattern has often been reported.[19,20,24-30] Studies report injuries are most frequently bilateral.[19,20,24-26,28,29,31] When unilateral injuries are broken down into left vs. right, studies are mixed with one reporting no differences regarding side of unilateral injury[25] and another describing right side unilateral injuries more common than left.[30] In this study, left side unilateral injuries were more common than right in both volleyball and non-volleyball athletes.

Treatment of spondylolysis with bracing has been studied often and show good-to-excellent results in many cases.[25-27,31] Physical therapy combined with rest and no bracing has also shown to be beneficial.[36] Prior studies including this cohort of patients[20,24] has shown that treatment without bracing led to shorter DoC than treatment with bracing. Likewise, treatment exclusively with HEP led to shorter DoC than treatment exclusively with PT. Not surprisingly, these findings were confirmed in both female volleyball and non-volleyball athletes in the current study.

This study has several limitations. The number of volleyball athletes is low, so definitive conclusions cannot be made; this is, however, the largest report of spondylolysis in volleyball athletes. A descriptive, chart review study which includes historical data may be limited by recall and/or reporting bias. It was noted that not all history questions were recorded for each patient, likewise, not all examinations or x-ray reports were complete, therefore reporting bias was present. No set treatment protocol was utilized and because multiple combinations of treatments were used, definitive conclusions are difficult to draw. Finally, duration of care was based on when the athlete was cleared to begin the return to play process, actual time to return to play was unknown.

Conclusions

Spondylolysis in female volleyball athletes is not uncommon. While spondylolysis is more common in males, in volleyball this injury is more common in females due to differences in participation numbers. Female volleyball athletes with spondylolysis are older than females participating in other sports and older than males with the same diagnosis. History findings are similar in volleyball and non-volleyball athletes, as are most examination and imaging findings. Female volleyball players demonstrate a reduced DoC if treated exclusively with HEP vs. PT and with no-bracing vs. bracing. All volleyball athletes with spondylolysis played a front row position where jumping/landing are regularly utilized skills; OHs were at particular risk. Player position appears to play a role in where injuries take place with OHs experiencing significantly more unilateral left-side injuries compared to MBs, OPPs and setters. Further research should investigate possible reasons why OHs are at increased risk for left-side spondylolysis injuries.

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