Low Back Pain in Volleyball Players

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It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.

—Charles Darwin
272 competitive adolescent athletes involved in 31 different sports (158 males, 113 females, 15.4±2.0 years, body mass index [BMI] 20.3±2.4 kg/m2) enrolled in 10-month prospective clinical trial

Schmidt et al. 2014
LBP in Adolescents

Schmidt et al., 2014

14 %
57 %
66 %
Fig. 4 Relationship between existing (positive) and non-existing (negative) lifetime prevalence of LBP in the different sports (n = 272) "Schmidt et al., 2014"
LBP in Adolescents

- Retrospective cross-sectional study
- Students 18.5-24.5 years at Higher Institute of Sport and Physical Education of Sfax, Tunisia
  - LBP reported by 879/5,958 of study participants (14.8%)

Triki et al., 2015
LBP in Adolescents

- Prevalence of LBP significantly higher ($p>0.001$) in females (17.6%) than in males (12.5%)

Triki et al., 2015
Risk Factors for LBP

- Repeated axial loading and hyperextension
- Misalignment of shoulders during serve or spike (smash)
- Repetitive hyperextension and rotation (spike and jump serve)
Risk Factors for LBP

- Prolonged or frequent bending and twisting high loads or awkward postures
- Sudden and repetitive lumber flexion
- Repeated and heavy lifting (weight training?)
- Whole body vibrations
Effects of Warm-up?

- Lumbar spine stiffness increased as a result of bench rest after a warm-up
- Effect seen in both spine extension and lateral bend axes but not in flexion or axial twist axes
- However - no decrease in stiffness associated with the active warm-up portion of the task was seen

Green et al. 2002
Volleyball Injury Distribution

Figure 3. Anatomic frequency distribution of volleyball-related time-loss injuries reported to HS RIO and the NCAA ISS over a 4-year interval (2005-2006 through 2008-2009). HS RIO, High School Reporting Injuries Online; NCAA ISS, National Collegiate Athletic Association’s Injury Surveillance System.

Reeser & Gregory 2015
Spondylolysis/Spondylolisthesis

- Increased risk for developing stress fractures of the pars interarticularis of the vertebral bodies of the lower lumbar spine
  
  Soler & Calderon 2000

- Most commonly the level of the fourth or fifth lumbar vertebral body (L5 > L4)
Spondylolysis/Spondylolisthesis

- Risk for developing the condition (including beach volleyball players, track and field athletes, gymnasts, and weight lifters) ranges from 1.5 to 8 times the 3–7% rate found among the general population.

Soler & Calderon 2000
Spondylolysis/Spondylolisthesis

- Full maturation of the bony pars does not occur until around the age of 25
- Spondylolysis more common during active growth spurts
- Iliopsoas inflexibility, thoracolumbar fascia tightness, abdominal weakness, and thoracic kyphosis
- Hamstring tightness
Classification of Spondylolysis

Wiltse-Newman

I. Dysplastic
II. Isthmic
   IIA, Disruption of pars as a result of stress fracture
   IIB, Elongation of pars without disruption related to repeated, healed microfractures
   IIC, Acute fracture through pars
III. Degenerative
IV. Traumatic
V. Pathologic

Wiltse et al., 1975
Spondylolysis/Spondylolisthesis

• Epidemiology:
• Certain sports have a significantly greater prevalence:
  – gymnastics (11–30%)
  – American football (20%)
  – weight lifting (23–30%)
  – wrestling (30–35%)
• Incidence of pars interarticularis defects in female gymnasts is 4X that of the general white female population
Genetics and Spondylolysis

- Occurs in 15%-70% of first-degree relatives of individuals with the disorder.
- Lysis is 2-3X more frequent in boys than girls, but slippage affects girls 2-3X more often than boys.
- Prevalence is approximately 6% in the white population, a rate that is 2-3X higher than that in the black population.
  
  Soler & Calderon 2000

- In the Inuit population, the rate is as high as 25%.
  
  Hu et al. 2008
Physical Examination

- Localized pain
- Worse with extension
- 1-legged hyperextension ("stork test")
- Kemp test
  - "quadrant" test
  - extension-rotation test
- Sensitivity?
- Specificity?
Spondylolisthesis

- Decreased lordosis
- Tight hip flexors
- Tight hamstrings
- Decreased SLR and popliteal angle
- “Step” deformity

From Cavalier et al., 2006
Imaging for Spondylolysis/listhesis

- Xrays – AP, lateral, +/- obliques?
- Standing lateral – assess degree of slip

- Long term complications may occur in up to 25% of patients with spondylolysis:
  - Chronic LBP
  - Spondylolisthesis (15%)
  - Sciatica
Spondylolisthesis

- Grade I - translation of up to 25%
- Grade II - 26% to 50%
- Grade III - 51% to 75%
- Grade IV - 76% to 100%
- Grade V - >100% (spondyloptosis)
Bone Scan - Spondylolysis

- Technetium-99m ($^{99m}$Tc) methylene diphosphonate (MDP) bone scintigraphy
- Normal bone scan with pars defect is consistent with a healed (fibrous) process or non-union
- Prognostic value = sensitive tool for diagnosis of active spondylolysis
Bone Scan - Spondylolysis

- Sensitivity of bone scan increased with use of single proton emission computed tomography (SPECT)
- Bone scan with SPECT
  - Shows level of lesion
  - Assess activity (i.e. potential for healing)
- Single photon emission computed tomography (SPECT)/computed tomography (CT)
- Co-registered - fused image
- More precise localization of sites of abnormal bony uptake
- Identification of causes
- Identification of osseous abnormalities without associated abnormal radiotracer uptake

From Trout et al., 2015
Vertebral Pedicle Fractures

From Trout et al., 2015
Spinous Process Avulsions

From Trout et al., 2015
Value of SPECT CT- “See” other things

- Facet hypertrophy
- Endplate apophyseal abnormalities
- Degenerative disk disease
- Endplate compression fracture
- Persistent transverse process ossification centre
- Transverse process fracture
- Transitional vertebra (+ back pain = Bertolotti syndrome)
- Sacral stress fracture
- Sacroiliac joint syndrome
- Diskitis and osteomyelitis
- Benign or malignant tumor

From Trout et al., 2015
CT for Bony Architecture

Reverse gantry oblique axial

Campbell et al., 2005
# Radiation Doses

## Table 2: Typical Dose Ranges for SPECT and SPECT/CT of the Pediatric Spine

<table>
<thead>
<tr>
<th>Examination Component</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECT</td>
<td>2.3</td>
</tr>
<tr>
<td>CT</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.5</strong></td>
</tr>
</tbody>
</table>

Source.—References 17,18.

Note.—The SPECT dose depends on the amount of radiopharmaceutical administered. The CT dose depends on the CT parameters (kilovolt peak, milliampere-seconds) and scan length. At our institution, CT is limited to the area of interest to minimize the CT component of the total examination dose.
What About MRI?

- 39/40 pars defects seen on CT and SPECT also had some degree of abnormality on MRI, but MRI correctly graded only 29
- Several subjects had MRI findings consistent with edema in the pars but no abnormalities on SPECT
- Limitations of MRI in terms of correctly grading the pars lesions were particularly apparent in patients with a pattern of findings on SPECT and CT indicating a stress reaction in the pars without a clear fracture line

T-2 weighted images
From Nakayama & Ehara 2015

MRI only identified 80% of lesions

Masci et al., 2006

Campbell et al., 2005
MRI Sequences

- Need sequences sensitive to bone marrow soft tissue edema for detection of the secondary bone marrow changes that come with a fatigue fracture:
  - Sagittal T1-weighted FSE sequence
  - Sagittal T2-weighted fat-suppressed FSE and coronal T2-weighted
  - Inversion recovery (STIR) sequences
Suggested Imaging Protocol

Fig. 8 Suggested protocol for examination of adolescent back pain where there is suspicion of spondylolysis

From Campbell et al., 2005
### MRI Classification of Spondylolysis

#### TABLE 1. MRI Grading System (Hollenberg et al.\(^9\)) for Stress Injuries to the Lumbar Pars Interarticularis

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>MRI Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal pars interarticularis</td>
<td>Normal marrow signal, Intact cortical margins</td>
</tr>
<tr>
<td>1</td>
<td>Stress reaction</td>
<td>Marrow edema, Intact cortical margins</td>
</tr>
<tr>
<td>2</td>
<td>Incomplete stress fracture</td>
<td>Marrow edema, Cortical fracture incompletely extending through pars</td>
</tr>
<tr>
<td>3</td>
<td>Acute complete fracture</td>
<td>Marrow edema, Fracture completely extending through pars</td>
</tr>
<tr>
<td>4</td>
<td>Chronic established defect</td>
<td>No marrow edema, Fracture completely extending through pars</td>
</tr>
</tbody>
</table>
Treatment of Spondylolysis

Early

Progressive

Terminal
Management of Spondylothesis

• Assessment of:
  – Flexibility (hamstrings)
  – Lower limb alignment (including leg lengths)
  – Foot structure (cavus vs flat feet)
  – Motor function (strength imbalances)

• Flexibility training and dynamic lumbar spinal stabilization exercises
Management of Spondylolysis

- Relative rest with appropriate activity modification x 3 months
- Bracing to minimize extension and resultant shear forces across the affected spinal segment?
- Only necessary for those individuals who remain symptomatic despite limiting their activity, or who require a physical/tactile reminder to avoid provocative activities
Bracing & Biomechanics

• Bracing
  – Controversial
  – Differing views in literature
  – Patients reported to heal with or without it
  – If used, what type?
    • Boston brace
    • Soft brace?
Use of Rigid Bracing

- Anti-lordotic modified Boston brace
- 23/24 hours
- 6 months with 6 month wean
- Stretching, strengthening
- Sports allowed in brace if no pain
- 52/67 (78%) excellent or good

Steiner & Micheli 1985
Dianne Murray – Coach UBC Thunderbirds 1977/78 CIAU champs
Bracing

- Bracing
  - With brace, 89% clinical success
  - Without brace, 86% clinical success
  - Not statistically significant, \( p=0.75 \)
- Data imply bracing not responsible for clinical improvement
- “Strong impetus to reconsider bracing as standard treatment”

Klein et al., J Pediatr Orthop, 2009
Management of Spondylolysis

- Athletes are allowed to return to sports when they have full, pain-free ROM, have achieved appropriate conditioning, spinal awareness, and sport-specific training, and can demonstrate sport-specific skills in a controlled environment without pain

Standaert & Herring 2007
Management of Spondylolysis

• In general, rehabilitation requires 2-4 months to complete, resulting in a return to sports approximately 5-7 months after diagnosis

Standaert & Herring 2007
Need for Follow-up Imaging?

- Bilateral pars defects or unilateral defect in a very young athlete requires routine standing lateral radiographs every 6 to 12 months until skeletal maturity is reached.

- Slip progression occurs during adolescent growth spurt.
Management of Spondylolysis

• Radiographically documented pars interarticularis defects that are “cold” on bone scan probably represent remote injuries and have little chance of bony union

• Treat to control pain, not achieve union
Evidence-Based Outcomes

• Good evidence that when chronic bilateral pars defects exist – 43-74% will progress to isthmic spondylolisthesis
• Low likelihood for progression of spondylolisthesis, especially if the initial slip is < 30 %
• Unilateral, incomplete & early lesions can obtain bony union
• Short-term resolution is norm either with/without bony union

Crawford et al., 2014
Kreiner et al., 2016
Indications for Surgery

• Classic indications for surgery:
  – failure of comprehensive conservative treatment for > 6 months
  – persistent back pain & pars non-union at 9–12 months (pars pseudoarthrosis)

• Increasing pain, worsening of preexisted neurological impairment and progressive olisthesis
Surgery

- Posterolateral fusion with or without instrumentation
- L5 - S1 “in situ fusion” with autogenous iliac crest bone graft
- Direct repair for spondylolysis and spondylolisthesis < 3 mm with normal disc
Degenerative Disc Disease

- Prevalence of disc alterations (including disc degeneration, bulging, and herniation) of 44% in volleyball players

Bartolozzi et al., 1991
Beach Volleyball – Bondi Beach
LBP in Professional Beach VB

- Cross-sectional study
  - 29 males
  - Mean age 28 years
  - Questionnaires, clinical examination and MRI

- 86% LBP during career
- 35% LBP in past 4 weeks
- 61% LBP in past 12 months
- No correlation between LBP and MRI changes

Külling et al. 2014
LBP in Professional Beach VB

- **23/29 (79%)** – at least 1 degenerated disc
  - L4-5 (48%), L5-S1 (52%)
  - 5 players (17%) – both
- **6/29 (21%)** spondylolysis
- **2/6 (33%)** spondylolisthesis
- (5% in general population)
Sacral Stress Fractures

• Insidious low-back, buttock, or vague pelvic pain

• Risk factors:
  – Insufficiency – normal loads to abnormal bone
  – Osteoporosis – Female Athlete Triad, RED-S
  – Fatigue – abnormal loads to normal bone
  – Recent increase in training intensity and deficient diet
Examination – Sacral Stress Fractures

- Pain with single-leg hop
- Tenderness to palpation of the sacrum
- +’ve Flexion, ABduction, and External Rotation tests (FABER or Patrick’s)
- Negative SLR
- Normal neurologic examination
Differential Diagnosis

- Sacroiliitis (inflammatory)
- Spondylolysis (pars defect)
- Piriformis pain
- SI joint dysfunction
- Back strain, radiculopathy
- Scoliosis, juvenile disc disorder, Scheuermann’s kyphosis
Figure 1 - A bone scan showing the increased uptake in the right sacral region
Treatment of Sacral Stress Fractures

- WB as tolerated until able to ambulate without pain (10 to 14 days)
- Nonimpact cross-training for 6 to 8 weeks, then resumption of running or impact activity
- Correction of risk factors: pelvic obliquity, core strength, and presence of Female Athlete Triad/RED-S low energy availability
Adapted Volleyball

• Adapted volleyball may be played by individuals with a variety of physical and mental impairments and disabilities including (but not limited to):
  – limb amputation
  – neuromuscular disorders
  – hearing loss (deafness)
Sitting Volleyball

i. Smaller court (10 X 6m total dimension, compared to 18 X 9m for the standing game)

ii. Lower net (1.15m for men/1.05m for women vs 2.43m for men/2.24m for women in regular volleyball)

iii. Participants must remain “seated” during competition (the rule stipulates that it is obligatory for a player’s buttock or part of the athlete’s torso to remain in contact with the floor at all times)
International Competition

- Sitting volleyball players must meet “minimum standard of disability”
- Classification defines their sport-specific level of functional limitation:
  - level of amputation
  - muscle strength
  - joint range of motion
  - differences in limb length
International Standards

- Minimum team standards
- “Class allocation”
- Minimal disability (MD) and disabled (D)
- Only one out of six players on court may carry a “minimal disability” classification
Lower Body Amputations and LBP

- Amputations affect activation of gluteal muscle group (namely gluteus medius) & creates Trendelenberg gait
- Constant lumbar side flexion toward amputated side during stance phase creates muscle tone through the paraspinals and quadratus lumborum
- Creates difficulty when trying to side bend the other way - i.e. an outside attacker who has to reach for an outside set
Lower Body Amputations and LBP

- Decreased mobility in the hip on the amputated side due to tighter hip flexors, adductors, quads, lateral rotators and hamstrings
- This tightness in the hip creates even more problems when players go to sit on the ground
Lower Body Amputations and LBP

- When players go to sit in the 'side saddle' position, and hips are not mobile enough to accommodate, they will strain through their low back.
- Different effect depending on whether the amputation is on the same side of their dominant or hitting arm.
Adapted Beach Volleyball

- Played with 3 players on a team:
  - Sitting beach VB court - 4m X 4m
  - Standing beach VB - 8m x 8m court
- Only 1 minimal disability athlete may be included per team (equivalent of a class A standing player)
- Remaining 2 players (no substitutions allowed) must be the equivalent to a standing class B or C rating
- Sitting & standing beach VB, standing indoor VB not in Paralympics
- Inaugural world championships in sitting & standing beach VB in 2016!
References


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