1

Disclosure

I have no financial relationships or conflicts of interest to disclose in relation to this presentation. This is an educational presentation. All content and recommendations are based on the best available evidence and are free from commercial influence or bias.

2

Biography

- Earned a BS in Legal Studies and AS in Paralegal Studies from Mountain State University in 2001
- Graduated from Palmer College of Chiropractic's West Campus in 2006.
- Served as faculty clinician at Palmer Florida for nine years.
- Served as Director of Clinics at Palmer Florida for five years.
- Named Dean of Clinics at Palmer Florida in 2023.

- Certifications and Workshops
  - Certified Chiropractic Sports Physician 2010
  - Safe Sport Trained
  - McMaster University – Evidence Based Practice Workshop
  - Process for Integrating Evidence (PIE) for CAM Educators

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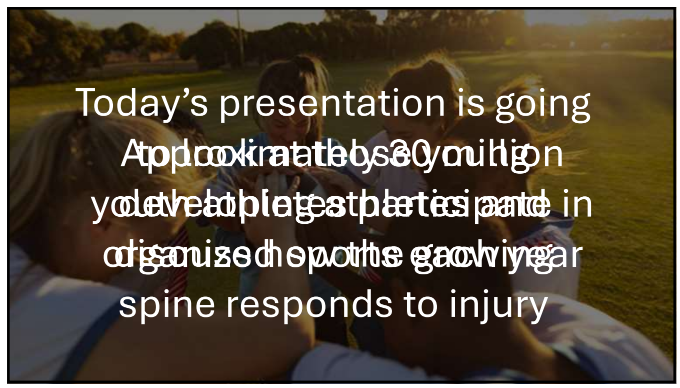
3



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NCHS Data Brief ■ No. 441 ■ August 2022

Organized Sports Participation Among Children Aged 6–17 Years: United States, 2020

Lindsey I. Black, M.P.H., Emily P. Terlizzi, M.P.H., and Anjel Vahratian, Ph.D., M.P.H.

Sports team participation has been associated with increased levels of physical activity (1) and improved physical and mental health among children and adolescents (2,3). Disparities in sports participation have been found across age, sex, race, disability, and socioeconomic subgroups (4–6). This report describes national estimates of parent-reported organized sports participation during the past 12 months among children aged 6–17 years. Data from the 2020 National Health Interview Survey (NHIS) are analyzed by sociodemographic characteristics.

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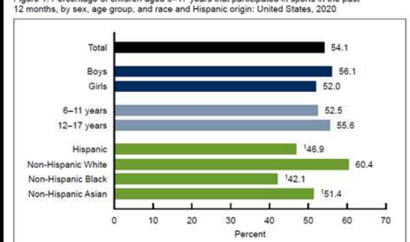
Figure 1. Percentage of children aged 6–17 years that participated in sports in the past 12 months, by sex, age group, and race and Hispanic origin: United States, 2020



[1]Significantly different from non-Hispanic White children ($p < 0.05$).
NOTES: Estimates are based on household interviews of a sample of the U.S. civilian noninstitutionalized population. Access data table for Figure 1 at: https://www.cdc.gov/nchs/data/databriefs/db441-tables.pdf#1.
SOURCE: National Center for Health Statistics, National Health Interview Survey, 2020.

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Benefit in participation in sports

- Great source of physical activity
- Helps build positive relationships
- Supports healthy discipline and good worth ethic
- It has also been shown that physical activity from sports is carried through into adulthood

7

Potential risk from participation in sports

- The body is under constant growth and development
- Growing competitiveness and desire to achieve a lot through their sport.
- Injury can impact the athlete social, academically and psychologically

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National Health Statistics Reports

Number 99 ■ November 18, 2016

Sports- and Recreation-related Injury Episodes in the United States, 2011–2014

by Yahtyng Sheu, Ph.D., Li-Hui Chen, Ph.D., and Holly Hedegaard, M.D., Office of Analysis and Epidemiology

Objective—Much of the research on sports- and recreation-related injuries focuses on a specific population, activity, or type of injury, and national estimates of the total burden of sports- and recreation-related injuries are limited. This study provides national estimates of the injury burden and examines the distribution of sports- and recreation-related injuries across demographic groups, activities, and injury circumstances.

Methods—Information on medically attended injury episodes for persons aged 5 years and over were obtained from the 2011–2014 National Health Interview Survey. Sports- and recreation-related injuries are categorized by the associated activity using a classification scheme based on the *International Classification of External Causes of Injury*.

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National Health Statistics Reports ■ Number 99 ■ November 18, 2016 Page 7

Table 1. Estimated annual number, percentage, and age-adjusted rate of sports- and recreation-related injury episodes among persons aged 5 years and over, by selected characteristics: United States, 2011–2014

Characteristic	Number, in thousands (percent)[1]	Rate (95% CI)[2]
Total	8,599 (100.0)	34.1 (31.6–36.5)
Sex		
Male	5,275 (61.3)	[3]41.2 (37.6–44.8)
Female	3,324 (38.7)	27.0 (23.7–30.2)
Age group (years)		
5–14	3,179 (37.0)	[3]76.6 (68.4–84.8)
15–24	2,400 (27.9)	55.6 (47.9–63.4)
25–44	1,790 (20.8)	21.9 (18.4–25.3)
45 and over	1,229 (14.3)	9.8 (7.9–11.7)
Male:		
5–14	1,823 (34.7)	[3]86.0 (74.4–97.6)
15–24	1,498 (28.4)	68.7 (57.1–80.2)
25–44	1,179 (22.3)	29.2 (23.5–34.9)
45 and over	775 (14.7)	13.1 (10.0–16.2)
Female:		
5–14	1,356 (40.8)	[3]66.8 (55.6–78.1)
15–24	902 (27.1)	42.3 (32.2–52.4)
25–44	612 (18.4)	14.7 (10.7–18.8)
45 and over	454 (13.7)	6.8 (4.7–9.0)
Race and ethnicity		
Hispanic	961 (11.2)	18.3 (15.1–21.6)
Non-Hispanic white	6,172 (71.8)	[3]42.5 (38.8–46.2)
Non-Hispanic black	769 (8.9)	23.6 (18.5–28.7)
Non-Hispanic other races	696 (8.1)	33.1 (25.1–41.2)
Place of injury occurrence		
Home (inside)	374 (4.0)	1.3 (0.8–1.8)
Home (outside)	1,101 (12.8)	4.6 (3.7–5.5)
School	1,961 (22.9)	8.6 (7.4–9.8)
Street, highway, curb	494 (5.8)	1.8 (1.3–2.3)
Sport facility, athletic field, playground	2,973 (34.7)	[3]11.4 (9.9–12.8)
Park or recreation area	785 (9.1)	2.9 (2.2–3.6)
River, lake, stream, ocean	361 (4.2)	1.3 (0.8–1.8)
Other	547 (6.4)	2.1 (1.5–2.7)
Place of medical care[4]		
Call to medical professional	250 (2.9)	0.9 (0.6–1.3)
Doctor's office or clinic	4,298 (50.0)	[3,5]16.5 (14.7–18.2)
Emergency vehicle	388 (4.5)	1.4 (1.0–1.9)
Emergency department	3,150 (36.6)	[5]13.1 (11.6–14.6)
Hospitalized overnight	229 (2.7)	0.9 (0.5–1.3)
Anyplace else	283 (3.2)	1.2 (0.6–1.7)

[1]Numbers and percentages may not sum to total due to rounding.
[2]Rates are per 1,000 persons with 95% confidence interval (CI).
[3]Indicates highest rate within the group (p < 0.05).
[4]Mutually exclusive categories using the highest level of medical care received based on the following hierarchy: hospitalized overnight, emergency department visit, attendance by an emergency vehicle, doctor's office or clinic visit, call to a medical professional or poison control center, or care received anyplace else.
[5]Indicates rates were similar between doctor's office or clinic and emergency room, but higher than other places of medical care (p < 0.05).
SOURCE: NCHS, National Health Interview Survey, 2011–2014.

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National Health Statistics Reports ■ Number 99 ■ November 18, 2016 Page 9

Table 3. Estimated annual number, percentage, and rate of sports and recreation injury episodes for persons aged 5 years and over, by leading types of activities and age group: United States, 2011–2014

	5–14 years			15–24 years			25 years and over		
Order	Activity	Number, in thousands (percent)	Rate (95% CI)[1]	Activity	Number, in thousands (percent)	Rate (95% CI)[1]	Activity	Number, in thousands (percent)	Rate (95% CI)[1]
1	General exercise[2]	417 (13.1)	10.1 (7.2–13.0)	Basketball	343 (14.3)	7.9 (5.2–10.6)	General exercise[2]	662 (21.9)	3.2 (2.4–4.0)
2	Football	375 (11.8)	9.0 (6.1–11.9)	General exercise[2]	324 (13.5)	7.5 (4.5–10.5)	Recreational sport[3]	362 (12.00)	1.7 (1.1–2.3)
3	Playground	309 (9.7)	7.4 (4.9–10.0)	Soccer	257 (10.7)	6.0 (3.6–8.3)	Basketball	264 (8.8)	1.3 (0.8–1.8)
4	Gymnastics/ cheerleading	302 (9.5)	7.3 (4.7–9.9)	Football	243 (10.1)	5.6 (3.1–8.2)	Pedal cycling	222 (7.4)	1.1 (0.6–1.5)
5	Pedal cycling	257 (8.1)	6.2 (3.8–8.6)	Gymnastics/ cheerleading	145 (6.0)	3.4 (1.2–5.3)	Water sport	213 (7.1)	1.0 (0.6–1.5)
...	Total	3,179 (100.0)	76.6 (68.4–84.8)	Total	2,400 (100.0)	55.6 (17.9–63.4)	Total	3,019 (100.0)	14.6 (12.8–16.3)

... Category not applicable.
[1]Rates are per 1,000 persons with 95% confidence interval (CI).
[2]Includes aerobics, exercising, weight training, running, and nonspecific school-related sports- and recreation-related activities.
[3]Includes tennis, racquetball, badminton, and other racquet sports, as well as golf, bowling, fishing, hunting, hiking, mountain climbing, and other leisure sports.
SOURCE: NCHS, National Health Interview Survey, 2011–2014.

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Age	Gender	Sport	Physical fitness
• Adolescent athletes have a higher risk of injury due to harder play and increasing hours of participation	• Male athletes have a higher incident of injury	• High risk sports – contact and jumping sports more likely to result in injury • Position played	• Previous injury • One study found obese adolescents at 34% increased risk of injury

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Developmentally, children are not small adults

Their injuries are unique to their age and may present differently than what we are used to seeing in our older athletes

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Anatomy Review

- Like the growth plates in our extremities, vertebral bodies have cartilaginous growth centers that are smaller and more elastic than adults
- And these vertebral end plates in the spine do not fuse to the accompanying vertebral body until much later in the teen year
- In fact, a child's spine continues to grow and develop from birth until full ossification at 25 years old
- Because of the musculoskeletal development of our young athletes, they are prone to acute and overuse injuries that are unique to the pediatric patient.

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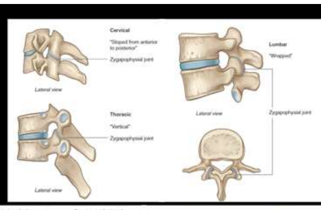
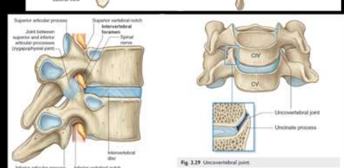
Anatomy Review (Adult segments)

- Cervical Z-Joints slope inferiorly from anterior to posterior
  - Facilitate Flex/Ext
- Typical cervical vertebral have uncinate process that curve up to articulate with the body of the vertebra above
  - Stability and motion guidance
- Thoracic Z-Joints oriented vertically
  - Limit Flex/Ext
  - Facilitate Rotation
- Lumbar Z-Joints are curved and interlock
  - Limit range of motion
  - Flex/Ext primary motion





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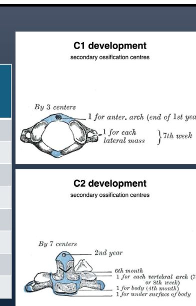
Fusion of Spinal Ossification Centers(Taylor)

OSSIFICATION CENTER	AGE OF APPEARANCE (YEARS)	AGE OF FUSION (YEARS)
C1 Posterior Arch	Birth	3
C1 Anterior Arch	Birth-1	6-7
C1 Tip of Transverse Process	18	21-25
C2 Odontoid	Birth	4
C2 Tip of Odontoid	3-6	8-12
C2 Body	Birth	4
C2 Neural Arch (Laminae)	Birth	2
C2 Endplate Ring Apophysis	Puberty	22-25



Adopted from *Skeletal Imaging: Atlas of the Spine and Extremities*

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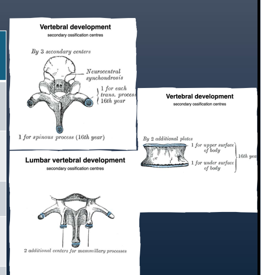
Fusion of Spinal Ossification Centers(Taylor)

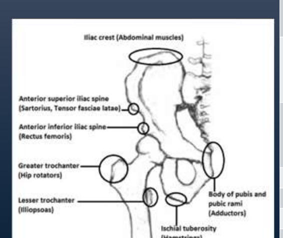
OSSIFICATION CENTER	AGE OF APPEARANCE (YEARS)	AGE OF FUSION (YEARS)
C3-C7 Vertebral Body T1-T12 L1-L5	Birth	3 4-5 5-6
C3-C7 Neural Arches (Laminae) T1-L4 L5	Birth	1 1-1.5 5
C3-C7 Endplate Ring Apophyses T1-L5 Ring Apophyses	11-12 11-16	17-18 17-25
T1-L5 Spinous Processes Transverse Processes Articular Processes	11-16	17-25
L1-L5 Mamillary Processes	11-16	17-25



Adopted from *Skeletal Imaging: Atlas of the Spine and Extremities*

17

Fusion of Spinal Ossification Centers(Taylor)



OSSIFICATION CENTER	AGE OF APPEARANCE (YEARS)	AGE OF FUSION (YEARS)
Ilium	Birth	14 w/ Ischium and Pubis
Ischium	Birth	4-8 w/ Pubis 14 w/ Ischium
Pubis	Birth	4-8 w/ Ischium 14 w/ Ilium
Iliac Crest Apophysis	14-16	18-25
Iliac Spine	16	18-25
Pubic Symphysis	16	18-25
Ischial Tuberosity Apophysis	16	18-25

Adopted from *Skeletal Imaging: Atlas of the Spine and Extremities*

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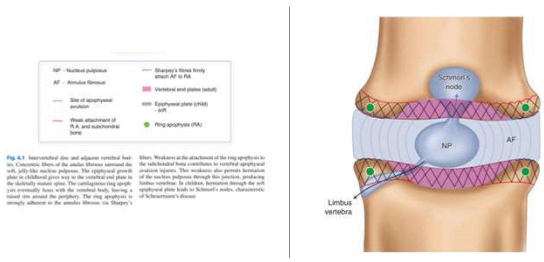

Micheli, L., Purcell, L. (eds) The Adolescent Athlete. Contemporary Pediatric and Adolescent Sports Medicine. Springer, Cham. https://doi.org/10.1007/978-3-319-56188-2_6

19

Imaging Consideration

- X-rays are indicated for athletes who suffer a traumatic injury
  - Especially if positive clinical findings are present
- Important to know the difference in anatomy from adults
- Vertebral fractures and facet joint dislocations are best demonstrated on CT
- MRI is useful for paraspinal musculature, spinal ligaments and IVD
  - MRI should also be ordered when neurological deficits are present, or you suspect a spinal cord injury

20

Cervical Spine Anatomy of a child is different than that of an adult

- ➢ Incomplete ossification
- ➢ Immature facets and uncinate processes
- ➢ More horizontally oriented cervical facets
- ➢ Increased capsular and spinal ligament laxity
- ➢ Less developed cervical musculature

- These differences in cervical spine anatomy result in increased hypermobility and elasticity of the cervical spine
- The cervical vertebral anatomy achieves adult-like proportions and mechanical properties at 8-10 yoa

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Cervical Spine – Soft Tissue Injuries

Most common conditions
Ligament sprain, paraspinal muscle strain, and stingers of brachial plexus and cervical nerve roots

In many sports, forces and injuries occur that result in whiplash type of injuries

Less debilitating injuries in children
Increased elasticity and mobility
leads to quicker recovery

22

Cervical Strain

- ➢ Rapid muscle contraction is most common cause of muscle strain
- ➢ Resistive flexion or extension
- ➢ Due to direct blow/trauma to the paracervical muscles

- Collision sports are more susceptible to muscle strain injuries
  - Wrestling, football, soccer, lacrosse, boxing and rugby
- Strains can also occur with fast movement during any sport

23

Cervical Sprain

- ➢ Forced flexion of the head and neck
- ➢ Extreme hyperflexion or hyperextension
- ➢ Twisting and rotation
- ➢ Capsular injury to the facet

- Sports susceptible to muscle sprain injuries
  - Gymnastics, Diving

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Diagnosis and Management

- Important to rule out serious pathology
  - Imaging Indicated due to trauma and clinic findings are present
- The patient may present with local pain, tenderness and swelling
  - Spasm will accompany muscle strain
- Treatment to address pain management
  - Rest and avoid activities that may stretch or irritate the injured tissue
  - Adjustments as indicated
- Move to rehab program when symptoms subside
  - Begin with gentle stretching
  - Move to strengthening exercises as tolerated

25

Return to Activity

- Gradual return to normal activities
- Avoid contact or high-risk sports until fully healed
- Monitor progress upon return to activity

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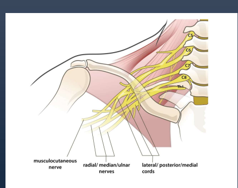
Stinger



Adapted from Dynamed:

- ➢ Traction injury to the brachial plexus due to forceful contralateral stretch
- ➢ Compression of the upper cervical nerve roots
- ➢ Rare in children under 10 years of age
- ➢ More common in adolescents and teens
  - ➢ Half of all high school football players report at least 1 stinger during their career
- Collision sports are more likely to result in a stinger injury

  Football, wrestling, rugby, hockey, gymnastics, boxing, and weightlifting

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Classification Systems

Referenced on Dynamed (Stingers/Burners) Background Information

- Seddon classification of nerve injuries
  - grade 1 (neurapraxia)
    - nerve stretch injury, with axonal integrity maintained
    - leads to transient, incomplete sensory or motor deficits
    - typically resolve within minutes
  - grade 2 (axonotmesis)
    - axon (and myelin sheath) damaged, and Wallerian degeneration occurs distal to the injury site
    - epineurium, Schwann cells, endoneurium, and perineurium remain intact
    - axonal regrowth occurs at 1-2 mm per day
    - motor deficits are more significant, and may be associated with sensory loss, although incomplete
    - most deficits resolve within several weeks, but complete recovery can take up to 18 months
  - grade 3
    - complete disruption of axons, endoneurium, perineurium, and epineurium
    - leads to complete sensory and/or motor deficits, persisting for ≥ 1 year
    - regeneration may occur in disorganized fashion, and often requires operative repair
    - recovery of grade 3A (neurotmesis) injuries are unlikely, while grade 3B (nerve root avulsion) injuries are irrecoverable

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Diagnosis

- Usually C5-6 motor and sensory distribution
- Transient burning and weakness in a single upper extremity, extending to the tips of fingers
- Neck pain and decreased cervical range of motion
- Rule out other pathology
- Grade 1 resolves within seconds to minutes
- Imaging not indicated if full recovery in 5 minutes
- Sideline management: withdrawal from play until symptoms resolve

29

Management (non-operative condition)

- Persistent symptoms beyond the game or 24 hours after injury
  - Imaging workup indicated
    - X-rays to evaluated the extent of the injury
    - CT to evaluate for fracture
    - MRI to evaluate the spinal cord and soft tissue
    - EMG for persistent muscle weakness
- Rest
- Adjustments
  - Especially to the thoracic spine
- Pain control
- Rehabilitation
  - Restore normal range of motion and strength
  - Strengthening exercises to the shoulder

30

Return to Activity for persistent symptoms

- Once pain, paresthesia's, neurologic deficits, and limited ROM have resolved
- UNLESS repeated injury, bilateral involvement or persistent weakness
- Repeated injuries in the same season and the athlete should be removed for the season

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Cervical Cord Neurapraxia (CCN)

➢Transient neurological deficit following trauma
➢Localizing to the cervical spinal cord
➢Hyperextension, hyperflexion or axial loading

- Mostly due to hypermobility of the cervical spine
- Congenital narrowing of the spinal canal may be a predisposing cause

- Prevalence in young athletes is unknown compared to mature athletes
  - Occurrence rate of 7 in 10,000

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Cervical Cord Neurapraxia (CCN)

- Forced hyperflexion or hyperextension results in a pincer mechanism of the spinal cord
  - An acute narrowing of the spinal canal

- The spinal canal will return to its normal diameter without structural damage

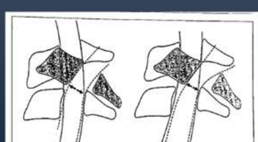

Figure 1 Extreme hyperextension of the cervical spine can result in an acute narrowing of the spinal canal. This "pincer" mechanism causes transient cervical cord compression and results in transient quadriplegia or quadriparesis. (Reproduced with permission from Torg J, Ramsey-Emrhein J: Cervical spine and brachial plexus injuries: Return to play recommendations. *Phys Sportsmed* 1997;25:60-88.)

Herman M. J. (2006). Cervical spine injuries in the pediatric and adolescent athlete. Instructional course lectures, 55, 641–646.

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Diagnosis and Management

- Transient quadriplegia
- Temporary burning, loss of sensation and tingling in the extremities
  - With or without motor dysfunction
- Full Recovery usually within 15 minutes
- Sensory changes may persist up to 2 days
  - On field, do not return to play. Immobilize c-spine and transport
- MRI needed to rule out serious injury
- Rest
- Adjustments
  - As indicated and tolerated
- Pain control
- Rehabilitation
  - Restore normal range of motion and strengthening the cervical spine musculature

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Return to Activity

- Graduate return to activity
- Must be symptom free
- Regained full strength and sensation
- Persistent symptoms require further investigation

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Cervical Spine – Serious Injuries

Spinal injuries are rare, but they do occur.
One fourth of all acute cervical spine injuries in children are due to sports.
4th leading cause of spinal cord injuries in adolescents following MVA, falls and violence.

Serious injuries may present like common cervical spine injuries
Fracture, ligament disruption, spinal instability, disc herniation and spinal cord injury

Adolescent athletes develop more serious cervical spine injuries than younger children, most likely due to intensity of play

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Cervical Spine Fracture

- Young athletes
  - Upper cervical spine (C1 and C2) fractures more common
  - Larger body ratio, higher center of gravity and ligament laxity due to insufficient neck musculature

- Burst (Jefferson) Fracture of C1
  - Multiple breaks in the ring of C1 due to axial loading: gymnastics and wrestling
- Odontoid fracture of C2
  - One of the most common due to the developing spine: football and rugby
- Hangman's fracture of C2
  - Break in the pars due to violent hyperextension: football and gymnastics

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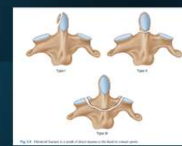


Fig. 5.7 Jefferson's fracture involves the ring of C1 and may involve the anterior and posterior arch

Micheli, L., Purcell, L. (eds) The Adolescent Athlete. Contemporary Pediatric and Adolescent Sports Medicine. Springer, Cham. https://doi.org/10.1007/978-3-319-56188-2_6

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Cervical Spine Fracture

- Adolescent athletes
  - Lower cervical spine fractures more common
  - At 8 yoa, athletes are more likely to sustain fractures at the C5-C6 level
  - At 10 yoa, the cervical spine begins to resemble the adult spine and injuries resemble those of adults
  - Adolescents have well-developed musculoskeletal systems and injuries become more localized to the cervicothoracic region

- Clay-Shovelers fracture
  - Spinous process fracture due to forceful contract or direct hit: Football, wrestling, weightlifting, rugby
- Compression fracture
  - Soft and pliable bones injured during axial compressions: gymnastics, diving and wrestling
- Teardrop fracture to anterior body
  - Serious injury
  - Violent flexion or extension: gymnastics and football
- Cervical Vertebral Epiphysiolysis
  - Growth plates are damaged due to repetitive or acute trauma: gymnastics, weightlifting and football

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Cervical spine fracture

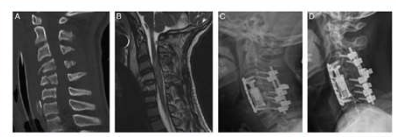

FIGURE 4. Lateral cervical spine computed tomography (A) and magnetic resonance imaging (B) demonstrating C4 and C5 burst fractures in a 15.8-year-old male hockey player who presented with quadriplegia due to a hyperflexion/axial loading injury. Postoperative radiograph (C) after circumferential C3-C6 fusion (C4/C5 corpectomies, intervertebral cage, anterior cervical plate, and bilateral C3, C5, and C6 lateral mass screws). Excellent fusion and cervical alignment are seen 7 years postoperatively with partial return of neurological function to American Spinal Injury Association Impairment Scale grade B (D).

Verhofste, B. P., Hedequist, D. J., Birch, C. M., Rademacher, E. S., Glotzbecker, M. P., Proctor, M. R., & Yen, Y. M. (2021). Operative Treatment of Cervical Spine Injuries Sustained in Youth Sports. Journal of pediatric orthopedics, 41(10), 617–624. https://doi.org/10.1097/BPO.0000000000001950

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Spinal Cord Injury without Radiographic Abnormality (SCIWORA)

- Traumatic flexion, extension or rotation injury without fracture or dislocation
- Clinical evidence of spinal cord injury
- Normal x-ray and CT exams

- More common in young children due to due to their hypermobility and ligament elasticity
- SPORTS is the most common cause of SCIWORA in children
- The spinal column stretches without breaking resulting in damage to the spinal cord
  - Spinal column can stretch up to 2 inches. The spinal cord cannot.
- Sports at greatest risk for spinal cord injury
  Gymnastics, Football (contact sports), diving

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SCIWORA and CONCUSSION

- The most common cause of SCIWORA in children is violent trauma
- Presents similarly to sports-related concussions
- The 2 diagnoses often present together

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Diagnosis

- Clinical presentation of spinal cord injury
  - Pain, numbness, tingling, weakness and paralysis
- Symptoms may be delayed
- A detailed neurological exam and xrays performed initially to evaluate the spine
- MRI is the best diagnostic tool
  - BUT it may also be normal
  - 12-15% of children have normal MRI findings
- Severity ranges from transient symptoms to complete cord rupture

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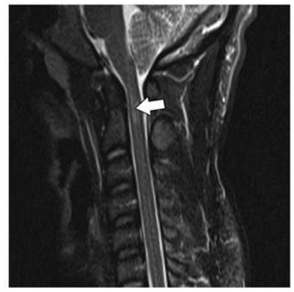

Fig. 2 —16-year-old boy with Glasgow Coma Scale score of 13 and motor and sensory deficits after football tackle. Sagittal STIR image shows short-segment nonhemorrhagic cord contusion (*arrow*) at atlantoaxial junction. Bone and ligamentous structures are intact. Diagnosis of spinal cord injury without radiographic abnormality is appropriate in this setting and for patients in this age group.

Dreizin, D., Kim, W., Kim, JS. Will the real SCIWORA please stand up? Exploring clinicoradiologic mismatch in closed spinal cord injuries AJR Am J Roentgenol. 2015; 205:853-860

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Management

- Surgical consult if suspected
- Immobilization for up to 12 weeks in non-surgical cases
- Worst prognosis in children less than 8
  - Increased head size and weak cervical muscles

45

Return to Activity

- No consensus on return to activity following a SCIWORA
- Patient must be fully resolved
- Each case is unique and different

46

Thoracic Spine Injuries

Not as common or severe has cervical spine injuries

Sprain/strain injuries are common and present similar to cervical spine injuries
Twisting, lifting and excessive movement

Traumatic injuries and compression fractures are also common in the thoracic spine

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Scheuermann Disease (Kyphosis)

- Often occurs during growth spurts (10-15 years)
- Excessive physical stress near the time of end plate maturation
- Load bearing, increased mobilization exercises and heavy weightlifting
- Microtrauma resulting in end plate fractures

- Sports with high likelihood
  Gymnastics, rowers and weightlifting

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Schmorl Node

- Common in lower thoracic and upper lumbar spine of adolescents
- Associated with Scheuermann Disease
- Nucleus pulposes herniates between vertebral body and ring apophysis

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Scheuermann Disease Diagnosis

- Postural deformity, pain and fatigue
  - Rigid and unable to correct with posture changes
- Thoracic kyphosis 40-50 degrees
- X-rays reveal 3 adjacent vertebra with anterior wedging
- Irregular end plates, Schmorl nodes and disc space narrowing
- Neurological and respiratory findings may be present in severe cases, requiring a surgical consult

50

Management

- Bracing may be necessary for severe cases
  - Milwaukee brace (spinaltech.com)
- Keep weightlifting at or below the athlete's body weight until skeletal maturity
- Rehab to focus on flexibility and strengthening of the spinal muscles
- Core stability exercises
- Postural training
- The condition stabilizes at spinal maturity

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FIG. 13-18 Lateral thoracic x-ray showing Scheuermann's disease. Notice the roughened bony superior and inferior end plates, particularly of those vertebrae indicated by the asterisks.

Figure 15. A lateral radiograph of the spine in a patient with Scheuermann kyphosis. The arrow indicates end-plate irregularities.

Fig. 12 Early Scheuermann disease in a 10-year-old male gymnast, presenting with back pain and increased thoracic kyphosis. Lateral radiograph (a) shows anterior wedging and irregular endplates of thoracic vertebrae T4 to T9. Sagittal T2-weighted (b) and T1-weighted (c) MR images show additional marrow edema adjacent to the vertebral endplates. The findings are suggestive of Scheuermann disease, early stage

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Return to Activity

- Athletic participation usually permitted when asymptomatic although contact and high risk sports may be contraindicated
- Swimming, yoga and low impact activities are good for the athlete
- Football, gymnastics and wrestling may need to be avoided until the spine is stabilized
- If returning to activity, the athlete's condition should be monitored for worsening symptoms

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Thoracic Vertebra Compression Fracture

- Traumatic, axial loading injury due to a fall on buttock or collision
- Occurs in young athletes due to the developing nature of the bone

- Sports with high likelihood

  Gymnastics, diving, football, weightlifting, skiing, snowboarding and skateboarding

54

Diagnosis and Management

- Mid back pain especially at the injury site
- Movement makes the pain worse
- Imaging indicated looking for anterior wedging of the vertebra
  - Xray or CT for fracture
  - MRI to evaluate for spinal cord injury
- Pain management initially
- Bracing may be useful in severe cases
- Surgery is rarely required unless severe collapse or neurological deficits

55

Return to activity

- Compression fractures usually heal within 12 weeks
- Gradual return to sport
  - Begin with light activity, moving to more intense, high impact participation gradually
- Important to strengthen the area and work on core stability
- Full return should occur after the fracture has completely healed

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Lumbar Spine Injuries

Back pain in pediatric patients is uncommon and may represent a more serious pathology

Important to evaluate for structural problems when low back pain is present because the incident of a sprain/strain in a pediatric lumbar spine is much less frequent than other types of injury

Overtraining has been shown to correlate with low back pain in child athletes

57

Spondylolysis

- Rare in children <5 yoa
- Most prevalent in 10–15 year old athletes
- Represents 40% of LBP cases that persist longer than 3 months
  - Most common cause of low back pain in pediatric athletes
- 70% of cases involve L5-S1, less common at L4-L5
  - Rare above L3
- Repetitive stress injury to the pars interarticularis, often bilateral
- Longstanding hyperextension and axial loading during childhood

- Sports with high likelihood
  Gymnastics, dancing, cheerleading, figure skating, diving, football, weightlifting and running

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- Usually bilateral
- Unilateral presentation results in sclerosis and enlargement of the contralateral pedicle
- Spondylolisthesis anterior displacement of the superior vertebra on the inferior

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Spondylolisthesis grading

- Grade I: 0–25% anterior slippage
- Grade II: 25–50%
- Grade III: 50–75%
- Grade IV: >75%

- Development of a spondylolisthesis occurs during the adolescent growth spurt

60

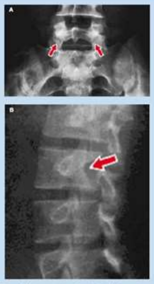

Figure 10. Anteroposterior radiograph (A) of lumbar spine. Arrows indicate sclerosis and fracture line of bilateral spondylolysis. Oblique radiograph (B) of lumbar spine. Arrow indicates sclerosis of the "neck of the Scotty dog."


Fig. 13 Spondylolysis and spondylolisthesis in a 12-year-old male football player, presenting with low back pain. Lateral radiograph shows a linear defect in the pars interarticularis (*arrow*) consistent with spondylolysis at L5, with grade I anterior spondylolisthesis of L5 on S1. When a pars defect is identified radiographically, further imaging usually is not needed

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Diagnosis

- Rarely due to an acute injury
- Postural findings – hypermobility
- Low back pain with focal tenderness
- Standing single leg hyperextension test and spinal palpation

- Imaging indicated
- Xrays are good at identifying the pars defect
- CT scan is good at identifying the presence of a spondylolisthesis
- MRI helps differentiate between acute or healing lesion

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Management

- Chiropractic care
  - Specific HVLA at the segments above and below
- Symptomatic relief
- Avoid irritating activities in the acute phase
- Core stability and muscle strengthening exercises

63

Discogenic Low Back Pain

- Rare in young athletes, increasing in adolescent competing in competitive sports
- Usually secondary to trauma
  - Repetitive microtrauma due to compressive forces
- Children have healthy, well hydrated disc so less prone to injury but the development bone is at risk
- May be associated with a vertebral endplate fracture
- The ring apophysis fuses to the vertebra at 18 yoa
  - Prior to 18, avulsion fracture of the end plate may occur

- Sports with high likelihood

  Running, jumping and contact sports

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Diagnosis and Management

- Low back pain with or without radiation/referred pain
- L4/5 and L5/S1 most common spinal levels affected
- X-rays and/or MRI indicated
- Rule out associated fractures
  - Compression fracture due to compromised disc
  - End plate fracture
  - Ring apophysis avulsion injury
- Chiropractic care, core stability and strengthening exercises

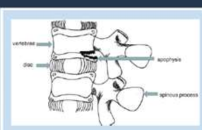

Figure 16. Vertebral body apophyseal avulsion fracture.

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Avulsion Fractures of the Pelvis

- Common in young athletes due to open growth plates
- Sudden and forceful movements – sprinting, kicking and jumping

- Sports with high likelihood

  Running, jumping and kicking sports (soccer and kicker in football)

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Diagnosis

- ASIS – Sartorius and TFL (kicking and sprinting injury)
  - Pain at the ASIS, difficulty walking
- AIIS – Rectus Femoris (kicking, soccer injury)
  - Pain at the AIIS, difficulty walking
- Ischial Tuberosity – Hamstring (sprinting or hurdles)
  - Pain in the buttock and over the ischial tuberosity, difficulty sitting
- Iliac Crest – Abdominal muscles, external obliques (forceful contraction – gymnastics and wrestling)
  - Pain over the iliac crest, difficulty twisting or bending
- Lesser Trochanter – Iliopsoas (running and kicking injury)
  - Pain in the groin and difficulty lifting the leg
- Symphysis Pubis – Adductor muscles, adductor longus (quick directional changes in soccer and hockey)
  - Pain in the inner thigh, difficulty squeezing the legs together

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Fig. 4 Acute avulsion of anterior superior iliac spine (ASIS, *arrow*) and chronic avulsion of ischial tuberosity (*arrowheads*) in a 16-year-old boy soccer player. The patient presented with acute pain after a kick due to the ASIS avulsion. Due to displacement of the ischial apophysis and continued activity there is exuberant callous formation

Rosendahl, K., & Strouse, P. J. (2016). Sports injury of the pediatric musculoskeletal system. La Radiologia medica, 121(5), 431–441. https://doi.org/10.1007/s11547-015-0615-0

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Diagnosis and Management

- Avoid confusing with a strain injury
- Imaging is indicated

- Rest for 6 weeks
- Pain management
- Rehabilitation for flexibility and strength to the area

- Surgery recommended if the bone fragment is displaced

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Return to activity

- Most injuries heal with conservative treatment

- Athletes may return to activity after full recovery

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Concussion Overview

- ➢The developing brain increases a child's risk of concussion and prolongs their recovery
- ➢Increased head to body ratio and weak muscles
- ➢Children 6-16 YOA most likely to suffer a concussion from organized sport than any other event

- Playground injuries
- Rough play
- Getting hit in the head
- Running injuries
- Ice skating
- Bicycle riding
- Skateboarding
- Careless behavior
- Collision Sports

71

Signs and Symptoms

- ✓Physical symptoms
- ✓Cognitive symptoms
- ✓Emotion symptoms
- ✓Sleep disturbances

- There is no definitive number of symptoms that indicate a concussion is present.
- No test identifies a concussion based on scoring and no test alone identifies a concussion.
- Diagnosis is made clinically with consideration given to the type of injury sustained and changes in the patients physical and cognitive behavior.

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Management and Return to Activity

- Physical and cognitive rest
- Return to physical activity and return to cognitive activity should occur simultaneously.
  - HOWEVER, return to sport should follow successful return to school.
- The American Academy of Pediatrics recommends children should return to some form of physical activity as soon as possible.
  - It's acceptable to begin return to school if symptoms are present but improving

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Return to Activity

- School plays a big role in the psychosocial development of the pediatric patient
  - Removal from school may result in isolation, anxiety, depression, and affect the child's relationships
- Loss of time from schoolwork may increase the stress placed upon a child due to makeup time needed.
  - Extra coursework may increase cognitive symptoms
  - Return to school on a limited status may be indicated.

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Return to School

- Successful Return to School should include:
  - Multidisciplinary approach to treatment
  - Frequent follow-up visits
  - Parental involvement
  - Appropriate school personnel included to help to manage the child's condition while at school

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Concussion resources

https://www.cdc.gov/heads-up/?CDC_AAref_Val=https://www.cdc.gov/headsup/resources/custom.html

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