Epidemiology of Pediatric and Adolescent Injury in Adventure and Extreme Sports

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Purpose

To provide an overview of the epidemiologic approach to understanding the distribution, etiology, and prevention of injury affecting pediatric and adolescent adventure and extreme sport (AES) participants.
Introduction

The last several decades have witnessed an explosion in both the popularity and participation in adventure and extreme sports (AES)


X-Games Austin, TX June 2-5, 2016
Household names like skateboarders Brighton Zeuner and Jaggar Eaton were the youngest competitors in the recent Austin 2-5, 2016 X-Games.
Introduction

- Mass media showing breathtaking stunts at the X-Games and the inclusion of skateboarding, in-line sports, and rock climbing showcased in the 2014 Youth Olympics Games (YOG) in Nanjing...
Introduction

...as well as BMX and mountain-biking at the Singapore and Nanjing YOG, are all helping to drive the popularity of AES among youth.
Introduction

In the USA, children and adolescents aged 6-17 years, recorded 2.8 billion annual outdoor recreation outings during 2007-2012, or 88 average outings per participant per year.

Outdoor Foundation Report, 2014
### # of Participants, ages 6-17, in Popular AES during 2008

<table>
<thead>
<tr>
<th>Outdoor Activity</th>
<th>% of Youth Population</th>
<th># of Youth Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycling (BMX, Mountain/non-paved surface)</td>
<td>6.3%</td>
<td>3,128,000</td>
</tr>
<tr>
<td>Climbing (Sport, indoor, boulder)</td>
<td>2.8%</td>
<td>1,379,000</td>
</tr>
<tr>
<td>Skateboarding</td>
<td>11.0%</td>
<td>5,469,000</td>
</tr>
<tr>
<td>Snowboarding</td>
<td>4.6%</td>
<td>2,267,000</td>
</tr>
<tr>
<td>Wakeboarding</td>
<td>2.2%</td>
<td>1,084,000</td>
</tr>
</tbody>
</table>

Outdoor Foundation Special Report on Youth, 2010
Introduction

Participation in AES involves performance in variable and often unpredictable environmental conditions which may be associated with significant physical risks.
Introduction

- We often first learn of youth injury or fatality suffered through participation in AES through media reports.

- For example, on March 23, 2015, KTLA news reported that 14-year-old Tyler Hoeft died after suffering head injuries during a national motocross competition in Wortham, TX.
Introduction

- Participants in child and adolescent AES and everyone who works with them, whether they are parents, coaches, sports medicine personnel, or sport governing bodies need to know answers to important questions such as:
  - What is the risk of injury and who is most likely to sustain injury?
  - When and where are injuries most likely to occur?
  - What is the outcome of injury?
  - What factors are associated with an increased risk of injury?
  - What preventive measures effectively reduce risk of injury?
van Mechelen’s 4-stage model depicting the epidemiologic approach to studying sports injury prevention has become the model of choice. Modified from van Mechelen W. Sports injury surveillance. One size fits all? Sports Med 1997;24:164-168
1. Quantifying Injury Occurrence
   - Who
   - Where/when
   - What

2. Explaining Injury Occurrence
   - How
   - Why

3. Identifying and Introducing Preventive Measures

4. Assessing the Effectiveness of Injury Prevention Measures

STEP 1
Who Is Affected By Injury? Age

Rates by age: Children aged 11-15 years, accounted for nearly 2/3 of all ED-treated ATV injuries in a 10-year year study of ≤15 year old children (NEISS),


<table>
<thead>
<tr>
<th>Age Group</th>
<th>N</th>
<th>%</th>
<th>Rate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 years</td>
<td>3,189</td>
<td>9</td>
<td>13</td>
<td>10-17</td>
</tr>
<tr>
<td>6-10 years</td>
<td>9,204</td>
<td>26</td>
<td>46</td>
<td>34-58</td>
</tr>
<tr>
<td>11-15 years</td>
<td>23,721</td>
<td>66</td>
<td>114</td>
<td>85-143</td>
</tr>
<tr>
<td>Total</td>
<td>36,114</td>
<td>100</td>
<td>56</td>
<td>42-69</td>
</tr>
</tbody>
</table>
### Who Is Affected By Injury? Rates by Sport

<table>
<thead>
<tr>
<th>Sport</th>
<th>Registered Athletes</th>
<th># of Injuries</th>
<th>% Injured</th>
<th># Injuries/1000 Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine skiing</td>
<td>202</td>
<td>12</td>
<td>5.9</td>
<td>59.4</td>
</tr>
<tr>
<td>Biathlon</td>
<td>162</td>
<td>1</td>
<td>0.6</td>
<td>16.1</td>
</tr>
<tr>
<td>XC skiing</td>
<td>165</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Figure skating</td>
<td>48</td>
<td>1</td>
<td>2.1</td>
<td>20.8</td>
</tr>
<tr>
<td>Ice hockey</td>
<td>120</td>
<td>7</td>
<td>5.8</td>
<td>58.3</td>
</tr>
<tr>
<td>Nordic combined</td>
<td>45</td>
<td>4</td>
<td>8.9</td>
<td>88.9</td>
</tr>
<tr>
<td><strong>Snowboard</strong></td>
<td><strong>79</strong></td>
<td><strong>9</strong></td>
<td><strong>11.4</strong></td>
<td><strong>113.9</strong></td>
</tr>
<tr>
<td>Ski jumping</td>
<td>78</td>
<td>4</td>
<td>5.1</td>
<td>51.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>899</strong></td>
<td><strong>38</strong></td>
<td><strong>4.2</strong></td>
<td><strong>42.3</strong></td>
</tr>
</tbody>
</table>

Who is Affected by Injury?
Rates by Participation level

- In a study of youth rock climbers, aged 11-19 years, recreational climbers incurred an injury rate of 4.71 per 1000 climbing hours (exposure units) compared to 4.27 per 1,000 h among elite climbers (OR=2.43; 0.88 – 6.72, p <0.05)

Where Does Injury Occur?

Anatomical location: Within Sport

- Between 2000-2007 head injury or TBI was identified in 60 of 298 cases (20.1%) of children and adolescents ≤ 18 years treated for off-road motorcycle or motocross injury at the Mayo Clinic.

Where Does Injury Occur?

Anatomical Location: Across Sport

Of the 4 million injuries reported for 7 extreme sports during 2000-2011, 11.3% were head and neck injuries (NEISS)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Incidence Rate Head/Neck injuries per 10,000 Person-Years</th>
<th>Incidence Rate Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain biking</td>
<td>1.08</td>
<td>1</td>
</tr>
<tr>
<td>Snowmobiling</td>
<td>1.64</td>
<td>1.51</td>
</tr>
<tr>
<td>Snow Skiing</td>
<td>2.46</td>
<td>2.28</td>
</tr>
<tr>
<td>Surfing</td>
<td>7.00</td>
<td>6.49</td>
</tr>
<tr>
<td>Snowboarding</td>
<td>8.60</td>
<td>9.46</td>
</tr>
<tr>
<td>Skateboarding</td>
<td>10.21</td>
<td>9.46</td>
</tr>
</tbody>
</table>

Data included all ages; however, most injuries affected teens and young adults.

Where Does Injury Occur?

Situational

- IR’s for youth rock climbing reveal a higher rate of injury for indoor (4.31 per 1,000 hours) vs. outdoor climbing (2.94 per 1,000 hours)

When Does Injury Occur?
Temporal factors: Frequency by Time of Year

Temporal factors such as time of day, season or year help to highlight periods of time when frequency of injury may be high and when efforts to reduce risk should be focused.

When Does Injury Occur?

Temporal factors: Change in Rates Over Time (1990-2008)

- Significant changes in rate of skate-boarding-related injury per 10,000 children and adolescents estimated overall and by sex
  - Significant decrease: 1990-1994
  - Significant increase: 1994-2008


What Is The Outcome? **Time Loss**

Proportion of injuries incurring time loss from climbing in days

What Is The Outcome?

Clinical outcome

- Increased degenerative changes in the cervical and thoracic spine were identified (plain radiographic or CT examination) in 248 adolescent motocross racers (mean age 14.2 years) compared with age-matched controls.

What Is The Outcome?

Catastrophic Injury

- The worst case scenario in AES is catastrophic injury.
- In 2006, 332 spinal injuries (7% of all injuries) affecting children ≤ 18 years were caused by ATV accidents, a 447% increase from 1997.


Actual numbers of ATV-related admissions from 1997 to 2006.
STEP 2

1. Quantifying Injury Occurrence
   -Who
   -Where/when
   What

2. Explaining Injury Occurrence
   -How
   -Why

3. Identifying and Introducing Preventive Measures

4. Assessing the Effectiveness of Injury Prevention Measures
How Does Injury Occur?

Mechanism of Injury

Why Does Injury Occur?

Risk Factors?

- On the basis of multivariate logistic regression
  - Climbers aged 15-19 years (target group) were at 11.3 times greater risk of injury than those aged 11-14 years
  - Compared with those who had no other injuries the OR of injury was 6.4 times greater for those who had sustained an injury from another sport


<table>
<thead>
<tr>
<th>Significant risk factors</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group</td>
<td></td>
</tr>
<tr>
<td>11-14</td>
<td>1</td>
</tr>
<tr>
<td>15-19</td>
<td>11.30 (2.33 to 54.85)</td>
</tr>
<tr>
<td>Injury sustained in other sports previous year</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>Yes</td>
<td>6.46 (1.62-25.68)</td>
</tr>
</tbody>
</table>
1. Quantifying Injury Occurrence
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STEP 3
Identifying and Introducing Preventive Measures

- Recommendations regarding helmet use, minimum age, etc.
- It is estimated that the **quadbar** could reduce the number of ATV-deaths related to overturn by 40%.

  Myers ML. All-terrain vehicle safety – potential effectiveness of the Quadbar as a crush protection device. Safety 2016 2,3; doi:10.3390/safety2010003
STEP 4

1. Quantifying Injury Occurrence
   - Who
   - Where/when
   - What

2. Explaining Injury Occurrence
   - How
   - Why

3. Identifying and Introducing Preventive Measures

4. Assessing the Effectiveness of Injury Prevention Measures
Assessing the Effectiveness of Preventive Measures?

- A systematic review of prevention studies supports the effectiveness of helmets in skiing and snowboarding in reducing the risk of head injuries in adult and youth populations (OR=0.41, 95% CI; 0.27-0.59).

Gaps in the Child/Adolescent AES Injury Epidemiology Literature

- The research literature on child/adolescent injury in AES is largely limited to descriptive studies.
- Incident-based reports (e.g., NEISS) do not account for potential variance in exposure of participants to risk of injury.
Future Research

- Need for guidance and support from sports organizations to develop exposure-based data collection systems (e.g., competitive) which provide
  - A clear definition of a reportable incident
  - Appropriate sample sizes and study duration
  - Test risk factors and prevention programs
  - Transition from descriptive to etiologically-based research designs

Evidence For Cause

- Randomized trial
- Cohort study
- Case-control study
- Cross-sectional study
- Correlational study
- Case series
- Case report
A parting thought

- Research opportunities in AES are plentiful
- Let’s help to create a safer participation environment for these child and adolescent AES participants