Autonomic dysfunctions in Paralympic athletes.

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Objectives

• To introduce anatomy and physiology of autonomic nervous system

• What do we know about autonomic dysfunctions in Paralympics athletes? Are the autonomic dysfunctions the same for Paralympic athletes with Spinal Cord Injury, Polio, or Multiple Sclerosis?

• To outline major known autonomic dysfunctions:
  • cardiovascular dysfunctions
  • control of sweating and temperature
  • bladder/bowel dysfunctions

• To discuss issues related to autonomic dysreflexia and boosting.

• What is the future?
Q 1. Autonomic nervous system is ...

A. ... part of the vertebrate nervous system that regulates involuntary actions

B. ... also known as vegetative

C. I have no clue what you are talking about

D. A+B
Where to start?

Sympathetic

Parasympathetic

CN III
CN IX
CN X

T 1

L 2

S 2
S 4
Fight and flight response
Introduction

• Since 1980 we stopped using medical classification for Paralympic games and implemented Functional classification.

• In order to appreciate the impact of autonomic nervous system on Paralympic athletes we have to appreciate medical conditions of these athletes.

• The knowledge of the medical conditions could give us insight to some specifics of the autonomic deficits in some of these conditions. Autonomic dysfunction in some medical conditions are studied in more details than in others.

  – Spinal cord injury
  – Spina bifida
  – Multiple sclerosis
  – Cerebral palsy
  – Friedreich’s ataxia
  – Polio
  – and others
Cardiovascular control in Paralympic athletes with SCI
**Cervical SCI:**

*Autonomic control*: Loss of supraspinal control of the spinal sympathetic neurons controlling heart and blood vessels below the level of injury; the parasympathetic (vagal) control of the heart is intact.

*Possible cardiovascular outcomes that could affect athletic performance:*
- Low arterial blood pressure,
- Orthostatic hypotension
- Frequent episodes of autonomic dysreflexia
- Impaired blood redistribution
- Low stroke volume, heart rate and cardiac output

**High-thoracic SCI (Injuries between T1-T5):**

*Autonomic control*: Loss of supraspinal control to the spinal sympathetic neurons controlling splanchnic and lower-body vasculature. Depending on the level of injury supraspinal control of the spinal sympathetic neurons controlling heart will be partially or fully intact; parasympathetic (vagal) control of the heart is intact.

**Mid-thoracic and lower SCI:**

*Autonomic control*: Loss of supraspinal control to only portion of the spinal sympathetic neurons controlling blood vessels below the level of injury; however, the heart has intact sympathetic (T1-T5) and parasympathetic (vagal) control.

*Possible cardiovascular outcomes that could affect athletic performance:*
- Resting blood pressure could be within normal range
- Episodes of autonomic dysreflexia are less common or absent
- Heart and blood pressure responses to exercise are typically intact
Responses in blood pressure to excesses
(Control non SCI, and individuals with Paraplegia and Tetraplegia)
• 7 Paralympic Wheelchair Rugby athletes

• Autonomic battery: SSRs, Orthostatic challenge test

• Performance assessment: HR peak, 4 min push, VO2 peak

• The degree of preserved SSRs (autonomic spinal integrity) but not motor function established by International Wheelchair Rugby Federation classification correlated with HR peak, 4min push distance, and VO2 peak.
Responses to orthostatic challenge test (sit up test) in SCI Paralympic athletes (London 2012, Paralympic Games n=57).
Sweating and Thermoregulation in Paralympic athletes with SCI
Sweating: blessing or curse?
• Individual with a complete lesion at T4 during early stages of thermoregulatory sweat test.

• Dotted line illustrates border of analgesia and uninterrupted line that of anaesthesia.

• Sweating is confined to the face, neck, upper limbs, and upper chest, and there was complete anhidrosis below that level in the first stages of the test.

• In later stages, sweating gradually extended to T10.

A starch iodine test results in purple to black discoloration which delineates the affected area of excessive sweating.
Aural temperature in athletes with tetraplegia (TP) high and low paraplegia (HP; LP) at rest, during exercise, and recovery in warm conditions.

Pronounced increased in auricular temperature was observed for TP athletes, who demonstrated a much greater imbalance in temperature regulation.

Increasing the exercise or environmental strain may result in the thermoregulatory responses of athletes with SCI being compromised.
Circulatory dysfunctions in other conditions

- **Spinal Bifida:** High arterial wall shear stress and endothelial dysfunction were reported in SB compared with SCI that could predispose these individuals to cardiovascular disease. Boot et al. *Spinal Cord.* 2003
- **Polio:** Orthostatic instability, due to peripheral nervous system deterioration and muscle atrophy is documented. Borg et al. *Acta Neurol Scand.* 1988.
- **MS:** Orthostatic hypotension and Postural orthostatic tachycardia syndrome (POTS) reported among individuals with MS. Adamec et al. *J Neurol Sci.* 2013
- **Cerebral palsy:**
Other Conditions and Temperature dysfunctions:

• **MS:** heat sensitivity and central regulation of body temperature are among major issue for individuals with MS. Davis et al *J Appl Physiol (1985)*. 2010

• **Polio:** known temperature dysfunctions (low amplitude of SSRs were reported) Emad et al *Iran Red Crescent Med J*. 2011

• **Spina Bifida:** skin temperature and peripheral circulation could be compromised depending on the severity of neurological deficits.
Autonomic dysreflexia and Boosting

Cerebral hemorrhage due to autonomic dysreflexia in a spinal cord injury patient

M Vallis, J B

Spinal Cord 2013, 51:736-740

Testing for boosting at the Paralympic games: policies, results and future directions.


- a systolic blood pressure of ≥180 mmHg was considered a positive test.
- the average systolic and diastolic blood pressures were 135 mm Hg (range 98-178) detected
- no positive test for boosting were detected

• Boosting deemed illegal by IPC due to possible harmful effects for health of athletes'

(www.paralympic.org)
What is next?
Autonomic nervous system assessment.
Evaluation of individuals with SCI 2008

STANDARD NEUROLOGICAL CLASSIFICATION
OF SPINAL CORD INJURY

MOTOR

<table>
<thead>
<tr>
<th>Level</th>
<th>Motor Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Elbow flexors</td>
</tr>
<tr>
<td>C6</td>
<td>Wrist extenders</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow extenders</td>
</tr>
<tr>
<td>C8</td>
<td>Finger flexors (pinch/grasp)</td>
</tr>
<tr>
<td>T1</td>
<td>Finger abductors (side)</td>
</tr>
</tbody>
</table>

SENSORY

<table>
<thead>
<tr>
<th>Level</th>
<th>Sensory Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Vibration</td>
</tr>
<tr>
<td>C6</td>
<td>Position</td>
</tr>
<tr>
<td>C7</td>
<td>Light touch</td>
</tr>
<tr>
<td>C8</td>
<td>Pain/Delayed pain</td>
</tr>
<tr>
<td>T1</td>
<td>Temperature (warm/cold)</td>
</tr>
</tbody>
</table>

Anatomic Diagnosis: (Supraconal, Conal, Cauda Equina)

General Autonomic Function

System/Function | Findings | Abnormal Conditions | Checkmark |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Autonomic control of the heart</td>
<td>Normal</td>
<td>Bradycardia</td>
<td></td>
</tr>
<tr>
<td>Autonomic control of blood pressure</td>
<td>Normal</td>
<td>Hypertension</td>
<td></td>
</tr>
<tr>
<td>Autonomic control of sweating</td>
<td>Normal</td>
<td>Hyperhidrosis</td>
<td></td>
</tr>
</tbody>
</table>

Lower Urinary Tract, Bowel, and Sexual Function

System/Function | Findings | Abnormal Conditions | Checkmark |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Urinary Tract</td>
<td>Awareness of need to empty bladder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowel</td>
<td>Sensation of need for bowel movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voluntary sphincter contract</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sexual Function

Gonadectomy | Psychogenic | Reflex |

Urodynamic Evaluation

System/Function | Findings | Checkmark |
<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Sensation during filling</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>Detrusor Activity</td>
<td>Non-specific</td>
<td></td>
</tr>
<tr>
<td>Sphincter</td>
<td>Normal</td>
<td></td>
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</tbody>
</table>

This form may be copied freely for educational purposes.

This assessment should use the terminology found in the International SCI Data Set (ASIA and ISCoS) (http://www.asia spinalinjury.org/bulletinBoard/dataset.php)
Questions to take home:

Should we do autonomic assessments in Paralympians?

What autonomic test to select in the future?

Should we develop and implement for athletes passport with autonomic parameters?