BUILDING BRAIN RESILIENCY AND HEALTHY AGING:

POSITIVE EFFECTS OF PHYSICAL ACTIVITY AND CONCUSSIONS IN THE AGING BRAIN

Mauricio A. Garcia-Barrera, PhD., R.Psych
Stacey Horton
UVRA Elder Academy
Institute of Aging & Lifelong Health
Land Acknowledgment

The land I enjoy: Traditional territories of the Lekwungen, the Songhees, Esquimalt and WSÁNEĆ Peoples.

The land I come from: the Catías, Nutabes, Tahamíes, and the Quimbaya Indigenous Peoples.
Complex Executive Behaviour: e.g., Decision making, problem solving

Behavioural regulation
Emotional Regulation
Attentional Control

Basic phenotypic expression of self-regulatory behaviours

Inhibiting
Updating
Shifting

Cognitive Processing

BOLD signal
fNIRS/EEG
Physiology

MRI/DTI
Structures & Networks
Proteins

Environmental Influences:
Physical Exercise (i.e., capacity)
Sports participation (i.e., sport type)
Socio-economic Status
Intergenerational transmission

Complex polygenic traits interactions

Garcia-Barrera, in prep. Adapted from Crosbie et al, 2008
Cognitive Development: Inverted -U
Diverse developmental trajectories

Performance Level

Lifespan

30 60
Larger within-group variability in middle adulthood:
Protective factors

• Education
• Multilinguism
• Lifestyle:
  – Social networks and interactions
  – Nutrition
  – Cognitive stimulating activities
  – Physical activity
An Empirical Comparison of the Therapeutic Benefits of Physical Exercise and Cognitive Training on the Executive Functions of Older Adults: A Meta-Analysis of Controlled Trials

Justin E. Karr, Corson N. Areshenkoff, Philippe Rast, and Mauricio A. Garcia-Barrera
University of Victoria
Protective factors

• Education
• Multilingualism
• Lifestyle:
  – Social networks and interactions
  – Nutrition
  – Cognitive stimulating activities
  – Physical activity
Developmental Trajectories

![Graph showing developmental trajectories across the lifespan from 5 to 65 years old. The x-axis represents the lifespan, and the y-axis represents the level of cognitive development. Multiple curves are plotted, each indicating a different trajectory of cognitive development.]
Aimed at examining the effects of an 8-week physical activity training on executive functioning, mood, stress, fatigue and sleep, and their interactions.

- Multi-method assessment approach
- Multi-dimensional approach to executive functioning
- Randomized control design with a waitlist control group
Executive Function Improvement Training Study (eFIT)

eFIT Timeline
The eFIT sample

- N= 104
- Age
- Ethnicity
  - 98% White,
  - 2% South Asian
- Location across Canada
- Gender
  - 74% female, 26% male
- Education
  - 6% HS, 14% some college,
  - 50% University, Master’s 23, PhD 4

<table>
<thead>
<tr>
<th>Provinces</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nova Scotia</td>
<td>2.89</td>
</tr>
<tr>
<td>Alberta</td>
<td>2.89</td>
</tr>
<tr>
<td>British Columbia</td>
<td>69.23</td>
</tr>
<tr>
<td>Manitoba</td>
<td>1.92</td>
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<tr>
<td>New Brunswick</td>
<td>0.96</td>
</tr>
<tr>
<td>Ontario</td>
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<td>Prince Edward Island</td>
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<tr>
<td>Quebec</td>
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</tr>
<tr>
<td>Yukon</td>
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<tr>
<td>Missing</td>
<td>0.00</td>
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<tr>
<td>Total</td>
<td>100.00</td>
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<table>
<thead>
<tr>
<th>Age</th>
<th>Active</th>
<th>Waitlist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>60</td>
<td>44</td>
</tr>
<tr>
<td>Mean</td>
<td>69.43</td>
<td>69.73</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>4.35</td>
<td>4.04</td>
</tr>
<tr>
<td>Minimum</td>
<td>65.00</td>
<td>65.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>81.00</td>
<td>86.00</td>
</tr>
</tbody>
</table>
ASSESSMENT:

- Questionnaires (Depression, anxiety, PA)
- 13 computerized tasks (Executive function, memory, attention)
- Ecological Momentary Assessment daily survey (burst design)
RESULTS
Between – Groups (PRE)
RESULTS
Between – Groups (PRE)
RESULTS
Between – Groups (POST)
RESULTS
Between – Groups (POST)
RESULTS
Within – Active Group

GDS

Paired Samples T-Test

<table>
<thead>
<tr>
<th>Measure 1</th>
<th>Measure 2</th>
<th>W</th>
<th>z</th>
<th>df</th>
<th>p</th>
<th>Rank-Biserial Correlation</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDS_Total</td>
<td>GDS..post.</td>
<td>189.000</td>
<td>2.029</td>
<td>0.036</td>
<td>0.494</td>
<td>0.064</td>
<td>0.769</td>
<td></td>
</tr>
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</table>

Note. Wilcoxon signed-rank test.
## RESULTS

Within – Active Group

<table>
<thead>
<tr>
<th>Measure 1</th>
<th>Measure 2</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>Cohen's d</th>
<th>95% CI for Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFI.Total</td>
<td>EFI.Total..post.</td>
<td>-2.137</td>
<td>35</td>
<td>0.040</td>
<td>-0.356</td>
<td>-0.691 to -0.017</td>
</tr>
</tbody>
</table>

*Note: Student’s t-test.*

Empathy
Impulse Control*
Organization*
Motivational Drive
Strategic Planning
**RESULTS**

**Within – Active Group**

### Digit Span Backward

**Paired Samples T-Test**

<table>
<thead>
<tr>
<th>Measure 1</th>
<th>Measure 2</th>
<th>W</th>
<th>z</th>
<th>df</th>
<th>p</th>
<th>Rank-Biserial Correlation</th>
<th>95% CI for Rank-Biserial Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSB.FinalScore.Pre</td>
<td>DSB.FinalScore.Post</td>
<td>54.000</td>
<td>-2.555</td>
<td>0.011</td>
<td>-0.609</td>
<td>-0.825</td>
<td>-0.235</td>
</tr>
</tbody>
</table>

*Note. Wilcoxon signed-rank test.*
PRELIMINARY RESULTS

Ecological Momentary Assessment

Active vs. Waitlist Control Group:
MPA Hours across 3 Measurement Bursts
• Comparison of effect sizes based on moderators

• Relevant moderators:
  • Time Since Injury
  • Participant Characteristics
  • Cognitive Domain
  • Cumulative Effect
Results

• Cognitive domain
  – highly variable
  – global abilities, orientation, attention, working memory, executive functioning, fluency, memory, visuospatial skills, verbal comprehension, processing speed, motor

• Time since injury
  – Most athletes recover within 7 to 14 days

• Worse outcomes
  – Younger
  – Less Educated
  – Female

• Effects on Cognition

  Executive Functioning is most sensitive to multiple mTBI
Sports-Related Concussions (SRC)
Updates to the definition of SRC:

- Doesn’t necessarily involve head impact
- Doesn’t necessarily involve LOC
Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

- Recognise
- Remove
- Re-evaluate
- Rest
- Rehabilitation
- Refer

- Recovery*
- Return to sport
- Reconsider
- Residual effects and sequelae
- Risk reduction
Sports concussion assessment and management: Future research directions

Michael McCrea, Donna K. Broshek, & Jeffrey T. Barth

7-14 days for adults, 4 weeks for children
Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

- Recognise
- Remove
- Re-evaluate
- Rest
- Rehabilitation
- Refer

- Recovery
- Return to sport*
- Reconsider
- Residual effects and sequelae
- Risk reduction
## Return to Sport

This tool is a guideline for managing an individual’s return to sport following a concussion and does not replace medical advice. Timelines and activities may vary by direction of a healthcare professional.

<table>
<thead>
<tr>
<th>STAGE 1: No sporting activity</th>
<th>STAGE 2: Light aerobic exercise</th>
<th>STAGE 3: Sport-specific exercise</th>
<th>STAGE 4: Non-contact drills</th>
<th>STAGE 5: Full-contact practice</th>
<th>STAGE 6: Back in the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical and cognitive rest until symptoms start to improve OR after resting for 2 days max.</td>
<td>Walking, swimming, stationary cycling. No resistance training. The pace of these activities should be at the point where you are still able to have a conversation.</td>
<td>Skating drills (ice hockey), running drills (soccer). No head-impact activities.</td>
<td>Progress to complex training drills (e.g. passing drills). May start resistance training.</td>
<td>Following medical clearance participate in normal training activities.</td>
<td>Normal game play</td>
</tr>
</tbody>
</table>

### Recovery

<table>
<thead>
<tr>
<th>Symptoms improve or 2 days rest max?</th>
<th>No new or worsening symptoms for 24 hours?</th>
<th>No new or worsening symptoms for 24 hours?</th>
<th>Yes: Move to stage 5</th>
<th>Symptom-free for 24 hours?</th>
<th>Yes: Move to stage 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes: Move to stage 2</td>
<td>Yes: Move to stage 3</td>
<td>Yes: Move to stage 4</td>
<td>Yes: Move to stage 5</td>
<td>Yes: Move to stage 6</td>
<td>Yes: Move to stage 7</td>
</tr>
<tr>
<td>No: Continue resting</td>
<td>No: Return to stage 1</td>
<td>No: Return to stage 2</td>
<td>No: Return to stage 3</td>
<td>No: Return to stage 4</td>
<td>No: Return to stage 5</td>
</tr>
</tbody>
</table>

*Time & Date completed:*

<table>
<thead>
<tr>
<th>Time &amp; Date completed:</th>
<th>Time &amp; Date completed:</th>
<th>Time &amp; Date completed:</th>
<th>Time &amp; Date completed:</th>
<th>Time &amp; Date completed:</th>
</tr>
</thead>
</table>

If new or worsening symptoms are experienced at any stage, go back to the previous stage for at least 24 hours. You may need to move back a stage more than once during the recovery process.

Medical clearance required before moving to stage 5.

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**BOTH TOOLS CAN BE USED IN PARALLEL; HOWEVER, RETURN TO SCHOOL SHOULD BE COMPLETED BEFORE RETURN TO SPORT IS COMPLETED**

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# Return-to-Sport Strategies

<table>
<thead>
<tr>
<th>Sport</th>
<th>Download Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrestling</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Water Polo</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Volleyball</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Soccer</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Ski Jumping</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Sailing</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Rugby</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Nordic</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Judo</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Hockey</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Freestyle Ski</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Equestrian</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Curling</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Cross-country Ski</td>
<td>PDF/UA</td>
</tr>
<tr>
<td>Canoe and Kayak</td>
<td>PDF/UA</td>
</tr>
</tbody>
</table>
# Return to School

This tool is a guideline for managing a student’s return to school following a concussion and does not replace medical advice. Timelines and activities may vary by direction of a health care professional.

## AT HOME

### STAGE 1:
- **Physical & cognitive rest**
  - Basic board games, crafts, talk on phone
  - Activities that do not increase your heart rate or cause you to break a sweat
  - Computer, TV, texting, video games, reading

  **Limit/Avoid:**
  - School work
  - Sports
  - Work
  - Driving until cleared by a health care professional

### STAGE 2:
- **Start with light cognitive activity:**
  - Gradually increase cognitive activity up to 30 min. Take frequent breaks.
  - Prior activities plus:
    - Reading, TV, drawing
    - Limited peer contact and social networking
    - Contact school to create return to School plan

### STAGE 3:
- **Back to school part-time**
  - Part-time school with maximum accommodations.
  - Prior activities plus:
    - Increase time at school
    - Decrease accommodations
    - Homework – up to 30 min/day
    - Classroom testing with adaptations

### STAGE 4:
- **Part-time school**
  - Increase school time with moderate accommodations.
  - Prior activities plus:
    - Start to eliminate accommodations
    - Increase homework to 60 min/day
    - Limit routine testing to one test per day with adaptations

### STAGE 5:
- **Full-time school**
  - Full days at school, minimal accommodations.
  - Prior activities plus:
    - All homework
    - Full extracurricular involvement
    - All testing

### STAGE 6:
- **Full-time school**
  - Full days at school, no learning accommodations.
  - Attend all classes
  - All homework
  - Full extracurricular involvement

**Note:** A student is tolerating an activity if symptoms are not exacerbated.

---

[Adapted from Return to Learn protocol by G.F. Strong School Program (Vancouver School Board), Adolescent and Young Adult Program, G.F. Strong Rehabilitation Centre]
# Return to Work

This tool is a guideline for managing an individual's return to work following a concussion and does not replace medical advice. The goal for each stage is to find the ‘sweet spot’ between doing too much and doing too little. Timelines and activities may vary by direction of a health care professional.

## AT HOME

<table>
<thead>
<tr>
<th>STAGE 1: Initial physical and cognitive rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Rest in a quiet and calm environment.</td>
</tr>
<tr>
<td>- Try activities that do not aggravate symptoms (e.g., listening to quiet music or colouring).</td>
</tr>
<tr>
<td>- Sleep as much as your body needs while trying to maintain a regular night sleeping schedule.</td>
</tr>
<tr>
<td>- Lengthy social visits.</td>
</tr>
<tr>
<td>- Screen time (smartphone, computer, television) and reading.</td>
</tr>
<tr>
<td>- Avoid: Sports or physical activities that increase your heart rate or cause you to break a sweat.</td>
</tr>
</tbody>
</table>

**NOTE:** It is recommended to discuss driving with a licensed medical professional for safety considerations.

<table>
<thead>
<tr>
<th>STAGE 2: Gradually increase activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>- When symptoms start to improve OR after resting for 2 days max, BEGIN STAGE 2</td>
</tr>
<tr>
<td>- When 30 minutes of activity is tolerated, BEGIN STAGE 3</td>
</tr>
<tr>
<td>- When 4 hours of activity is tolerated, with breaks as needed, BEGIN STAGE 4</td>
</tr>
</tbody>
</table>

## AT WORK

<table>
<thead>
<tr>
<th>STAGE 3: Prepare to return to work—at home</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Gradually increase cognitive activity.</td>
</tr>
<tr>
<td>- Continue to increase cognitive activity.</td>
</tr>
<tr>
<td>- Continue to return to pre-injury physical activities (e.g., grocery shopping, gardening, jogging, light weight training).</td>
</tr>
<tr>
<td>- Contact workplace to discuss a tailored Return to Work plan.</td>
</tr>
<tr>
<td>- Attempt to commute to work if it aggravates symptoms or drains energy.</td>
</tr>
<tr>
<td>- A regular sleeping schedule supports a successful return to work.</td>
</tr>
<tr>
<td>- Work your way up to 2 hours of activity, with breaks as needed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAGE 4: Prepare to return to work—at work</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Work accommodations can include: flexible hours, reduced workload, extra time for tasks, access to a quiet, distraction-free work environment.</td>
</tr>
<tr>
<td>- Arrange to return to work on a graduated basis. Consider number of hours per day and appropriate accommodations.</td>
</tr>
<tr>
<td>- Work your way up to an additional 2 hours of activity, with breaks as needed.</td>
</tr>
<tr>
<td>- Have a plan to leave work and return to Stage 2 if symptoms worsen.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAGE 5: Begin graduated return to work</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Return to work according to your graduated return to work plan, with the agreed upon number of hours per day and accommodations.</td>
</tr>
<tr>
<td>- At work, start with less demanding activities before more difficult ones.</td>
</tr>
<tr>
<td>- Gradually increase working hours week-to-week, or sooner, as appropriate.</td>
</tr>
<tr>
<td>- Monitor energy levels for completing household tasks and participating in social or recreational activities after the work day.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAGE 6: Regular work hours with modifications, as needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Decrease accommodations as energy and capacity increases.</td>
</tr>
<tr>
<td>- Accommodations can be phased out in &quot;trial&quot; periods, to ensure that they are no longer needed.</td>
</tr>
<tr>
<td>- Full return to work schedule with usual expectations for productivity, without accommodations.</td>
</tr>
</tbody>
</table>

## Full return to work

- Full regular work schedule with usual expectations for productivity, without accommodations.

**NOTE:** Only return to job duties that may have safety implications for you or others when cleared by a licensed medical professional (e.g., operating heavy equipment, working from heights, driving).

## Work with accommodations, as needed

- Once you have COMPLETED STAGE 6, Return to Work strategy completed.

Recognizing that workplace environments vary by industry and occupation, returning to work may focus more on a return to cognitive activity, physical activity, or a combination of both. It is normal to experience symptoms during recovery; you do not have to wait to be symptom-free before returning to work. However, after Stage 2, if new or worsening symptoms appear at any stage, go back to the previous stage for at least 24 hours. You may need to move back a stage more than once during the recovery process.

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Medical retirement from sport after concussions
A practical guide for a difficult discussion
Schematic Diagram of CT Scanning Gantry
Magnetic Resonance Imaging

(A) No external field
(B) External field applied
(C) Radio frequency pulse applied

<table>
<thead>
<tr>
<th>Spins:</th>
<th>Precession:</th>
<th>Net magnetization vector:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomly oriented</td>
<td>More up than down</td>
<td>Out of phase (M = 0)</td>
</tr>
<tr>
<td>Non-contributory</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NEUROANATOMY 2e, Figure 4.5
Concussions are a serious brain injury.

Concussion Awareness Week • Sept 26 - Oct 2
Learn more at www.cattonline.com
Dr. Bennet Omalu
Chronic Traumatic Encephalopathy: A unique type of tauopathy
CTE Neuropathology

The gross neuropathology, described as “characteristic” of CTE, includes:

1) frontal and temporal atrophy, thinning of the hypothalamic floor, shrinkage of the mammillary bodies, pallor of the substantia nigra, hippocampal sclerosis, and reduction in brain mass
   2) enlarged ventricles
   3) cavum septum pellucidum with or without septal fenestrations.

Microscopic features described as characteristic have included:

1) localized neuronal and glial accumulations of phosphorylated tau (p-tau) with varying microscopic morphologies, involving perivascular areas of the cerebral cortex and sulcal depths
   2) multifocal axonal varicosities involving deep cortex and subcortical white matter
   3) variable and often absent Beta amyloid deposits
   4) TDP-43-positive inclusions and neurites.

Iverson et al., 2018, Journal of Alzheimer’s Disease 61, 17–28
From scientist to salesman

How Bennet Omalu, doctor of ‘Concussion’ fame, built a career on distorted science
The Need for Traumatic Neuropr... from Clin...
Sports concussion assessment and management: Future research directions

Pre-Injury Factors
- Genetics
- Neurobiologic Vulnerabilities

Trauma Burden
- Injury Severity
- Biomechanics
- Repetitive Exposure

Biomarkers
- Structural/
  Functional Imaging
- Blood Biomarkers

Psychological Function
- Premorbid
- Post-injury Comorbidities

Environmental Factors
- Social Support
- Life Stressors
- Activity Level

Motivational Factors
- Expectation
- Secondary Gain

Neurobiological Health

Neurocognitive Function

Neurobehavioral Function

Psychological Health and Wellness

Life Function & Quality

Multi-Domain Predictor Variables

Multi-Dimensional Outcome
Resilience

- strength
- growth
- reaction
- power
- optimism
- motivation
- vision
- change
- idea
- success
- leadership
- attitude
- defense
- learning
- flexibility
- adversity
- teamwork
- education
- possible
- vital
- business
- overcome
- empower
- persistence
- positive
- possible
-Against
- impossible
- vital
- trouble
- business
- overcome
- motivate
- obstacle
- learn
- solution
Looking toward the future

Repeated measures

Prevention programs and new interventions

Neuroimaging
Funding sources
GRACIAS!
THANK YOU!

QUESTIONS?