

Canadian Concussion Centre LiUNA Free Webinar Series

Topic: Concussion in Women

February 20, 2024

Presenter:

Dr. Carmela Tartaglia



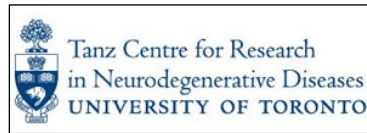
Speaker's Biography:

Dr. Tartaglia is an Associate Professor and Clinician-Scientist at the University of Toronto. She received her medical degree from McGill University, completed her residency at the University of Western Ontario and did three years of clinical/research fellowship in cognitive/behavioral neurology at the University of California, San Francisco Memory and Aging Center. She maintains a cognitive/behavioral clinic where she sees people with neurodegenerative disease and post-concussion syndrome within the UHN Memory Clinic. Her clinical and research interests lie in neurodegenerative diseases with a focus on frontotemporal lobar degeneration (FTLD) and possible chronic traumatic encephalopathy.

Concussion in Women



Carmela Tartaglia, MD
Canadian Concussion Centre, UNIVERSITY
HEALTH NETWORK
Tanz Centre for Research in Neurodegenerative
Diseases



Disclosures

- CIHR, NIH, Weston Brain Institute
- Clinical Trials: Biogen, Roche, Anavex, Janssen, Novo Nordisk, UCB
- Consultant: Eli Lilly, Eisai

OBJECTIVES

At the end of this presentation, the learner will be able to:

- Discuss sex and gender differences in concussion and persisting symptoms of concussion
- Learn about the risks of delayed effects of concussion

TYPES OF BRAIN INJURIES

- **Concussion/mild traumatic brain injury (mTBI)**
 - often used interchangeably
 - mTBI Glasgow Coma Scale 13-15 at 30min post-injury +
 - <30min LOC
 - <24hr post-traumatic amnesia
 - Impaired mental status at time of accident (confusion, disorientation etc)
 - Transient neurological deficit
- **Moderate-severe TBI:** bruising or contusion, tearing/laceration, bleeding

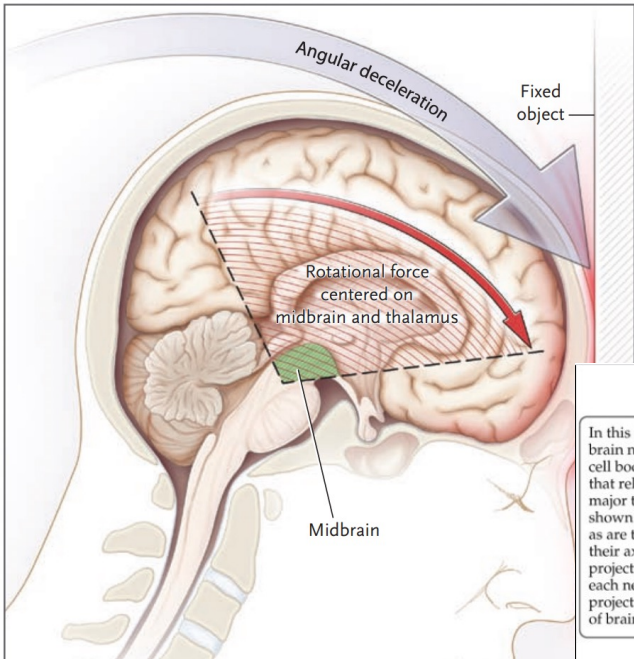
MILD TRAUMATIC BRAIN INJURY/ CONCUSSION

- Growing epidemic (sports, military, falls, abuse etc)
- Incidence of mTBI: 200–300/100,000 persons per year for hospitalized patients; 2X as high if non-hospitalized patients included (>700/10000)
- 750,000 concussions/year in NA
- **About 150,000 concussions in Ontario/year**
- Under-reported-most stats from hospitals (most w/ LOC only)

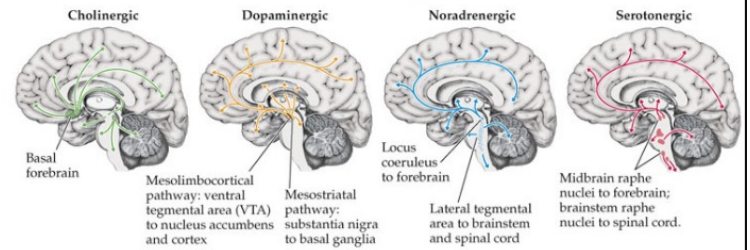
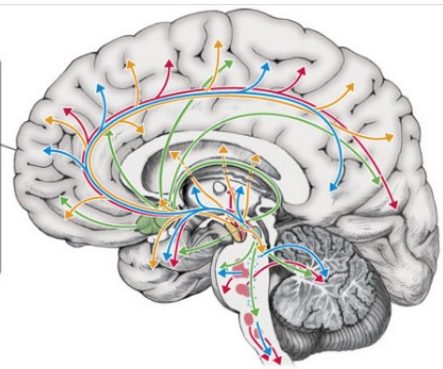


CONCUSSION



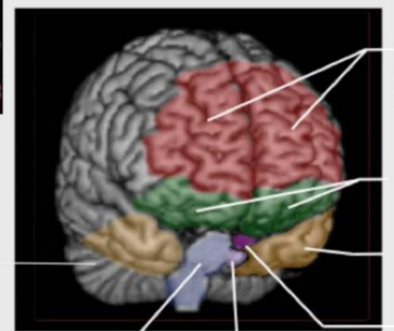
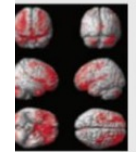


In this midline view, the brain nuclei containing cell bodies of neurons that release four of the major transmitters are shown in different colors, as are the projections of their axons. Although the projections may overlap, each neurotransmitter projects to a distinct set of brain targets.



THE MIND'S MACHINE 2e, Figure 4.4
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Brain regions vulnerable to TBI and relationship to neurobehavioral sequelae



- Dorsolateral prefrontal cortex** (executive function, working memory, complex attention, judgment, insight, planning)
- Orbitofrontal cortex** (emotional and social behavior)
- Temporal pole** (memory retrieval, social behavior)
- Amygdala** (emotional learning, fear conditioning)
- Entorhinal-hippocampal complex** (declarative memory, sensory gating, attention)
- Ventral brain stem** (arousal, ascending modulatory neurotransmitter systems)
- Cerebellum** (coordination, working memory, mood regulation)

SYMPTOM HETEROGENEITY AMONG PATIENTS

COGNITIVE SYMPTOMS

Difficulty thinking-confusion
Slowed processing
Difficulty remembering
Unable to concentrate

PERSONALITY/MOOD

Irritable
Depression
Anxiety
Lability
Impulsivity
Sleep changes

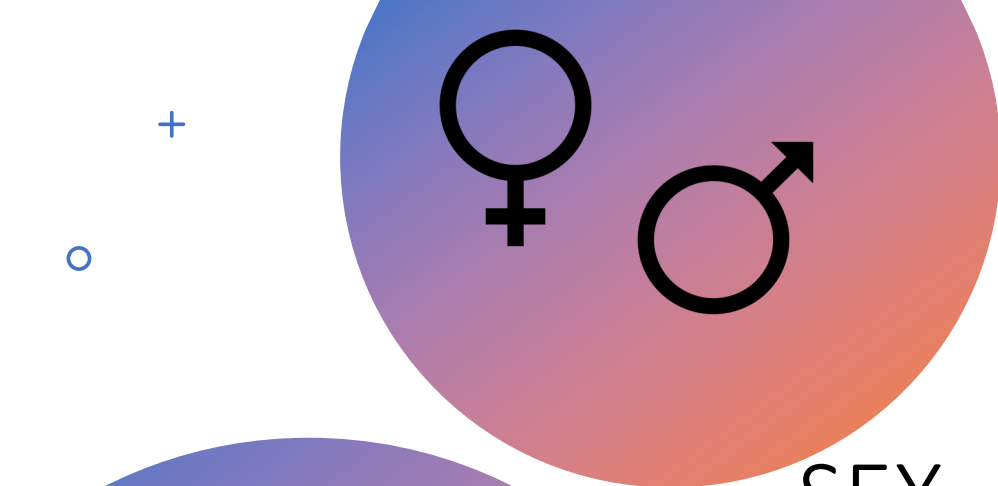
PHYSICAL

Headache
Vision abnormalities
Dizziness/Vertigo
Sensitivity to light or noise
Balance problems
Fatigue

PERSISTENT post- CONCUSSION SYMPTOMS

AKA POST-CONCUSSION SYNDROME

- “...Failure of normal clinical recovery—that is, symptoms that persist beyond expected time frames (ie, >10–14 days in adults and >4 weeks in children).”
- 10% (-58%) of people do not recover from concussion/mTBI within 3 months:
 - > 15% experience prolonged symptoms (150000)
 - ~23,000 Ontarians/year endure prolonged symptoms
- Concussions can lead to serious somatic, affective, & cognitive sequelae
- Persist for months, years or rarely permanently following injury
- Can occur after 1 but more common after repeated concussions



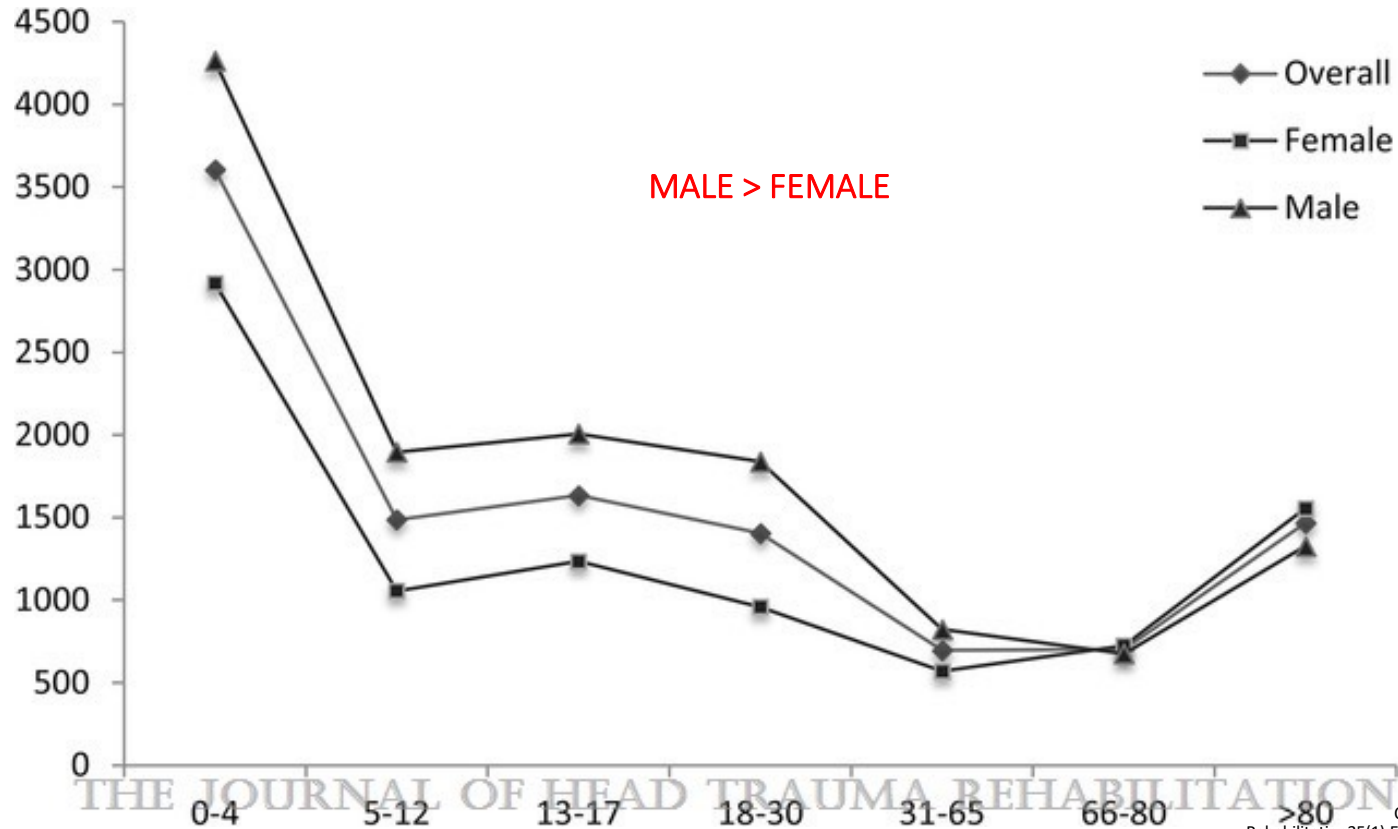
SEX & GENDER

- Sex (FEMALE vs MALE) = the different biological and physiological characteristics of males and females, such as reproductive organs, chromosomes, hormones, etc.
- Gender (WOMAN vs MAN) = the socially constructed characteristics of women and men – such as social norms, roles and relationships of and between groups of women and men

Concussion Prevalence

- Many studies have shown more males than females having concussions due to greater exposure to environments where concussions are common (high-risk labour, contact sports, military)
- BUT

Age and sex differences in concussion incidence. Incidence per 100 000 residents of Ontario, Canada, in each age group and by sex. ED indicates emergency department; GP, general practitioner.



Females participating in sex-comparable sports (eg, basketball, soccer) had a 1.4 times greater incidence of reported concussion than males.

Table 3. Practice and Game Concussion Injury Rates (IRs) by Male and Female Sports

| National Collegiate Athletic Association Sport | IR (95% Confidence Interval) | | | Rate Ratio ^a | Total IR/10 000 AEs (Hootman et al ⁴) | Rate Ratio ^b |
|--|------------------------------|----------------------|-------------------|-------------------------|---|-------------------------|
| | Practice | Game | Total | | | |
| Men's baseball | 0.48 (0.30, 0.75) | 2.58 (1.94, 3.35) | 1.20 (0.94, 1.50) | 5.38 | 0.7 | 1.71 |
| Women's softball | 1.40 (0.97, 1.95) | 3.67 (2.82, 4.68) | 2.34 (1.90, 2.86) | 2.62 | 1.4 | 1.67 |
| Men's basketball | 2.65 (2.23, 3.13) | 6.07 (4.81, 7.55) | 3.34 (2.91, 3.81) | 2.29 | 1.6 | 2.08 |
| Women's basketball | 3.25 (2.75, 3.82) | 9.66 (8.45, 11.50) | 4.67 (4.14, 5.26) | 2.97 | 2.2 | 2.12 |
| Men's ice hockey | 1.59 (1.09, 2.23) | 20.66 (17.22, 24.57) | 5.94 (5.05, 6.93) | 12.99 | 4.1 | 1.45 |
| Women's ice hockey | 2.90 (1.90, 4.25) | 17.81 (13.30, 23.34) | 6.57 (5.19, 8.20) | 6.14 | 9.1 | 0.72 |
| Men's lacrosse | 2.36 (1.73, 3.14) | 22.98 (18.20, 28.63) | 5.44 (4.53, 6.49) | 9.74 | 2.6 | 2.09 |
| Women's lacrosse | 2.64 (1.88, 3.61) | 14.91 (11.14, 19.55) | 4.99 (4.02, 6.13) | 5.64 | 2.5 | 2.0 |
| Men's soccer | 1.72 (1.34, 2.17) | 13.15 (11.94, 16.38) | 4.19 (3.66, 4.78) | 7.64 | 2.8 | 1.50 |
| Women's soccer | 2.41 (1.96, 2.92) | 18.90 (16.76, 21.45) | 6.45 (5.83, 7.19) | 7.84 | 4.1 | 1.58 |

Abbreviation: AEs, athlete-exposures.

^a Rate ratio between game and practice IRs.

^b Rate ratio between results of Hootman et al⁴ and current IRs.

Association of Sex With Adolescent Soccer Concussion Incidence and Characteristics

Abigail C. Bretzin, PhD, ATC¹; Tracey Covassin, PhD, ATC²; Douglas J. Wiebe, PhD¹; [et al](#)

» [Author Affiliations](#) | [Article Information](#)

JAMA Netw Open. 2021;4(4):e218191. doi:10.1001/jamanetworkopen.2021.8191

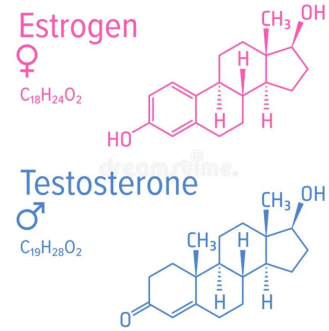
- 43 741 male and 39 637 female soccer athletes participated in MHSAA soccer during the 3 consecutive academic years of study (2016-2017: n = 751 schools; 2017-2018: n = 750 schools; and 2018-2019: n = 747 schools).
 - high school injury surveillance project, the risk of documented SRC was 1.88 times higher among adolescent girls than adolescent boys.
 - boys most often sustained SRC from player contact (48.4%), SRCs in girls were most often from equipment contact (eg, ball or goalpost [41.9%]),
 - boys had 1.54 greater odds of immediate removal from play and returned to play 2 days sooner than girls.

POSSIBLE MECHANISMS UNDERLYING SEX DIFFERENCES ON CONCUSSION

- Effects of gonadal steroid hormones
- Effects of brain anatomy and neural function
- Biomechanical differences in head and neck anatomy
- Different mechanisms of injury leading to mild traumatic brain injury/concussion

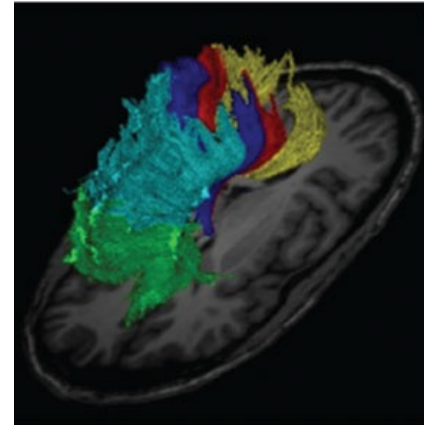
SEX HORMONES

- Higher levels of estrogen and progesterone increase pain perception leading to a greater reaction to concussion and more severe symptoms (particularly in luteal phase- progesterone is at its highest level)
- More severe symptoms and worse outcome following concussion in non-Oral Contraceptive Pill (OCP) users propose unfavorable effects of circulating sex hormones which stabilize with OCPs



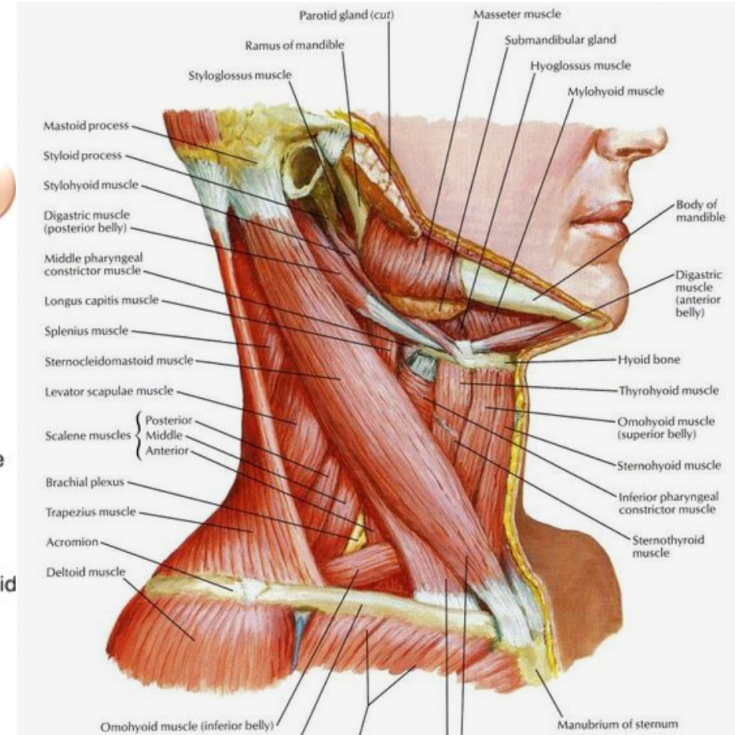
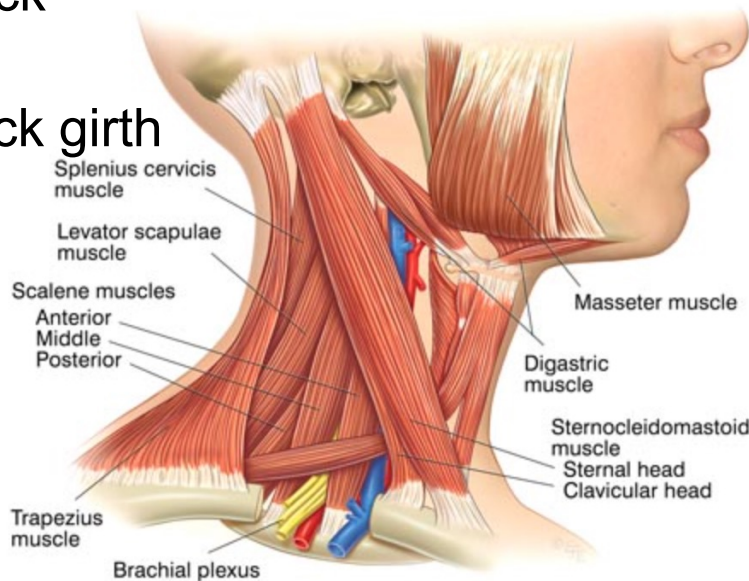
BRAIN ANATOMY

- Smaller brain size and brain reserve
- Smaller axon fiber diameter
- Less axonal microtubules
- Structural vulnerability (particularly in temporal cortices)
- More fibers crossing corpus callosum
 - greater interhemispheric communication that makes females more vulnerable to effects of corpus callosum injury which sustains the greatest amount of axonal damage following concussion



HEAD-NECK ANATOMY

- Smaller head size
- Weaker neck muscles
- Smaller neck girth



- Neck-strength-to-head-size
- Greater angular acceleration at the neck

GENDER DIFFERENCES

- Differences in reporting:
 - Females more likely to report concussion symptoms including headache/migraine, difficulty concentrating, vision/hearing problems, low energy, sleep disturbances, and emotional instability compared to males
 - Women more likely to report headaches, dizziness, loss of confidence, lack of initiative and need for supervision after a concussion than men
 - Men reported a greater sensitivity to noise, more sleep disturbances, restlessness and more difficulty setting realistic goals
 - Females reported higher % of symptoms following a concussion
 - *Some studies that did not find any sex-related differences*

MECHANISM OF INJURY

- Concussion affected a wide range of activities, including occupational injuries, and a broad spectrum of mechanisms including MVC, fall, and trauma. There was a significant relationship between gender and mechanism of injury in young patients with PCS.

Table 1: Demographics of patients with post-concussion syndrome

| Variables | Women (n = 186) | | | Men (n = 251) | | |
|-----------------------------|-----------------|------------|------------|---------------|------------|-------------|
| | <50 years | 50 + years | Total | <50 years | 50 + years | Total |
| Total cases (n [%])* , # | 143 (76.9%) | 43 (23.1%) | 186 (100%) | 211 (84.1%) | 40 (15.9%) | 251 (100%) |
| Mechanism of injury (n [%]) | | | | | | |
| Sport (n [%])* , # | 65 (45.5%) | 3 (7.0%) | 68 (36.6%) | 140 (66.4%) | 13 (32.5%) | 153 (61.0%) |
| MVC (n [%])* , # | 33 (23.1%) | 14 (32.6%) | 47 (25.3%) | 21 (10.0%) | 12 (30.0%) | 33 (13.1%) |
| Fall (n [%])* , # | 22 (15.4%) | 20 (46.5%) | 42 (22.6%) | 13 (6.2%) | 9 (22.5%) | 22 (8.8%) |
| Trauma (n [%]) | 8 (5.6%) | 2 (4.7%) | 10 (5.4%) | 16 (7.6%) | 1 (2.5%) | 17 (6.8%) |
| NOS (n [%]) | 15 (10.5%) | 4 (9.3%) | 19 (10.2%) | 21 (10.0%) | 5 (12.5%) | 26 (10.4%) |
| Total | 143 (100%) | 43 (100%) | 186 (100%) | 211 (100%) | 40 (100%) | 251 (100%) |

CONCUSSION RECOVERY

- Concussion recovery (# of days to resume daily activities or become asymptomatic after a concussion)
 - Females need more days to completely recover & return to baseline than males (Covassin et al., 2016; Henry, et al, 2016; Merritt, et al, 2019; Zuckerman et al., 2014)
 - Females more likely to have symptoms that last longer than a month (Bauman, Ray, & Joseph, 2017; Covassin, Savage, Bretzin, & Fox, 2018; Eisenberg, Andrea, Meehan, & Mannix, 2013; Zemek et al., 2016)
 - Female collegiate concussed athletes took longer to recover from concussions than male collegiate concussed athletes in all sports except lacrosse (McCrory et al., 2013).
 - Older females are more vulnerable to the development of chronic PCS than males (Farace & Alves, 2000a; King, 2014b)
 - BUT some studies reported no sex-related differences in post-concussion outcomes (Black et al., 2017; Henry et al., 2016).
 - *? partially explained by a greater frequency of psychiatric disorders including mood and anxiety disorders in women, particularly young women* (Gulland, 2016; McManus, Bebbington, Jenkins, & Brugha, 2016);
 - *? Partially explained by past history of migraines/headaches* (Burch, et al. *Headache* **61**, 60–68 (2021).; Woldeamanuel, Y. W. & Cowan, R. P.. *J. Neurol. Sci.* **372**, 307–315 (2017).; GBD 2016 Headache Collaborators. *Lancet Neurol.* **17**, 954–976 (2018).

• OUTCOME

- retrospective population-based case-controlled 25 yr retrospective study using province-wide (Man) medical health data collected 1 Apr-31 Mar 1990–1991 to 2014–2015
- 28021M (mean age \pm sd, 25 \pm 18yrs) & 19462W (30 \pm 21 years) in concussion group; 81871M (25 \pm 18 years) & 57159W (30 \pm 21yrs) in the matched control group; Outcomes: ADHD, Mood disorder

Table 2 Hazard ratios for risk of attention-deficit hyperactivity disorder diagnosis

| Age at diagnosis | | Mean \pm SD | |
|---------------------|---------|---------------------|---------|
| Control | | 17.2 \pm 11.7 | |
| Concussion | | 17.8 \pm 11.9 | |
| Model 1a | | Model 1b | |
| HR (95% CI) | P value | HR (95% CI) | P value |
| 1.40 (1.33 to 1.47) | <0.001 | 1.39 (1.32 to 1.46) | <0.001 |
| Model 2a | | Model 2b | |
| 1.29 (1.14 to 1.45) | <0.001 | 1.28 (1.14 to 1.45) | <0.001 |
| Model 3a | | Model 3b | |
| 1.39 (1.32 to 1.46) | <.001* | 1.38 (1.31 to 1.45) | <.001* |
| 1.20 (0.98 to 1.48) | 0.08† | 1.20 (0.97 to 1.47) | 0.09† |
| 0.92 (0.51 to 1.67) | 0.78‡ | 0.94 (0.52 to 1.70) | 0.83‡ |
| Model 4a | | Model 4b | |
| 1.28 (1.21 to 1.35) | <0.001 | 1.27 (1.21 to 1.34) | <0.001 |
| Model 5a | | Model 5b | |
| 1.01 (1.00 to 1.02) | 0.23 | 1.01 (1.00 to 1.02) | 0.30 |

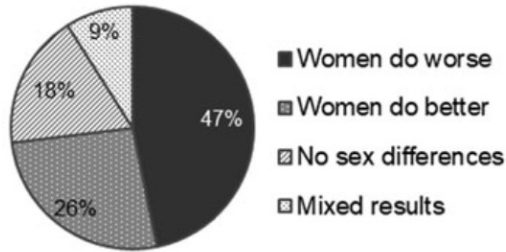
SEX effect ADHD, Mood/Anxiety

Table 3 Hazard ratios for risk of mood and anxiety disorder diagnosis

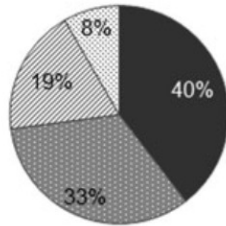
| Age of diagnosis | | Mean \pm SD | |
|---------------------|---------|---------------------|---------|
| Control | | 36.5 \pm 19.1 | |
| Concussion | | 36.0 \pm 18.2 | |
| Model 1a | | Model 1b | |
| HR (95% CI) | P value | HR (95% CI) | P value |
| 1.75 (1.71 to 1.78) | <0.001 | 1.72 (1.69 to 1.76) | <0.001 |
| Model 2a | | Model 2b | |
| 1.07 (1.03 to 1.12) | <0.001 | 1.07 (1.03 to 1.11) | 0.001 |
| Model 3a | | Model 3b | |
| 1.74 (1.71 to 1.78) | <.001* | 1.72 (1.69 to 1.75) | <.001* |
| 1.04 (0.96 to 1.13) | 0.35† | 1.04 (0.96 to 1.13) | 0.31† |
| 1.16 (0.95 to 1.42) | 0.14‡ | 1.17 (0.96 to 1.43) | 0.12‡ |
| Model 4a | | Model 4b | |
| 1.73 (1.70 to 1.77) | <0.001 | 1.71 (1.68 to 1.75) | <0.001 |
| Model 5a | | Model 5b | |
| 0.96 (0.95 to 0.96) | <0.001 | 0.96 (0.95 to 0.96) | <0.001 |

SEX EFFECTS ON TBI IN HUMAN STUDIES

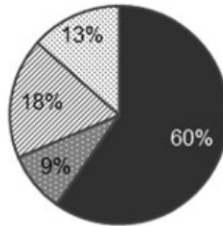
TBI outcomes in human studies (n = 156)



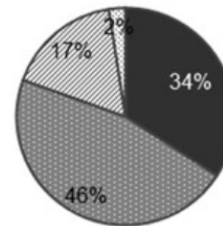
Non-stratified (n = 48)



Mild-moderate (n = 67)

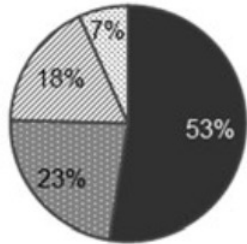


Moderate-severe (n = 41)

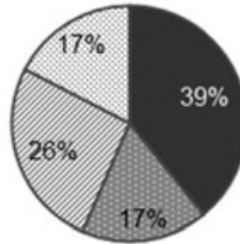


SEX EFFECTS ON TBI IN HUMAN STUDIES

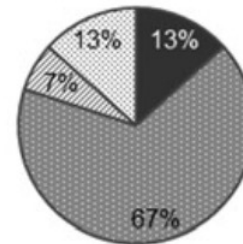
0 - 1000 patients (n = 118)



1000 - 10,000 patients (n = 23)

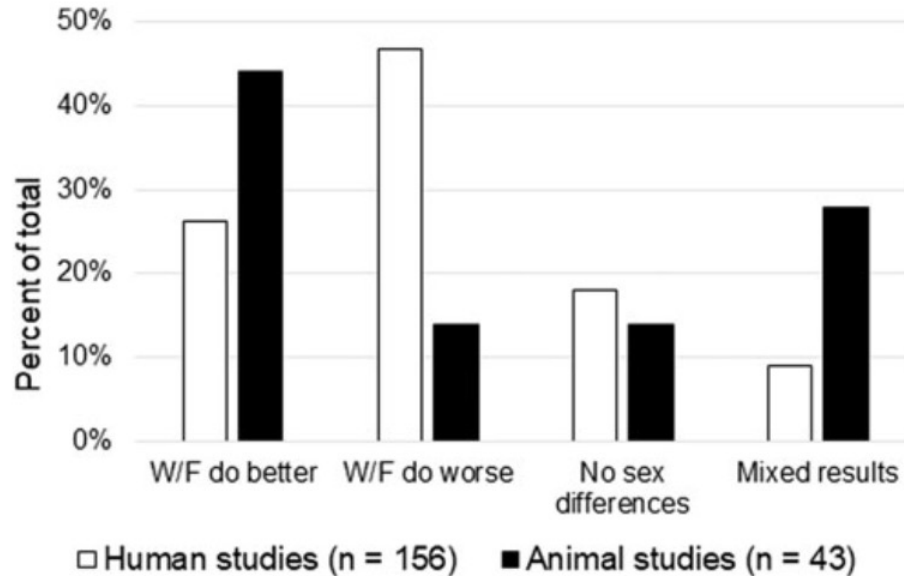


> 10,000 patients (n = 15)



- Women do worse
- Women do better
- ▨ No sex differences
- ▨ Mixed results

HUMAN & ANIMAL MODELS



MECHANISM OF INJURY

- Differential risk of concussion:
 - Sports
 - Falls
 - Motor vehicle accidents
 - Occupation:
 - Occupation-related concussions may be caused by different mechanisms at the workplace including moving or falling objects, falls, bodily movement collisions, and violence
 - Majority of work-related injuries among female workers occurred in the education and healthcare sectors
 - Female employees account for > 40 % of head injuries including all levels of severity,
 - Younger males aged 20–24 years and older females in the 50–54 age group were at the greatest risk of head injuries, mostly in the form of concussion
 - Trauma

INTIMATE PARTNER VIOLENCE (IPV) IN CANADA



- Includes physical, emotional, sexual, verbal, social and financial abuse
- Former or current legal marriage or cohabitation or dating relationship
- 2009 General Social Survey on Victimization: 6.2%, or ~1.2 million Canadians 15 years of age +, reported experiencing spousal violence in 5 preceding the survey
 - IPV is not rare
 - traverses all socioeconomic boundaries
- affects 1 in 4 women over their lifetime in Canada; international estimates are higher (1 in 3)
- Up to 92% of hits are to the head or face in this context and are likely to be repetitive
- Males = females experienced spousal violence
- Females 3X more likely (34% vs. 10%) to experience serious spousal violence in the past 5 years including being beaten, choked or sexually assaulted

IPV & Concussion/mTBI

- Concussion/mTBI incidence unknown in IPV and is often overlooked or misdiagnosed
 - Prevalence of IPV-related TBI 19-100% if reported injuries to the head (diverse groups)
 - Underdiagnosed: injury to the head, face, or neck, and suspected IPV does not always lead to a TBI diagnosis
- 42% of women survivors experience injury as a result of IPV (Statistics Canada, 2016)
 - Most common injuries are from battery to the face, head, and neck
 - Usually long term and repeated violent encounters
 - Women exposed to IPV are 2X as likely to experience depression, and nearly 2X as likely to have alcohol use disorders, compared to women who have not experienced IPV

IPV & Concussion/mTBI

- IPV can cause brain injury resulting in fatigue, depression, memory loss, confusion, impaired judgment, and difficulty with tasks that may impair ability to leave an abuser
- Survivors of IPV-related TBI may initially present with addiction and/or mental health issues rather than trauma - masking TBI symptoms
- Women survivors of IPV are unlikely to report violence to frontline workers unless directly asked

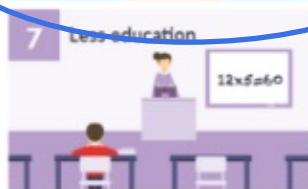
IPV & Concussion/mTBI

- Sustaining a second brain injury before healing of previous brain trauma can result in poor memory, impaired judgment, decreased function and sometimes death
- Problems with diagnosis of mTBI because symptom overlap with PTSD, dissociation, and substance abuse - one diagnosis does not preclude others
- Critical that IPV survivors with TBI identified and supported at earliest possible point of contact to avoid repetitive trauma to the brain and related outcomes
- Need to address psychological & physical concerns

DELAYED EFFECTS OF CONCUSSION/MTBI

- TBI (all severities) associated with increased risk of dementia
- Lancet Report: TBI is a modifiable risk factor for dementia
 - Single mTBI increased risk of dementia (OR 1.6, 95% CI 1.6–1.7)
 - Multiple TBIs increased the risk of dementia OR 2.8, 2.5–3.2
 - Study of 178779 veterans with TBI with propensity matched veterans without TBI found dementia risk was associated with TBI severity (**HR 2.4, 95% CI 2.1–2.7 for mild TBI without loss of consciousness; 2.5, 2.3–2.8 for mild TBI with loss of consciousness; and 3.8, 3.6–3.9 for moderate to severe TBI**)
 - Cohort study of 28815 older adults with concussion, found the risk of dementia doubled, with 1 in 6 developing dementia over a mean follow-up of 3.9 years

DELAYED EFFECTS OF TBI



Source: Livingston et al. A. et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission

www.alz.co.uk

WOMEN & DEMENTIA

- More women live with dementia than men.
- The prevalence of DEMENTIA is higher for women than for men

2/3 of Americans with Alzheimer's disease are women

1/6 estimated lifetime risk of of a woman in her 60s developing Alzheimer's disease

1/3 chance of a woman developing Alzheimer's disease

MTBI/CONCUSSION & DEMENTIA

- Increasing evidence that mTBI can increase risk of Dementia
 - retrospective population-based case-controlled 25 yr retrospective study using province-wide (Man) medical health data collected 1 Apr-31 Mar 1990–1991 to 2014–2015
 - 28021M (mean age \pm sd, 25 \pm 18yrs) & 19462W (30 \pm 21 years) in concussion group; 81871M (25 \pm 18 years) & 57159W (30 \pm 21yrs) in the matched control group
 - Outcomes: Dementia, ADHD, PD, Mood disorder

| Table 4 Hazard ratios for risk of dementia diagnosis | | | |
|--|-------------------------------|----------------------------------|----------------|
| Age of diagnosis | | | |
| | Mean\pmSD | | |
| Control | 73.8 \pm 19.3 | | |
| Concussion | 71.0 \pm 19.6 | Corrected for SEF and CMI | |
| Model 1a | | Model 1b | |
| HR (95% CI) | P value | HR (95% CI) | P value |
| 1.75 (1.63 to 1.87) | <0.001 | 1.72 (1.61 to 1.84) | <0.001 |
| Model 2a Sex interaction | | Model 2b | |
| 0.95 (0.83 to 1.09) | 0.49 | 0.93 (0.82 to 1.07) | 0.33 |
| Model 3a Multiple concussion | | Model 3b | |
| 1.70 (1.59 to 1.82) | <.001* | 1.67 (1.56 to 1.79) | <.001* |
| 1.63 (1.26 to 2.11) | <0.001† | 1.62 (1.25 to 2.10) | <0.001† |
| 1.19 (0.62 to 2.28) | 0.60‡ | 1.20 (0.63 to 2.30) | 0.60‡ |
| Model 4a Controlling for other conditions of interest | | Model 4b | |
| 1.55 (1.45 to 1.67) | <0.001 | 1.54 (1.43 to 1.65) | <0.001 |
| Model 5a Proportionality model | | Model 5b | |
| 0.97 (0.97 to 0.98) | <0.001 | 0.97 (0.97 to 0.98) | <0.001 |

Mild Traumatic Brain Injuries and Future Risk of Developing Alzheimer's Disease: Systematic Review and Meta-Analysis

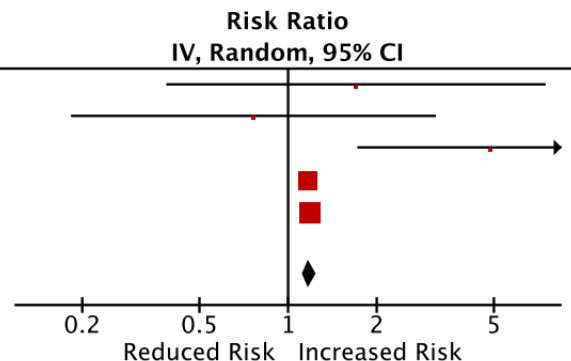
Table 1
Study characteristics, baseline demographics, factors adjusted for, follow up duration and relative risks

| Author + Region | Study Design | Sample Size | Head Injury Measure | AD Measure | Follow-up (y) | Age (y), Mean (SD)* | Female n (%) | RR (95% CI)** | Adjustment |
|--------------------------------------|--------------|-------------|----------------------|-------------------------|---------------|---------------------|--------------|--------------------|---|
| Graves et al. (1990) USA [36] | Case-control | 260 | Structured Interview | DSM-III-R, NINCDS-ADRDA | 10–30 | 64.9 (NR) | 60 (46) | 4.85 (1.72, 13.66) | Age, family history of AD |
| Schofield et al. (1997) USA [35] | Cohort | 271 | Structured Interview | NINCDS-ADRDA | >30 | 75.3 (7.3) | 197 (73) | 1.70 (0.39, 7.50) | Age, sex, education |
| Plassman et al. (2000) USA [34] | Cohort | 1776 | Medical Records | DSM-III-R, NINCDS-ADRDA | 51–53 | 72.9 (NR) | 0 | 0.76 (0.18, 3.18) | Education, age, <i>APOE ε4</i> |
| Tolppanen et al. (2017) Finland [37] | Case-control | 352,581 | National Register | NINCDS-ADRDA, DSM-IV | >5 | 80.1 (7.1) | 230,580 (65) | 1.18 (1.15, 1.22) | Socioeconomic position, physical health, drug use |
| Fann et al. (2018) Denmark [33] | Cohort | 2,794,852 | National Register | ICD-9 | 4–18 | 80.7 (8.7) | NR | 1.17 (1.12, 1.22) | Sociodemographic, substance abuse, stroke, cardiovascular diseases, diabetes, hip fracture, asthma or chronic obstructive pulmonary diseases, use of antipsychotics, antidepressants, antiepileptics, benzodiazepines and related drugs |

| Study or Subgroup | log[Risk Ratio] | SE | Weight | Risk Ratio IV, Random, 95% CI |
|-----------------------|-----------------|-------|---------------|-------------------------------|
| Schofield 1997 | 0.531 | 0.757 | 0.2% | 1.70 [0.39, 7.50] |
| Plassman 2000 | -0.271 | 0.728 | 0.2% | 0.76 [0.18, 3.18] |
| Graves 1990 | 1.578 | 0.529 | 0.3% | 4.85 [1.72, 13.66] |
| Fann 2018 | 0.154 | 0.021 | 47.1% | 1.17 [1.12, 1.22] |
| Tolppanen 2017 | 0.168 | 0.016 | 52.3% | 1.18 [1.15, 1.22] |
| Total (95% CI) | | | 100.0% | 1.18 [1.11, 1.25] |

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 8.03$, $df = 4$ ($P = 0.09$); $I^2 = 50\%$

Test for overall effect: $Z = 5.63$ ($P < 0.00001$)



SUMMARY

- Concussions result from brain trauma
- Sex & gender effects are significant on concussion prevalence and recovery: physiological, social constructs
- Concussions frequent in Intimate Partner Violence & underreported
- Delayed effects of concussion need to be considered - neurodegeneration

RESOURCES

- <https://www.pinkconcussions.com/>
- [https://www.uhn.ca/Krembil/Canadian-Concussion](https://www.uhn.ca/Krembil/Canadian-Concussion-Centre/Education#about)
- Centre/Education#about<https://braininjuryguidelines.org/concussion/fileadmin/media/adult-concussion-guidelines-3rd-edition.pdf>
- <https://www.womenscollegehospital.ca/care-programs/sexual-assault-domestic-violence-care-centre/>

THANK YOU

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