Appendices

Appendix 1

NRL Community Rugby League Policy and Guidelines for the Management of Concussion

TYPE OF POLICY	Participation
EFFECTIVE DATE	9 March 2021
POLICY OWNER	NRL Participation, Game Development and Community
POLICY CONTACT	NRL Participation & Game Development Operations Manager

A. REASON FOR GUIDELINES

These guidelines have been developed based on the Consensus Statement produced from the 5th International Conference on Concussion in Sport to ensure that First Responders, Medical Practitioners, Coaches and Parents have an awareness of how to appropriately manage concussion in Rugby League.

B. GUIDELINES STATEMENT

These guidelines will provide the opportunity for First Responders and Medical Practitioners to have an awareness recognising the signs and symptoms of concussion, the appropriate management of a suspected concussion and the graduated return to sport process once a concussion has been diagnosed.

C. SCOPE

This policy is applicable to District, Division, Group or Leagues that participate in Rugby League under the Community On-field Policy.

1.0. INTRODUCTION

These Guidelines are based on the Consensus Statement produced following the 5th International Conference on Concussion in Sport held in Berlin in October 2016. The Guidelines should be followed at all times and any decision regarding return to play after concussive injuries should only be made by a doctor with experience in dealing with such injuries.

The NRL also supports the Concussion in Sport Australia Position Statement and recommends it as a valuable resource for First Responders, Medical Practitioners, coaches, parents and others involved in community rugby league (https://www.concussioninsport.gov.au).

2.0. SUMMARY

· The most important element in the management of concussion must always be the welfare of the player - in both the short and long term. All players with concussion, or suspected of having a concussion, should seek urgent medical assessment.

· Concussion is a disturbance in brain function resulting from trauma that is transmitted to the brain either directly or indirectly. There is no absolute need for direct head impact for a concussion to occur. There are no

structural changes (e.g. brain bleeds) and the changes that do occur are currently believed to be largely temporary and recover spontaneously.

· Complications can occur if a player continues playing before they have fully recovered from a concussion. Therefore, a player who is suspected of having a concussion must be taken out of the game or training session immediately. A player who has suffered a suspected concussion or exhibits the symptoms of concussion should not return to play in the same game or training session (or any game/training session until medically cleared by a doctor), even if they appear to have recovered. Concussion is an evolving condition which may develop over minutes to hours (and sometimes days). Some symptoms or signs may resolve only to be replaced by others later. The management of head injuries may be difficult for non-medical personnel. It is often unclear whether you are dealing with concussion, or there is a more severe structural head injury, especially in the early phases of an injury. Concussion is considered a medical condition and therefore needs to be assessed and managed by an appropriately qualified doctor.

- In the period following a concussion, a player should not be allowed to return to play or train until they have had a formal medical clearance using the NRL Head Injury Recognition and Referral form by a doctor.
- A Graduated Return to Play Program (as outlined below) should be followed to manage the return to training and/or play following a concussion. Children and adolescents generally take longer to recover from a concussion and additional time (around double that of an adult) should be allowed in developing a return to play/training program for a child or adolescent.
- A child or adolescent is defined as a person aged 18 years and younger, an adult is defined as a person who has attained the age of 19 years and above.
- Players suspected of having a concussion must not be allowed to drive, operate machinery, drink alcohol, take anti-inflammatory medication (including aspirin and Ibuprofen), or use strong painkillers or sleeping tablets until they have been medically cleared to do so by a doctor.

3.0. BACKGROUND

When considering the management of concussion, the welfare of the player - both in the short and long term - must always remain paramount.

Since 2001, there have been five international conferences addressing the key issues in the understanding and management of concussion. After each meeting, a summary has been published to improve the safety and health of athletes who suffer concussive injuries during participation in sport. The most recently published conference was held in Berlin in October 2016. The summary from the Berlin meeting provides consensus guidelines for current best practice management of concussion[1]. The NRL's current guidelines for the management of concussion are based on the Berlin conference, as well as research conducted on concussion in the NRL, World Rugby, AFL and other international sports over a number of years.

The NRL also supports the Concussion in Sport Australia Position Statement and recommends it as a valuable resource for trainers, first aid providers, coaches, parents, medical practitioners and others involved in community rugby league (https://www.concussioninsport.gov.au).

4.0. WHAT IS CONCUSSION?

"Traumatic Brain Injury" (TBI) is the term used to describe injuries to the brain that are caused by trauma. The most severe injuries involve structural damage e.g. fractures of the skull, bleeding in or around the brain. These structural injuries require urgent medical attention.

Concussion falls into the milder spectrum of TBI (mTBI = mild traumatic brain injury) and involves a disturbance of brain function with no structural damage and no probable permanent injury to the brain.

Concussion is caused by trauma to the brain, which can be either direct contact with the head (e.g. head clash, impact to the ground, etc) or indirect by a force to any part of the body transmitted to the head (e.g. shoulder charge or tackle).

When the force is transmitted to the brain it can "stun" the nerve tissue and affect the way the nerves work. This can result in a number of symptoms and signs depending on the area of brain that is affected. Concussions, therefore, present in many different ways and the symptoms and signs often change or evolve over time.

Symptoms include but are not limited to headache, blurred vision, dizziness, nausea, poor balance, fatigue and feeling "not quite right". A concussed player may also exhibit confusion, memory loss and reduced ability to think clearly and process information. Loss of consciousness is not common and occurs in less than 10% of cases of concussion. **A player does not have to lose consciousness to have concussion.**

The essential injury in concussion is functional disturbance rather than structural damage. The changes that occur are currently believed to be temporary and usually recover spontaneously if managed correctly. The recovery period and process vary from person to person and injury to injury.

Most cases of concussion in Rugby League recover within 14 days from the time of injury, although in a small number of cases the recovery time may be weeks to months. Children and adolescents may take longer to recover.

5.0. WHAT ARE THE POTENTIAL COMPLICATIONS FOLLOWING CONCUSSION?

The complications which can possibly occur following a concussion include:

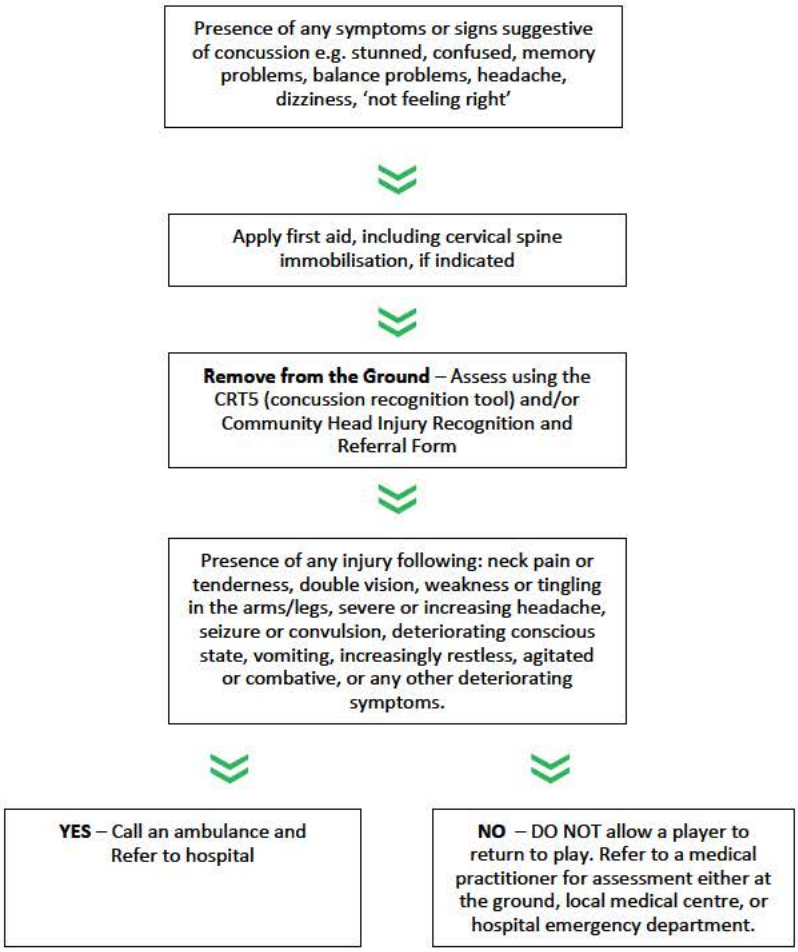
- Increased risk of other musculoskeletal injury (possibly due to reduction in reaction time) or repeated concussion (with the second injury often much more severe than the first);
- Prolonged symptoms;
- Symptoms of depression, anxiety and other psychological problems;

- Severe brain swelling (especially in young players); and
- Potential long-term brain malfunction/degeneration (not currently definitively proven but currently the topic of research).

Complications are not common, however, the risk of complications from a concussion is increased by allowing the player to return to play (or training) before they have recovered completely. It is therefore essential to recognise a possible concussion, confirm the diagnosis with a doctor, and keep the player out of training and competition until the player has recovered completely.

Concussion can cause problems with memory and processing of information, which interferes with the player's ability to learn in the classroom, therefore, a child or adolescent should not return to school until cleared by a medical practitioner to do so. A successful return to school should occur before attempting a return to training or sport.

6.0. STEPS IN THE MANAGEMENT OF CONCUSSION



NOTE: Any player with a loss of consciousness, basic first aid principles should be applied i.e. **D**anger, **R**esponse, **S**end for help, **A**irway, **B**reathing, **C**PR, and **D**efibrillation (**DRSABCD**). Care must always be taken with the player's neck, as it may have also been injured in the collision. An ambulance should be called, and the player(s) transported to hospital for assessment and management.

7.0. GAME DAY MANAGEMENT

The most important steps in the early management of concussion include:

A. Recognising the injury;
B. Removing the player from the game or training; and
C. Referring the player to a medical practitioner (doctor) for assessment.

A. Recognising the injury – (suspecting concussion)
(i) Visible clues - when to suspect concussion:

- Loss of consciousness or non-responsive
- Lying on the ground - not moving, or slow to stand
- Unsteady on feet / balance problems / poor coordination
- Grabbing / clutching at head
- Dazed, blank or vacant look
- Confused / not aware of plays or events

(ii) Loss of consciousness, confusion and disturbance of memory are classical features of concussion, but it is important to remember that they are not present in every case.

(iii) There are several non-specific symptoms that may be present, and which should raise the suspicion of concussion: headache, blurred vision, balance problems, dizziness, feeling "dazed" or "lightheaded", "don't feel right", drowsiness, fatigue and difficulty concentrating.

(iv) Tools such as the pocket Concussion Recognition Tool 5 (CRT5) (link below) can be used to help in the identification of a suspected concussion along with the Head Injury Recognition & Referral Form (HIRRF) (link below).
CRT5 - bjsports-2017-097508CRT5
HIRRF - https://www.playrugbyleague.com/concussion

It is important to understand that brief sideline evaluation tools (such as Concussion Recognition Tool 5 CRT5 and SCAT5*) are designed to help in the identification of a suspected concussion. It is still imperative to arrange a more comprehensive medical assessment by an appropriately experienced medical practitioner (doctor).

*Note: the SCAT5 is a medical practitioner (doctor) only assessment tool.

B. Removing the player from the activity including training, warm-up or game.
(i) Initial management of a head injury or suspected concussion must always follow first aid rules, including airway, breathing, CPR and spinal immobilisation.

(ii) **Any player who is removed from the Activity with a suspected concussion must be referred to a Doctor for assessment with their Head Injury Recognition & Referral Form as soon as possible (preferably the same day)**

(iii) A player who has suffered a suspected concussion or exhibits the symptoms of concussion should not return to play in the same game (or any game until medically cleared to play by a doctor), even if they appear to have recovered

The assessor should not be swayed by the opinion of the player, coaching staff, parents or anyone else suggesting premature return to play. Concussion is an evolving condition and symptoms and signs can vary over minutes to hours and days. The incident must be recorded on the Head Injury Recognition & Referral Form.

C. Referring the player to a medical practitioner for assessment

(i) The management of a head injury is difficult for non-medical personnel. Following an injury, it is often unclear if you are dealing with a concussion or with a more severe underlying structural head injury.

(ii) **ALL players with a suspected concussion should seek medical assessment by a medical practitioner (doctor) as soon as possible even if the signs and symptoms resolve. If any Red Flags are present (refer to the CRT5) or if you have any other concerns the individual should be sent urgently to an Emergency Department (ED), preferably by ambulance. An urgent General Practitioner (GP)assessment is acceptable if an ED is not practically possible for concerns other than the CRT5 Red Flags.**

(iii) It is recommended that clubs prepare a pre-game checklist of the appropriate services, including:

- local doctors or medical centres;
- local Hospital Emergency Departments; and
- ambulance services (000).

Management of an unconscious player

1. First Aid principles of DRSABCD should be used. It is extremely important to treat all unconscious players as though they also have a neck injury (Spinal Immobilisation).
2. An unconscious player should only be moved (onto a stretcher) by qualified health professionals, trained in spinal immobilisation techniques in accordance with the NRL Neck Injury and Cervical Collar Policy. If no qualified person is present, **do not move the player** - wait for the ambulance and paramedics.
3. Urgent hospital referral is necessary if there is concern regarding the risk of a serious or structural head or neck injury --- **call 000**.
4. Any player with ANY of the following 9 RED FLAGS as outlined in the Concussion recognition Tool 5 (CRT5) in the context of a possible head injury should be referred to a hospital urgently, via Ambulance ---**call 000**:
    - Loss of consciousness
    - Seizures / fits or convulsions
    - Severe or increasing headache
    - Double vision
    - Vomiting
    - Deterioration of conscious state after being injured, e.g. increased drowsiness
    - Report of neck pain / tenderness
    - Burning, numbness, tingling or weakness in arms/legs. (potential spinal cord symptoms)
    - Increasingly restless, agitated or combative

5. The Head Injury Recognition & Referral Form must be used.

If, at any time, there is any doubt, the player should be immediately referred to hospital.

8.0. FOLLOW UP MANAGEMENT

In accordance with the current Concussion Guidelines, there is no defined mandatory period of time that a player must be withheld from play following a concussion, although an adult seeking to participate in the following rounds' matches (or any available games in less than an 11 day period) requires written clearance from a specialist concussion Doctor. A 6-stage graduated return to play/train must be undertaken (in those that are 18 years old, a more conservative approach is recommended such that generally twice the time to complete the return to play/train is taken and a return to school/learning/work should be completed before a return to play/train protocol is started). The duration of exclusion from play is based on an individual's recovery as managed by a medical practitioner (doctor).

- A player who has sustained a concussion MUST NOT be allowed to return to school or play before obtaining the appropriate medical clearance from a doctor.
- Return to work, learning and school should take precedence over return to sport.
- The decision regarding the timing of return to training should always be made by a medical practitioner -Doctor; or Neurologist, Neurosurgeon or Sport and Exercise Physician with a documented strong interest in concussion management.
- In cases of uncertainty about the player's recovery, always adopt a more conservative approach, "if in doubt sit them out".

9.0. MULTIPLE AND CONCERNING CONCUSSIONS

- When a player:

i. Has sustained two (2) diagnosed concussions within the one (1) Season (including preseason training and games), has prolonged concussion symptoms (>14 days) or an unusual presentation; or
ii. Over time (not just within the one (1) season):

- Is developing concussion symptoms with less force; or
- Is experiencing progressively increasing length of concussion symptoms; or
- Has an increasing symptom load (a greater number of concussion symptoms); or
- Has a decreasing time period between concussive / possible concussive events; or

- Has significant mental health issues (e.g. anxiety, depression) potentially related to head injuries, then, the NRL requires that the player be formally sent for assessment with a specialist with a recognised interest in sport related concussion management (Neurologist, Neurosurgeon or Sport and Exercise Physician) as part of a multi- disciplinary Team approach. The assessment should also include formal neuropsychological testing if recommended by the Concussion Specialist providing the opinion. This should occur to ensure the player has fully recovered from their concussions, to assess the risks of further concussions and to determine whether the player is currently fit to participate in training and/or matches. A copy of the Concussion specialist's opinion should also be made available to the appropriate governing body on request.

In any case where a player has been diagnosed as having suffered a significant head injury, traumatic brain injury or concussive injury, the player's Club must ensure that the player does not participate in a match or engage in training in any form until such a time as properly qualified medical opinion is obtained by the Club which supports the conclusion that the Player has fully recovered from the effects of the injury.

10.0. RETURN TO PLAY/SPORT

- Players should not attempt a return to play until they have returned to work or school/ learning without resolution of their symptoms.
- Return to training or play should be gradual.
- Rehabilitation after a concussion should be supervised by a medical practitioner and should follow the stepwise symptom limited progression outlined below.
- Initially, complete rest for the first 24 to 48 hours – including mental and physical rest (recovery). Children and adolescents should be treated more conservatively, so an initial 48 hours rest is recommended.
- A 6 stage Graduated Return to Sport (GRTS) Program can look like the following. This return to sport program should only be commenced after the initial rest period of 24 to 48 hours and successful return to learning/school.

Each stage should be a minimum of 24 hours' duration. Longer return to sport timeframes are generally recommended in community sport settings. Also, longer time frames (twice as long) are suggested in children and adolescents 18 years old and not yet attained the age of 19 years old. Contact training should only be attempted at the end of the GRTS program and only after a final doctors' assessment and clearance using NRL Head Injury Recognition and Referral Form.

If symptoms return at any stage of the Graduated Return to Sport Program, then the player should move back to the previous symptom-free stage once all symptoms have resolved.

1. **Symptom-limited activity** – daily activities that do not provoke or worsen symptoms;

2. **Light Aerobic Exercise** – for example, walking, exercise bike with heart rate less than ~70% max (no resistance/weight training);

3. **Sport Specific Exercise** – for example, running drills without risk of head contact;

4. **Non-contact training** and start resistance (weight) training;

5. **Full contact training – ONLY** after medical clearance by a doctor using NRL Head Injury Recognition and Referral Form– coaching staff should assess tackling and other skills for correct technique;

6. **Return to play/games.**

- **Adults:** If a player wishes to return to play in the **following rounds' match** (or any available match within less than an 11-day period following the injury) they must be cleared in writing by a specialist concussion Doctor
- **Children and Adolescents:** If a player wishes to return to play in less time than the GRTS stipulates (less than14 days) from the time of injury, they must be cleared in writing by a specialist concussion doctor.

A specialist concussion doctor has to be one of the following with a documented strong interest in concussion management:

1. **Neurologist**
2. **Neurosurgeon**
3. **Sport and Exercise Physician (Sports Physician)**

Player honesty is important when questioning about symptoms. Remember that playing or training with symptoms of concussion can increase the risk of injury, result in concussion complications and prolonged symptoms, result in reduced performance, increase the risk of other injuries (musculoskeletal) and could potentially be catastrophic. Each case of concussion is unique, so management should be individualised by the treating doctor.

11.0. CHILDREN AND ADOLESCENTS

A child or adolescent is defined as a person aged 18 years and younger, an adult is defined as a person who has attained the age of 19 years and above.

The same principles regarding recognition, detection, management and return to sport apply to children and adolescents, however, it is widely accepted that children and adolescents with concussion should be managed **more conservatively**. This includes longer initial rest and slower return to train and play programs, usually twice as long as the recommended for adults. Additionally, a successful symptom-free return to school or learning should be completed before a graded return to play or training is commenced.

Note: the NRL's elite levels of the game have their own policies regarding the management of head injuries and concussion. These policies may vary from some of the principles of the Concussion in Sport Position Statement and these Guidelines when there is appropriately qualified, experienced medical staff overseeing the care and wellbeing of professional rugby league players with advanced care pathways.

Reference:

[1] McCrory P, Meeuwisse W, Dvorak Jet al. Consensus statement on concussion in sport - the 5th International Conference on Concussion in Sport held in Berlin, October 2016. Br J Sports Medicine. 2017;51:838-847.

Appendix 2

Tackle Ready Program

TackleReady Deliverer's Manual

NRL

The TackleReady program allows participants to learn correct and safe techniques, preparing them for the tackle version of Rugby League. The six- session program, delivered by accredited NRL Tackle Ready deliverers, aims to increase player confidence and physical competence in all tackling situations.

To enhance the overall enjoyment of participants, the TackleReady program compliments the NRL SafePlay Code and Tag Rugby League competitions to offer a safe and progressive introduction to tackle Rugby League.

The TackleReady program addresses concerns commonly influencing parent's perception towards Rugby League; in relation to their child's size, strength and abilities. Therefore, the TackleReady Program focuses on key competencies to reduce the effects of varying size, maturation and skill level.

Our Objectives

Players
Provide a systematic introduction to tackling and being tackled with the aim of enhancing players competence and confidence leading to a greater level of enjoyment.

Coaches
Educate entry level club coaches with the necessary skills to teach new Rugby League participants how to tackle and how to be tackled safely.

Parents
Give parents peace of mind, and highlight the games commitment to offering a safe, inclusive environment.

Applying Positive Coaching Techniques

Program Delivery

To achieve the best result, Tackle Ready Program Deliverers should follow the program delivery model as prescribed. Remember the objective of this program is to educate players, coaches and parents.

This guide will help make sure you've covered all bases when delivering the Tackle Ready Program.

Manage

- Prior to commencing a Tackle Ready Program contact the relevant person at the club to confirm times, dates and number of participants.
- Let them know how much space you'll require, and what the program involves. It's imperative that club officials understand that coaches are expected to help deliver the program. Ask the club to provide you with contact details for all coaches.
- Prior to session 1, deliverers will provide a brief introduction to parents and coaches. Here you will outline the learning objectives for the players and hand out an information flyer that provides a summary of each session.
- It's important to maintain communication with your coaches throughout the program. You should provide them with session plans before each session, and ensure they understand the purpose of each activity.

Prepare

- Make sure you review each session, and have all the equipment required. This includes
  - Balls
  - Markers
  - Hit Shields
  - Parent Information Flyer's
  - Session Plan for Coaches
  - Whistle
- Tackle Ready Deliverers should wear Tackle Ready Deliverer uniform, and display any promotional equipment where possible.
- Arrive early to set up equipment.
- Meet with the club coaches prior to the session and make sure they understand their roles and responsibilities.

Deliver

- Begin each session by bringing the group together. Sit down and explain what they will learn during the session. Remember to set expectations around behaviour and involvement.
- Ask lots of open-ended questions throughout the session about what they are learning so you can be sure they have a good understanding.
- Deliver the prescribed program, using the COACHING PROCESS on page 9.
- Give the coaches an opportunity to ask questions and provide feedback.

Review & Reflect

You should review and reflect after every session. Reflection is an important improvement tool in coaching and part of the review process. Asking yourself the following questions will help you to develop as a Tackle Ready Deliverer and enable you to provide the players and coaches with an even better experience.

- Did I achieve the aim of the session?
- What worked well?
- What didn't work well?
- Things to improve on for next time.

STEEDEN

The Coaching Process

To ensure we get the most out of training sessions and to help us achieve our aims of making training fun and stimulating for the players, coaches should follow this coaching process. Getting started, observing and responding appropriately.

Get Started

Get started quickly – Explain the basic objectives and rules - Keep instructions to a minimum

For New Activities: Provide quick demonstration so the players can **SEE IT,** and do a half paced walk through so the players can **DO IT** .

Observe

Is it safe? / Are they appropriately challenged? / Are they involved? / Is it fun?

Did I answer **yes** to all these questions? if so,

STEP BACK

- Let them play
- Provide positive feedback
- Give them time

Did I answer **no** to any of these questions? If so, you can

STEP IN

- Stop the activity
- Change the activity
- Change something (rule, field size, player)
- Ask a question

There's no doubt about it. Coaching children of this age can be challenging. However adopting some simple group management strategies can improve the learning environment immensely and help you deliver the best possible session.

Prevention is Better Than Cure.

Use these three steps to encourage positive behaviour during your session.

Set your Expectations	Use Positive Reinforcement	Plan Ahead
The players need to know what's expected of them. At the start of each session, remind the children of the behaviours you expect. Be realistic, and keep your expectations simple. Limit these expectations to two or three things. For example, coaches might say "I need you to... - **help me make sure everyone is having fun"** - **use your listening ears"** - **play by the rules"** Throughout the session, if you see a player misbehaving, you can simply ask them a question like "Is that helping Johnny have fun?" "Are you using your listening ears?" or "Was that part of the rules?" This puts the ball in their court and makes the child reflect on their own behaviour.	Offering positive rewards for good behaviour is a great way to keep the group under control. You want to show the group that it pays to listen and do the right thing by rewarding those who are behaving positively. Here are some simple rewards you might like to try: - - **Stamp or Sticker** - **-Awarding ten points** - **Having them demonstrate for the next game** - **Allowing them to play a game that they enjoy at the end of the session** Don't be afraid to get involved and play the games with the kids. Children learn by seeing and doing, and they will learn from you.	Being well planned, and limiting the amount of time that the children are waiting around will limit opportunities for them to misbehave. The transition between one activity to the next should be swift, and instruction should be kept to a minimum. Use coloured markers to help manage your group. This can reduce the amount of time it takes to split the team into smaller groups or kick off a new activity. i.e. "Everyone find a blue hat". Sometimes the children will disengage if they find an activity boring, so have some short simple games up your sleeve that you can use to help reengage their attention.

10 Ways to Encourage Positive Behaviour

Keeping Everyone Safe

Keeping Everyone Safe

The NRL is a Child Safe organisation and is committed to promoting a safe environment for all children and to assist everyone involved in Rugby League to fulfil their safeguarding and child protection responsibilities. As a sport, we must promote the safety and welfare of children as the top priority. Coaches will need to ensure the safety of all participants before, during and after each session. Things that you will need to consider to safely deliver each of your sessions are:

Child Safety

When coaching children you will need to adhere to the child safety guidelines in your state, including having a working with children check/ Blue Card, maintaining appropriate boundaries and reporting any suspicious or potential abuse to the relevant authorities. As there is currently no national child safety system or legislation, you will need to understand what is required in your state or territory. For more information on child safety laws in your state go to **www.playbytherules.net.au**, and for information on the NRL's Child Protection and Safeguarding Children go to **https://www.nrl.com/community/inclusion/rights-and-responsibilities/**

When interacting with children it is recommended that you maintain appropriate boundaries to keep children safe. These boundaries include:

- **Physical boundaries**
  - Only use physical contact that is appropriate for the development of a particular skill and with the permission of the child.
  - Work within sight of others at all times.
  - Use drills to develop fitness, not as a punishment.
- **Emotional boundaries**
  - Use positive feedback on performance, not negative feedback about the person.
  - Be encouraging and avoid put downs.
- **To protect yourself and your child, avoid being alone with a child**
  - Do not isolate yourself and a child and avoid being alone with any child.
  - If a child approaches you and wants to talk to you privately, do so in an open area and in sight of other adults (e.g. other coaches, officials or parents).
  - Try to have at least one adult with you in a change room with children.

Lastly, as coaches you must report suspicious or potential physical, sexual or psychological abuse to the relevant authority in your state.

Environmental Conditions

Ensure that you are aware of any potential temperature extremes or electrical storm activity and plan accordingly. For example, if hot weather is forecast remind participants about sun protection, hydration and provide adequate breaks in a shaded area.

Please refer to the NRL's policies for **Heat**, **Sun Protection** and **Electrical Storm Safety** for more information.

Hydration/Hygiene

Children can overheat and dehydrate quickly as they are not able to regulate their body temperature as well as adults. Hot and humid conditions can lead to increased fluid losses through sweat, reminding participants of the importance of hydration and ensuring that they have access to water throughout the session is vital to player safety. If extreme heat is forecast, consider postponing the session to a cooler part of the day to prevent any heat related illness.

If a participant complains of dizziness, light headedness, muscle cramps, nausea or headache, they may be suffering from dehydration. In this instance remove them from the session, sit them in a shaded area and get them to sip cool fluids.

It is strongly recommended that participants have their own water bottle which can be used throughout the session to minimise the potential transfer of infectious disease. If communal water bottles are being used, remind all participants to hold the water bottle away from their mouth as they drink and ensure that the bottles are thoroughly cleaned after each session.

Please refer to the NRL **Infectious Disease Policy** for more information.

All NRL Policies can be found at **www.playrugbyleague.com/policies**

Injury Prevention and Injury Assessment

Taking steps to prevent injury is as important as injury assessment. Injury prevention includes ensuring all players complete a warm up and are encouraged to use protective equipment such as mouthguards.

Injury Prevention

Spending time to teach players how to fall safely, how to make a tackle and how to be tackled safely will be the most effective way to protect against injury. Custom-fitted mouthguards are strongly recommended to help protect against injury in the event of unforeseen circumstances. Headgear can also be worn to potentially minimise cuts and abrasions around the head area.

Injury assessment

If any injury has occurred during a training session you will need to follow basic First Aid procedures of DRSABCD and TOTAPS.

DRSABCD

This initial process should always be followed by the first responder. This could be the coach, League First Aid officer or Sports Trainer.

Danger

- Check for Danger
  - To yourself
  - To others/bystanders
  - To the casualty

Response

- Check for a Response
  - Is the casualty conscious or unconscious?

Send for Help

- Call triple zero (000) for an ambulance
  - Or ask another person to make the call.

Airway

- Check the Airway
  - Is the airway clear and open?

Breathing

- Check for Breathing
  - Look Listen Feel
  - Look to see if the chest is rising and falling
  - Listen for the sound of breathing
  - Feel for air from nose or mouth

Circulation

- If there are no signs of life (casualty unconscious, unresponsive, not moving and not breathing normally) commence CPR.
  - CPR protocol: Thirty (30) compressions, followed by two (2) breaths (rate of approximately one hundred (100) compressions per minute).

Defibrillation

- Apply a defibrillator if available.

TOTAPS

After assessing the injured person using DRSABCD, follow the TOTAPS assessment. This should be completed by a Sports Trainer or First Aider as they receive all of the relevant training.

Talk - Ask the injured player

- How did this happen?
- Where does it hurt?
- How did you land? Twisted/straight?
- Did you hear or feel clicking, locking, grating, snap, rip, tear or giving way?
- What kind of pain? Throbbing, burning, searing pain? Pins and needles? Toothache pain?
- Ask any other questions relevant to the players suspected condition.

Observe – Look for the following:

- Bones: alignment, deformity or unusual shape
- Soft tissue: contours shape, comparing both sides
- Note any swelling
- Colour: redness, inflammation, pale or bluish colour

Touch – This should only occur after the above has been completed

- Be gentle and consider player comfort
- Do not drag the player to their feet
- Is it tender to touch?
- Start away from the injured site and work towards and beyond
- What is the extent of the painful area?
- Try to locate the exact site and relate it to a particular anatomical structure.

Active - Movement

- Ask the player to move the injured limb until restricted by pain
- Significant restriction indicates possible serious injury

Passive - Movement

- You, as the examiner, gently move the injured area to the point of pain or restriction
- Return to play should not be considered unless pain free full range of movement is evident

Skills

- Ask player to stand unaided
- Ask them to walk, jog and carry out specific skills related to the injured part
- Return to play if pain free

Return to play should not be considered unless pain free full range of movement is evident

Concussion

Although you will be teaching young children to tackle safely in a controlled environment there is still the chance a concussion could occur. As a result, you will need to have a basic understanding of what a concussion is and what the signs and symptoms are.

What is a concussion?

Concussion is a disturbance in brain function rather than a structural injury to the brain. It is caused by direct and indirect force to the head, face, neck or elsewhere where the force is transmitted to the head. A player does not need to have been knocked unconscious to have a concussion. Loss of consciousness is seen on only 10-15% of concussion cases.

For more information, visit
www.playrugbyleague.com/concussion

Concussion Management

The 3 most important steps of concussion management are:

1. Recognise
Although some signs and symptoms of a suspected concussion are obvious (e.g. loss of consciousness) it is important that you know and can recognise the subtler signs and symptoms of concussion. These include:

- Headache
- Dizziness
- Confusion
- Ringing Ears
- Nausea
- Repeated Vomiting
- Vision Disturbance
- Loss of Balance
- Memory Loss (amnesia)
- Difficulty concentrating

2. Remove
Any participant who is suspected of having a concussion must be removed from the activity immediately and must not be allowed to return to the training session. Ensure that the player is monitored and is not left alone for at least 1-2 hours.

3. Refer
A player with a suspected concussion should be referred to medical practitioner or an accredited NRL sports trainer. Remember only a medical professional can diagnose a concussion.

Emergency plan in case of serious injury

In the unlikely event of a serious injury you need to ensure you have an emergency plan. When putting together an emergency plan you need to consider the following.

- Make sure you have access to a landline or mobile phone.
- Make sure you know the emergency phone numbers (e.g. 000, 112)
- Make sure you know the street address of the venue and nearest cross street.
- Make sure you know where the entrance to the venue is located and ensure it is unlocked and unobstructed.
- Make sure a designated person meets the emergency vehicle and someone is available to accompany the injured person in the ambulance.

Whenever an injury occurs, the coach must ALWAYS follow the advice of an adequately qualified person before determining whether a player is ready to participate in game or training sessions.

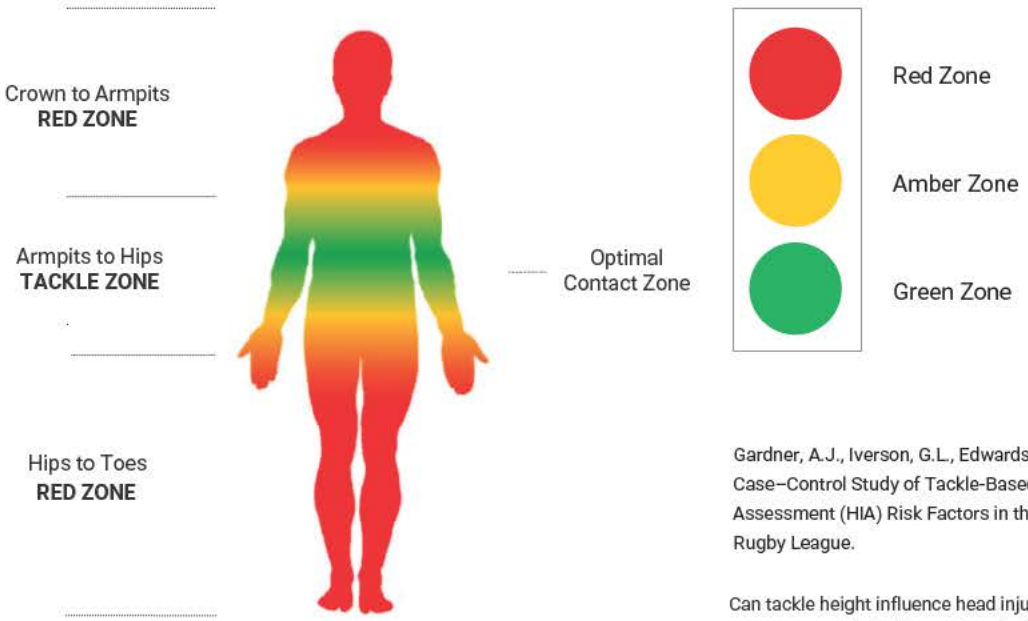
Safe Tackle Technique

In the development of the TackleReady program, research has been used to ensure children are being taught correct and safe techniques. Initially a study conducted by Trinity College Dublin identified the safest Tackle Zone. In 2021, Gardner et al released their findings from a study undertaken in the National Rugby League competition that replicated the earlier research.

These findings, in particular Gardner et al, have had a strong influence in the way our deliverers and coaches instruct children learning how to negotiate tackle situations and have led to the identification of a Green Zone. We have defined this as the "bellybutton area" to ensure it is simple and easy to comprehend for the young participants.

In it's simplest form, the research found that the defender is most at risk of injury in tackles, particularly if the tackle is made in an upright position, and that the likelihood of injury is at it's lowest when the defender and ball carrier are both bent when the tackle occurs.

Instruction on forming these bent body positions is inherent in the TackleReady program, especially in the Making a Tackle, and Running into a Tackle activities.



Gardner, A.J., Iverson, G.L., Edwards, S. et al. A Case–Control Study of Tackle-Based Head Injury Assessment (HIA) Risk Factors in the National Rugby League.

Can tackle height influence head injury assessment risk in elite rugby union? Gregory J. Tierney*, Ciaran K. Simms Trinity Centre for Bioengineering, Trinity College Dublin, Ireland.

Physical Preparation

Fundamental Movement Skills

Fundamental movement skills are very important to a child's physical development. When confident and competent in these skills, children can develop sport-specific and complex movement skills. These skills allow children to enjoy sports and physical activities. Most importantly, with a firm grasp of the fundamental movement skills, a child may enjoy a long life of physical activity.

Proprioception

Proprioception is the body's position sense, or body awareness. When our bodies move, our muscles and bones bend, straighten, pull, and compress at the joints. Inside our joints are proprioceptors which send information to the brain about the position of our muscles and joints in space. Our proprioceptors are hard workers, constantly sending signals to our brain to tell us where our body parts are, and to help us move. All this without us consciously thinking about movement.

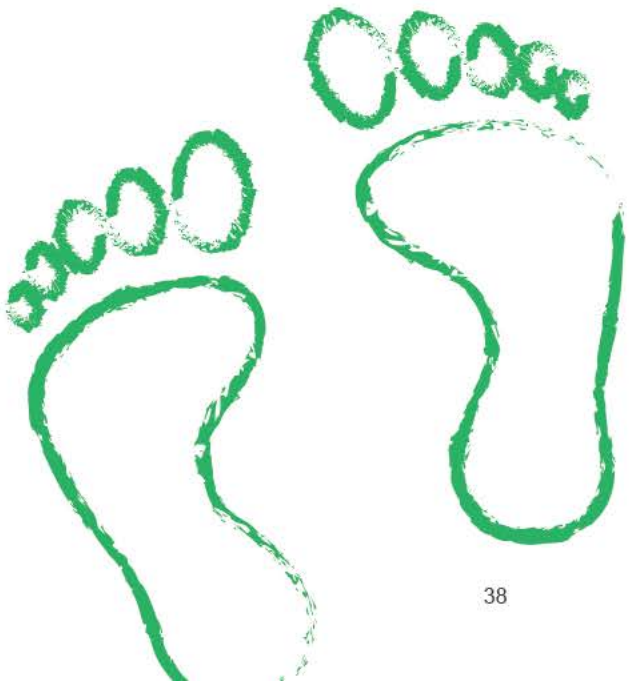
Developing proprioception improves the players ability to move efficiently, improving skill performance and enabling them to protect themselves in various situations.

Balance & Coordination

Balance is the ability to maintain a controlled body position during task performance. To function effectively across environments and tasks, we need the ability to maintain controlled positions during both static (still) and dynamic (moving) activities.

Age appropriate balance and coordination allows the child to be involved in the sports participation with a reasonable degree of success as it aids fluid body movement for physical skill performance.

With good balance and coordination the child is likely to have appropriate postural responses when needed (e.g. putting hands out to protect themselves when they fall off their bike). The physical attributes of balance and coordination also allow appropriate posture for table top tasks and subsequent success at fine motor tasks.



Mascot Moves

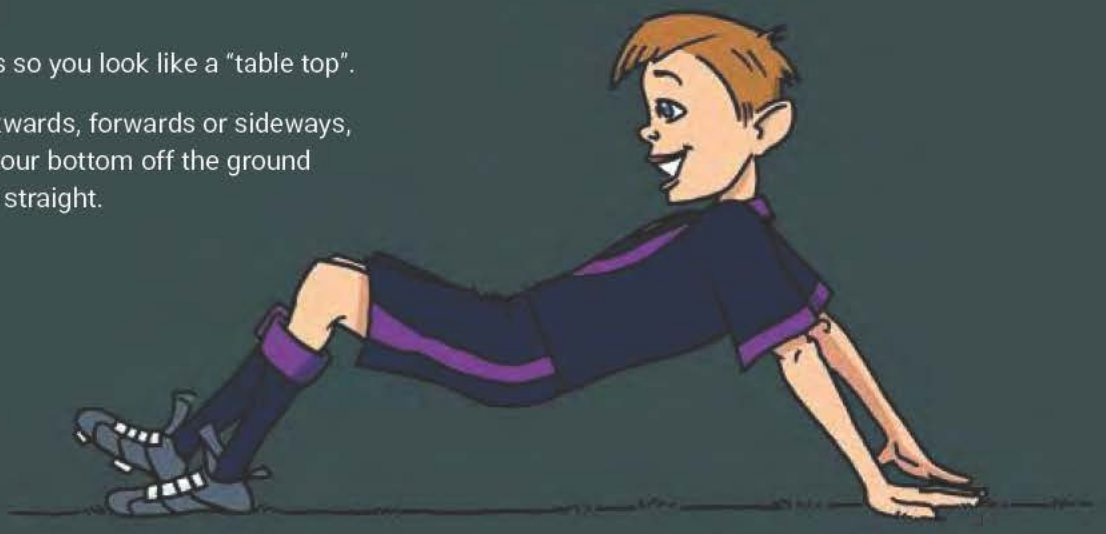
Mascot Moves are a great way to develop fundamental movement skills, gross motor skills, balance, flexibility, endurance and proprioception.

Tiger Crawl

1. Start in the standing position.
2. Bend over and put both hands on the ground.
3. Now, walk forward with the same leg and arm together.
4. Try and keep your back straight, and look forwards.

Storm Cloud

1. Start by squatting down to the ground.
2. Lean backwards and place your hands on the ground.
3. Raise your hips so you look like a "table top".
4. Now walk backwards, forwards or sideways, while holding your bottom off the ground with your back straight.

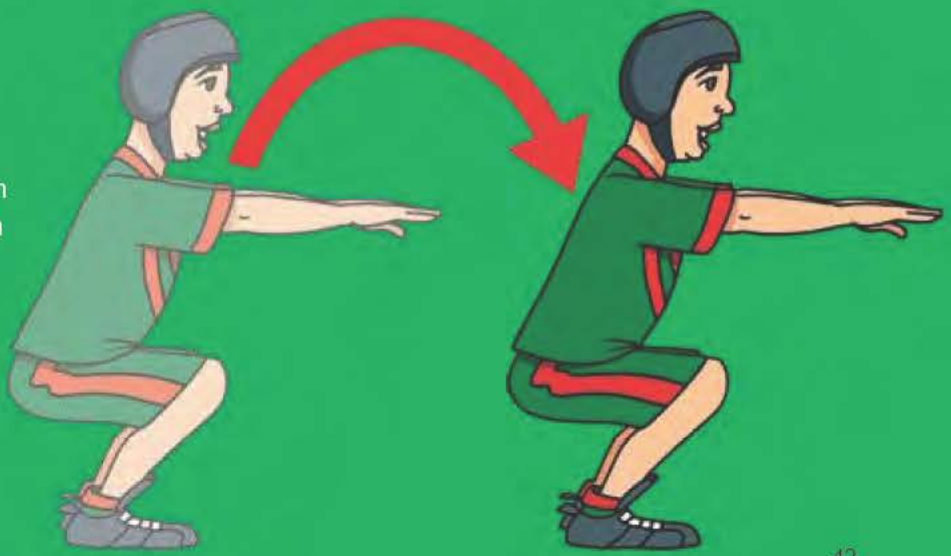


Eel Squirm

1. Start in a standing position and bend over with your legs straight placing your hands on the ground.
2. Try touching the ground as close to your toes as you can.
3. Slowly walk your hands away from your feet, as far as you can.
4. Finally walk your feet back to your hands, always keeping your hands on the ground.

Bunny Hops

1. Starting in the standing position, feet hip width apart and squat down low, keeping back straight and chin up.
2. Jump as long and as high as you can, landing on both feet before squatting again ready for your next jump.
3. It's important to pause and regain your balance between each hop.

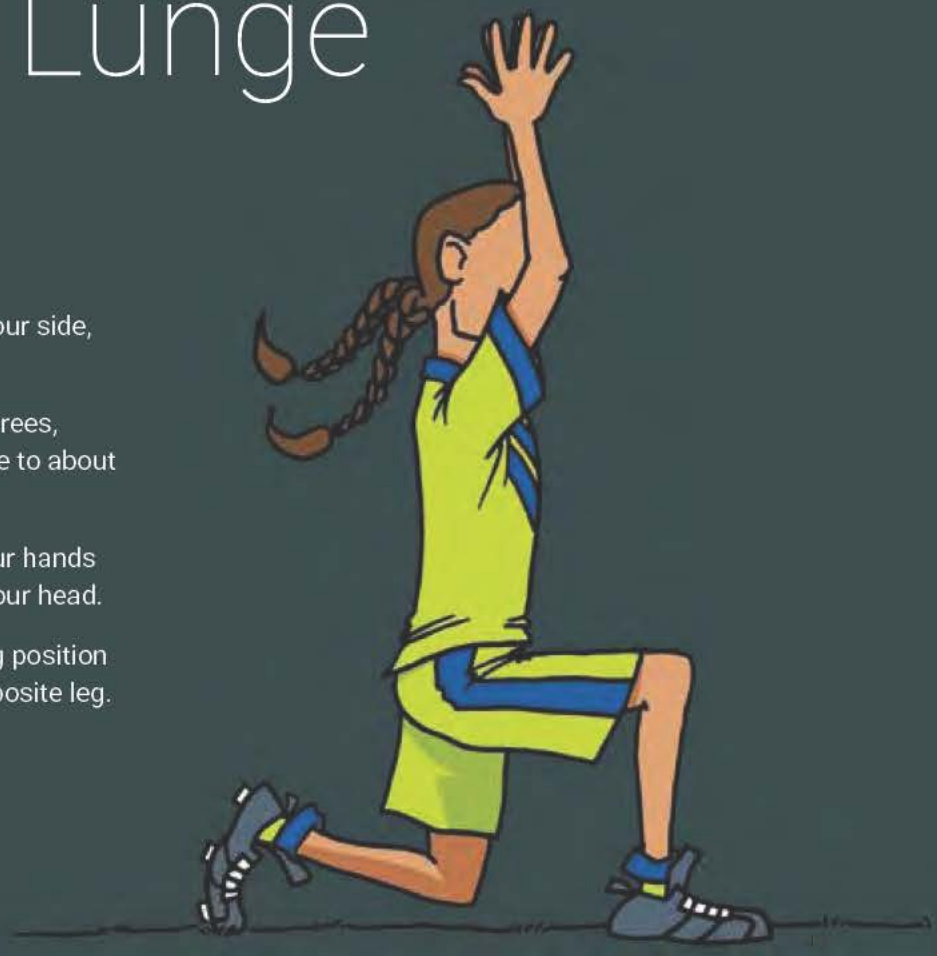


Panther Prowl

1. Start in the standing position. Bend over and put both hands on the ground.
2. Spread your arms and legs wide so your torso is close to, but not touching the ground.
3. Now move your right arm and left leg forward, then the left leg and right arm at the same time, then repeat,
4. Keep the body close to the ground throughout the entire exercise.

Viking Lunge

1. Standing tall, with arms by your side, take one big step forwards,
2. Bend your front leg to 90 degrees, whilst dropping the back knee to about a centimeter off the ground.
3. In the same motion, raise your hands to the side, and clap above your head.
4. Then go back to your starting position before repeating with the opposite leg.



Bulldog Bound

1. Squat low with a wide stance, and lean forward.
2. With fists clenched, reach as far forward as you can, and place fists on the ground.
3. Now pull your legs past your feet so that your hands and arms end up between your legs before reaching out again and repeating.

Titans Tumble

1. Make yourself small by bending at the knees and hips and tuck your chin into your chest.
2. Roll over one shoulders using your legs to generate momentum and bring yourself back to your feet in one fluid motion.
3. Then repeat and roll over the opposite shoulder.

Bronco Buck

1. Squat low, placing your hands on the ground in front.
2. Transfer your weight to your hands and kick with both feet up and out to the side.
3. Transfer weight back to your feet and move both hands so that you are back in the starting position before repeating, this time kicking your feet out to the opposite side.

Soaring Eagle

1. Standing tall with arms stretched out to the side, leap forwards onto one foot.
2. Lean forward with legs and back straight, raising your back leg directly behind you.
3. Balance for 2-3 seconds before standing tall and leaping onto the opposite foot and repeat.

Carioca Cowboy

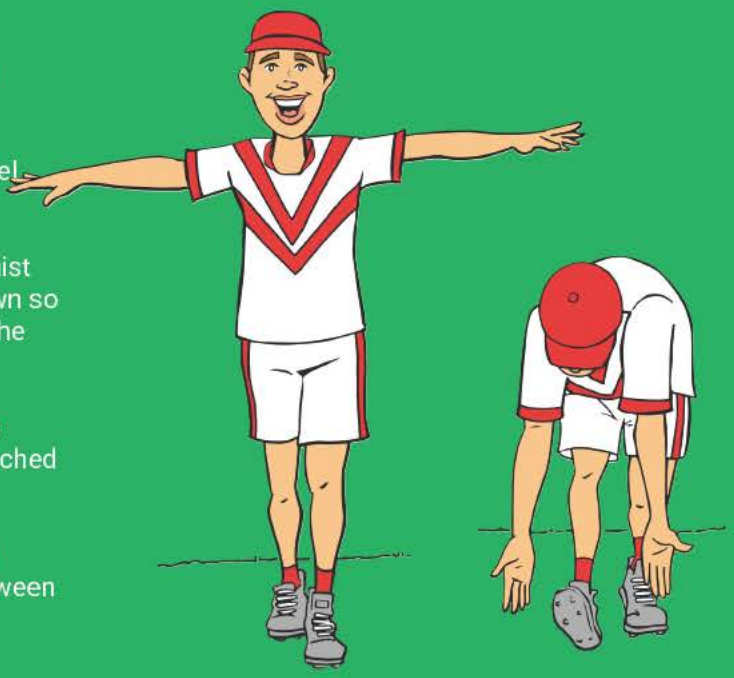
1. Start with your feet a little wider than hip-distance apart, knees soft.
2. Use your left foot to push off, crossing it behind the right foot and transferring your weight onto it.
3. Move your right foot to the side until you're back to your starting stance.
4. Now cross your left foot in front, stepping onto it. Move your right foot to the side.
5. Continue moving to your right, crossing the left foot behind, then forward, until you reach the end of your planned distance.
6. Then reverse your direction.

Rooster Rustle

1. Crouch down so that your rear-end is touching your heels
2. Stay in that position and walk across the grid
3. Use a small bounce in your walk to carry momentum forward, swing your arms to help

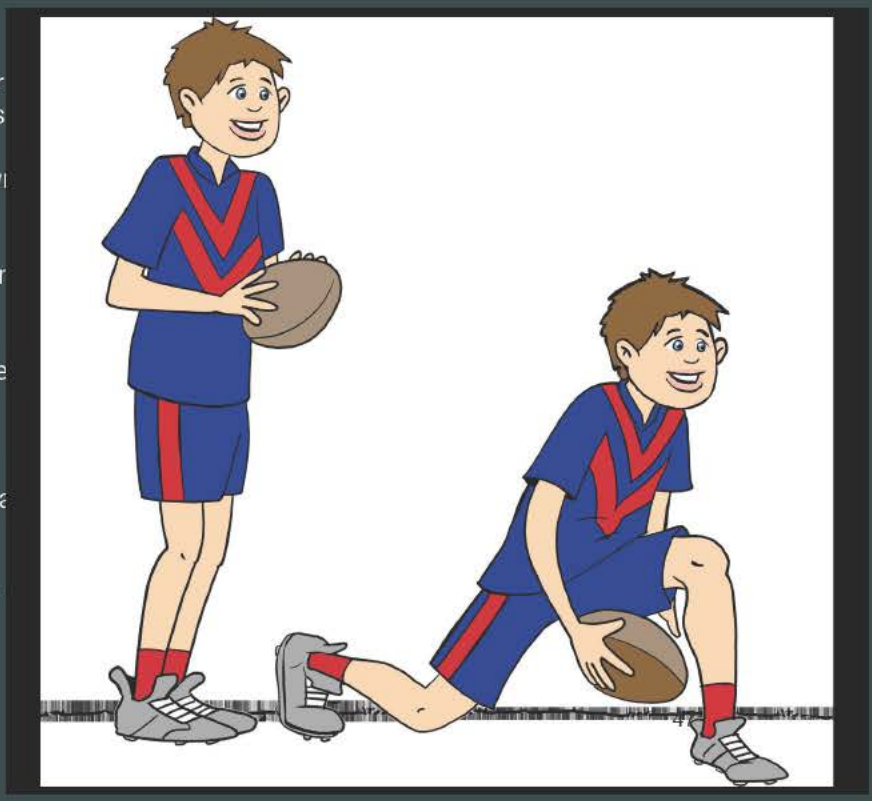
Dragon Dive

1. Stand with your feet shoulder length apart
2. Stretch your arms out to the side level with your shoulders
3. Step into the grid and bend at the waist and knees and swoop your arms down so your fingers skim across the top of the grass
4. Continue walking as you return to an upright position with you; arms stretched out the side at shoulder length
5. Continue to walk forward and repeat every third step so you alternate between leads legs when you swoop



Knights Kneel

1. Stand up straight with your feet shoulder length apart gripping a ball in both hands
2. Take one big step forward and bend dow until your lead leg is at 90 degrees
3. Pass the ball under your lead leg from or hand to the other
4. Return to an upright position and grip the ball in both hands
5. Take another big step forward with your opposite leg and bend down until your lea leg is at 90 degrees
6. Pass the ball from one hand to the other the opposite direction as before

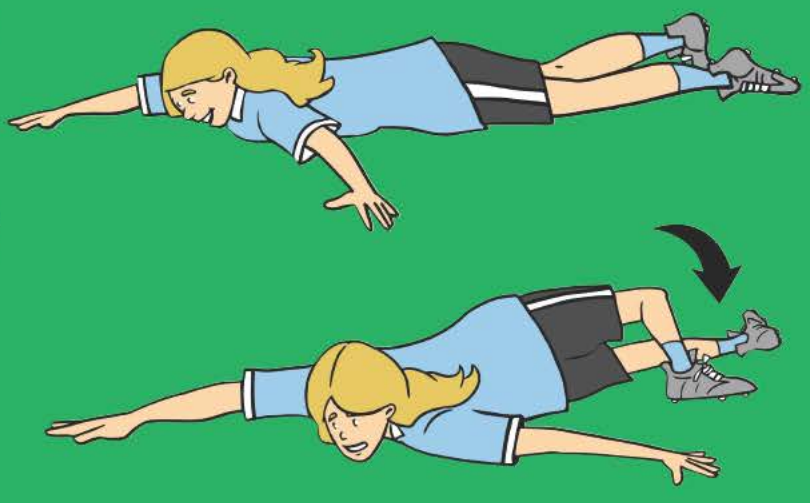


Warrior Walk

1. Stand with your feet shoulder length apart
2. Step out with one foot and turn at 90 degrees
3. Squat down by bending at the knees and hips keeping your back straight
4. As you squat stretch your arms out to the side at shoulder length
5. Now straighten up and step around 180 degrees with your other foot and face the other direction
6. Squat down by bending at the knees and hips keeping your back straight
7. As you squat stretch your arms out to the side at shoulder length
8. Repeat 5 times each side.

Shark Glide

1. Lay down on your front with your legs straight
2. Stretch your arms out to the side level with your shoulders
3. Twist at the hips keeping your arms and shoulders flat on the ground
4. Try and get your right foot to touch the ground as far over on your left side as possible, then return it to where you started
5. Now take your left foot and try and touch the ground as far over on your right side as possible, then return to where you started
6. Repeat 5 times each leg



Teaching the Tactical and Technical Skills of TackleReady

The Tackle Ready program focuses of three key technical skill areas. Safe Landing, The Tackle and Running into Tackle. Each of these skill areas are made up of some key terminology and buzzwords that aim to provide simple and effective instructions that are easy to understand.

Safe Landing

Sink, Tuck, Roll

Sink

1. Make yourself small
2. Hinge at the knees & hips

Tuck

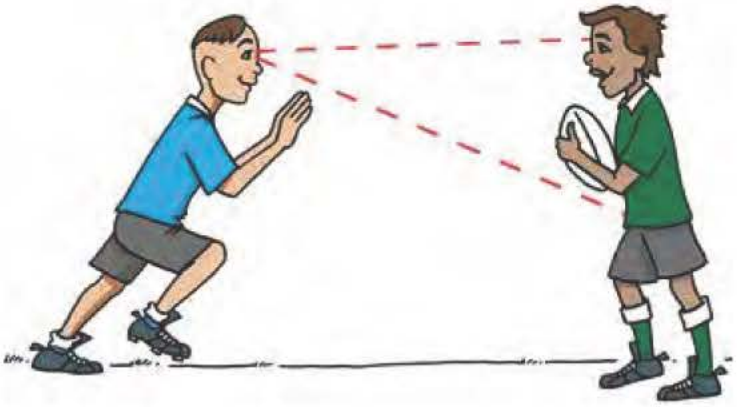
1. Bring ball to midline of the body
2. Tuck your arms and chin tight

Roll

1. Collapse, don't fall.
2. Land on large part of the body

Making a Tackle

Approach, Hit, Wrap, Push & Roll



Approach

1. Chin up
2. Eyes at the target
3. Hands up
4. Short feet into contact

Wrap

1. Head to the Side & Tight
2. Feet Close to Ball Carrier
3. Arms Wrapped
4. Squeeze

Hit

1. Aim for Tackle Zone (Belly Button)
2. Chin Up
3. Back Straight
4. Contact with Shoulder

Push & Roll

1. Use ball carrier's momentum
2. Push towards the ball carrier
3. Roll them onto their back
4. Land on top with control

Running into a Tackle

Protect, Brace, Land, Play the Ball

Protect

1. Secure grip on the ball with finger spread
2. Tuck the ball into the midline of the body
3. Protect the ball with the non-ball carrying arm

Land

1. Make yourself small
2. Hinge at the knees & hips
3. Land Safely

Brace

1. Eyes up
2. Shorten your steps
3. Lean forward
4. Find Space

Play the Ball

1. Snap your knees up
2. Sweep your leg around
3. Touch the ball with your foot

Delivering the TackleReady Program

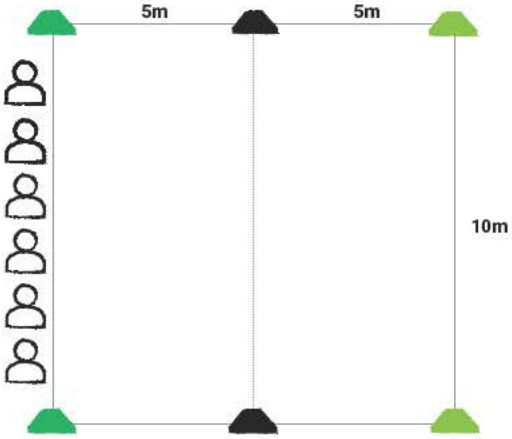
Session 1: PHYSICAL LITERACY & PARENT INDUCTION

Session summary:
The aim of this session is to prepare the kids physical skills by introducing our NRL Mascot Moves. Safe Landing & Running into a Tackle will also be introduced during this session. Before we start we will hold a quick parent meeting.

Parent Induction:
Before you begin your session, call the parents over to introduce yourself and discuss what you'll be covering throughout the program. Remember to hand out the A5 parent information flyer's.

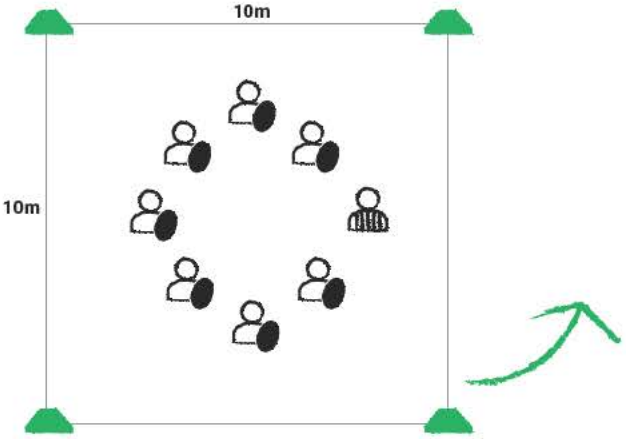
Activity 1: Mascot Moves

- Players line up along the start line.
- On the coaches call, the players perform a mascot move to either the 5m (easier moves) or 10m line (challenging moves) and return to the start line.
- The coach should encourage good technique by rewarding players with positive recognition.



Activity 2: Safe Landing

- Coach demonstrates safe landing technique (Sink, Tuck & Roll)
- To begin players find a clear space and jog on the spot. When the coach calls left, right, forwards or backwards all players fall as instructed.
- Practice falling in each direction 3-4 times.



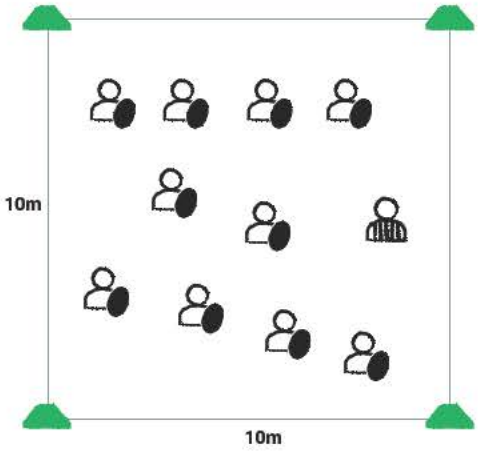
Activity 3: Fall with the Ball

› With a ball, players run around in a 10 x 10 grid; practicing their carry, side steps and spatial awareness.

› On the coaches call, players fall to the ground onto their left or right and quickly return to their feet.

› This is repeated 2-4 times each side.

› This can be progressed into using the Titans Tumble Mascot Move.

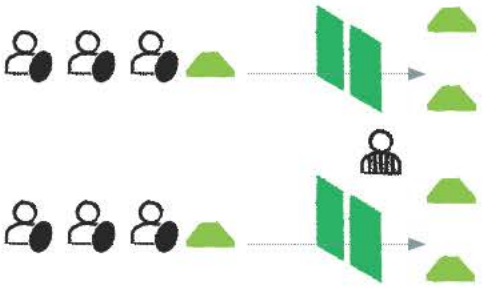


Activity 4: Running Into a Tackle

› Two lines of players stand opposite hit shields held by parents or assistant coaches.

› On the coaches call, players at the front of the line, run towards the hit shields. The shield holders meet players with soft resistance, but allow them through the space.

› The players role is to protect the ball, brace for a tackle and drive through resistance of the pads before falling safely and playing the ball.



Equipment required:

› Balls 

› Markers 

› Hit Shields 

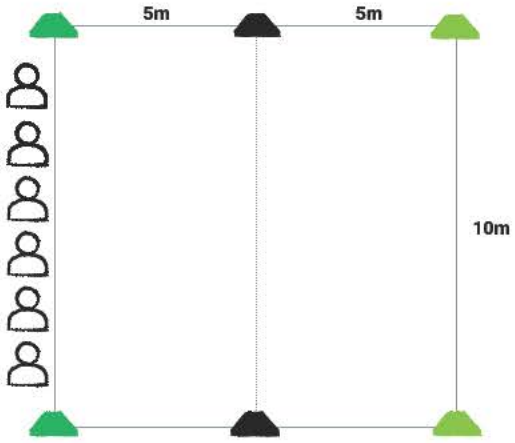
› Whistle 

Session 2: PREPARING TO TACKLE

Session summary:
During this session, participants will learn how to keep themselves and their opponent's safe when tackling and being tackled. We continue to practice our safe landing technique and running into a tackle and introduce the **Tackle Zone**.

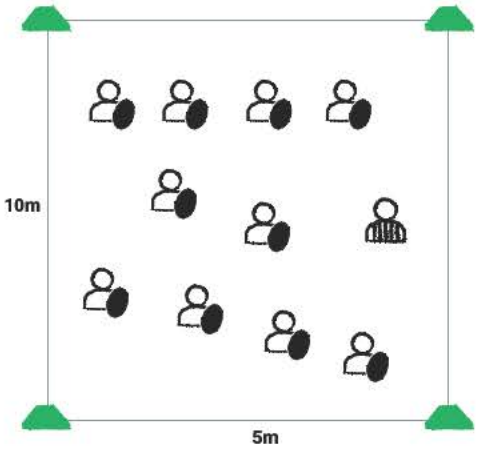
Activity 1: Mascot Moves

- Players line up along the start line.
- On the coaches call, the players perform a mascot move to either the 5m (easier moves) or 10m line (challenging moves) and return to the start line.
- The coach should encourage good technique by rewarding players with positive recognition.



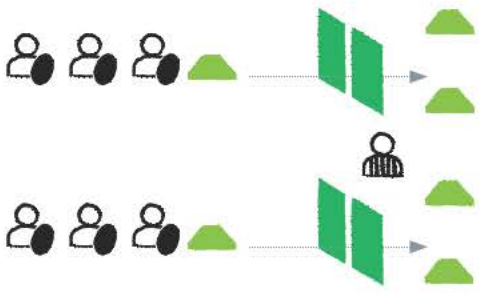
Activity 2: Fall with the Ball

- With a ball, players run around in a 10 x 10 grid; practicing their carry, side steps and spatial awareness.
- On the coaches call, players fall to the ground onto their left or right and quickly return to their feet.
- This is repeated 2-4 times each side.
- This can be progressed into using the Titans Tumble Mascot Move.



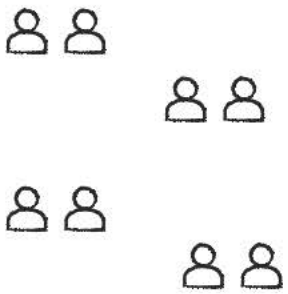
Activity 3: Running Into a Tackle

- Two lines of players stand opposite hit shields held by parents or assistant coaches.
- On the coaches call, players at the front of the line, run towards the hit shields. The shield holders meet players with soft resistance, but allow them through the space.
- The players role is to protect the ball, brace for a tackle and drive through resistance of the hit shields before falling safely and playing the ball.



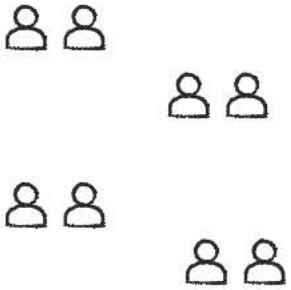
Activity 4: Hands & Knees Tackle

- Players in pairs find a clear space.
- Player 1 starts on their hands and knees, holding the ball tight to the body in one hand, and Player 2 starts with their ear on P1's back, arms wrapped, squeezing tight with shoulder pushed into P1's side.
- On the coaches call, P1 drives with their legs, maintaining their head, arm and shoulder position whilst P2 offers low resistance before rolling onto their back once they begin to move, keeping the ball tucked in tight.
- The tacklers aim is to turn thier partner onto their back and end up on top.
- This must be practiced using both shoulders.



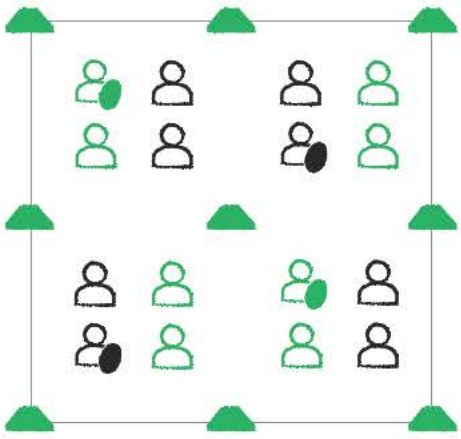
Activity 5: Knees Tackle

- In pairs, on knees facing one another, Player 1 starts with hands on Player 2's shoulders and P2 starts with hands on P1's side.
- When ready P1 swings arms out to the side like a scarecrow. P2 effects a tackle by dropping under P1's arm, making shoulder contact to the belly button area, wrapping and locking arms around the body and squeezing tight, before pushing and rolling P1 to the side and finishing on top.
- P1 should use safe landing technique as they go to ground.



Activity 6: Knee Footy

- Players split into teams of 2 or 3.
- Each team is given 3 attempts to score a try at the opposite end of the playing area. Their opponents try to prevent them from scoring.
- After each tackle, the player in possession taps the ball on their knee and passes backwards to their team mate. Defenders must retreat 2m before they can effect another tackle.
- All players can only move on their knees and defenders must roll the ball carrier to the side when making a tackle, not backwards.



Equipment required:

- Balls 
- Markers 
- Hit Shields 
- Whistle 

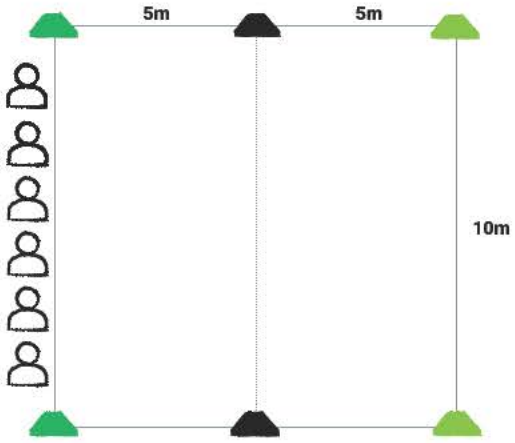
Session 3: INTRODUCING THE TACKLE

Session summary:

It's time to introduce the **Tackle**. Progressing on from previous sessions, remembering our safe landing and running into a tackle technique, we will introduce the fundamentals of a one on one tackle.

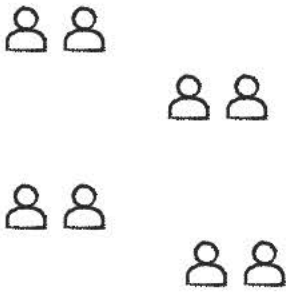
Activity 1: Mascot Moves

- Players line up along the start line.
- On the coaches call, the players perform a mascot move to either the 5m (easier moves) or 10m line (challenging moves) and return to the start line.
- The coach should encourage good technique by rewarding players with positive recognition.



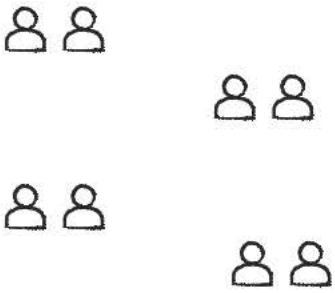
Activity 2: Knees Tackle

- In pairs, on knees facing one another, Player 1 starts with hands on Player 2's shoulders and P2 starts with hands on P1's side.
- When ready P1 swings arms out to the side like a scarecrow. P2 effects a tackle by dropping under P1's arm, making shoulder contact to the belly button area, wrapping and locking arms around the body and squeezing tight, before pushing and rolling P1 to the side and finishing on top.
- P1 should use safe landing technique as they go to ground.



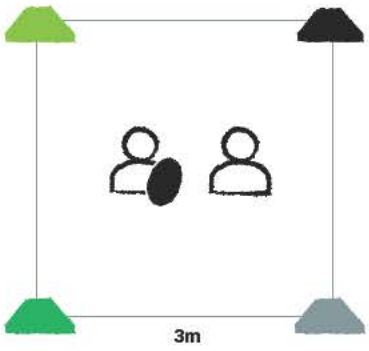
Activity 3: Standing Tackle

- In pairs, standing an facing one another, Player 1 starts with hands on Player 2's shoulders and P2 starts with hands on P1's side.
- When ready P1 swings arms out to the side like a scarecrow. P2 effects a tackle by dropping under P1's arm, making shoulder contact to the belly button area, wrapping and locking arms around the body and squeezing tight, before pushing and rolling P1 to the side and finishing on top.
- P1 should use safe landing technique as they go to ground.



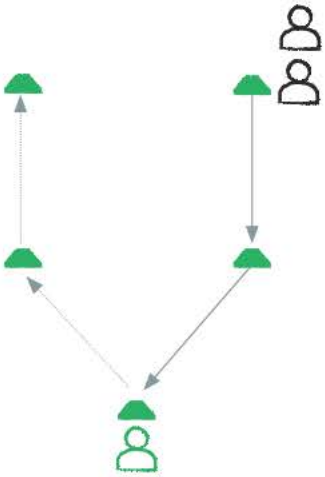
Activity 4: Score a Try / Save a Try

- Four different coloured markers are placed in a square, 3 metres apart.
- In pairs, players start in the middle of the square.
- To begin, Player 1 holds ball in two hands. Player 2 has shoulder at belly button area, arms wrapped around P1's body with head tight to the side.
- Coach calls a colour. P1 attempts to score a try on the corresponding marker. P2 squeezes tight around P1's legs to effect a tackle.
- The ball carrier will use safe landing technique when falling.



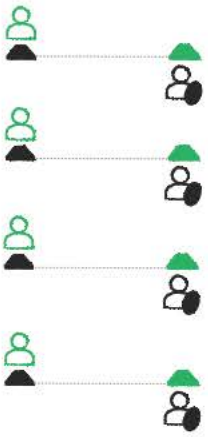
Activity 5: High 10's / Low 10's

- In pairs, Player 1 stands one side of a 5 x 5m square with feet hip width apart with hands up parallel with their head.
- Player 2 starts on one corner of the square.
- On the coaches call, P2 runs straight towards the other side of the square before changing direction to approach P1 at a slight angle.
- On approach, P2 shortens steps before planting their foot between P1's feet, give them a high 10.
- P1 then retreats to the opposite corner of the square and repeats, now coming from the opposite corner.
- Progress to Low 10's with P1 bringing hands to their hips. As P2 approaches P1, they sink so their shoulder is level with P2's belly button, ensuring that their head is to the side and tight to the hips, and feet close.



Activity 6: Introduction to Tackling

- Several 1m lines are set up, with a marker in between them
- In pairs, players stand opposite each other standing to the left or right of their marker with one player holding the ball.
- On the coaches call each player walks/jogs towards the middle of the markers,staying on their side of the line.
- The ball carrier walks/jogs in a straight line. The tackler effects a tackle using correct APPROACH, HIT, WRAP, PUSH & ROLL technique, using the appropriate shoulder.
- Swap the ball each time, and swap sides so the player practices tackling with both shoulders.



Equipment required:

- Balls 
- Markers 
- Whistle 

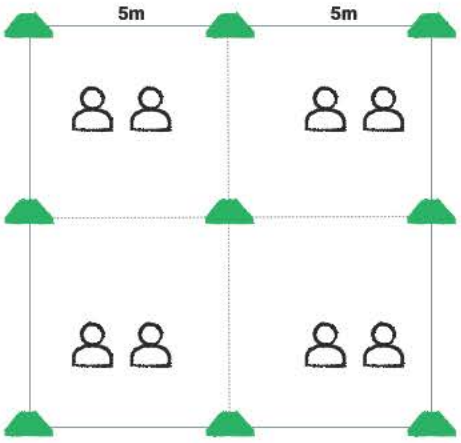
Session 4: TACKLE SELECTION

Session summary:

The aim of this session is to help players identify and adopt appropriate tackle technique for various situations.

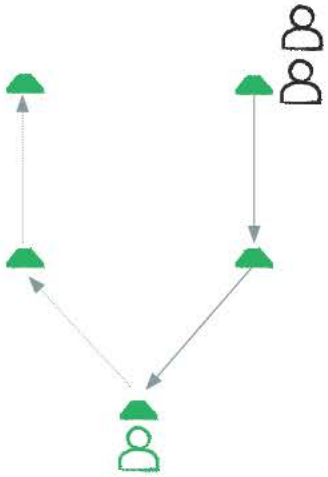
Activity 1: Mascot Move Tag

- In groups of two or three, players begin in the middle of a 5x5m grid
- One player will become the tagger.
- Staying inside their grid, using a Mascot Move. (Tiger Crawl, Bunny Hops, Storm Clouds or Bulldog Bounds only), the tagger chases the other players and attempts to tag them. If a player is tagged, they become the tagger.
- This is repeated for each mascot move.



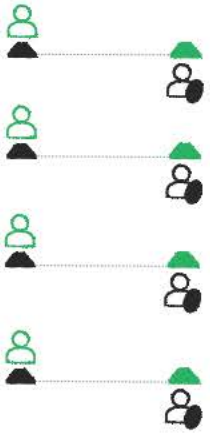
Activity 2: High 10's / Low 10's

- In pairs, Player 1 stands one side of a 5 x 5m square with feet hip width apart with hands up parallel with their head.
- Player 2 starts on one corner of the square.
- On the coaches call, P2 runs straight towards the other side of the square before changing direction to approach P1 at a slight angle.
- On approach, P2 shortens steps before planting their foot between P1's feet, give them a high 10.
- P1 then retreats to the opposite corner of the square and repeats, now coming from the opposite corner.
- Progress to Low 10's with P1 bringing hands to their hips. As P2 approaches P1, they sink so their shoulder is level with P2's belly button, ensuring that their head is to the side and tight to the hips, and feet close.



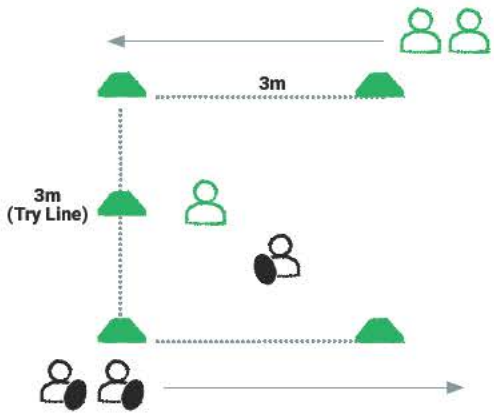
Activity 3: Introduction to Tackling

- Several 1m lines are set up, with a marker in between them
- In pairs, players stand opposite each other standing to the left or right of their marker with one player holding the ball.
- On the coaches call each player walks/jogs towards the middle of the markers,staying on their side of the line.
- The ball carrier walks/jogs in a straight line. The tackler effects a tackle using correct APPROACH, HIT, WRAP, PUSH & ROLL technique, using the appropriate shoulder.
- Swap the ball each time, and swap sides so the player practices tackling with both shoulders.



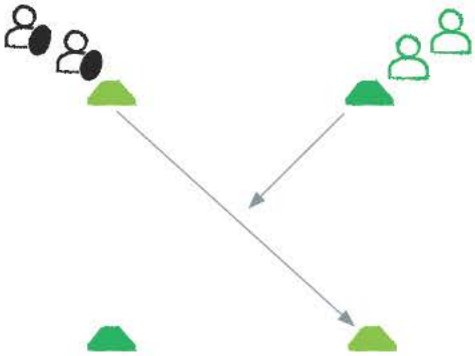
Activity 4: Front on Tackle Grid

- Players split into two even groups and line up on opposite corners of the 3m x 3m grid. One group are the attackers and the other group are the defenders.
- On the coaches call, both players run around the marker opposite them, turn and enter the grid.
- The ball carrier then attempts to score a try between the two markers (gate) on their side of the grid, whilst the defender attempts to make a tackle.
- The purpose of the gate is to encourage the ball carrier to stick to one of the grids, forcing either a left shoulder or right shoulder tackle. This can be progressed by removing the gate, so a try can be scored anywhere along the try line.



Activity 5: Side on Tackle Grid

- Players split into two even groups and line up on parallel corners of the 3m x 3m grid. One group are the attackers and the other group are the defenders.
- The attacker walks/jogs across the grid towards the opposite corner.
- The defender times their run to effect a side on tackle in the middle of the grid, ensuring that their head is behind the ball carrier.
- Players then move to the other side of the grid to use other shoulder.



Equipment required:

- Balls 
- Markers 
- Whistle 

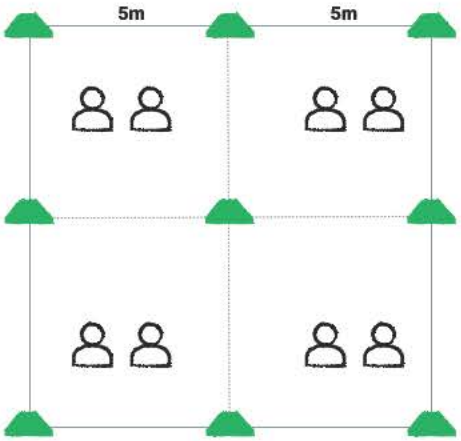
Session 5: GAME INTRODUCTION

Session summary:

After revising all of the skills introduced so far, we will progress to a 3 v 3 game. This will allow the players to practice tackling and being tackled in a game-environment.

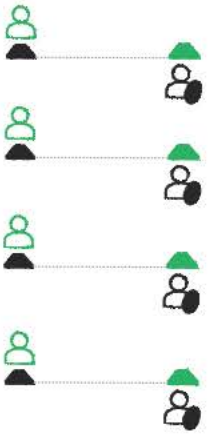
Activity 1: Mascot Move Tag

- In groups of two or three, players begin in the middle of a 5x5m grid
- One player will become the tagger.
- Staying inside their grid, using a Mascot Move. (Tiger Crawl, Bunny Hops, Storm Clouds or Bulldog Bounds only), the tagger chases the other players and attempts to tag them. If a player is tagged, they become the tagger.
- This is repeated for each mascot move.



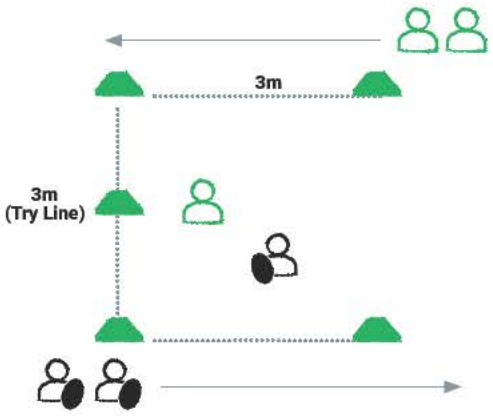
Activity 2: Introduction to Tackling

- Several 1m lines are set up, with a marker in between them.
- In pairs, players stand opposite each other standing to the left or right of their marker with one player holding the ball.
- On the coaches call each player walks/jogs towards the middle of the markers,staying on their side of the line.
- The ball carrier walks/jogs in a straight line. The tackler effects a tackle using correct APPROACH, HIT, WRAP, PUSH & ROLL technique, using the appropriate shoulder.
- Swap the ball each time, and swap sides so the player practices tackling with both shoulders.



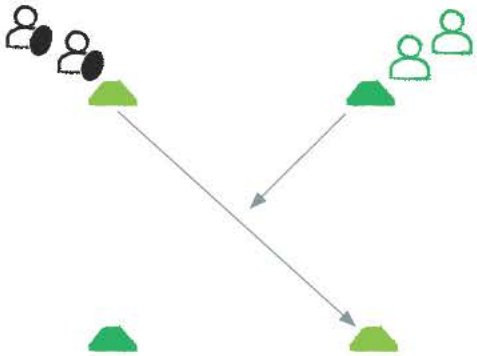
Activity 3: Front on Tackle Grid

- Players split into two even groups and line up on opposite corners of the 3m x 3m grid. One group are the attackers and the other group are the defenders.
- On the coaches call, both players run around the marker opposite them, turn and enter the grid.
- The ball carrier then attempts to score a try between the two markers (gate) on their side of the grid, whilst the defender attempts to make a tackle.
- The purpose of the gate is to encourage the ball carrier to stick to one of the grids, forcing either a left shoulder or right shoulder tackle. This can be progressedby removing the gate, so a try can be scored anywhere along the try line.



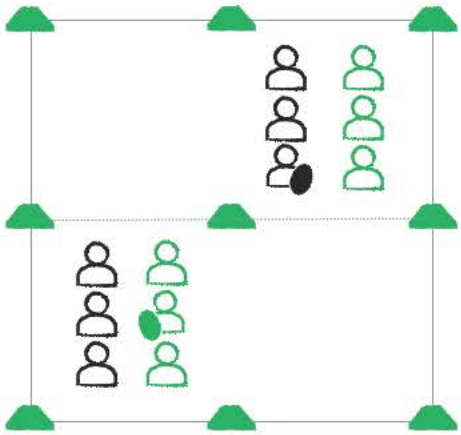
Activity 4: Side on Tackle Grid

- Players split into two even groups and line up on parallel corners of the 3m x 3m grid. One group are the attackers and the other group are the defenders.
- The attacker walks/jogs across the grid towards the opposite corner.
- The defender times their run to effect a side on tackle in the middle of the grid, ensuring that their head is behind the ball carrier.
- Players then move to the other side of the grid to use other shoulder.



Activity 5: 3v3 Tackle Game

- Players split into teams of 3, and start at either end of a 5m wide channel. (If you have more than 6 players, multiple channels can be set up next to each other)
- Each team has 3 chances to score a try. After a tackle, the attacking team will play the ball and pass the ball backwards to restart play. The defending team retreats 3-5m back to the referee before progressing forward once play restarts.
- If an error occurs, it counts as one chance, and play restarts with a play the ball.
- As the game progresses, the coach may choose to make the field wider to increase the difficulty.



Equipment required:

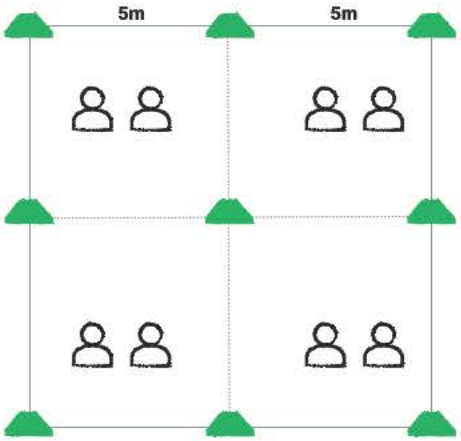
- Balls 
- Markers 
- Whistle 

Session 6: GAME SIMULATION

Session summary:
Let's play! During the sixth and final session we will pull everything together and progress to a 6 v 6 game.

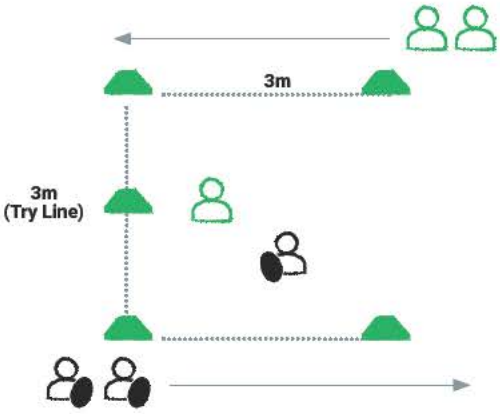
Activity 1: Mascot Move Tag

- In groups of two or three, players begin in the middle of a 5x5m grid
- One player will become the tagger.
- Staying inside their grid, using a Mascot Move. (Tiger Crawl, Bunny Hops, Storm Clouds or Bulldog Bounds only), the tagger chases the other players and attempts to tag them. If a player is tagged, they become the tagger.
- This is repeated for each mascot move.



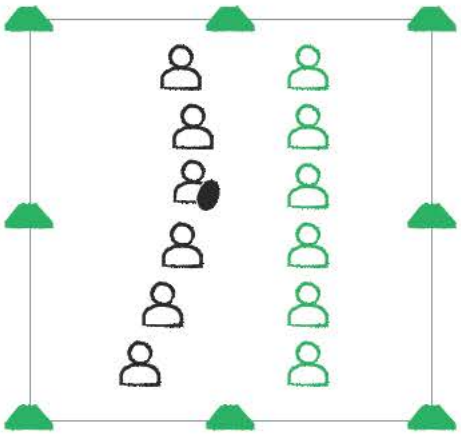
Activity 2: Front on Tackle Grid

- Players split into two even groups and line up on opposite corners of the 3m x 3m grid. One group are the attackers and the other group are the defenders.
- On the coaches call, both players run around the marker opposite them, turn and enter the grid.
- The ball carrier then attempts to score a try between the two markers (gate) on their side of the grid, whilst the defender attempts to make a tackle.
- The purpose of the gate is to encourage the ball carrier to stick to one of the grids, forcing either a left shoulder or right shoulder tackle. This can be progressedby removing the gate, so a try can be scored anywhere along the try line.



Activity 3: 6v6 Tackle Game

- Players split into teams of 6, and starts at either end of a 10m wide channel.
- Each team has 6 chances to score a try. After a tackle the attacking team play the ball and passes backwards to restart play. The defending team retreats to the referee/coach.
- If an error occurs, it counts as one chance, and play restarts with a play the ball.
- As the game progresses, the coach may choose to make the field wider to increase the difficulty.



Equipment required:

- Balls 
- Markers 
- Whistle 

TACKLEREADY RESOURCES

We have developed a suite of resources to assist TackleReady Deliverers offer their teams with the best possible experience. Game development staff can order these resources via the SKOOP platform at www.skoop.com.au.

TackleReady Activity Book

Includes fun activities that reinforce some of the key coaching points. These should be given to the participants during session 1.

Parent Flyer

Includes information about the aims and objectives of the program. These need to be provided to parents during session 1.

Posters

These are available to display at the club house or changing rooms to show people what the program is all about.

Social Media Tiles

These are customisable tiles that can be provided to the clubs to use on facebook, instagram or twitter.

Player Certificates

These are customisable on the Skoop platform, and can be downloaded and printed to be handed out at the final session

A-Frames & Flags

These are to be displayed when delivering the program to help raise awareness. The A-Frames also have illustrations on one side to help the kids see the key coaching points.

skoop

NOTES

NOTES

NOTES


NRL

Appendix 3

QRL Statewide Competitions

Operations Manual

2023 STATEWIDE COMPETITIONS

OPERATIONS MANUAL

CONTENTS

4.10. If any such occurrence arises, the procedure shall be as follows:

- The Competitions Manager (or their nominee), in conjunction with the referee and both team's management will make any decision on the postponing or cancelling of any scheduled game;
- After the commencement of a competition match, a referee may temporarily suspend play if, in their view, continuation of play would place the safety of Players and/or the Match Officials at risk.
- If a game is to be delayed due to severe weather conditions, a decision will be made on the length of delay.
- Where a game is in progress and is stopped due to an emergency, the following steps must be taken:
    - As the emergency is a 'time out', a direction will be given by the referee regarding field position, possession and the number of the tackle, at the time of cessation of play;
    - If the game re-commences within a reasonable time, play will continue as with any 'time out' – with the same field position, possession and the next tackle count.
    - If the game cannot be continued, the circumstances shall be reported to the Competitions Manager (or their nominee).

5. COGNITIVE TESTING

5.1. Each player in all Statewide Competitions is to undergo two Baseline Cognitive and Concussion Tests, via Cognigram and Smartabase, or any other platform as instructed by the QRL. Two separate tests are required – one for long term player health and one for immediate match day assessment and return to play.

5.2. Baseline testing must take place prior to the player taking the field in any trials or competition matches.

5.3. All players shall be required to complete the relevant (Junior or Senior) mandatory online education module prior to taking the field in any competition match, detailed in **section 37**.

5.4. Refer to **Appendix 5** for additional information and procedures.

6. COIN TOSS AND TEAM RUN-ON

6.1. Captains of each team, or their nominated player representative, are required to take part in the coin toss in the presence of the match referee before each team's warm up.

6.2. The toss may be broadcast (at the discretion of the host broadcaster), and captains are required to comply with any reasonable requests from the host broadcaster for a brief interview immediately after the toss has been completed.

6.3. In all cases the visiting team will take the field first when directed by the QRL Ground Manager or Match Officials, followed by the home team also when directed by the QRL Ground Manager or Match Officials.

6.4. Team Officials must adhere to requests of Game Day Operations Team members regarding entry or return to the field of play to meet scheduled game times.

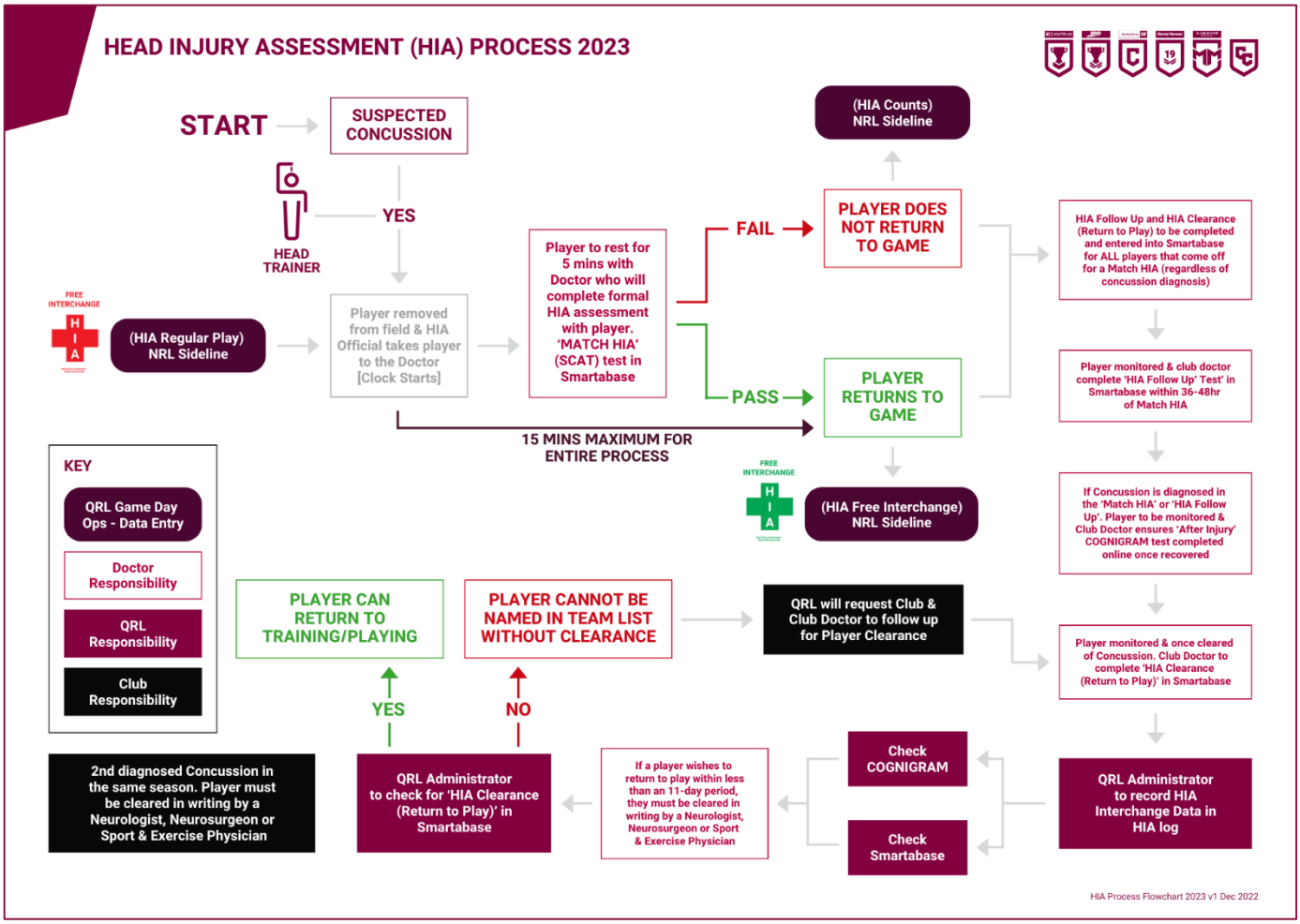
7. COMPETITION FORMAT

7.1. The Hostplus Cup and the BMD Premiership are open aged competitions for players attaining a minimum age of 18 years in the year of competition. Players turning 17 years' in the year of the competition can apply for a written exemption to the Competitions Manager via their relevant Hostplus Cup or BMD Premiership Head Coach and CEO. ***Training program to start no earlier than the 2nd weekend in November.***

7.2. The Hastings Deering Colts is a restricted age competition for players who will turn 18, 19, 20 or 21 years' in the year of the competition (i.e. players born in 2002, 2003, 2004 or 2005). Players turning 17 years' in the year of the competition can apply for a written exemption to the Competitions Manager via their relevant Hostplus Cup Head Coach and CEO. ***Training program to start no earlier than the 2nd weekend in November.***

7.3. The Harvey Norman U19s is a restricted age competition for female players who will turn 17, 18 or 19 years' in the year of the competition (i.e. players born in 2004, 2005 or 2006). ***Training program to start no earlier than the 2nd last weekend of November. Induction Day and Wellbeing and Education sessions ONLY can be held before this date.***

APPENDIX 5 - CONCUSSION MANAGEMENT POLICY AND PROCEDURE



BACKGROUND

All Clubs and persons bound by these Rules must comply in all respects with the provisions of the NRL Community Rugby League Policy and Guidelines for the Management of Concussion. As well as the following QRL Policy and Flow Chart, a breach of any of the provisions of the NRL Guidelines and QRL Policies may be enforced by the imposition of a penalty or penalties if a contravention of any of these provisions is found to have occurred.

QRL CONCUSSION POLICY

The following is to be the protocol of management of Concussion in all Queensland Statewide Competitions.

CONCUSSION AND RETURN-TO-PLAY DECISIONS

Any player with a suspected concussion should immediately be removed from the field of play by the HIA process and should not be permitted to return to play the same day unless the Doctor attending to the player allows him to continue in the match.

It is recommended that the SCAT 5 tool (Sport Concussion Assessment Tool 5) be used by the Doctor in the clinical assessment of concussion on game day via the relevant QRL provided Concussion management system (Smartabase) HIA process.

Return to play after a concussion should only take place after a thorough evaluation process by the Club Doctor via the relevant QRL provided Concussion management systems (Cognigram & Smartabase) HIA Follow-Up process. This should confirm that the player is free of all signs and symptoms of a concussion.

The diagnosis of concussion remains a clinical decision based on a number of factors including symptoms, signs, cognitive impairment and behavioural changes.

If a player is diagnosed as having a concussion, the player must not be allowed to return to play or training on that day until cleared by the Club doctor via the relevant QRL provided Concussion management system (Smartabase) Return to Play Sign Off process.

STEP 1 – BASELINE COGNITIVE TESTING

1. For each Player, establish a preseason baseline for normal psychometric state via the use of Cognigram. Each club is to appoint administrator/s to conduct the testing and notify the QRL of these administrators. On the rare occasion, that a baseline cannot be achieved, either obtain formal neuropsychometric testing or accept the “invalid” test as that Player’s baseline. Cognigram testing should be done annually on all players registered with the club and any Player who had an invalid baseline.

2. Each Player must also undertake a Smartabase cognitive baseline test in order for game day SCAT5 comparison tests to be performed.

Conduct preseason education of players, coaching and training staff to emphasise that concussion is not a trivial injury and repeat concussions can lead to long-term consequences which can be prevented if concussion is managed appropriately.

STEP 2 – ON-FIELD ASSESSMENT – SPORTS TRAINERS

Identifying a concussion as early as possible is paramount and Trainers should be competent in this very important aspect of their duties. The assessment by the Trainer should include the use of Maddocks Score modified questions.

Maddocks Score:
"I am going to ask you a few questions, please listen carefully and give me your best answer;

- What ground are we at today?
- Which half is it now?
- Who scored last in this game?
- What team did you play last week?
- Did your team win the last game?

Incorrect response indicates that the player should be removed from the field.

In addition, the player should be immediately removed from the field of play if any of the following signs are present after a direct or indirect blow to the head:

a) loss of consciousness (LOC)
b) player lying motionless on the ground or slow to get up
c) player exhibits balance or motor coordination problems (player stumbles, has slow / laboured movements or unsteady gate)
d) player is disoriented or confused (inability to respond appropriately to questions; not aware of plays or scores)
e) player exhibits a loss of memory
f) player has dazed, blank or vacant look on face
g) player has visible facial injury in combination with any of the other signs.

WHEN IN DOUBT THE DOCTOR IS IN CHARGE.

Note: If the Player is unconscious or has neck pain, the player should be immobilised and treated as a spinal injury.

Smelling salts (ammonium carbonate) or similar substances must never be used following a head injury.

STEP 3 – HEAD INJURY ASSESSMENT (HIA) BY THE GAME DAY DOCTOR

i) The Player should be allowed to rest for 5 minutes. This is included in the total 15-minute HIA period.
ii) The Medical Officer ascertains any concussive symptoms, performs a cervical and neurological examination and performs an online SCAT 5 via Smartabase.
iii) The Game Day Doctor may add an exercise challenge.
iv) If the clinical diagnosis of concussion is made the Player will not return the field of play on the same day.
v) Please note: HIA's are to be conducted over a **mandatory** 15-minute period.

While the Player is being assessed for a concussion the team will have a free interchange.

If the Player is deemed to not have a concussion, the player may be allowed to return to the field of play but must be regularly re-evaluated by the Head Sports Trainer throughout the remainder of the game.

STEP 4 – POST CONCUSSION ASSESSMENT TO BE CONDUCTED BY THE CLUB DOCTOR

a) **Post-Match:**

i) Medical review regarding ongoing symptoms;

ii) Assign the Player to the care of a responsible adult i.e. family member, sports trainer or club official and it should be noted that the injured player should not be alone for at least the next 24hrs. If the situation arises the medical officer may need to determine if or when the player can take a scheduled flight home;

iii) Give the caregiver a head injury sheet (e.g. SCAT, UPMS) and advise them to monitor the Player particularly over the next four hours;

iv) Advise the carer of the warning signs and symptoms of deterioration;

v) Advise the Player to avoid alcohol and non-steroidal anti-inflammatory medication the day after injury;

vi) Following a concussive episode, the Player should not be allowed to drive that day.

b) **The next day and the following week:**

vii) Evaluation is conducted by the club doctor within 36-48 hours (via QRL provided concussion management system – Smartabase, HIA follow up). Analysis is performed to enquire about ongoing symptoms.

viii) All players with a diagnosed concussion during Match HIA or Follow Up HIA must complete an online Cognigram After Injury Cognitive test (directed by Club Doctor) to an acceptable level before returning to training and playing.

ix) The evaluation to return to play may include a post injury cognitive test as well as other neurological and physical tests.

x) If Cognigram cognitive tests have not returned to normal within 10 days of the incident consideration must be given to referring the patient to specialist services.

xi) In the recovery period, it is important to emphasise to the player that the player requires physical and cognitive rest.

xii) It should be noted that return to sport is only after the 'Return to Play Sign Off' medical clearance (via QRL provided concussion management system – Smartabase) by the Club Doctor after thorough assessment including SCAT and not limited by a further Cognigram test returning to baseline.

xiii) The above 'Return to Play Sign Off' medical clearance must be completed before the player can return to training and/or playing.

xiv) Only the Club Doctor can clear a player to return to training and play after a concussion. If other medical opinions and clearances are sought the club doctor must give the final clearance.

xv) Numerous failed HIA's may result in the QRL Chief Medical Officer requesting further analysis

c) **Players wishing to return to play following concussion**

i) Players wishing to return to play prior to 11 days post-concussive episode are required to gain clearance from a Neurologist, Neurosurgeon or Sports Physician.

ii) Players who suffer two (2) concussive episodes in the same season must also gain clearance from a Neurologist, Neurosurgeon or Sports Physician regardless of time out of the game.

Appendix 4

NSWRL Major and Pathways Competitions Handbook

Handbook (Rules, Policies and By-Laws)

NSWRL MAJOR & PATHWAYS COMPETITIONS

1. Admission Charges and Tickets

1.1. Guideline for admission charges

1.1.1. Adults: to a maximum of $10.00

7.8.3. Played as 2 x 30-minute halves, with a 10-minute half time break.

7.9. The Andrew John's Cup

7.9.1. 16's competition for male players

7.9.2. A player must be 15 turning 16 years of age in the 2023 calendar year (by 31 Dec 2023).

7.9.3. Played as 2 x 30-minute halves, with a 10-minute half time break.

7.10. Lisa Fiaola Cup

7.10.1. 17's competition for female players

7.10.2. A player must be 15 turning 16 years or 16 turning 17 years of age in the 2023 calendar year (by 31 Dec 2023).

7.10.3. Played as 2 x 30-minute halves, (subject to change in a gala day format) with a 10-minute half time break.

7.11. The NSWRL Country Championships – Men's

7.11.1. Open Age competition for male players

7.11.2. A player must have turned 17, years of age before taking the field of play.

7.11.3. Played as 2 x 40-minute halves, with a 10-minute half time break.

7.12. The NSWRL Country Championships - Female

7.12.1. Open Age competition for female players

7.12.2. A player must have turned 17, years of age before taking the field of play.

7.12.3. Played as 2 x 30-minute halves, with a 10-minute half time break.
(See Appendix C)

7.13. Forfeits

7.13.1. Any team that forfeits in any NSWRL Major or Pathway Competitions will be issued with a" show cause" notice requesting them to prove as to why the team should not be removed from the competition immediately. If there is no valid reason or the response is inadequate the team may be removed.

7.13.2. In addition to 7.13.1, any team that forfeits will be issued a monetary fine.

7.13.3. In NSWRL Major and Pathway Competitions teams must have a minimum 17 fit and ready players to participate in a match and not forfeit.

7.14. Competition Points

7.14.1. Competition points are awarded as follows:

Win = 2 points
Draw = 1 point
Loss = 0 points
Bye = 2 points
Forfeit = 2 points and the average of the deferential points for all games played for the team that has forfeited

8. Concussion

8.1. In the event of any one or more of the following signs, listed in rules 8.2 and 8.3, being observed in respect of a player by the club Head Trainer or Club Medical Officer or Match Day appointed Medical Officer during a match, the player must be taken from the field and either prevented from returning to the field of play (if in the case of signs

listed in rule 8.2) or assessed by the Club Medical Officer (if in the case of signs listed in rule 8.3).

8.2. Clear signs of concussion which require immediate removal from the field and no return to play:
- 8.2.1. Any obvious loss of consciousness (or prolonged immobility of > 2 seconds).
- 8.2.2. No protective action in fall to ground directly observed (not bracing for impact/floppy or stiff).
- 8.2.3. Impact seizure (stiffening or shaking of arms or legs on impact).
- 8.2.4. Memory impairment (e.g., fails Maddocks test).
- 8.2.5. Confusion or disorientation.
- 8.2.6. Balance disturbance (loss of control over movements).
- 8.2.7. Player reports significant, new or progressive concussive symptoms.
- 8.2.8. Dazed, blank/vacant stare or not their normal self.
- 8.2.9. Behaviour changes atypical to the player.

8.3. The following require assessment, either on the field or off depending on the circumstances for a Head Injury Assessment (HIA) by the attending club Medical Officer:
- 8.3.1. Loss of responsiveness.
- 8.3.2. Possible "balance disturbance", directly observed.

Note: "Balance disturbance" is defined as when a player is unable to stand steadily unassisted or walk normally and steadily, without in the context of a possible head injury.

8.4. Subject to the provisions of rule 8.13, if a player is required to leave the field of play as a consequence of the identification of one or more of the above features to complete (in accordance with rule 8.3) a Head Injury Assessment (HIA), this interchange will not be included for the purposes of calculating the number of interchanges.

8.5. The period of time for a HIA is 15 minutes and no player is allowed to return to the field of play until the 15-minute period has been served. The time cannot be less.

8.6. The time period for a HIA is to begin from the time at which the player is in the care of the Club Medial Officer. If the player has been cleared by the Club Medial Officer during the HIA timeframe, the player must report immediately to the NSWRL HIA/Interchange Official at the completion of the 15-minute HIA time period to return to the field of play. This cannot be done before or after, must be right on 15 minutes.

8.7. The HIA 15-minute time period will not be assessed against the official match time or clock. The timing of the HIA period will be monitored by the NSWRL appointed HIA/Interchange Official.

8.8. If a player is required to be assessed for a period longer than the specified HIA period, then subject to the provisions of rule 8.13 that player would then be adjudicated as an interchange for the purposes of calculating the number of interchanges. The club is required to hand over their next interchange card available, in sequential order, immediately to the NSWRL HIA/Interchange official.

8.9. Any player who is required to leave the field of play for any further (that is a second) HIA, in the same match, will not be allowed to return to play in that match.

8.10. In the event of an on-field incident which has required two players from the same club to be taken from the field of play for a HIA, the Club Medical Officer and/or Match appointed Doctor, may request, from the NSWRL HIA/Interchange Official, an additional 5-minute period for one of the HIA players to complete the necessary assessments.

8.11. If the player has suffered a concussive injury in an incident that was a consequence of foul play, which resulted in the offending player to being sent off or sin-binned, the interchange will take place in accordance with the process and the time limit associated with the HIA will not apply.

8.12. In the event that a HIA takes place in the 15-minute period prior to half time, the HIA period will be deemed to have been completed at the end of the half time period. The club must indicate to the NSWRL HIA/Interchange Official immediately at the completion of half time whether the player is to return to the field of play.

8.13. Provisions governing the use of the concussion substitute:

8.13.1 In the event that a player is observed to display clear signs of concussion which require immediate removal from the field and no return to play in accordance with rule 8.2; or if a player is not permitted to return to play for the remainder of the match after the completion of a HIA conducted in accordance with this rule 8, then:

8.13.1.1 That team's concussion substitute may be activated as a substitute for the player removed from or not permitted to return to play in the match;

8.13.1.2 The concussion substitute may remove the vest worn in accordance with these rules for the purpose of clearly identifying that player as the concussion substitute;

8.13.1.3 That player, originally named in the team as the concussion substitute, may then take his or her place on the players bench as one of the four interchange players (in substitute for the player removed from or not permitted to return to play in the match);

8.13.1.4 Notwithstanding rule 8.4, the original interchange made for the purpose of the player leaving the field to be administered a HIA will then be included for the purposes of calculating the number of interchanges.

8.14. For the avoidance of doubt, a team will be permitted to name no more than one (1) concussion substitute in its team for a match. Under no circumstances will two or more concussion substitute players be permitted for any team for any match, in circumstances where more than one player for a team in a match is observed to display clear signs of concussion which require immediate removal from the field and no return to play in accordance with rule 8.2, or is not permitted to return to play for the remainder of the match after the completion of a HIA conducted in accordance with this rule 8.

8.15. When a player returns to the field of play after being cleared from HIA, that player must be interchanged for the player that originally went on the field when the HIA

occurred. This interchange is not a 'free' interchange – it is a period of 15-minutes to allow for an assessment of a possible concussive incident.

8.16. In the event that a club has used all of its allocated interchanges, while a player is completing a HIA and that player is unable to return to the field of play at the completion of the HIA, the club must immediately remove a player from the field of play and complete the match with 12 players.

8.17. NSWRL mandates that all clubs complete a base line concussion test for all player's pre-season. Baselines for the following Pathways Competitions are to be store on the Clubs Smartabase portal – The Knock-On Effect NSW Cup, The Harvey Norman Women's NSW Premiership, Jersey Flegg, SG Ball Cup, Tarsha Gale Cup, Laurie Daley Cup, Harold Matthews Cup and the Andrew Johns Cup.

8.18. The NSWRL will use the appointed HIA/Interchange Official for each match, who will monitor the application of the time and interchange process throughout all NSWRL Major and Pathway competition matches.

8.19. At the completion of the match, the HIA/Interchange Official is to ensure that the Doctor has completed the NSWRL Head Injury Assessment form, via the online platform provided (Smartabase) for Pathways Competitions, and via paper form for all other Major Competitions, for each suspected head or neck injury that has been sustained by a player or players during the match.

8.20. Clubs must only use the HIA for the reasons detailed in the NSWRL Head Injury Assessment.

8.21. Any club which is proven to have used a HIA interchange for any reason other than that detailed in section 8 of this Handbook, will be deemed to have gained an unfair tactical advantage in the match and be subject to penalty and rules breach under the NSWRL guidelines. A show cause notice will be issued.

8.22. Any player who suffered a concussive injury and was ruled by the Club Medical Officer (to be unable to continue in the match, will not be allowed to play until they have completed the required Graduated Return to Play Steps (GRTP), based on a players age (CLICK HERE)

8.23. All medical clearances must be completed by the Doctor and submitted as per competition requirements.

8.24. Any player found to have received a concussion for the second time within the same season must complete the same process as 8.22, with the only difference being that the clearance to commence the Return to Play protocols must be given by a Concussion Specialist. This will be sent via and will be reviewed by the NSWRL Chief Medical Officer.

8.25. It is recommended that Clubs, for the purpose of identifying symptoms of Delayed Concussion, for any player who is taken from the field for a HIA assessment and subsequently cleared and permitted to return to the field of play by the game day Doctor, must also receive a follow up medical examination within 48 hours. If the player shows any signs of concussion at this stage the player must follow a GRTP, as managed by a general practitioner (doctor).

8.26. Any club, or player found to have breached the concussion rules, as defined above, will be issued with a breach notice and penalties may apply.

8.27. For further information, please refer to the NSWRL Major and Pathways Competitions Concussion Policy (CLICK HERE)

9. Dismissed Players

Temporarily Dismissed Players

9.1. A player who is temporarily suspended (sin-binned) must immediately retire from the playing field to the dressing room, or an area designated by the NSWRL Match Operations Officials until the period of temporary suspension has expired.

9.2. Time of suspension begins only when the referee restarts play or indicates time on.

9.3. If more than one player is temporarily suspended in relation to the same incident, the period of time off commences at the same time and players will return to the field together.

9.4. When the temporary suspension expires, players must enter the field of play from an onside position.

9.5. Temporary suspension does not include time off and half time, the period of temporary suspension is the actual time that the ball is in play.

9.6. Periods of temporary suspension is 10 minutes for all competitions to which this Handbook applies.

Permanently Dismissed Players

9.7. A player who is permanently dismissed (sent off and not sin-binned) must immediately retire to the teams dressing room, or an area designated by the Match Operations Officials until they have changed out of their playing uniform.

9.8. After changing, the player must not re-enter the field of play, under any circumstances.

10. Doctors and Serious Injuries

10.1. For all Jersey Flegg Cup and The Knock-On Effect NSW Cup Matches, clubs must each provide a doctor to attend all competition match, including final series matches.

10.2. For all Harvey Norman Women's NSW Premiership, Presidents Cup, Ron Massey Cup, Mojo Homes Cup, Denton Engineering Cup, Sydney Shield, SG Ball, Tarsha Gale Cup, Laurie Daley Cup, Harold Matthews Cup, Andrews Johns Cup, Lisa Fiaola and the NSWRL Men's and Women's Country Championships, a Match Day Doctor must be supplied by the Home team, to be in attendance for the duration of the Match.

10.3. For travel interstate and overseas the NSWRL has made allowances within the NSWRL travel policy for clubs to travel with a doctor.

10.4. Only players, match officials and registered sports trainers are permitted on the field.

10.4 Doctors are only permitted on the field of play if a serious injury has occurred, and the Head Trainer has notified the touch judge or referee. The referee will stop the match to allow the Doctor to assess the injured player.

10.5 The NSWRL Match Operations Official is to escalate reporting of serious injury as per the Incident Reporting Flow-Chart in their handbook.

Appendix 6

NRL and RLPA Transition Program

TRANSITION PROGRAM INFORMATION

Wellbeing and Education

ARE YOU IN TRANSITION...?

Do you have a current NRL Top 30 contract OR NRLW Contract?

→ No → Have you had a contract for 1 or more years in the past?

- Yes → **Are you currently?**
  - Playing State Cup
  - Playing in UK Leagues
  - Uncontracted
  - In a period of stand down
  - Retired from NRL/NRLW
- No → Please get in touch if you need support.

Are you currently? → Yes → **Welcome to the Transition Program!**
You are in a type of Transition and we are here to support you.

INTRODUCTION:

The Transition program exists to support **every** NRL & NRLW contracted player through the transitions they will experience in their career. That includes gaps between contracts, moving to Super League or State Cup, and of course retirement.

As your time in the NRL comes to a temporary or permanent end, and you transition into a different way of life, the Transition team is here to support you throughout the first 5 years.

If you would like more information or support please feel free to reach out to anyone the Transition Team or speak to your Club Wellbeing Manager.

CURRENT SUPPORT & BENEFITS AVAILABLE

- Transition Mentor
- Medical
- Concussion Assessment
- Career Coaching
- Education Grants
- Financial Guidance
- Counselling & Psych Support
- Connection Events
- Business Network & Jobs Board

NRL & RLPA Transition Contacts

NICOLA SKINNER
NRL Transition Program Manager

TOM SYMONDS
RLPA Player Operations

Transition Mentors


Jeremy Latimore NSW


Dene Halatau NSW


Tim Mannah NSW


Jason Nightingale NSW


Mitchell Allgood NSW


Ray Thompson North Queensland


Ali Lauititi New Zealand


Andrew Ryan Newcastle


David Solomona Queensland


Kevin Kingston Penrith

TRANSITION MENTOR:

Your Mentor will keep in contact with you, offer support, resources, guidance and mateship throughout your Transition. All Mentors are past players, who have been through retirement themselves, and have a passion for wellbeing helping people feel connected.

CAREER COACHING & JOBS BOARD:

Access to 1:1 Careers Coaching on demand face-to-face, phone or via zoom. Whether it is identifying what you want to do, preparing for and then applying for work, or identifying courses and activities to help you in your career, we are here to help!

Contact:

RETIRED PLAYERS BUSINESS NETWORK:

This network focusses on assisting Retired NRL players to connect, share opportunities, and support the growth of each others business and professional endeavours, including quarterly networking events.

CONNECTION EVENTS:

Throughout the year there will be opportunities to keep connected! Including quarterly Keep Fit Keep Connected gym & coffee sessions, quarterly Retired Players Reunion events, and catch ups with your Transition Mentor.

MEDICAL COVER IN TRANSITION:

NRL Clubs are required to cover the "gap" for medical treatment of football related injuries for 12 months post NRL contract. To be eligible for medical cover, the following are essential:

1. Exit Medical – completed by your Club Doctor, we encourage you to keep a copy of this.

2. Private Health Insurance – you must hold up to date private health insurance. Obtain adequate cover as soon as your NRL contract ends.

3. 12 Months – medical cover must be arranged within 12 months of your last NRL contract.

Important: medical cover ends if you sign a new playing contract in any competition (including State Cup and Super League). Ensure you discuss with your agent, current NRL Club and new Club so that you can negotiate appropriate medical cover and timing of treatment.

Contact: NRL Club Doctor or

TRANSITION MEMBER EDUCATION GRANTS:

Your entitlement amount is based on the number of years you were contracted in the NRL (Top 30 or Dev List). Grants are paid 50% on enrolment and 25% on completion.

Contact: for more information or to begin the application process.

NEURO-PSYCH ASSESSMENT & RECOMMENDATIONS :

In 2013 Dr Andrew Gardner co-founded Australia's first pubic health sports concussion clinic for adults. His clinic at Royal Prince Alfred Hospital in Sydney provides free evaluation and medical recommendations to athletes suffering concussion. We encourage EVERY retired player to book in for a free comprehensive neuro-psych assessment.

Contact: Dr Andrew Gardner –

COUNSELLING & PSYCH SUPPORT:

You and your partner have free access to the NRL Mental Heath Support Network. This includes quick access to Psychologists and Counsellors.

To access **please call Stephanie Clemmet on**

Stephanie is a Registered Psychologist and will ensure you are connected to the support you need.

TRANSITION 1:1 FINANCIAL SESSION:

Ben Nash and the team at Pivot Wealth are here to help as you navigate your finances in Transition. You can schedule in a private and confidential session for yourself and your partner at anytime.

Book your preferred session time through Ben's -

Any issues with booking or timings please contact Ben Nash –

PIVOT

Appendix 8

Retired Professional Rugby League Players Brain Health Study

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Retired Professional Rugby League Players Brain Health Study

National Rugby League Philanthropic Support
Progress Report – October 28, 2021

2019 Rugby League World Cup 9's Teams line up in Sydney ahead of the tournament at BankWest Stadium. Credit: NRL photos.
Source: https://www nrl.com/news/2019/10/17/world-cup-9s-all-the-teams/

Retired Professional Rugby League Players Brain Health Study

National Rugby League Philanthropic Support
Progress Report – October 28, 2021

Principal Investigator

Andrew J. Gardner, Ph.D.
Associate Professor, School of Medicine and Public Health, University of Newcastle
Hunter Medical Research Institute
Email:

Co-Principal Investigator

Grant L. Iverson, Ph.D.
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School
Director, MassGeneral Hospital *for* Children™ Sport Concussion Program
Director, Concussion Research Program
Spaulding Research Institute
Associate Director, Traumatic Brain Injury Program,
Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

Investigator

Christopher R. Levi, B Med Sci MBBS
Fellow Australian Academy of Health & Medical Science
Director, John Hunter Health and Innovation Precinct (JHHIP)
Senior Staff Specialist, Neurologist, John Hunter Hospital
Conjoint Professor of Medicine, The University of Newcastle

In collaboration with

SPAULDING™ REHABILITATION NETWORK

HARVARD MEDICAL SCHOOL

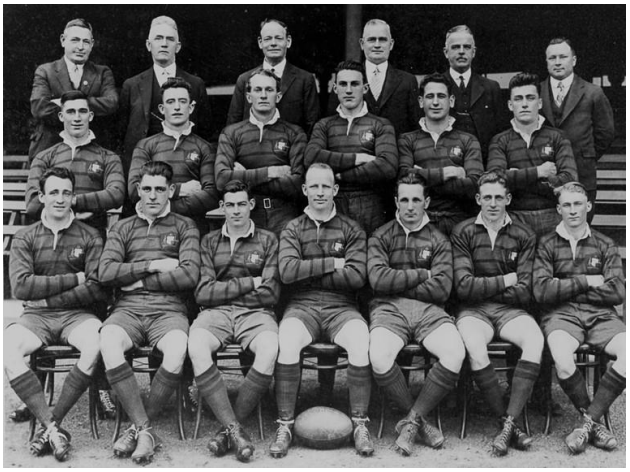
MASSACHUSETTS GENERAL HOSPITAL

SPAULDING™ RESEARCH INSTITUTE

MassGeneral Hospital *for* Children™

Table of Contents

We are engaged in a *program of research* that will provide a clear picture of the current state of the science and produce novel, impactful findings aimed at informing and ultimately improving the health of current and retired professional rugby league players.



Australian Rugby League Team (Kangaroos), ca. 1930 © Melba Studios, Sydney / WikiCommons
https://theculturetrip.com/pacific/australia/articles/a-brief-history-of-the-national-rugby-league-australia/

Players from all NRL clubs pose for an official photo during the 2008 NRL Fan Day at Stadium Australia on February 2, 2008 in Sydney , Australia The Centenary Fan Day featured 400 players from all 16 NRL clubs as part of the biggest public fan day in rugby league history
Matt King: Getty Images
https://www abc net au/news/2008-02-02/all-16-nrl-teams-pose-for-a-mass-photo-at-the-2008/1027834?nw=0

Our Progress: At a Glance
(November 2019-October 2021)

The Penrith Panthers celebrate after their win over the South Sydney Rabbitohs. Photo / Photosport
https://www.nzherald.co.nz/sport/nrl-penrith-panthers-edge-south-sydney-rabbitohs-to-win-thrilling-grand-final/4GUAFEYR2R75TE6VAQM2CDWNZQ/

10	Multidisciplinary investigators from Australia and the United States
168	Health surveys completed by retired NRL players.
162	To date, 162 retired NRL players have undergone in-person brain health evaluations, 49 of whom were examined during this reporting period.
12	Published studies relevant to the brain health of retired NRL players.
1	Study relating to the tackle-related risk factors for concussion that has been *completed and submitted* for publication (currently under scientific peer review).
1	Published study on surveillance of concussions and recovery time across two NRL seasons.
1	Published study designed to improve the medical management of concussion in *current women* NRL players (SCAT5 Normative Values).
1	Published study examining wearable sensors, in Junior Rugby League players, designed to detect high impact blows to the head.
1	Proposed study that examines outcomes from the NRL medical bunker injury surveillance system, conducted in collaboration with a diverse team of investigators and stakeholders.

Executive Summary

Dear Executive Leadership of the National Rugby League,

Thank you for your philanthropic support of our research. With your support, we have assembled a multidisciplinary team of experts from Australia and the United States to conduct transformative research that is important to the brain health of both current and retired National Rugby League (NRL) players. We have been extraordinarily productive operating this important research program during the global pandemic. Without question, the pandemic disrupted our ability to do some of the work, especially some of the in-person study visits. At the same time, it allowed us to focus our efforts in other areas, harnessing our existing data and leveraging "big data" to advance knowledge in important ways.

We are aggressively pursuing *new and important studies* relating to the health and welfare of the *current* professional player in both the men's and women's league. Our original proposal included studies relating to the brain health of *retired* professional players only. During the pandemic, we have pursued several additional studies, i.e. "bonus" studies that were not in our original proposal, relating to concussions and brain health in *current* and retired NRL players. We have been tremendously productive. We are delighted to share with you the progress listed below.

1. **The Research Team**: During the reporting period, we assembled and mobilized a multidisciplinary research team of ***10*** investigators from Australia and the United States.

2. **Retired Rugby League Players Health Survey**: To date we have distributed 195 health surveys to retired NRL players, of which 168 have been completed and returned.

3. **In-Person Brain Health Study**: To date, we have collected in-person comprehensive brain health evaluation data on a total sample of 162 retired NRL players (of whom 61 have completed the clinical measures and 101 have completed both the clinical measures and the experimental brain imaging). During this reporting period, we have enrolled 49 retired players for brain health evaluations (30 have completed the clinical measures and 19 completed both the clinical measures and the experimental brain imaging).

4. **Brain Health Studies *of, or relevant to,* Retired NRL Players (12 studies)**: During the reporting period, we *published* 12 studies that directly assess, or are relevant to, the long-term brain health of retired NRL players.

    - We *published* one study using experimental neuroimaging to examine the *white matter microarchitecture* of the brains of retired NRL players.

      Wright DK, Gardner AJ, Wojtowicz M, Iverson GL, O'Brien TJ, Shultz SR, & Stanwell P. (2021). **White matter abnormalities in retired professional rugby league players with a history of concussion**. *Journal of Neurotrauma,* 38(8):983-988. doi: 10.1089/neu.2019.6886. PMID: 32245344.

    - We *published* one study using experimental neuroimaging to examine the *functional connectivity* within the brains of retired NRL players.

      Guell X, Arnold Anteraper S, Gardner AJ, Whitfield-Gabrieli S, Kay-Lambkin F, Iverson GL, Gabrieli J, Stanwell P. (2020). **Functional connectivity changes in retired professional rugby league players: a data-driven functional magnetic resonance imaging study**. *Journal of Neurotrauma, 37*(16):1788-1796. doi: 10.1089/neu.2019.6782. PMID: 32183583.

- We *published* two survey studies of men from the US general population that showed that earlier age of first exposure to gridiron football was *not* associated with greater later in life brain health problems. We also published a comprehensive narrative review on this topic. We *are preparing* a study for publication that examines associations between age of first exposure to rugby, and total number of years of professional exposure, and later in life brain health in retired NRL players.

  Iverson, G.L., Caccese, J.B., Merz, Z.C., Büttner, F., Terry, D.P. (2021). **Age of First Exposure to Football Is Not Associated with Later-in-Life Cognitive or Mental Health Problems**. *Frontiers in Neurology*, 12:647314.

  See article on journal website by clicking here:
  https://www.frontiersin.org/articles/10.3389/fneur.2021.647314/full

  Iverson GL, Terry DP, Cassese JB, Büttner F, Merz ZC. (2021). **Age of First Exposure to Football is not Associated with Midlife Brain Health Problems**. *Journal of Neurotrauma*, 38(5):538-545. doi: 10.1089/neu.2020.7041. PMID: 33126834.

  Iverson GL, Buttner F, & Caccese JB (2021). **Age of first exposure to contact and collision sports and later in life brain Health: A narrative review.** *Frontiers in Neurology*, 12:727089. doi: 10.3389/fneur.2021.727089. PMID: 34659092.

  See article on journal website by clicking here:
  https://www.frontiersin.org/articles/10.3389/fneur.2021.727089/full

- We *published* a survey study of men from the US general population who played gridiron football in high school. They did *not* experience worse later in life cognitive problems or mental health problems than men who did not play youth football.

  Iverson, G. L., Merz, J. C., & Terry, D. P. (in press; 2021). **High School Football and Midlife Brain Health Problems**. *Clinical Journal of Sports Medicine.*

- We *published* a study that examines *predictors of self-reported cognitive decline* in retired NRL players.

  Van Patten R, Iverson GL, Terry DP, Levi CR, and Gardner AJ. (2021). **Predictors and Correlates of Perceived Cognitive Impairment in Retired Professional Rugby League Players**. *Frontiers in Neurology*, online first. doi: 10.3389/fneur.2021.676762.

  See article on journal website by clicking here:
  https://www.frontiersin.org/articles/10.3389/fneur.2021.676762/full

- We *published* a study that examines *predictors of depression* in retired NRL players.

  Iverson GL, Van Patten R, Terry DP, Levi CL, and Gardner AJ. (2021). **Predictors and Correlates of Depression in Retired Professional Rugby League Players**. *Frontiers in Neurology*, 12:655746. doi: 10.3389/fneur.2021.655746. PMID: 22868156.

  See article on journal website by clicking here:
  https://www.frontiersin.org/articles/10.3389/fneur.2021.655746/full

- We *published* a series of 4 studies relating to how to diagnose chronic traumatic encephalopathy (CTE), or traumatic encephalopathy syndrome, in a living person. We used a large epidemiological database from the United States for 3 of those studies, and we conducted an online survey for one study. These studies illustrate major flaws in the proposed criteria for diagnosing CTE in research participants, former contact and collision sport athletes, and military Veterans. Major improvements in the criteria are needed to avoid high rates of false positive diagnoses in clinical populations such as men with depression or anger control problems.

  Iverson, G. L. & Gardner, A. J. (2019). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Depression.** *Journal of Neuropsychiatry and Clinical Neurosciences.* doi: 10.1176/appi.neuropsych.19010021.

  See article on journal website by clicking here:
  Risk of Misdiagnosing Chronic Traumatic Encephalopathy in Men With Depression | The Journal of Neuropsychiatry and Clinical Neurosciences (psychiatryonline.org)

  Iverson, G. L. & Gardner, A. J. (2020). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Anger Control Problems.** *Frontiers in Neurology - Neurotrauma, 11,* 739. doi: 10.3389/fneur.2020.00739.

  See article on journal website by clicking here:
  Frontiers | Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men With Anger Control Problems | Neurology (frontiersin.org)

  Iverson, G.L. & Gardner, A.J. (2021). **Symptoms of Traumatic Encephalopathy Syndrome are Common in the United States General Population.** *Brain Communications, 3*(1):fcab001. doi: 10.1093/braincomms/fcab001.

  See article on website by clicking here:
  https://academic.oup.com/braincomms/article/3/1/fcab001/6119624

  Iverson, G.L., Merz, Z.C., & Terry, D.P. (2021). **Examining the Research Criteria for Traumatic Encephalopathy Syndrome in Middle-Aged Men from the General Population Who Played Contact Sports in High School.** *Frontiers in Neurology*. doi: 10.3389/fneur.2021.632618.

  See article on journal website by clicking here:
  Frontiers | Examining the Research Criteria for Traumatic Encephalopathy Syndrome in Middle-Aged Men From the General Population Who Played Contact Sports in High School | Neurology (frontiersin.org)

5. **Studies of Importance to the Health and Welfare of *Current* Men and Women NRL Players (6 studies, 4 published).** We have aggressively pursued a program of research relating to the health and welfare of *current* NRL players. The 6 studies described below were *not part of our original proposal*, but they became a focus of our work during discretionary research time created by the COVID-19 pandemic.

   - We published one major study that documents the incidence of concussion during match play in the NRL, over the course of the 2017 and 2018 seasons, and the recovery time for the athletes.

     Iverson GL and Gardner AJ (2021). **Incidence of Concussion and time to return to play in the National Rugby League**. Clinical Journal of Sports Medicine, *online first*. doi: 10.1097/JSM.0000000000000965. PMID: 34446647.

   - The Sport Concussion Assessment Tool-Fifth Edition (SCAT5) is used by the medical staff of the NRL to assess men and women players, on the sideline and after the match, for concussion. The SCAT5 includes measures of symptoms, balance, and cognitive functioning. There are no published normative reference data for NRL players. We *published a study* that provides *SCAT5 normative reference values for the women's NRL*. We used their baseline preseason health assessments to create these norms.

     We are preparing *a second study* that will provide *SCAT5 normative reference values for the men's NRL*. We are using their baseline preseason health assessments to create these norms. These normative reference values will be constructed so that they are refined and maximally useful for Indigenous, Pasifika, and White players.

     Iverson GL, Howell DR, van Patten R., Bloomfield P, & Gardner AJ. (2021). **Sport Concussion Assessment Tool-5th Edition (SCAT5): Normative Reference Values for the National Rugby League Women's Premiership.** *Frontiers in Sports and Active Living,* 3:653743. doi: 10.3389/fspor.2021.653743. PMID: 34124655.

     See article on journal website by clicking here:
     https://www.frontiersin.org/articles/10.3389/fspor.2021.653743/full

   - The development of wearable sensor technology has enabled the measurement of linear and angular forces applied to a player's head during participation in contact and collision sport. This technology, in the future, might prove to be useful for identifying players at risk for sustaining a concussion in real-time during a match. As part of the process for evaluating the usefulness of wearable sensor technology, it is important to verify that the output is accurate (i.e., an impact recorded by the sensors actually occurred). We evaluated the wearable sensor technology output through a video verification study to identify the accuracy of the sensors in elite junior representative rugby league (Harold Matthews) players during one season.

     Carey L, Terry DP, McIntosh AS, Stanwell P, Iverson GL, Gardner AJ (2021). **Video Analysis and Verification of Direct Head Impacts Recorded by Wearable Sensors in Junior Rugby League Players**. *Sports Med Open*. 2021 Sep 16;7(1):66. doi: 10.1186/s40798-021-00353-3. PMID: 34529180.

     See article on journal website by clicking here:
     https://sportsmedicine-open.springeropen.com/articles/10.1186/s40798-021-00353-3

- We have submitted for peer review a study that examines the association between tackle characteristics in the NRL and concussion to identify potential risk factors and inform future injury prevention initiatives.

- Video footage of live game play has become an important part of the injury surveillance process in professional contact and collision sports. Observable signs of concussion appear to be sensitive to concussion diagnosis when reviewing know injuries, but the evaluation of specific video signs and their relationship with an in-game medical evaluation, has not been reported. We completed a video evaluation of on-field motor incoordination in players who were removed from play to complete a Head Injury Assessment (HIA). We examined the relationship between video evidence of motor incoordination and the player's performance on the in-game SCAT5 (post-concussion symptom reporting, cognitive and balance screening), together with the player's recovery time, as measured by their return to NRL match play.

  Iverson, G.L., Van Patten, R., &Gardner, A.J. (2021). **Examining Whether Onfield Motor Incoordination Is Associated with Worse Performance on the SCAT5 and Slower Clinical Recovery Following Concussion**. *Frontiers in Neurology*, 11:620872.

  See article on journal website by clicking here:
  https://www.frontiersin.org/articles/10.3389/fneur.2020.620872/full

6. **Plans for this Coming Year**: We have ambitious plans for the coming year. We will, of course, continue with our large-scale health survey of retired NRL players. We will continue the in-person brain health study of retired players at the University of Newcastle. We will pursue and publish a series of studies that advance knowledge in the medical and scientific community relating to the long-term mental health and cognitive health of former amateur and professional athletes. We will continue with the brain donation program, and we will publish studies relating to neuropathology. We will publish a major study that will provide normative reference values for the SCAT5 for the men's league, that can be used by the NRL medical staff. And, working in collaboration with a diverse team of investigators and stakeholders, we will complete and publish a study that examines outcomes from the new NRL medical bunker injury surveillance system.

Yours Faithfully,

Andrew Gardner, Ph.D., Associate Professor,
School of Medicine and Public Health,
The University of Newcastle

Grant L. Iverson, Ph.D., Professor,
Department of Physical Medicine and
Rehabilitation, Harvard Medical School

Core Research Team

Principal Investigators

Andrew J. Gardner, Ph.D.
Associate Professor, Priority Research Centre for Stroke and Brain Injury,
School of Medicine and Public Health, The University of Newcastle
Co-Director, Hunter New England Local Health District Sports Concussion Clinic
Email:

Grant L. Iverson, Ph.D.
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School;
Director, MassGeneral Hospital *for* Children™ Sport Concussion Program
Director, Concussion Research Program, Spaulding Research Institute
Associate Director, Traumatic Brain Injury Program,
Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

Research Team

Rudolph Castellani, M.D.
Professor and Vice-Chair of Pathology Research & Section Chief of Neuropathology

David Howell, Ph.D., ATC
Assistant Professor, Department of Orthopedics, University of Colorado School of Medicine;
Children's Hospital Colorado Sports Medicine Center

Christopher R. Levi, B Med Sci MBBS & Fellow Australian Academy of Health & Medical Science
Executive Director, Sydney Partnership for Health, Education, Research & Enterprise
Co-Director, Hunter New England Local Health District Sports Concussion Clinic

Zachary Merz, Ph.D.
Staff Neuropsychologist, LeBauer Department of Neurology, Moses H. Cone Memorial Hospital,
Greensboro, NC, USA

Claire Shepherd, Ph.D.
Director of the Sydney Brain Bank; Director Dementia Team Laboratory at Neuroscience Research Australia

Peter Stanwell, Ph.D.
Professor, School of Health Sciences, The University of Newcastle

Douglas Terry, Ph.D.
Neuropsychologist, Vanderbilt University Medical Center
Assistant Professor, Department of Neurological Surgery, Vanderbilt University School of Medicine
Co-Director, Vanderbilt Sports Concussion Center
Director, Center for Cognitive Neurosurgical Studies

Ryan Van Patten, Ph.D.
Neuropsychologist, Department of Physical Medicine and Rehabilitation, Harvard Medical School;
Spaulding Rehabilitation Hospital

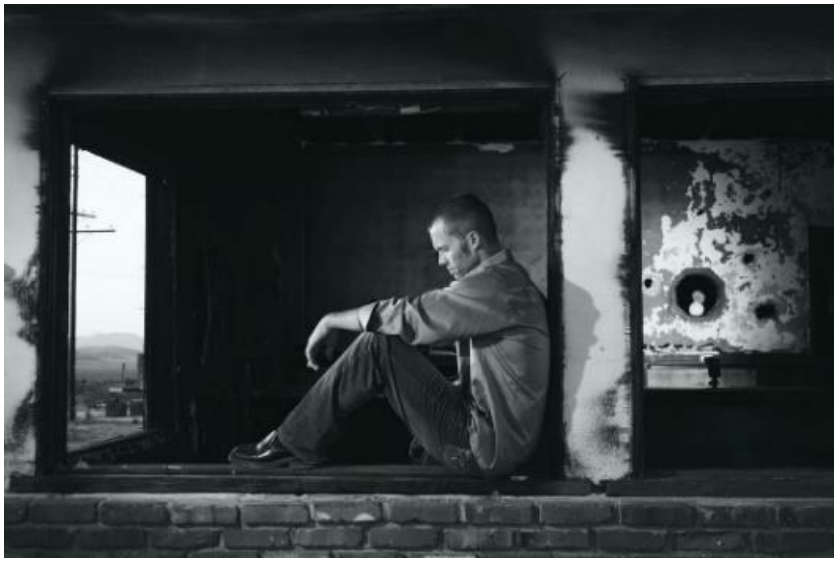
Articles Published in Medical and Scientific Journals

Between November of 2019 and October 2021, we have published 16 studies in medical and scientific journals. Those studies are summarized below. In addition, we have submitted one study for publication, and it is currently in the scientific peer review process. We are actively working on 3 studies for publication. The studies are summarized below.

Background and Importance: This study is important because it illuminated fundamental problems with the criteria for diagnosing chronic traumatic encephalopathy, and traumatic encephalopathy syndrome, in retired athletes, military veterans, and people from the general population. There is considerable risk for *misdiagnosis*, and there is a pressing need to try to improve the diagnostic criteria.

Iverson, G. L. & Gardner, A. J. (2019). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Depression.** *Journal of Neuropsychiatry and Clinical Neurosciences.* doi: 10.1176/appi.neuropsych.19010021.

Objective: In recent years, it has been proposed that depression represents one clinical subtype of chronic traumatic encephalopathy (CTE). This is the first study to examine the specificity of the research criteria for the clinical diagnosis of CTE in men with depression from the general population.
Methods: Data from the National Comorbidity Survey Replication, an in-person survey that examined the prevalence and correlates of mental disorders in the United States, were used for this study. Men diagnosed as having a major depressive episode in the past 30 days were included (N=101; mean age=39.4 years, SD=12.9, range=18–71). They were deemed to meet research criteria for CTE if they presented with the purported supportive clinical features of CTE (e.g., impulsivity and substance abuse, anxiety, apathy, suicidality, and headache).
Results: Approximately half of the sample (52.5%) met the proposed research criteria for CTE (i.e., traumatic encephalopathy syndrome). If one accepts the delayed-onset criterion as being present, meaning that the men in the sample were presenting with depression years after retirement from sports or the military, then 83.2% of this sample would meet the research criteria for diagnosis.
Conclusions: The clinical problems attributed to CTE, such as depression, suicidality, anxiety, anger control problems, and headaches, co-occurred in this sample of men with depression from the general population—illustrating that these problems are not specific or unique to CTE. More research is needed to determine whether depression is, in fact, a clinical subtype of CTE.



Iverson, G. L. & Gardner, A. J. (2020). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Anger Control Problems.** *Frontiers in Neurology - Neurotrauma, 11*, 739. doi: 10.3389/fneur.2020.00739.

Background: There are no validated or agreed upon criteria for diagnosing chronic traumatic encephalopathy (CTE) in a living person. In recent years, it has been proposed that anger dyscontrol represents a behavioral clinical phenotype of CTE. This is the first study to examine the specificity of the diagnostic research criteria for traumatic encephalopathy syndrome (TES, the clinical condition proposed to be CTE) in men from the US general population who have anger dyscontrol problems. It was hypothesized that a substantial percentage of these men would meet the research criteria for TES.

Methods: Data from 4,139 men who participated in the National Comorbidity Survey Replication, an in-person survey that examined the prevalence and correlates of mental disorders in the United States, were included in this study. Men who were diagnosed with intermittent explosive disorder in the past year were the clinical sample of interest (n = 206; 5.0% of all men in the database), and the remaining men were used as a comparison sample. They were classified as meeting the research criteria for TES if they presented with the purported supportive clinical features of CTE (e.g., impulsivity/substance abuse, anxiety, apathy, suicidality, headache).

Results: In this sample of men from the general population with intermittent explosive disorder, 27.3% met a conservative definition of the proposed research criteria for CTE (i.e., traumatic encephalopathy syndrome). If one assumes the delayed-onset criterion is present, meaning that the men in the sample are compared to former athletes or military veterans presenting with mental health problems years after retirement, then 65.0% of this sample would meet the research criteria for TES.

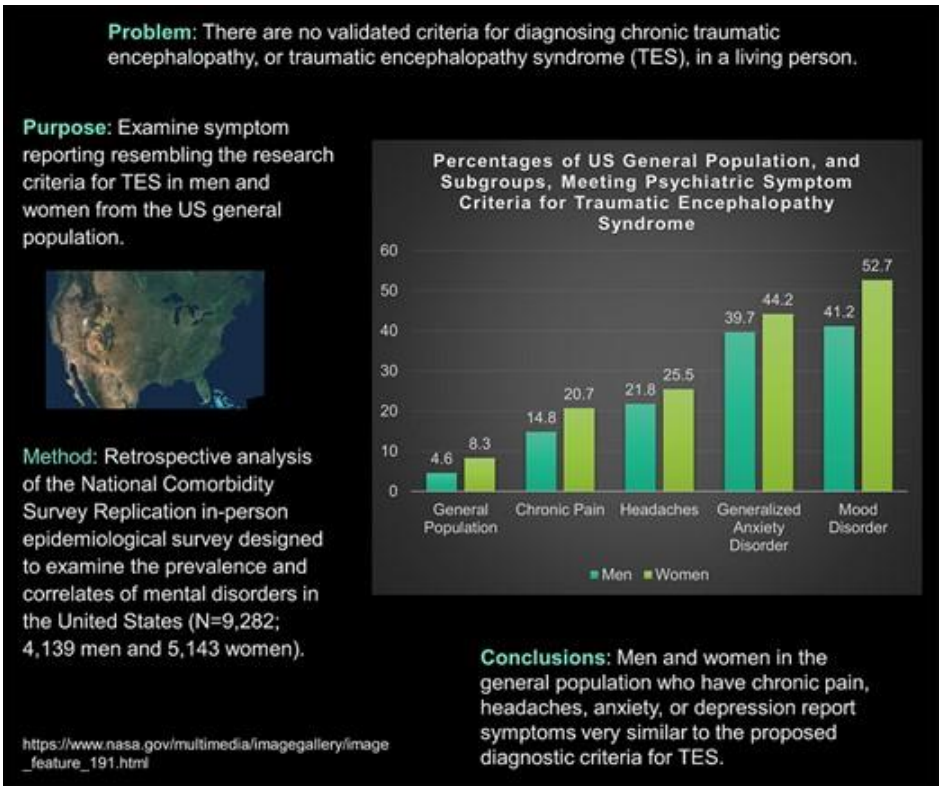
Conclusions: These results have important implications. Using conservative criteria, at least one in four men from the general population, who have serious anger control problems, will meet the symptom criteria for TES. If one considers former athletes and military veterans with anger control problems who present many years after retirement and who experienced a documented decline in their mental health, nearly two-thirds will meet these research criteria. More research is needed to examine risks for misdiagnosing TES and to determine whether anger dyscontrol is a clinical phenotype of CTE.

Source: https://www.apa.org/topics/anger/control

Iverson, G.L. & Gardner, A.J. (2021). **Symptoms of Traumatic Encephalopathy Syndrome are Common in the United States General Population.** *Brain Communications, 3*(1):fcab001. doi: 10.1093/braincomms/fcab001.

Background and Importance: This study is important because it illuminates some fundamental problems with the criteria for diagnosing chronic traumatic encephalopathy (CTE), and traumatic encephalopathy syndrome, in retired athletes, military veterans, and people from the general population. There is considerable risk for *misdiagnosis*, and there is a pressing need to try to improve the diagnostic criteria.

Study Abstract: There are no validated criteria for diagnosing chronic traumatic encephalopathy, or traumatic encephalopathy syndrome, in a living person. The purpose of this study is to examine symptom reporting resembling the research criteria for traumatic encephalopathy syndrome in men and women from the US general population. This is a retrospective analysis of publicly available data from a cross-sectional epidemiological study. The National Comorbidity Survey Replication was designed to examine the prevalence and correlates of mental disorders in the USA. The study included a nationally representative sample of 9282 adults (4139 men and 5143 women). An in-person interview and survey were conducted in the homes of men and women from the general population. The study was conducted with participants residing in New York City, Los Angeles, Chicago, Philadelphia, Detroit, San Francisco, Washington DC, Dallas/Fort Worth, Houston, Boston, Nassau-Suffolk NY, St. Louis, Pittsburgh, Baltimore, Minneapolis and Atlanta. Symptoms from the research criteria for the diagnosis of traumatic encephalopathy syndrome were applied to men and women in the general population and in sub-groups of people with health problems and mental health problems. A small percentage of the US general population met symptom criteria for traumatic encephalopathy syndrome (6.6–11.9%, depending on the definition applied). People with chronic pain were much more likely to meet criteria (i.e. 14.8–30.5%), and two out of three people who have experienced suicidality in the past year met symptom criteria for traumatic encephalopathy syndrome (65.2–72.2%). The majority of women with a mood disorder and chronic pain met criteria (62.7–89.8%). This is the largest study, to date, examining the aspects of the research criteria for the diagnosis of traumatic encephalopathy syndrome in the general population, and the first study to examine these criteria in women. This study has important clinical and public health implications. The potential rate for misdiagnosing traumatic encephalopathy syndrome in adults who are experiencing chronic pain, idiopathic mental health problems or both is high.



Iverson, G.L., Merz, Z.C., & Terry, D.P. (2021). **Examining the Research Criteria for Traumatic Encephalopathy Syndrome in Middle-Aged Men from the General Population Who Played Contact Sports in High School.** *Frontiers in Neurology*. doi: 10.3389/fneur.2021.632618. Click here to read abstract on PubMed.

NB: This study was not part of our original proposal. We have been pursuing it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: There is societal interest and concern about possible long-term effects of playing professional football on brain health. Researchers have reported that some former National Football League (NFL) players show differences in brain structure, microstructure, neurochemistry, and neurophysiology. Some former players perform more poorly on neurocognitive testing than control participants. Survey studies reveal that a subgroup of former players rate themselves as having poor mental health and cognitive functioning, although the majority do not perceive themselves to have these problems. Post-mortem studies have revealed diverse forms of neuropathology in some former players, including chronic traumatic encephalopathy neuropathologic change. Mortality studies, based on reviews of death certificates, have found greater rates of cardiovascular disease compared to former major league baseball players, but not compared to the general population. Compared to the general population, former NFL players have greater rates of Alzheimer's disease and amyotrophic lateral sclerosis as contributory causes of death, but not psychiatric illness or suicide.

Source: https://www.latimes.com/sports/highschool/story/2019-08-23/top-25-high-school-football-teams-results

There is also societal interest and concern regarding the long-term brain health of men who played high school football, although far less research has been done with them. Two studies have used data from the National Longitudinal Study of Adolescent to Adult Health to examine the associations between playing football during adolescence and mental health approximately 15 years later, during their late 20s. The researchers reported that playing football during adolescence was not associated with greater mental health problems, including lifetime rates of depression, current symptoms of depression (i.e., within the past seven days;), lifetime rates of anxiety, suicidal ideation within the past year, or substance abuse (i.e., nicotine, cannabis, alcohol). Researchers using data from the Wisconsin Longitudinal Study reported that playing high school football was not associated with cognitive problems or depression in older adults, when these men were approximately 65 years old. Using medical record linkage methodology, two studies have concluded that former high school football players are not at increased risk for later in life neurodegenerative diseases.

A notable gap in the literature relates to the brain health of middle-aged men who played high school football. We designed a survey study to examine whether middle aged men who played high school football experience worse mental health or cognitive functioning than men who did not play high school football. Based on the literature to date with men in their 20s who played football, we adopted the null hypothesis. We assumed that men who played high school football would *not* report (i) a greater lifetime history of depression or anxiety, (ii) greater mental health or cognitive problems in the past year, or (iii) greater current post-concussion-like symptoms or symptoms of depression.

Study Abstract

Objective: There are no validated or agreed upon diagnostic clinical criteria for chronic traumatic encephalopathy or traumatic encephalopathy syndrome. This study examines the leading research criteria for traumatic encephalopathy syndrome (TES) in middle-aged men in the general population.

Method: Participants were 409 men between the ages of 35 and 55 recruited through an online crowdsourcing platform. Participants provided demographic information, medication history, concussion history, contact sport history, current medication use, and current symptoms. Research criteria for TES were applied to the sample.

Results: Over half of the total sample met TES symptom criteria (56.2%), without applying the neurotrauma exposure criteria. Those with 4+ prior concussions had higher rates of meeting TES criteria compared to those with 0-3 prior concussions, but the results were not statistically significant (69.8 vs. 54.6%; $\chi^2 = 3.58$, $p = 0.06$). Exposure to contact sports was not related to higher rates of TES (ps $\geq$ 0.55). In a binary logistic regression predicting the presence of mild or greater TES, significant predictors were sleep difficulties [Odds ratio (OR) = 6.68], chronic pain (OR = 3.29), and age (OR = 1.04). Neurotrauma exposure was not a significant predictor ($p = 0.66$). When analyzing those with no prior concussions or contact sport histories ($n = 126$), 45.2% met symptom criteria for mild or greater TES; chronic pain and sleep difficulties were associated with a higher prevalence of meeting criteria for TES in this subgroup (ps < 0.001).

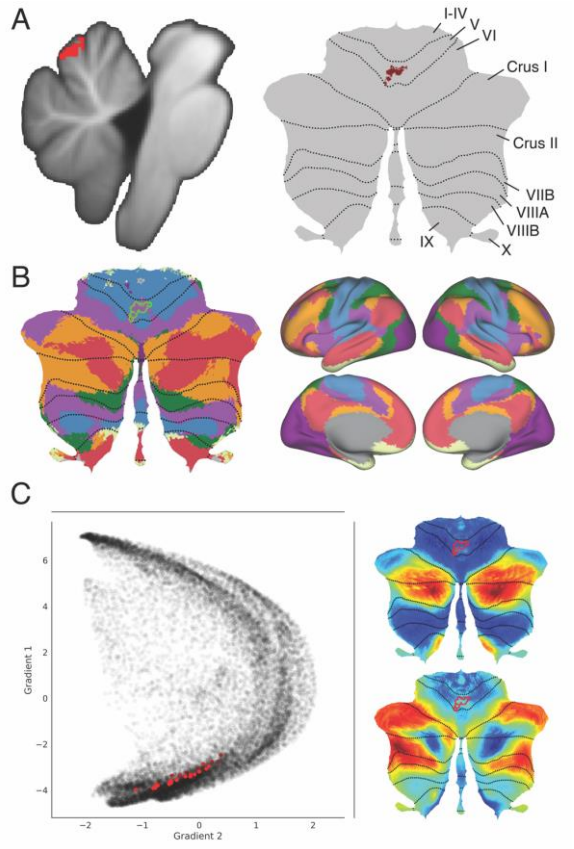
Conclusions: Men who participated in contact sports in high school or college were not more likely to meet criteria for TES than men who participated in non-contact sports or no sports. In a multivariable model, sleep problems and chronic pain were predictive of meeting the symptom criteria for TES, but the repetitive neurotrauma exposure criterion was not a significant predictor of meeting the TES symptom criteria.

Scott Varley, The Orange County Register, Via AP
Source: https://www.usatoday.com/story/sports/2020/07/20/high-school-football-start-late-california/5472355002/

Guell X, Arnold Anteraper S, Gardner AJ, Whitfield-Gabrieli S, Kay-Lambkin F, Iverson GL, Gabrieli J, Stanwell P. (2020). **Functional connectivity changes in retired professional rugby league players: a data-driven functional magnetic resonance imaging study**. *Journal of Neurotrauma*, *37*(16):1788-1796. doi: 10.1089/neu.2019.6782. PMID: 32183583.

Background and Importance: This was an exploratory study using experimental brain imaging and advanced analytical techniques. This study was important because it revealed differences in resting-state functional connectivity in retired professional rugby league players compared to healthy community control participants.

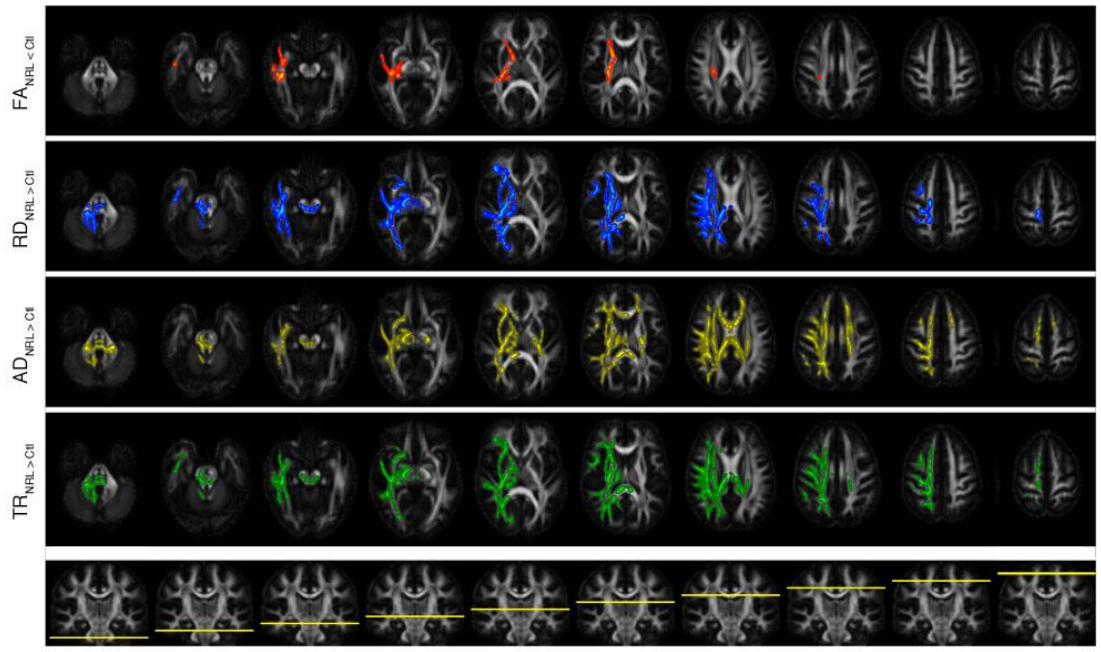
Abstract: There is considerable interest in the long-term brain health of retired contact and collision sport athletes; however, little is known about possible underlying changes in functional brain connectivity in this group. We evaluated whole-brain functional connectivity patterns using multi-voxel pattern analysis (MVPA) to determine whether alterations in functional connectivity distinguish retired professional athletes from a matched group of healthy community control subjects. Thirty-two retired athletes with a history of multiple self-reported sport-related concussions and 36 healthy community control subjects who were similar in age and education, completed functional magnetic resonance imaging. We identified brain regions with abnormal functional connectivity patterns using whole-brain MVPA as implemented in the Conn toolbox. First-level MVPA was performed using 64 principal component analysis (PCA) components. Second-level F test was performed using the first three MVPA components for retired athletes > controls group contrast. *Post hoc* seed-to-voxel analyses using the MVPA cluster results as seeds were performed to characterize functional connectivity abnormalities from brain regions identified by MVPA. MVPA revealed one cluster of abnormal functional connectivity located in cerebellar lobule V. This region of lobule V corresponded to the ventral attention network. *Post hoc* seed-to-voxel analysis using the cerebellar MVPA cluster as a seed revealed multiple areas of cerebral cortical hyper-connectivity and hypo-connectivity in retired athletes when compared with controls. This initial report suggests that cerebellar dysfunction might be present and clinically important in some retired athletes.



Wright DK, Gardner AJ, Wojtowicz M, Iverson GL, O'Brien TJ, Shultz SR, & Stanwell P. (2021). **White matter abnormalities in retired professional rugby league players with a history of concussion**. *Journal of Neurotrauma*, 38(8):983-988. doi: 10.1089/neu.2019.6886. PMID: 32245344.

Background and Importance: This is the first study investigating diffusion tensor imaging metrics in a small sample of recently retired professional NRL players. Diffusion tensor imaging is an experimental MRI technique that measures water movement in tissue and is sometimes used to infer the integrity of the white matter tracts connecting various regions in the brain. Voxel-based analysis revealed several differences in metrics thought to measure the integrity of white matter of NRL players when compared to controls. These differences persisted after statistically accounting for the fact that NRL players endorsed more problematic alcohol use compared to controls. Further research, longitudinal in design, is warranted to clarify the consequences, if any, repetitive neurotrauma has on long-term structural brain changes and clinical outcomes.

Abstract: The topic of potential long-term neurological consequences from having multiple concussions during a career in collision sports is controversial. We sought to investigate white matter microstructure using diffusion tensor imaging (DTI) in retired professional Australian National Rugby League (NRL) players (n = 11) with a history of multiple self-reported concussions compared with age- and education-matched controls (n = 13) who have had no history of brain trauma. Diffusion-weighted images were acquired with a Siemens 3T scanner. All participants completed a clinical interview. There were no significant differences between groups on measures of depression, anxiety, stress, or post-concussion symptoms; however, NRL players scored significantly higher on the alcohol use disorder identification test (AUDIT). Voxelwise analyses of DTI measures were performed using tract-based spatial statistics (TBSS) with age and AUDIT scores included as covariates. TBSS revealed significantly reduced fractional anisotropy (FA), and increased radial diffusivity (RD), axial diffusivity (AD), and trace (TR) in white matter regions of recently retired NRL players compared with controls. FA was significantly reduced in the right superior longitudinal fasciculus and right corticospinal tract while TR, RD, and AD were increased in these regions, as well as the corpus callosum, forceps major, right uncinate fasciculus, and left corticospinal tract. In summary, DTI in a small cohort of recently retired professional NRL players with a history of multiple concussions showed differences in white matter microstructure compared with age- and education-matched controls with no history of brain trauma.



Iverson GL, Terry DP, Cassese JB, Büttner F, Merz ZC. (2021). **Age of First Exposure to Football is not Associated with Midlife Brain Health Problems**. *Journal of Neurotrauma*, 38(5):538-545. doi: 10.1089/neu.2020.7041. PMID: 33126834.

NB: This study was not part of our original proposal. We have been pursuing it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: Football has been one of the most popular sports in the United States for decades, with more than one million youth participating at the high school level each year. It is reasonable to estimate that tens of millions of men in the United States played high school football. In recent years, several states, such as New Jersey, New York, Massachusetts, and Illinois, have held hearings or considered legislation to ban tackle football below the age of 12. Advocacy groups for this legislation have relied, in part, on some studies that have put forward a theory that playing football before the age of 12 is associated with psychiatric, cognitive, and neurological problems later in life. The origin of the theory appears to be a small study of former National Football League (NFL) players illustrating that those who started playing before the age of 12 performed more poorly on a reading test and two neuropsychological tests. Much research is needed on this important topic.

Source: https://www.cbsnews.com/news/youth-football-concussion-symptoms-treatment-vary-by-age/

Study Abstract: The purpose of this study was to determine if earlier age of first exposure to football is associated with worse brain health in middle-aged men who played high school football. We assessed 123 men ages 35-55, who played high school football, using (i) a survey of demographic information as well as medical, sport participation, and concussion history; (ii) the Patient Health Questionnaire-8 (PHQ-8); and (iii) the British Columbia Post-Concussion Symptom Inventory (BC-PSI). Sixty-two (50.4%) men reported football participation starting before the age of 12 [i.e., age of first exposure (AFE)<12 years] and 61 (49.6%) reported football participation at or after the age of 12 (AFE≥12 years). Compared to AFE≥12 years, former high school football players that began playing tackle football before age 12 did not differ in the rates at which they had been prescribed medications for mental health problems or in the rates at which they had recently experienced symptoms of anxiety, depression, memory loss, chronic pain, or headaches. Moreover, there was no difference in their lifetime history of treatment by a mental health professional. The groups did not differ significantly on PHQ-8 (U=1,839.0, p=.791) or BC-PSI total scores (U=1828.5, p=.751). These findings suggest that earlier age of first exposure to football is not associated with worse brain health in middle-aged men in this sample who played high school football.

Iverson, G.L., Caccese, J.B., Merz, Z.C., Büttner, F., Terry, D.P. (2021). **Age of First Exposure to Football Is Not Associated with Later-in-Life Cognitive or Mental Health Problems**. *Frontiers in Neurology*, 12:647314.

Background: The purpose of this study was to determine if earlier age of first exposure to football is associated with worse brain health in middle-aged and older adult men who played high school football.

Methods: Men from the United States, aged 35 and older, who reported playing high school football, completed a customized, online health survey via the Amazon Mechanical Turk (mTurk) platform. Survey items included physical, psychological, and cognitive symptoms over the past week and over the past year, sports participation history (including age of first exposure to football), medical history, and concussion history. Participants also completed the Patient Health Questionnaire-8 (PHQ-8) and the British Columbia Post-Concussion Symptom Inventory (BC-PSI).

Results: There were 186 men (age M = 51.78, SD = 10.93) who participated in high school football, and 87 (46.8%) reported football participation starting before the age of 12 and 99 (53.2%) reported football participation at or after the age of 12. Those who started playing football at an earlier age reported a greater number of lifetime concussions (M = 1.95, SD = 1.79) compared to those who started playing at age 12 or later (M = 1.28, SD = 1.52; U = 3,257.5, $p = 0.003$). A similar proportion of men who played football before vs. after the age of 12 reported a lifetime history of being prescribed medications for depression, anxiety, chronic pain, headaches, or memory problems. When comparing men who played football before vs. after the age of 12, the groups did not differ significantly in their ratings of depression, anger, anxiety, headaches, migraines, neck or back pain, chronic pain, concentration problems, or memory problems over the past week or the past year. The two groups did not differ significantly in their ratings of current symptoms of depression (PHQ-8; U = 4,187.0, $p = 0.74$) or post-concussion-like symptoms (BC-PSI; U = 3,944.0, $p = 0.53$). Furthermore, there were no statistically significant correlations between the age of first exposure to football, as a continuous variable, and PHQ-8 or BC-PSI scores.

Conclusion: This study adds to a rapidly growing body of literature suggesting that earlier age of first exposure to football is not associated with later-in-life brain health.

Iverson GL, Buttner F, & Caccese JB (2021). **Age of first exposure to contact and collision sports and later in life brain Health: A narrative review.** *Frontiers in Neurology*, 12:727089. doi: 10.3389/fneur.2021.727089. PMID: 34659092.

NB: This important study was not part of our original proposal. We have been pursuing them with discretionary time during the COVID-19 pandemic.

Abstract: A controversial theory proposes that playing tackle football before the age of 12 causes later in life brain health problems. This theory arose from a small study of 42 retired National Football League (NFL) players, which reported that those who started playing tackle football at a younger age performed worse on selected neuropsychological tests and a word reading test. The authors concluded that these differences were likely due to greater exposure to repetitive neurotrauma during a developmentally sensitive maturational period in their lives. Several subsequent studies of current high school and collegiate contact/collision sports athletes, and former high school, collegiate, and professional tackle football players have not replicated these findings. This narrative review aims to (i) discuss the fundamental concepts, issues, and controversies surrounding existing research on age of first exposure (AFE) to contact/collision sport, and (ii) provide a balanced interpretation, including risk of bias assessment findings, of this body of evidence. Among 21 studies, 11 studies examined former athletes, 8 studies examined current athletes, and 2 studies examined both former and current athletes. Although the literature on whether younger AFE to tackle football is associated with later in life cognitive, neurobehavioral, or mental health problems in former NFL players is mixed, the largest study of retired NFL players (N = 3,506) suggested there was not a significant association between earlier AFE to organized tackle football and worse subjectively experienced cognitive functioning, depression, or anxiety. Furthermore, no published studies of current athletes show a significant association between playing tackle football (or other contact/collision sports) before the age of 12 and cognitive, neurobehavioral, or mental health problems. It is important to note that all studies were judged to be at high overall risk of bias, indicating that more methodologically rigorous research is needed to understand whether there is an association between AFE to contact/collision sports and later in life brain health. The accumulated research to date suggests that earlier AFE to contact/collision sports is not associated with worse cognitive functioning or mental health in (i) current high school athletes, (ii) current collegiate athletes, or (iii) middle-aged men who played high school football. The literature on former NFL players is mixed and does not, at present, clearly support the theory that exposure to tackle football before age 12 is associated with later in life cognitive impairment or mental health problems.

Source: Photo: Richard Briggs.
https://www.canberratimes.com.au/story/6779105/canberra-junior-league-players-get-coronavirus-chance/

Iverson, G. L., Merz, J. C., & Terry, D. P. (in press, 2021). **High School Football and Midlife Brain Health Problems.** *Clinical Journal of Sports Medicine.*

Objective: To examine whether middle aged men who played high school football experience worse mental health or cognitive functioning than men who did not play high school football.

Design: Cross-sectional cohort study.

Setting: Online survey completed remotely.

Participants: A total of 435 men between the ages of 35 and 55 completed the study, of whom 407 were included in the analyses after excluding participants who answered embedded validity items incorrectly (n=16), played semi-professional football (n=2), or experienced a recent concussion (n=10).

Assessment of Risk Factors: Self-reported high school football participation, compared to those who played contact sports, non-contact sports, and no sports.

Main Outcome Measurements: Lifetime history of depression or anxiety; mental health or cognitive problems in the past year; current depression symptoms and post-concussion-like symptoms.
Results: Middle-aged men who played high school football did not have a higher prevalence of being prescribed medication for anxiety or depression or receiving treatment from a mental health professional. Similarly, there were no significant differences between groups on the rates in which they endorsed depression, anxiety, anger, concentration problems, memory problems, headaches, migraines, neck or back pain, or chronic pain over the past year. A greater proportion of those who played football reported sleep problems over the past year and reported being prescribed medication for chronic pain and for headaches.

Conclusions: Men who played high school football did not report worse brain health compared to those who played other contact sports, non-contact sports, or did not participate in sports during high school.

Van Patten R, Iverson GL, Terry DP, Levi CR, and Gardner AJ. (2021). **Predictors and Correlates of Perceived Cognitive Impairment in Retired Professional Rugby League Players**. *Frontiers in Neurology*, online first. doi: 10.3389/fneur.2021.676762.

Background and Importance: This study examined the association between a retired player's health profile and their self-reported cognitive decline. Importantly, this study investigated whether self-reported cognitive decline is associated with historical sport variables such as number of concussions and duration of participation in contact sport, as well as potentially co-occurring symptoms of depression, resilience, sleep difficulties, and chronic pain. This study also evaluated whether these former players' self-reported cognitive decline is associated with objectively-measured cognitive functioning.

Objective: Rugby league is an international full-contact sport, with frequent concussive injuries. Participation in other full-contact sports such as American football has been considered to be a risk factor for neuropsychiatric sequelae later-in-life, but little research has addressed the mental and cognitive health of retired professional rugby league players. We examined predictors and correlates of perceived (self-reported) cognitive decline in retired National Rugby League (NRL) players.
Methods: Participants were 133 retired male elite level rugby league players in Australia. Participants completed clinical interviews, neuropsychological testing, and self-report measures. The Informant Questionnaire on Cognitive Decline in the Elderly, self-report (IQCODE-Self), measured perceived cognitive decline.
Results: The median age of the sample was 55.0 (M = 53.1, SD = 13.9, range = 30–89) and the median years of education completed was 12.0 (M = 11.9, SD = 2.6, range = 7–18). The retired players reported a median of 15.0 total lifetime concussions (M = 28.0, SD = 36.6, range = 0–200). The mean IQCODE-Self score was 3.2 (SD = 0.5; Range = 1.3–5.0); 10/133 (7.5%) and 38/133 (28.6%) scored above conservative and liberal cutoffs for cognitive decline on the IQCODE-Self, respectively. Perceived cognitive decline was positively correlated with current depressive symptoms, negatively correlated with years of professional sport exposure and resilience, and unrelated to objective cognition and number of self-reported concussions. A multiple regression model with perceived cognitive decline regressed on age, concussion history, professional rugby league exposure, depression, resilience, objective cognitive functioning, daytime sleepiness, and pain severity showed depression as the only significant predictor.
Conclusion: This is the first large study examining subjectively experienced cognitive decline in retired professional rugby league players. Similar to studies from the general population and specialty clinics, no relationship was found between objective cognitive test performance and perceived cognitive decline. Depressive symptoms emerged as the strongest predictor of perceived cognitive decline, suggesting that subjective reports of worsening cognition in retired elite rugby league players might reflect psychological distress rather than current cognitive impairment.

Source: https://www nrl.com/news/2017/08/14/top-50-players-in-the-nrl-50-41/

Iverson GL, Van Patten R, Terry DP, Levi CL, and Gardner AJ. (2021). **Predictors and Correlates of Depression in Retired Professional Rugby League Players**. *Frontiers in Neurology*, 12:655746. doi: 10.3389/fneur.2021.655746. PMID: 22868156.

Background and Importance: This study examined the association between a retired player's health profile and their self-reported depression. Importantly, this study investigated whether depression is associated with historical sport variables such as number of concussions and duration of participation in contact sport, as well as potentially co-occurring symptoms of resilience, sleep difficulties, and chronic pain.

Background: There is considerable interest in determining whether later-in-life depression is associated with lifetime history of concussions or the duration of a career in professional contact and collision sports. Rugby league is a high-intensity collision sport involving a large number of tackles per game and a high rate of concussions. We examined predictors and correlates of depression in retired elite level rugby league players in Australia.
Methods: Retired elite level rugby league players (*N* = 141, age: M = 52.6, SD = 13.8; Range = 30-89 years) completed the Depression, Anxiety, and Stress Scale (DASS), Brief Pain Inventory, Connor-Davidson Resilience Scale (CD-RISC), and Epworth Sleepiness Scale; they also reported on lifetime history of concussions. The DASS depression score was regressed on age, total number of self-reported concussions, years played professionally, CD-RISC score, BPI pain interference score, and ESS score.
Results: The retired players reported a median of 15 total lifetime concussions [interquartile range (IQR) = 6-30], and a median of 8 years playing professional sports (IQR = 3.5-11). The proportion of the sample endorsing at least mild current depression was 29%. The DASS depression score was positively correlated with the DASS anxiety (r = 0.54) and DASS stress scores (r = 0.58). The CD-RISC score was negatively correlated with the depression score (r = -0.53). Depression scores were not significantly correlated with pain severity (r = 0.14), and were weakly correlated with life interference due to pain (r = 0.20) and years playing professional sports (r = -0.17). Depression scores were not significantly correlated with lifetime history of concussions (r = 0.14). A multiple regression model, with age, total number of self-reported concussions, years played professionally, the CD-RISC, Brief Pain Inventory-pain interference score, and Epworth Sleepiness Scale score as predictors was significant, with 35% of the variance in DASS depression accounted for. The two significant independent predictors of depression were lower resilience and greater life interference due to pain.
Conclusions: This is the first large study of depression in retired rugby league players. Depression in these retired players was not meaningfully associated with lifetime history of concussions or number of years playing elite level collision sport. Depression was associated with current anxiety, stress, resilience, and life interference due to chronic pain.

Source: https://www.sportingnews.com/au/league/news/nrl-finals-2021-grand-final-melbourne-storm-penrith-panthers-south-sydney-rabbitohs-manly-sea-eagles/1bbjn8s2dbcmi1lw121oj519ky

Iverson GL and Gardner AJ (2021). **Incidence of Concussion and time to return to play in the National Rugby League**. Clinical Journal of Sports Medicine, *online first*. doi: 10.1097/JSM.0000000000000965. PMID: 34446647.

NB: This important study was not part of our original proposal. We have been pursuing it with discretionary time during the COVID-19 pandemic.

Background and Importance: The accurate identification and effective medical management of concussions are important for promoting the safety and health of contact and collision sport athletes. Several professional sporting leagues around the world, such as the National Football League, National Hockey League, Australian Football League, Cricket Australia, professional rugby union, and the National Rugby League (NRL) have implemented strategies for improving the identification of concussion through sideline video surveillance, deploying trained spotters in the arena, and using spotters with access to multiple camera angles and replay capabilities (in a centralized location). The NRL is the elite professional level club rugby league competition in Australia. Over the past six seasons, the NRL has refined the process for identifying concussions by implementing a rule that allows for medical staff to evaluate a player who sustains a blow to the head, during the game, to determine whether or not he might have sustained a concussion. The purpose of this study is to: (i) examine the rates of concussion over the course of two NRL seasons (2017-2018); (ii) examine the number of days until a concussed player is provided a medical clearance to return to full contact training or match play; and (iii) examine the number of subsequent games missed by concussed athletes. This is a descriptive observational cohort study of the number of concussions identified in the league across two seasons and recovery time. We assumed that there would be no significant differences across the two seasons.

Study Abstract
Objectives: To examine the rates of concussion and recovery time over the course of two seasons of the National Rugby League (NRL).
Design: Descriptive cohort study.
Setting: The NRL match play concussion injury surveillance system.
Participants: All NRL players who participated in the 2017 and 2018 season.
Outcome Measures: The (i) frequency of sideline injury surveillance identified head impact events in real-time during the games; (ii) frequency of head injury assessments conducted by the medical staff; (iii) frequency of medically diagnosed concussions; (iv) number of days to medical clearance to return to play; and (v) number of games missed following concussion.
Main Results: There were 472 head injury assessments conducted during the games and 149 medically diagnosed concussions over the course of two NRL seasons (1 concussion every 2.70 games). The median number of days until medical clearance was 6 (M=6.85, SD=8.03, interquartile range=4-7; range=0-79 days). There was a statistically significant difference in number of days to be medically cleared to return to full contact or match play between seasons (U=3,517.00, p=.001), and the percentage of players medically cleared to return to play at five days post injury was 60.6% in 2017 and 27.6% in 2018. Most players (87.9%) did not miss a game following injury.
Conclusions: There is approximately one concussion sustained for every three games in the NRL. Most players are medically cleared to return to play in 4-7 days.

Source: https://www.thesenior.com.au/story/7189235/nrl-goes-with-watered-down-18th-man/?cs=13241

Carey L, Terry DP, McIntosh AS, Stanwell P, Iverson GL, Gardner AJ (2021). **Video Analysis and Verification of Direct Head Impacts Recorded by Wearable Sensors in Junior Rugby League Players**. *Sports Med Open*. 2021 Sep 16;7(1):66. doi: 10.1186/s40798-021-00353-3. PMID: 34529180.

Background: Rugby league is a high-intensity collision sport that carries a risk of concussion. Youth athletes are considered to be more vulnerable and take longer to recover from concussion than adult athletes.

Purpose: To review head impact events in elite-level junior representative rugby league and to verify and describe characteristics of X-patch™-recorded impacts via video analysis.

Study Design: Observational case series.

Methods: The X-patch™ was used on twenty-one adolescent players (thirteen forwards and eight backs) during a 2017 junior representative rugby league competition. Game-day footage, recorded by a trained videographer from a single camera, was synchronised with X-patch™-recorded timestamped events. Impacts were double verified by video review. Impact rates, playing characteristics, and gameplay situations were described.

Results: The X-patch™-recorded 624 impacts ≥ 20g between game start and finish, of which 564 (90.4%) were verified on video. Upon video review, 413 (73.2%) of all verified impacts ≥ 20g where determined to be direct head impacts. Direct head impacts ≥ 20g occurred at a rate of 5.2 impacts per game hour; 7.6 for forwards and 3.0 for backs (range = 0–18.2). A defender's arm directly impacting the head of the ball carrier was the most common event, accounting for 21.3% (n = 120) of all impacts, and 46.7% of all "hit-up" impacts. There were no medically diagnosed concussions during the competition.

Conclusion: The majority (90.4%) of head impacts ≥ 20g recorded by the X-patch™ sensor were verified by video. Double verification of direct head impacts in addition to cross-verification of sensor-recorded impacts using a secondary source such as synchronised video review can be used to ensure accuracy and validation of data.

Key Points: There was a substantial number of false-positive high acceleration impacts recorded that occurred before, during, or after the games. Wearable instrumented technology has limitations as a primary data source and should be used in conjunction with video review.

The vast majority of high acceleration impacts (≥ 20g) that occurred during game time were verified on video review.

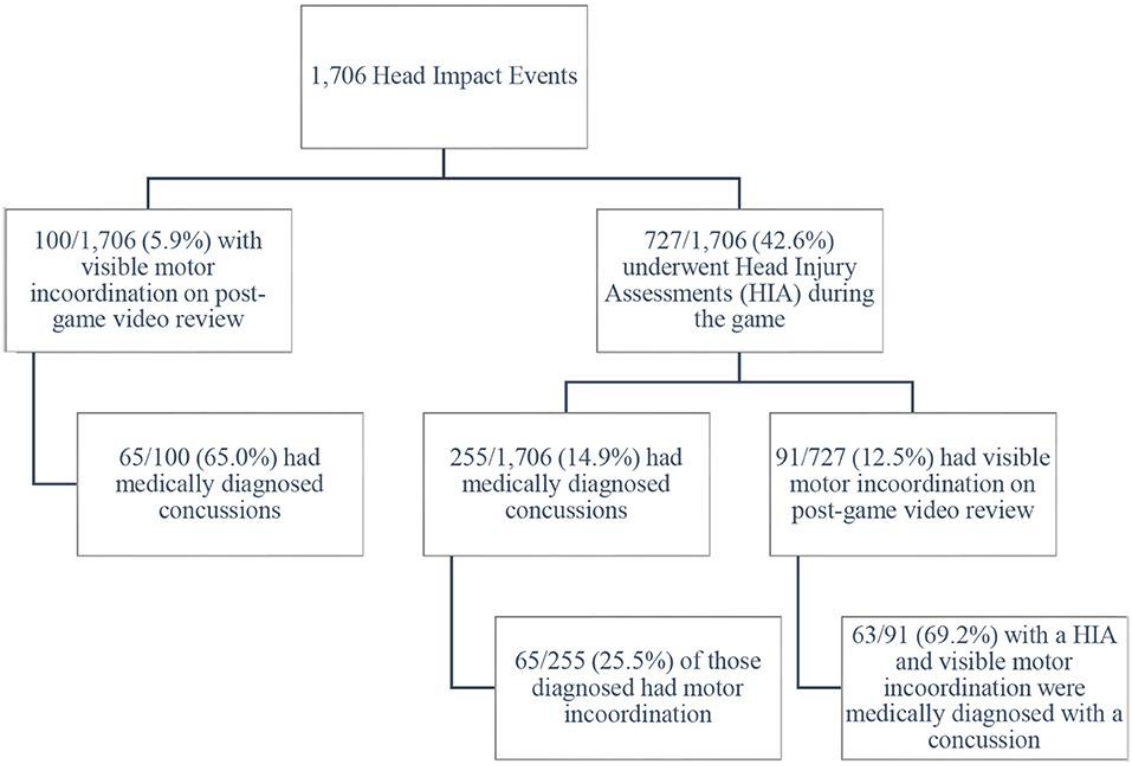
Careful time synchronisation of impact sensor-recorded events and match video is vital to help cross-validation and to reduce over-estimation of an athlete's direct head impact exposure.

Iverson, G.L., Van Patten, R., &Gardner, A.J. (2021). **Examining Whether Onfield Motor Incoordination Is Associated with Worse Performance on the SCAT5 and Slower Clinical Recovery Following Concussion**. *Frontiers in Neurology*, 11:620872.

Objective: To examine the relationship between video-identified onfield motor incoordination, the acute assessment of concussion, and recovery time during three seasons of National Rugby League (NRL) play.

Methods: Blows to the head ("head impact events") were recorded by sideline video operators and medical staff. Any player with a suspected concussion underwent a Head Injury Assessment in which he was taken off the field and medically evaluated, including the administration of the Sports Concussion Assessment Tool, 5th Edition (SCAT5). Video footage was later examined to determine the presence or absence of onfield motor incoordination following the head impact event.

Results: Motor incoordination was identified in 100/1,706 head impact events (5.9%); 65 of the 100 instances of motor incoordination (65.0%) were ultimately medically diagnosed with a concussion. In 646 athletes for whom SCAT5 data were available, those with motor incoordination were more likely to report both dizziness and balance problems than those without motor incoordination, but there were no group differences on an objective balance test. Additionally, there was no relationship between presence/absence of motor incoordination and number of games missed or time to medical clearance for match play.



Conclusion: In NRL players, motor incoordination is a readily observable onfield sign that is strongly associated with a medical diagnosis of concussion and with self-reported dizziness/balance problems. However, onfield motor incoordination is not associated with objective balance performance and it is not predictive of time to recover following concussion.

Iverson GL, Howell DR, van Patten R., Bloomfield P, & Gardner AJ. (2021). **Sport Concussion Assessment Tool-5th Edition (SCAT5): Normative Reference Values for the National Rugby League Women's Premiership.** *Frontiers in Sports and Active Living*, 3:653743. doi: 10.3389/fspor.2021.653743. PMID: 34124655.

NB: This important study was not part of our original proposal. We have been pursuing them with discretionary time during the COVID-19 pandemic.

Background and Importance: There are no normative reference values for the Sport Concussion Assessment Tool-Fifth Edition (SCAT5) for men or women athletes in the NRL.

The Sport Concussion Assessment Tool-Fifth Edition (SCAT5) has been promoted by the Concussion in Sport Group as a standardized acute clinical assessment for athletes suspected of concussion. **The SCAT5 is the foundation for the medical evaluation of concussion on the sideline of all NRL matches**. It is comprised of existing tests, such as the Standardized Assessment of Concussion (SAC), modified Balance Error Scoring System (M-BESS), and a modification of the Post-Concussion Symptom Scale. Previous versions, the SCAT, SCAT2, and SCAT3, have been published over the past 15 years. The SCAT has been, and is, widely used in professional and amateur sports. There are two distinct ways to interpret SCAT5 performance following a suspected or known concussion. First, the clinician can compare post-injury scores with age- and sport-specific normative data. Second, the clinician can compare post-injury test scores to the individual's personal pre-injury baseline data. The clinician might also choose to use both methods, when possible.

Plan: We will develop and publish normative reference data for the SCAT5 for men and women athletes in the NRL.

Progress to Date on the Women's Study: The purpose of this study is to provide normative reference values for the SCAT5 for professional women's rugby league players. The new professional league for women in this sport had its first season in 2018. Preseason baseline testing was administered individually to 156 professional women rugby league players. All women registered in the National Rugby League Women (NRLW) from the 2018 and 2019 seasons are included in this study. We have completed all statistical analyses and prepared a first draft of the article for publication. We anticipate completing and publishing this study over the next several months.

This study is important because it provides, for the first time, sport-specific normative data for the interpretation of SCAT5 performance of professional women rugby league players.

Source: Anisa Tokabobo, 6, carrying the ball, with other female players after the NSW Rugby League and Queensland Rugby League joined forces to announce the new sponsorship. Picture: Gregg Porteous. https://www.theaustralian.com.au/sport/nrl/professional-womens-rugby-league-on-the-way-nswrl-boss/news-story/b6951c27fcff17de24763b40812d8b0d

Article Submitted for Publication

The study summarized below has been completed and submitted for publication.

Gardner AJ, Iverson GL, Edwards S, and Tucker R. (2021, under review). **A case–control study of tackle-based head injury assessment (HIA) risk factors in the National Rugby League**.

NB: This study was not part of our original proposal. We have been pursuing it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: This study examines the association between tackle characteristics and concussion to identify potential risk factors and inform future injury prevention initiatives.

Abstract
Background: The tackle is the in-game activity carrying the greatest risk for concussion in rugby. A recent evaluation of tackle characteristics in rugby union precipitated a rule modification to reduce head impact risk during tackles. This study aims to replicate the work conducted in rugby Union by examining the association between tackle characteristics and head injury events in professional rugby league.
Methods: 446 tackles resulting in a head injury assessment (HIA) and 5,694 tackles that did not result in a head injury from two National Rugby League (NRL) seasons, were reviewed and coded. Tackle height, body position of players, and contact area on an opponent's body were evaluated, with the propensity of each situation to cause an HIA calculated as HIAs per 1000 events.
Results: The propensity for tacklers to sustain a head injury was 0.99 HIAs per 1000 tackles, 1.74-fold greater than for the ball carrier (0.57 HIAs per 1,000 tackles). There was a 3.2-fold higher risk for an HIA when the tackler was upright compared to bent-at-the-waist. The greatest risk of a tackler HIA occurred when head contact was very low (knee, boot) or high (head and elbow). HIAs were most common following head-to-head impacts. The lowest propensity for tackler HIA was found when the tackler's head was in proximity with the ball carrier's torso.
Conclusions: The result of this study replicated the findings in professional rugby union. This has implications for the injury prevention initiatives implemented to reduce HIA risk because the majority of injuries are sustained by the tackler.

Source: https://www.nrl.com/news/2020/07/05/choose-who-should-win-tackle-of-the-week-round-8/

Studies in Progress

Gardner AJ, Howell DR, Bloomfield P, & Iverson GL. (2021). Sport Concussion Assessment Tool-5th Edition (SCAT5): Normative Reference Values for the National Rugby League.

Manuscript in preparation.

NB: This important study was not part of our original proposal. We have been pursuing them with discretionary time during the COVID-19 pandemic.

Progress to Date on the Men's Study: The purpose of this study is to provide normative reference values for the SCAT5 for professional men's rugby league players, stratified by cultural background/race (i.e., White, Indigenous, and Pasifika). Preseason baseline testing was administered individually to 1,010 (n=683 White, n=245 Pacifika, and n=82 Indigenous) professional male rugby league players. All men registered in the National Rugby League (NRL) from the 2018 and 2019 seasons are included in this study. We anticipate completing and publishing this study over the next several months.

Source: https://www.portnews.com.au/story/2428144/south-sydney-rabbitohs-break-20-year-hoodoo-with-victory-in-parramatta-photos/

Gardner AJ, Terry DP, Caccese JB, and Iverson GL (2021). **Age of first exposure to rugby league and later life mental health and cognitive functioning in retired professional rugby league players**.

Manuscript in preparation.

Background and Importance: Gridiron football has been one of the most popular sports in the United States for decades, with more than one million youth participating at the high school level each year. It is reasonable to estimate that tens of millions of men in the United States played high school football. In recent years, several states, such as New Jersey, New York, Massachusetts, and Illinois, have held hearings or considered legislation to ban tackle football below the age of 12. Advocacy groups for this legislation have relied, in part, on some studies from Boston University that have put forward a theory that playing football before the age of 12 is associated with psychiatric, cognitive, and neurological problems later in life. The origin of the theory appears to be a small study of former National Football League (NFL) players illustrating that those who started playing before the age of 12 performed more poorly on a reading test and two neuropsychological tests.

Purpose: In this study, we will examine whether earlier age of first exposure to rugby league is associated with worse later in life brain health in retired professional rugby league players.

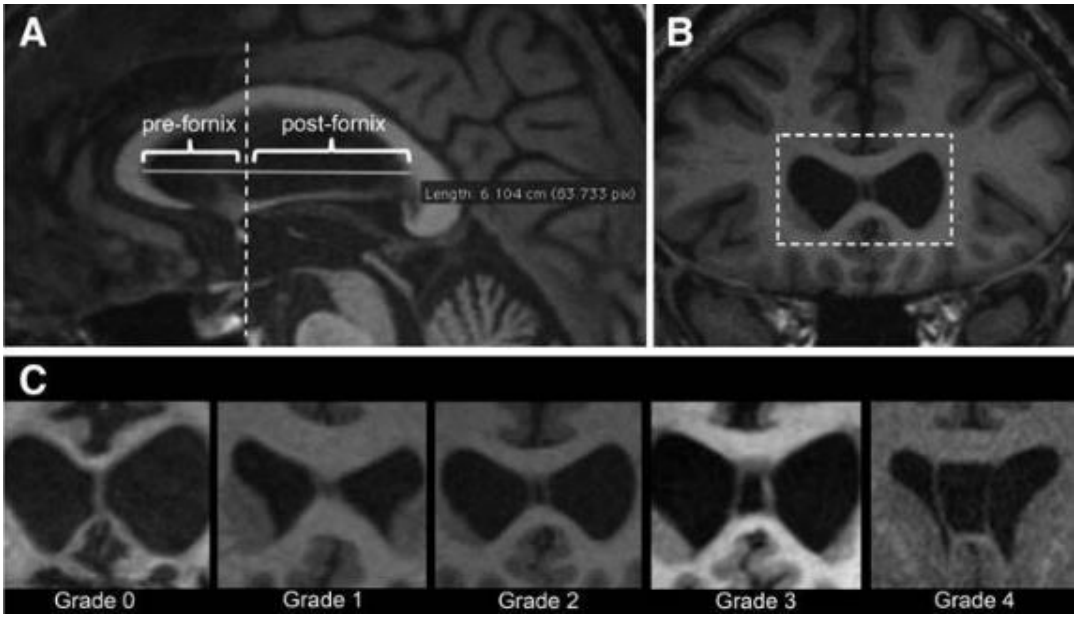
Source: https://www.portnews.com.au/story/3994736/australian-secondary-schools-rugby-league-15-years-national-championships-day-2-photos/

Stanwell P, Iverson GL, Van Patten R, Castellani RJ, McCrory P, and Gardner AJ. (2021). **Examining for Cavum Septum Pellucidi and Ventricular Enlargements in Retired Elite-Level Rugby League Players**.

Manuscript in preparation.

Background and Importance: A cavum septum pellucidum (CSP) has been reported as a visible brain anomaly in normal individuals as well in some former combat and collision sport athletes. The appearance of CSP with fenestrations and ventricular enlargement are considered associated features of the neuropathological diagnosis of chronic traumatic encephalopathy. Forty-one retired rugby league players and 41 healthy community controls, similar in age and education, underwent structural MRI scans. CSP grade, CSP length, corpus callosum septal length, and Evans' ratios (for lateral ventricle size) were rated by two of the current study authors. All participants also self-reported concussion exposure histories, depressive symptoms, daytime sleepiness, and impulsivity. They completed a neuropsychological test battery assessing premorbid intellectual functioning, attention, processing speed, language, visuospatial skills, memory, and aspects of executive functioning.

Purpose: In this study, we will examine CSP anatomic features and lateral ventricle size in retired elite rugby league players and controls.



Source: Figure 1 - cavum septum pellucidum (CSP) grading diagrams and CSP grade and length from Gardner RC, et al (2016). *J Neurotrauma*, 33:157-161.

Appendix A. Original Aims and Progress to Date

Aim 1: The Retired Rugby League Players Health Survey. We proposed to make a health survey study available to all former NRL players. This project has been implemented and remains available to all former NRL players in Australia and New Zealand.

Purpose: To examine the physical, psychological, and cognitive health of former professional rugby league players.

Method: Retired NRL players will complete a comprehensive health survey measuring chronic pain, sleep problems, chronic health conditions, depression, anxiety, stress, substance use, neurological conditions, cognitive health, and quality of life. We will set a goal of enrolling 1,000 former players in this study.

Anticipated Outcomes: An understanding of the health, well-being, and quality of life of former professional rugby league players. From this, we can determine the extent to which former players might benefit from specific types of health care services.

Progress: To date, we have distributed 195 health surveys, of which 168 have been completed and returned. We are continuing to recruit participants for Aim 1. There have been no adverse effects from the COVID-19 pandemic for the ongoing progress of Aim 1.

Aim 2: Examine the Brain Health of Retired Professional Rugby League Players (In-person Clinical Evaluation and Multimodal Neuroimaging). We have continued to conduct in-person comprehensive studies of the brain health of retired NRL players.

Purpose: To comprehensively evaluate the brain health of former professional rugby league players.

Method: Retired professional rugby league players will undergo an in-person comprehensive brain health evaluation in Newcastle. We will also recruit sex-, age-, and education-matched community control subjects with no history of participation in organised collision sports or history of neurotrauma. The evaluation includes psychological testing, cognitive testing, and experimental multimodal brain imaging. The neuroimaging includes a standard structural high-resolution MRI scan of the brain, diffusion tensor imaging (DTI), resting state MRI (rsMRI), susceptibility weighted imaging (SWI), and magnetic resonance spectroscopy (MRS). The experimental neuroimaging can only be done at a single university because the imaging data obtained from different scanners, at different sites, is not directly comparable. This is a well-recognized problem that neuroimaging researchers from around the world contend with, and it is the reason why virtually all experimental neuroimaging studies are done at a single site on a single scanner. This in-person comprehensive assessment is available to all former National Rugby League players prepared to travel to Newcastle. We have developed the capacity to enrol 50-100 retired NRL players per year in this study.

Anticipated Outcomes: We will complete a series of studies that will transform our understanding of the brain health of retired NRL players. This study will determine if former NRL players are at a greater risk of developing psychological disorders, neurobiological changes in their brains, cognitive impairment, and other health conditions compared to community controls.

Subject Recruitment Progress: A total of 33 retired NRL players have completed the clinical brain health evaluations during the funding period. Of those, 19 have also completed experimental brain imaging. Our ability to conduct this aspect of the research program has been adversely affected by the COVID-19 pandemic. We have a list of approximately 30 potential participants that have expressed interest in being involved that we have not yet been able to see for an in-person evaluation. We have

recruited them for Aim 1 and we sent them health questionnaires while we wait for the opportunity to see them for the in-person evaluation. The access to the brain MRI has been limited due to staffing and COVID-19 protocols.

Database Development Progress: We have improved the design of our comprehensive database. We have conducted ongoing quality assurance relating to the database.

Scientific Progress: During the pandemic, we have *increased our time and productivity* relating to conceptualizing study methodologies, conceptualizing statistical analyses, and preparing manuscripts for publication in medical and scientific journals. We have published two neuroimaging-focused papers in 2020.

Pursuit of Three Major Studies: We are currently pursuing 3 major studies. The first study relates to better understanding of perceived cognitive decline in retired NRL players. We are examining the extent to which modifiable factors like resilience, depression, chronic pain, and sleep problems contribute to self-reported decline in cognitive functioning. Similarly, our second major study is examining predictors and correlates of depression in retired NRL players. Through these two studies we will better understand the extent to which current health problems are related to both subjective cognitive functioning and psychological health in former players, and by doing so we will be in a better position to develop evidence-informed treatment and rehabilitation for them. For our third study, we are examining whether earlier age of first exposure to rugby is associated with worse later in life brain health. This topic is being studied extensively in the US with former professional football players.

Aim 3: Determine if Greater Exposure to Repetitive Neurotrauma is Associated with Later-in-Life Depression or Cognitive Impairment. We will develop a new mild neurotrauma exposure index for rugby league players (no such index currently exists for professional rugby players). We will then determine whether greater exposure to neurotrauma is associated with later-in-life depression or cognitive functioning. The new exposure index will be applied to the former players in Aim 1 who complete the health survey and to the former players from Aim 2 who complete the comprehensive brain health evaluations.

Purpose: To develop a new mild neurotrauma exposure index for rugby league players, and to determine whether greater exposure to neurotrauma is associated with later-in-life depression or cognitive functioning.

Method: Several exposure indexes will be evaluated. First, we will examine self-reported lifetime history of number of concussions. Second, we will develop an exposure index based on previously published research on head impacts recorded by sensors placed behind the ears of rugby league players. Third, we will develop a new exposure index based on video review of the total number of tackles across two complete NRL seasons.

Anticipated Outcomes: We will learn the cumulative amount of head injuries NRL players have sustained over the course of their career, the extent to which retired players experience difficulties with depression or cognitive functioning, and whether higher rates of exposure are related to worse psychological/cognitive functioning later-in-life.

Progress: This work is ongoing. This study was not scheduled for the first year of our research proposal. Most of this work will occur during Years 2 and 3.

Aim 4: Reduce the Likelihood of Misdiagnosis of Chronic Traumatic Encephalopathy (CTE) and Traumatic Encephalopathy Syndrome (TES) in Former Rugby League Players. We will conduct three specific studies within this aim. All studies are designed to advance knowledge relating to the clinical diagnosis of CTE. Our focus is on reducing the likelihood of *misdiagnosis* of CTE in retired NRL players (i.e., false or incorrect diagnoses).

Study #1: Systematic review of the course and clinical features of CTE as understood from all known cases in the 20th Century. We will review the original source description of all cases of CTE described in published articles from the 20th century and code the clinical descriptions of all identified cases.

Anticipated Outcome: This systematic review will result in a definitive description of the clinical phenotype of CTE as understood in the 20th century, prior to the recent explosion of interest in former football players and military Veterans. This is necessary before diagnostic criteria can be fully understood, validated, and applied to former contact and collision sport athletes and combat Veterans. A major focus will be on the psychiatric features and the course of the clinical condition (static, progressive, fulminating, or improving). Very importantly, this work will be memorialized in the creation of a comprehensive database that will be used for the systematic review. We will, for the first time, create an independent database that can be analysed to compare and contrast existing and future diagnostic systems for CTE and TES.

Progress: We have made major progress on this study. We have done a careful literature search and identified all published studies from 1929-1999. We identified 90 possible cases from 13 published articles (30-42) and 3 books (43-45). We have reviewed those studies and extracted information relating to the course and clinical features of CTE. We have designed a database for this study. And, we have used information gleaned from this study to complete another study, described below, relating to anger control problems and CTE. We anticipate completing this study during Year 2.

Study #2: Compare several clinical diagnostic systems for CTE in all presumed cases of CTE from the 20th century. It is not known the extent to which cases of presumed CTE from the 20th century would meet the modern preliminary research criteria for traumatic encephalopathy syndrome (TES) (1), or other proposed criteria for CTE (1-5). We will create a master database of the clinical features of all cases identified in the systematic review. We will compare and contrast the systems and make recommendations for improving the diagnostic algorithms.

Progress: This study is closely related to, and builds upon, Study #1. We have completed an analysis that compares and contrasts all of the proposed diagnostic systems for CTE. We anticipate completing this study during Year 2.

Study #3: Examine the specificity of the research criteria for the clinical diagnosis of traumatic encephalopathy syndrome in men and women from the general population. It is mission critical to understand whether or not men and women in the general population might be *misdiagnosed* as having CTE or TES. We will examine the specificity of the current criteria for TES in adults from the US population who completed the National Comorbidity Survey Replication survey.

Method: The National Comorbidity Survey Replication survey was conducted in-person in the homes of a nationally representative sample of adult respondents (N=9,282, 4,139 men and 5,143 women). We will review the research criteria for "traumatic encephalopathy syndrome," including three proposed core features of CTE, (i) "cognitive", (ii) "behavioural" (i.e., anger dyscontrol), and (iii) "mood" (i.e., depression or hopelessness). We will examine the prevalence of men and women from the community who definitively meet the core criterion for "cognitive/behavioural/mood" difficulties in that they could have been diagnosed with one of these conditions in the past 30 days.

In addition, to meet criteria for TES, the person must have two or more "supportive features" out of nine potential features (i.e., impulsivity, anxiety, apathy, paranoia, suicidality, headache, motor signs, documented decline in functioning or a progression of symptoms, or a delayed onset—such as having problems at least 2 years after the end of a career in contact sports). We will examine the prevalence of 5 of the 9 supportive features that are available in the NCS-R database (i.e., impulsivity, anxiety, apathy, suicidality, and headache) because paranoia, motor signs, decline in functioning, and delayed onset of symptoms were deemed to be less reliable or missing variables in the NCS-R database. A secondary analysis will be conducted using hypothetical assumptions relating to delayed onset of mental health problems (e.g., after a sporting career or military service) and a documented decline in functioning.

Anticipated Outcomes: This program of research will lead to a greater understanding of the clinical diagnosis of CTE and traumatic encephalopathy syndrome. The goal of this program of research is to refine the diagnostic criteria and greatly reduce the rate of *misdiagnosis* of CTE and TES in former contact and collision sport athletes. That is, if high rates of meeting symptom based diagnostic criteria for CTE/TES exist in people from the general population, who have little to no concussion history, then the current CTE/TES criteria are likely to lead to large numbers of false positive errors.

Progress: The original proposal included the single study listed above. *We have greatly exceeded the proposal deliverables in this area.* We have published two major studies to date, with the study listed above currently under review. In addition, we have conducted an important new (bonus) study on this topic.

Aim 5: Improving the Methodology for the Post-Mortem Diagnosis of Chronic Traumatic Encephalopathy (CTE). We are now collaborating with Dr. Claire Shepherd, the Director of the Sydney Brain Bank. We have established a brain donation program for retired NRL players. In addition, we have established a collaboration with three academic neuropathologists in North America, two from the United States and one from Canada, who have expertise in the neuropathology of CTE and Alzheimer's disease. We will conduct studies designed to improve the methodology for identifying CTE neuropathologic change.

Why this research is important: There is steadily emerging evidence that the neuropathology described as unique to CTE may not be unique. CTE pathology has been identified in people with no known participation in collision or contact sports and no known exposure to repetitive neurotrauma (46-51). Moreover, throughout history, some clinical cases have been described as not being progressive—and there is now evidence that CTE neuropathology might not be progressive in some people. The CTE pathology found in a large study in the United Kingdom (50) was mostly conceptualized as "stage I", and in a large study in Canada it was sparse, almost always less than what has been described as stage I (46), and not supportive of progressive pathology or a substrate for a progressive clinical disease. Similarly, some retired National Football League players or boxers have sparse p-tau ("stage I" or "stage II" CTE) (52), and some of these individuals died in their 80s—which seems to be inconsistent with the pathology being inexorably progressive.

Over the past 5 years, there have been numerous reviews that have concluded that there are tremendous gaps in our knowledge relating to both the neuropathology and the clinical features of CTE (19, 22, 27, 53-60). In fact, in March of 2019, Stewart and colleagues published a statement from 61 authors from diverse disciplines and multiple countries expressing concern that the media attention, and how CTE has been portrayed in the medical and scientific literature, risks causing harm. The statement emphasized several points, including (i) that the clinical syndrome of CTE has not been fully defined, (ii) its prevalence is not known, (iii) the neuropathological criteria are preliminary, (iv) a single focus of pathology is insufficient to diagnose a disease, and (v) we have an incomplete

understanding of the extent and/or distribution of neuropathology required to produce clinical symptoms or neurological deficits (61).

In conclusion, it is essential for us to pursue this line of research because the extent to which the emergence, course, or severity of clinical symptoms are caused by or correlated with CTE neuropathology is unknown. It is also unclear whether symptoms can be predicted by specific combinations of CTE pathology and other co-morbid neuropathologies, thresholds for accumulation of pathology, or regional distributions of pathologies. More research is needed to determine the extent to which the perivascular deposition of p-tau in neurons and astrocytes is present in people with no known history of repetitive neurotrauma, and to determine whether or not, or the extent to which, the neuropathology of CTE is unique, distinct, progressive, and associated with specific clinical phenotypes.

Anticipated Outcomes: There is an urgent and pressing need to determine the extent to which CTE neuropathology is unique and whether or not it causes specific clinical symptoms. Our team will conduct pioneering research designed to better understand CTE neuropathology, the extent to which it is present in non-athlete community control subjects, whether it is progressive, and if it is associated with clinical symptoms or disorders.

Progress: Dr. Shepperd and her team launched a project in which they are examining the brains in the Sydney Brain Bank for chronic traumatic encephalopathy-neuropathologic change. There has been no adverse effect from the COVID-19 pandemic for the ongoing progress of this work. With regard to retired NRL players, there have been 4 brain donations from deceased players and 21 retired players have pledged to donate their brains for research.

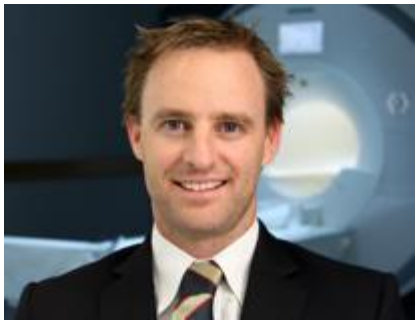
References for Appendix A: Original Aims

1. Montenigro PH, Baugh CM, Daneshvar DH, Mez J, Budson AE, Au R, et al. Clinical subtypes of chronic traumatic encephalopathy: literature review and proposed research diagnostic criteria for traumatic encephalopathy syndrome. Alzheimers Res Ther. 2014;6(5):68.
2. Jordan BD. The clinical spectrum of sport-related traumatic brain injury. Nature reviews Neurology. 2013;9(4):222-30.
3. Victoroff J. Traumatic encephalopathy: review and provisional research diagnostic criteria. NeuroRehabilitation. 2013;32(2):211-24.
4. Reams N, Eckner JT, Almeida AA, Aagesen AL, Giordani B, Paulson H, et al. A Clinical Approach to the Diagnosis of Traumatic Encephalopathy Syndrome: A Review. JAMA Neurol. 2016;73(6):743-9.
5. Laffey M, Darby AJ, Cline MG, Teng E, Mendez MF. The utility of clinical criteria in patients with chronic traumatic encephalopathy. NeuroRehabilitation. 2018;43(4):431-41.
6. Karr JE, Areshenkoff CN, Rast P, Hofer SM, Iverson GL, Garcia-Barrera MA. The unity and diversity of executive functions: A systematic review and re-analysis of latent variable studies. Psychol Bull. 2018;144(11):1147-85.
7. Conley AC, Cooper PS, Karayanidis F, Gardner AJ, Levi CR, Stanwell P, et al. Resting State Electroencephalography and Sports-Related Concussion: A Systematic Review. J Neurotrauma. 2018.
8. Luoto TM, Raj R, Posti JP, Gardner AJ, Panenka WJ, Iverson GL. A Systematic Review of the Usefulness of Glial Fibrillary Acidic Protein for Predicting Acute Intracranial Lesions following Head Trauma. Front Neurol. 2017;8:652.
9. Iverson GL, Gardner AJ, Terry DP, Ponsford JL, Sills AK, Broshek DK, et al. Predictors of clinical recovery from concussion: a systematic review. Br J Sports Med. 2017;51(12):941-8.
10. Manley G, Gardner AJ, Schneider KJ, Guskiewicz KM, Bailes J, Cantu RC, et al. A systematic review of potential long-term effects of sport-related concussion. Br J Sports Med. 2017;51(12):969-77.
11. Schneider KJ, Leddy JJ, Guskiewicz KM, Seifert T, McCrea M, Silverberg ND, et al. Rest and treatment/rehabilitation following sport-related concussion: a systematic review. Br J Sports Med. 2017;51(12):930-4.
12. Panenka WJ, Gardner AJ, Dretsch MN, Crynen GC, Crawford FC, Iverson GL. Systematic Review of Genetic Risk Factors for Sustaining a Mild Traumatic Brain Injury. J Neurotrauma. 2017;34(13):2093-9.

13. Evans VC, Iverson GL, Yatham LN, Lam RW. The relationship between neurocognitive and psychosocial functioning in major depressive disorder: a systematic review. J Clin Psychiatry. 2014;75(12):1359-70.
14. Gardner AJ, Tan CO, Ainslie PN, van Donkelaar P, Stanwell P, Levi CR, et al. Cerebrovascular reactivity assessed by transcranial Doppler ultrasound in sport-related concussion: a systematic review. Br J Sports Med. 2015;49(16):1050-5.
15. Silverberg ND, Gardner AJ, Brubacher JR, Panenka WJ, Li JJ, Iverson GL. Systematic review of multivariable prognostic models for mild traumatic brain injury. J Neurotrauma. 2015;32(8):517-26.
16. Gardner AJ, Iverson GL, Williams WH, Baker S, Stanwell P. A systematic review and meta-analysis of concussion in rugby union. Sports Med. 2014;44(12):1717-31.
17. Gardner A, Iverson GL, Levi CR, Schofield PW, Kay-Lambkin F, Kohler RM, et al. A systematic review of concussion in rugby league. Br J Sports Med. 2015;49(8):495-8.
18. Gardner A, Iverson GL, Stanwell P. A systematic review of proton magnetic resonance spectroscopy findings in sport-related concussion. Journal of Neurotrauma. 2014;31(1):1-18.
19. Gardner A, Iverson GL, McCrory P. Chronic traumatic encephalopathy in sport: a systematic review. British Journal of Sports Medicine. 2014;48(2):84-90.
20. Schneider KJ, Iverson GL, Emery CA, McCrory P, Herring SA, Meeuwisse WH. The effects of rest and treatment following sport-related concussion: a systematic review of the literature. British Journal of Sports Medicine. 2013;47(5):304-7.
21. Iverson GL, Terry DP, Luz M, Zafonte R, McCrory P, Solomon GS, et al. Anger and depression in middle-aged men: Implicaitons for a clinical diagnosis of chronic traumatic encephalopathy. Journal of Neuropsychiatry and Clinical Neurosciences. 2019.
22. Iverson GL, Keene CD, Perry G, Castellani RJ. The Need to Separate Chronic Traumatic Encephalopathy Neuropathology from Clinical Features. J Alzheimers Dis. 2018;61(1):17-28.
23. Wojtowicz M, Gardner AJ, Stanwell P, Zafonte R, Dickerson BC, Iverson GL. Cortical thickness and subcortical brain volumes in professional rugby league players. Neuroimage Clin. 2018;18:377-81.
24. Gardner AJ, Iverson GL, Wojtowicz M, Levi CR, Kay-Lambkin F, Schofield PW, et al. MR Spectroscopy Findings in Retired Professional Rugby League Players. Int J Sports Med. 2017;38(3):241-52.
25. Webner D, Iverson GL. Suicide in professional American football player in the past 95 years. Brain Injury. 2016;30(13-14):1718-21.
26. Iverson GL. Suicide and Chronic Traumatic Encephalopathy. J Neuropsychiatry Clin Neurosci. 2016;28(1):9-16.
27. Iverson GL, Gardner AJ, McCrory P, Zafonte R, Castellani RJ. A critical review of chronic traumatic encephalopathy. Neurosci Biobehav Rev. 2015;56:276-93.
28. Castellani RJ, Perry G, Iverson GL. Chronic effects of mild neurotrauma: putting the cart before the horse? Journal of Neuropathology and Experimental Neurology. 2015;74(6):493-9.
29. Iverson GL. Chronic traumatic encephalopathy and risk of suicide in former athletes. British Journal of Sports Medicine. 2014;48(2):162-5.
30. Parker HL. Traumatic Encephalopathy (`Punch Drunk') of Professional Pugilists. J Neurol Psychopathol. 1934;15(57):20-8.
31. Raevuori-Nallinmaa S. [Cerebral injury in boxing]. Duodecim. 1950;66(5):398-403.
32. Critchley M. Medical aspects of boxing, particularly from a neurological standpoint. Br Med J. 1957;1(5015):357-62.
33. Neubuerger KT, Sinton DW, Denst J. Cerebral atrophy associated with boxing. AMA archives of neurology and psychiatry. 1959;81(4):403-8.
34. Courville CB. Punch drunk. Its pathogenesis and pathology on the basis of a verified case. Bulletin of the Los Angeles Neurological Society. 1962;27:160-8.
35. Spillane JD. Five boxers. Br Med J. 1962;2(5314):1205-10.
36. Mawdsley C, Ferguson FR. Neurological Disease in Boxers. Lancet. 1963;2(7312):795-801.
37. Payne EE. Brains of boxers. Neurochirurgia (Stuttg). 1968;11(5):173-88.
38. Johnson J. Organic psychosyndromes due to boxing. British Journal of Psychiatry. 1969;115:45-53.
39. Corsellis JA, Bruton CJ, Freeman-Browne D. The aftermath of boxing. Psychol Med. 1973;3(3):270-303.
40. Harvey PK, Davis JN. Traumatic encephalopathy in a young boxer. Lancet. 1974;2(7886):928-9.
41. Geddes JF, Vowles GH, Robinson SF, Sutcliffe JC. Neurofibrillary tangles, but not Alzheimer-type pathology, in a young boxer. Neuropathology and applied neurobiology. 1996;22(1):12-6.
42. Case records of the Massachusetts General Hospital. Weekly clinicopathological exercises. Case 12-1999. A 67-year-old man with three years of dementia. N Engl J Med. 1999;340(16):1269-77.
43. Martland HS. Punch drunk. Journal of the American Medical Association. 1928;19:1103-7.

44. Critchley M. Punch-drunk syndromes: the chronic traumatic encephalopathy of boxers. In: Maloine, editor. Hommage a Clovis Vincent. Strasbourg: Imprimerie Alascienne; 1949. p. 131-45.
45. Roberts A. Brain damage in boxers: A study of prevalence of traumatic encephalopathy among ex-professional boxers. London: Pitman Medical Scientific Publishing Co.; 1969.
46. Noy S, Krawitz S, Del Bigio MR. Chronic Traumatic Encephalopathy-Like Abnormalities in a Routine Neuropathology Service. J Neuropathol Exp Neurol. 2016;75(12):1145-54.
47. Puvenna V, Engeler M, Banjara M, Brennan C, Schreiber P, Dadas A, et al. Is phosphorylated tau unique to chronic traumatic encephalopathy? Phosphorylated tau in epileptic brain and chronic traumatic encephalopathy. Brain Res. 2016;1630:225-40.
48. Fournier CN, Gearing M, Upadhyayula SR, Klein M, Glass JD. Head injury does not alter disease progression or neuropathologic outcomes in ALS. Neurology. 2015;84(17):1788-95.
49. Koga S, Dickson DW, Bieniek KF. Chronic Traumatic Encephalopathy Pathology in Multiple System Atrophy. J Neuropathol Exp Neurol. 2016;75(10):963-70.
50. Ling H, Holton JL, Shaw K, Davey K, Lashley T, Revesz T. Histological evidence of chronic traumatic encephalopathy in a large series of neurodegenerative diseases. Acta Neuropathol. 2015;130(6):891-3.
51. Iverson GL, Luoto TM, Karhunen PJ, Castellani RJ. Mild Chronic Traumatic Encephalopathy Neuropathology in People With No Known Participation in Contact Sports or History of Repetitive Neurotrauma. J Neuropathol Exp Neurol. 2019.
52. McKee AC, Stein TD, Nowinski CJ, Stern RA, Daneshvar DH, Alvarez VE, et al. The spectrum of disease in chronic traumatic encephalopathy. Brain: A Journal of Neurology. 2013;136(1):43-64.
53. Aldag M, Armstrong RC, Bandak F, Bellgowan PSF, Bentley T, Biggerstaff S, et al. The Biological Basis of Chronic Traumatic Encephalopathy following Blast Injury: A Literature Review. J Neurotrauma. 2017;34(S1):S26-S43.
54. Agoston D, Arun P, Bellgowan P, Broglio S, Cantu R, Cook D, et al. Military Blast Injury and Chronic Neurodegeneration: Research Presentations from the 2015 International State-of-the-Science Meeting. J Neurotrauma. 2017;34(S1):S6-S17.
55. Asken BM, Bauer RM. Chronic Traumatic Encephalopathy: The Horse Is Still Chasing the Cart. J Orthop Sports Phys Ther. 2018;48(9):672-5.
56. Asken BM, Sullan MJ, DeKosky ST, Jaffee MS, Bauer RM. Research Gaps and Controversies in Chronic Traumatic Encephalopathy: A Review. JAMA Neurol. 2017;74(10):1255-62.
57. Asken BM, Sullan MJ, Snyder AR, Houck ZM, Bryant VE, Hizel LP, et al. Factors Influencing Clinical Correlates of Chronic Traumatic Encephalopathy (CTE): a Review. Neuropsychol Rev. 2016;26(4):340-63.
58. Zuckerman SL, Brett BL, Jeckell A, Yengo-Kahn AM, Sills AK, Solomon GS. Chronic Traumatic Encephalopathy and Neurodegeneration in Contact Sports and American Football. J Alzheimers Dis. 2018;66(1):37-55.
59. Solomon G. Chronic traumatic encephalopathy in sports: a historical and narrative review. Dev Neuropsychol. 2018;43(4):279-311.
60. Solomon GS, Sills A. Chronic traumatic encephalopathy and the availability cascade. Phys Sportsmed. 2014;42(3):26-31.
61. Stewart W, Allinson K, Al-Sarraj S, Bachmeier C, Barlow K, Belli A, et al. Primum non nocere: a call for balance when reporting on CTE. The Lancet Neurology. 2019;18(3):231-3.

Appendix B. Biographies



Andrew J. Gardner, Ph.D. – Principal Investigator
Director Brain Injury Research Program, Priority Research Centre for Stroke and Brain Injury
School of Medicine and Public Health, University of Newcastle
Co-Director, Hunter New England Local Health District Sports Concussion Clinic

I am a Mid-Career Research Fellow with the School of Medicine & Public Health at The University of Newcastle and the Hunter Medical Research Institute (HMRI). I am is also a Co-Director of the Hunter New England Local Health District (HNE LHD)'s Sport Concussion Clinic, and the concussion consultant to Rugby Australia.

I have conducted research in the field of sports concussion for over a decade, having first worked as a research assistant for the New England Paediatric Head Trauma Program in 2003. My research and expert opinion have also been sought for the development of policy papers produced by Brain Injury Australia, Alzheimer's Australia (NSW), and Sports Medicine Australia (SMA)'s concussion policy. I was also involved in the production and delivery of the SMA Community and Medical Concussion Workshops in NSW that came off the back of the release of this policy. I have been previously complete three fellowship at Harvard Medical School (2012 funded through a Hunter Medical Research Institute PhD travel award, 2013 on an Australian Endeavour Research Fellowship, and 2018 through a Fulbright Postdoctoral Award). In 2015 I was awarded the Discovery Award from Research Australia as the national early career researcher of the year for 2015. In 2016 I was awarded the Beryl Nashar Young Researcher Award by the University of Newcastle alumni advisory committee, an award that recognises achievements of early- and mid-career researchers. In 2016 I also received an 'Emerging Health Researcher Commendation Award' from the Bupa Health Foundation, an award that recognises the valuable contribution of emerging health researchers to health outcomes for all Australians. In 2017 I was awarded a University of New England Alumni Early Career Achievement Award, recognising his outstanding contribution to the field of sport and neuropsychology, and was made a 2017 AMP Tomorrow Maker to support the clinical and research work within the HNE LHD Sports Concussion Clinic. I also received the 2017 Vice-Chancellor's Award for Early Career Research and Innovation Excellence for the Faculty of Health. In 2018 I received a Fulbright Postdoctoral Award and I was also a 2018 NSW Young Tall Poppy Science Award recipient, recognition as one of Australia's outstanding young scientific researchers and communicators, and the inaugural Hunter New England Local Health District Psychology Researcher of the Year Award for 2018.

I have established strong research collaborations with international experts from Harvard Medical School. I have created strong relationships through community engagement and sports concussion educational programs and work at the interface of research and clinical application through the HNE LHD Sports Concussion Clinic. I am continuing to develop my research program by focusing on the investigation of concussion across the full spectrum, from the acute, sub-acute, and chronic problems associated with sports concussion in active and retired athletes of all levels of competition.

Christopher R. Levi, MBBS B Med Sci, FRACP, FAAHMS - Investigator
Executive Director, Sydney Partnership for Health, Education, Research & Enterprise
Co-Director, Hunter New England Local Health District Sports Concussion Clinic

I am Professor of Neurology at University of NSW, Sydney and the Executive Director of The Sydney Partnership for Health, Education, Research & Enterprise (SPHERE) which is a Health driven partnership "working together to promote better health and wellbeing for our community". SPHERE is a collaborative partnership with 14 Founding Members (both academic and health care delivery organisations). I am running an operating budget of approximately $6M per annum aiming to support translational research and research translation across all areas of health and medical research. My personal research focus is on stroke and sport-related concussion. Together with PI Gardner, I am a founder and Co-Director of the Priority Research Centre for Stroke and Brain Injury, and the Co-Director of the Hunter New England Local Health District (HNE LHD)'s Sport Concussion Clinic. I am also a member of the National Rugby League "concussion clinical experts" panel and provide pro bono expert second opinion consultation to NRL club medical officers in challenging or complicated concussion cases.

I took up my appointment at SPHERE in 2017, prior to this I had spent the previous 20 years establishing on of Australia's leading stroke research groups, the Priority Research Centre for Stroke and Brain Injury. and Australia's only public hospital adult sports concussion clinical service. My overarching vision has been the discovery and translation of new therapies for stroke and the investigation of the neurological complications of mild traumatic brain injury. I have been a part of a number of ground-breaking discoveries and led prestigious clinical trials in stroke and have co-supervised PI Gardner's PhD and post-doctoral research program that have produced significant impacts on clinical practice and policy in sports concussion.

I have been elected as a Fellow of the Australian Academy of Health and Medical Science as evidence of the level of esteem and respect from the national research community. I have over 300 peer-reviewed publications and over 200 invited talks and sessions chaired at major national and international meetings, as well as extensive experience serving on steering committees of major clinical trials. His strong international reputation is supported by publications in preeminent journals such as *Nature Genetics, New England Journal of Medicine* and *The Lancet*.

Grant L. Iverson, Ph.D. – Co-Principal Investigator
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School /
Director, Concussion Research Program, Spaulding Rehabilitation Network /
Director, MassGeneral Hospital *for* Children™ Sports Concussion Program /
Associate Director of the Traumatic Brain Injury Program at Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

I am a Professor in the Department of Physical Medicine and Rehabilitation at Harvard Medical School. I serve as the Director of the Concussion Research Program for the Spaulding Rehabilitation Network. I serve as the Director of the MassGeneral Hospital *for* Children™ Sports Concussion Program. I also serve as the Associate Director of the Traumatic Brain Injury Program at Home Base, A Red Sox Foundation and Massachusetts General Hospital Program.

I devote my career to research and clinical practice in the field of concussion. We conduct leading and clinically-relevant research with athletes, civilians, active duty service members, and Veterans who have sustained mild injuries to their brains. Our research program is lifespan oriented, with children, adolescents, adults, and older adults. We have published more than 500 empirical articles, reviews, and book chapters. I lead a multidisciplinary group of researchers from the United States, Canada, Finland, and Australia to advance knowledge and improve health care for the local, state, regional, national, and global communities that we serve.

I have been carefully and intensely reviewing the world literature on chronic traumatic encephalopathy (CTE) and other possible long-term effects of repetitive neurotrauma on brain health for the past 7 years. I have assembled a team of diverse, multidisciplinary experts in neuropathology, neurology, neurobiology, psychiatry, rehabilitation medicine, and neuropsychology to critically examine the literature, conduct new clinical studies, and conduct post-mortem CTE neuropathology studies with community control subjects.

I am routinely asked to serve in a leadership or advisory capacity on matters relating to sport-related concussion and mild TBI in civilians and military personnel. In these roles, we are tasked with synthesizing, translating, and disseminating research findings. From 2008-2010, I was a founding member of the Traumatic Brain Injury Subcommittee of the Defense Health Board, a chartered civilian advisory board to the United States Secretary of Defense. We were tasked with reviewing evidence relating to pre- and post-deployment screening for mild TBI in the military. In 2009, as part of a DoD national working group, we set the agenda for future research on mild TBI diagnostics. I served as a Consensus Panel Member for the Concussion in Sport group during both the 3rd (2008) and 4th (2012) International Conferences on Concussion in Sport at FIFA Headquarters in Zurich, Switzerland, and the 5th International Conference in Berlin (2016). I served as an Advisor for the Diagnostic & Statistical Manual of Mental Disorders, 5th Edition (DSM-5), Neurocognitive Disorders Workgroup (in Traumatic Brain Injury). I served as Vice Chair of the Policy and Planning Committee of the National Academy of Neuropsychology from 2007-2013. This committee is responsible for writing position and education papers on important topics for the Academy. I was a Member of the Board of Governors of the International Neuropsychological Society from 2008-2011. I am currently a member of the Board of Governors of the International Brain Injury Association. I was the President of the National Academy of Neuropsychology in 2015, the largest organization of professional neuropsychologists in the world, and was on their Board of Governors from 2014-2018. In 2015, I was part of a multidisciplinary group of thought leaders and investigators who put forward a call for improving evaluation, treatment, and rehabilitation services for concussion. I serve on the Scientific Advisory Board for the NCAA-DoD Concussion Assessment, Research, and Education (CARE) Consortium, the largest multi-site prospective concussion study in history. As such, I am well-positioned to ensure that this program of research is impactful, well disseminated, and translational.

Some of our latest research can be viewed on PubMed:
https://www.ncbi.nlm.nih.gov/pubmed/?term=Iverson+GL

Former Elite Level Rugby League Players Brain Health Research Program

National Rugby League Philanthropic Support Progress Report – October 31, 2022

Principal Investigator

Andrew J. Gardner, Ph.D.
Associate Professor, School of Medicine and Public Health, University of Newcastle
Hunter Medical Research Institute
Email:
Note: from January 1 2023, A/Prof Gardner will be moving institutes. His new affiliation will be:
Sydney School of Health Sciences, Faculty of Medicine and Public Health, The University of Sydney

Co-Principal Investigator

Grant L. Iverson, Ph.D.
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School
Director, MassGeneral Hospital for Children Sports Concussion Program
Director, Concussion Research Program
Schoen Adams Research Institute at Spaulding Rehabilitation
Associate Director, Traumatic Brain Injury Program,
Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

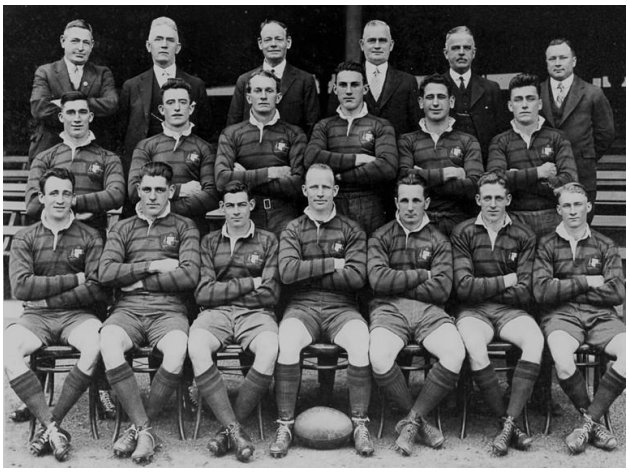
Investigator

Christopher R. Levi, B Med Sci MBBS
Fellow Australian Academy of Health & Medical Science
Director, John Hunter Health and Innovation Precinct (JHHIP)
Senior Staff Specialist, Neurologist, John Hunter Hospital
Conjoint Professor of Medicine, The University of Newcastle

In collaboration with

Table of Contents

We are engaged in a *program of research* that will provide a clear picture of the current state of the science and produce novel, impactful findings aimed at informing and ultimately improving the health of current and former elite-level rugby league players.



Australian Rugby League Team (Kangaroos), ca. 1930 © Melba Studios, Sydney / WikiCommons
https://theculturetrip.com/pacific/australia/articles/a-brief-history-of-the-national-rugby-league-australia/

Players from all NRL clubs pose for an official photo during the 2008 NRL Fan Day at Stadium Australia on February 2, 2008 in Sydney , Australia The Centenary Fan Day featured 400 players from all 16 NRL clubs as part of the biggest public fan day in rugby league history
Matt King: Getty Images
https://www abc net au/news/2008-02-02/all-16-nrl-teams-pose-for-a-mass-photo-at-the-2008/1027834?nw=0

Executive Summary

Dear Executive Leadership of the National Rugby League,

Thank you for your philanthropic support of our research. With your support, we have assembled a multidisciplinary team of experts to conduct transformative research that is important to the brain health of both current and retired National Rugby League (NRL) players. We have been extraordinarily productive operating this important research program.

Four Important Updates

1. We have moved the location of the research program from the Calvary Mater Hospital, Newcastle, to the Prince of Wales Hospital, Randwick.
2. We have received Federal Government funding through the Australian Institute of Sport (AIS) to do research with former Olympians of non-collision sports to serve as a comparison group.
3. We have commenced the longitudinal aspect of the research program by recruiting some of our original former players and healthy community control participants for re-assessment.
4. The research program's principal investigator, A/Prof. Gardner, has secured a National Health and Medical Research Council (NHMRC) Investigator Grant through The University of Sydney to continue to work full-time on this research program for the next 5 years (2023-2027: Investigator Grant title: "Repetitive Neurotrauma and the Risk for Dementia in Former Athletes").

Current Efforts and Progress

We are delighted to share with you the progress listed below.

1. **The Research Team**: We assembled and mobilised a multidisciplinary research team of ***18*** investigators from Australia, the United Kingdom, and the United States.

2. **Retired Rugby League Players Health Survey**: To date we have distributed 215 health surveys to retired NRL players, of which 168 have been completed and returned.

3. **In-Person Brain Health Study**: To date, we have collected in-person comprehensive brain health evaluation data on a total sample of 174 former NRL players (of whom 54 have completed the clinical measures and 120 have completed both the clinical measures and the experimental brain imaging).

4. We have **published 24 studies** in medical and scientific journals. They are listed in a section of this report, and they are summarized in Appendix A.

5. **Brain Health Studies of, or Relevant to, Former NRL Players**: We have recently published 10 studies that directly assess, or are relevant to, the long-term brain health of former NRL players.

    - ✓ We published a study that examines *predictors of self-reported cognitive decline* in former NRL players.

    - ✓ We published a study that examines predictors of depression in former NRL players.

    - ✓ We published a study using experimental neuroimaging to examine the *white matter microarchitecture* of the brains of former elite level rugby league (i.e., NRL) players.

    - ✓ We published a study using experimental neuroimaging to examine the *functional connectivity* within the brains of former NRL players.

- ✓ We published a study examining the presence of a *cavum septum pellucidum* within the brains of former NRL players.

- ✓ We published two survey studies of men from the US general population that showed that earlier age of first exposure to gridiron football was *not* associated with greater later in life brain health problems. We also published a large narrative review on this topic.

- ✓ We published a survey study of men from the US general population who played gridiron football in high school. They did *not* experience worse later in life cognitive problems or mental health problems than men who did not play youth football.

- ✓ We published a major study, using epidemiological data from more than 9,000 men and women from the US, that illustrates major flaws in the proposed criteria for diagnosing chronic traumatic encephalopathy (CTE) in research participants, former contact and collision sport athletes, and military Veterans. Major improvements in the criteria are needed to avoid high rates of false positive diagnoses.

- ✓ We published a study evaluating traumatic encephalopathy syndrome (TES) in over 400 middle-aged men in the general US population. Consistent with our previous work with other samples, we found major flaws in the proposed criteria for diagnosing traumatic encephalopathy syndrome.

- ✓ We published a study examining the prevalence of Chronic Traumatic Encephalopathy Neuropathological Change (CTE-NC) from brains donated to the Sydney Brain Bank.

6. **Studies of Importance to the Health and Welfare of *Current* Men and Women NRL Players.** We have aggressively pursued a program of research relating to the health and welfare of *current* NRL players. The 6 studies described below were *not part of our original proposal*, but they became a focus of our work during discretionary research time created by the COVID-19 pandemic.

   - ✓ We published one major study that documents the **incidence of concussion during match play in the NRL**, over the course of the 2017 and 2018 seasons, and the recovery time for the athletes.

   - ✓ The **Sport Concussion Assessment Tool-Fifth Edition (SCAT5)** is used by the medical staff of the NRL to assess men and women players, on the sideline and after the match, for concussion. The SCAT5 includes measures of symptoms, balance, and cognitive functioning. There are no published normative reference data for NRL players. **We published a study that provides *SCAT5 normative reference values for the women's NRL***. We used their baseline preseason health assessments to create these norms. We are preparing *a second study* that will provide *SCAT5 normative reference values for the men's NRL*. We are using their baseline preseason health assessments to create these norms. These normative reference values will be constructed so that they are refined and maximally useful for Indigenous, Pasifika, and White players.

   - ✓ **Video footage of live game play** has become an important part of the **injury surveillance** process in professional contact and collision sports. We completed a video evaluation of on-field motor incoordination in players who were removed from play to complete a Head Injury Assessment (HIA). We examined the relationship between video evidence of motor incoordination and the player's performance on the in-game SCAT5 (post-concussion symptom reporting, cognitive testing, and balance testing), together with the player's recovery time, as measured by their return to NRL match play.

- ✓ The development of **wearable sensor technology** has enabled the measurement of linear and angular forces applied to a player's head during participation in contact and collision sport. These products have been proposed to assist with the ability to determine whether a possible concussion has occurred. However, as part of this process for evaluating the utility of wearable sensor technology, it is important to verify that the output is accurate (i.e., an impact recorded by the sensors was evident). We evaluated the wearable sensor technology output through a video verification study to identify the accuracy of the sensors in elite junior representative rugby league (Harold Matthews) players during one season.

- ✓ We published a study examining the **international collision sport consensus video signs of concussion** in NRL players.

- ✓ We published a study that examines the **association between tackle characteristics in the NRL and concussion** to identify potential risk factors and inform future injury prevention initiatives.

7. **Plans for this Coming Year**: We have ambitious plans for the coming year. Examples of projects we will pursue are listed below.

   - ✓ We will continue the in-person brain health study of retired players at The University of Sydney and the Prince of Wales Hospital, Randwick. We will begin recruiting and examining the brain health of former women rugby league players. We will continue to bring back for review our former players and control participants who were seen 5 or more years ago. We will assess former Olympians from non-collision sports as a comparison group. We will publish studies that advance knowledge in the medical and scientific community relating to the long-term mental health and cognitive health of former amateur and professional athletes.

   - ✓ We will continue with the brain donation program, and we will publish studies relating to post-mortem neuropathology.

   - ✓ We will publish a major study that will provide normative reference values for the SCAT5 for the men's league, and this data can be used by the NRL medical staff.

   - ✓ We will publish a study that examines the association between specific game play characteristics and their association with tackle characteristics and risk for a Head Injury Assessment (HIA) in the NRL.

   - ✓ Working in collaboration with a diverse team of investigators and stakeholders, we will complete and publish a study that examines outcomes from the new NRL medical bunker injury surveillance system.

We are grateful for the past philanthropic support from the NRL for our research program. With your ongoing support, we will continue to advance knowledge and improve health care—not just for amateur and elite rugby league players—but for the broader community of athletes at home and abroad.

Yours Faithfully,

Andrew Gardner, Ph.D., Associate Professor, Sydney School of Health Sciences, Faculty of Medicine & Health, The University of Sydney

Grant L. Iverson, Ph.D., Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School

Core Research Team

Principal Investigators

Andrew J. Gardner, Ph.D.
Associate Professor
Sydney School of Health Sciences, Faculty of Medicine and Health, The University of Sydney
Email:

Grant L. Iverson, Ph.D.
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School;
Director, MassGeneral Hospital for Children Sports Concussion Program
Director, Concussion Research Program, Spaulding Research Institute
Associate Director, Traumatic Brain Injury Program,
Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

Research Team

Vanessa Case, RN
School of Medicine and Public Health, College of Health, Medicine, and Wellbeing, The University of Newcastle

Rudolph J. Castellani, M.D.
Professor, Department of Pathology, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA

Michael Cook, PhD
PhD Candidate (completed and conferred 14.10.2022), School of Medicine and Public Health, College of Health, Medicine, and Wellbeing, The University of Newcastle

David Howell, Ph.D., ATC
Assistant Professor, Department of Orthopedics, University of Colorado School of Medicine;
Children's Hospital Colorado Sports Medicine Center, Denver, Colorado, USA.

Prashant Jhala, B.Phys.
Physiotherapist and PhD Candidate, School of Medicine and Public Health, The University of Newcastle

Ben Jones, Ph.D.
Professor, Carnegie Applied Rugby Research (CARR) centre, Carnegie School of Sport, Leeds Beckett University, Headingley, UK

Martin Lang, B.BioMedSci
PhD Candidate, School of Medicine and Public Health, The University of Newcastle

Christopher R. Levi, B Med Sci MBBS & Fellow Australian Academy of Health & Medical Science
Hunter New England Local Health District

Shreya McLeod, B.Phys.
Physiotherapist and PhD Candidate, School of Medicine and Public Health, The University of Newcastle

Zachary Merz, Ph.D.
Staff Neuropsychologist, LeBauer Department of Neurology, Moses H. Cone Memorial Hospital, Greensboro, North Carolina, USA

Manish Mohan
PhD Candidate, Carnegie Applied Rugby Research (CARR) centre, Carnegie School of Sport, Leeds Beckett University, Headingley, UK

Paul Rasser, B.Sci
PhD Candidate, School of Medicine and Public Health, The University of Newcastle

Claire Shepherd, Ph.D.
Director of the Sydney Brain Bank; Director Dementia Team Laboratory at Neuroscience Research Australia (NeURA), University of New South Wales

Emily Spiegelhalter
PhD Candidate, Carnegie Applied Rugby Research (CARR) centre, Carnegie School of Sport, Leeds Beckett University, Headingley, UK

Peter Stanwell, Ph.D.
Professor, School of Health Sciences, The University of Newcastle

Oliver Smith, B.BioMedSci
Sydney School of Health Sciences, The University of Sydney

Douglas Terry, Ph.D.
Neuropsychologist, Vanderbilt University Medical Center; Assistant Professor, Department of Neurological Surgery, Vanderbilt University School of Medicine; Co-Director, Vanderbilt Sports Concussion Center; Director, Center for Cognitive Neurosurgical Studies, Nashville, Tennessee, USA

Ryan Van Patten, Ph.D.
Neuropsychologist,
Providence Veterans Administration Medical Center, Providence, RI, USA
Department of Psychiatry and Human Behavior, Alpert Medical School of Brown University, Providence, Rhode Island, USA

Articles Published in Medical and Scientific Journals

Between November of 2019 and October 2022, we have published 24 studies in medical and scientific journals. Those studies are summarised below. Many of these important studies were not part of our original proposal. We pursued them with discretionary time during the COVID-19 pandemic.

1. Stanwell P, Iverson GL, Van Patten R, Castellani RJ, McCrory P, and Gardner AJ. (2022). **Examining for Cavum Septum Pellucidi and Ventricular Enlargements in Retired Elite-Level Rugby League Players**. *Frontiers in Neurology, Neurotrauma,* 13:817709. doi: 10.3389/fneur.2022.817709. PMID: 35493804.

2. McCann H, Bahar AY, Burkhardt K, Gardner AJ, Halliday GM, Iverson GL, & Shepherd CE. (2022). **Prevalence of chronic traumatic encephalopathy in the Sydney Brain Bank**. *Brain Communications*, 4(4):fcac189. doi: 10.1093/braincomms/fcac189. PMID: 35950093. Click here to see article on the publisher's website.

3. Iverson GL, Williams MW, Gardner AJ, & Terry DP. (2022). **Systematic Review of Preinjury Mental Health Problems as a Vulnerability Factor for Worse Outcome After Sport-Related Concussion.** *Frontiers in Neurology – Neurotrauma,* 13:915357. doi: 10.1177/2325967120950682. PMID: 33614790.

4. Wright DK, Gardner AJ, Wojtowicz M, Iverson GL, O'Brien TJ, Shultz SR, & Stanwell P. (2021). **White matter abnormalities in retired professional rugby league players with a history of concussion**. *Journal of Neurotrauma*, 38(8):983-988. doi: 10.1089/neu.2019.6886. PMID: 32245344.

5. Iverson, G.L. & Gardner, A.J. (2021). **Symptoms of Traumatic Encephalopathy Syndrome are Common in the United States General Population.** *Brain Communications, 3*(1):fcab001. doi: 10.1093/braincomms/fcab001. [*This is a bonus review paper. It was not listed in our 2017 grant application as part of the original proposal*.] Click here to download a pdf of the article.

6. Iverson GL, Buttner F, & Caccese JB (2021). **Age of first exposure to contact and collision sports and later in life brain Health: A narrative review.** *Frontiers in Neurology*, 12:727089. doi: 10.3389/fneur.2021.727089. PMID: 34659092. Click here to read the article on the publisher's website.

7. Iverson GL and Gardner AJ (2021). **Incidence of Concussion and time to return to play in the National Rugby League**. Clinical Journal of Sports Medicine, *online first*. doi: 10.1097/JSM.0000000000000965. PMID: 34446647.

8. Iverson, G.L., Merz, Z.C., & Terry, D.P. (2021). **Examining the Research Criteria for Traumatic Encephalopathy Syndrome in Middle-Aged Men from the General Population Who Played Contact Sports in High School.** *Frontiers in Neurology*. doi: 10.3389/fneur.2021.632618. Click here to read the article on the publisher's website.

9. Iverson GL, Terry DP, Cassese JB, Büttner F, Merz ZC. (2021). **Age of First Exposure to Football is not Associated with Midlife Brain Health Problems**. *Journal of Neurotrauma*, 38(5):538-545. doi: 10.1089/neu.2020.7041. PMID: 33126834.

10. Iverson GL, Howell DR, van Patten R., Bloomfield P, & Gardner AJ. (2021). **Sport Concussion Assessment Tool-5th Edition (SCAT5): Normative Reference Values for the National Rugby League Women's Premiership.** *Frontiers in Sports and Active Living*, 3:653743. doi:

10.3389/fspor.2021.653743. PMID: 34124655. Click here to read the article on the publisher's website.

11. Van Patten R, Iverson GL, Terry DP, Levi CR, and Gardner AJ. (2021). **Predictors and Correlates of Perceived Cognitive Impairment in Retired Professional Rugby League Players**. *Frontiers in Neurology*, online first. doi: 10.3389/fneur.2021.676762. Click here to read the article on the publisher's website.

12. Iverson GL, Van Patten R, Terry DP, Levi CL, and Gardner AJ. (2021). **Predictors and Correlates of Depression in Retired Professional Rugby League Players**. *Frontiers in Neurology*, 12:655746. doi: 10.3389/fneur.2021.655746. Click here to read the article on the publisher's website.

13. Gardner AJ, Iverson GL, Edwards S, and Tucker R. (2021). **A case–control study of tackle-based head injury assessment (HIA) risk factors in the National Rugby League**. *Sports Medicine – Open*, 7(1):84-94. doi: 10.1186/s40798-021-00377-9. PMID: 34787721. Click here to read the article on the publisher's website.

14. Iverson GL, Caccese JB, Merz ZC, Buttner F, & Terry DP. (2021). **Age of first exposure to football is not associated with later-in-life cognitive or mental health problems**. *Frontiers in Neurology – Neurotrauma*, 12:647314. doi: 10.3389/fneur.2021.647314. PMID: 34025554. Click here to read the article on the publisher's website.

15. Iverson GL, Merz ZC, & Terry DP. (2021). **Playing high school football is not associated with an increased risk for suicidality in early adulthood**. *Clinical Journal of Sports Medicine*, 31(6): 469-474. doi: 10.1097/JSM.0000000000000890. PMID: 34704972. Click here to read the article on the publisher's website.

16. Iverson GL, Van Patten R, & Gardner AJ. (2021). **Examining Whether Onfield Motor Incoordination is Associated with Worse Performance on the SCAT5 and Slower Clinical Recovery following Concussion**. *Frontiers in Neurology – Neurotrauma,11:620872*. doi: 10.3389/fneur.2020.620872. PMID: 33732202. Click here to read the article on the publisher's website.

17. Carey L, Terry DP, McIntosh A, Stanwell P, Iverson GL, & Gardner AJ. (2021). **Video Analysis and Verification of Direct Head Impacts Recorded by Wearable Sensors in Junior Rugby League Players**. *Sports Medicine – Open, 7(1):66*. doi: 10.1186/s40798-021-00353-3. PMID: 34529180. Click here to read the article on the publisher's website.

18. Cook, MJ, Gardner, AJ, Wojtowicz M, Williams WH, Iverson GL, Stanwell P. (2021). **Task-related functional magnetic resonance imaging activations in patients with acute and subacute mild traumatic brain injury: A coordinate-based meta-analysis**. *NeuroImage: Clinical*, 25;102129. doi: 10.1016/j.nicl.2019.102129. PMID: 31891819.

9. Goodin P, Gardner AJ, Dokani N, Nizette B, Ahmadizadeh S, Edwards S, Iverson GL. (2021). **Development of a Machine Learning Based Classifier for Identification of Head and Body Impacts in Elite Level Australian Rules Football Players**. *Frontiers in Sports and Active Living, 3:725245*. doi: 10.3389/fspor.2021.725245. PMID: 34870193. Click here to read the article on the publisher's website.

20. Iverson, G. L. & Gardner, A. J. (2020). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Anger Control Problems.** *Frontiers in Neurology - Neurotrauma, 11,* 739. doi: 10.3389/fneur.2020.00739. Click here to read the article on the publisher's website.

21. Guell X, Arnold Anteraper S, Gardner AJ, Whitfield-Gabrieli S, Kay-Lambkin F, Iverson GL, Gabrieli J, Stanwell P. (2020). **Functional connectivity changes in retired professional rugby league players: a data-driven functional magnetic resonance imaging study**. *Journal of Neurotrauma, 37*(16):1788-1796. doi: 10.1089/neu.2019.6782. PMID: 32183583.

22. Gardner AJ. (2020). **Reliability of Using the Proposed International Consensus Video Signs of Potential Concussion for National Rugby League Head Impact Events**. *Neurosurgery, 88(3):538-543.* doi: 10.1093/neuros/nyaa437. PMID: 33027812.

23. Gardner AJ, Howell DR, & Iverson GL. (2020). **The association between multiple prior concussions, cognitive test scores, and symptom reporting in youth rugby league players**. *Brain Injury*, 34(2):224-228. doi: 10.1080/02699052.2019.1683894. PMID: 31661635.

24. Iverson, G. L. & Gardner, A. J. (2019). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Depression.** *Journal of Neuropsychiatry and Clinical Neurosciences.* doi: 10.1176/appi.neuropsych.19010021. Click here to read the article on the journal's website.

Appendix A. Abstracts for the Articles Published in Medical and Scientific Journals

1. Stanwell P, Iverson GL, Van Patten R, Castellani RJ, McCrory P, and Gardner AJ. (2022).
Examining for Cavum Septum Pellucidi and Ventricular Enlargements in Retired Elite-Level Rugby League Players. *Frontiers in Neurology, Neurotrauma,* 13:817709.
doi: 10.3389/fneur.2022.817709. PMID: 35493804.

Background and Importance: A cavum septum pellucidum (CSP) has been reported as a visible brain anomaly in normal individuals as well in some former combat and collision sport athletes. The appearance of CSP with fenestrations and ventricular enlargement are considered associated features of the neuropathological diagnosis of chronic traumatic encephalopathy.

Abstract
Objective: A cavum septum pellucidum (CSP) has been reported as a visible brain anomaly in normal individuals as well in some former combat and collision sport athletes. The appearance of CSP with fenestrations and ventricular enlargement are considered associated features of the neuropathological diagnosis of chronic traumatic encephalopathy. The current study examined CSP anatomic features and lateral ventricle size in retired elite rugby league players and controls.
Methods: Forty-one retired rugby league players and 41 healthy community controls, similar in age and education, underwent structural MRI scans. CSP grade, CSP length, corpus callosum septal length, and Evans' ratio (for lateral ventricle size) were rated by two of the current study authors. All participants also self-reported concussion exposure histories, depressive symptoms, daytime sleepiness, and impulsivity. They completed a neuropsychological test battery assessing premorbid intellectual functioning, attention, processing speed, language, visuospatial skills, memory, and aspects of executive functioning.
Results: The two raters had high agreement for CSP grade (Cohen's $\kappa = 0.80$), CSP length [intraclass correlation (ICC) = 0.99], corpus callosum septal length (ICC = 0.73), the CSP/septal ratio (ICC = 0.99), and the Evans' ratio (ICC = 0.75). Twenty-five retired players (61.0%) had an abnormal CSP compared to 17 controls [41.5%; $\chi 2$ (1, 82) = 3.12, p = 0.08, odds ratio = 2.21]. The CSP/septal ratio was larger for retired players than for the controls. The Evans' ratio did not differ between the two groups. In the retired rugby league players (n = 41), those with normal (n = 16) and abnormal (n = 25) CSP grades did not differ across age, age of first exposure to collision sport, years of sport exposure, concussion history, or 23 clinical and cognitive variables.
Conclusion: This study revealed a difference in the size of the CSP between retired professional rugby league players and controls. There was no significant difference in the size of the ventricles between the two groups. There were no significant differences between those with vs. without an abnormal CSP on age of first exposure to rugby league, years of exposure to repetitive neurotrauma, number of lifetime concussions, depression, impulsivity, perceived cognitive decline, or on any neuropsychological test.

2. McCann H, Bahar AY, Burkhardt K, Gardner AJ, Halliday GM, Iverson GL, & Shepherd CE. (2022). **Prevalence of chronic traumatic encephalopathy in the Sydney Brain Bank**. *Brain Communications*, 4(4):fcac189. doi: 10.1093/braincomms/fcac189. PMID: 35950093. Click here to see article on the publisher's website.

Background and Importance: The relationship between repetitive traumatic brain injury (TBI) and a neurological condition was first recognized in the early 1900s with the description of 'punch drunk' syndrome, traumatic encephalopathy and dementia pugilistica in boxers. Omalu et al. initially reported post-mortem neuropathology in case studies of professional American football players and a professional wrestler. Other studies have reported chronic traumatic encephalopathy neuropathologic change (CTE-NC) in individuals who participate in Australian rules football, Australian rugby league, rugby union, soccer, baseball, ice hockey, and in cases of military personnel subjected to blasts. It is not clear how much CTE-NC is required to manifest clinical disease, and both cardinal and supportive pathological features of CTE-NC (neuronal tau and TDP-43-positive inclusions and neurites) are widely seen in other neurodegenerative conditions and the normal aged brain. Multiple studies have shown that not all cases with a history of repetitive mild neurotrauma in sports display CTE-NC. In this study the cortical regions of 636 neurodegenerative disease and normal healthy control cases in the Sydney Brain Bank were assessed, to ascertain the prevalence of CTE-NC using both the first and second consensus criteria for CTE-NC. A subset of cases was identified with a history of TBI with or without loss of consciousness and a small proportion of these cases also had a history of contact sport played regularly at the professional or club level. We provide evidence of low prevalence of CTE-NC, even in cases with history of TBI.

Abstract

Background: Chronic traumatic encephalopathy neuropathologic change can only be definitively diagnosed post-mortem. It has been associated with repetitive mild neurotrauma sustained in amateur and professional contact, collision and combat sports, although it has also been documented in people with a single severe traumatic brain injury and in some people with no known history of brain injury. The characteristic neuropathology is an accumulation of perivascular neuronal and astrocytic phosphorylated tau in the depths of the cortical sulci. The tau-immunopositive neurons and astrocytes that are considered pathognomonic for chronic traumatic encephalopathy are morphologically indistinguishable from Alzheimer-related neurofibrillary tangles and ageing-related tau astrogliopathy, respectively, although they are found in different spatial distributions throughout the cortex. **Methods:** The Sydney Brain Bank collection consists of neurodegenerative diseases and neurologically normal controls. We screened 636 of these cases for chronic traumatic encephalopathy neuropathologic change. A subset of 109 cases had a known history of traumatic brain injury. Three cortical regions were screened for the presence of neuronal and astrocytic phosphorylated tau according to the current 2021 National Institute on Neurological Disorders and Stroke/National Institute of Biomedical Imaging and Bioengineering consensus criteria for chronic traumatic encephalopathy. **Results:** Five cases (0.79%) showed pathological evidence of chronic traumatic encephalopathy and three of these had a history of traumatic brain injury. Three cases had coexisting Alzheimer's and/or Lewy body disease pathology meeting criteria for neurodegenerative disease. Another eight cases almost met criteria for chronic traumatic encephalopathy neuropathological change except for an absence of neuronal tau or a strict perivascular arrangement. Ageing-related tau astrogliopathy was found in all eight cases as a coexisting neuropathology. Traumatic brain injury was associated with increased odds ratio [1.79, confidence interval 1.18–2.72] of having a higher neurofibrillary tangle stage and phosphorylated TAR DNA binding protein 43 (OR 2.48, confidence interval 1.35–4.54). **Conclusions:** Our study shows a very low rate of chronic traumatic encephalopathy neuropathological change in brains with or without neurodegenerative disease from the Sydney Brain Bank. Our evidence suggests that isolated traumatic brain injury in the general population is unlikely to cause chronic traumatic encephalopathy neuropathologic change but may be associated with increased brain ageing.

3. Iverson GL, Williams MW, Gardner AJ, & Terry DP. (2022). **Systematic Review of Preinjury Mental Health Problems as a Vulnerability Factor for Worse Outcome After Sport-Related Concussion.** *Frontiers in Neurology – Neurotrauma*, 13:915357. doi: 10.1177/2325967120950682. PMID: 33614790.

Background and Importance: Identifying those individuals who may be more at risk for prolonged recovery following concussion is an important clinical prognostic strategy.

Abstract
Background: It is difficult to predict who will experience prolonged health problems after sustaining a sport-related concussion.
Purpose: To synthesize the literature and conduct a gap analysis on the association between preinjury mental health problems and clinical outcome from sport-related concussion.
Study Design: Systematic review; Level of evidence, 4.
Methods: Data sources were PubMed, PsycINFO, MEDLINE (and MEDLINE in Process), CINAHL, Cochrane Library, EMBASE, SPORTDiscus, Scopus, and Web of Science. Studies published before February 2019 that addressed preinjury mental health problems as a possible predictor of worse clinical outcome or clinical recovery from concussion were eligible for inclusion.
Results: Of 4013 studies screened, 358 full texts were reviewed, and 12 studies involving 3761 participants (n = 471 [12.5%] with preexisting mental health problems) were ultimately included. The participants with a preinjury history of mental health problems were at greater risk for having persistent symptoms or worse outcome in 9 of 12 studies. The studies had major methodological differences, and most studies were not focused on mental health as a primary predictor or prognostic factor. Rather, they included it as a secondary or tertiary predictor. The sample sizes with preinjury mental health problems in most studies were small or very small (ie, <25). The age of onset, type, course, severity, and duration of mental health problems were not defined. The extent to which mental health problems were present before the season, during baseline testing, was not reported.
Conclusion: Preinjury mental health problems appear to confer risk for worse clinical outcome after sport-related concussion. Future research is needed to (1) examine this risk factor in large representative populations of middle school students, high school students, and collegiate athletes; (2) quantify the risk for each mental health condition; (3) understand the mechanisms underlying this increased risk; and (4) develop more refined treatment and rehabilitation approaches for these student-athletes.

4. Wright DK, Gardner AJ, Wojtowicz M, Iverson GL, O'Brien TJ, Shultz SR, & Stanwell P. (2021). **White matter abnormalities in retired professional rugby league players with a history of concussion**. *Journal of Neurotrauma*, 38(8):983-988. doi: 10.1089/neu.2019.6886. PMID: 32245344.

Background and Importance: This is the first study investigating diffusion tensor imaging metrics in a small sample of recently retired professional NRL players. Diffusion tensor imaging is an experimental MRI technique that measures water movement in tissue and is sometimes used to infer the integrity of the white matter tracts connecting various regions in the brain. Voxel-based analysis revealed several differences in metrics thought to measure the integrity of white matter of NRL players when compared to controls. These differences persisted after statistically accounting for the fact that NRL players endorsed more problematic alcohol use compared to controls. Further research, longitudinal in design, is warranted to clarify the consequences, if any, repetitive neurotrauma has on long-term structural brain changes and clinical outcomes.

Abstract: The topic of potential long-term neurological consequences from having multiple concussions during a career in collision sports is controversial. We sought to investigate white matter microstructure using diffusion tensor imaging (DTI) in retired professional Australian National Rugby League (NRL) players (n = 11) with a history of multiple self-reported concussions compared with age- and education-matched controls (n = 13) who have had no history of brain trauma. Diffusion-weighted images were acquired with a Siemens 3T scanner. All participants completed a clinical interview. There were no significant differences between groups on measures of depression, anxiety, stress, or post-concussion symptoms; however, NRL players scored significantly higher on the alcohol use disorder identification test (AUDIT). Voxelwise analyses of DTI measures were performed using tract-based spatial statistics (TBSS) with age and AUDIT scores included as covariates. TBSS revealed significantly reduced fractional anisotropy (FA), and increased radial diffusivity (RD), axial diffusivity (AD), and trace (TR) in white matter regions of recently retired NRL players compared with controls. FA was significantly reduced in the right superior longitudinal fasciculus and right corticospinal tract while TR, RD, and AD were increased in these regions, as well as the corpus callosum, forceps major, right uncinate fasciculus, and left corticospinal tract. In summary, DTI in a small cohort of recently retired professional NRL players with a history of multiple concussions showed differences in white matter microstructure compared with age- and education-matched controls with no history of brain trauma.

5. Iverson, G.L. & Gardner, A.J. (2021). **Symptoms of Traumatic Encephalopathy Syndrome are Common in the United States General Population.** *Brain Communications, 3*(1):fcab001. doi: 10.1093/braincomms/fcab001. [*This is a bonus review paper. It was not listed in our 2017 grant application as part of the original proposal*.] Click here to download a pdf of the article.

Background and Importance: This study is important because it illuminates some fundamental problems with the criteria for diagnosing chronic traumatic encephalopathy (CTE), and traumatic encephalopathy syndrome, in retired athletes, military veterans, and people from the general population. There is considerable risk for *misdiagnosis*, and there is a pressing need to try to improve the diagnostic criteria.

Abstract: There are no validated criteria for diagnosing chronic traumatic encephalopathy, or traumatic encephalopathy syndrome, in a living person. The purpose of this study is to examine symptom reporting resembling the research criteria for traumatic encephalopathy syndrome in men and women from the US general population. This is a retrospective analysis of publicly available data from a cross-sectional epidemiological study. The National Comorbidity Survey Replication was designed to examine the prevalence and correlates of mental disorders in the USA. The study included a nationally representative sample of 9282 adults (4139 men and 5143 women). An in-person interview and survey were conducted in the homes of men and women from the general population. The study was conducted with participants residing in New York City, Los Angeles, Chicago, Philadelphia, Detroit, San Francisco, Washington DC, Dallas/Fort Worth, Houston, Boston, Nassau-Suffolk NY, St. Louis, Pittsburgh, Baltimore, Minneapolis and Atlanta. Symptoms from the research criteria for the diagnosis of traumatic encephalopathy syndrome were applied to men and women in the general population and in sub-groups of people with health problems and mental health problems. A small percentage of the US general population met symptom criteria for traumatic encephalopathy syndrome (6.6–11.9%, depending on the definition applied). People with chronic pain were much more likely to meet criteria (i.e. 14.8–30.5%), and two out of three people who have experienced suicidality in the past year met symptom criteria for traumatic encephalopathy syndrome (65.2–72.2%). The majority of women with a mood disorder and chronic pain met criteria (62.7–89.8%). This is the largest study, to date, examining the aspects of the research criteria for the diagnosis of traumatic encephalopathy syndrome in the general population, and the first study to examine these criteria in women. This study has important clinical and public health implications. The potential rate for misdiagnosing traumatic encephalopathy syndrome in adults who are experiencing chronic pain, idiopathic mental health problems or both is high.

6. Iverson GL, Buttner F, & Caccese JB (2021). **Age of first exposure to contact and collision sports and later in life brain Health: A narrative review.** *Frontiers in Neurology*, 12:727089. doi: 10.3389/fneur.2021.727089. PMID: 34659092. Click here to read the article on the publisher's website.

NB: This important study was not part of our original proposal. We pursued it with discretionary time during the COVID-19 pandemic.

Abstract: A controversial theory proposes that playing tackle football before the age of 12 causes later in life brain health problems. This theory arose from a small study of 42 retired National Football League (NFL) players, which reported that those who started playing tackle football at a younger age performed worse on selected neuropsychological tests and a word reading test. The authors concluded that these differences were likely due to greater exposure to repetitive neurotrauma during a developmentally sensitive maturational period in their lives. Several subsequent studies of current high school and collegiate contact/collision sports athletes, and former high school, collegiate, and professional tackle football players have not replicated these findings. This narrative review aims to (i) discuss the fundamental concepts, issues, and controversies surrounding existing research on age of first exposure (AFE) to contact/collision sport, and (ii) provide a balanced interpretation, including risk of bias assessment findings, of this body of evidence. Among 21 studies, 11 studies examined former athletes, 8 studies examined current athletes, and 2 studies examined both former and current athletes. Although the literature on whether younger AFE to tackle football is associated with later in life cognitive, neurobehavioral, or mental health problems in former NFL players is mixed, the largest study of retired NFL players (N = 3,506) suggested there was not a significant association between earlier AFE to organized tackle football and worse subjectively experienced cognitive functioning, depression, or anxiety. Furthermore, no published studies of current athletes show a significant association between playing tackle football (or other contact/collision sports) before the age of 12 and cognitive, neurobehavioral, or mental health problems. It is important to note that all studies were judged to be at high overall risk of bias, indicating that more methodologically rigorous research is needed to understand whether there is an association between AFE to contact/collision sports and later in life brain health. The accumulated research to date suggests that earlier AFE to contact/collision sports is not associated with worse cognitive functioning or mental health in (i) current high school athletes, (ii) current collegiate athletes, or (iii) middle-aged men who played high school football. The literature on former NFL players is mixed and does not, at present, clearly support the theory that exposure to tackle football before age 12 is associated with later in life cognitive impairment or mental health problems.

7. Iverson GL and Gardner AJ (2021). **Incidence of Concussion and time to return to play in the National Rugby League**. Clinical Journal of Sports Medicine, *online first*. doi: 10.1097/JSM.0000000000000965. PMID: 34446647.

NB: This important study was not part of our original proposal. We pursued it with discretionary time during the COVID-19 pandemic.

Background and Importance: The accurate identification and effective medical management of concussions are important for promoting the safety and health of contact and collision sport athletes. Several professional sporting leagues around the world, such as the National Football League, National Hockey League, Australian Football League, Cricket Australia, professional rugby union, and the National Rugby League (NRL) have implemented strategies for improving the identification of concussion through sideline video surveillance, deploying trained spotters in the arena, and using spotters with access to multiple camera angles and replay capabilities (in a centralized location). The NRL is the elite professional level club rugby league competition in Australia. Over the past six seasons, the NRL has refined the process for identifying concussions by implementing a rule that allows for medical staff to evaluate a player who sustains a blow to the head, during the game, to determine whether or not he might have sustained a concussion. The purpose of this study is to: (i) examine the rates of concussion over the course of two NRL seasons (2017-2018); (ii) examine the number of days until a concussed player is provided a medical clearance to return to full contact training or match play; and (iii) examine the number of subsequent games missed by concussed athletes. This is a descriptive observational cohort study of the number of concussions identified in the league across two seasons and recovery time. We assumed that there would be no significant differences across the two seasons.

Study Abstract
Objectives: To examine the rates of concussion and recovery time over the course of two seasons of the National Rugby League (NRL).
Design: Descriptive cohort study.
Setting: The NRL match play concussion injury surveillance system.
Participants: All NRL players who participated in the 2017 and 2018 season.
Outcome Measures: The (i) frequency of sideline injury surveillance identified head impact events in real-time during the games; (ii) frequency of head injury assessments conducted by the medical staff; (iii) frequency of medically diagnosed concussions; (iv) number of days to medical clearance to return to play; and (v) number of games missed following concussion.
Main Results: There were 472 head injury assessments conducted during the games and 149 medically diagnosed concussions over the course of two NRL seasons (1 concussion every 2.70 games). The median number of days until medical clearance was 6 (M=6.85, SD=8.03, interquartile range=4-7; range=0-79 days). There was a statistically significant difference in number of days to be medically cleared to return to full contact or match play between seasons (U=3,517.00, p=.001), and the percentage of players medically cleared to return to play at five days post injury was 60.6% in 2017 and 27.6% in 2018. Most players (87.9%) did not miss a game following injury.
Conclusions: There is approximately one concussion sustained for every three games in the NRL. Most players are medically cleared to return to play in 4-7 days.

8. Iverson, G.L., Merz, Z.C., & Terry, D.P. (2021). **Examining the Research Criteria for Traumatic Encephalopathy Syndrome in Middle-Aged Men from the General Population Who Played Contact Sports in High School.** *Frontiers in Neurology*. doi: 10.3389/fneur.2021.632618. Click here to read the article on the publisher's website.

NB: This study was not part of our original proposal. We have pursued it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: There is societal interest and concern about possible long-term effects of playing professional football on brain health. Researchers have reported that some former National Football League (NFL) players show differences in brain structure, microstructure, neurochemistry, and neurophysiology. Some former players perform more poorly on neurocognitive testing than control participants. Survey studies reveal that a subgroup of former players rate themselves as having poor mental health and cognitive functioning, although the majority do not perceive themselves to have these problems. Post-mortem studies have revealed diverse forms of neuropathology in some former players, including chronic traumatic encephalopathy neuropathologic change. Mortality studies, based on reviews of death certificates, have found greater rates of cardiovascular disease compared to former major league baseball players, but not compared to the general population. Compared to the general population, former NFL players have greater rates of Alzheimer's disease and amyotrophic lateral sclerosis as contributory causes of death, but not psychiatric illness or suicide.

There is also societal interest and concern regarding the long-term brain health of men who played high school football, although far less research has been done with them. Two studies have used data from the National Longitudinal Study of Adolescent to Adult Health to examine the associations between playing football during adolescence and mental health approximately 15 years later, during their late 20s. The researchers reported that playing football during adolescence was not associated with greater mental health problems, including lifetime rates of depression, current symptoms of depression (i.e., within the past seven days;), lifetime rates of anxiety, suicidal ideation within the past year, or substance abuse (i.e., nicotine, cannabis, alcohol). Researchers using data from the Wisconsin Longitudinal Study reported that playing high school football was not associated with cognitive problems or depression in older adults, when these men were approximately 65 years old. Using medical record linkage methodology, two studies have concluded that former high school football players are not at increased risk for later in life neurodegenerative diseases.

A notable gap in the literature relates to the brain health of middle-aged men who played high school football. We designed a survey study to examine whether middle aged men who played high school football experience worse mental health or cognitive functioning than men who did not play high school football. Based on the literature to date with men in their 20s who played football, we adopted the null hypothesis. We assumed that men who played high school football would *not* report (i) a greater lifetime history of depression or anxiety, (ii) greater mental health or cognitive problems in the past year, or (iii) greater current post-concussion-like symptoms or symptoms of depression.

Study Abstract

Objective: There are no validated or agreed upon diagnostic clinical criteria for chronic traumatic encephalopathy or traumatic encephalopathy syndrome. This study examines the leading research criteria for traumatic encephalopathy syndrome (TES) in middle-aged men in the general population.
Method: Participants were 409 men between the ages of 35 and 55 recruited through an online crowdsourcing platform. Participants provided demographic information, medication history, concussion history, contact sport history, current medication use, and current symptoms. Research criteria for TES were applied to the sample.
Results: Over half of the total sample met TES symptom criteria (56.2%), without applying the neurotrauma exposure criteria. Those with 4+ prior concussions had higher rates of meeting TES criteria compared to those with 0-3 prior concussions, but the results were not statistically significant

(69.8 vs. 54.6%; $\chi^2 = 3.58$, $p = 0.06$). Exposure to contact sports was not related to higher rates of TES (ps ≥ 0.55). In a binary logistic regression predicting the presence of mild or greater TES, significant predictors were sleep difficulties [Odds ratio (OR) = 6.68], chronic pain (OR = 3.29), and age (OR = 1.04). Neurotrauma exposure was not a significant predictor ($p = 0.66$). When analyzing those with no prior concussions or contact sport histories ($n = 126$), 45.2% met symptom criteria for mild or greater TES; chronic pain and sleep difficulties were associated with a higher prevalence of meeting criteria for TES in this subgroup (ps < 0.001).

Conclusions: Men who participated in contact sports in high school or college were not more likely to meet criteria for TES than men who participated in non-contact sports or no sports. In a multivariable model, sleep problems and chronic pain were predictive of meeting the symptom criteria for TES, but the repetitive neurotrauma exposure criterion was not a significant predictor of meeting the TES symptom criteria.

9. Iverson GL, Terry DP, Cassese JB, Büttner F, Merz ZC. (2021). **Age of First Exposure to Football is not Associated with Midlife Brain Health Problems**. *Journal of Neurotrauma*, 38(5):538-545. doi: 10.1089/neu.2020.7041. PMID: 33126834.

NB: This study was not part of our original proposal. We have pursued it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: Football has been one of the most popular sports in the United States for decades, with more than one million youth participating at the high school level each year. It is reasonable to estimate that tens of millions of men in the United States played high school football. In recent years, several states, such as New Jersey, New York, Massachusetts, and Illinois, have held hearings or considered legislation to ban tackle football below the age of 12. Advocacy groups for this legislation have relied, in part, on some studies that have put forward a theory that playing football before the age of 12 is associated with psychiatric, cognitive, and neurological problems later in life. The origin of the theory appears to be a small study of former National Football League (NFL) players illustrating that those who started playing before the age of 12 performed more poorly on a reading test and two neuropsychological tests. Much research is needed on this important topic.

Study Abstract: The purpose of this study was to determine if earlier age of first exposure to football is associated with worse brain health in middle-aged men who played high school football. We assessed 123 men ages 35-55, who played high school football, using (i) a survey of demographic information as well as medical, sport participation, and concussion history; (ii) the Patient Health Questionnaire-8 (PHQ-8); and (iii) the British Columbia Post-Concussion Symptom Inventory (BC-PSI). Sixty-two (50.4%) men reported football participation starting before the age of 12 [i.e., age of first exposure (AFE)<12 years] and 61 (49.6%) reported football participation at or after the age of 12 (AFE≥12 years). Compared to AFE≥12 years, former high school football players that began playing tackle football before age 12 did not differ in the rates at which they had been prescribed medications for mental health problems or in the rates at which they had recently experienced symptoms of anxiety, depression, memory loss, chronic pain, or headaches. Moreover, there was no difference in their lifetime history of treatment by a mental health professional. The groups did not differ significantly on PHQ-8 (U=1,839.0, p=.791) or BC-PSI total scores (U=1828.5, p=.751). These findings suggest that earlier age of first exposure to football is not associated with worse brain health in middle-aged men in this sample who played high school football.

10. Iverson GL, Howell DR, van Patten R., Bloomfield P, & Gardner AJ. (2021). **Sport Concussion Assessment Tool-5th Edition (SCAT5): Normative Reference Values for the National Rugby League Women's Premiership.** *Frontiers in Sports and Active Living*, 3:653743. doi: 10.3389/fspor.2021.653743. PMID: 34124655. Click here to read the article on the publisher's website.

NB: This important study was not part of our original proposal. We pursued them with discretionary time during the COVID-19 pandemic.

Background and Importance: There are no normative reference values for the Sport Concussion Assessment Tool-Fifth Edition (SCAT5) for men or women athletes in the NRL.

The Sport Concussion Assessment Tool-Fifth Edition (SCAT5) has been promoted by the Concussion in Sport Group as a standardized acute clinical assessment for athletes suspected of concussion. **The SCAT5 is the foundation for the medical evaluation of concussion on the sideline of all NRL matches**. It is comprised of existing tests, such as the Standardized Assessment of Concussion (SAC), modified Balance Error Scoring System (M-BESS), and a modification of the Post-Concussion Symptom Scale. Previous versions, the SCAT, SCAT2, and SCAT3, have been published over the past 15 years. The SCAT has been, and is, widely used in professional and amateur sports. There are two distinct ways to interpret SCAT5 performance following a suspected or known concussion. First, the clinician can compare post-injury scores with age- and sport-specific normative data. Second, the clinician can compare post-injury test scores to the individual's personal pre-injury baseline data. The clinician might also choose to use both methods, when possible.

Plan: We will develop and publish normative reference data for the SCAT5 for men and women athletes in the NRL.

Progress to Date on the Women's Study: The purpose of this study is to provide normative reference values for the SCAT5 for professional women's rugby league players. The new professional league for women in this sport had its first season in 2018. Preseason baseline testing was administered individually to 156 professional women rugby league players. All women registered in the National Rugby League Women (NRLW) from the 2018 and 2019 seasons are included in this study. We have completed all statistical analyses and prepared a first draft of the article for publication. We anticipate completing and publishing this study over the next several months.

This study is important because it provides, for the first time, sport-specific normative data for the interpretation of SCAT5 performance of professional women rugby league players.

11. Van Patten R, Iverson GL, Terry DP, Levi CR, and Gardner AJ. (2021). **Predictors and Correlates of Perceived Cognitive Impairment in Retired Professional Rugby League Players**. *Frontiers in Neurology*, online first. doi: 10.3389/fneur.2021.676762. Click here to read the article on the publisher's website.

Background and Importance: This study examined the association between a retired player's health profile and their self-reported cognitive decline. Importantly, this study investigated whether self-reported cognitive decline is associated with historical sport variables such as number of concussions and duration of participation in contact sport, as well as potentially co-occurring symptoms of depression, resilience, sleep difficulties, and chronic pain. This study also evaluated whether these former players' self-reported cognitive decline is associated with objectively-measured cognitive functioning.

Objective: Rugby league is an international full-contact sport, with frequent concussive injuries. Participation in other full-contact sports such as American football has been considered to be a risk factor for neuropsychiatric sequelae later-in-life, but little research has addressed the mental and cognitive health of retired professional rugby league players. We examined predictors and correlates of perceived (self-reported) cognitive decline in retired National Rugby League (NRL) players.
Methods: Participants were 133 retired male elite level rugby league players in Australia. Participants completed clinical interviews, neuropsychological testing, and self-report measures. The Informant Questionnaire on Cognitive Decline in the Elderly, self-report (IQCODE-Self), measured perceived cognitive decline.
Results: The median age of the sample was 55.0 (M = 53.1, SD = 13.9, range = 30–89) and the median years of education completed was 12.0 (M = 11.9, SD = 2.6, range = 7–18). The retired players reported a median of 15.0 total lifetime concussions (M = 28.0, SD = 36.6, range = 0–200). The mean IQCODE-Self score was 3.2 (SD = 0.5; Range = 1.3–5.0); 10/133 (7.5%) and 38/133 (28.6%) scored above conservative and liberal cutoffs for cognitive decline on the IQCODE-Self, respectively. Perceived cognitive decline was positively correlated with current depressive symptoms, negatively correlated with years of professional sport exposure and resilience, and unrelated to objective cognition and number of self-reported concussions. A multiple regression model with perceived cognitive decline regressed on age, concussion history, professional rugby league exposure, depression, resilience, objective cognitive functioning, daytime sleepiness, and pain severity showed depression as the only significant predictor.
Conclusion: This is the first large study examining subjectively experienced cognitive decline in retired professional rugby league players. Similar to studies from the general population and specialty clinics, no relationship was found between objective cognitive test performance and perceived cognitive decline. Depressive symptoms emerged as the strongest predictor of perceived cognitive decline, suggesting that subjective reports of worsening cognition in retired elite rugby league players might reflect psychological distress rather than current cognitive impairment.

12. Iverson GL, Van Patten R, Terry DP, Levi CL, and Gardner AJ. (2021). **Predictors and Correlates of Depression in Retired Professional Rugby League Players**. *Frontiers in Neurology*, 12:655746. doi: 10.3389/fneur.2021.655746. Click here to read the article on the publisher's website.

Background and Importance: This study examined the association between a retired player's health profile and their self-reported depression. Importantly, this study investigated whether depression is associated with historical sport variables such as number of concussions and duration of participation in contact sport, as well as potentially co-occurring symptoms of resilience, sleep difficulties, and chronic pain.

Background: There is considerable interest in determining whether later-in-life depression is associated with lifetime history of concussions or the duration of a career in professional contact and collision sports. Rugby league is a high-intensity collision sport involving a large number of tackles per game and a high rate of concussions. We examined predictors and correlates of depression in retired elite level rugby league players in Australia.
Methods: Retired elite level rugby league players (*N* = 141, age: M = 52.6, SD = 13.8; Range = 30-89 years) completed the Depression, Anxiety, and Stress Scale (DASS), Brief Pain Inventory, Connor-Davidson Resilience Scale (CD-RISC), and Epworth Sleepiness Scale; they also reported on lifetime history of concussions. The DASS depression score was regressed on age, total number of self-reported concussions, years played professionally, CD-RISC score, BPI pain interference score, and ESS score.
Results: The retired players reported a median of 15 total lifetime concussions [interquartile range (IQR) = 6-30], and a median of 8 years playing professional sports (IQR = 3.5-11). The proportion of the sample endorsing at least mild current depression was 29%. The DASS depression score was positively correlated with the DASS anxiety (r = 0.54) and DASS stress scores (r = 0.58). The CD-RISC score was negatively correlated with the depression score (r = -0.53). Depression scores were not significantly correlated with pain severity (r = 0.14), and were weakly correlated with life interference due to pain (r = 0.20) and years playing professional sports (r = -0.17). Depression scores were not significantly correlated with lifetime history of concussions (r = 0.14). A multiple regression model, with age, total number of self-reported concussions, years played professionally, the CD-RISC, Brief Pain Inventory-pain interference score, and Epworth Sleepiness Scale score as predictors was significant, with 35% of the variance in DASS depression accounted for. The two significant independent predictors of depression were lower resilience and greater life interference due to pain.
Conclusions: This is the first large study of depression in retired rugby league players. Depression in these retired players was not meaningfully associated with lifetime history of concussions or number of years playing elite level collision sport. Depression was associated with current anxiety, stress, resilience, and life interference due to chronic pain.

13. Gardner AJ, Iverson GL, Edwards S, and Tucker R. (2021). **A case–control study of tackle-based head injury assessment (HIA) risk factors in the National Rugby League**. *Sports Medicine – Open*, 7(1):84-94. doi: 10.1186/s40798-021-00377-9. PMID: 34787721. Click here to read the article on the publisher's website.

NB: This study was not part of our original proposal. We pursed it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Background and Importance: This study examines the association between tackle characteristics and concussion to identify potential risk factors and inform future injury prevention initiatives.

Abstract
Background: The tackle is the in-game activity carrying the greatest risk for concussion in rugby. A recent evaluation of tackle characteristics in rugby union precipitated a rule modification to reduce head impact risk during tackles. This study aims to replicate the work conducted in rugby Union by examining the association between tackle characteristics and head injury events in professional rugby league.
Methods: 446 tackles resulting in a head injury assessment (HIA) and 5,694 tackles that did not result in a head injury from two National Rugby League (NRL) seasons, were reviewed and coded. Tackle height, body position of players, and contact area on an opponent's body were evaluated, with the propensity of each situation to cause an HIA calculated as HIAs per 1000 events.
Results: The propensity for tacklers to sustain a head injury was 0.99 HIAs per 1000 tackles, 1.74-fold greater than for the ball carrier (0.57 HIAs per 1,000 tackles). There was a 3.2-fold higher risk for an HIA when the tackler was upright compared to bent-at-the-waist. The greatest risk of a tackler HIA occurred when head contact was very low (knee, boot) or high (head and elbow). HIAs were most common following head-to-head impacts. The lowest propensity for tackler HIA was found when the tackler's head was in proximity with the ball carrier's torso.
Conclusions: The result of this study replicated the findings in professional rugby union. This has implications for the injury prevention initiatives implemented to reduce HIA risk because the majority of injuries are sustained by the tackler.

14. Iverson GL, Caccese JB, Merz ZC, Buttner F, & Terry DP. (2021). **Age of first exposure to football is not associated with later-in-life cognitive or mental health problems**. *Frontiers in Neurology – Neurotrauma*, 12:647314. doi: 10.3389/fneur.2021.647314. PMID: 34025554. Click here to read the article on the publisher's website.

Background and Importance: American football has been one of the most popular sports in the United States for decades, with more than one million youth participating at the high school level each year. In recent years, there have been growing public health concerns regarding the long-term effects of youth football participation. over the past 10 years, there has been approximately a 10% decline in high school football participation (1), and several states, such as New Jersey, NewYork, Massachusetts, and Illinois, have held hearings or considered legislation to ban tackle football below the age of 12 (or before high school). Advocacy groups for this legislation have relied, in part, on some studies that have put forward a theory that playing football before the age of 12 is associated with psychiatric, cognitive, and neurological problems later in life. The origin of this theory appears to be a small study of former National Football League (NFL) players illustrating that those who started playing football before the age of 12, compared with those who started at age 12 or later, performed worse on a reading test and two neuropsychological tests.

Abstract
Objective: The purpose of this study was to determine if earlier age of first exposure to football is associated with worse brain health in middle-aged and older adult men who played high school football.
Methods: Men from the United States, aged 35 and older, who reported playing high school football, completed a customized, online health survey via the Amazon Mechanical Turk (mTurk) platform. Survey items included physical, psychological, and cognitive symptoms over the past week and over the past year, sports participation history (including age of first exposure to football), medical history, and concussion history. Participants also completed the Patient Health Questionnaire-8 (PHQ-8) and the British Columbia Post-Concussion Symptom Inventory (BC-PSI).
Results: There were 186 men (age M = 51.78, SD = 10.93) who participated in high school football, and 87 (46.8%) reported football participation starting before the age of 12 and 99 (53.2%) reported football participation at or after the age of 12. Those who started playing football at an earlier age reported a greater number of lifetime concussions (M = 1.95, SD = 1.79) compared to those who started playing at age 12 or later (M = 1.28, SD = 1.52; U = 3,257.5, p = 0.003). A similar proportion of men who played football before vs. after the age of 12 reported a lifetime history of being prescribed medications for depression, anxiety, chronic pain, headaches, or memory problems. When comparing men who played football before vs. after the age of 12, the groups did not differ significantly in their ratings of depression, anger, anxiety, headaches, migraines, neck or back pain, chronic pain, concentration problems, or memory problems over the past week or the past year. The two groups did not differ significantly in their ratings of current symptoms of depression (PHQ-8; U = 4,187.0, p = 0.74) or post-concussion-like symptoms (BC-PSI; U = 3,944.0, p = 0.53). Furthermore, there were no statistically significant correlations between the age of first exposure to football, as a continuous variable, and PHQ-8 or BC-PSI scores.
Conclusion: This study adds to a rapidly growing body of literature suggesting that earlier age of first exposure to football is not associated with later-in-life brain health.

15. Iverson GL, Merz ZC, & Terry DP. (2021). **Playing high school football is not associated with an increased risk for suicidality in early adulthood**. *Clinical Journal of Sports Medicine*, 31(6): 469-474. doi: 10.1097/JSM.0000000000000890. PMID: 34704972. Click here to read the article on the publisher's website.

Background and Importance: There is societal concern that playing football might be associated with an increased risk for depression, suicidality, and suicide later in life. This concern has been fuelled by intense media coverage of some current and former National Football League (NFL) players who have completed suicide. Current and former athletes are expressing concerns about developing a brain disease and committing suicide. Some of these athletes have referred, specifically, to a concern about chronic traumatic encephalopathy (CTE), whereas others have not referred to CTE by name.

Abstract
Objective: To determine if playing high school football is associated with suicide ideation between the ages of 24 and 32 years.
Design: Data were analyzed from the National Longitudinal Study of Adolescent to Adult Health. This prospective cohort study sampled nationally representative US participants at 4 time points from 1994 to 2008. SETTING: In-home assessment.
Participants: There were 3147 boys (age: median = 14.9, SD = 1.8) who participated during adolescence in 1994 to 1995 (wave I), of whom 2353 were reinterviewed in 2008 (wave IV, age: median = 29.1, SD = 1.8).
Assessment of Risk Factors: Football participation, history of psychological counselling, suicide ideation, and a suicide attempt in the past year during high school.
Main Outcome Measures: Lifetime history of depression, suicide ideation within the past year, and feeling depressed in the past 7 days at wave IV.
Results: Men who played high school football, compared with those who did not, reported similar rates of lifetime diagnosis of depression, suicide ideation in the past year, and feeling depressed in the past 7 days. Those who played football reported similar rates of suicide ideation in the past year when they were in their early 20s. Individuals who underwent psychological counselling during adolescence were more likely to report a lifetime history of depression and suicide ideation in the past year.
Conclusions: Young men who played high school football are not at an increased risk for suicide ideation during both their early 20s and late 20s. By contrast, those who experienced mental health problems in high school were much more likely to experience suicide ideation during their 20s.

16. Iverson GL, Van Patten R, & Gardner AJ. (2021). **Examining Whether Onfield Motor Incoordination is Associated with Worse Performance on the SCAT5 and Slower Clinical Recovery following Concussion**. *Frontiers in Neurology – Neurotrauma,11:620872*. doi: 10.3389/fneur.2020.620872. PMID: 33732202. Click here to read the article on the publisher's website.

Background and Importance: Motor incoordination is a sign of potential concussion that can often be plainly seen on the field, from the sideline, from the stands, and on television. It is a useful visual sign of a possible concussive injury that can also be evaluation on video review. Evaluating the clinical association to specific sign of potential concussion are important for predicting diagnosis and recovery.

Abstract
Objective: To examine the relationship between video-identified onfield motor incoordination, the acute assessment of concussion, and recovery time during three seasons of National Rugby League (NRL) play.
Methods: Blows to the head ("head impact events") were recorded by sideline video operators and medical staff. Any player with a suspected concussion underwent a Head Injury Assessment in which he was taken off the field and medically evaluated, including the administration of the Sports Concussion Assessment Tool, 5th Edition (SCAT5). Video footage was later examined to determine the presence or absence of onfield motor incoordination following the head impact event.
Results: Motor incoordination was identified in 100/1,706 head impact events (5.9%); 65 of the 100 instances of motor incoordination (65.0%) were ultimately medically diagnosed with a concussion. In 646 athletes for whom SCAT5 data were available, those with motor incoordination were more likely to report both dizziness and balance problems than those without motor incoordination, but there were no group differences on an objective balance test. Additionally, there was no relationship between presence/absence of motor incoordination and number of games missed or time to medical clearance for match play.
Conclusion: In NRL players, motor incoordination is a readily observable onfield sign that is strongly associated with a medical diagnosis of concussion and with self-reported dizziness/balance problems. However, onfield motor incoordination is not associated with objective balance performance and it is not predictive of time to recover following concussion.

17. Carey L, Terry DP, McIntosh A, Stanwell P, Iverson GL, & Gardner AJ. (2021). **Video Analysis and Verification of Direct Head Impacts Recorded by Wearable Sensors in Junior Rugby League Players**. *Sports Medicine – Open, 7(1):66*. doi: 10.1186/s40798-021-00353-3. PMID: 34529180. Click here to read the article on the publisher's website.

Abstract

Background: Rugby league is a high-intensity collision sport that carries a risk of concussion. Youth athletes are considered to be more vulnerable and take longer to recover from concussion than adult athletes.

Objective: To review head impact events in elite-level junior representative rugby league and to verify and describe characteristics of X-patch(TM)-recorded impacts via video analysis.

Study Design: Observational case series.

Methods: The X-patch(TM) was used on twenty-one adolescent players (thirteen forwards and eight backs) during a 2017 junior representative rugby league competition. Game-day footage, recorded by a trained videographer from a single camera, was synchronised with X-patch(TM)-recorded timestamped events. Impacts were double verified by video review. Impact rates, playing characteristics, and gameplay situations were described.

Results: The X-patch(TM)-recorded 624 impacts ≥ 20g between game start and finish, of which 564 (90.4%) were verified on video. Upon video review, 413 (73.2%) of all verified impacts ≥ 20g where determined to be direct head impacts. Direct head impacts ≥ 20g occurred at a rate of 5.2 impacts per game hour; 7.6 for forwards and 3.0 for backs (range = 0-18.2). A defender's arm directly impacting the head of the ball carrier was the most common event, accounting for 21.3% (n = 120) of all impacts, and 46.7% of all "hit-up" impacts. There were no medically diagnosed concussions during the competition.

Conclusion: The majority (90.4%) of head impacts ≥ 20g recorded by the X-patch(TM) sensor were verified by video. Double verification of direct head impacts in addition to cross-verification of sensor-recorded impacts using a secondary source such as synchronised video review can be used to ensure accuracy and validation of data.

18. Cook, MJ, Gardner, AJ, Wojtowicz M, Williams WH, Iverson GL, Stanwell P. (2021). **Task-related functional magnetic resonance imaging activations in patients with acute and subacute mild traumatic brain injury: A coordinate-based meta-analysis**. *NeuroImage: Clinical*, 25;102129. doi: 10.1016/j.nicl.2019.102129. PMID: 31891819.

Background and Importance: Task-based functional magnetic resonance imaging (fMRI) has been used to examine neuroanatomical and functional changes following mild traumatic brain injury (mTBI). Prior studies have lacked consistency in identifying common regions of altered neural activity during cognitive tasks. This may be partly due to differences in task paradigm, patient heterogeneity, and methods of fMRI analysis.

Abstract
Objective: We conducted a meta-analysis using an activation likelihood estimation (ALE) method to identify regions of differential brain activation in patients with mTBI compared to healthy controls.
Methods: We included experiments that performed scans from acute to subacute time points post-injury.
Results: The seven included studies recruited a total sample of 174 patients with mTBIs and 139 control participants. The results of our coordinate based meta-analysis revealed a single cluster of reduced activation within the right middle frontal gyrus (MFG) that differentiated mTBI from healthy controls.
Conclusions: We concluded that the cognitive impairments in memory and attention typically reported in mTBI patients may be associated with a deficit in the right MFG, which impacts the recruitment of neural networks important for attentional control.

19. Goodin P, Gardner AJ, Dokani N, Nizette B, Ahmadizadeh S, Edwards S, Iverson GL. (2021). **Development of a Machine Learning Based Classifier for Identification of Head and Body Impacts in Elite Level Australian Rules Football Players**. *Frontiers in Sports and Active Living, 3:725245*. doi: 10.3389/fspor.2021.725245. PMID: 34870193. Click here to read the article on the publisher's website.

Background and Importance: A number of professional sporting leagues have implemented sideline video surveillance as a strategy for improving the identification of concussion. This is an important strategy. However, concern has also been raised that concussion may not be the only risk to the health of contact and collision sport athletes, but also the career accumulation of subconcussive impacts that may result in current or future health issues. Cumulative exposure to repetitive head impacts, over time during a single season, might be a risk factor for sustaining a concussion during that season in elite American college football players, but cumulative exposure to head impacts was not associated with concussion risk in high school football players. Impact recording is an important process that has been add as a further surveillance tool in some sports. Validating impact detection is required for accurate exposure monitoring, making classification of all impacts, a critical step for evaluating relevant data and the subsequent risk.

Abstract
Background: Exposure to thousands of head and body impacts during a career in contact and collision sports may contribute to current or later life issues related to brain health. Wearable technology enables the measurement of impact exposure.
Objective: The validation of impact detection is required for accurate exposure monitoring. In this study, we present a method of automatic identification (classification) of head and body impacts using an instrumented mouthguard, video-verified impacts, and machine-learning algorithms.
Methods: Time series data were collected via the Nexus A9 mouthguard from 60 elite level men (mean age = 26.33; SD = 3.79) and four women (mean age = 25.50; SD = 5.91) from the Australian Rules Football players from eight clubs, participating in 119 games during the 2020 season. Ground truth data labelling on the captures used in this machine learning study was performed through the analysis of game footage by two expert video reviewers using SportCode and Catapult Vision. The visual labelling process occurred independently of the mouthguard time series data. True positive captures (captures where the reviewer directly observed contact between the mouthguard wearer and another player, the ball, or the ground) were defined as hits. Spectral and convolutional kernel based features were extracted from time series data. Performances of untuned classification algorithms from scikit-learn in addition to XGBoost were assessed to select the best performing baseline method for tuning.
Results: Based on performance, XGBoost was selected as the classifier algorithm for tuning. A total of 13,712 video verified captures were collected and used to train and validate the classifier. True positive detection ranged from 94.67% in the Test set to 100% in the hold out set. True negatives ranged from 95.65 to 96.83% in the test and rest sets, respectively.
Conclusion: This study suggests the potential for high performing impact classification models to be used for Australian Rules Football and highlights the importance of frequencies <150Hz for the identification of these impacts.

20. Iverson, G. L. & Gardner, A. J. (2020). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Anger Control Problems.** *Frontiers in Neurology - Neurotrauma, 11*, 739. doi: 10.3389/fneur.2020.00739. Click here to read the article on the publisher's website.

Background and Importance: This study is important because it illuminated fundamental problems with the criteria for diagnosing chronic traumatic encephalopathy, and traumatic encephalopathy syndrome, in retired athletes, military veterans, and people from the general population. There is considerable risk for *misdiagnosis*, and there is a pressing need to try to improve the diagnostic criteria.

Abstract
Objective: In recent years, it has been proposed that depression represents one clinical subtype of chronic traumatic encephalopathy (CTE). This is the first study to examine the specificity of the research criteria for the clinical diagnosis of CTE in men with depression from the general population.
Methods: Data from the National Comorbidity Survey Replication, an in-person survey that examined the prevalence and correlates of mental disorders in the United States, were used for this study. Men diagnosed as having a major depressive episode in the past 30 days were included (N=101; mean age=39.4 years, SD=12.9, range=18-71). They were deemed to meet research criteria for CTE if they presented with the purported supportive clinical features of CTE (e.g., impulsivity and substance abuse, anxiety, apathy, suicidality, and headache).
Results: Approximately half of the sample (52.5%) met the proposed research criteria for CTE (i.e., traumatic encephalopathy syndrome). If one accepts the delayed-onset criterion as being present, meaning that the men in the sample were presenting with depression years after retirement from sports or the military, then 83.2% of this sample would meet the research criteria for diagnosis.
Conclusions: The clinical problems attributed to CTE, such as depression, suicidality, anxiety, anger control problems, and headaches, co-occurred in this sample of men with depression from the general population-illustrating that these problems are not specific or unique to CTE. More research is needed to determine whether depression is, in fact, a clinical subtype of CTE.

21. Guell X, Arnold Anteraper S, Gardner AJ, Whitfield-Gabrieli S, Kay-Lambkin F, Iverson GL, Gabrieli J, Stanwell P. (2020). **Functional connectivity changes in retired professional rugby league players: a data-driven functional magnetic resonance imaging study**. *Journal of Neurotrauma*, *37*(16):1788-1796. doi: 10.1089/neu.2019.6782. PMID: 32183583.

Background and Importance: This was an exploratory study using experimental brain imaging and advanced analytical techniques. This study was important because it revealed differences in resting-state functional connectivity in retired professional rugby league players compared to healthy community control participants.

Abstract: There is considerable interest in the long-term brain health of retired contact and collision sport athletes; however, little is known about possible underlying changes in functional brain connectivity in this group. We evaluated whole-brain functional connectivity patterns using multi-voxel pattern analysis (MVPA) to determine whether alterations in functional connectivity distinguish retired professional athletes from a matched group of healthy community control subjects. Thirty-two retired athletes with a history of multiple self-reported sport-related concussions and 36 healthy community control subjects who were similar in age and education, completed functional magnetic resonance imaging. We identified brain regions with abnormal functional connectivity patterns using whole-brain MVPA as implemented in the Conn toolbox. First-level MVPA was performed using 64 principal component analysis (PCA) components. Second-level F test was performed using the first three MVPA components for retired athletes > controls group contrast. *Post hoc* seed-to-voxel analyses using the MVPA cluster results as seeds were performed to characterize functional connectivity abnormalities from brain regions identified by MVPA. MVPA revealed one cluster of abnormal functional connectivity located in cerebellar lobule V. This region of lobule V corresponded to the ventral attention network. *Post hoc* seed-to-voxel analysis using the cerebellar MVPA cluster as a seed revealed multiple areas of cerebral cortical hyper-connectivity and hypo-connectivity in retired athletes when compared with controls. This initial report suggests that cerebellar dysfunction might be present and clinically important in some retired athletes.

22. Gardner AJ. (2020). **Reliability of Using the Proposed International Consensus Video Signs of Potential Concussion for National Rugby League Head Impact Events**. *Neurosurgery, 88(3):538-543.* doi: 10.1093/neuros/nyaa437. PMID: 33027812.

Abstract

Objective: To review the reliability of the proposed international consensus video signs of concussion in National Rugby League (NRL) head impact events (HIEs).

Methods: The video signs of concussion were coded for every HIE during the 2019 NRL season. Coding was conducted blinded to the concussion status. Frequency, sensitivity, specificity, and a receiver operating characteristic curve were calculated.

Results: There were 943 HIEs identified over the 2019 NRL season, of which 106 resulted in a diagnosed concussion. The most frequently observed video sign in concussed athletes was blank/vacant look (54%), which was also the most sensitive video sign (0.54, CI: 0.44- 0.63), while the most specific was tonic posturing (0.99, CI: 0.99-1.00). In 43.4% of diagnosed concussions none of the 6 video signs were present. The 6 video signs demonstrated a “fair” ability to discriminate between concussion and non-concussion HIEs (area under the curve).

Conclusion: International consensus agreement between collision sports for extant = 0.76). video signs of concussion and the definition of those extant video signs are clinically important. The selection of signs requires rigorous assessment to examine their predictive value across all sports and within individual sports, and to determine further video signs to compliment and improve the identification of possible concussion events within various sports. The current study demonstrated that, for NRL-related HIEs, the diagnostic accuracy of video signs varies.

23. Gardner AJ, Howell DR, & Iverson GL. (2020). **The association between multiple prior concussions, cognitive test scores, and symptom reporting in youth rugby league players**. *Brain Injury*, 34(2):224-228. doi: 10.1080/02699052.2019.1683894. PMID: 31661635.

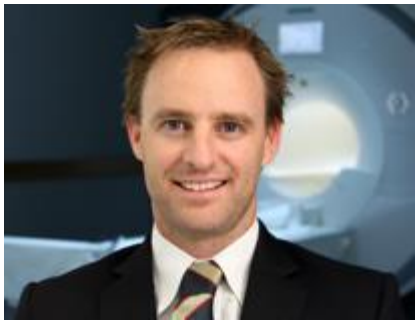
Abstract
Objective: To examine the effect of prior concussion history on cognitive test performance and concussion symptom reporting among adolescent youth rugby league athletes.
Participants: Participants were male elite level youth rugby league players (N = 73; Mean Age = 15.8; SD = 0.9; range = 14-18 years).
Main Outcome Measure: CogSport performance based on participants group; those who reported no previous concussions (n = 30),1-2 previous concussions (n = 19), and ≥3 previous concussions (n = 29).
Results: 73 participants with valid CogSport scores were included in the cognitive analyses. All participants were included in the symptom analyses. There were no differences between the groups with 0,1-2, or ≥3 previous concussions for processing speed, attention, learning, or working memory. There was a trend for those with multiple prior concussions to report more baseline preseason symptoms.
Conclusions: There were no differences in scores on the CogSport test among those with a history of 0,1-2, or ≥3 prior concussions. Consistent with prior studies, youth with a history of multiple past concussions are more likely to endorse baseline preseason symptoms.

24. Iverson, G. L. & Gardner, A. J. (2019). **Risk for Misdiagnosing Chronic Traumatic Encephalopathy in Men with Depression.** *Journal of Neuropsychiatry and Clinical Neurosciences.* doi: 10.1176/appi.neuropsych.19010021. Click here to read the article on the journal's website.

NB: This study was not part of our original proposal. We pursued it with discretionary time during the COVID-19 pandemic. It is relevant to youth and professional rugby league players.

Objective: In recent years, it has been proposed that depression represents one clinical subtype of chronic traumatic encephalopathy (CTE). This is the first study to examine the specificity of the research criteria for the clinical diagnosis of CTE in men with depression from the general population.
Methods: Data from the National Comorbidity Survey Replication, an in-person survey that examined the prevalence and correlates of mental disorders in the United States, were used for this study. Men diagnosed as having a major depressive episode in the past 30 days were included (N=101; mean age=39.4 years, SD=12.9, range=18–71). They were deemed to meet research criteria for CTE if they presented with the purported supportive clinical features of CTE (e.g., impulsivity and substance abuse, anxiety, apathy, suicidality, and headache).
Results: Approximately half of the sample (52.5%) met the proposed research criteria for CTE (i.e., traumatic encephalopathy syndrome). If one accepts the delayed-onset criterion as being present, meaning that the men in the sample were presenting with depression years after retirement from sports or the military, then 83.2% of this sample would meet the research criteria for diagnosis.
Conclusions: The clinical problems attributed to CTE, such as depression, suicidality, anxiety, anger control problems, and headaches, co-occurred in this sample of men with depression from the general population—illustrating that these problems are not specific or unique to CTE. More research is needed to determine whether depression is, in fact, a clinical subtype of CTE.

Appendix B. Biographies



Andrew J. Gardner, Ph.D. – Principal Investigator
Sydney School of Health Sciences, Faculty of Medicine and Health, The University of Sydney

I am a Mid-Career Research Fellow with the Sydney School of Health Sciences at The University of Sydney. I am about to commence a 5-year (2023-2027) NHMRC Investigator Grant at The University of Sydney, focused entirely on this program of research (Title: “Repetitive Neurotrauma and the Risk for Dementia in Former Athletes”).

I am a member of the World Rugby Concussion Working Group, I am co-leading the World Rugby Brain Health Services program, I am a member of the AFL’s concussion scientific advisory board, and I am the concussion consultant for Rugby Australia. I have conducted research in the field of sports concussion for over a decade. My research and expert opinion have also been sought for the development of policy papers produced by Brain Injury Australia, Alzheimer’s Australia (NSW), and Sports Medicine Australia (SMA)'s concussion policy. I was also involved in the production and delivery of the SMA Community and Medical Concussion Workshops in NSW that came off the back of the release of this policy. I have been previously complete three fellowship at Harvard Medical School (2012 funded through a Hunter Medical Research Institute PhD travel award, 2013 on an Australian Endeavour Research Fellowship, and 2018 through a Fulbright Postdoctoral Award). In 2015 I was awarded the Discovery Award from Research Australia as the national early career researcher of the year for 2015. In 2016 I was awarded the Beryl Nashar Young Researcher Award by the University of Newcastle alumni advisory committee, an award that recognises achievements of early- and mid-career researchers. In 2016 I also received an 'Emerging Health Researcher Commendation Award' from the Bupa Health Foundation, an award that recognises the valuable contribution of emerging health researchers to health outcomes for all Australians. In 2017 I was awarded a University of New England Alumni Early Career Achievement Award, recognising his outstanding contribution to the field of sport and neuropsychology, and was made a 2017 AMP Tomorrow Maker to support the clinical and research work within the HNE LHD Sports Concussion Clinic. I also received the 2017 Vice-Chancellor's Award for Early Career Research and Innovation Excellence for the Faculty of Health. In 2018 I received a Fulbright Postdoctoral Award and I was also a 2018 NSW Young Tall Poppy Science Award recipient, recognition as one of Australia’s outstanding young scientific researchers and communicators, and the inaugural Hunter New England Local Health District Psychology Researcher of the Year Award for 2018.

I have established strong research collaborations with international experts from Harvard Medical School and Leeds Beckett University. I am continuing to develop my research program by focusing on the investigation of concussion across the full spectrum, from the acute, sub-acute, and chronic problems associated with sports concussion in active and retired athletes of all levels of competition.

Some of our latest research can be viewed on PubMed:
https://pubmed.ncbi.nlm.nih.gov/?term=Author%3A+Gardner%2C+A

Grant L. Iverson, Ph.D. – Co-Principal Investigator
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School /
Director, Concussion Research Program, Spaulding Rehabilitation Network /
Director, MassGeneral Hospital for Children Sports Concussion Program /
Associate Director of the Traumatic Brain Injury Program at Home Base, A Red Sox Foundation and Massachusetts General Hospital Program

I am a Professor in the Department of Physical Medicine and Rehabilitation at Harvard Medical School. I serve as the Director of the Concussion Research Program for the Spaulding Rehabilitation Network. I serve as the Director of the MassGeneral Hospital for Children Sports Concussion Program. I also serve as the Associate Director of the Traumatic Brain Injury Program at Home Base, A Red Sox Foundation and Massachusetts General Hospital Program.

I devote my career to research and clinical practice in the field of concussion. We conduct leading and clinically-relevant research with athletes, civilians, active duty service members, and Veterans who have sustained mild injuries to their brains. Our research program is lifespan oriented, with children, adolescents, adults, and older adults. We have published more than 525 empirical articles, reviews, and book chapters. I lead a multidisciplinary group of researchers from the United States, Canada, Finland, and Australia to advance knowledge and improve health care for the local, state, regional, national, and global communities that we serve.

I have been carefully and intensely reviewing the world literature on chronic traumatic encephalopathy (CTE) and other possible long-term effects of repetitive neurotrauma on brain health for the past 7 years. I have assembled a team of diverse, multidisciplinary experts in neuropathology, neurology, neurobiology, psychiatry, rehabilitation medicine, and neuropsychology to critically examine the literature, conduct new clinical studies, and conduct post-mortem CTE neuropathology studies with community control subjects.

I am routinely asked to serve in a leadership or advisory capacity on matters relating to sport-related concussion and mild TBI in civilians and military personnel. In these roles, we are tasked with synthesizing, translating, and disseminating research findings. From 2008-2010, I was a founding member of the Traumatic Brain Injury Subcommittee of the Defense Health Board, a chartered civilian advisory board to the United States Secretary of Defense. We were tasked with reviewing evidence relating to pre- and post-deployment screening for mild TBI in the military. In 2009, as part of a DoD national working group, we set the agenda for future research on mild TBI diagnostics. I served as a Consensus Panel Member for the Concussion in Sport group during both the 3rd (2008) and 4th (2012) International Conferences on Concussion in Sport at FIFA Headquarters in Zurich, Switzerland, the 5th International Conference in Berlin (2016), and the 6th International Conference in Amsterdam (2022). I served as an Advisor for the Diagnostic & Statistical Manual of Mental Disorders, 5th Edition (DSM-5), Neurocognitive Disorders Workgroup (in Traumatic Brain Injury). I served as Vice Chair of the Policy and Planning Committee of the National Academy of Neuropsychology from 2007-2013. This committee is responsible for writing position and education papers on important topics for the Academy. I was a Member of the Board of Governors of the International Neuropsychological Society from 2008-2011. I am currently a member of the Board of Governors of the International Brain Injury Association. I was the President of the National Academy of Neuropsychology in 2015, the largest organization of professional neuropsychologists in the world, and was on their Board of Governors from 2014-2018. In 2015, I was part of a multidisciplinary group of thought leaders and investigators who put forward a call for improving evaluation, treatment, and rehabilitation services for concussion. I serve on the Scientific Advisory Board for the NCAA-DoD Concussion Assessment, Research, and Education (CARE) Consortium, the largest multi-site prospective concussion study in history. As such, I am well-positioned to ensure that this program of research is impactful, well disseminated, and translational.

Some of our latest research can be viewed on PubMed:
https://www.ncbi.nlm.nih.gov/pubmed/?term=Iverson+GL