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Sex differences in head impact kinematics & neck strength in university rugby union players

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Brain Injuries in Rugby

- 'Concussion' the most common injury sustained during professional men's games Kemp et al. (2018)

- 75% of male community and 85% of male elite players have experienced at least one brain injury Hume et al., (2017)

- Repeated head impacts associated with neurocognitive challenges. Neurodegenerative disease presenting in retired players Hume et al., (2017); Black (2020); Lee, (2019)

- Limited data for women's game, despite accounting for 29% of worldwide rugby population World Rugby (2018)

- Lack of female research & androcentric data problem also in medical and health sciences, vehicle safety testing...

Physical Sex Differences & Brain Injury Risk

- Sports, military & automobile accident BI research – mainly male focused

- Female cervical spine geometry cannot be scaled from male Bonivtch, et al., (2006)
  - Dimorphisms in spinal anatomy linked to increased head-neck movement in vehicle collisions Stemper et al. (2011)
  - Increased female susceptibility to whiplash & concussive injuries Mohan & Huynh (2019)
  - Male cervical spine better at resisting inertial loading of c-spine - greater intervertebral coupling and stability Stemper & Derosia (2009)

- Female axons smaller, fewer microtubules than male Dolle et al. (2018)
  - May contribute to more extensive axonal injury from comparable biomechanical forces
- Not just neck strength – which is significant Salmon et al. (2013); Williams et al. (2021)

Female vs Male Sport-Related Brain Injury

- Females 2.6 times more likely to suffer a concussion in sport Antona-Makoshi et al., (2018); Prien et al., (2019)
- Different head impact mechanisms (soccer/football) Bretzin et al, (2021)
- More likely to report dizziness, fatigue and difficulty concentrating (Kaushik et al., 2005; Priess-Farzanegan et al., 2009)
- Longer return to play & differing symptom burden Covassin, (2007), Bretzin et al. (2017)
- Lack of female-specific research Costello (2014); Cowley et al. (2021)

Sex Differences - Rugby Union Context

- Cervical spine sex dimorphisms important in development of injury prevention & identification frameworks
- Evidence-based practices
  - Generalising male data to females may not be appropriate
  - Female-specific data required to develop
- Differences in injury/performance data
  - Both physical sex differences and gender differences likely contributors
  - Development, coaching expertise, equipment/medical provision
- Historical trends with men's rugby
  - Women's game where men's was in mid 1990's re professionalisation
- Training methods have improved but we need to do better as women's game increases in popularity

Methods, Findings & Implications

European Journal of Sport Science

Routledge
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Sex differences in neck strength and head impact kinematics in university rugby union players

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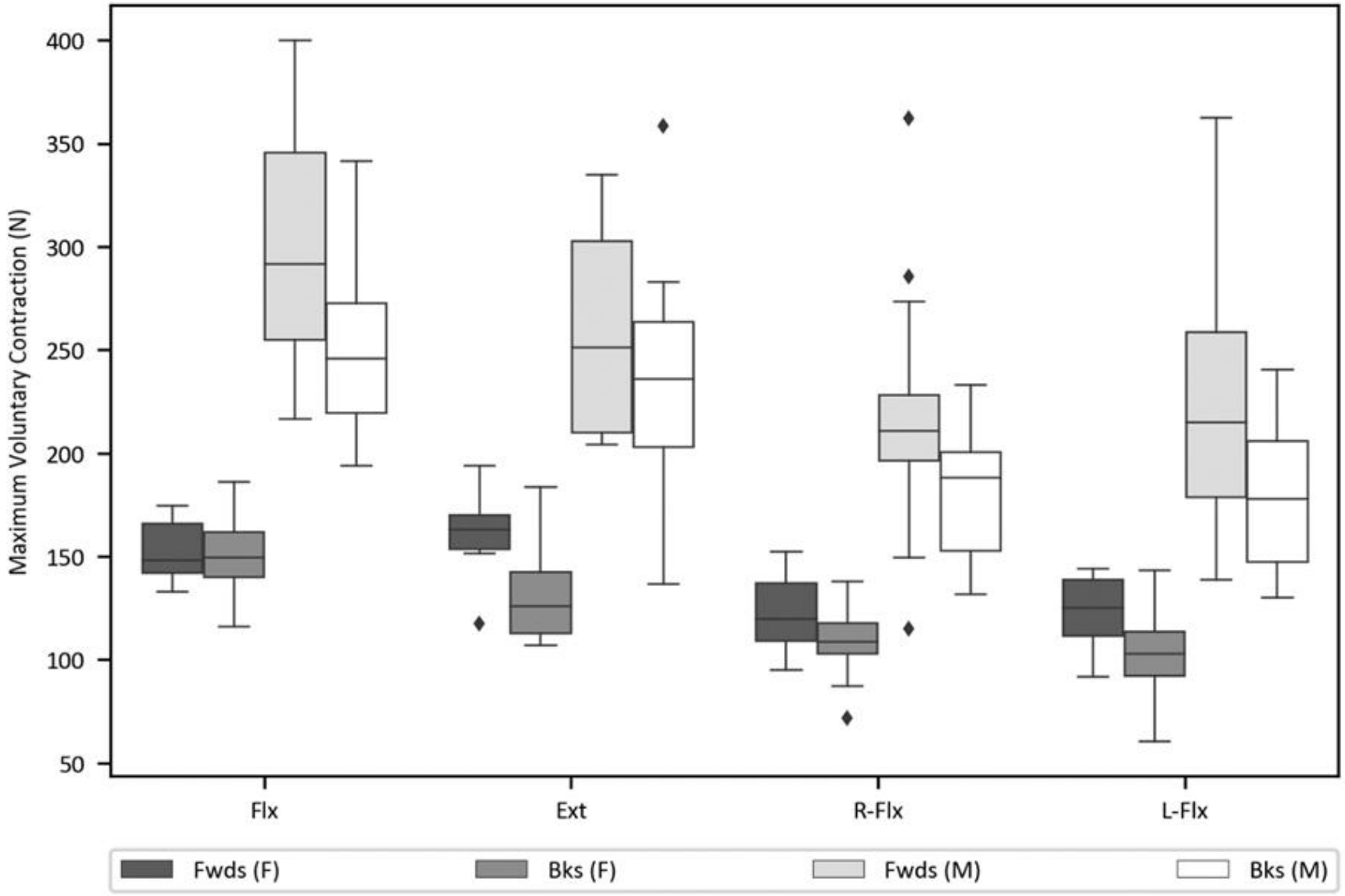
- Neck strength testing
- Head impact measurement
- Sex differences
- Gender differences
- Global Survey
- Future Priorities

Isometric Neck Strength Testing

- Developed safe and repeatable testing method
- INSTA adjustable for each athlete, strapped down to limit accessory muscle involvement
- Force/time plot in real time
- Tested max & endurance, muscle imbalances between flexion, extension, left and right lateral flexion
- Some surprising findings..

Neck Strength Results

- Female neck strength 47% lower than male
- Females less positional specificity between forwards and backs



Head Impact Kinematics Methods

- Custom-made instrumented mouthguards (iMG) fitted to 13 women and 21 men
- Acceleration sensors embedded within mouthguards - iMG
- Measures head linear and angular acceleration
- iMG data paired with video analysis to assess context and mechanisms
- 7 male and 6 female games
- Tight-sensor skull coupling to minimize movement artefact

Head impacts occur

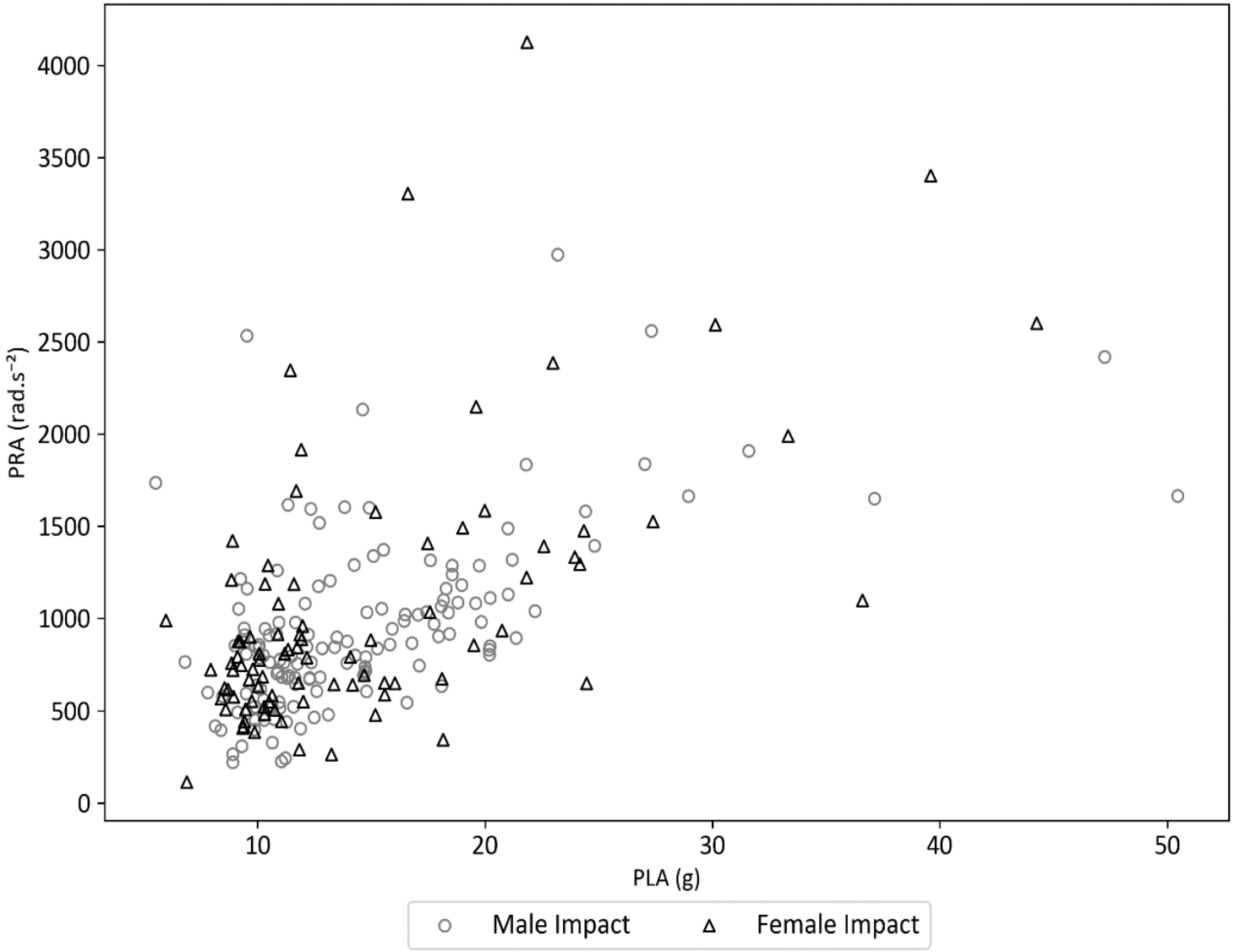
Impact detected and recorded by iMG

Impacts transmitted to sideline receiver in real time

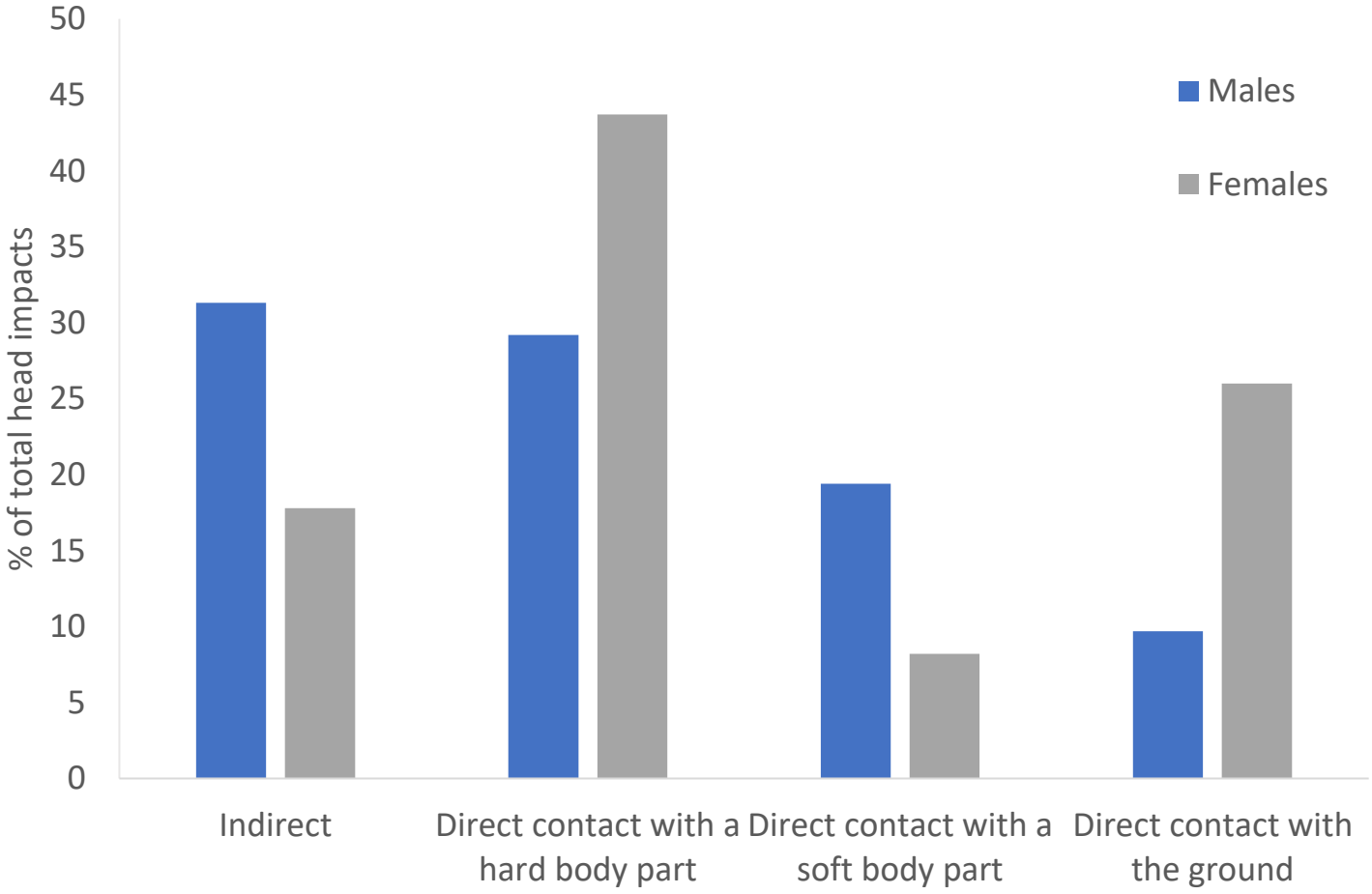
Impact waveforms presented on UI

Head Impact Magnitude (iMG Data)

- 145 male and 73 female impacts were video-verified
- Sex differences in impact magnitude did not significantly differ
- Median Peak linear acceleration (PLA)
  - Male = 12.5 *g* (IQR 7.0)
  - Female = 11.7 *g* (IQR 7.0)
- Median Peak Rotational Acceleration (PRA)
  - Male = 849.4 rad·s^{-2} (IQR 479.8)
  - Female = 800.2 rad·s^{2} (IQR 677.7)



Head Impact Mechanisms

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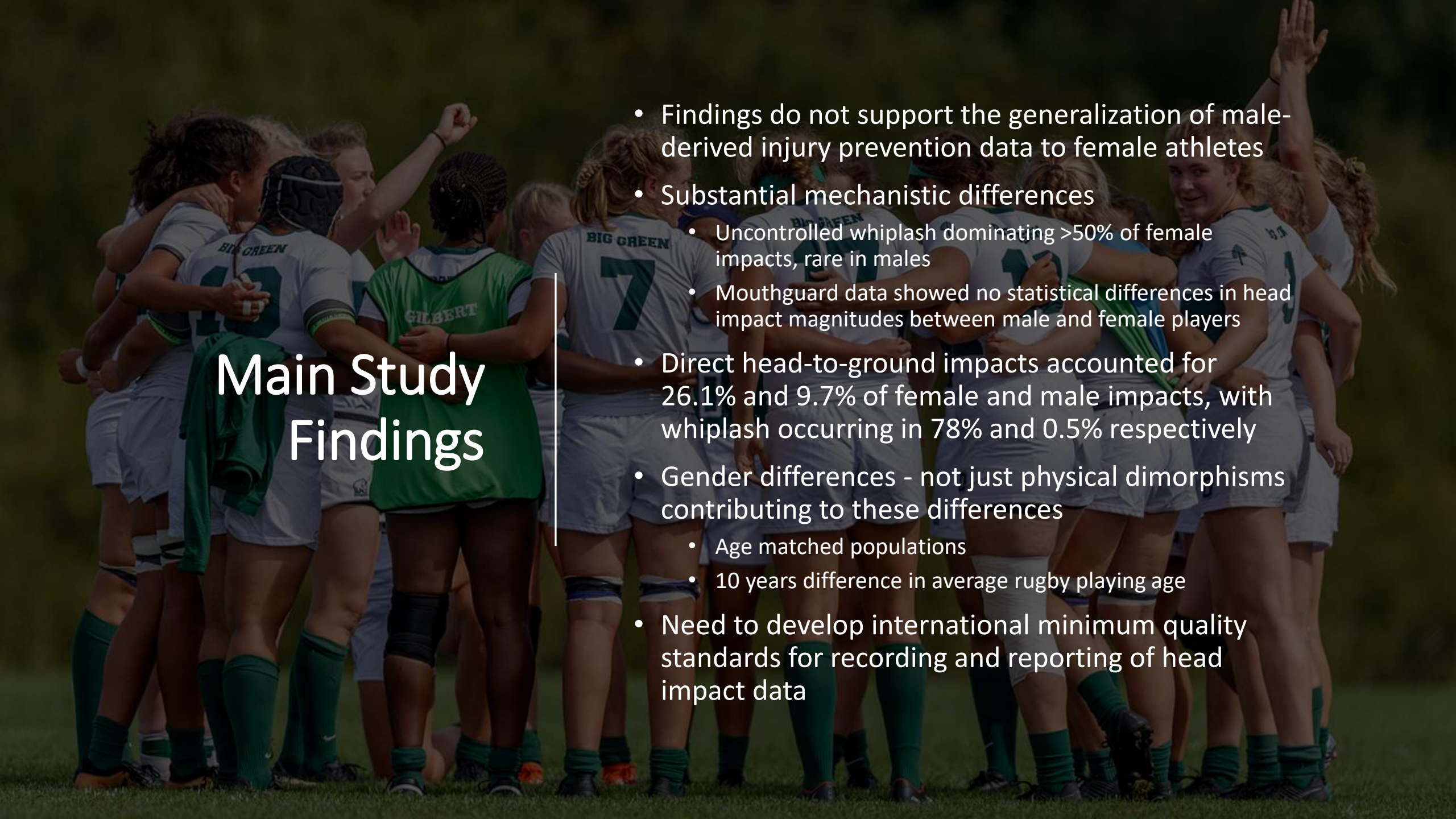

Main Study Findings

- Findings do not support the generalization of male-derived injury prevention data to female athletes
- Substantial mechanistic differences
  - Uncontrolled whiplash dominating >50% of female impacts, rare in males
  - Mouthguard data showed no statistical differences in head impact magnitudes between male and female players
- Direct head-to-ground impacts accounted for 26.1% and 9.7% of female and male impacts, with whiplash occurring in 78% and 0.5% respectively
- Gender differences - not just physical dimorphisms contributing to these differences
  - Age matched populations
  - 10 years difference in average rugby playing age
- Need to develop international minimum quality standards for recording and reporting of head impact data

Global Women's Rugby Survey & Future Priorities

- University study findings inspired global survey by multidisciplinary research team

- Physical sex differences AND gender differences should be considered in:
  - Training
  - Injury prevention
  - Injury identification
  - RTP
  - Injury rehab frameworks

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