# Effects of Playing High School Football on Mental Health in Early Adulthood: An Observational Study

Joint work with Sameer Deshpande*, Jordan Weiss, and Dylan Small**

*First Author; ** Principal Investigator

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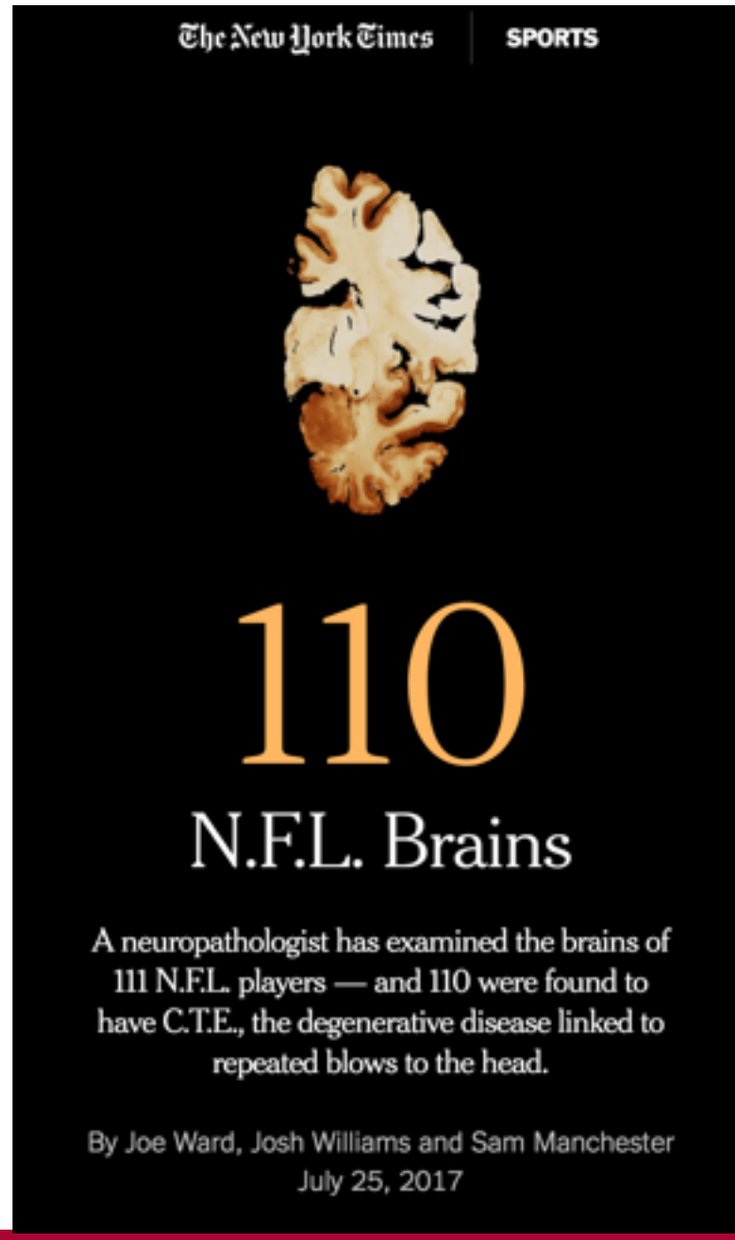
- **Current evidence:** remains inconclusive…

# Current state of the evidence: Post-mortem CTE studies



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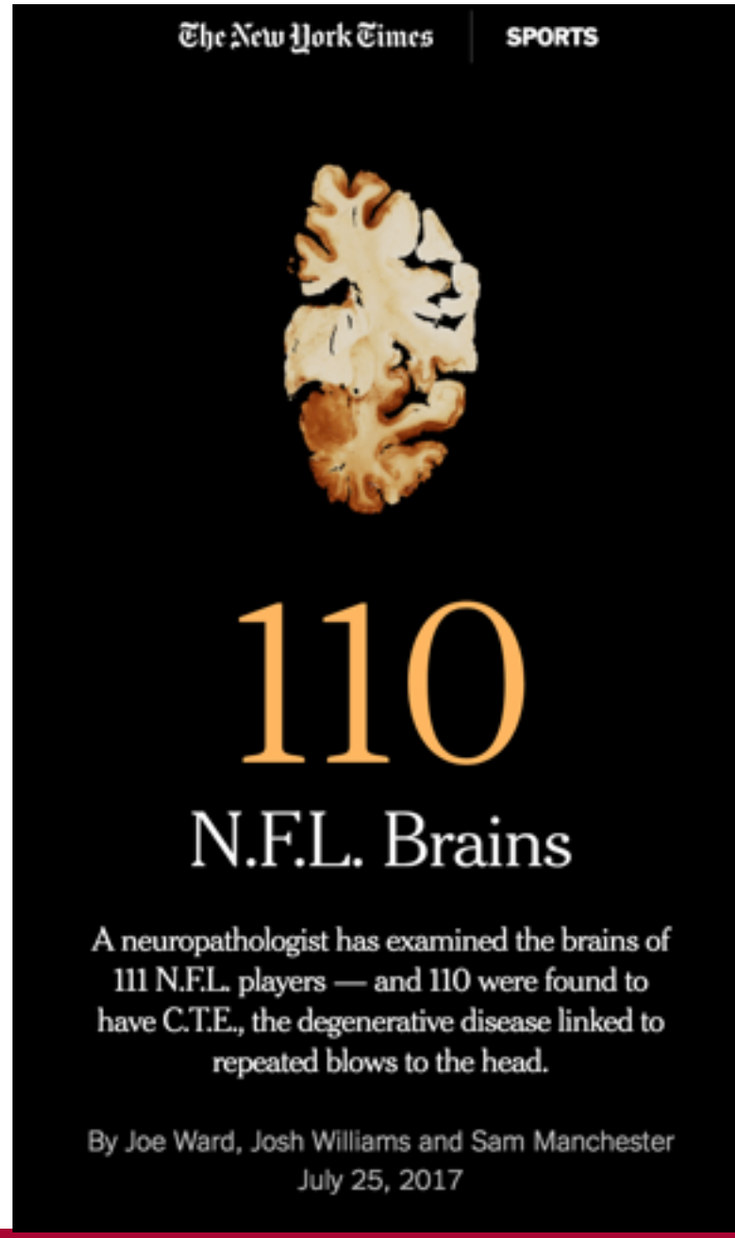

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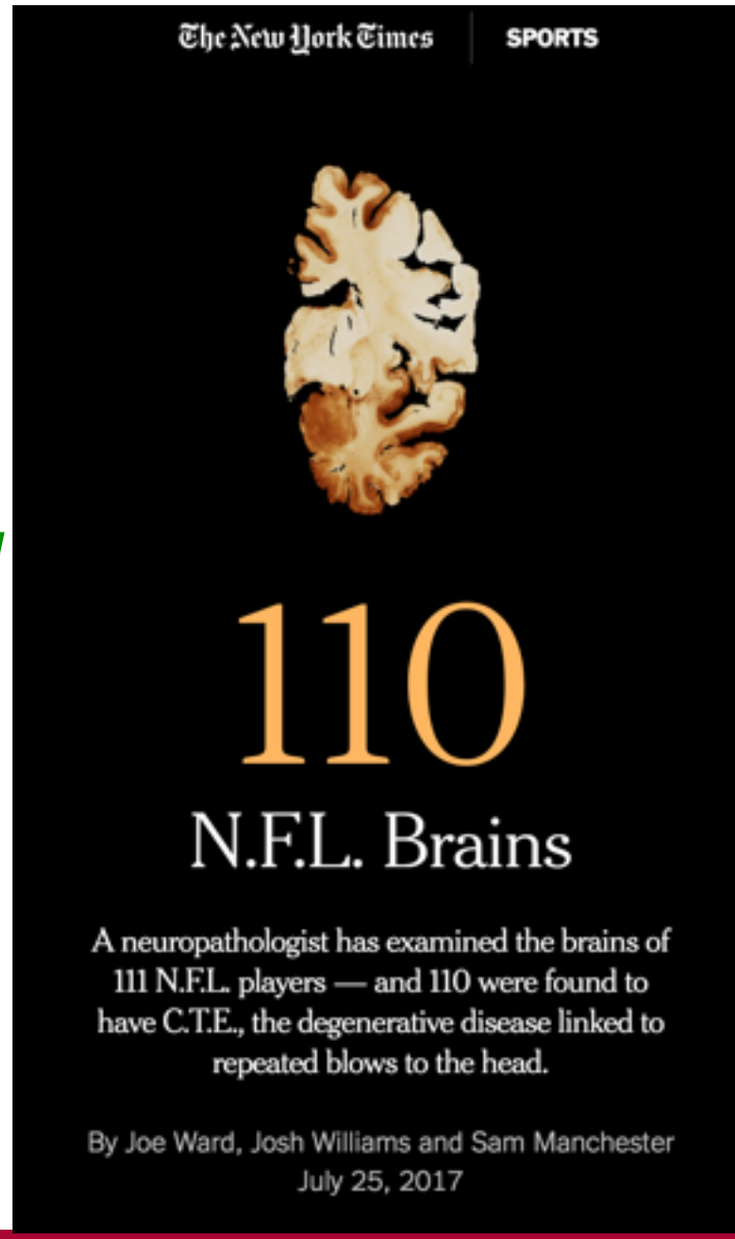

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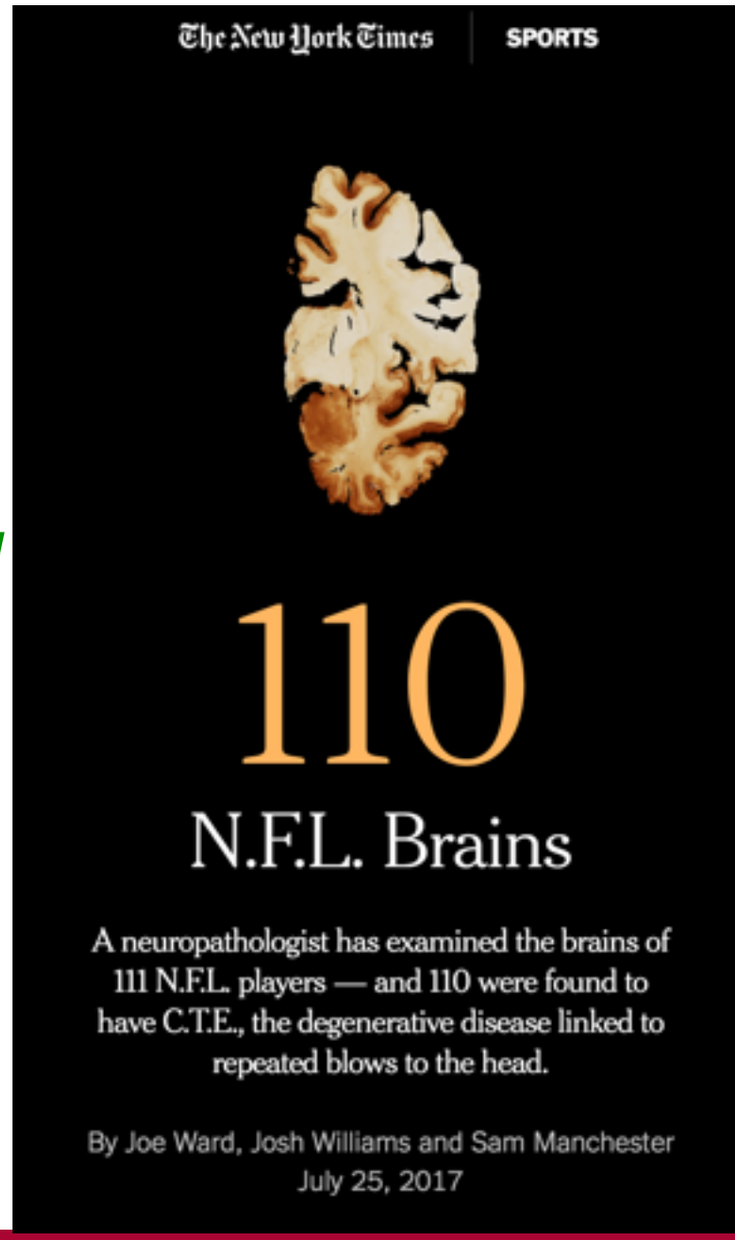
  - *(1)* ***Severe referral bias — donation to brain bank associated with dementia and depression status****, (2) neuropathology overlaps broadly with several neurodegenerative comorbidities (Schwab and Hazrati, 2018), (3) Does not generalize well to most common levels of exposure (i.e. youth and HS football).*



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  \- *(1)* ***No adjustment for important confounders*** *(e.g. adolescent IQ, general health, etc.), (2) relevance of exposure to current players, (3) no measure of dose.*

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- *(1) Relevance of exposure to current players, (2) **Sensitivity of cognitive outcome measures to mTBI-related disease**, (3) no measure of dose.*

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- **Adjusting for important confounders:** availability of rich set of important baseline covariates.

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- **Control:** 2,216 control subjects, 808 participated or intended to participate in a non-collision sport (e.g. basketball or swimming) and 1,408 were non-athletes.

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  ★ *Personality (e.g. Angry Hostility Scale)*

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- **Avoid data-snooping:** Like a RCT, publicly register a pre-analysis plan prior to joint analysis of outcomes and exposure (Rubin, 2007).

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- **Rich set of baseline covariates:** sociodemographic status, school performance/engagement, life plan, social engagement, psychological characteristics, physical functioning.

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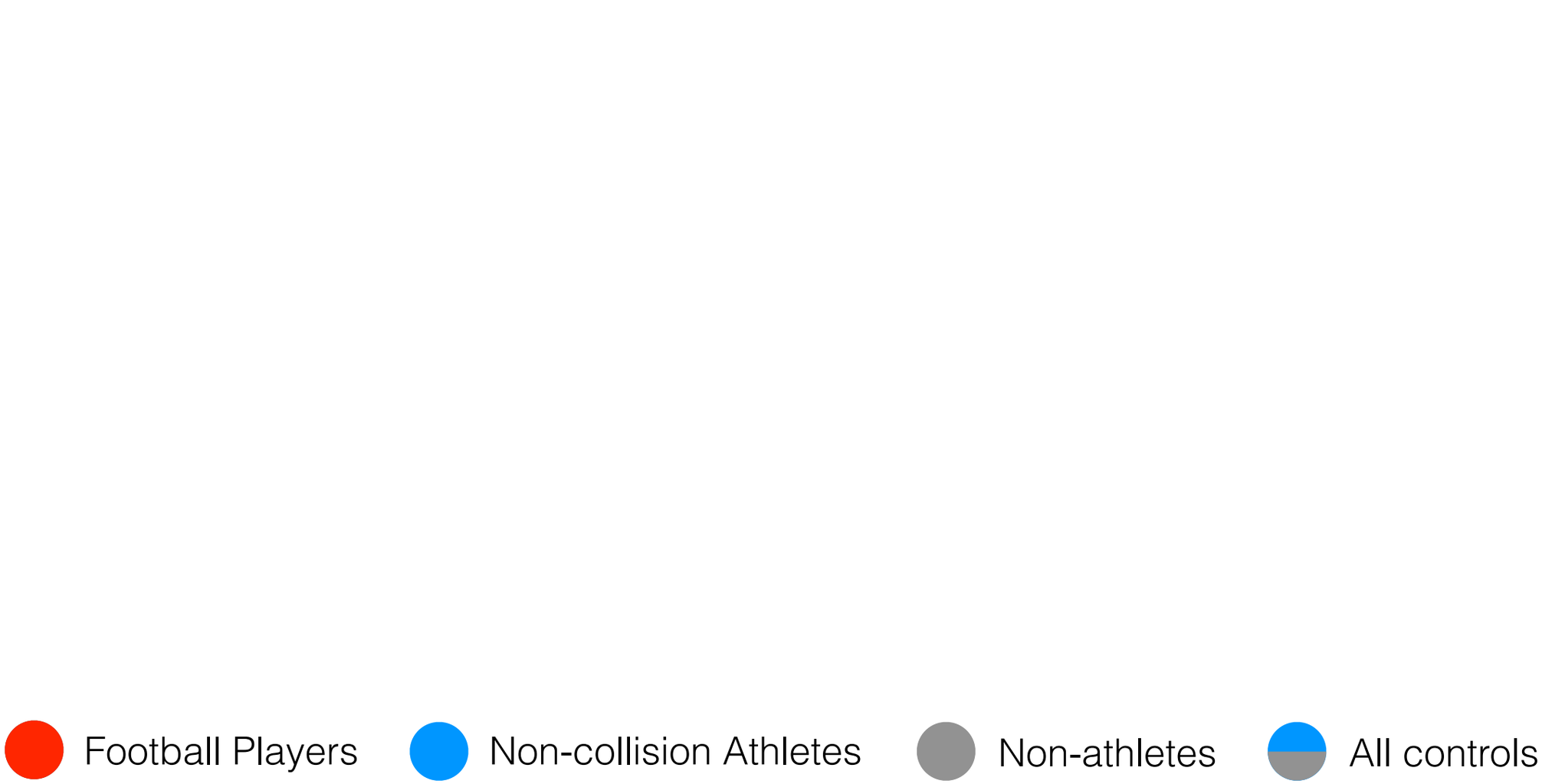
- **Solution:** Developed an ordered testing procedure that seeks reassurance that the natural comparison is not an oversimplification of these *versions* while not sacrificing power in the main comparison (Hasegawa et al., 2018).

# Testing in order: all controls, versions of control, and equivalence of controls



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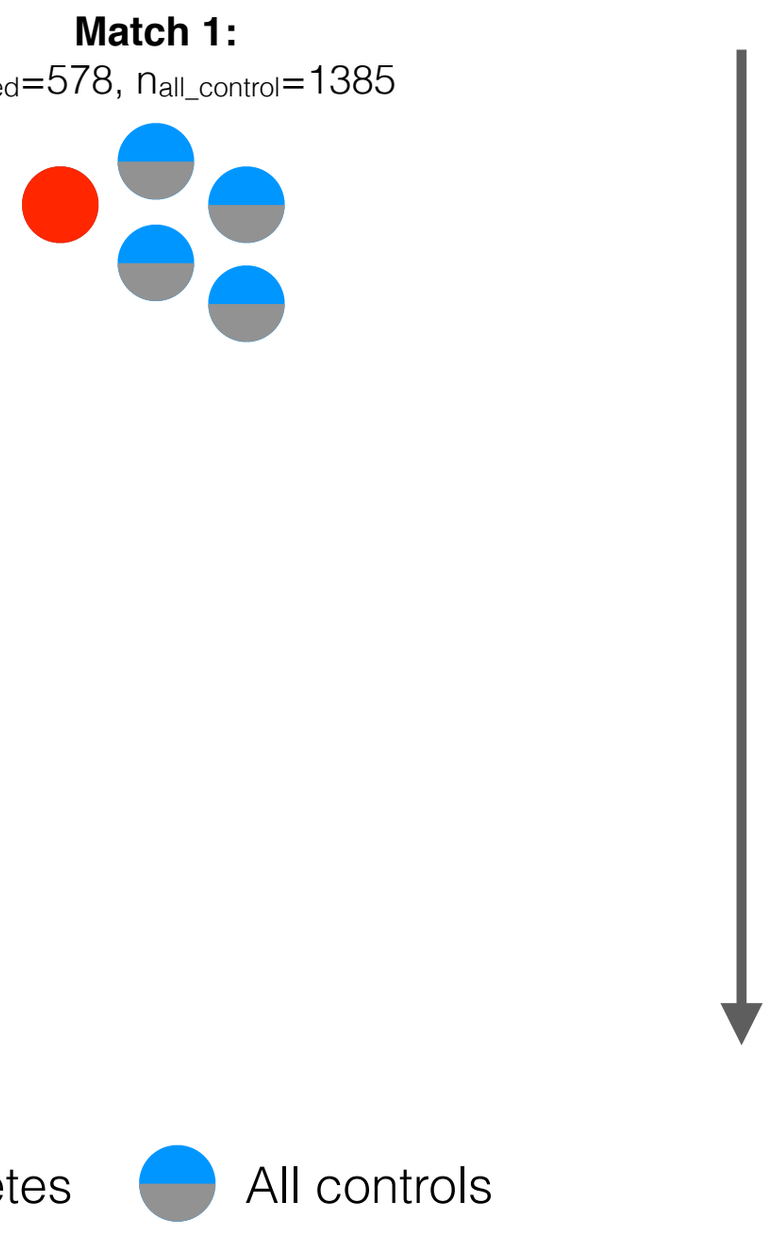
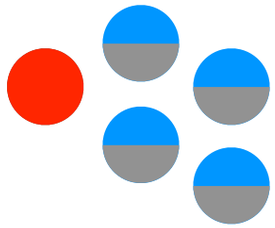
- **Match 1:** treatment vs. all controls — maximize power.



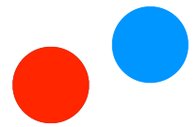
# Testing in order: all controls, versions of control, and equivalence of controls

- **Match 1:** treatment vs. all controls — maximize power.
- **Match 2 & 3:** treatment vs. non-collision athletes & treatment vs. non-athletes — are athletes inherently different than non-athletes? do positive effects of playing a sport counteract negative effects from head-injury exposure?

**Match 1:**
$n_{treated}$=578, $n_{all\_control}$=1385



**Match 2:**
$n_{treated}$=444, $n_{non\text{-}collision}$=606



**Match 3:**
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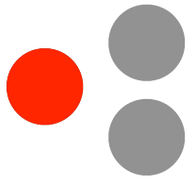

Football Players  Non-collision Athletes  Non-athletes  All controls

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- **Match 4:** equivalence test of non-collision athletes vs. non-athletes — seek further reassurance that the comparison in Match 1 is appropriate.

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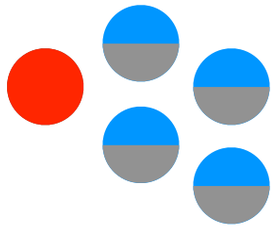

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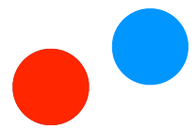

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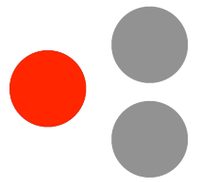
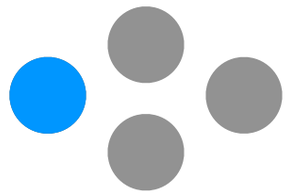


**Match 4:**
$n_{non\text{-}collision}$= 596, $n_{non\text{-}athlete}$= 1047



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- Open to advice, comments, and suggestions from experts on Add Health to help us refine our analysis plan.

# Thank you!

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# BACKUP SLIDE [1/2]: An additional feature of our observational study design

- **Minimize variance without making additional modeling assumptions:** Agnostic covariance adjustment using flexible machine learning algorithms (Rosenbaum, 2002).

# BACKUP SLIDE [2/2]: Flexible covariance adjustment: Bayesian Additive Regression Trees (BART)

- Under hypothesis of an additive treatment effect $\tau$ can infer potential outcomes had all subjects received control.

- Can use machine learning algorithms to "model" potential outcomes under control to reduce variance coming from residual imbalances in prognostic covariates after matching.

- Correctness of "model" not required for valid inference, that comes from randomization or like-randomized observational study.

- BART is a flexible, Bayesian regression algorithm with nice regularization properties.