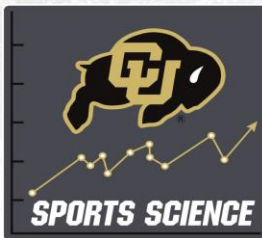
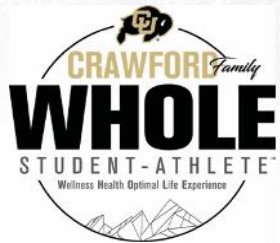




Defining Thresholds and Trends in Women's Sports

Sydney Stanton and Carter Zborowski





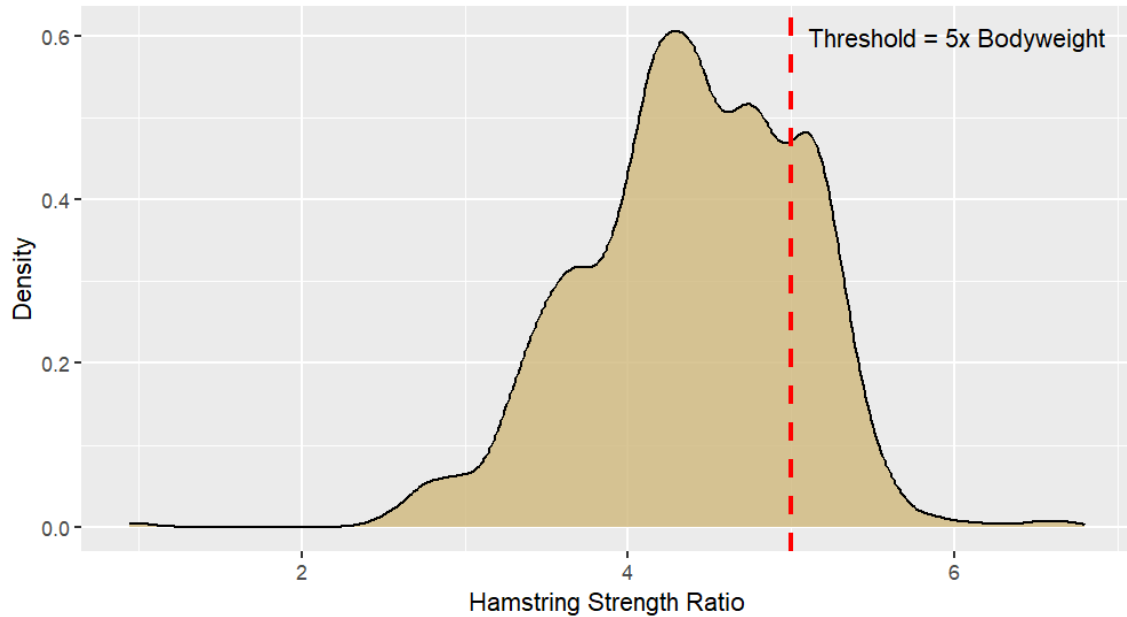
Question 1:

What are meaningful thresholds for strength metrics as they relate to lower body injury risk?



Hamstring Strength Threshold

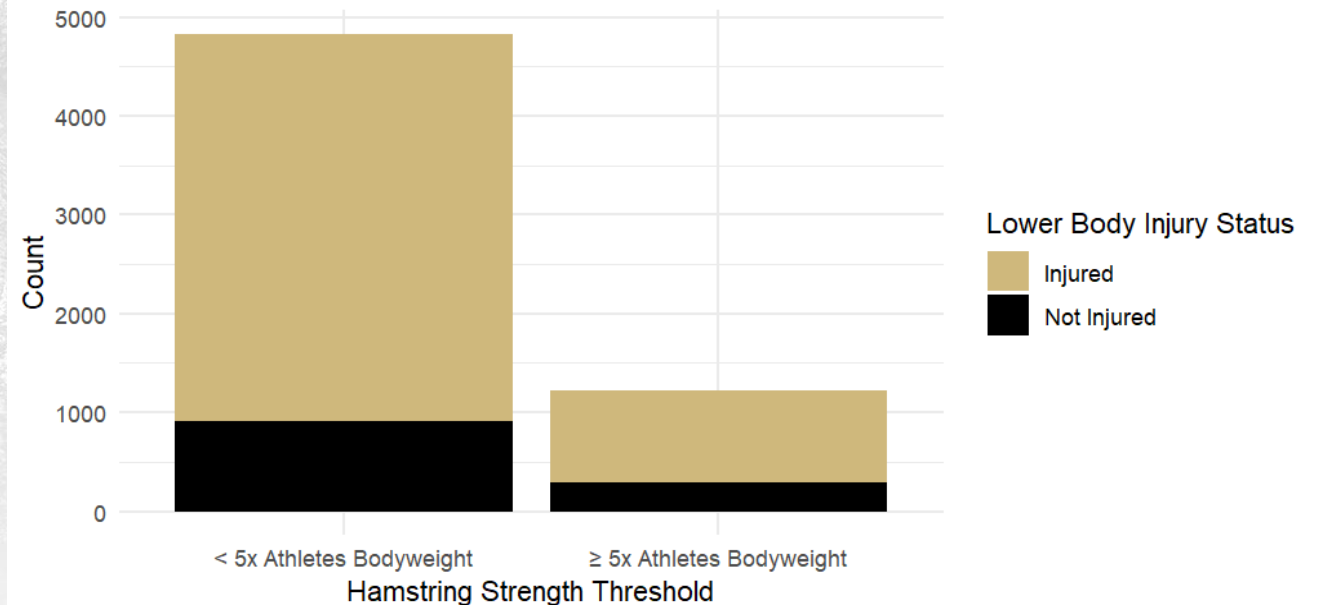
Density Plot: Hamstring Strength Ratio



Statistically Significant:
p-value= 0.000672

Female athletes who are above the threshold have a 22% lower risk of a lower body injury.

Lower Body Injury Count by Hamstring Strength Threshold



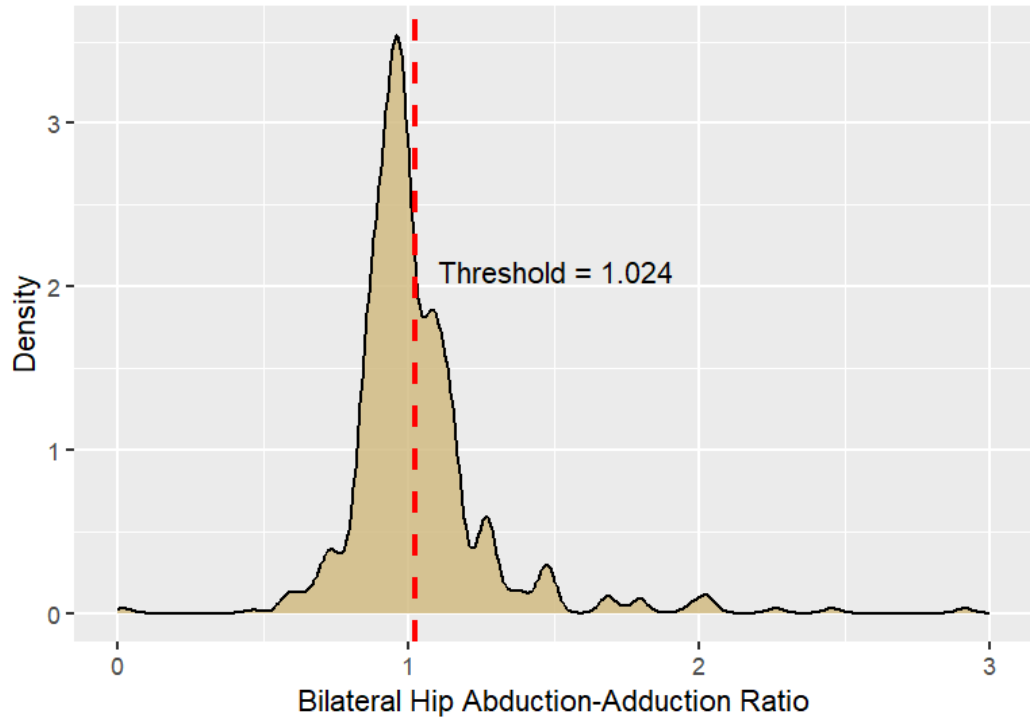


Hip Performance Metrics Thresholds



Bilateral Hip Abduction Adduction Threshold

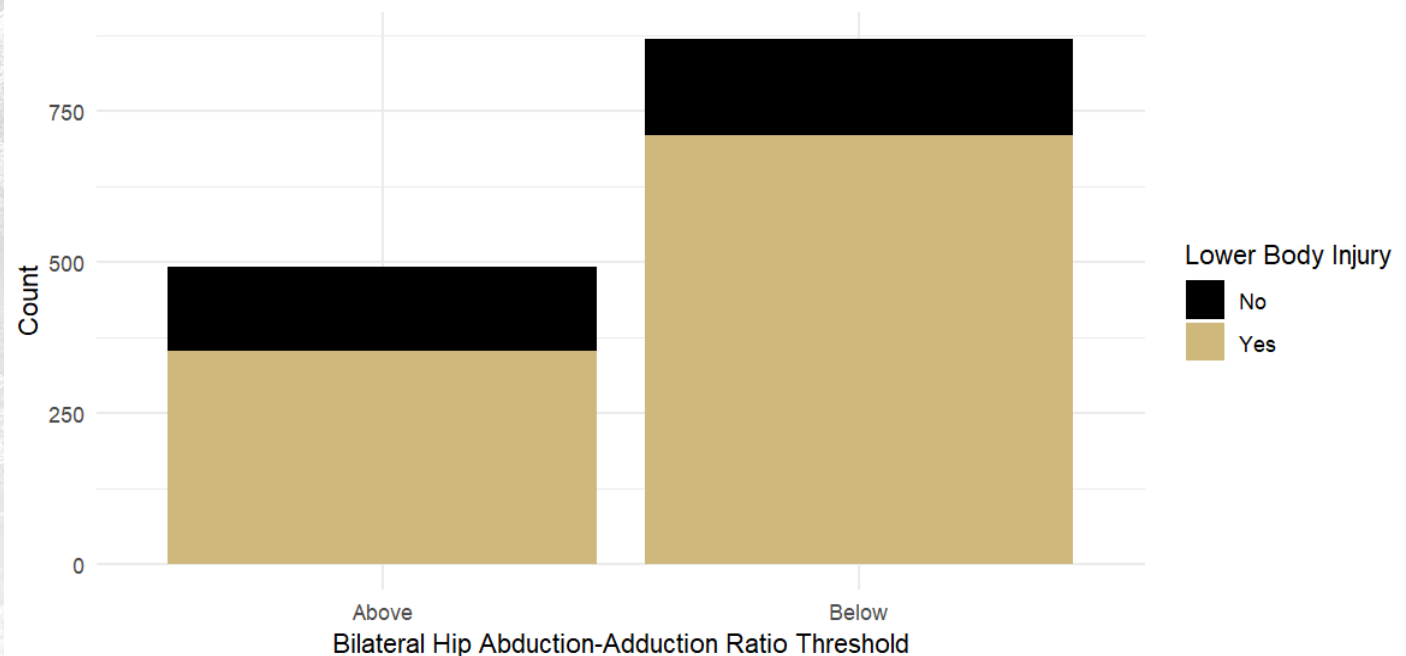
Density Plot: Bilateral Hip Abduction-Adduction Ratio



Statistically Significant:
 $p\text{-value} = 1.15e^{-06}$

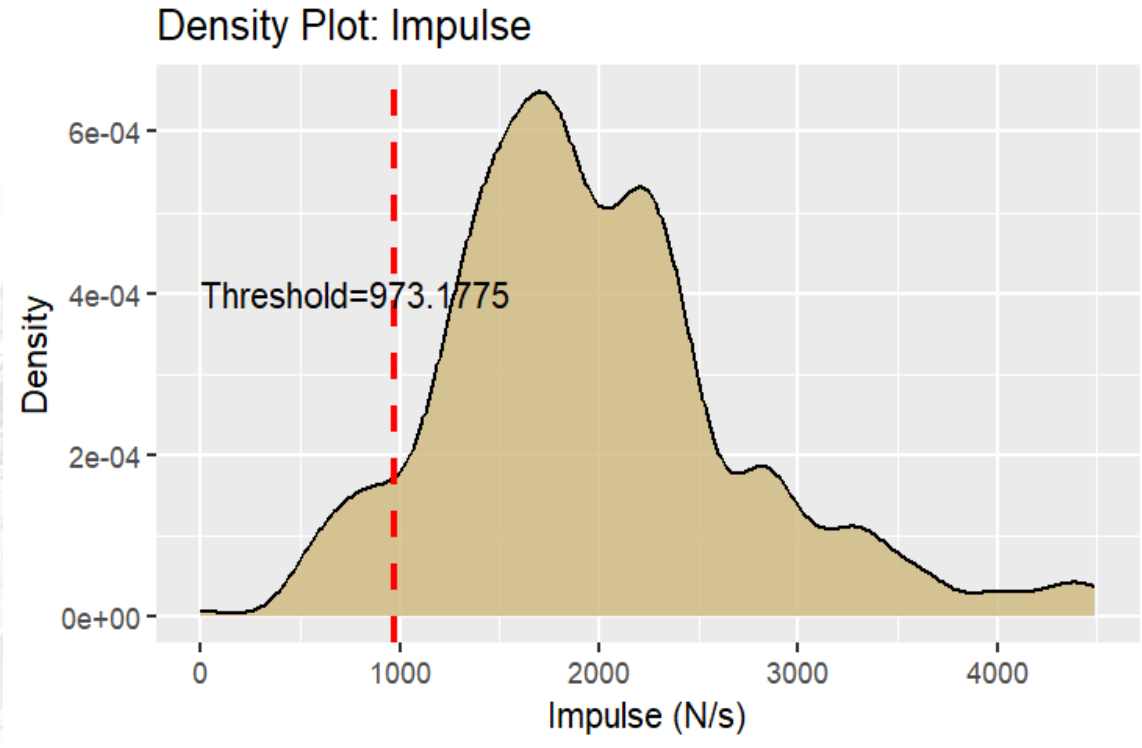
Female athletes who are above the threshold have about a 45% lower risk of a lower body injury.

Lower Body Injury Count Above vs Below the Bilateral Hip Abduction-Adduction Threshold



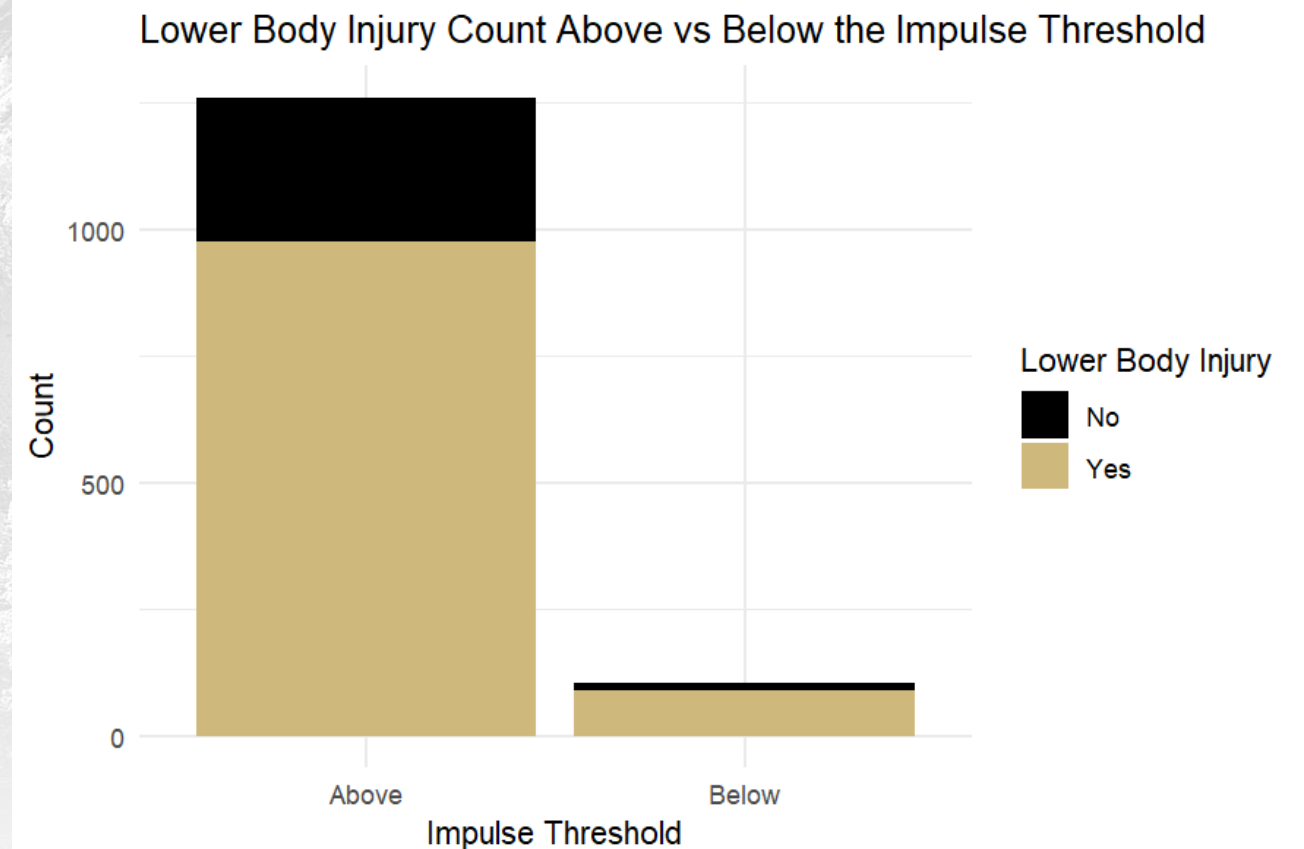


Impulse Threshold



Statistically Significant:
p-value= 0.0153

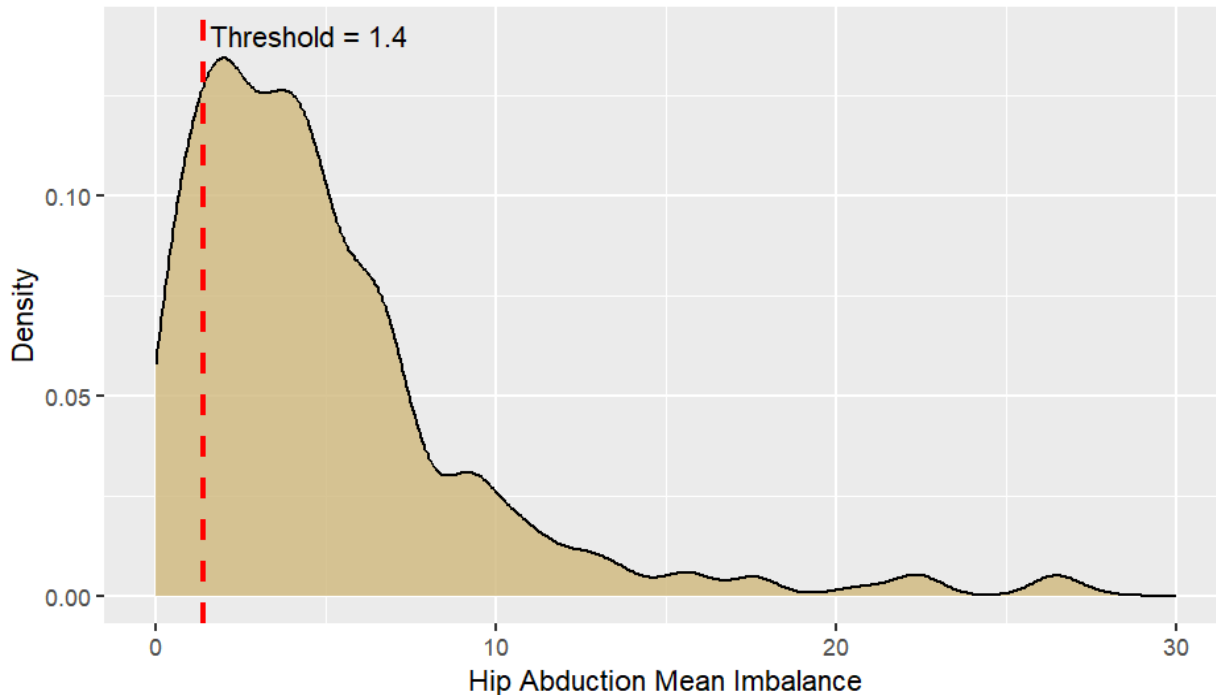
Female athletes who are above the threshold have about a 46% lower risk of a lower body injury.





Average Hip Abduction Imbalance Threshold

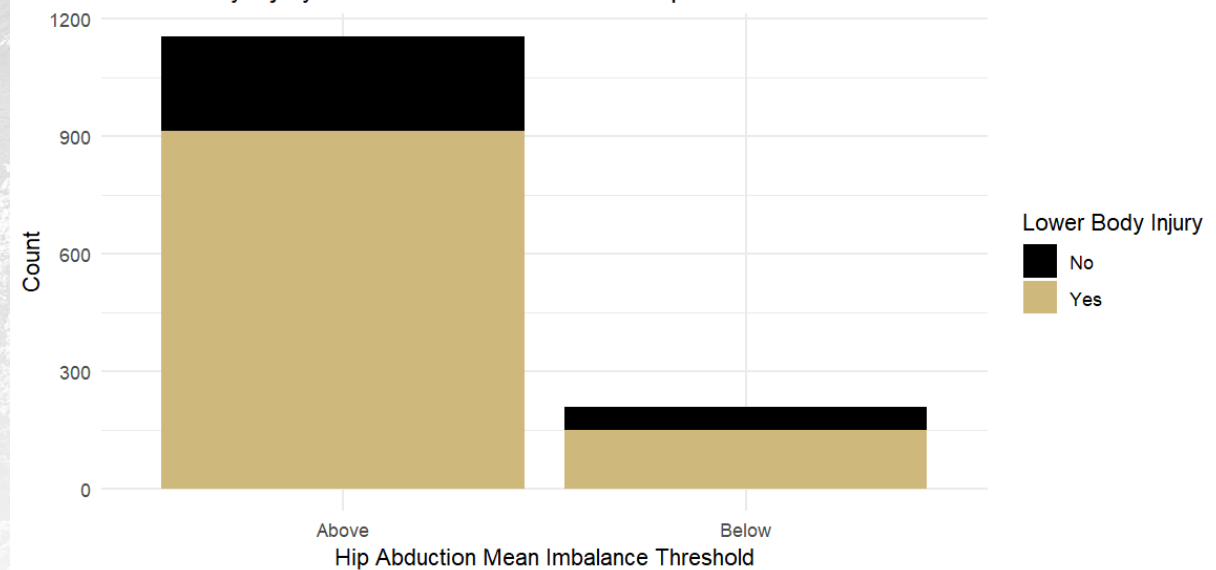
Density Plot: Hip Abduction Mean Imbalance



Statistically Significant:
p-value= 0.0126

Female athletes above the threshold have 1.48 times higher odds of sustaining a lower body injury.

Lower Body Injury Count Above vs Below the Hip Abduction Mean Imbalance Threshold



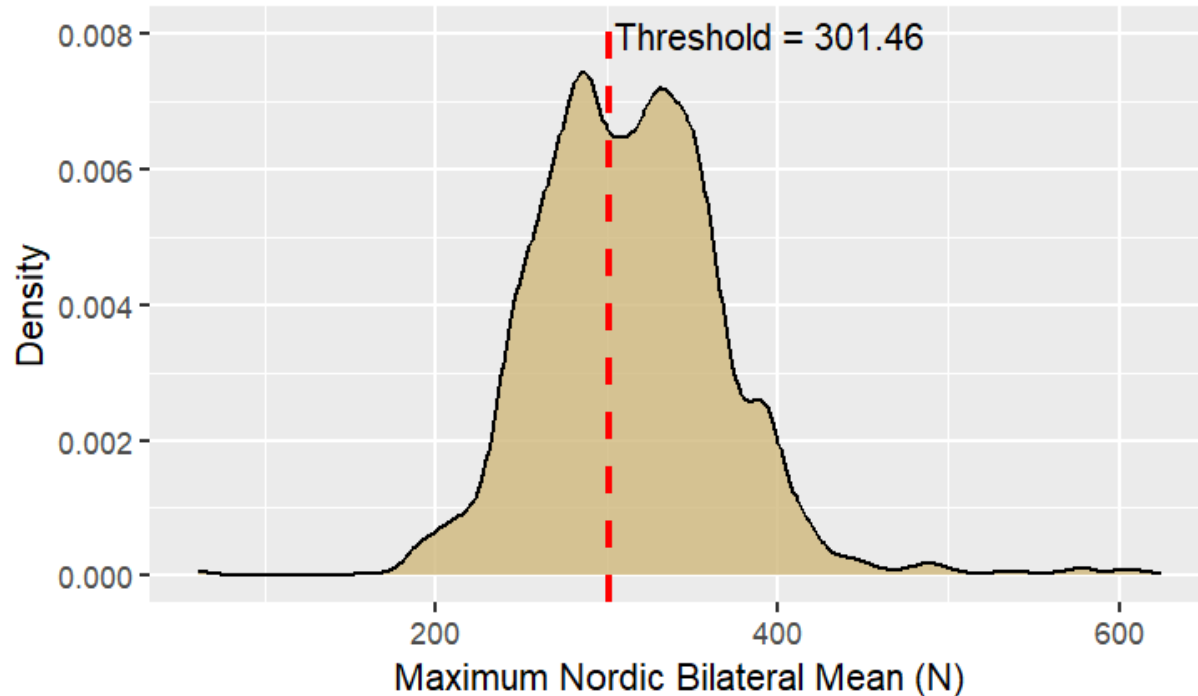


Nordic Performance Metrics Thresholds



Average Maximum Nordic Bilateral Threshold

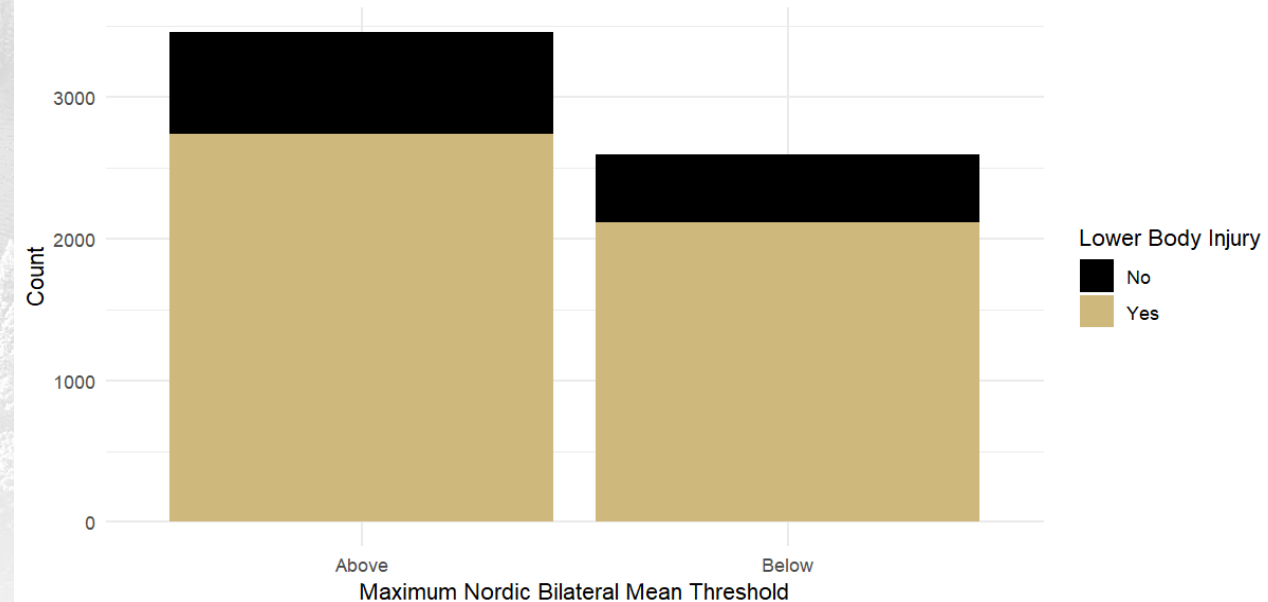
Density Plot: Maximum Nordic Bilateral Mean



Statistically Significant:
p-value= 0.0028

Female athletes who are above the threshold have about 17% lower risk of a lower body injury.

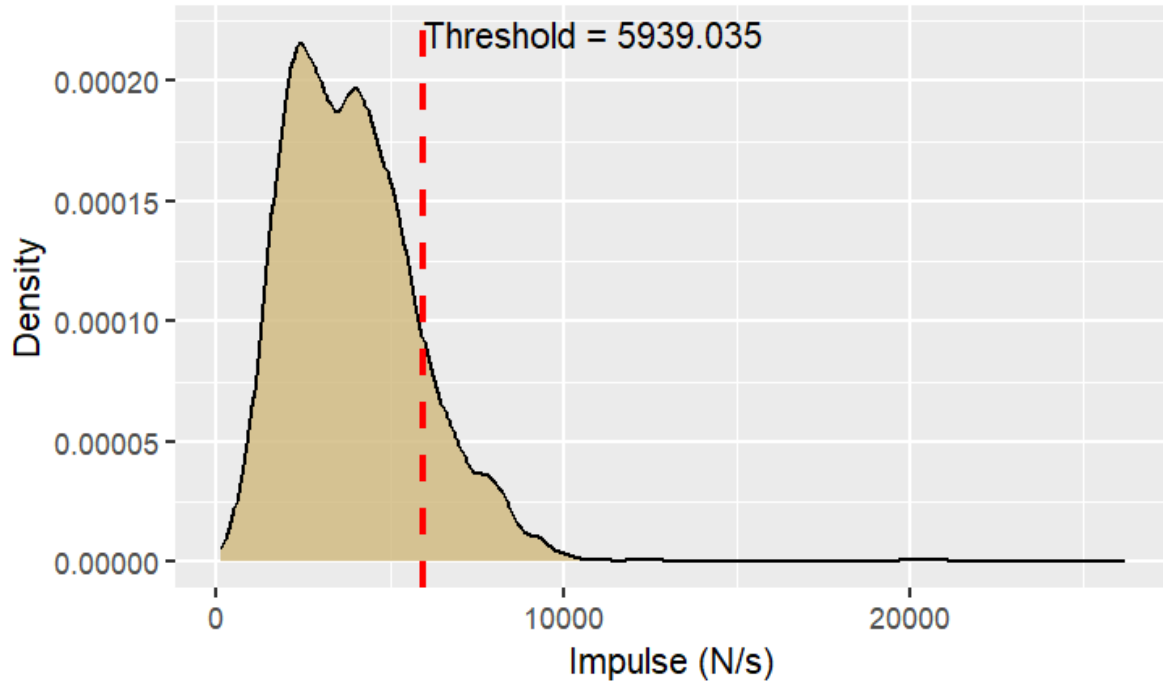
Lower Body Injury Count Above vs Below the Maximum Nordic Bilateral Mean Threshold





Impulse Threshold

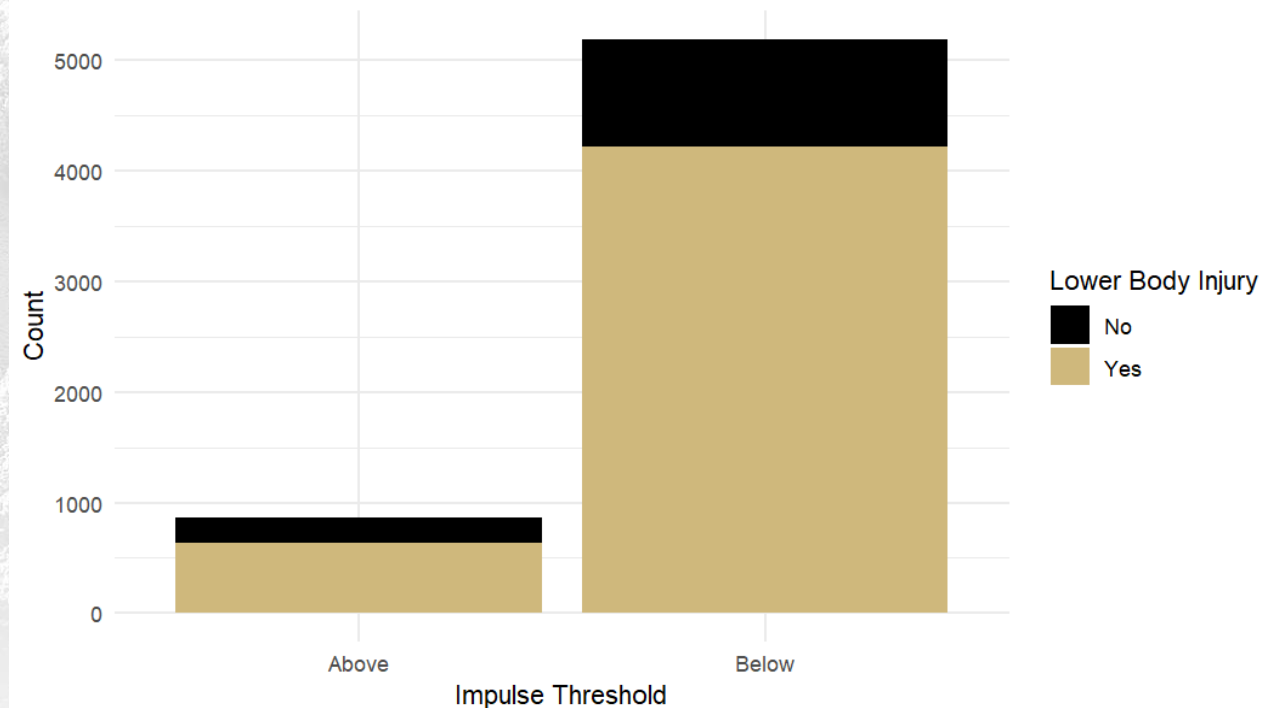
Density Plot: Impulse



Statistically Significant:
p-value = $1.5e^{-09}$

Female athletes who are above the threshold have about a 38% lower risk of a lower body injury.

Lower Body Injury Count Above vs Below the Impulse Threshold



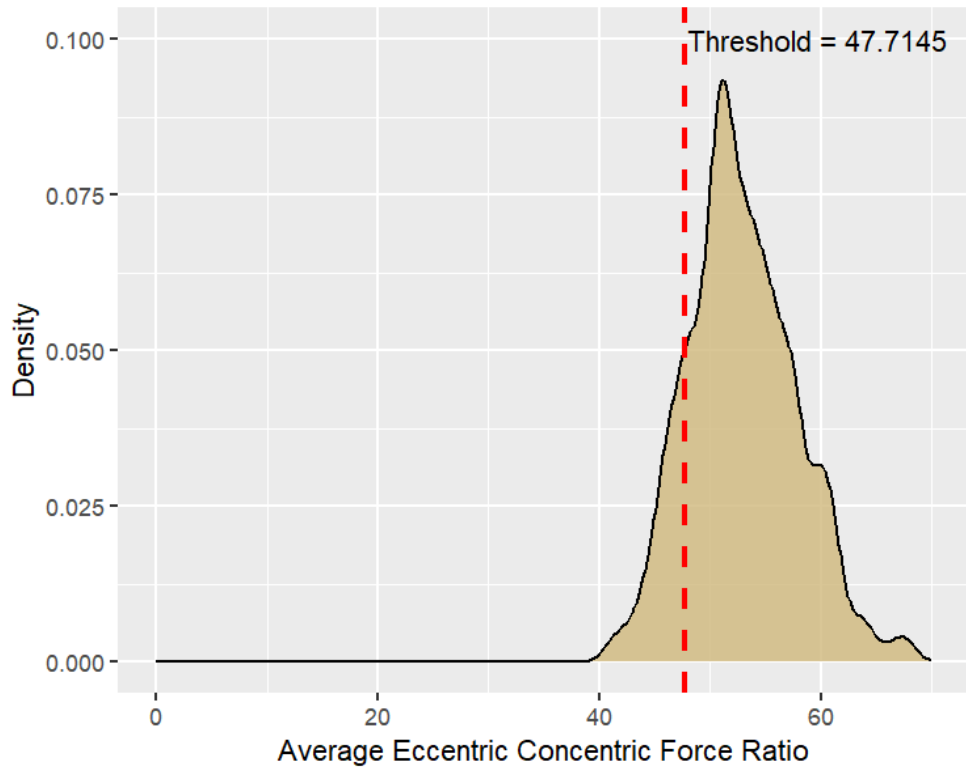


Countermovement Jump Metrics Thresholds



Average Eccentric Concentric Force Ratio Threshold

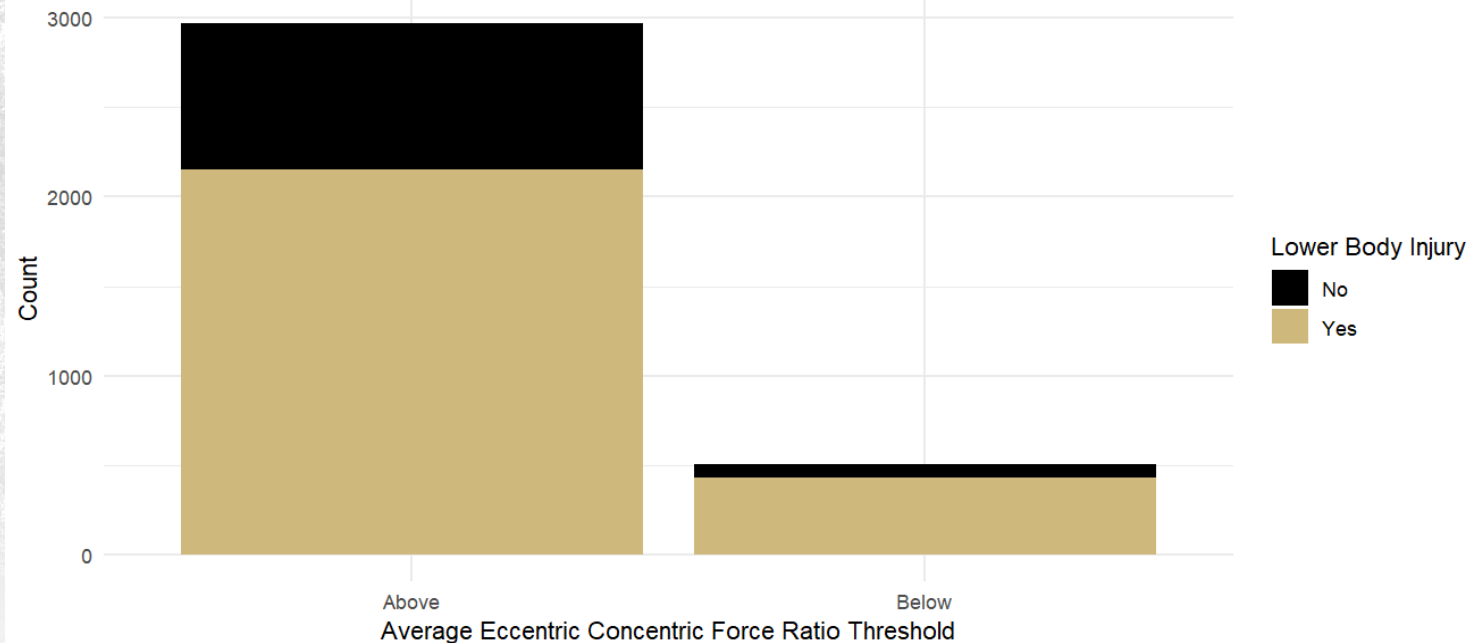
Density Plot: Average Eccentric Concentric Force Ratio



Statistically Significant:
 $p\text{-value} = 3.87e^{-09}$

Female athletes who are above the threshold have about a 54% lower risk of a lower body injury.

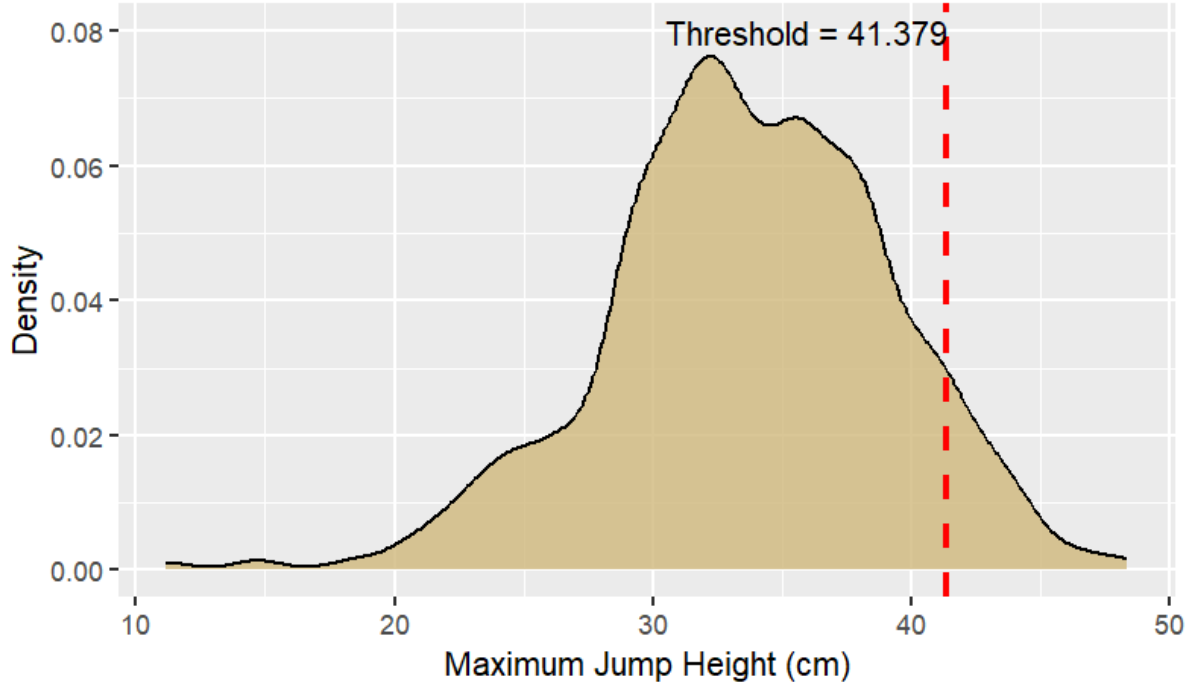
Lower Body Injury Count Above vs Below the Average Eccentric Concentric Force Ratio Threshold





Maximum Jump Height Threshold

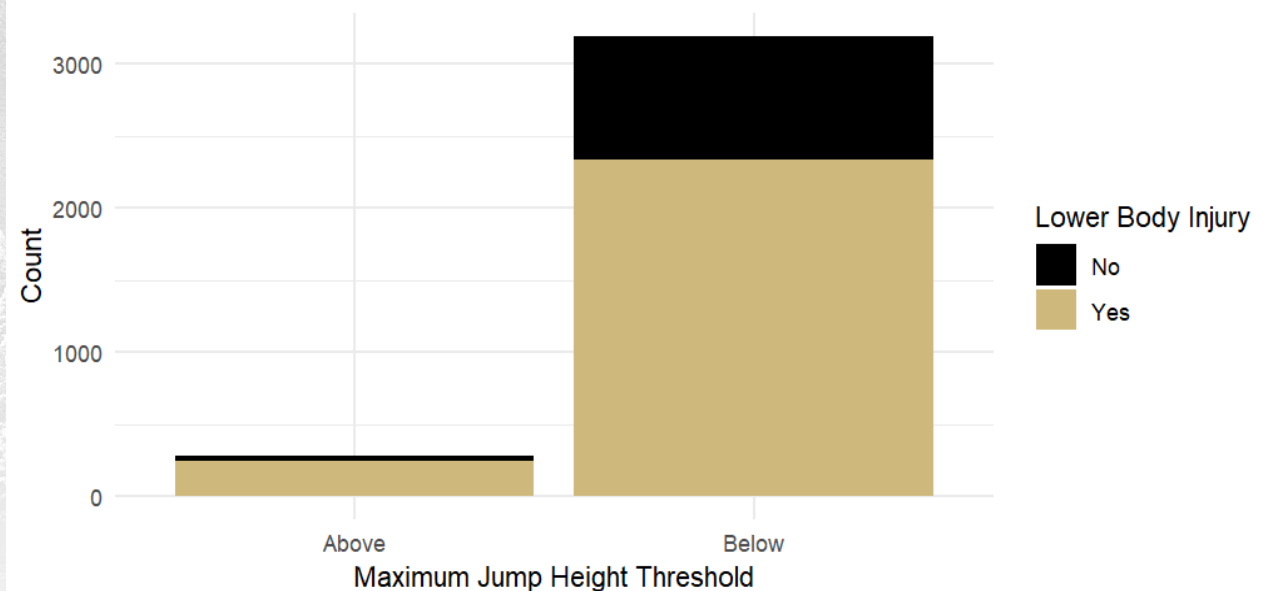
Density Plot: Maximum Jump Height



Statistically Significant:
 $p\text{-value} = 1.66e^{-07}$

Female athletes who are above the threshold have 2.66 times higher odds of sustaining a lower body injury.

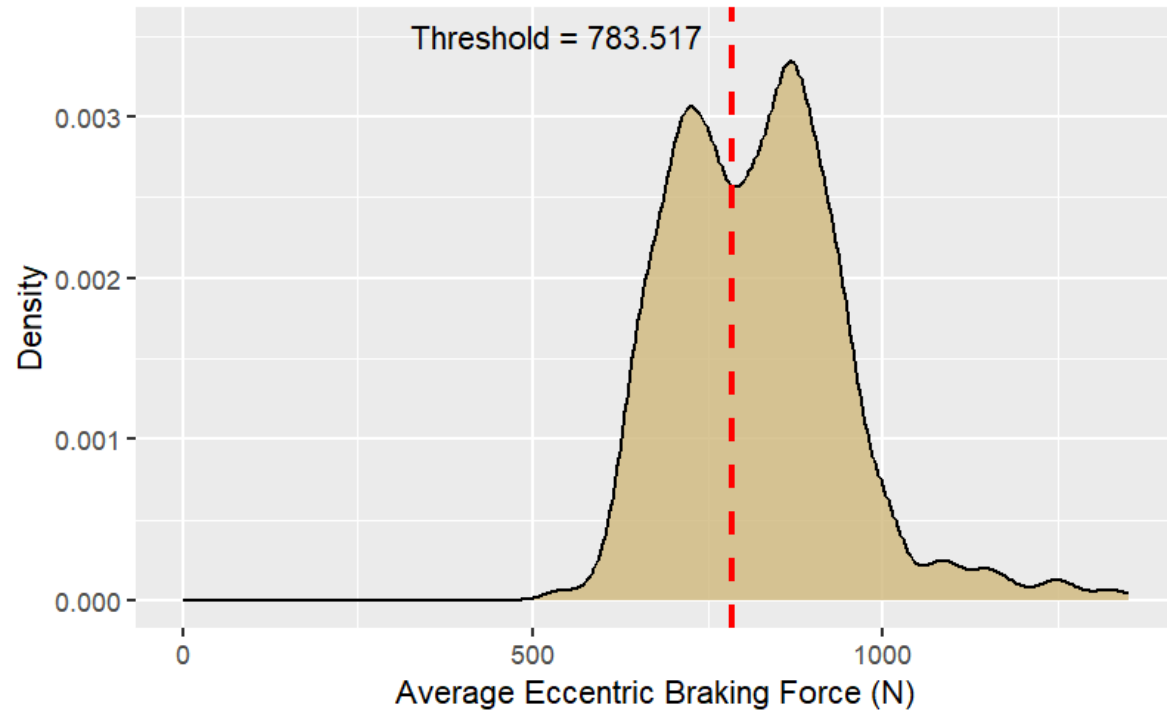
Lower Body Injury Count Above vs Below the Maximum Jump Height Threshold





Average Eccentric Braking Force Threshold

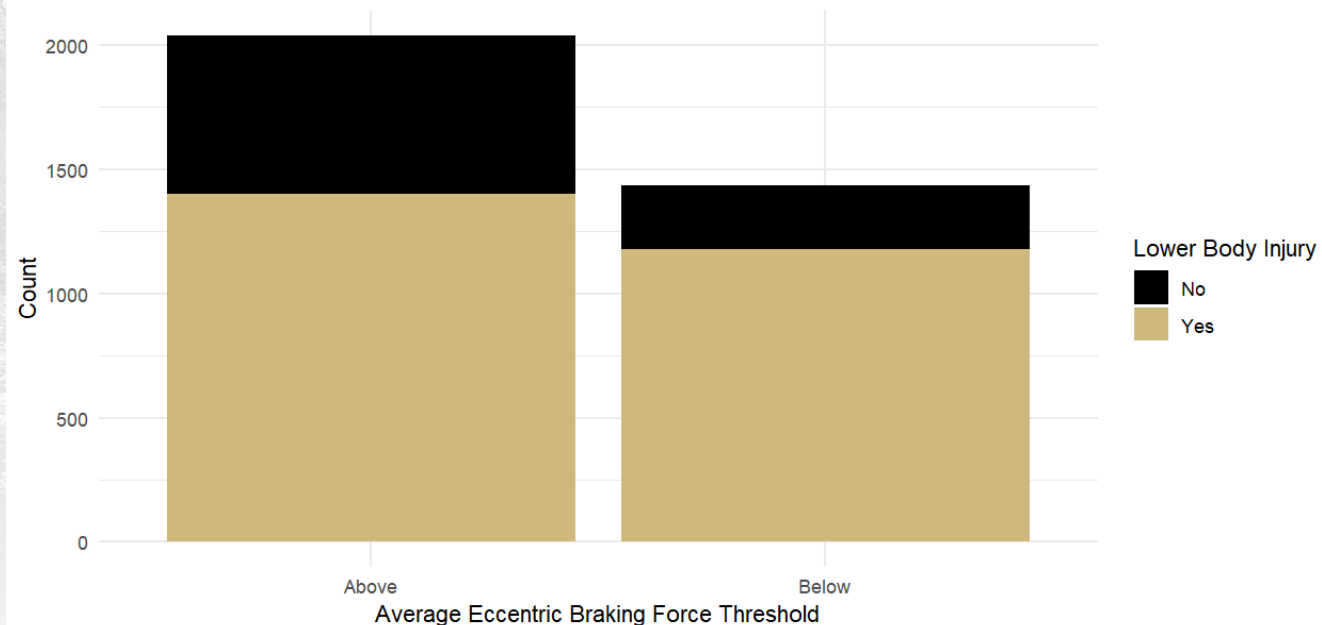
Density Plot: Average Eccentric Braking Force



Statistically Significant:
 $p\text{-value} = 2e^{16}$

Female athletes who are above the threshold have about a 53% lower risk of a lower body injury.

Lower Body Injury Count Above vs Below the Average Eccentric Braking Force Threshold



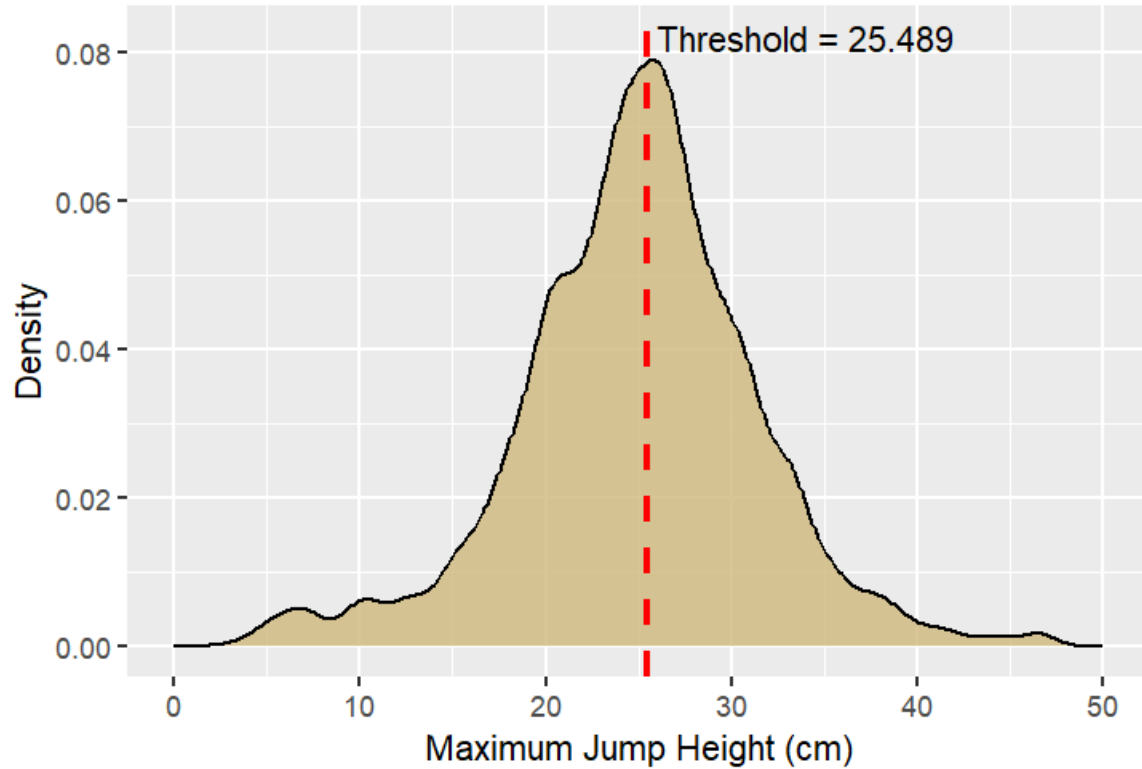


Hop Jump Metrics Thresholds



Maximum Jump Height Threshold

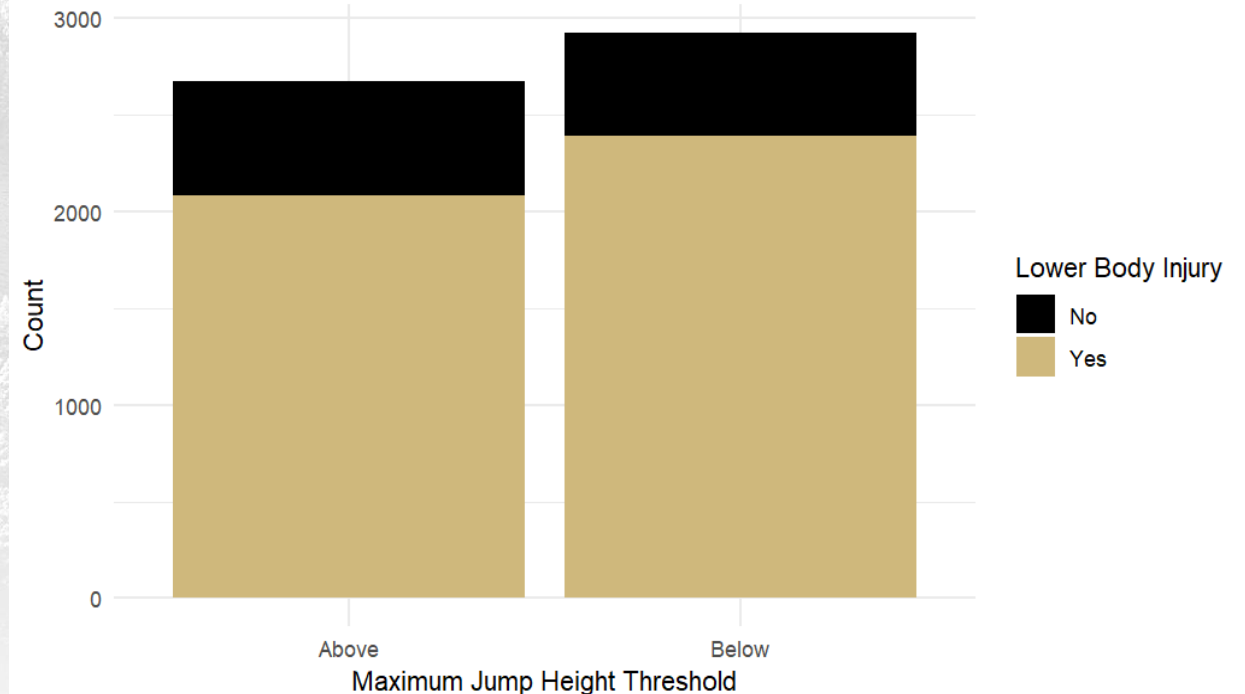
Density Plot: Maximum Jump Height



Statistically Significant:
p-value= 0.000293

Female athletes who are above the threshold have about a 22% lower risk of a lower body injury.

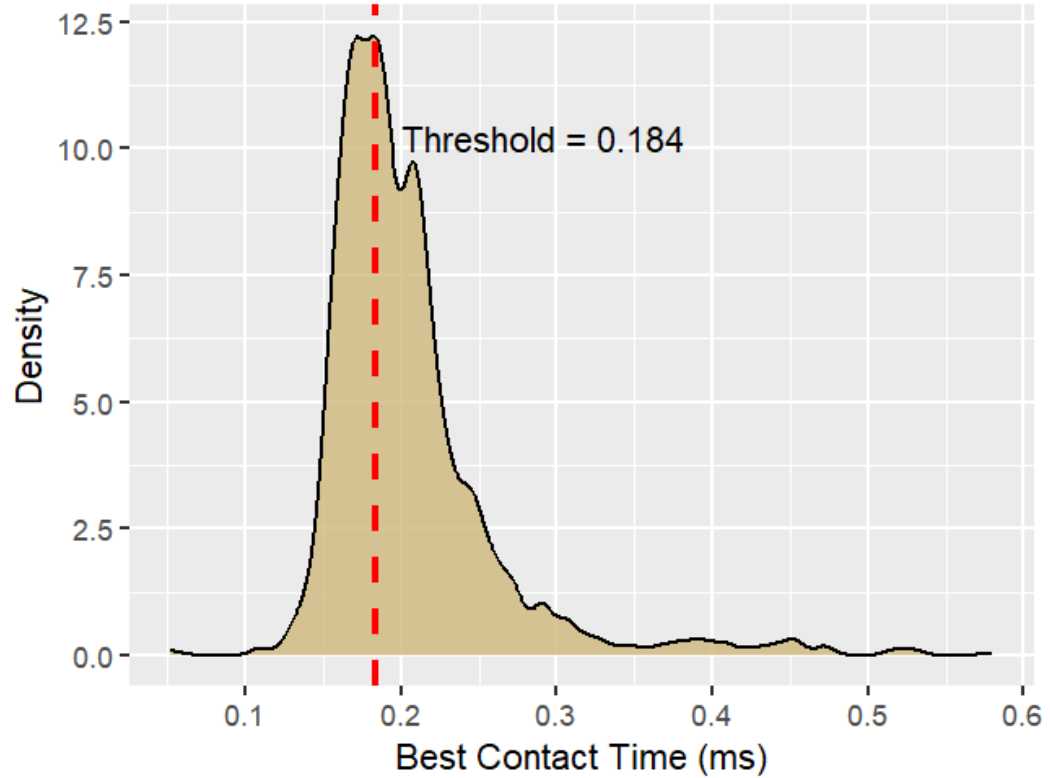
Lower Body Injury Count Above vs Below the Maximum Jump Height Threshold





Best Contact Time Threshold

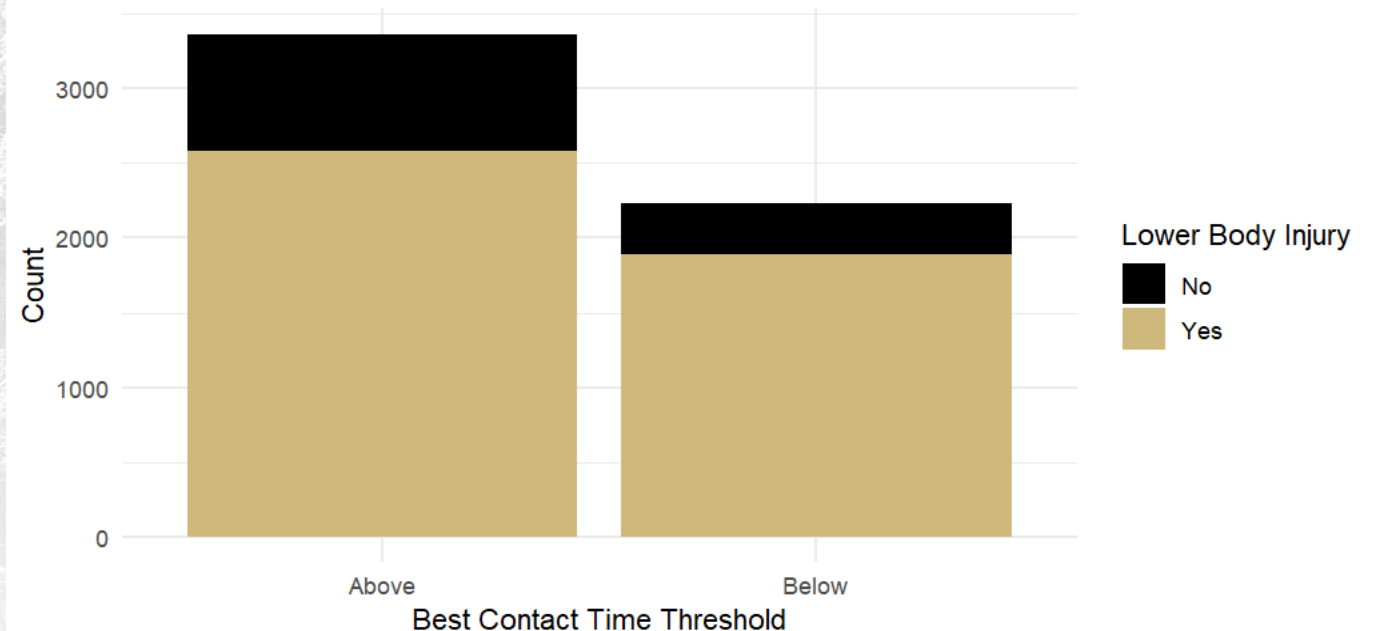
Density Plot: Best Contact Time



Statistically Significant:
 $p\text{-value} = 8.93e^{-13}$

Female athletes who are above the threshold have about a 40% lower risk of a lower body injury.

Lower Body Injury Count Above vs Below the Best Contact Time Threshold



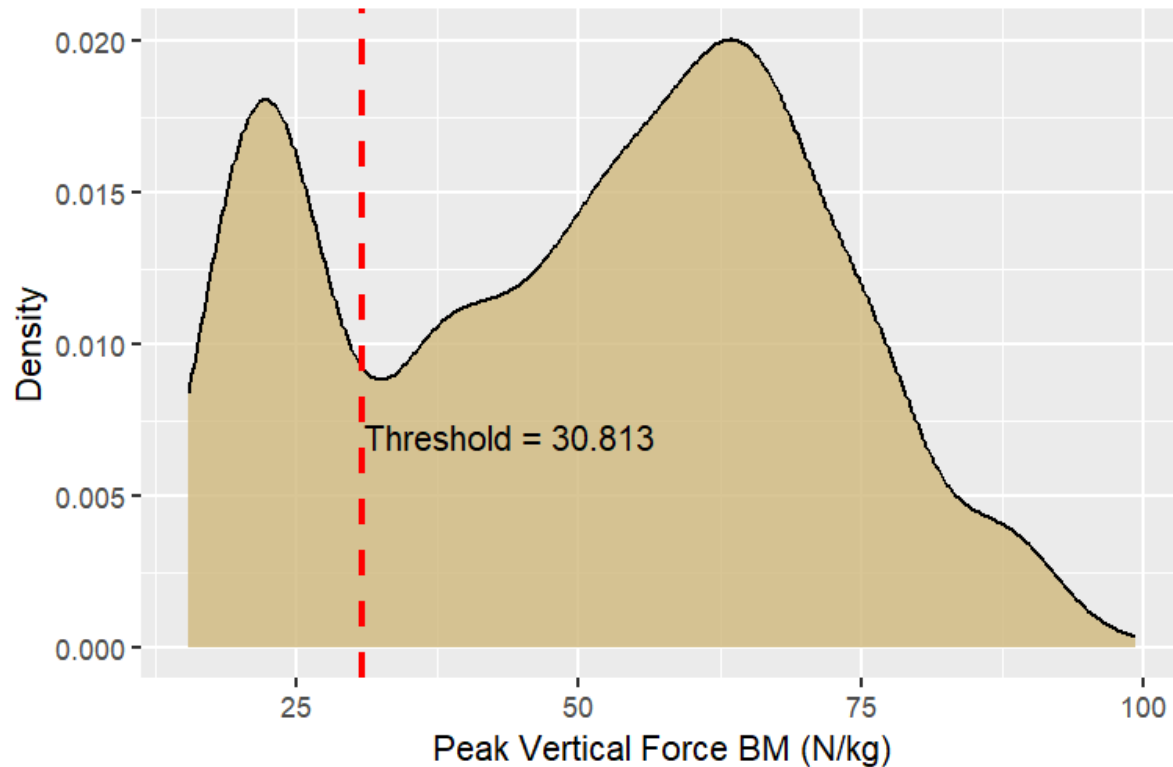


Isometric Mid-Thigh Pull Test Thresholds



Peak Vertical Force Threshold

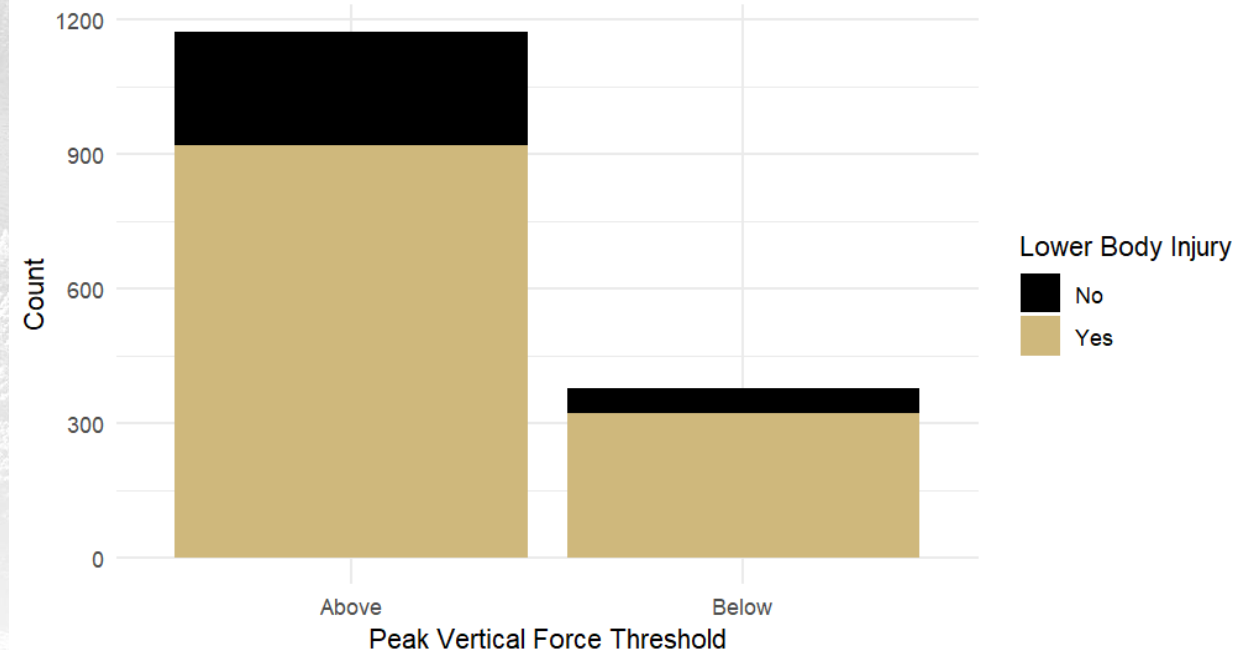
Density Plot: Peak Vertical Force BM (N/kg)



Statistically Significant:
p-value= 0.0032

Female athletes who are above the threshold have about a 38% lower risk of a lower body injury.

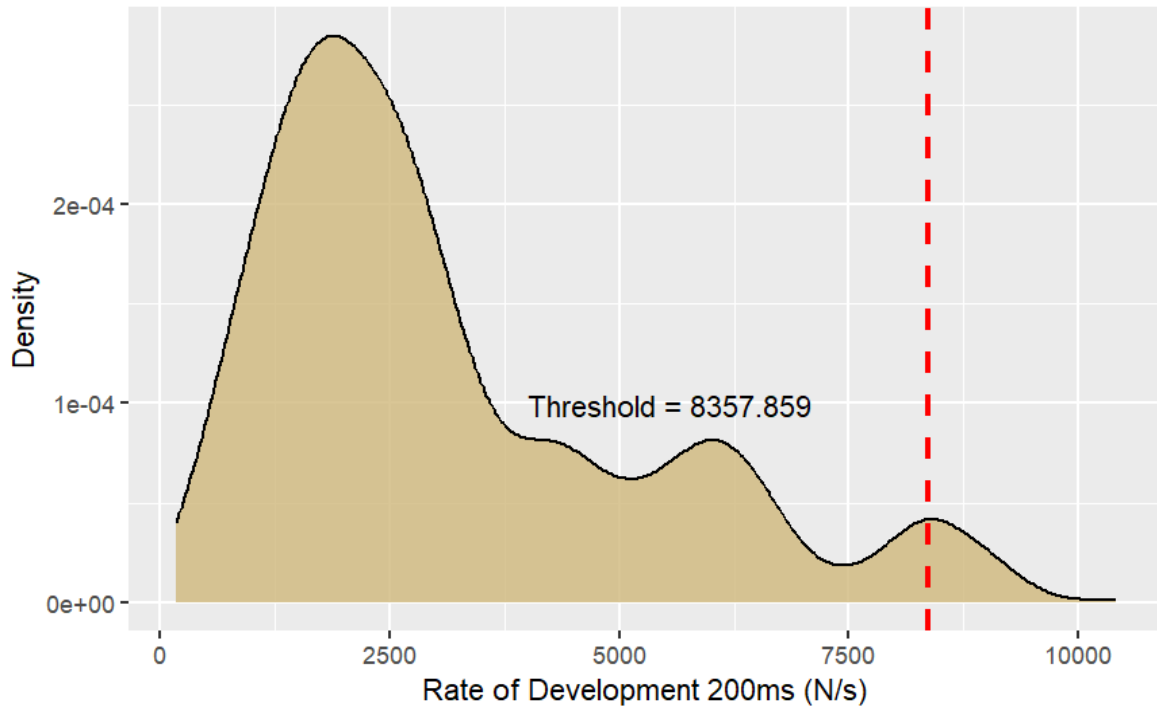
Lower Body Injury Count Above vs Below the Peak Vertical Force Threshold





Rate of Force Development at 200ms Threshold

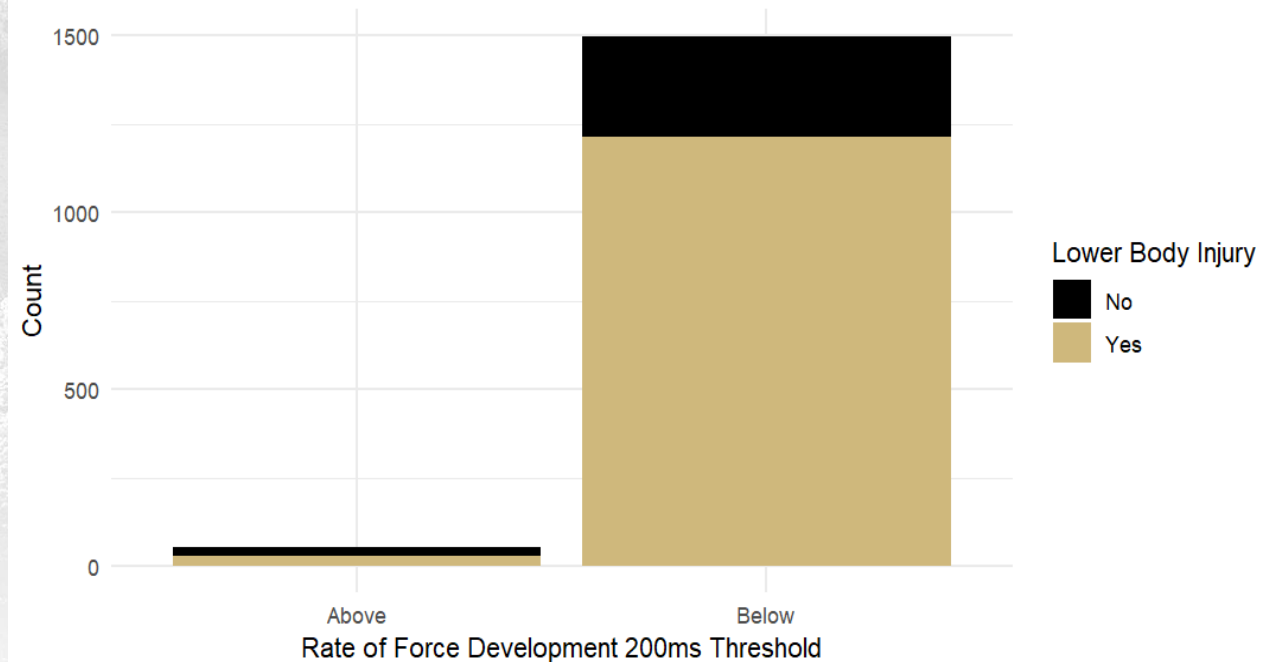
Density Plot: Rate of Force Development 200ms (N/s)



Statistically Significant:
 $p\text{-value} = 8.34e^{-06}$

Female athletes who are above the threshold for rate of force development at 200ms have about a **72% lower risk** of a lower body injury.

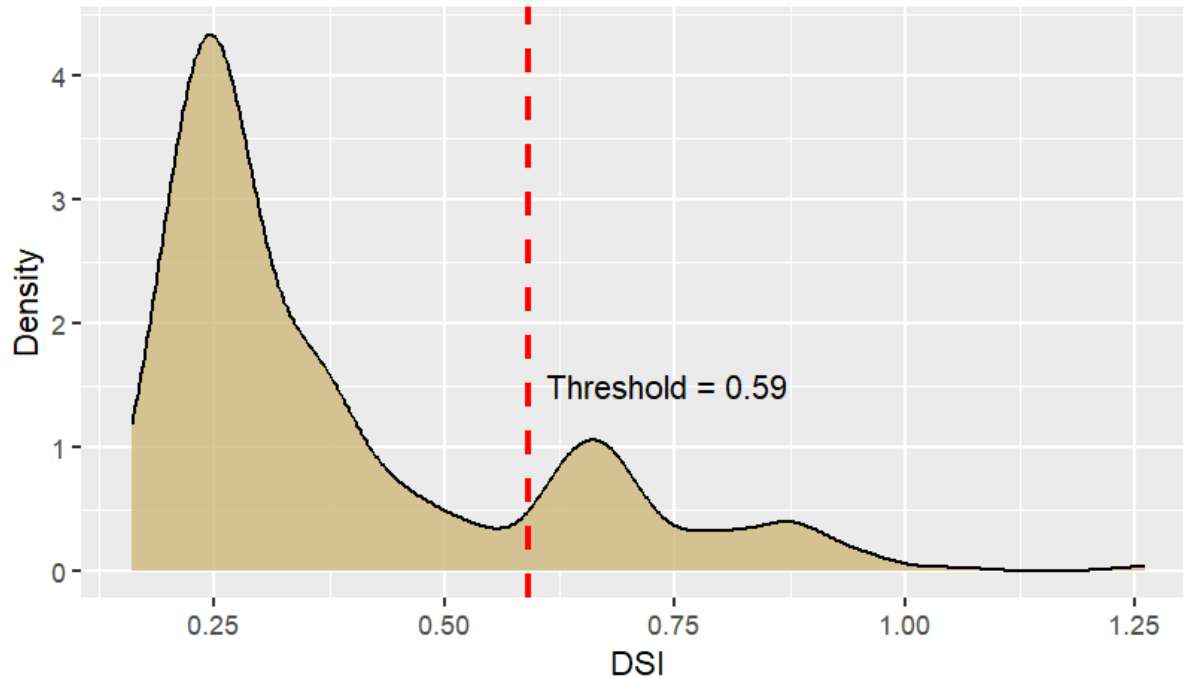
Lower Body Injury Count Above vs Below the Rate of Development 200ms Threshold





Dynamic Strength Index (DSI) Threshold

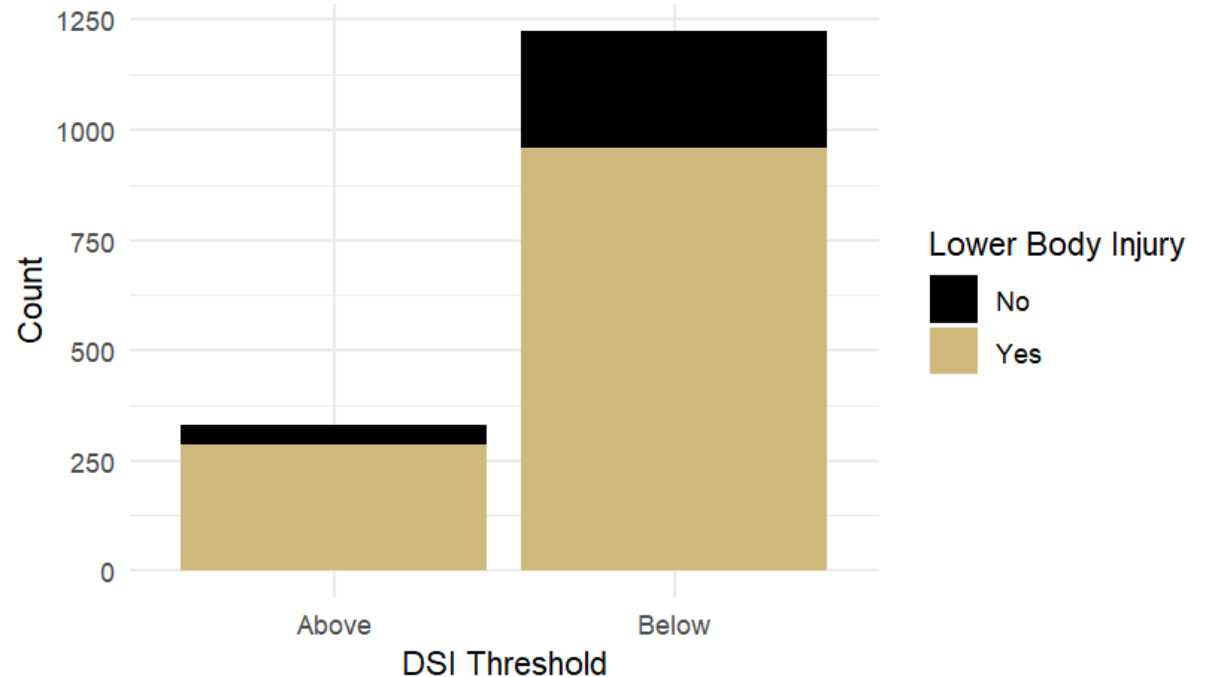
Density Plot: Dynamic Strength Index



Statistically Significant:
p-value= 0.00103

Female athletes above the threshold have 1.78 times higher odds of sustaining a lower body injury.

Lower Body Injury Count Above vs Below the DSI Threshold



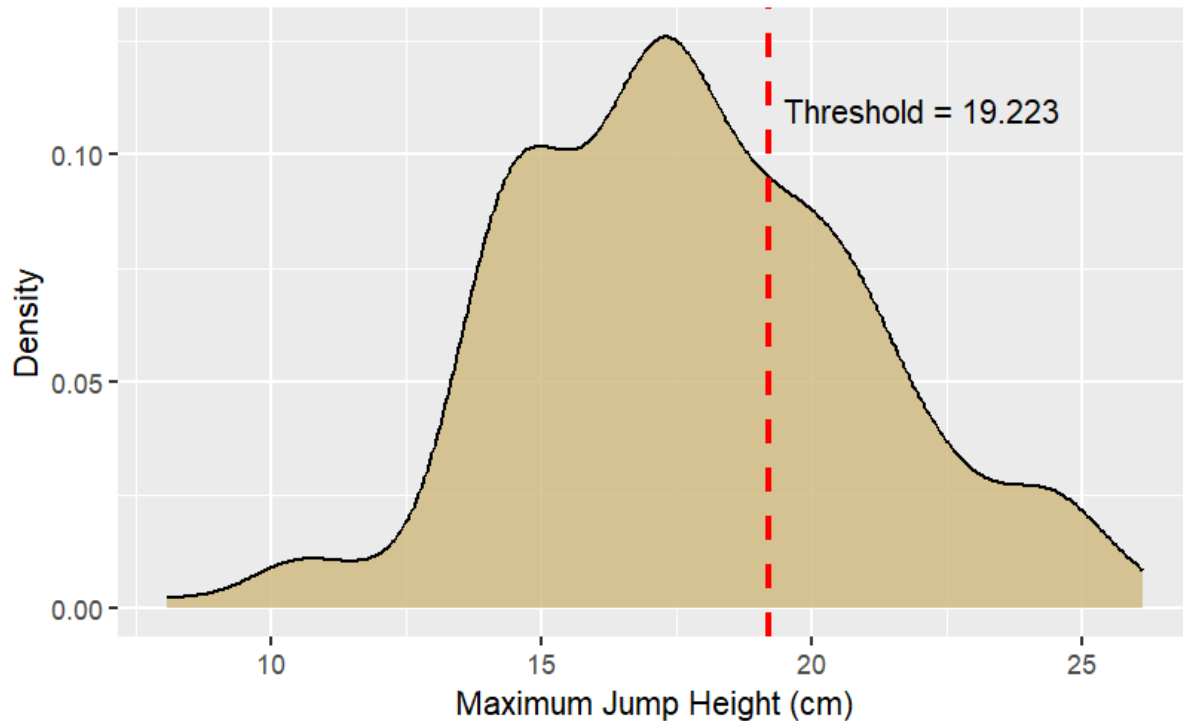


Single Leg Jump Metrics Thresholds



Maximum Jump Height Threshold

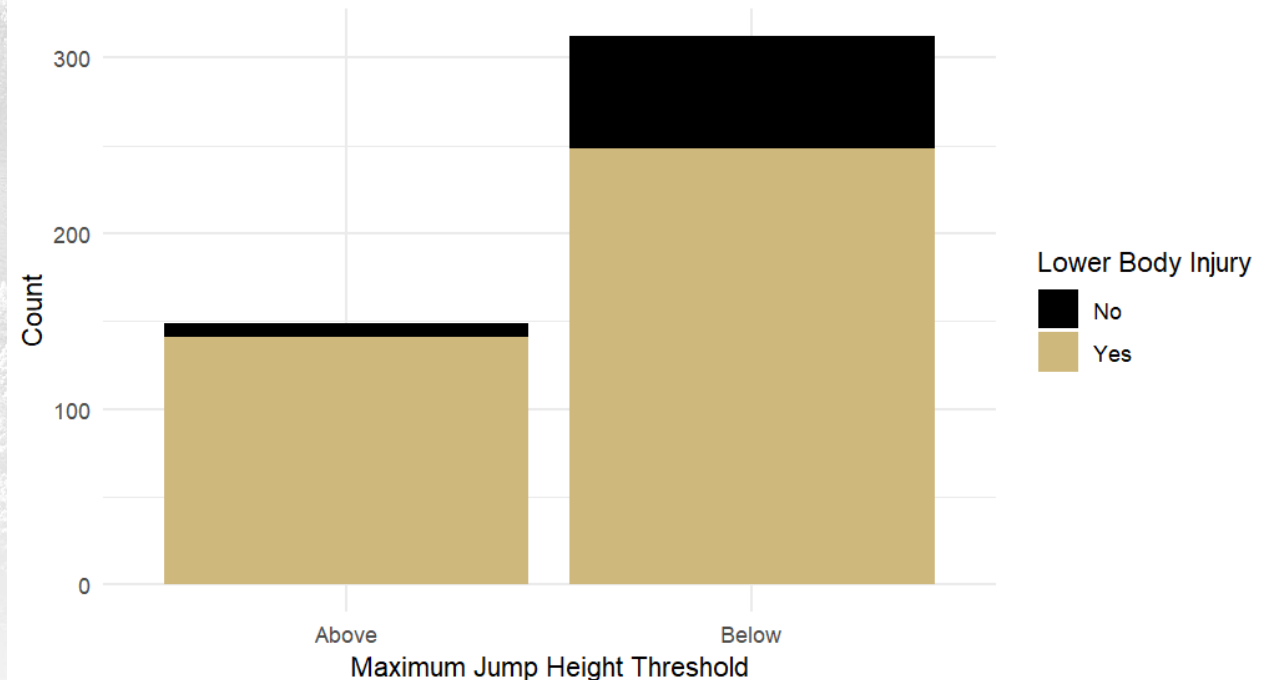
Density Plot: Maximum Jump Height



Statistically significant: p-value= 0.000101

Female athletes above the threshold have 4.55 times higher odds of sustaining a lower body injury.

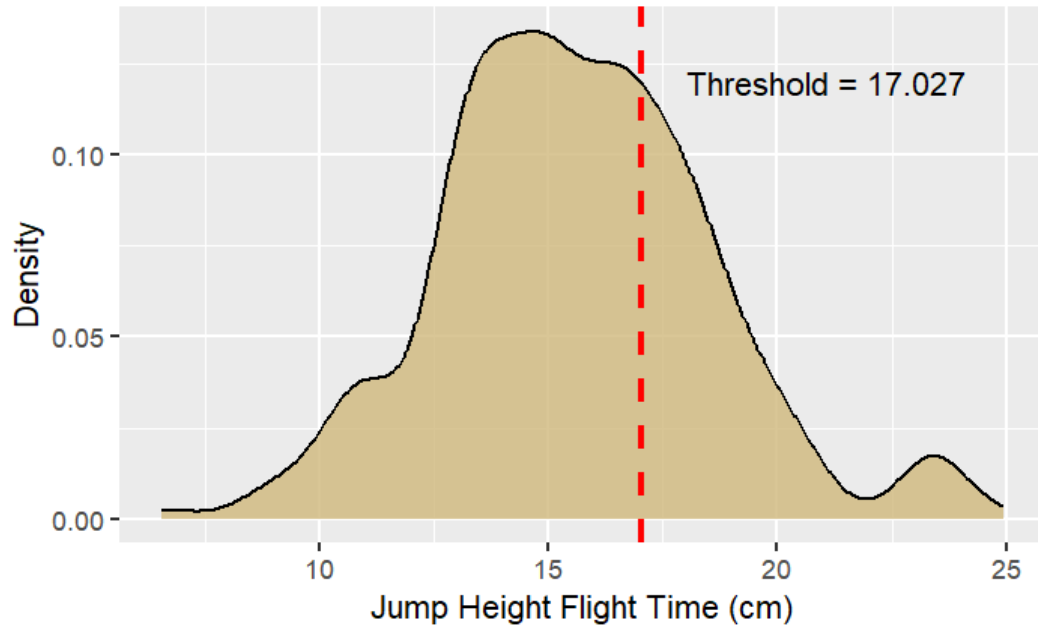
Lower Body Injury Count Above vs Below the Maximum Jump Height Threshold





Jump Height Flight Time Threshold

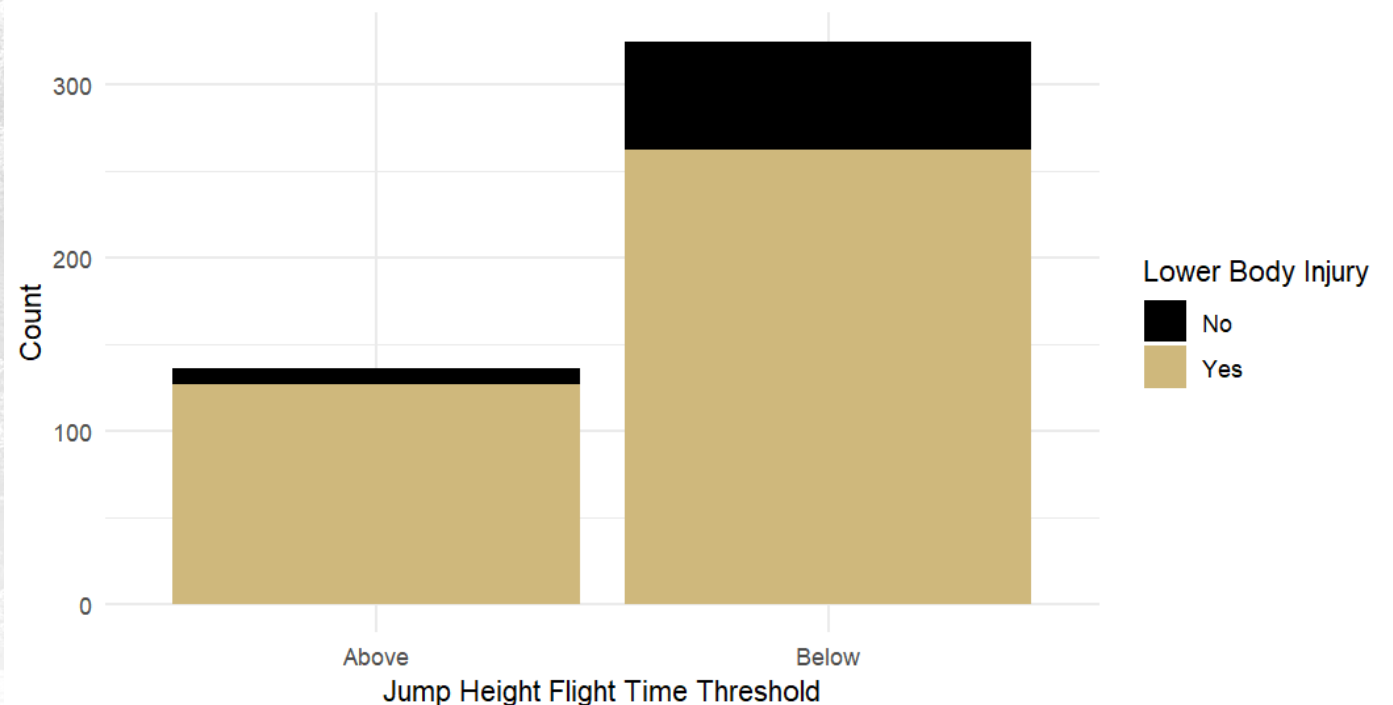
Density Plot: Jump Height Flight Time



Statistically significant:
p-value= 0.00103

Female athletes above the threshold have 3.39 times higher odds of sustaining a lower body injury.

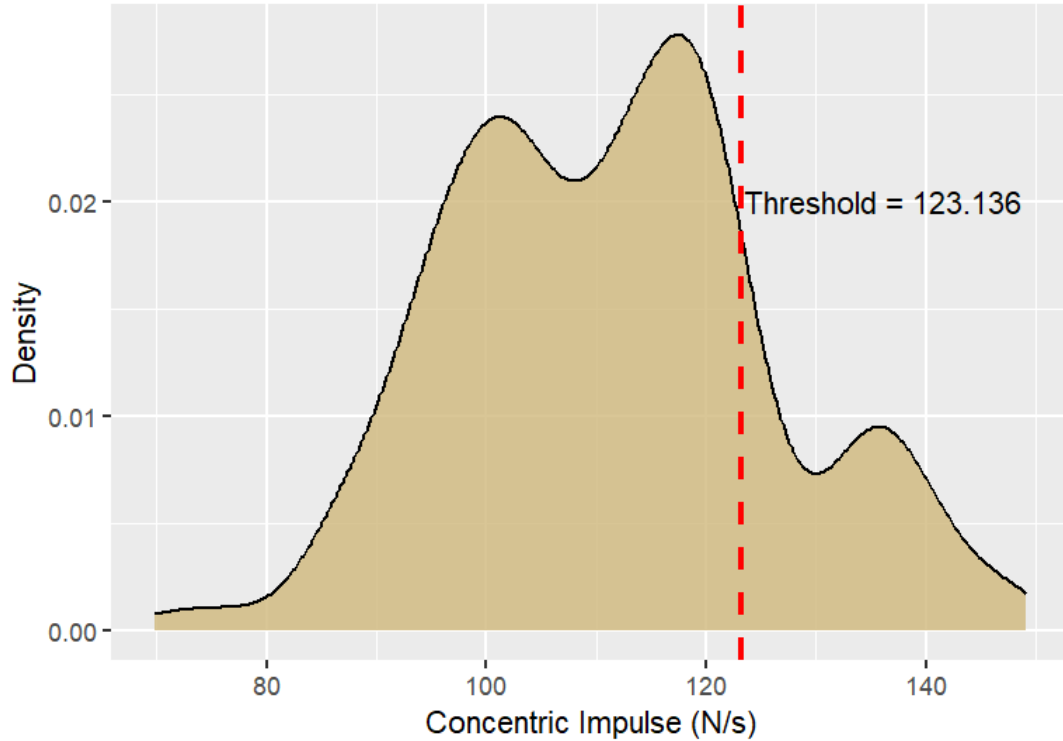
Lower Body Injury Count Above vs Below the Jump Height Flight Time Threshold





Concentric Impulse Threshold

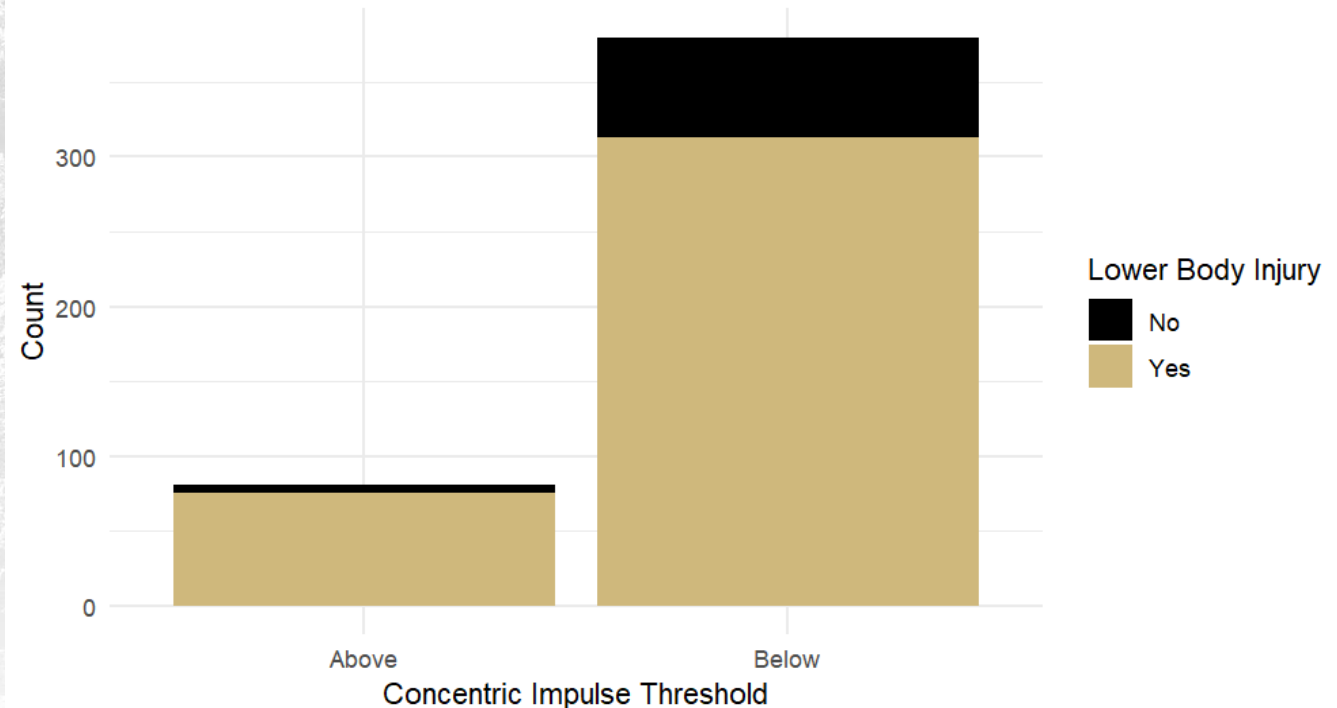
Density Plot: Concentric Impulse



Statistically significant: p -value= 0.0142

Female athletes above the threshold have 3.25 times higher odds of sustaining a lower body injury.

Lower Body Injury Count Above vs Below the Concentric Impulse Threshold





Question 2:

What trends in strength do we see across the women's team sports?



CMJ Metrics



Modified RSI

Women's Basketball

Normative Percentiles:

25th: 0.351

50th: 0.417

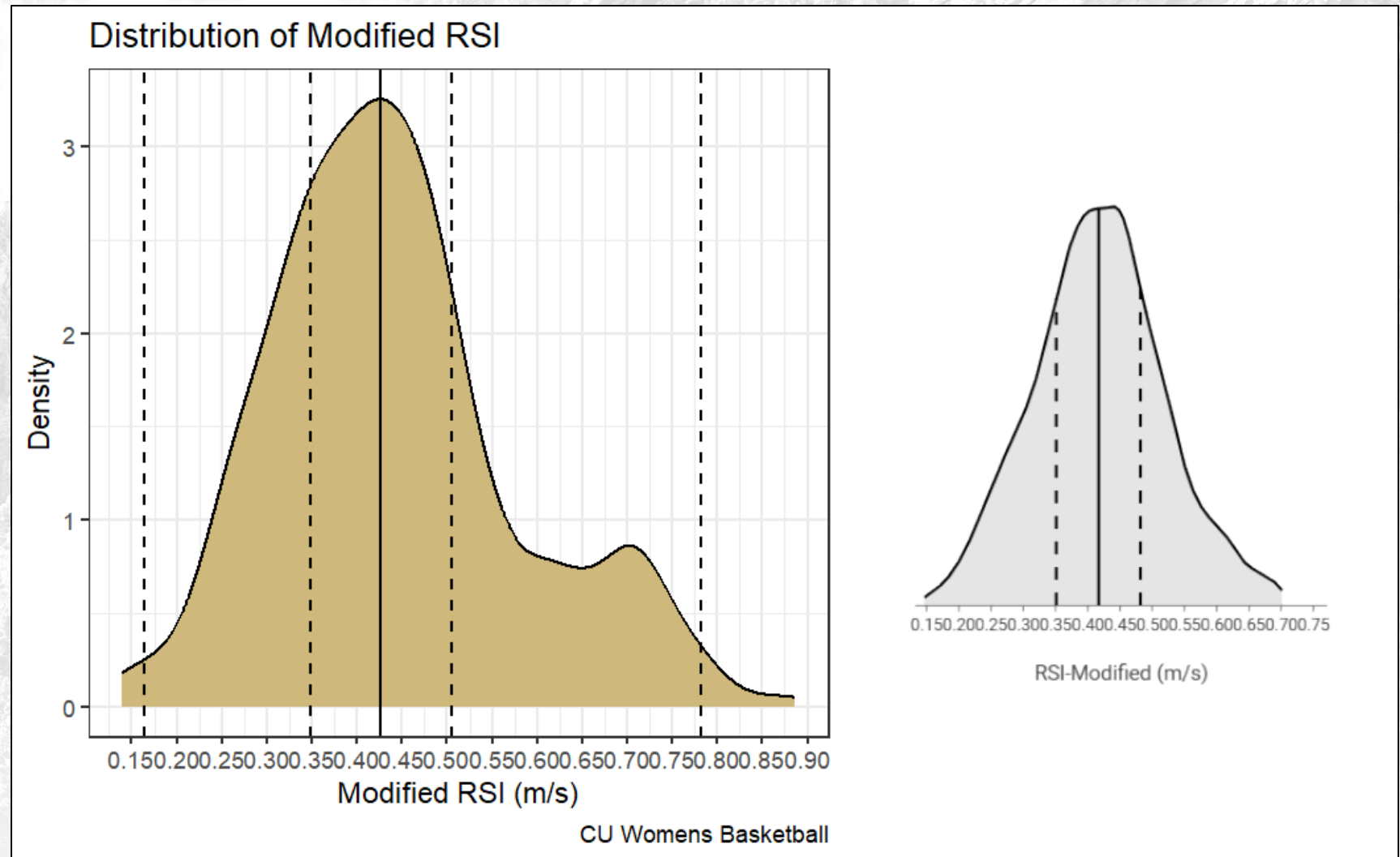
75th: 0.482

CU Data Percentiles:

25th: **0.348**

50th: 0.426

75th: 0.505

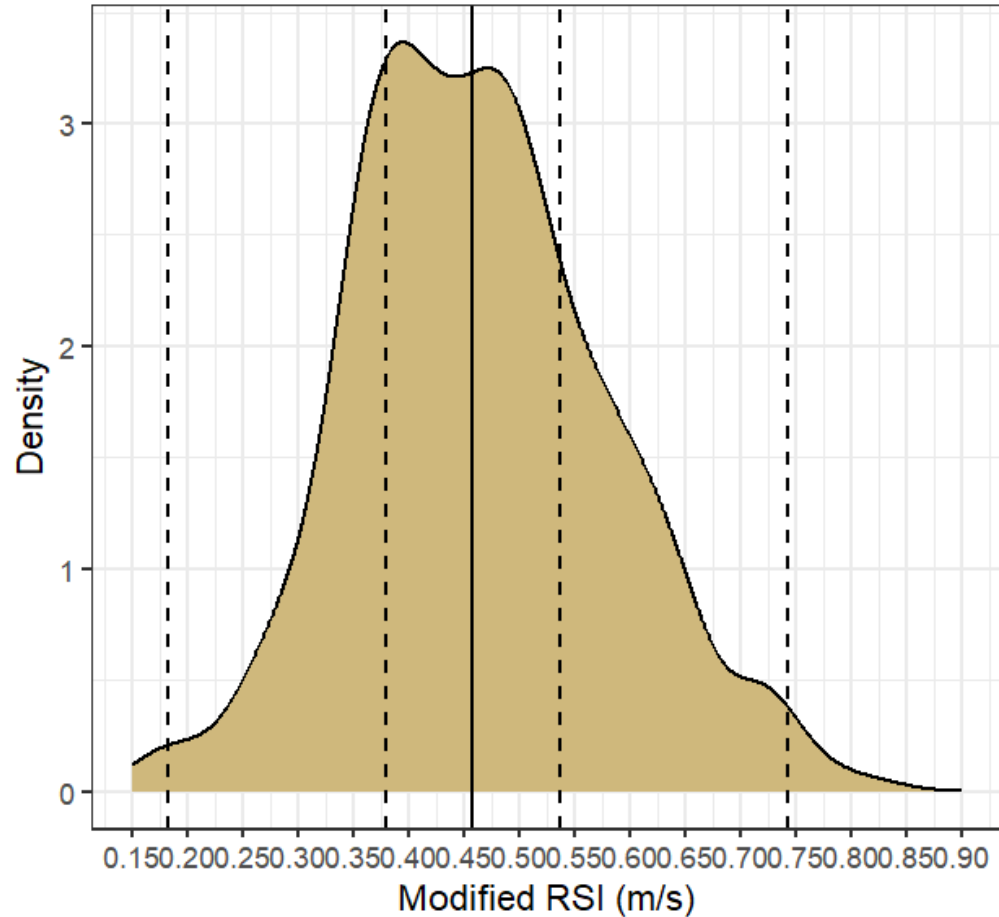




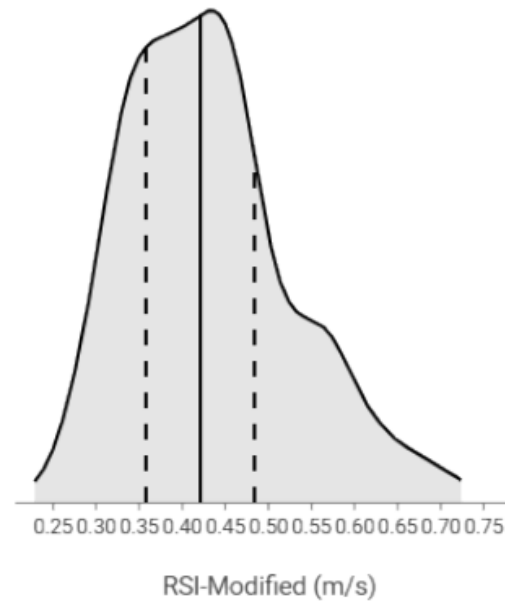
Modified RSI

Women's Volleyball

Distribution of Modified RSI



CU Womens Volleyball



Normative Percentiles:

25th: 0.358

50th: 0.421

75th: 0.484

CU Data Percentiles:

25th: 0.380

50th: 0.457

75th: 0.536



Modified RSI

Women's Soccer

Normative Percentiles:

25th: 0.358

50th: 0.416

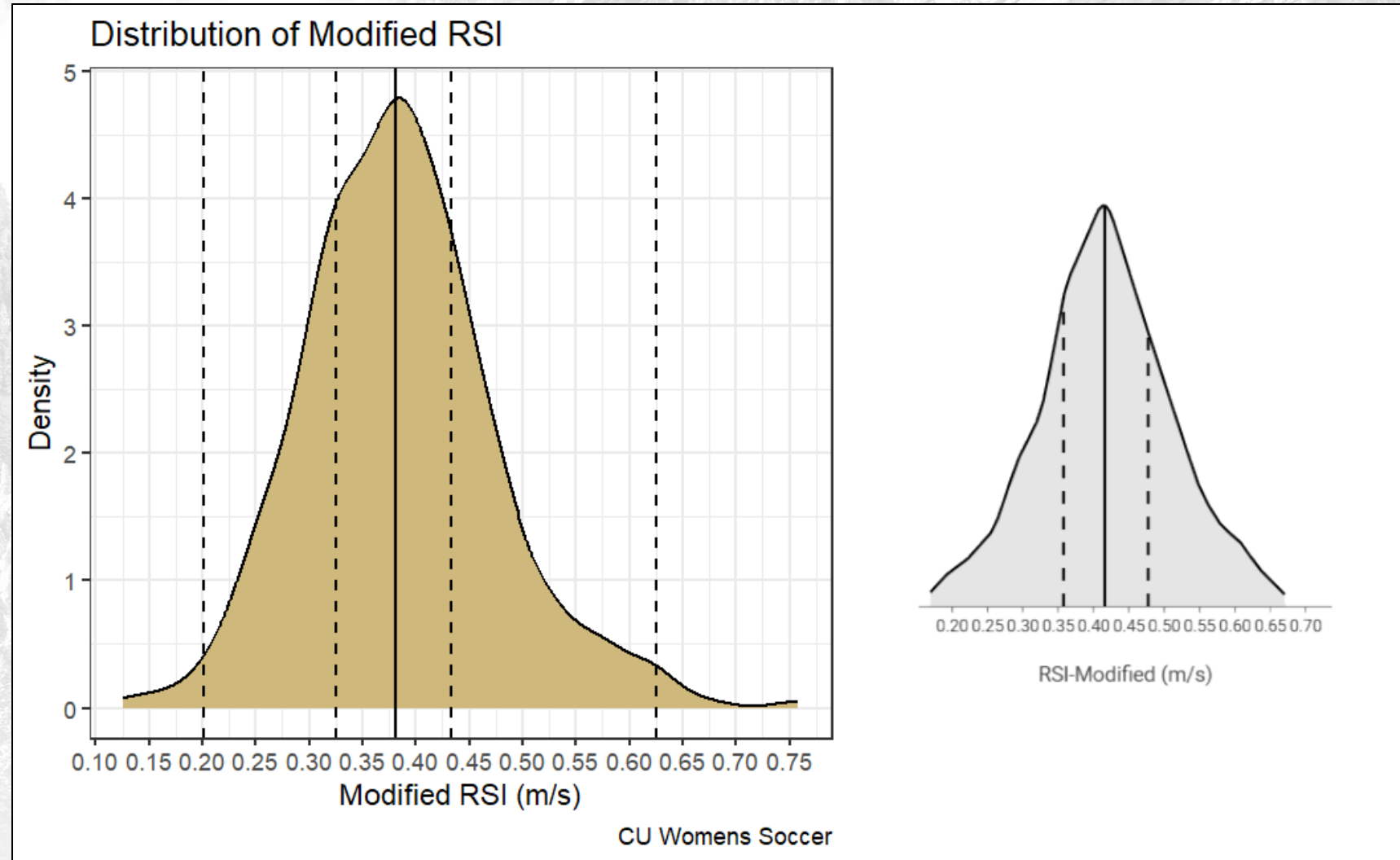
75th: 0.477

CU Data Percentiles:

25th: **0.325**

50th: **0.381**

75th: **0.433**

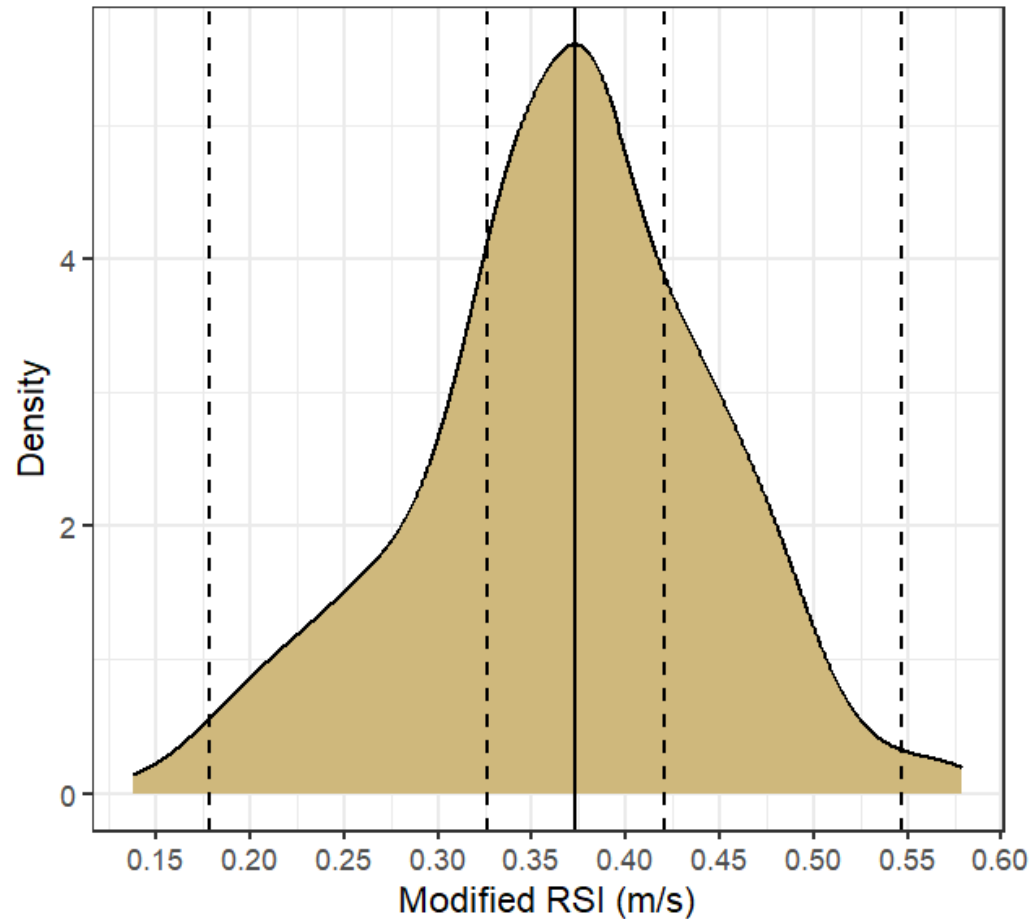




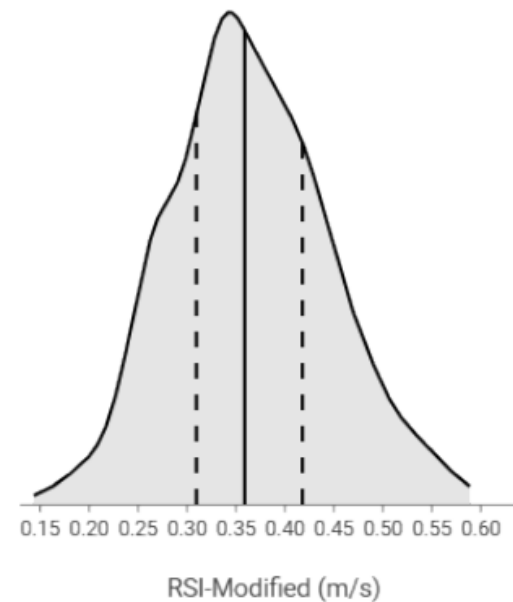
Modified RSI

Women's Lacrosse

Distribution of Modified RSI



CU Womens Lacrosse



Normative Percentiles:

25th: 0.310

50th: 0.359

75th: 0.418

CU Data Percentiles:

25th: 0.327

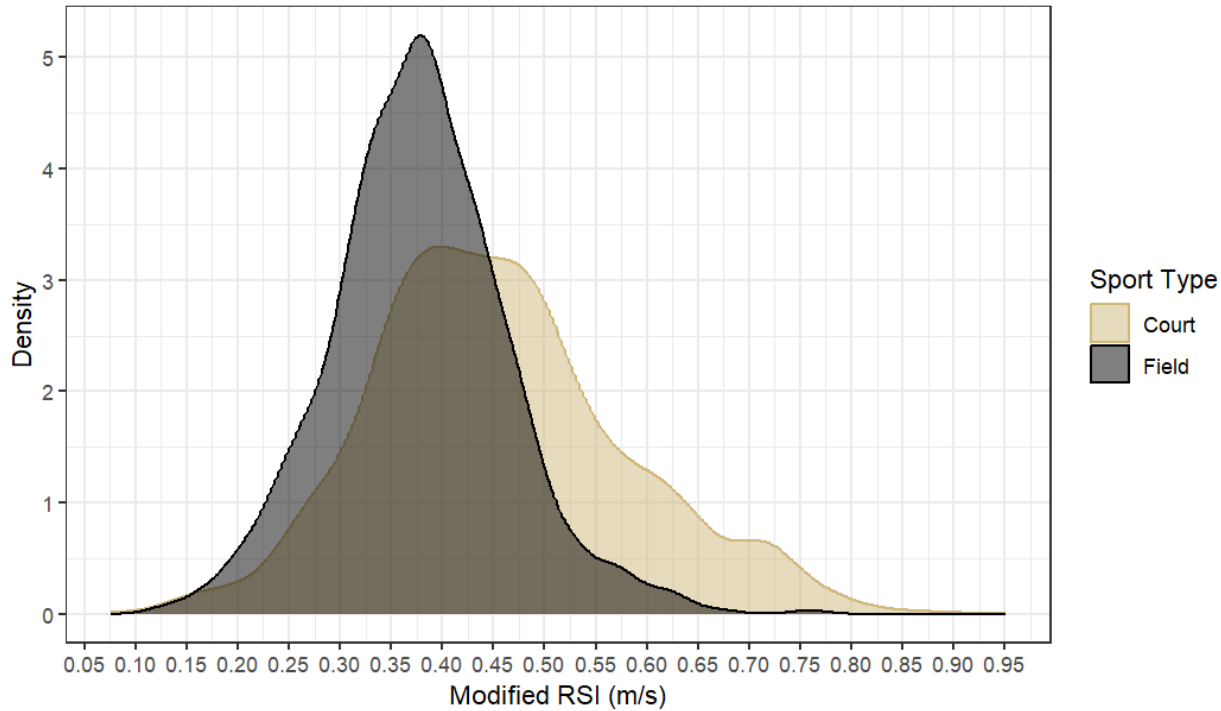
50th: 0.373

75th: 0.420



Modified RSI

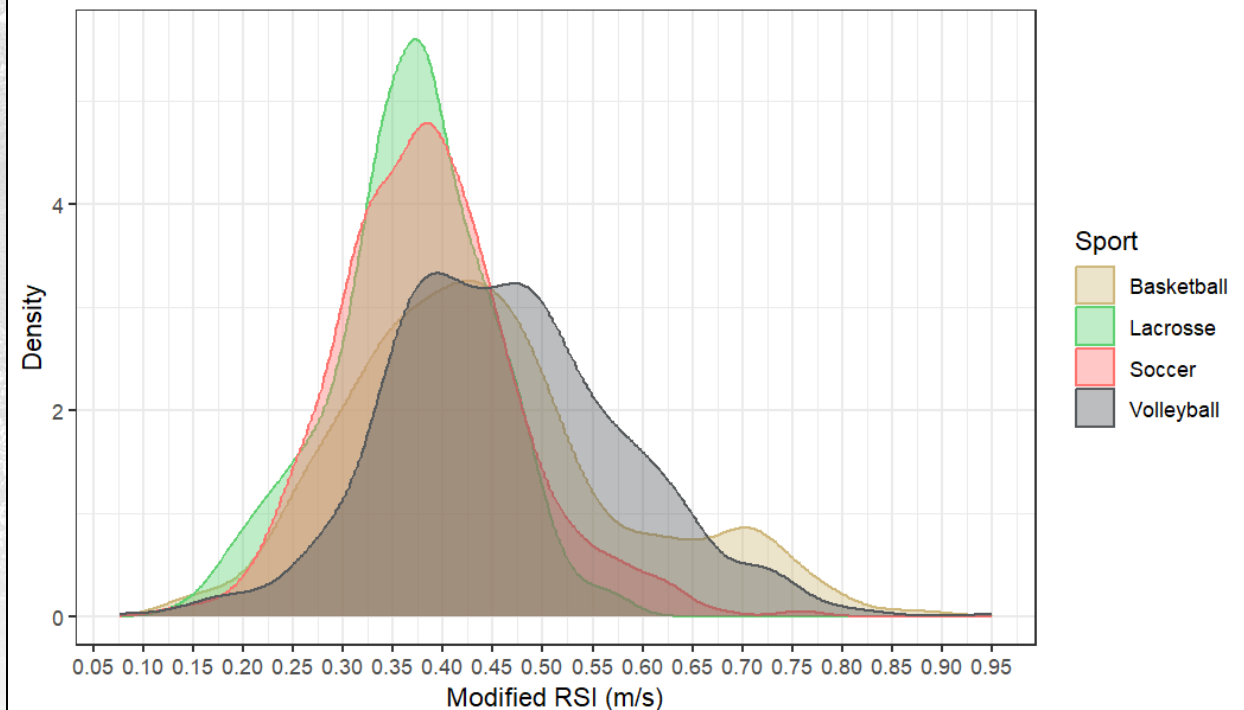
Distribution of Modified RSI Across Sports



Modified RSI:

Lacrosse <<< Soccer <<< Basketball <<< Volleyball

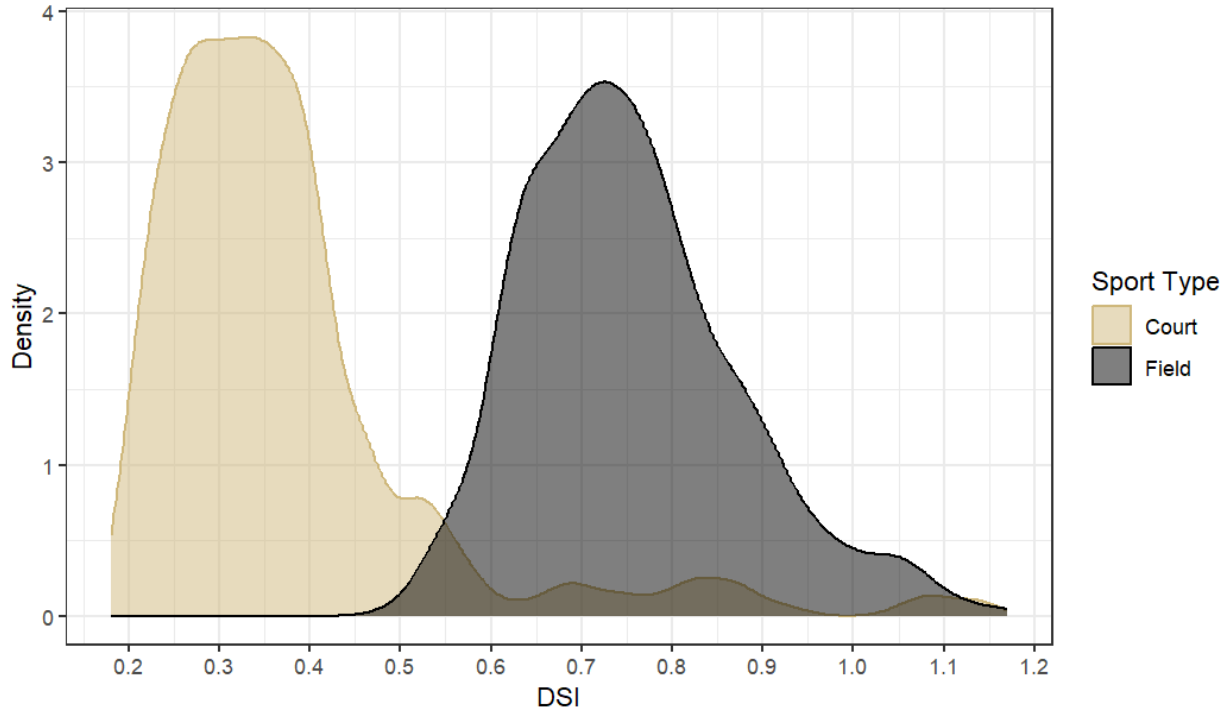
Distribution of Modified RSI Across Sports





DSI

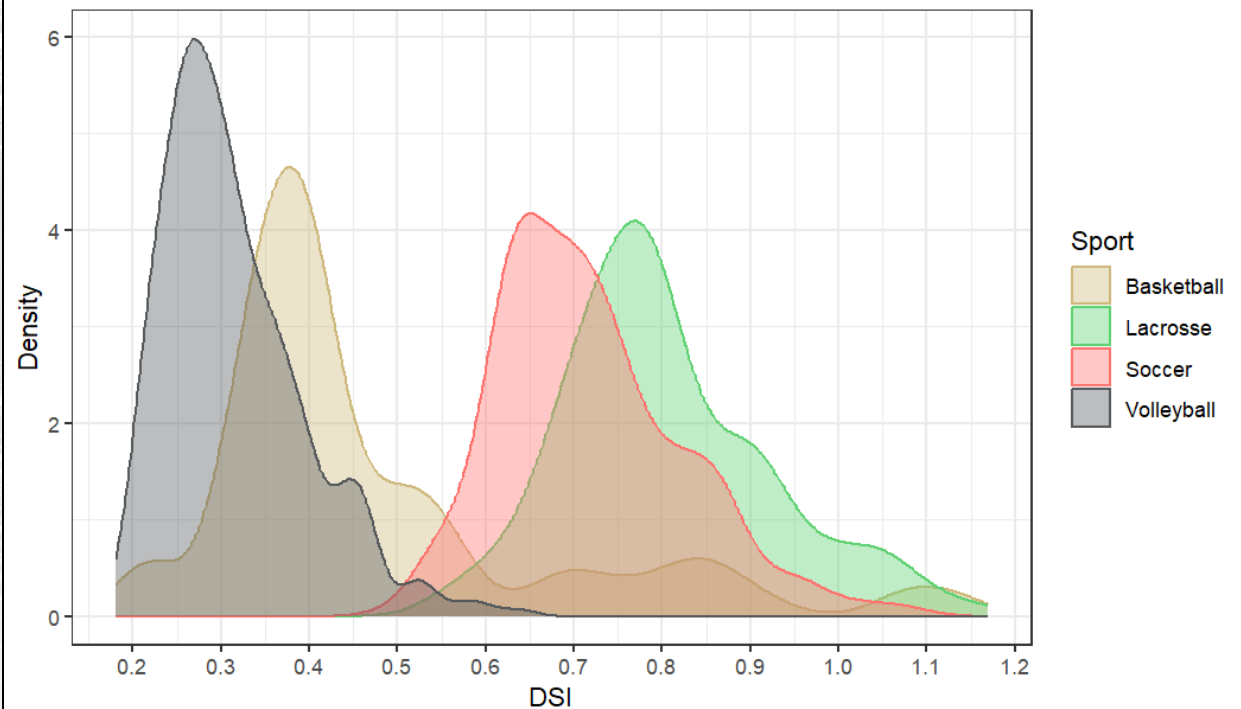
Distribution of DSI Across Sports



DSI:

Volleyball <<< Basketball <<< Soccer <<< Lacrosse

Distribution of DSI Across Sports





HJ Metrics



Hop Jump RSI

Women's Basketball

Normative Percentiles:

25th: 0.79

50th: 1.74

75th: 2.13

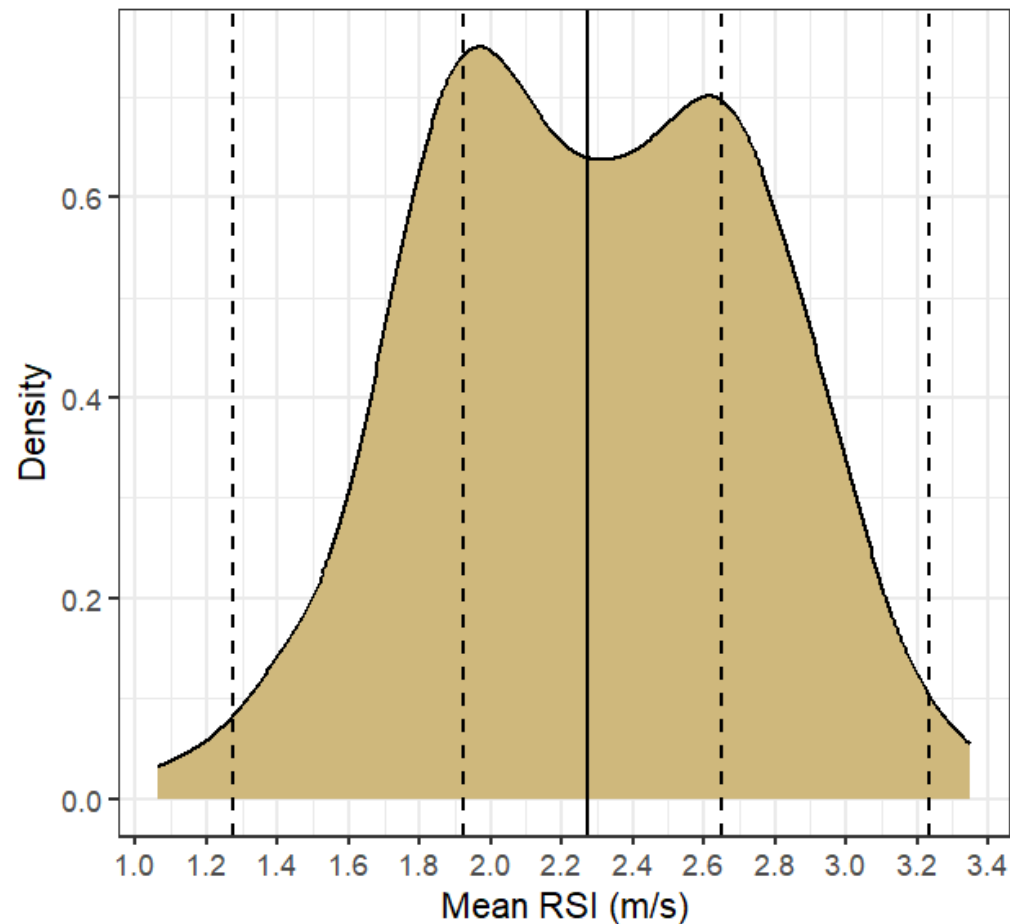
CU Data Percentiles:

25th: 1.925

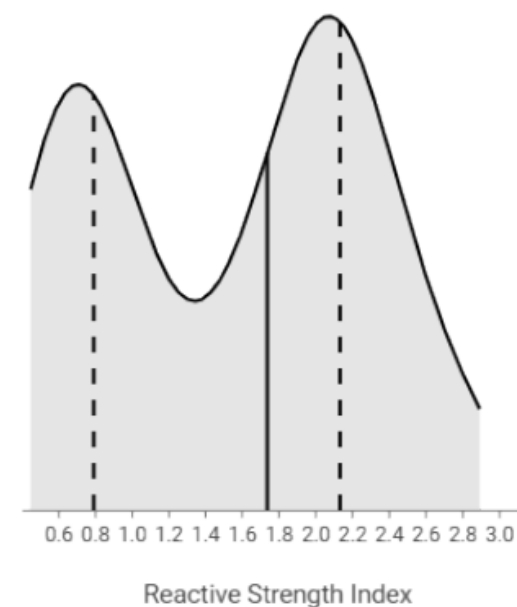
50th: 2.273

75th: 2.650

Distribution of Mean RSI (Flight Contact Time)



CU Womens Basketball

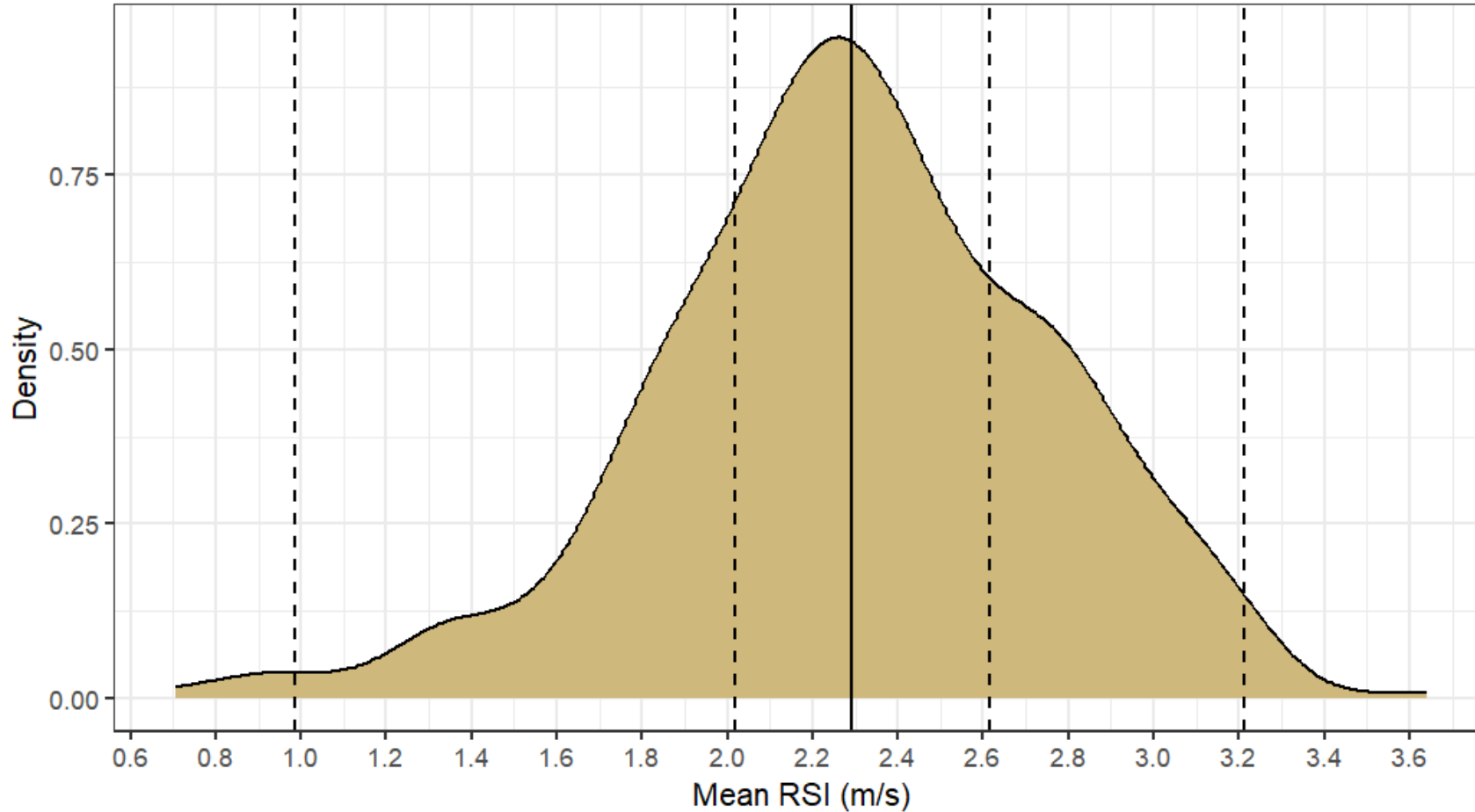




Hop Jump RSI

Women's Volleyball

Distribution of Mean RSI (Flight Contact Time)



CU Data Percentiles:

25th: 2.018

50th: 2.293

75th: 2.616

CU Womens Volleyball



Hop Jump RSI

Women's Soccer

Normative Percentiles:

25th: 2.00

50th: 2.27

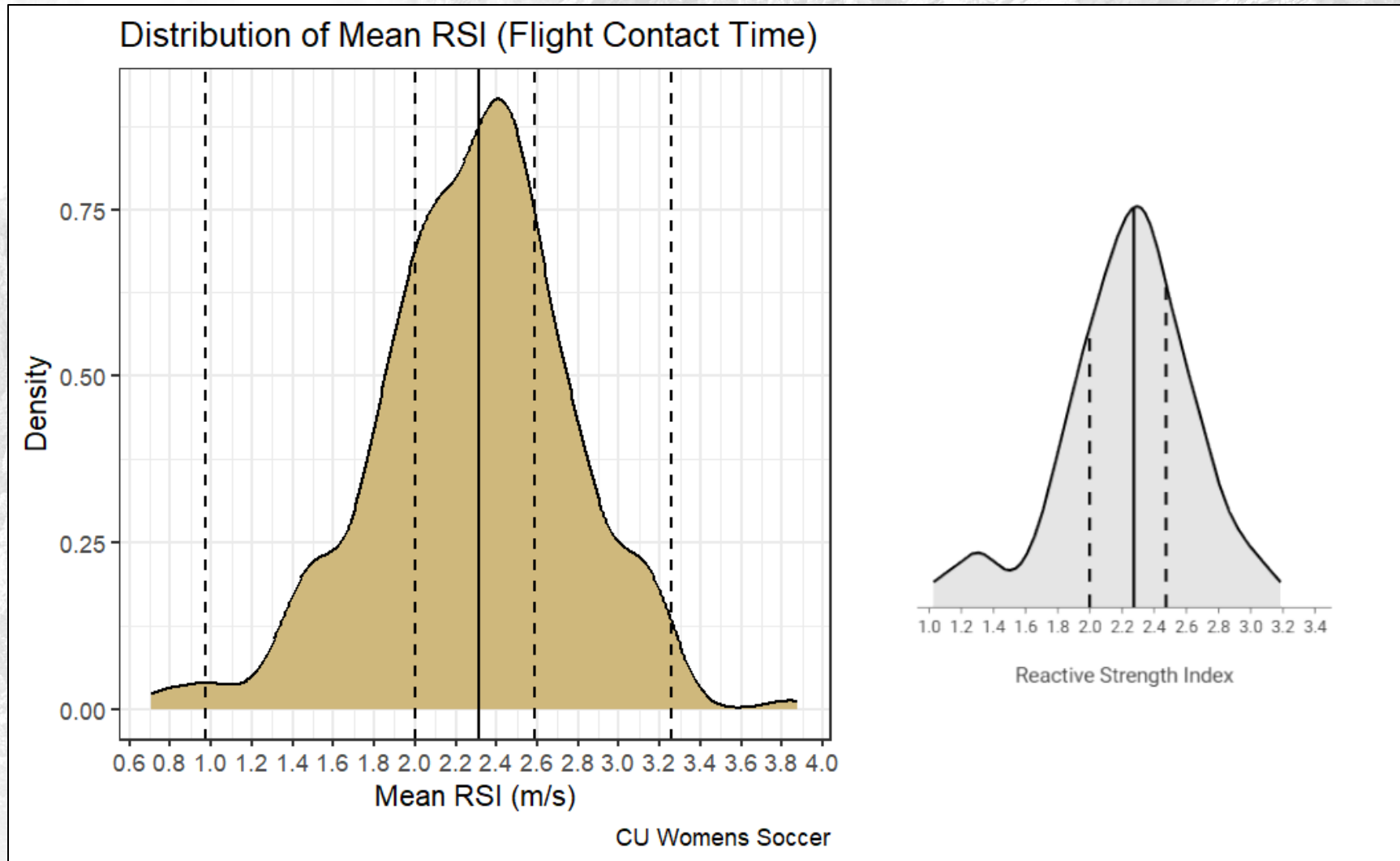
75th: 2.47

CU Data Percentiles:

25th: 2.001

50th: 2.315

75th: 2.586

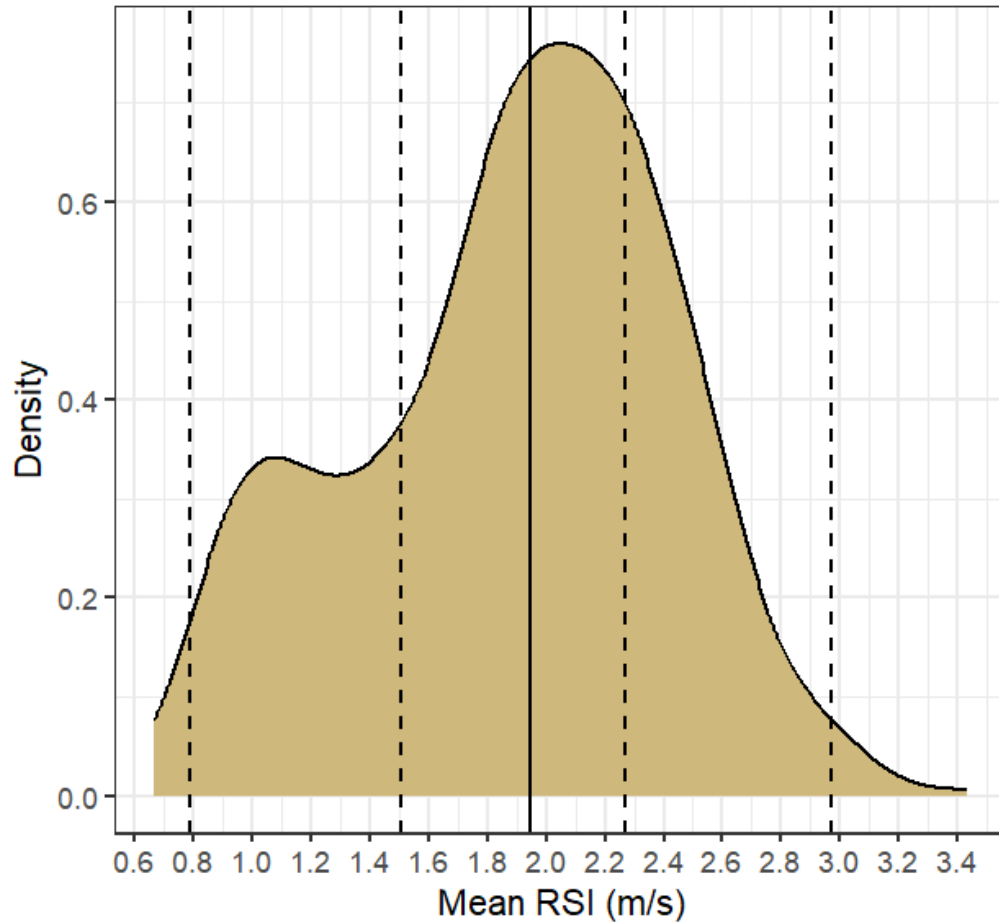




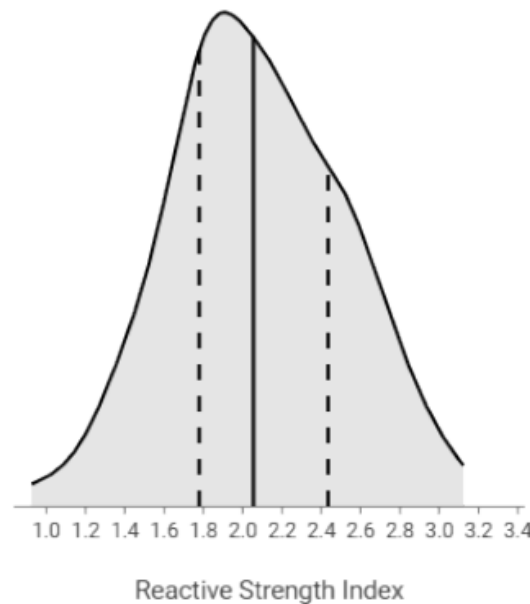
Hop Jump RSI

Women's Lacrosse

Distribution of Mean RSI (Flight Contact Time)



CU Womens Lacrosse



Normative Percentiles:

25th: 1.78

50th: 2.05

75th: 2.43

CU Data Percentiles:

25th: **1.506**

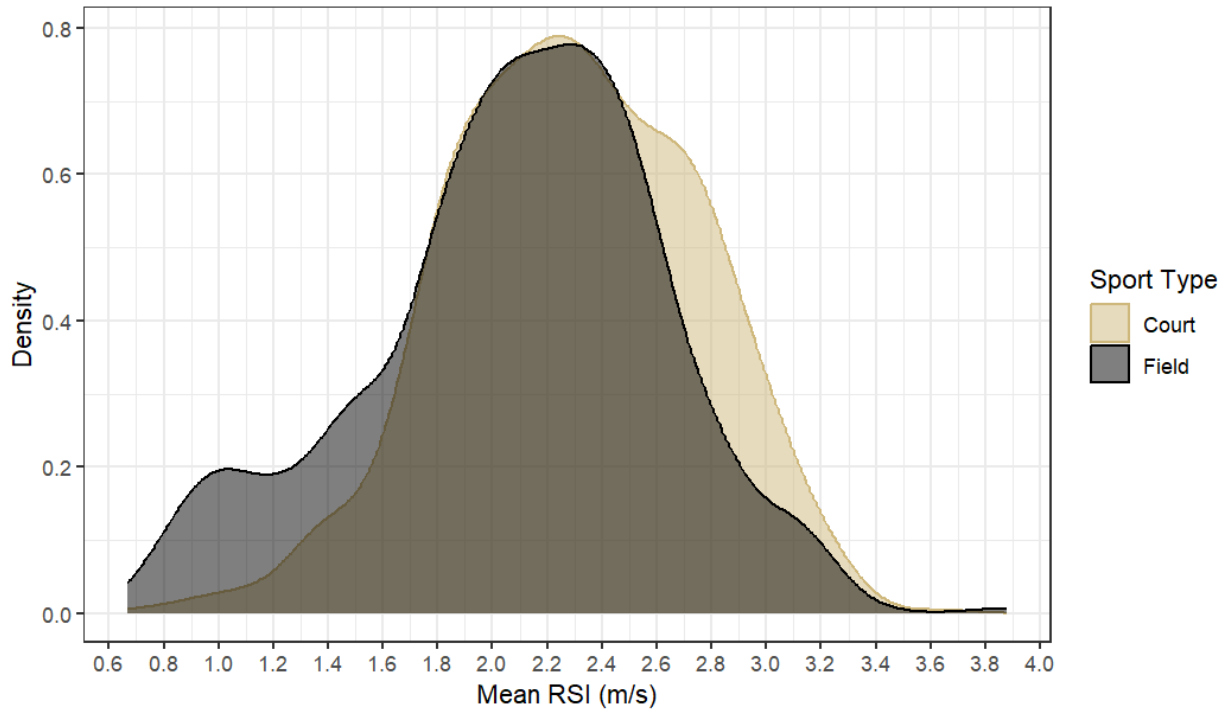
50th: **1.948**

75th: **2.267**



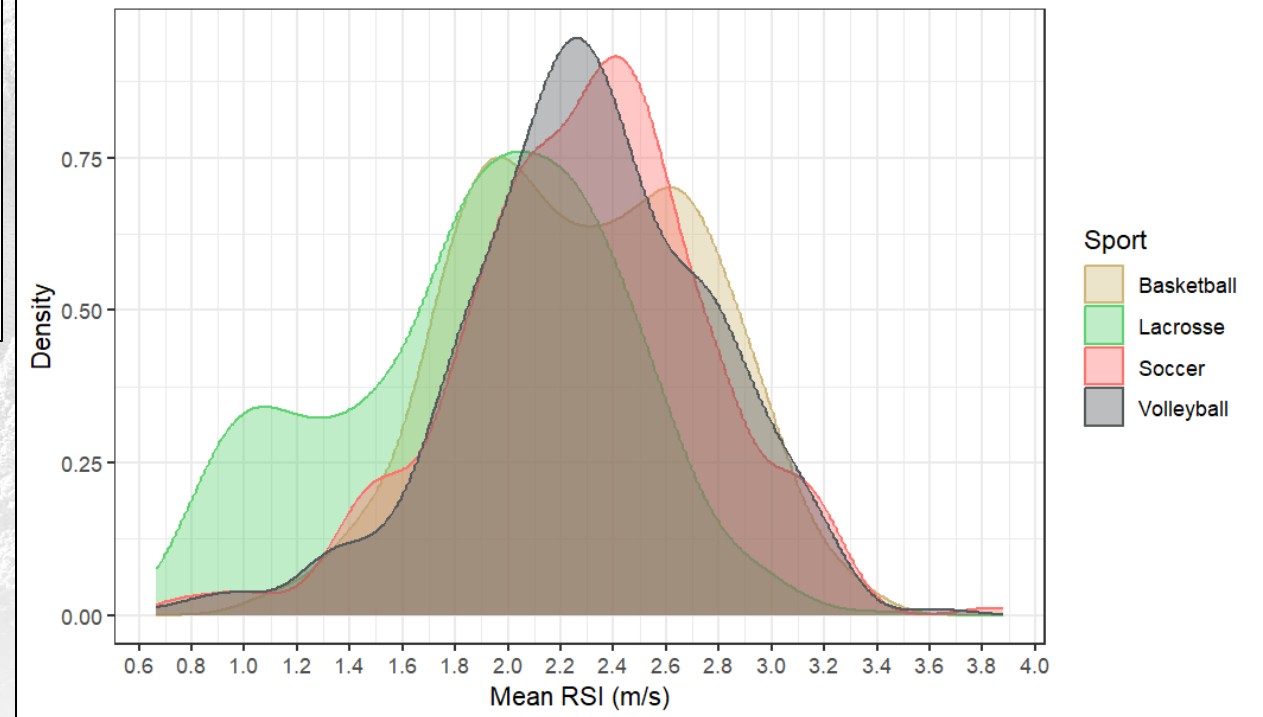
Hop Jump RSI

Distribution of Mean RSI (Hop Jump) Across Sports



Mean RSI:
Lacrosse <<< Basketball, Soccer, Volleyball

Distribution of Mean RSI (Hop Jump) Across Sports





Nordic Metrics



Nordic Force

Women's Basketball

Normative Percentiles:

25th: 262

50th: 308

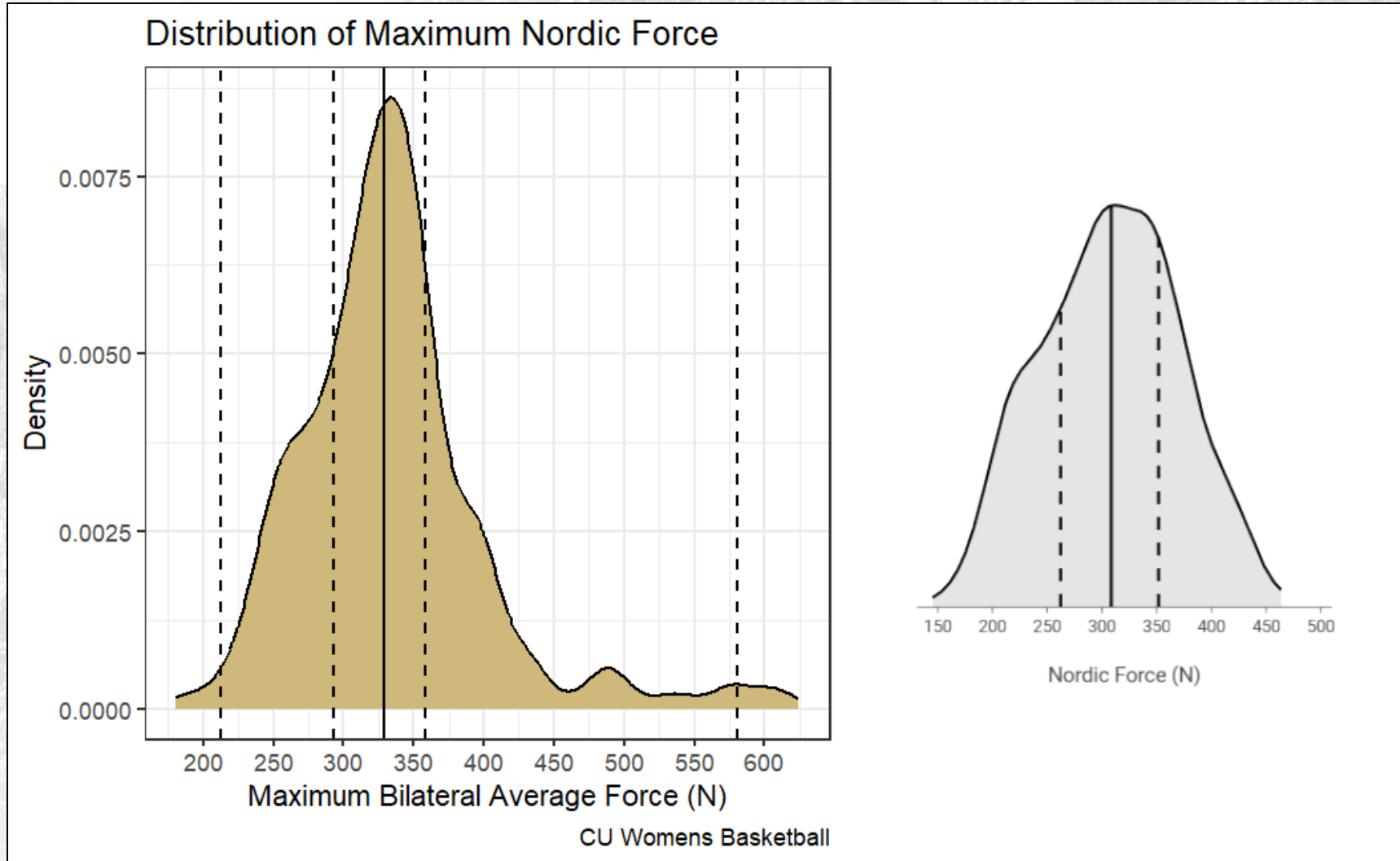
75th: 352

CU Data Percentiles:

25th: 293

50th: 329

75th: 358

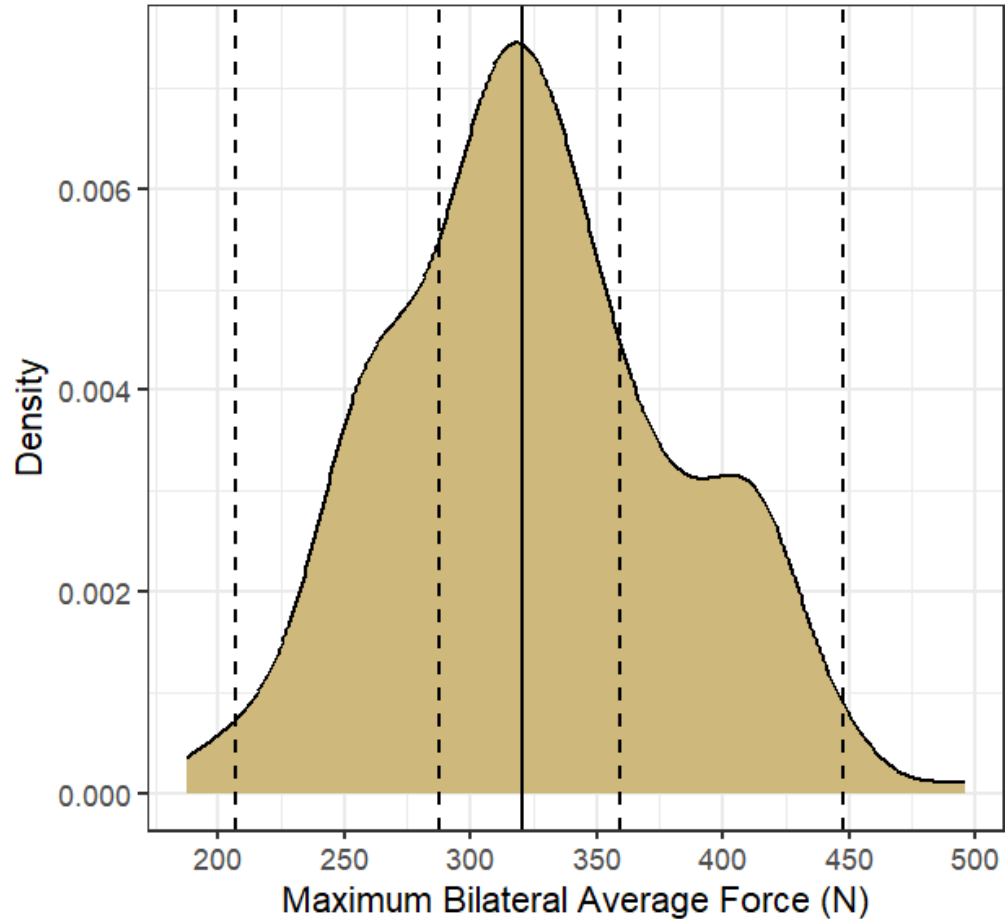




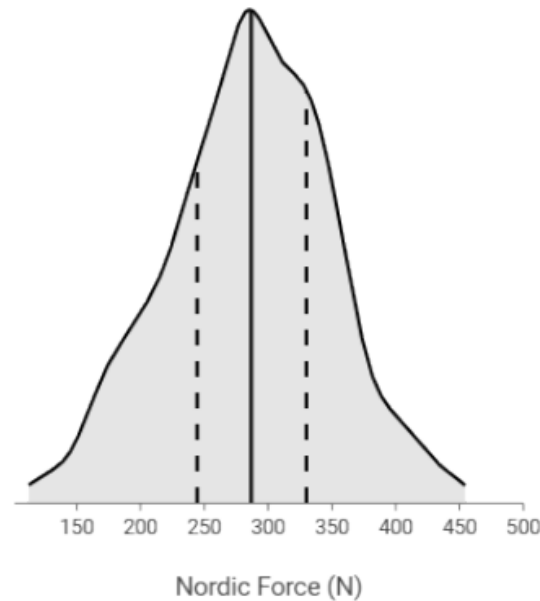
Nordic Force

Women's Volleyball

Distribution of Maximum Nordic Force



CU Womens Volleyball



Normative Percentiles:

25th: 244

50th: 287

75th: 330

CU Data Percentiles:

25th: 288

50th: 320

75th: 359



Nordic Force

Women's Soccer

Normative Percentiles:

25th: 264

50th: 298

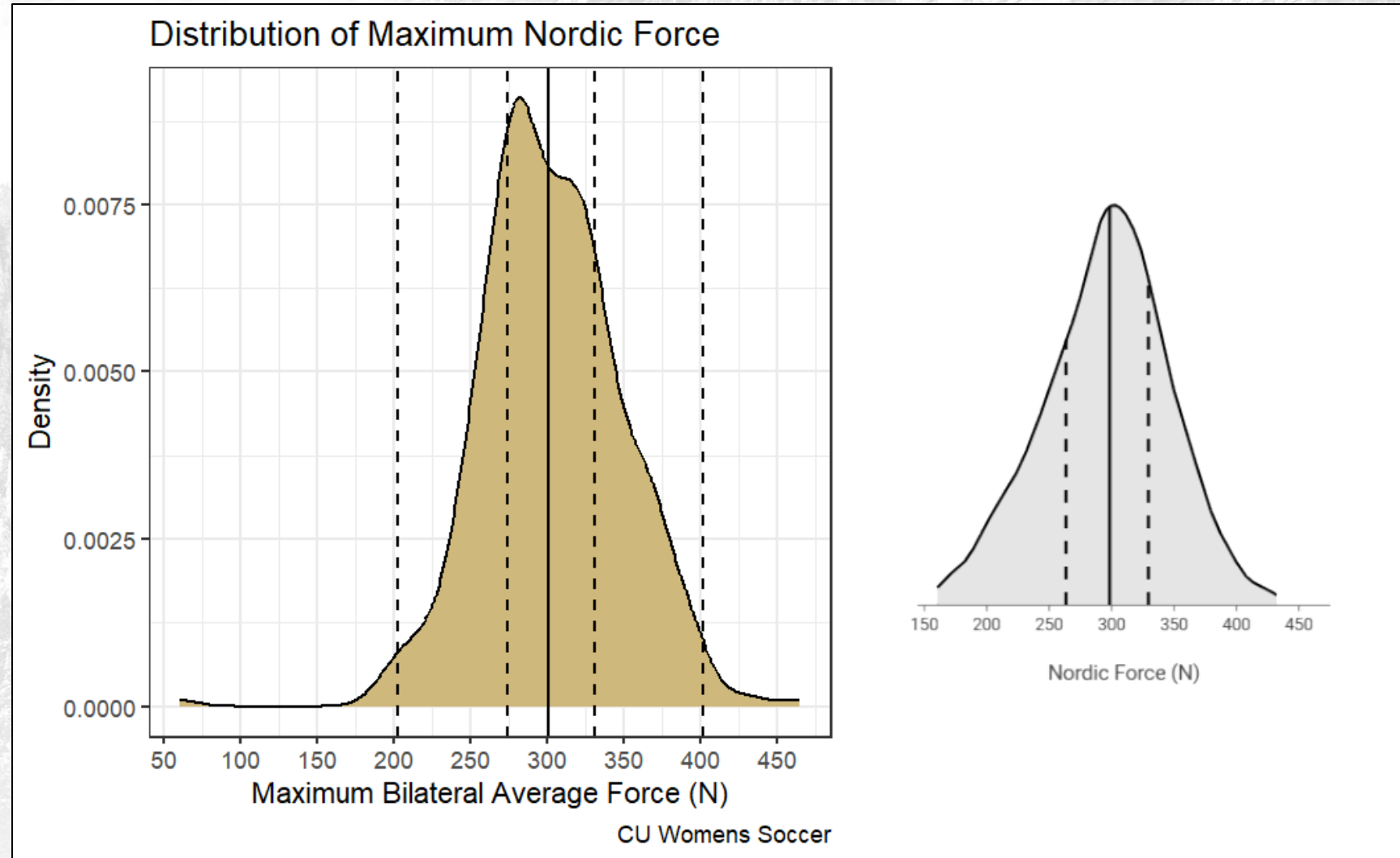
75th: 330

CU Data Percentiles:

25th: 274

50th: 301

75th: 331

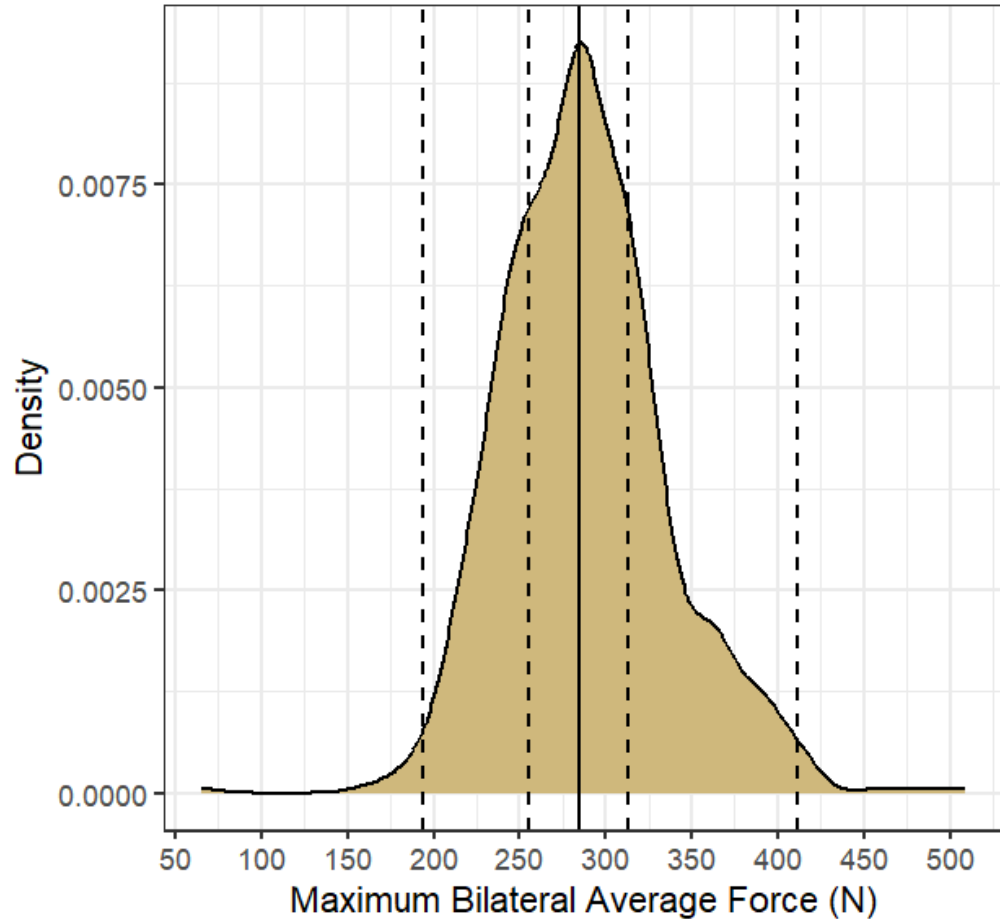




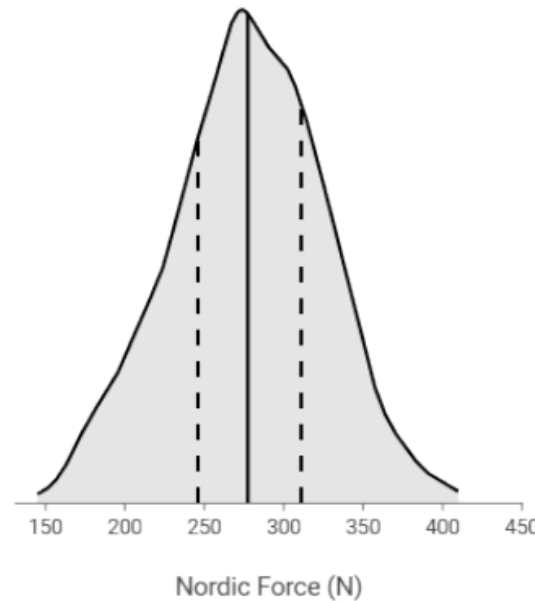
Nordic Force

Women's Lacrosse

Distribution of Maximum Nordic Force



CU Womens Lacrosse



Normative Percentiles:

25th: 246

50th: 277

75th: 311

CU Data Percentiles:

25th: 255

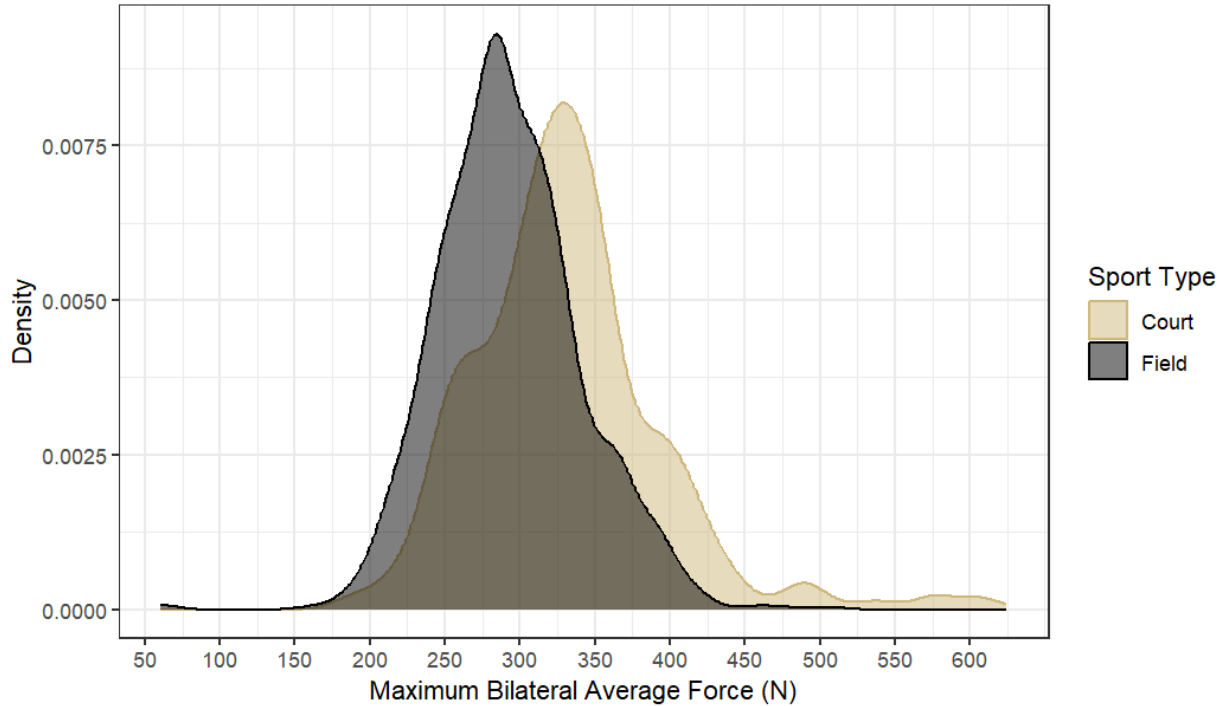
50th: 285

75th: 313



Nordic Force

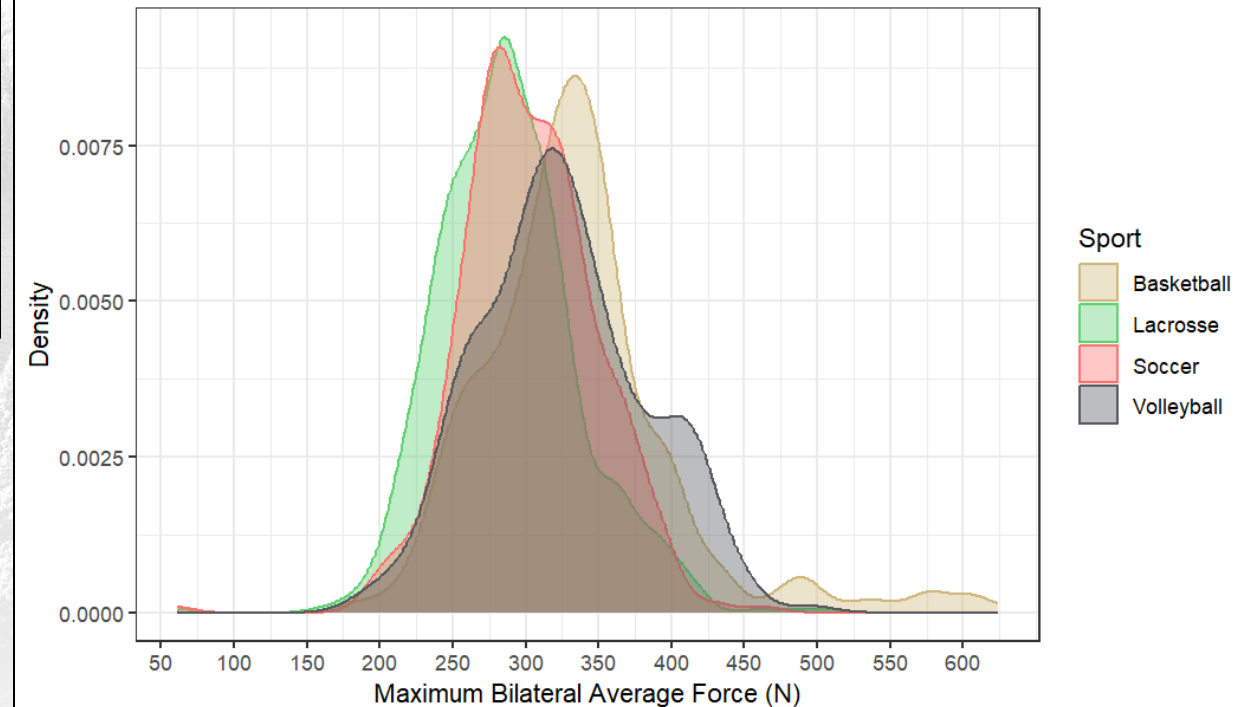
Distribution of Maximum Nordic Force Across Sports



Relative Bilateral Force:
Basketball <<< Soccer <<< Volleyball, Lacrosse

Bilateral Force:
Lacrosse <<< Soccer <<< Volleyball < Basketball

Distribution of Maximum Nordic Force Across Sports





Hip Abduction/Adduction Metrics



Abduction Force

Women's Basketball

Normative Percentiles:

25th: 297

50th: 330

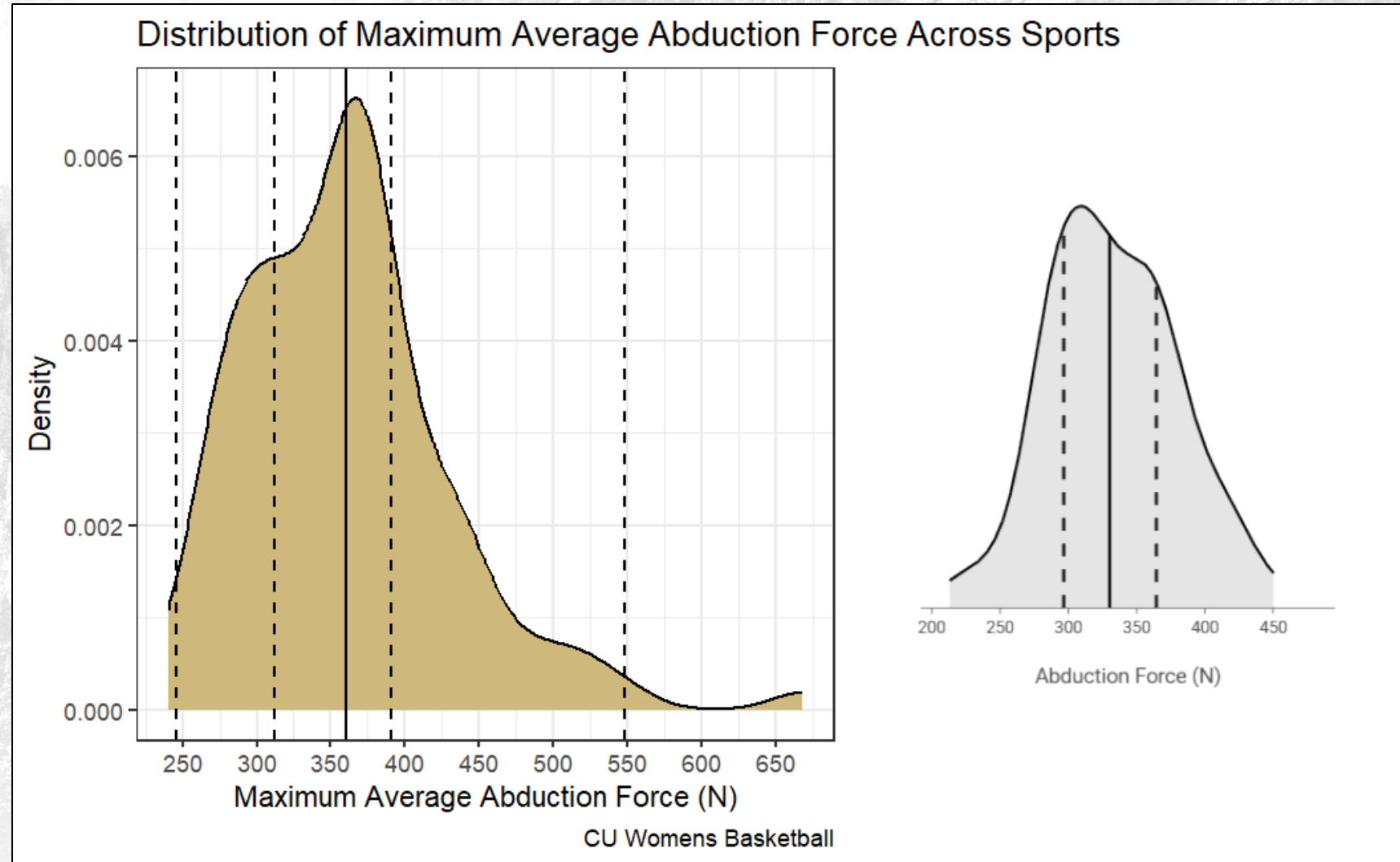
75th: 364

CU Data Percentiles:

25th: 312

50th: 361

75th: 390

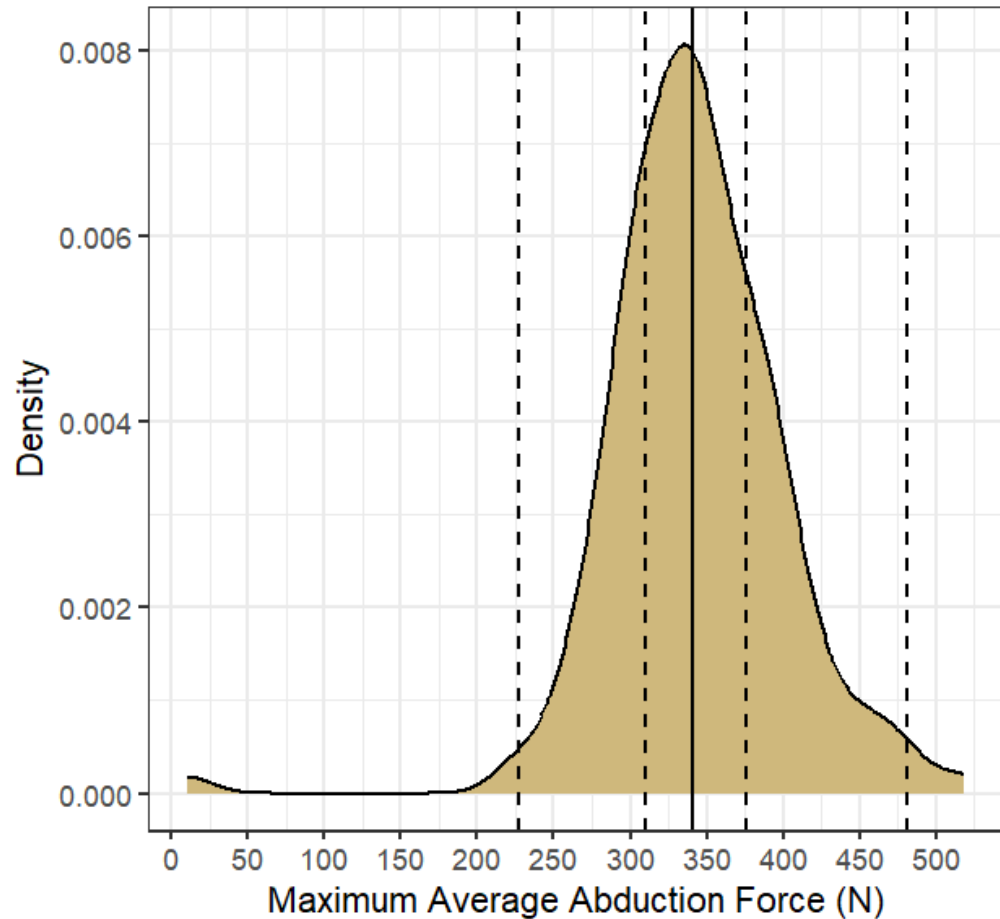




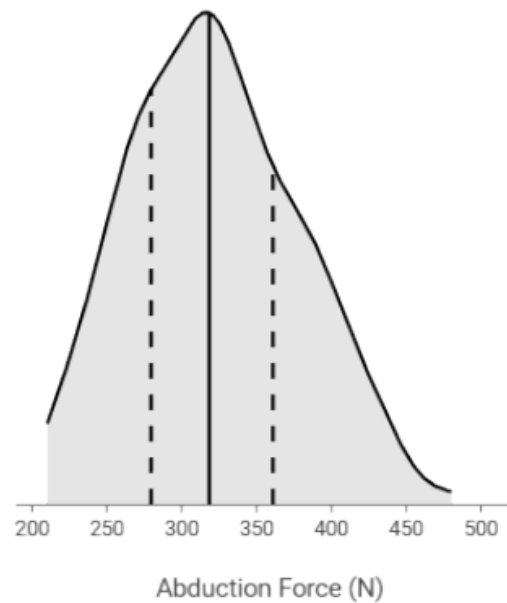
Abduction Force

Women's Volleyball

Distribution of Maximum Average Abduction Force Across Sports



CU Womens Volleyball



Normative Percentiles:

25th: 280

50th: 318

75th: 361

CU Data Percentiles:

25th: 310

50th: 340

75th: 376



Abduction Force

Women's Soccer

Normative Percentiles:

25th: 281

50th: 310

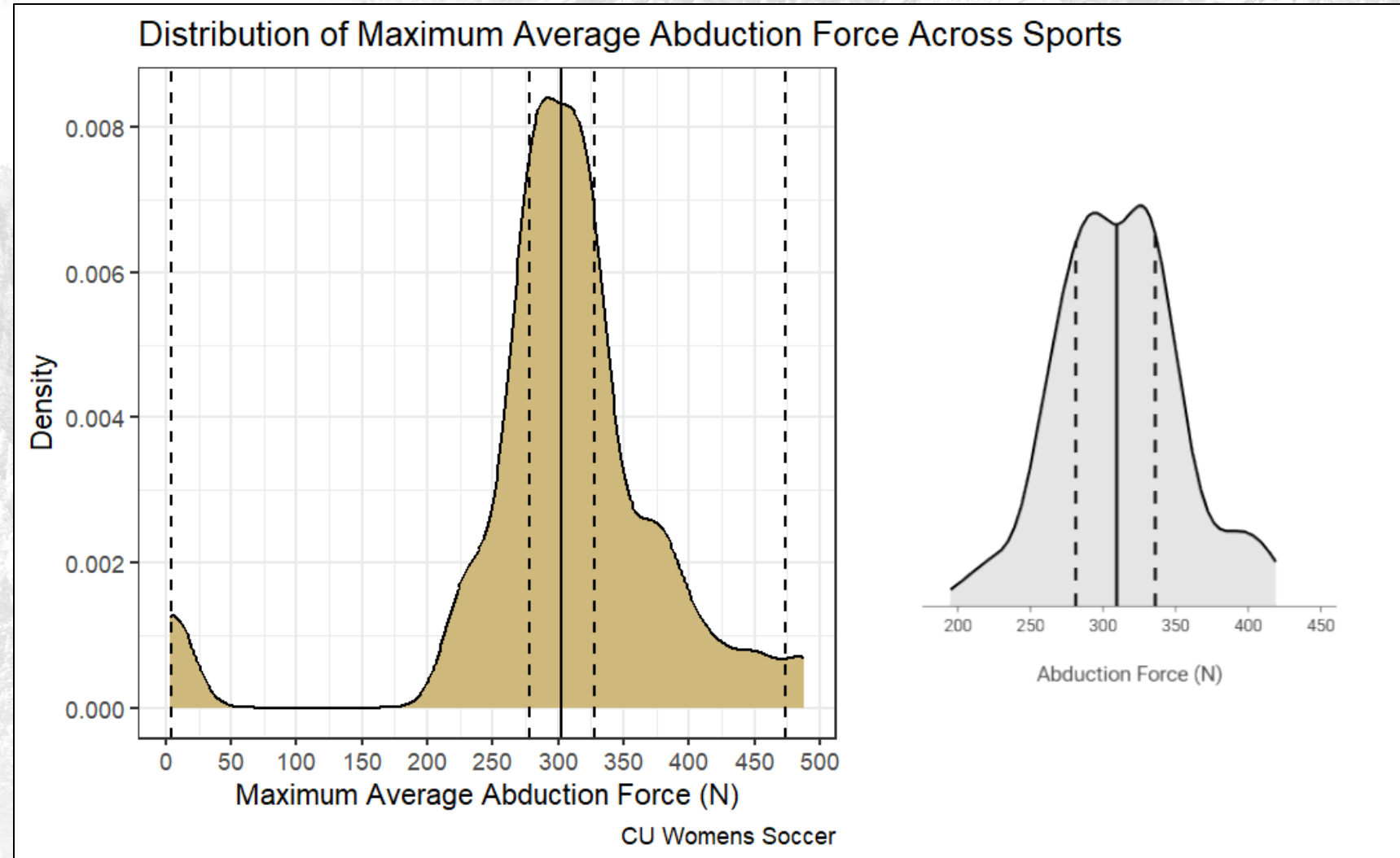
75th: 336

CU Data Percentiles:

25th: **278**

50th: **303**

75th: **328**

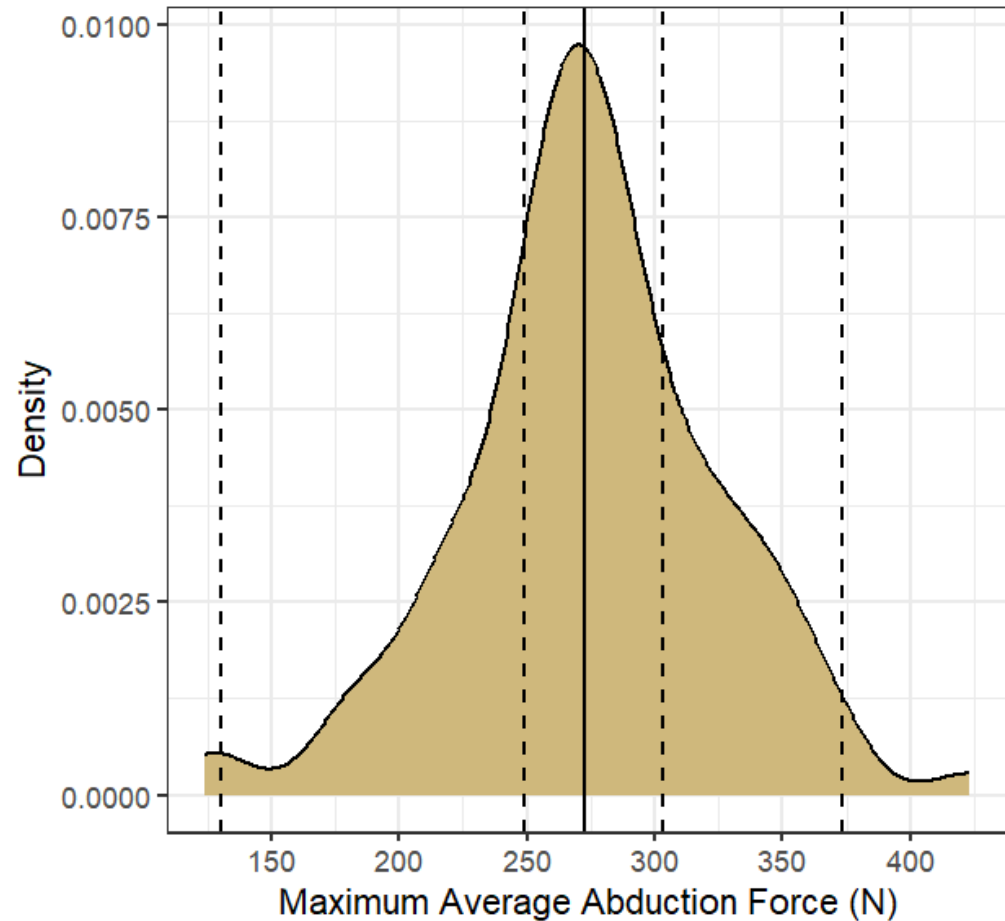




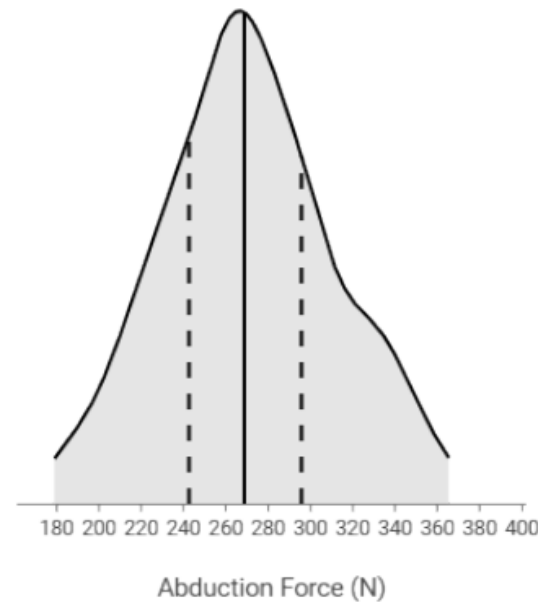
Abduction Force

Women's Lacrosse

Distribution of Maximum Average Abduction Force Across Sports



CU Womens Lacrosse



Normative Percentiles:

25th: 243

50th: 269

75th: 296

CU Data Percentiles:

25th: 249

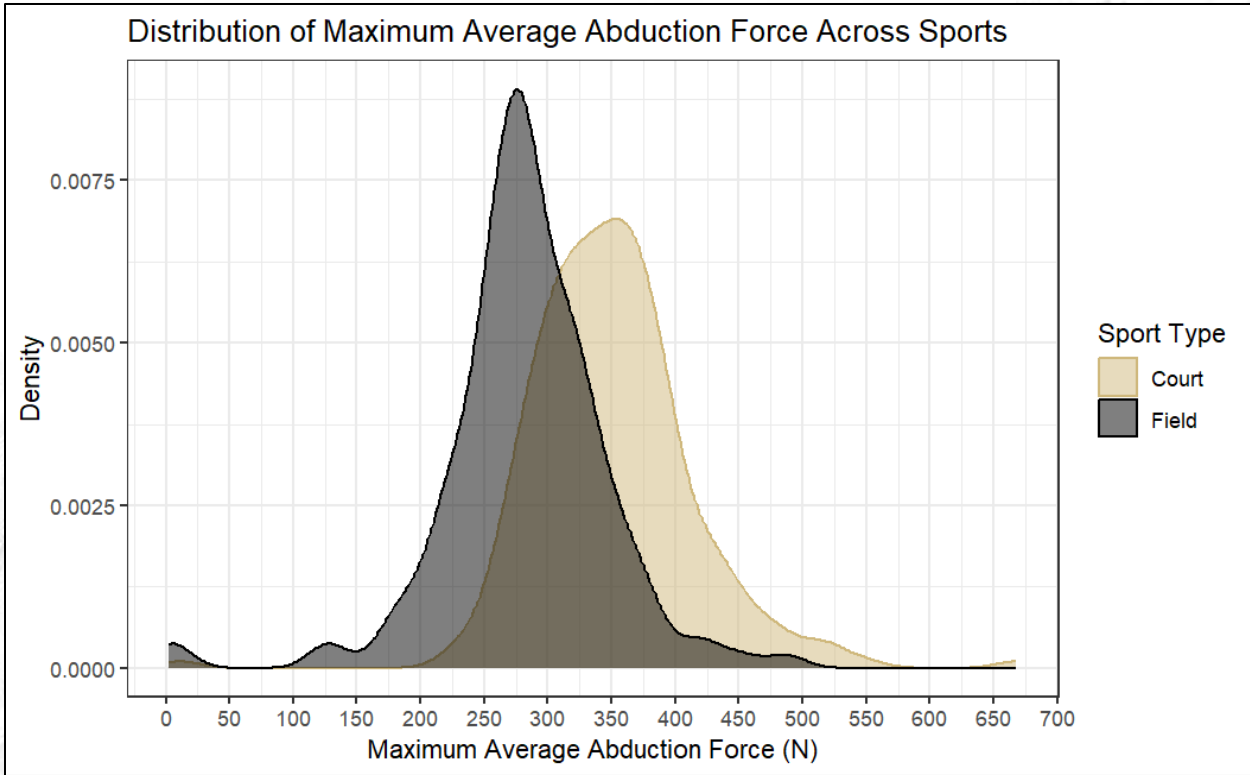
50th: 272

75th: 303

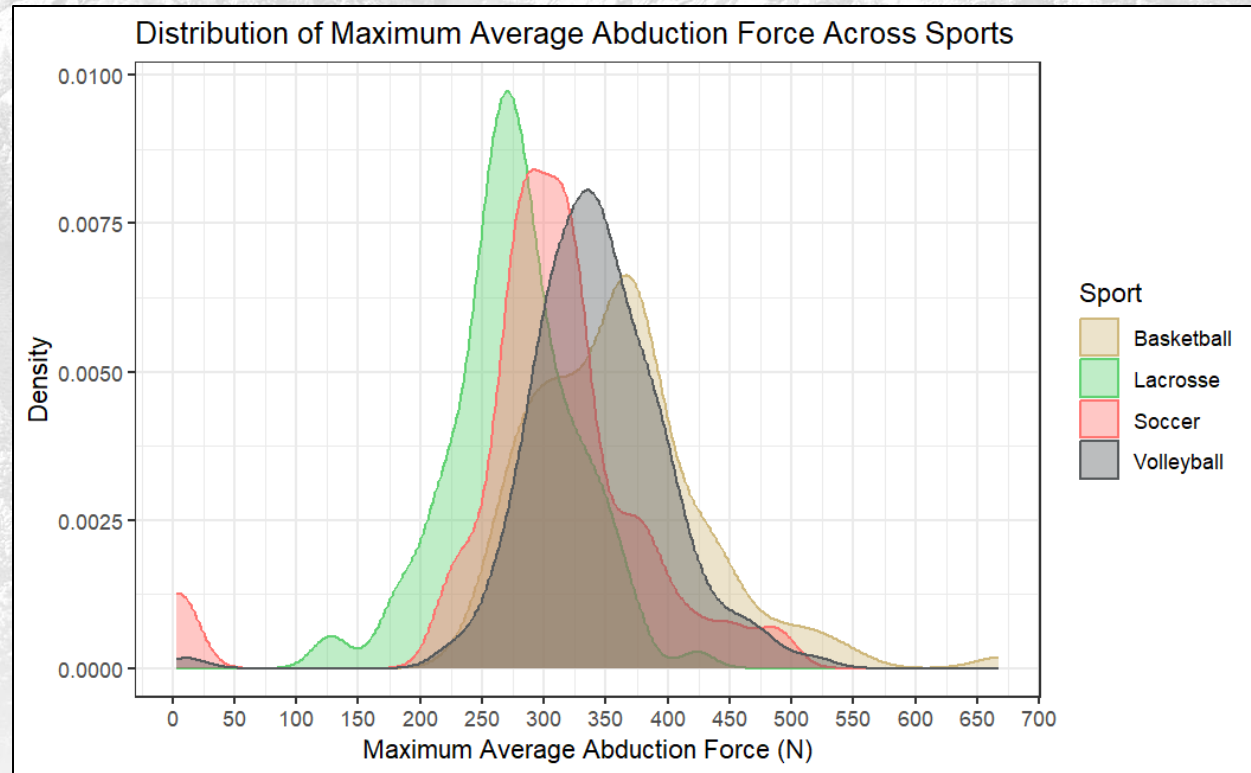


Abduction Force

Abduction Force:
Lacrosse < Soccer <<< Volleyball <<< Basketball



Relative Abduction Force:
Soccer, Lacrosse <<< Basketball, Volleyball





Concluding Thoughts

Question 1: We found 24 meaningful thresholds for many strength metrics as they related to lower body injuries in female athletes in the CU basketball, soccer, volleyball, lacrosse population.

Question 2: For most hamstring and hip strength metrics CU women's athletes in these four sports are performing as expected or even a little higher in comparison to normative data. There is more distance from the normative data in Foredeck metrics especially for lacrosse in hop jump metrics.