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◈ Poster #124

◈ Patient Specific Risk Factors Affect Anterior Cruciate Ligament Rupture-Concurrent Meniscal and Chondral Injuries in Young Athletes

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Objective

- To compare ACL injury risks based on contact versus non-contact mechanisms of injury and skeletal maturity
- To evaluate sport-specific rates of concomitant intra-articular pathology
- To identify patient-specific predictive risk factors for injury by sport.
- We hypothesized that more contact ACL injuries would occur in football, more noncontact in Soccer and Basketball.
- We also hypothesized that a larger size/mass would more often be associated with concurrent intraarticular injuries with contact mechanism of injury.

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Materials and Methods

- A single center retrospective cohort study of acute, primary ACL reconstructions
- IRB Approved.
- Surgical case logs were queried by CPT code 29888 to identify potential subjects from January 2012 to April 2020.
- Included subjects were aged 21 and below

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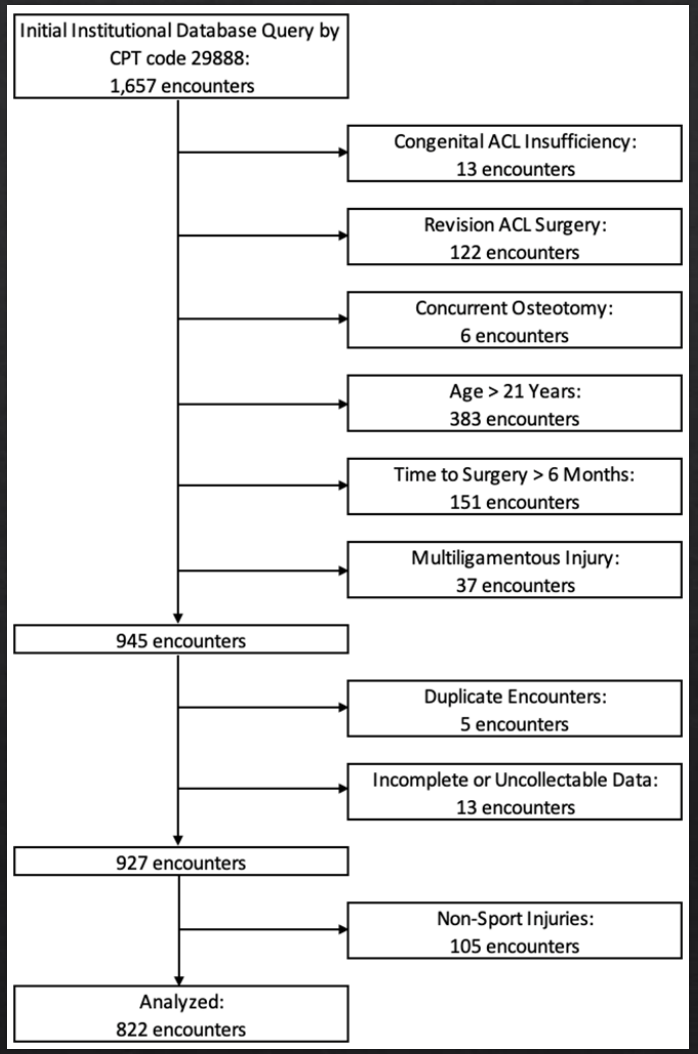
Materials and Methods-Inclusion/Exclusion Criteria



Materials and Methods

- Skeletal maturity was determined via knee imaging (XR, MRI)
- Meniscal and chondral injury characterized by involved compartment, location, pattern.
- Logistic regression was utilized to identify predictors of injury. Interaction variables were included to parse specific impacts of non-independent predictors.

Results

- Our analysis included a total of 822 ACL injuries. Soccer (32.6%), football (26.8%), basketball (23.8%) were the most common sports where injury occurred (Table 1). Other demographic data is found in Table 1.

Demographics

	Soccer	Football	Basketball
n (%)	268 (39.2%)	220 (32.2%)	196 (28.7%)
Age (years ± SD)	16.33 (± 1.69)	15.85 (± 1.82)	16.34 (± 1.58)
BMI (kg/m2 ± SD)	24.82 (± 4.95)	25.51 (± 6.65)	25.07 (± 4.69)
BMI < 18.5 (%)	11 (4.1%)	19 (8.6%)	3 (1.5%)
BMI 18.5-25 (%)	153 (57.1%)	105 (47.7%)	113 (59.2%)
BMI 25-30 (%)	67 (25.0%)	57 (25.9%)	50 (25.5%)
BMI 30-35 (%)	25 (9.3%)	17 (7.7%)	22 (11.2%)
BMI 35-40 (%)	10 (3.7%)	16 (7.3%)	7 (3.6%)
BMI > 40 (%)	2 (0.7%)	6 (2.7%)	1 (0.5%)
Males (%)	155 (57.8%)	194 (88.2%)	81 (41.3%)

Results

Soccer

- Soccer injuries were the most common in our cohort (32.6%)
- More likely to occur in skeletally mature (SM) athletes (p=.016).
- Increased BMI was a risk factor for concomitant meniscal (OR 1.12, 95%CI [1.05,1.20], p=.001) and chondral injury (OR 1.09, 95%CI [1.03,1.17], p=.005).

Results

Football

- Skeletally immature (SI) athletes comprised a significant proportion of ACL injuries ($p<.001$),
- More frequently injured via contact mechanisms ($p=.025$)
- Demonstrated increased overall meniscal ($p=.002$), medial meniscal ($p=.015$) and chondral injuries ($p=.018$).
- SI football players were a predictor of concomitant meniscal (OR 0.38, 95%CI [0.20,0.71], $p=.002$) and chondral pathology ($p=.018$).

Results

Basketball

- A significant proportion of ACL injuries occurred in SM patients (p=.003) via non-contact mechanism (p<.001).
- Older age was associated with concurrent meniscal injury (OR 0.14, 95%CI [0.04,0.42], p=.001)
- Increased BMI was associated with both meniscal (OR 0.28, 95%CI [0.13,0.58], p<.001) and chondral injury (OR 1.12, 95%CI [1.04,1.21], p=.002).

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Results

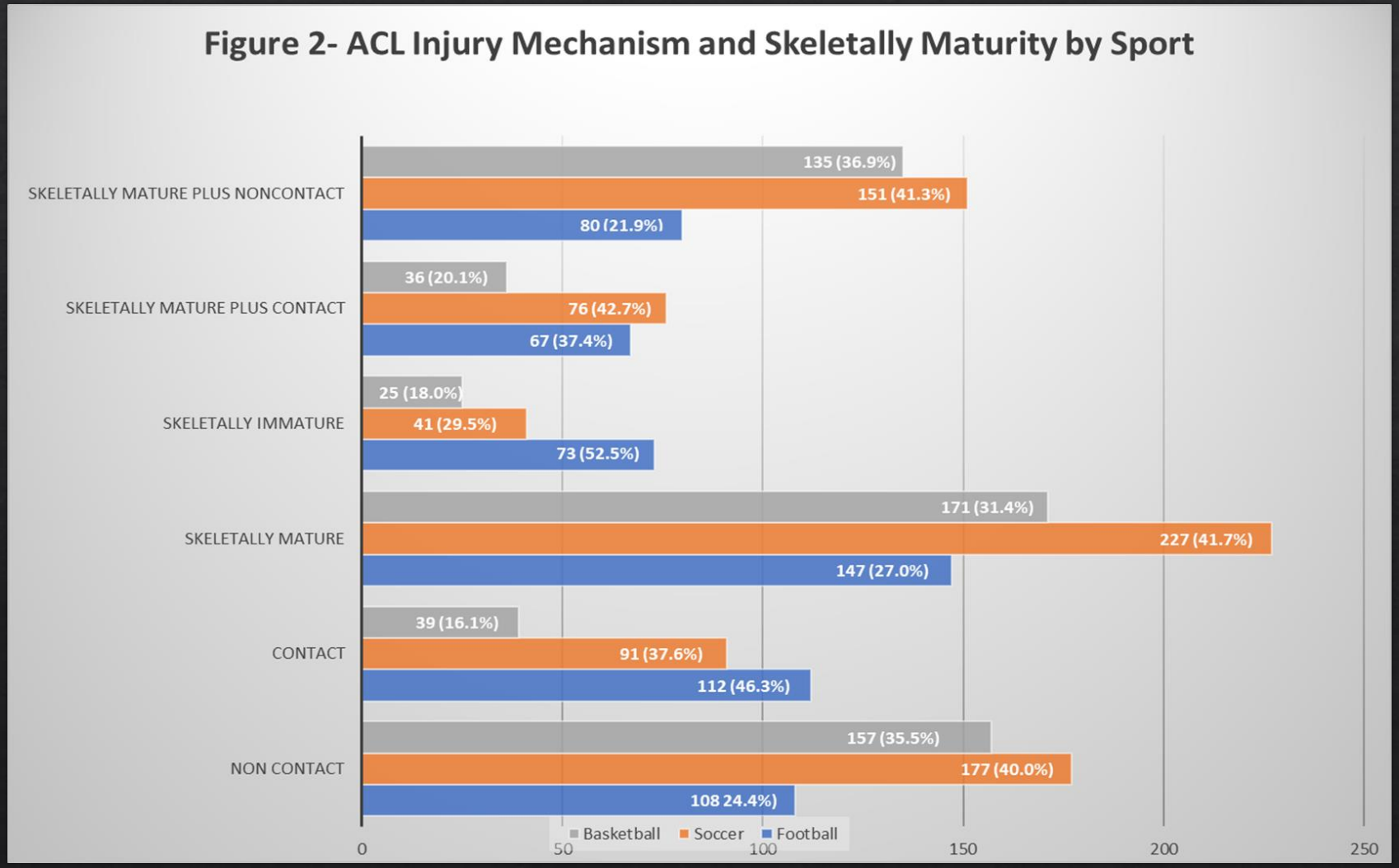

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Table 3 Concomitant intra-articular pathology stratified by sport injury – contact vs non-contact

Concomitant Sport Injuries	Skeletally Mature	Skeletally Immature	p-value
Contact Injury (n = 268)			
Meniscal Injury	143 (53.4%)	40 (14.9%)	.052
Medial Meniscus Tear	75 (28.0%)	11 (4.1%)	**.001**
Lateral Meniscus Tear	108 (40.3%)	36 (13.4%)	.880
Bicompartmental Meniscus Tear	40 (14.9%)	7 (2.6%)	.069
Chondral Injury	49 (18.3%)	5 (1.9%)	**.002**
Medial Compartment	36 (13.4%)	3 (1.1%)	**.006**
Lateral Compartment	20 (7.7%)	0 (0.0%)	**.007**
Patellofemoral Compartment	6 (2.2%)	2 (0.7%)	1.000
Non-Contact Injury (n = 554)			
Meniscal Injury	340 (61.4%)	61 (11.0%)	.108
Medial Meniscus Tear	183 (33.0%)	28 (5.1%)	.082
Lateral Meniscus Tear	263 (47.5%)	46 (8.3%)	.179
Bicompartmental Meniscus Tear	106 (19.1%)	13 (2.3%)	.053
Chondral Injury	98 (17.7%)	9 (1.6%)	**.010**
Medial Compartment	77 (13.9%)	6 (1.1%)	**.012**
Lateral Compartment	29 (5.2%)	4 (0.7%)	.460
Patellofemoral Compartment	10 (1.8%)	1 (0.2%)	.700

Results

Predictors of Intra-Articular Injury (Table 4)

- In basketball, increased BMI was associated with meniscal and chondral injury.
- In football, there was no association with BMI and injury.
- With regards to the interaction variable of Age::Skeletal Maturity in football athletes demonstrated significant risk MMT (p=.020) and chondral injuries (p=.026), where delayed physeal closure conferred an increased risk.
- Similarly for soccer athletes, Age::Skeletal Maturity was significant predictor of meniscal injury (p=.030), where early or delayed physeal closure conferred an increased risk.
- This interaction was not predictive in basketball injuries.

Table 4

A) Football Predictors of Intra-articular Pathology

	Meniscus Tear		Medial Meniscus Tear		Lateral Meniscus Tear		Chondral Injury	
Characteristic	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value
Age	---[a]	---[a]	1.18 [0.94, 1.50]	.200	1.56 [0.89, 2.85]	.130	1.15 [0.88, 1.52]	.300
Sex	0.34 [0.20, 0.71]	**.016**	---[a]	---[a]	0.37 [0.15, 0.86]	**.024**	---[a]	---[a]
Body Mass Index (kg/m^2)	---[a]	---[a]	---[a]	---[a]	1.29 [0.90, 1.90]	.200	1.02 [0.96, 1.08]	.600
Skeletal Maturity	0.38 [0.20, 0.71]	**.002**	0.00 [0.00, 0.02]	**.015**	---[a]	---[a]	0.00 [0.00, 0.00]	**.018**
Age::Skeletal Maturity	---[a]	---[a]	2.45 [1.24, 5.82]	**.020**	---[a]	---[a]	4.90 [1.56, 27.60]	**.026**
Age::BMI	---[a]	---[a]	---[a]	---[a]	0.98 [0.96, 1.00]	.140	---[a]	---[a]
BMI::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	1.23 [1.04, 1.55]	**.030**
Sex::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]

B) Basketball Predictors of Intra-articular Pathology

	Meniscus Tear		Medial Meniscus Tear		Lateral Meniscus Tear		Chondral Injury	
Characteristic	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value
Age	0.14 [0.04, 0.42]	**.001**	0.39 [0.14, 1.04]	.260	0.26 [0.08, 0.72]	**.013**	1.00 [0.79, 1.27]	.900
Sex	---[a]	---[a]	---[a]	---[a]	0.62 [0.32, 1.18]	.200	---[a]	---[a]
Body Mass Index (kg/m^2)	0.28 [0.13, 0.58]	**< .001**	0.60 [0.31, 1.10]	.110	0.44 [0.22, 0.85]	**.018**	1.12 [1.04, 1.21]	**.002**
Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	0.31 [0.10, 0.90]	**.035**	0.00 [0.00, 5.88]	.150
Age::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	5.22 [0.82, 109]	.200
Age::BMI	1.08 [1.03, 1.14]	**< .001**	1.03 [1.00, 1.07]	.091	1.05 [1.01, 1.10]	**.018**	---[a]	---[a]
BMI::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]
Sex::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]

C) Soccer Predictors of Intra-articular Pathology

	Meniscus Tear		Medial Meniscus Tear		Lateral Meniscus Tear		Chondral Injury	
Characteristic	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value	Odds Ratio [95% CI]	p-value
Age	0.84 [0.66, 1.05]	.130	---[a]	---[a]	0.90 [0.73, 1.10]	.300	---[a]	---[a]
Sex	---[a]	---[a]	0.60 [0.33, 1.07]	.083	---[a]	---[a]	0.55 [0.26, 1.12]	.100
Body Mass Index (kg/m^2)	1.12 [1.05, 1.20]	**.001**	1.10 [1.04, 1.17]	**< .001**	---[a]	---[a]	1.09 [1.03, 1.17]	**.005**
Skeletal Maturity	0.00 [0.00, 0.44]	**.030**	0.52 [0.19, 1.27]	.200	0.00 [0.00, 1.84]	.083	0.13 [0.01, 0.66]	.051
Age::Skeletal Maturity	1.65 [1.06, 2.63]	**.030**	---[a]	---[a]	1.46 [0.96, 2.28]	.080	---[a]	---[a]
Age::BMI	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]
BMI::Skeletal Maturity	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]
Sex::Skeletal Maturity	---[a]	---[a]	6.53 [0.90, 48]	.057	---[a]	---[a]	11.6 [0.38, 354]	.110

[a] = variable removed from best fit predictive model by stewise procedure; :: = interaction variable; **bold** = significant variable in the model

Discussion

- The findings of the present study support the hypothesis that more contact ACL injuries would occur in football and more non-contact would occur with soccer and basketball
- Additionally, ACL rupture in football was associated with skeletally immature athletes.
- Increased BMI was significantly associated with concurrent injury in basketball and soccer related ACL rupture.

Discussion

- Notably, in football, skeletal maturity was a prognosticator for concomitant meniscal and/or chondral injury in football-related ACL injury
- Interaction analysis revealed that SI football players demonstrated an increased incidence of medial meniscus and medial compartment chondral injuries compared to similarly aged peers.
- That finding suggests that athletes with delayed physeal closure, when sustaining contact ACL injury in football, were at increased risk for concurrent intraarticular injury.
- This raises concerns about young athletes who are skeletally immature and their risk for ACL injury as well as concurrent intraarticular pathology during contact sport.

Limitations

- This study was designed to assess injury patterns and does not report clinical outcomes or detailed biomechanics of individual subject injuries
- This analysis was retrospective, and subject to inherent biases and confounders including regional bias, information bias, and systematic bias
- This cohort represents only a subset of ACLRs performed during the study period, and generalizability has not been established
- Skeletal maturity was determined via closure of the distal femoral physis as opposed to formal bone age studies, which may have provided more detailed assessment of skeletal maturity status

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Conclusion

- Skeletally Immature athletes sustaining sport-related ACL tears demonstrated increased ratio of meniscal and chondral injuries with contact injury mechanism, particularly in football where contact ACL injuries were more common.
- Conversely soccer and basketball related ACL ruptures tended to occur in skeletally mature athletes via non-contact injury mechanisms
- BMI seemed to play a larger role in predicting concomitant intra-articular injury in basketball and soccer compared to football
- With the rise of youth sports participation and early sport specialization, it is important to identify the risks and common injury patterns for appropriate treatment of adolescent athletes.

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