**Literature Review - Points**

**1 - Intelligent injury pred(Soccer) - Focus on non-contact injuries (2023)**

[Pdf](https://pdf.sciencedirectassets.com/280203/1-s2.0-S1877050923X0009X/1-s2.0-S1877050923015685/main.pdf?X-Amz-Security-Token=IQoJb3JpZ2luX2VjEHwaCXVzLWVhc3QtMSJGMEQCIE3PIamxMHV8uNtI8lJGJD4PuPlvoUlFyvVdlKv0CZJ8AiBBfqea%2FgUS3JAqT50GXaBzzpEEj0DiuFe71sotf7p69Sq8BQj1%2F%2F%2F%2F%2F%2F%2F%2F%2F%2F8BEAUaDDA1OTAwMzU0Njg2NSIMmffc6FHZvoN0Qws4KpAF%2Bxazo5TZwcN3YG%2BWGKPmwJSZzhkZaZ4ySpyXYjHRwd3qM5NFQSJk%2BLpPzEaadD%2F8%2Bb3VGipTdLki5BaH2NysB1Cdfl8R80A3yZQH4zBdxf%2BUf%2FQj3zid6HtmZniLdGaw3bHjJg7zTrXpOQ4d2EHOV5lmlcWSO7iCjFvBoGCrlEvnS52QTpj8UARy8V%2FsKwL4pvtyGNCvzAUtBiQTYy8M%2Bc2elZUvzDDmP9FXjdaB4BroUtB5rivlT3avP4bC2uYbCVwCNLJ19D9%2BRtblnIw%2BdEDnt9L42DcebPsdw5lAOo1RBCbPP50ONBxyxs9NyD4GQSOGQ2GOKqfQs45%2BtXN9mopl%2Bvj2MmtZiGHXYLhq4OlpMuQzekFUciBmhv5ZVcjFGzcGP9ZMDh1gOkaRNjTlBjasVp4GCf05r9AhnCEackFOI2KrS7pssfNlbfpR1mPRNaeIuO3NCFQSeDu7mLg9nZlYMnLYj8L4EqDSsdCfm3TpcokehjLsfV%2F%2FXeUjONFJeQamaBW6Ki9Ve%2F5QiCX6o7seFUBZBvL1Q4zA%2FdgqXih2U8vqNdYPJJ2mytAOn%2BjH7uOtUClvKLtzuFWIj2AwmqD77tBfDuE%2FxIo4zD20y6ct0bYBrCcpDbVCrfj198ww%2F3Zdrmq9b7h89uysPI2HDIYg%2Bo39nv%2FpJOzDcSQGMYO2AFTAz78uJIIxjIgxymAg1Bv%2BEB1Iy7NyQ1QUlTFZkXDTIOvPpJMCa4csnNWHIClWG2kjBEZvUmVpJXVFDzacEtntzyrbFayS0a12ASOMHcsr2HTSGj5wVVJPI4stlXkY3wUb9cYYW9%2B4iI11Jrmhlw7O5YXRZRpjfReBtA0fit4oRaKz7AEI%2B8ygKQoisFkwq8ykuQY6sgGeVAZ7%2B3h1w1fRefJr9R8CmdVlFpuksLSLel7gisp%2BhkLa953%2Fmq9YUCLj2dVAAM0xmYiSNU6u5vGh%2Bvz%2F7cKRRSPolxW52dRnsSOKQpP4ffzC3WT%2Fl6%2FwgdN%2Fpqm0o1%2F9p8ez8ZoKwnew1rjnSiMegeAgQmElO0k1CZkzgoCE3XpCwrbqYFY3XWtPW3QCauUAiFCf7ROwhhVtsRzwxg9T8ARLOhoS%2Bbuy9Rmcoz61WUfR&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Date=20241104T201606Z&X-Amz-SignedHeaders=host&X-Amz-Expires=300&X-Amz-Credential=ASIAQ3PHCVTYTVPXQX4L%2F20241104%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Signature=f46148607e55f05cf6ef2e3d382366c9411ce4a3174984eb66eaea2ac35ca6a0&hash=8765367db0ef7c2f3402659283ff0c65ace0a417b0171fd0ea8ddef25ef385c6&host=68042c943591013ac2b2430a89b270f6af2c76d8dfd086a07176afe7c76c2c61&pii=S1877050923015685&tid=spdf-a9179c8d-61cd-43e3-ba69-cae6198e9c36&sid=b792aa4b789ab9486a3b983-e148ab7c6cddgxrqb&type=client&tsoh=d3d3LnNjaWVuY2VkaXJlY3QuY29t&ua=13035b0a06545750065952&rr=8dd747a70d96bdd1&cc=ie)

* Injuries have a big impact on team performance which can affect team finances/ profitability.
* Poor weather affects injury likelihood
* Cold weather can affect muscle efficiency
* Stress/ Genes
  + COL5A1 - Gene linked to achilles injuries
* Challenges with ML - black box models lack transparency, prone to overfitting, difficult to implement
* Coaches can adjust decisions if a player is likely to get injured
* Data Availability has affected previous models
* Building a personal injury risk profile
* Wet pitches & cold exposure increase injury risk
* Studies don’t include with a wide range of data features

**2 - Common NFL Injuries (1991)**

[PDF](https://link.springer.com/article/10.2165/00007256-199112020-00005)

* 1.2million injuries annually across America
* Lower extremities is 50% of all injuries, knee injuries 22-36.5%, upper extremities account for 30%
* Coaching experience can affect injury rate
* Preseason can reduce injury rate
* 51% of injuries occur in practice, contact sessions are 4.7 times more likely to produce injuries. 86% of practice injuries occur in preseason practice
* Spine injuries declined between 1975-1984 due to rule changes and conditioning
* Maintaining a safe playing surface reduces injury rate
* Emphasise conditioning over contact drills in preseason
* Ensure a managed return to play
* Tailor training programs based on physical development
* Focus on tackling technique and safety in practice

**3 - D1 Injury Analysis (2022)**

[PDF](https://scholarcommons.sc.edu/cgi/viewcontent.cgi?article=7640&context=etd)

* A problem is the prior likelihood of injury is quite low so classes are very imbalanced
* Scheduling and rest days play an important role in injury risk
* Overall workload was most important
* Data availability and quality was a big issue

**4 - Week 1- 4 Post-Covid (2021)**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC8365220/pdf/main.pdf)

* Lack of preseason did affect injury rate
* Higher injury rate compared with previous seasons
* Lack of data
* Preseason allows for proper conditioning to prevent injuries

**5 - Quarterback Injury Analysis (2004)**

[PDF](https://journals.sagepub.com/doi/epub/10.1177/0363546503261737)

* Between 1980-2001, 1534 QB injuries reported
* On average missing 18.8 days (median of 6)
* Shoulder injury second most common at 15.2%
* Head injury most common at 15.4%
* Direct trauma most common reason for shoulder injury 82.3%
* AC joint sprain most common
* 70% of shoulder injuries from tackles
* 47.3% as passer, 12.6% as runner, 9.6% after the pass
* Throwing motion caused 14% of shoulder injuries
* Overuse injuries:
  + Rotator cuff tendonitis(6.1%)
  + Bicep tendonitis(3.9%)

**6 - External Factors effecting injury rates (2023)**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC10399261/pdf/10.1177_23259671231177633.pdf)

* Teams who didn’t make the playoffs had higher injury report
* Not much effect of bye week timing & Cumulative travel distance

**7 - Injury Prediction Framework (2019)**

[PDF](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9063267)

* Concussions have increased reaching 16% in 17/18
* CTE is a major problem for NFL players, with 96% of deceased players having been diagnosed with it
* Data is very imbalanced

**8 - ML for injury prediction(Soccer) - (2022)**

[PDF](https://sportsmedicine-open.springeropen.com/articles/10.1186/s40798-022-00465-4)

* Various Data points - internal load(psychological) & external load(velocity)
* Lack of consensus on most important features
* The need for explainable AI to better interpret the results

**9 - Using FMS to predict injuries (2007)**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC2953296/pdf/najspt-02-147.pdf)

* A small study to see if the FMS can predict injuries
* Players with a score <14 were 11 times more likely to get injured in the first 3 weeks of the season
* Research was limited as only 46 players were tested

**10 - Full Season Post Covid (2024)**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC10985286/pdf/xmed-v5-e45688.pdf)

* The effects of limited preseason were massive, however returned to normal after 1 season

**11 - Musculoskeletal Injuries (2023)**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC10286201/pdf/10.1177_23259671231168875.pdf)

* NFL generates $16B in 2019
* NFL injury incidence rate per 1000 athlete - between 23.1-64.7
* 65% of Musculoskeletal injuries in lower extremities

**12 - Playing Surface analysis (2009)**

[PDF](https://journals.sagepub.com/doi/epub/10.1177/0363546508328108)

* Artificial surfaces have higher peak torque & additional rotational stiffness which can lead to more injuries

**13 - Weather injury analysis(2003)**

[PDF](https://journals.lww.com/acsm-msse/fulltext/2003/07000/risk_of_knee_and_ankle_sprains_under_various.8.aspx)

* Knee and ankle injuries less likely when weather is colder
* Significantly lower rates of ankle sprain on grass to turf & lower rates of most knee sprains
* No significant difference on ACL rate in stadium or surface all conditions
* Winter seasons tend to have higher injury rates at the start of the season compared to summer competitions
* Data is from 1980-89

**14 - Psychological effects on injuries**

[PDF](https://pmc.ncbi.nlm.nih.gov/articles/PMC3761721/pdf/jssm-09-347.pdf)

**15 - COL5A1**

[PDF](https://journals.sagepub.com/doi/epub/10.1177/0363546509338266)

1. **Introduction to Injury Prediction in Sports**

**Quotes**

* “injuries not only pose a threat to the athlete's health but also impact the team's overall performance and financial prospects.” [1]
* ‘An estimated 1.2 million football-related injuries are sustained annually.” [2]
* “Overall, lower extremity injuries accounted for 50% of all injuries (with knee injuries ac- counting for up to 36%). Upper extremity injuries accounted for 30%. In general, sprains and strains account for 40% of injuries, contusions 25%, fractures 10%, concussions 5% and dislocations 15%. “ [2]
* NFL generated an astounding $16 billion in revenue in 2019.28 The incidence of injury is also well reported, with rates between 4.1 and 7.9 injuries per 1000 athlete-exposures in high school football,5,37 9.3 and 40.6 in collegiate football,71 and 23.1 and 64.7 in the NFL. [11]
* For all injuries, the vast majority occurred with contact (82.3%); 14.4% occurred with no contact, and 3.3% were not specified. [5]
* NFL exhibiting a steady increase over the last six years peaking in an alarming concussion rate of 16% for the last reported 2017/18 season. This ultimately paved way for the C.T.E(Chronic Traumatic Encephalopathy) [2], a neuro-degenerative brain disease found in 96% of deceased ex-NFL players [7]

2. **Influence of External Factors on Injury Rates**

**Quotes**

* Both artificial surfaces produced higher torques (*P* < .001) than natural grass surfaces. [12]
* The rotational stiffness for both artificial surfaces was higher (*P* < .001) than each of the natural grass surfaces. [12]
* High rotational traction between football shoes and playing surfaces may yield a potential for injury to the lower extremity [12]
* This study reports that in the NFL knee and ankle sprains are generally less likely in outdoor stadiums (both natural grass and AstroTurf) when the temperature is cooler. [13]
* In general, football competitions that are played over a fall to winter season show higher injury rates early in the season, whereas summer football competitions and indoor sports such as basketball do not [13]
* Cumulative team travel distance did not significantly predict the number of injuries per 1000 AEs. Furthermore, there was no statistically significant difference in injury rates between NFL teams that did versus did not play a game overseas in their season. [6]
* In addition, there was no statistically significant difference in injuries per 1000 AEs between weeks that NFL teams had their bye week during the season [6]
* There was a statistically significant difference in injury rates between NFL teams that did versus did not make the playoffs.
* Research has shown that playing football on wet artificial turf or natural grass increases the risk of lower extremity injuries, particularly ankle sprains and knee ligament tears [1]
* Cold exposure can increase muscle glycolysis and lactate accumulation suggesting a lower muscle efficiency and/or an effect of a lower perfusion in cold muscle [1]
* Cervical spine injuries have the potential to be catastrophic, but they declined dramatically in the decade 1975 to 1984, due to the impact of rule changes modifying tackling and blocking techniques and improved fitness, equipment and coaching.[2]

3. **Genetic and Physiological Factors in Injury Likelihood**

**Quotes**

* injured players reported a higher level of susceptibility to experiencing stress than non-injured players. [14]
* A study has found that football players with a specific variant of the COL5A1 gene had a higher risk of suffering from Achilles tendon injuries [15]
* The ratio of internal (e.g. physiological and psychological factors) and external (e.g. data collected via GPS) workload variables has been demonstrated to be important as a predictor of injury. [8]
* professional football players with a lower composite score (<14) on the FMS had a greater chance of suffering a serious injury over the course of one season. [9]

4. **Injury Distribution**

**Quotes**

* “Overall, lower extremity injuries accounted for 50% of all injuries (with knee injuries accounting for up to 36%). Upper extremity injuries accounted for 30%. In general, sprains and strains account for 40% of injuries, contusions 25%, fractures 10%, concussions 5% and dislocations 15%. “ [2]
* NFL injury incidence rate per 1000 athlete - between 23.1-64.7 [11]
* Roughly 65% of football-related musculoskeletal injuries are of the lower extremity, and the most common injuries encountered include knee sprains, ankle sprains, hamstring and adductor strains, and shoulder sprains. [11]
* professional football players with a lower composite score (<14) on the FMS had a greater chance of suffering a serious injury over the course of one season. [9]
* [between 1980 and 2001] a total of 1534 quarterback injuries were reported to the NFLISS involving all body parts. There was a mean of 18.8 and a median of 6.0 days of playing time lost for all injuries. [5]
* For all injuries, the vast majority occurred with contact (82.3%); 14.4% occurred with no contact, and 3.3% were not specified. [5]
* Nearly 70% of shoulder injuries occurred while the quarterback was being tackled; 47.3% occurred while being tackled as the passer, 12.6% occurred while being tackled as the ball carrier, and 9.6% occurred while being tackled after the pass. Only 14% of injuries were reported as being secondary to the actual throwing motion [5]
* The most common single shoulder injury identified was an AC joint sprain incurred while being tackled [5]
* There was a mean of 22.1 and a median of 12.5 days of playing time lost for AC joint injuries.[5]
* Overuse injuries were responsible for 14% of the injuries, the most common being rotator cuff ten- dinitis (6.1%) followed by biceps tendinitis (3.5%). [5]

5. **Challenges in Injury Prediction Modeling**

**Quotes**

* One significant concern is the "black box" nature of these models, which can hinder validation and implementation due to the lack of reporting transparency [1]
* While machine learning methods have the potential for accurate predictions, they often result in overfitted models with poor performance in prospective validation. [1]
* One of the major challenges is that data is often derived from a single club, over a limited time period, where players come and go, resulting in a missed opportunity for observation or the lack of access to a more complete injury and workload history [1]
* The limitation of sample size and data types restricts the predictive capabilities of the models. Therefore, the development of more comprehensive, unbiased models is necessary to improve injury prediction accuracy and reduce the risk of injury.[1]
* Innovations and novelty in this area should focus on a broader range of data sources, encompassing the full spectrum of types from workload and surveys to DNA. [1]
* We were not given complete access to the data set. [3]
* The most significant challenge facing anyone trying to model sports injuries is the imbalance between injury cases commonly seen in this type of data. [3]
* So, the need to resample the data was realised to deal with the highly unbalanced data in order to avoid the under-sampling and oversampling issues that could arise later. [7]
* The lack of consensus regarding which features to consider for analysis, let alone those subsequently proving to be key in predicting players’ injuries, makes it difficult at this time for practitioners to rely on these studies when choosing which training load features upon which to focus. [8]
* By expanding the focus to multiple seasons’ data, account- ing for data imbalance, and using explainable artificial intelligence, machine learning should help to unlock new insights into the workload–injury relationship. [8]

7. **Preventative Measures and Risk Management in Sports**

**Quotes**

* The intelligent system will offer coaches and medical staff actionable insights to help them take preventative measures and decrease the likelihood of injuries. [1]
* Monitoring Creatine Kinase levels could potentially help identify athletes at higher risk of injury, allowing for targeted interventions and prevention strategies. [1]
* Internal factors, along with external factors such as training load, weather conditions, and playing surfaces, should be considered when developing a comprehensive approach to injury prevention in football. [1]
* By leveraging multiple classifiers, the system can better adapt to each player's unique profile and provide personalised injury prevention strategies. [1]
* In addition, improved equipment, coaching and physical conditioning also help to reduce injuries. [2]
* The epidemiological data support the ideas that contact drills should be limited and that intrasquad full contact scrimmages should be minimised to reduce the rate of injury. [2]
* Preseason practice sessions should be shortened and should emphasise conditioning rather than contact drills. [2]
* Playing surface should be carefully maintained. If an inordinate number of lower extremity injuries are noted, the playing field should be inspected. [2]
* The coaching staff should be helped to develop an off-season conditioning programme in which previously injured athletes are encouraged to participate.[2]
* Injured athletes should not be allowed to return to competition too soon. [2] - Managed RTP
* Appropriate training in the techniques of blocking and tackling is most important [2]
* The findings of our study confirmed our hypothesis that players were at a higher risk of injury during the early 2020-2021 regular season following cancellation of preseason games due to Covid-19. [4]
* Highlight the importance of the NFL training camp in preparing NFL athletes for the rigours of the NFL regular season and its influence on injury prevention. [4]

8. **Future Directions and Recommendations for Injury Prediction**

**Quotes**

* Adapt to each player's unique profile and provide personalised injury prevention strategies.[1]
* Future work should focus on refining data collection and organisation, exploring sequential approaches to injury prediction, and expanding the scope of data sources to achieve better accuracy and usefulness for coaching staff in preventing player injuries. [1]
* This is a database study, and incomplete data entry and inaccurate reporting of injuries could confound the season-to-season injury differences. [4]
* By expanding the focus to multiple seasons’ data, account- ing for data imbalance, and using explainable artificial intelligence, machine learning should help to unlock new insights into the workload–injury relationship. [8]