

Anterior Cruciate Ligament Knee Injury Detection of Sports Persons using Machine Learning Techniques



Jaskaran Kaur, Sandeep Sharma

Abstract:- ACL is one of most common knee injury in sports person which increases as the participation in sports increases. People participating in basketball, football, hockey and athletics generally faces more weight bearing on hip, knee and ankle which is directly breaking of muscular tissues of ACL. After this it is mandatory to rehabilitate and back to the field for sport person at same pre-injury stage. But it requires mental and physical strength to recover from ACL tear and proper treatment needs health management. In a growing age of Information Technology the use of computer and its applications are extensively used in almost all areas. The main objective of this paper is to check the use of expert system or the use of any computerized equipment while diagnosis Anterior Cruciate Ligament injury. There are many techniques and machines to predict the knee injury grade like MRI but to check the accuracy level computer expert system Machine learning techniques are best for the results.

Keywords: Anterior Cruciate Ligament, Rehabilitation, Knee Injury, Expert system, Treatment.

I. INTRODUCTION

Ligament is a structure that holds bones together and helps to control movement and motion of the knee. Two ligaments are deep inside the knee that cross each other is called ACL or Anterior Cruciate Ligament and Posterior Ligament. ACL is mostly diagnosed by physical check up and by X-Ray or MRI and other physiotherapy check up. ACL is one of the four major knee injuries could be in 10 yr old age group to any age those who participate in game and it is also because of age which is above 50 yrs [13]. ACL injury reduces physical activities of person is unable the person to put weight on knee. By the help of X-Rays, MRI and Ultrasound injury level and its type can easily noted by doctors. But each technique to diagnose an injury is different. [4] In case of X-Rays fractures are easily seen but ligament and tendons cannot be found in X-Ray .For this limitation of X-Ray MRI and Ultrasound is recommended by doctors. Two clinical tests are recommended by physiotherapists Anterior Drawer’s test and Lachman’s test. **A R.I.C.E model** can be followed to get relief from pain. In this model **R** stands for rest and avoids weight bearing, **I** stand for icing on injury for 20 minutes, **C** is for compression by wrapping a bandage around the knee and last **E** is elevation by support of pillow below the knee.

Revised Manuscript Received on April 30, 2020.

* Correspondence Author

Jaskaran Kaur*, Dept. of Computer Engineering and Technology, Guru Nanak Dev University, Amritsar, Punjab, India.

Dr. Sandeep Sharma, Dept. of Computer Engineering and Technology, Guru Nanak Dev University, Amritsar, Punjab, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

ICE model can follow by doctors of physiotherapist advice and need to do regularly at home itself. Treatment of any types of disease and injury is always based on the symptoms, level of injury, physical and report based examination and the most important reason from which activity the injure occurred. Treatment can be surgical and non surgical. As above mentioned Grade of injury at grade 1 it non-surgical that can recover by therapy or bracing and grade 3 is a surgical injury that is grafting or reconstruction of ligament.

Table no. 1 Classification and Symptoms of ACL

Type of Grade	Percent of injury	Symptoms
Grade -1	25% (mild injury)	It provide good stability to knee joints to walk and run with mild pain
Grade-2	50% (partial injury)	Partial injuries are less observed injuries and ligament is also partially torn, stretched which loose stability.
Grade-3	90% (complete injury)	Completely torn and no stability, no pain in ligament. Surgery is commonly recommended in most of the cases.

Treatment of any types of disease and injury is always based on the symptoms, level of injury, physical and report based examination and the most important reason from which activity the injure occurred. Treatment can be surgical and non surgical. As above mentioned Grade of injury at grade 1 it non-surgical that can recover by therapy or bracing and grade 3 is a surgical injury that is grafting or reconstruction of ligament.

Anterior Cruciate Ligament is strongest factor which leads to osteoarthritis in 9 of 10 are suffering from knee injury. It is nature of injury that if there is any ligament injury and it cannot be said that only ACL injure is there. [2] It is 80% possibility that combination of two joint injuries is present that is ACL and MCL (Mensical Cruciate Ligament). This is because joints are attached to each other which provide support and pivotal movement easily. Even AMERICAN Foundation stated that treatment by Indian doctors and American has major difference. It is reported in 2017 still there is no decrease in ACL injure which is due to lack of treatment, knowledge and the most important prevention program for different age is not provided. Prediction is going on health management. ACL injury study states that human contribution with new expert system is required for betterment in treatment is required which will cover those areas of medical line where no effort has been made.

Researchers for last few years took ACL a vital issue and showed so much difference in studies. The department of epidemiology research clearly defines the youth and adults facing injury at high rate and it approximately around 175,000 to 20,000 annually in United States alone. 80% of Anterior Cruciate Ligament injury is being analyzed than other injuries. [2] Only 83% of athletes return to sports after rehabilitation. It took 6 months to 13 months time to recovery and start making balance.

More than 75% of grafting is chosen by both male and female ACL percentage also increases in high schools like in basketball 5.5% in male and 26.5% in female followed by volleyball 8.8% in both and 71% in football. ACL fester one major part of the body and person feel decreased. The concern is to return to sports field after injuries which include estimations like age, gender, injury type, surgery or grafting of ACL. ACL injury of knee is growing and the expense of medical facilities and recovery -both are parallel. [2] It is a reprehensible but can be rehabilitated. It is being observed by studies when a person jumps, runs and sprints in recursive manner the knee and spine generates more pressure. Organization of Arthritis foundation osteoarthritis Action Alliance help the researchers in improving

II. LITERATURE SURVEY

Claudino, et al. (2019) predicts the accuracy of different AI method and techniques by measuring activities performed by various team sports likes football, hockey, basketball, athletics, volleyball, etc. [1] Major methods of classifications like support vector machine, neural network, classifier, tree decision are used.

Joshua, et al. (2018) proposed return to sports rates by ACL reconstruction by one of two grafts that's Allograft or Auto graft which is a revision of increase in number of patients for graft. [8] Primary goal is to control the injury of athletes and successful grafting of ACL but anyhow with time there is increase in injury 10,000 annually.

Mark D. Stojanovic, et al. (2014) a review for prevention and training of ACL injuries and to propose a preventive measure of ACL injure to avoid rate of injure increases. [13] Female injury rate is 4 -6 times more than male person and operative treatment is better than non -operative in grade 3. The research evaluates that more preventive measures are required both in male and female.

Chang, et al. (2019) detects injury using deep learning by applying simple dynamic patch algorithm. Its predicts complete ACL injury but do not specify any particular sports persons. Its describes about how the range of injury varies.

Yang, et al. (2019) proposed study of Artificial Intelligence that about 10% better results is evaluated by implementing convolution neural network. Results obtained based on the performance are better and reduces the complexity.

Karimi, et al. (2016) used 3 processing models i.e. preprocessing, classifications and segmentation that are used for the detection of Mensical tear. It is necessarily required that resultant after diagnosis need to be predicted correct with automatic detection techniques but somehow fails as obstacles arises.

Nicholas Bien, et al (2018) stated that by use of deep learning with MRI techniques for ACL and MCL knee tear

prevention of injury at early stage, control osteoarthritis and also others community groups support in nurturing to meet the resources and availability of training programs which are effective for neuromuscular and tear of knee.[8] Many workgroups of prevention are there at initial stage setting their primary goal to identifying the gap between the scientific knowledge related to osteoarthritis. Researchers of knee surgery and Arthroscopy International Society of Arthroscopy, European Society of sports traumatic all participated with their studies and experiences go through in sports and judged that early age like at age 10 years in children lead their life with long-term consequences, long-term loss of quality of life and as well as more risk for another injury which may or may not happen in time 6 months to 2 years after first injury.

Rehabilitation requires significant time for a person to return to field of sports. Physiotherapists and health care center took responsibility for providing equipments and treatment for betterment of injured children and adults. Ramifications is challenging in ACL as there are many limitation yet to work and to relate with scientific knowledge. Other extrinsic factors are also counted that are game surface, type of game and environment of game.

Justin M. Losciale, et al. (2019) recently examines the relation of ACL injured person to return to sports and success of grafting undergone patients. [7] A previous study does not present any option to return to sports after ACL injury and criteria to reduce the risk of patient's injury. Now author evaluated that grafting is optimal choice for extreme suffering from knee injury where there is only 3% chances to reduce in ACL 2nd injury.

injury detection provides better results which helps the clinical experts for valuable treatment and also increases quality of result. Convolution Neural Network and Logistic Regression is combined to classify the MRI series and to improve the quality.

Prognosis of ACL Reconstructive by **Abhijit, Oliva, et al. (2013)** proposed a paper that states that knee Osteoarthritis (disease of joints) in men is 40.1% and in women is 56.5% which can be experienced at age of 25 to 40 yrs. [14] There are measure to avoid second ACLR injury but avoid OA is a big limitation. The work done in paper by Data Driven Approach with divides and conquer rule to estimate ACL recovery after Reconstruction in male and female. After that to calculate flow of energy in movement of knee and rotation of knee Residual Curvature is applied. DDP approach is used to slow down the limitation.

Table 2. Survey of ACL injury Author	Publisher with year	Type of injury	Testing Model	Sports	Expert system used
Claudion, et al.	Springer -2019	Not specified	Bayesian network, tree classifier and k-means clustering.	Basket ball, volleyball, soccer and football.	Artificial Intelligence.
Chang, et al.	Springer -2019	Complete Acl tear	Dynamic patch based sample	Not specified	Deep learning
Yang, et al.	Springer -2019	Acl tear	Two deep convolution neural network	Not specified	Artificial Intelligence
Nicholas, et al.	Plos Medicine -2018	ACL and Mensical tear	Neural network	Not specified	Deep learning
Karimi, et al.	Springer -2017	Mensical tear	Fuzzy logic	Not specified	Deep learning
Justin, et al.	Journal of orthopedic & Sports -2019	Not specific	MRI (Radiography)	Not mentioned	No expert system
Joshua, et al.	Sports Injr Med (2018)	Acl 3 rd grade injury	Only exercise is mentioned	Football	No system
Mathew, et al	British medicine journal of sports -2018	Acl but No specific grade	MRI by doctor (radiologist)	Athletics	Logistic regression
Marko, et al.	Research gate	Grade 3	Basket ball and soccer	injury, prevention, training, exercise, and intervention	modify or eliminate various neuromuscular risk factors in order to ultimately reduce ACLI.

Use of Machine Learning Techniques to predict other Disease

Uma Maheshwari, et al. (2017) prediction of heart disease by using Neural Network and Logistic Regression. Prediction is based on historical and present data available. P-value is calculated based on the dataset and the accuracy, specificity and sensitivity of data is predicted which results

best. The future work is to improve the accuracy of collected data of patients.

Reda shbib, et al. (2019) proposed simple and fast clustering algorithm that result low error rate and is superior in detecting brain tumors. Brain MRI image segmentation is used to detect the disease at initial stage.

S. C. satapathy, et al. (2015) author explains the use of various data mining techniques for the prediction of heart disease. Fuzzy K-nn predicts and gives the resultant as accurate that makes more use of data mining techniques.

Hammad, et al. (2019) states that detection of plant disease is important for the betterment to grow species. Early detection of disease by machine learning and visualization techniques improves growth which is possible to increase accuracy level. Dataset taken from Plant Village applied deep learning techniques on 14 different crops varieties and 26 diseases were detected. Further improvement on size of dataset and factors affecting plant disease.

Table 2(2) Use of Machine learning techniques in different areas.

Author	Publisher with year	Type of disease	Testing Model	Expert system used
Uma Maheshwari, et al.	IJERT (2017)	Heart disease	Neural network and logic regression	Machine learning
Reda shbib, et al.	IJERT .org (2019)	Brain tumor	Fuzzy logic clustering	Data mining
S.C. satapathy, et al.	Springer (2015)	Heart disease	Fuzzy K-NN approach	Data mining
Hammad, et al.	IEEE (2019)	Plant disease	Convolution neural network	Deep learning

1. Gaps In Existing Literature Survey

The following table of gaps in existing literature by various authors describes the work done by them, testing methods

used by them, expert system and gaps that need to work and eliminate for prevention of ACL injury.

Table 3. Gaps in Existing Literature

Author	Publisher with year	Work done	Testing method	Gaps in existing paper	Expert system used
Claudion, et al.	Springer (2019)	To check which AI method is used for which sports and to predict accuracy of AI methods	Neural network, decision tree, naïve Bayesian	To identify specific AI technique that will predict highest accuracy.	AI techniques
Chang, et al.	Springer (2019)	To evaluate accuracy of complete ACL tear using patch based sampling	Deep learning, MRI detection	More work on Image segmentation is required	AI techniques
Yang, et al.	Springer (2019)	Review of clinical outcomes of mensical tear	No method applied	To specify Acl reconstruction support to heal mensicus	No expert system used
Nicholas, et al.	Plos Medicine (2018)	Deep learning improves accuracy of dataset.	Deep learning methods	To improves the use of these methods in clinical usage.	Deep learning system provides better accuracy.
Karimi, et al.	Springer (2017)	Improving the mensical tear accuracy	Fuzzy methods,SVM.	Gap to cover the 3D mensical for more improvement.	Fuzzy logic system
Justin, et al.	Journal of orthopedic & Sports (2019)	It provides prevention criteria ,demographic and risk factors in a improved manner	MRI (Radiography)	Less effort by doctors to improve condition of patients .	No expert system used
Joshua, et al.	Gavin publisher (2018)	Author mentioned how useful is different types grafting and predict injury rates.	Autograft and Allograft are two different effects used to check the rate of injury in patients .	There is lack of knowledge of physical training	NO expert system and visual learning to overcome limitation is mentioned
Marko D Stojanovic ,et al.	Pub med (2014)	10 yrs study (2001-10) on re-injury which 20% to 30% at any age	MRI and physical testing	Non- operative method are more risky and need to control and awareness centre should be more	No method or system

III. RESULT AND DISCUSSION

- Naïve Bayesian predicts 54% accuracy when applied on Australian football which is poor value. Similarly on other hand supervised learning is also not recommended as it also does not produce good results.
- Coaches and students may now be to predict better performance results using AI techniques.
- Decision making becomes much more accurate with decision tree, K-nearest and Markov process.
- The gap to cover is to evaluate injury risk and performance of individual sports with specific AI technique.
- Major gap that every paper found is dataset of ACL injury is not available on UCI or any medical related sites.

IV. CONCLUSION

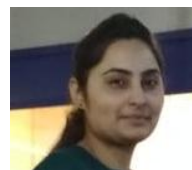
Anterior Cruciate Ligament is a term of medical line that describes about knee injuries. In this paper we have done the extensive survey of knee injury which is very common in sports persons. In this survey we have observed that most of the researchers those are have not mentioned the use of any expert system as well the use of other computer devices to predict the injury as well as to diagnosis it. So this could be benefit to the various researchers to add the use of computers in this field. ACL expert system will be beneficial to doctors as they can diagnose the injury by giving symptoms and can check the accuracy of the injury. Further research is done to increase the accuracy to predict ACL different grades in sports persons.

REFERENCES

1. Claudion , et al. Current Approaches to the Use of Artificial Intelligence for Injury Risk Assessment and Performance Prediction in Team Sports: a Systematic Review Sports Medicine <https://doi.org/10.1186/s40798-019-0202-3> (2019)
2. Kyritsis P and Witvrouw E. Return to Sport after Anterior Cruciate Ligament Reconstruction: A Literature Review .DOI: 10.4172/2165-7025.1000193 (2014)
3. Chang, et al. Deep Learning for Detection of Complete Anterior Cruciate Ligament Tear Springer Publisher vol 32(6) doi: <https://doi.org/10.1007/s10278-019-00193-4> (2019)
4. Yang, et al. Outcomes of Meniscus Repair in Children and Adolescents Musculoskelet Med vol 12(2)9 doi: [10.1007/s12178-019-09554-6](https://doi.org/10.1007/s12178-019-09554-6) (2019)
5. Nicholas, et al. Deep-learning-assisted diagnosis for knee magnetic resonance imaging: Development and retrospective validation of MRNet PLoS Med vol 15 doi: [10.1371/journal.pmed.1002699](https://doi.org/10.1371/journal.pmed.1002699) . (2018)
6. Karimi, et al. A Computer-Aided Type-II Fuzzy Image Processing for Diagnosis of Meniscus Tear Springer Volume 29(6) doi: [10.1007/s10278-016-9884-y](https://doi.org/10.1007/s10278-016-9884-y) (2016)
7. Justin, et al. The Association Between Passing Return-to-Sport Criteria and Second Anterior Cruciate Ligament Injury Risk: A Systematic Review With Meta-analysis, Journal of Orthopedic & Sports Physical Therapy@ jospt.org (2019)
8. Joshua E, et al. Proposed Autograft Superiority to Allograft Use in Return to Sport Rates Following Revision ACL Reconstruction: A Literature Review Insler JE and Sherman OH. Sports Injr Med: JSIMD-138. DOI: 10.29011/2576-9596. (2018)
9. Montassar Tabben, Cristiano Eirale,Philippe Landreau, Rachid Bouras, Mathew G Wilson, Scott Gillogly, Roald Bahr: ACL injury incidence, severity and patterns in professional male soccer players in a Middle Eastern league, doi:10.1136/bmjsem-000461 (2018)
10. Clare L Ardern, Nicholas F Taylor, Julian A Feller, Kate E Webster Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and metaanalysis including aspects of physical functioning and contextual factors 10.1136/bjsports-2 013-093398 <http://bjsm.bmj.com> (2019)

11. Helen C. Smith, Pamela Vacek, Robert J. Johnson,James R. Slauterbeck, Javad Hashemi, Sandra Shultz : Risk Factors for Anterior Cruciate Ligament Injury: A Review of the Literature — Part 1: Neuromuscular and Anatomic Risk bruce.beynonn@uvm.eduDOI:1177/1941738111428281(2012)
12. Marko D Stojanovic: Preventing ACL Injuries in Team-Sport Athletes: A Systematic Review of Training Interventions Article in Research in Sports Medicine An International Journal DOI:10.1080/15438627.2012.680988 Source: PubMed (2014)
13. Abhijit Chandra, et al. Prognosis of Anterior Cruciate Ligament (ACL) Reconstruction: A Data Driven Approach achandra@iastate.edu(2016)
14. K. Uma Maheshwari and J. Jasmine Neural Network based heart disease prediction. International Journal of Engineering Research & Technology (IJERT) (2017)
15. S. C. Satapathy, et al. Heart Disease Prediction System Using Data Mining Technique by Fuzzy K-NN Approach DOI: 10.1007/978-3-319-13728-5_42 Springer International Publishing Switzerland (2015).
16. Reda Shbib, et al. MRI Brain Image Segmentation Using Modified Fuzzy Logic Clustering. International Journal of Engineering Research & Technology (IJERT) <http://www.ijert.org> Vol. 8 (2019)
17. Muhammad Hammad Saleem, et al. Plant Disease Detection and Classification by Deep Learning ,vol 8(11), 468 <https://doi.org/10.3390/plants8110468> Plants (2019)

AUTHOR'S PROFILE



Jaskaran Kaur Perusing M.TECH in Department of Computer engineering and technology from Guru Nanak Dev University. Completed post graduation in Masters of Business and Administrative from Amritsar College of engineering, and technology and graduation in B.TECH in Computer science and engineering from Amritsar college of engineering and technology, Amritsar.



Sandeep Sharma is a head professor in Department of Computer Engineering and technology, Guru Nanak Dev University , Amritsar. He received his B.E , M.E and Phd in Computer Science and Engineering. His area of research interests is in Big Data , Cloud computing and Parallel processing.