

# Applying Bayes' Classification to Predict Conditional Probabilities of a Test Case for Specified Injuries in Biomechanical Judo Combating



Reena Hooda, Deepak Dhaka

**Abstract:** Judo is technical combating game that is based on the biomechanical practices and lies in the category of most probable traumatic & injurious games. Judo is all about throwing the opponent to win the bout. Uke (defender) continuously make efforts to defend himself from being displaced or to take advantage of Tori's (attacker) body weight shifting by counter attacking through reversing the transferred force back to Tori with added strength and misbalanced him. As a defender, Uke try to avoid the back fall as this leads to loss of bout completely. This unusual evasion greatly invites the Judo trauma as a result of sudden twisting of Uke body in avoiding back fall. The injuries like abrasion, sprain or muscle strain are common during practices and are temporary. The major injuries like spine & head injuries that can cause the paralysis or memory loss and breakage of Humerus (upper arm of shoulder) or disjunct of tibia in knee, elbow damage can spoil the carrier of Judoka as he cannot fight back in original form after such injuries. Therefore a prudent observation of probable injuries, their classification and association with Judo techniques is quite significant. Bayes' classification can easily predict that which class of techniques like hip techniques, hands or legs techniques, throwing techniques, joint lock techniques or the choking techniques is more prone to particular set of specified injuries while playing by males or females under 3 categories of weight say lightweight, middle weight and high weight. Such study is beneficial to Judokas and coaches to avoid possible injuries. For this purpose, the research paper apply Bayes' theorem to classify the conditional probabilities of 3 different classes of Judo injuries C1, C2 and C3 by taking 17 different Judo techniques under different Judo techniques classes, for instance, Ashi-Waza, Te-Waza, Kansetu-Waza, Sutemi-Waza and Shime-Waza in training data to compute posteriori. The tatami (Judo Mat) quality to absorb the pressure & reduce the risk of Judo traumas is also highlighted. For the further scope of the study, other behavioral aspects like attitude and beliefs that influences the Judokas performance, their learning & position winning area also reflected.

**Keywords:** Bayes' Classification, Biomechanical Judo, Conditional Probability, Injuries, Judo techniques.

**Revised Manuscript Received on 30 July 2019.**

\* Correspondence Author

**Dr. Reena Hooda\***, Assistant Professor. Indira Gandhi University Meerpur (Rewari). Haryana (India),

**Dr. Deepak Dhaka**, Faculty, BPSMV Khanpur Kalan, Sonapat. Haryana (India).

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## I. INTRODUCTION

Judo is perfectly a biomechanical & a contact sport that applies the biomechanical theories in combating to control the Uke body as well as balancing the Tori himself. [13] [9] Discovered by Professor Jigoro Kano in 1882 by reading the ancient self-defense techniques,

Kodokan Judo is most popular modern biomechanical martial art in Asia [9] that categories the different techniques on the basis of required force & muscle power of body parts to misbalance the Uke in combating. [1] International Judo Federation covers over 200 countries. [9] Judo is thoroughly based on scientific learning & making the best combination of locomotion of limbs, trunk & head, maintaining center of gravity, right position of lever, muscle power to transform required level of energy to downfall the Uke on tatami. The rigorous monitoring of technical deficiencies as well their refinement make Judo a continuous intellectual bodily and ethical human act. [1] [18] It is a movement game that includes the pedagogics of biomechanical skills & art of implementing these learned skills while playing different Judo techniques to get the controlled bodily movements. Judo is all about controlling the motions of Tori and Uke, and the best controller between the two become the winner. However, Judo is not just winning a game; it aims at developing perspicacious mind & pleasant personality, healthy physique, controlled behaviors in various circumstances, fitness, courage and self-defense to fit into role model of society. Moreover it is not a chance game; it is a learned practice that developed over time and important part of physical education that inculcate other knowledge paradigms like biology, kinesiology & its sub-branch biomechanics, anatomy, physiology as well as psychology to design overall graph of winning factors. [1] Classification of Judo techniques is thoroughly a biomechanical process that divides the techniques on the basis of muscles and body parts that was done by Professor Jigoro Kano from very beginning. The subdivision of techniques was done in to hand techniques called Te-Waza, hip techniques called Koshi-Waza, leg & foot techniques called Ashi-Waza and the throwing techniques named Sutemi-Waza which involves transferring personal weight to the Uke in throwing. [17] The different Judo terms discovered by professor Jigoro Kano are Kuzushi means unbalancing the Uke, Tsukuri means take entry position closer to Uke and Kake means throwing the Uke, Hikidashii.e.



pulling out the Uke by gripping, Ashimoki is the leg grabbing are commonly used in training Judokas. [17] [18] As a combating game, Judo is more probable to risk of injuries during a bout thus requires careful attention in identifying Judo injuries to take preventive measures. [9] Injury means any kind of abnormalities in normal body structure due to external circumstances like unbearable pressure, falling, stretching, fractures etc. [9] Certain influencing variables can be considered as performance evaluator, the factors that affect the performance adversely other than the muscular actions are muscular fatigue, metabolism that transfer energy from food and psychological or social factors etc. [2] Judo techniques specially the throwing techniques could be dangerous to life; it can put judoka on wheel chair and in worst case can lead to death. The untrained and starters or the kids are more probable to Judo injuries during practice or combating. So Artificial Intelligence (AI) can be used as a tool for safety analysis that what kind of techniques and the way of playing will be safe to avoid the Judo traumas during trainings and competitions. For this reason, one of the AI branch i.e. Bayes' theorem or the Bayes' classification is applied to predict the conditional probabilities of happening of Injuries. This subdivision of Artificial Intelligence that provide more practical approach to learning problems by computing probabilities for a given hypothesis is a powerful machine learning algorithm for predictive modeling based on the conditional probabilities. It is one of the most popular supervised learning methods of data mining for prediction of happening of an even accurately with some prior knowledge about the event. The method even more useful as it can update its beliefs or probabilities after receiving new information. [20] [25] [26]

## II. LITERATURE SURVEY

### A. Possible Judo Injuries

Judo injuries can be small (common) and serious (major) based on the techniques Judokas apply during combating & training, their learning experiences and speed & velocity of force on the body. The small injuries may be like fractures, abrasion, sprain, cuts and bruises etc. Serious may be skull damage, pelvis damage or sacrum injuries and spinal injuries etc. Sacrum is the lower part of the spine which provides a strong base to spine and support the whole upper body weight. This vertebra is too strong made from five separate vertebrae that later join to form single vertebrae. With this reason, the body of children is more flexible than the adults. [6] Sacrum lies between fifth lumbar vertebrae and tail bone coccyx. Exterior part of the sacrum is the pelvis that is solid and immovable. [6] Spinal injuries are the problems in spine say spinal vertebrae and their joints. Spine divided in to four parts, upper part is the cervical part, second is thoracic, third is the lumbar part and last is the sacrum on tail part ended with coccyx. Spine has the major component like spinal cord, spinal nerve, disk, ligaments and vertebra etc. Following are the injuries:

1. *Whiplash Injury*: It is neck injury occur in the cervical vertebrae due to fast and sudden movement of neck backward and forward or turn, or due to hypertension [7] that leads to pain in neck, difficulty in neck movement and headache.
2. *Spinal Injury*: Spinal cord is long tabular structure that ranges from endpoints of brain stem (from cervical vertebrae) to lumbar region up to lower border of first

vertebra in lumbar. It is the most important part between brain and whole body that passes messages between brain and body parts like tissues, muscles or organs etc. It acts as a connector between brain & the nerves of the whole body and made up the central nervous system. If there is damage in spinal cord, nerves or spinal canal or other spinal parts due to sudden excessive pressure over vertebrae, stretched or torn ligaments or broken caused spinal injuries. Fracture in spine may be of two types: stable that requires rest or bracing or instable that requires the surgery. Fractures in ligaments can be inter-spinous or anterior ligament fractures. The vertebrae compressed due to unanticipated pressure or unbearable weight on body back. The ligaments can then be torn or stretched up to extreme degree that loosens the joining part i.e. connective tissues of two adjacent vertebrae. As a result vertebrae may slip causing dislocation. Dislocation may be due to sudden forward move of the upper body part while stabling the legs and can cause the spinal cord instable injuries. [7][8] Any problem in spine cause loss of sensation in back and limbs & muscle control, body become insensitive to stimuli, muscle contraction and memory loss. If nerves injured and contracts, it cause severe pain in arms and legs. Based on the injury position, if injury is in neck area of spine, it simply cause the loss of sensation, feeling even loss of control on limbs however, if injury is in down part of the spine & damage in the cord, the legs may be paralyzed. Even sacrum may be effected badly may cause the lower body movement problems and pain while sitting or walking. If injury is too much that damage the cord as well as nerves between vertebrae, it can cause permanent paralysis. However only small injury in cord than paralysis may be temporarily and can be treated and recovered with rest, if not controlled, it again lead to permanent paralysis. [8] Spinal cord damage is more hazardous and life threatening when blockades the breathing and wreckage urinary bladder that resulted in infrequent urine leakages and this rate is very high among the female Judokas. [11] [13]

3. *Sprains (moch in Hindi)*: it include the ricking or twisting of ligaments (not dislocation) like twisting of ankles, wrist or spinal joints during playing cause pain in joint. It is simply a joint injury due to over exercising, overstretching or sudden twist of the body parts. [10] [13] [15]
4. *Strains*: Strains referred as unusual force over the body that can cause stretching of the object or the body parts specially muscles and ligaments upto a damaging degree. Technically it is a tearing injury to a muscle or can even root the mental strain. It can be due to pushing or holding an excessive weight, sudden twisting or lifting and excessive exercises that resulted in a continuous back pain. [10] [13]
5. *Herniated Disk*: It is also called fractured disk or slipped disk and kind of spinal injury in which nucleus i.e. center of the disk can be pressed extremely and resulted in breakage or fracture and can even compress the spinal nerves. It causes severe pain, weakness and sudden shock feelings in body during walking, sitting or bodily movements. [14]

6. *Cuts and Bruises*: Bruises are reddish purple marks on the body that occurs due to cuts in the body causes blood vessels to burst and tied under the upper skin i.e. skin surface of the body. They are the results of bones damage, strains, sprains, dislocations and muscles swelling etc. [13]
7. *Head Wounds*: these are the injuries in skull, scalp and brain or nerves resulted in vomiting, perplexity, headache, recurrent eye movements (closing of eyes faster for a case), loss of muscle controls & memory loss due to damage in nerves or wounds in brain, slipping mood & unconsciousness, leaking of liquids from nose & ear and can cause death in worst scenario. [12] [13] [15]
8. *Varicose Veins*: When veins doesn't function properly because of exercising too much or standing for a long duration like for a whole day duties or by the injuries in the body prevent the flow of blood toward heart, slower movement of blood causes such type of problems. Varicose veins generally occur only in legs that we can see as long tree branches type blue veins. [12] [13] [15]
9. *Knee Injuries*: Ligaments supports the joints and help in body motions, they may damage as a result of impulsive bend of leg and knee. Sprains in the ligaments can cause swelling and pain during movements of legs. Ligaments outside the joints are known as medial, lateral, collateral or exterior ligaments and inside the knee joint are the cruciate ligaments. If the inner ligaments i.e. cruciate ligaments damaged or torn, it may cause permanent damage to the knee and require knee surgery. Lateral or medial ligaments are shock observer that lies between femur (thigh bone) and tibia (shin bone) [16], any damage in these ligaments is called cartilage damage that occur when knee moves swiftly while foot remain on the same position on the earth surface causing the twist in knee, this cartilage damage consequent the severe pain, swelling and immobility of knee. [13] Dislocation of the patella (knee cap) from the end of the femur causes too much pain and this dislocation can be seen from the front view of the leg where knee spilt from actual position. It became more staid when extreme pressure on the knee cause damage to meniscus or ligaments resulted in disjoint of tibia (shin bone) from the femur causing problems of walking or uplifting weight. [13] [16]
10. *Shoulder Injuries*: shoulder is one of the largest and complex joint. The main parts of shoulder are acromion, clavicle, capsular, rotator cuff and ligaments etc. [16] Rotator cuff helps in movement of shoulder and stabilize the joint and is made up of four muscles. Any damage to these muscles can bar the shoulder movement. There is a ball socket joint between humeral head i.e. the bone of upper arm and scapula i.e. shoulder blade. Rotator cuffs adjust the position of humeral head and scapula during movement thus any change in this adjustment due to impulsive outer pressure on the shoulder may lead to misbalancing in the adjustment and cause shoulder injury. Swelling of tendon due to throwing the Uke's body with too much force & speed can bolt the shoulder movements. [13] [14] [16] Ligaments and tendon have different functionality as ligaments attaches bone to bone where tendon joins bone with the muscle. [14] Humerus fracture in upper arm due to fall cause swelling, inability to move elbow.

- Fracture in Acromioclavicular (AC) joint injury or the AC separation lies on the shoulder top between acromion (peak or front of the shoulder) and collar bone (clavicle) due to sudden fall on shoulder, this injury can be felt with the finger touch and even can see as elevated point on shoulder. [13] [14] [15] [16]
11. *Sciatica*: It is a pressure on the sciatic nerve run through the lower back to hips and buttocks to legs and only affects the one side of the legs not both. It occurs due to herniated disk or nerve compression causes severe pain in the back and cause problem in sitting. [10] [14]
12. *Ribs Injury*: When bones of the rib cage damaged due to fall or extra pressure on the chest resulted in pain, breathing problem and in worst case blood vessels or lungs can damaged. [21]
13. *Hypoxia*: It is occur in Chocking technique of Judo in which lungs doesn't get sufficient oxygen. [22] [24]
14. *Abrasion*: This is very common in Judo and treating as a small injury. It is merely rubbing of the skin on ground.

## B. Causes of Injuries

There are various reasons for traumas in Judo; the most common is the avoidance of back fall as this will cause the loss of game in Judo during fighting. The different throwing techniques for instance Uchi Matta, Seoi Nagge and Tomoe Nage can cause the shoulder, neck, head, ears damage or spine injuries. In holding techniques like arm lock, grip tightening can cause the fracture in body parts like fingers, lower back. Other major reason for the injury is lack of falling skills to prevent the injuries. [9] Excessive exercises like gripping practices, locking by arms and legs cause osteoarthritis [9] i.e. a disease cause intense pain, harshness and slowness in knees, finger joints and other joints. [10] The three building blocks of spine that are upper cervical area of spine that is neck area, the outward curve of thoracic area of middle spine called kyphosis and lumber area having inward curve of the spine called lordosis maintain the center of gravity in the body and avoid the falls. If this alignment change due to problems in these spinal parts including sacrum can cause the loss of gravity, body loss its normal structure, seems imbalanced (bend curve from side look) also known as sagittal imbalance [11] The injuries in the spine may or may not be identifies by x-rays or city scan. [11] If cannot be identified, other symptoms are identifies like neck pain, sudden fall, slowness in limbs. [9] [11] The rapid weight reduction in hours before the weighting for combatting to fit in a particular weight category adversely affect the body and metabolism, this is called weight cycling that is one of the bigger reasons of mishaps during combating. Change in metabolism during weight cycling cause the bone injuries. Some Judokas do hydration, avoid fluids before weight count also imbalance the body respiratory system and resulted in loosed control over body and minds during combating due to lack of sufficient energy level. In throwing techniques or spinning, sudden twisting problems during weight lifting before shifting of weight to opponent is another trauma reasons. Psychological factors like motivation, attitude, beliefs, confidence level and fear also play role indirectly over physical activities. [9]

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Injuries can be avoided by experiencing falling skills and learn to distribute weight between different body parts and tatami quality can minimize the centered pressure on spine or shoulders, upper body strength, flexibility, required muscle power concentration at lever in minimizing the Judo accidents. [4] [9]

### III. OBJECTIVES OF STUDY

1. Literature survey to collect only relevant data for theme of the research, basic understating of the Judo biomechanical concepts as well as classification of the Judo techniques like hip techniques, locking techniques, throwing techniques and chocking techniques etc.
2. Observing the probable injuries occurred during training and categories as small (common), major (serious) or super serious along with the causes.
3. Construct a matrix to identify relationship between different injuries and selected Judo combating techniques.
4. Categorize the different Judo combating techniques into predefined classes of Judo techniques.
5. Apply Bayes' theorem to build a model on training data for classification & prediction of conditional probabilities of different injuries.
6. Observation of results while considering the other influencing factors may cause havoc during combating and resulting in Judo traumas.
7. Define the future scope of work.

A rigorous literature survey is conducted to find the relevant data to describe certain possibilities of injuries in Judo. The different medical sites are also visited to understand the scientific terms like sacrum, ligaments, lumber, pelvis, spinal nerves, metabolism, humerus, femur, tibia and Acromioclavicular etc. that are relevant to understand and define injuries in different body parts and their effects on body. [7] [8] Apart from basic knowledge about Judo terms & techniques, to widen the ken of knowledge about Judo techniques, fighting methods, plentiful online data is observed through Google Search Engine.

For the study, 17 Judo techniques are explored and the possible injuries are listed in Table 1 that links the probable injuries to the different Judo techniques, linkage is subjective that done on the bases literature studies and perception as a coach.

To shorten the table 1, Injuries are combined in their super classes, for instance spinal Cord, Ligaments fracture, Dislocation in lumber areas, sacrum fracture, vertebra & nerves compression are include in Spine Injuries; skull, scalp, brain injuries are included in head injuries; ligaments fractures, dislocation of patella, meniscus damage or the disjoint of tibia are considered as knee injuries, further Acromioclavicular joint problem, Humerus fracture, Rotator cuff problems are incorporated as shoulder injuries. [7] [8] [11] [13] [14] [15] [16] the symbol tick✓ in table 1 indicates the possible Injuries in different Judo techniques.

### IV. METHODOLOGY

**Table1: List the Probable injuries as per the Judo Techniques with tick✓ indicating the injury.**

Sr. No.	Name of Judo Techniques	W hi pl as h Inj ur y	Spi nal Inj ur y	Str ain	Spr ain	Hern iated Disk	Abra sion	Hy poxia	Ri bs Inj ur y	Kn ee Inj ur y	An kle Inju ries	Elbo w Injur y	Hea d Injur y	Shoulde r Injury	Death
1.	Uchi mata	✓	✓	✓	✓	✓	✓						✓	✓	
2.	Tai Otoshi	✓	✓	✓	✓	✓	✓					✓	✓	✓	
3.	Uchi mata Sukashi	✓	✓	✓	✓	✓	✓					✓	✓	✓	
4.	Seoi Otoshi	✓										✓		✓	
5.	Uki Otoshi	✓	✓									✓	✓	✓	
6.	Ashi Guruma			✓	✓		✓			✓				✓	
7.	Seoi Nage	✓	✓	✓	✓		✓					✓	✓	✓	
8.	Ippon Seoi Nage											✓		✓	
9.	O Goshi			✓		✓	✓								
10.	Harai Goshi			✓	✓	✓	✓			✓	✓	✓		✓	

11.	Ude Hishigi Juji gatame			✓	✓							✓		✓	
12.	Ude garami											✓		✓	
13.	Hiza Hishigi							✓	✓						
14.	Tomoe Nage	✓	✓				✓								
15.	Ko Uchi Gari			✓	✓					✓					
16.	Choke	✓	✓					✓					✓		✓
17.	Harai Tsurikomi Ashi		✓	✓	✓						✓	✓		✓	

Three categories are identified in Judo championship i.e. Sub-junior, Junior, and senior. The current Bayes' classification is just taking the senior (after schooling) Judokas (Males and Females). The different Judo techniques are fall under Te-Waza (Hands techniques), Ashi-Waza (legs and foot techniques), Koshi-waza (Hip techniques), Kansetu-Waza (Joint locking) and Shime-Waza (Choking techniques) under which Tai Otoshi, Uki Otoshi, Uchi mata Sukashi, Seoi Otoshi, Ashi Guruma, Harai Goshi, Uchi mata, Hane Goshi, O Goshi, Harai Goshi, choke, Ude Hishigi Juji gatame, Ude garami, Tomoe Nage, Ko Uchi Gari, Harai Tsurikomi Ashi, Seoi Nage and Hiza Hishigi are included for Bayes' Classification to predict the different class injuries. [24]

**A. Bayes' classification**

Bayes' theorem was proposed by statistician Reverend Thomas Bayes, named after him as a Naive Bayes classifier with strong (naïve) assumption of predicate's independence to count conditional class probabilities for classification & prediction. This supervised learning method is based on the

prior knowledge of conditions for happening of an event. [20] [25] [26]

Training Data set (D) is in Table 2 which is based on Table 1, the spine injury, head injury, shoulder injury in throw only, whiplash, herniated disk are considered serious (major), death is super serious and other injuries are considered as common injuries (small) that are not riskier to life or carrier. Value of gender predicate is randomly selected for training data set, as Judoka throwing & falling has the same effect on both females and males, therefore, it is assumed that both has same risk factors and is probable to injuries in same ratio. There are three weight categories [27]: women have less than 57kg, under 70kg and above 70 kg whereas men have less than 73kg, under 90kg and above 90kg as proposed by Judo federation however, these weights are never stable and might be changed during competitions, therefore to remove the ambiguity the weights are aliased as lightweight, middle weight and heavy weight. [27] Judokas whether male or females can perform all the selected 17 techniques shown in table 2.

**Table 2: Training Data Set for Bayes' Classification.**

Sr. No.	Name of Judo Technique	Technique Class	Weight	Gender	Injury Class (Common/ Major)
1.	Uchi mata	Ashi-Waza	Heavy weight	Males	Major
2.	Tai Otoshi	Te-Waza	Middle weight	Males	Major
3.	Uchi mata Sukashi	Te-Waza	Heavy weight	Males	Major
4.	Seoi Otoshi	Te-Waza	Heavy weight	Females	Major
5.	Uki Otoshi	Te-Waza	Lightweight	Males	Major
6.	Ashi Guruma	Ashi-Waza	Middle weight	Males	Common
7.	Seoi Nage	Te-Waza	Middle weight	Females	Major
8.	Ippon Seoi Nage	Te-Waza	Lightweight	Females	Common
9.	O Goshi	Koshi-Waza	Heavy weight	Females	Major
10.	Harai Goshi	Ashi-Waza	Middle weight	Males	Major
11.	Ude Hishigi Juji gatame	Kansetu-Waza	Lightweight	Males	Common
12.	Ude garami	Kansetu-Waza	Middle weight	Females	Common
13.	Hiza Hishigi	Kansetu-Waza	Lightweight	Males	Common
14.	Tomoe Nage	Sutemi-Waza	Heavy weight	Males	Major
15.	Ko Uchi Gari	Ashi-Waza	Lightweight	Males	Common
16.	Choke	Shime-Waza	Heavy weight	Males	Supper Serious
17.	Harai Tsurikomi Ashi	Ashi-Waza	Middle weight	Females	Common

## B. Hypothesis

1. Attributes or the predicates are conditionally independent as per the Bayes' Theorem. [20] [25] [26]
2. Both man and women are probable to injury during combating. There is no difference between female and male Judokas both can be subjected to injuries.
3. All X and classes are non-zero that means at least one value should be there for Bayes' Classification as the theorem specify that the conditional probability must be non-zero.
4. The inexperienced or lightweight Judokas are more probable to common injuries. The Te-Waza, Sutemi Waza and Shime-Waza are more probable to major Injuries as compared to Koshi-Waza Ashi-Waza and Kansetu-Waza.

## C. Bayesian Probabilities

According to Bayes' classification, 2 types of probabilities are there [20] [25] [26]:

Posterior probability =  $[P(H/X)]$ ;

Prior probability (initial probability) =  $[P(H)]$ ; Where H is the Hypothesis and X is the data tuple.

$$[P(H/X)] = \frac{P(X/H) \cdot P(H)}{P(X)}; \text{ i.e.}$$

$$\text{Posterior} = \frac{\text{Evidence or Marginal Probability} \cdot \text{Prior}}{\text{likelihood}} \quad (1)$$

or H can be described as a cause and X can be as effect as bayes' Theorem describe that if you want to calculate  $P(H/X)$  then you must have the prior knowledge of  $P(X/H)$  as refer in (1).

## V. RESULTS AND DISCUSSIONS

The Bayes' classification of conditional probabilities predicts that X belongs to class  $C_i$  if probability  $P(C_i/X)$  is highest among all the probabilities of all m Classes where m is the total number of Classes. [20] [25]

Each tuple is represented by an Attribute Vector  $X=(X_1, X_2, X_3, \dots, X_5)$ ; 5 indicates that attributes in Table2.

Based on posterior probability in (1), replace the hypothesis H with the specified classes  $C_i$ .

$$\text{For each } C_i: [P(C_i/X)] = \frac{P(X/C_i) \cdot P(C_i)}{P(X)}; \quad (2)$$

If  $P(X)$  is constant, then there is need to maximize  $P(X/C_i) \cdot P(C_i)$ . It reduces the computation cost of (2). [26].

Classes:

$C_1$ : Injury Class= Common;

$C_2$ : Injury Class= Major;

$C_3$ : Injury Class= Super Serious;

Test case:

$X=(\text{Weight} = \text{"Leightweight"}, \text{Gender} = \text{"Male"}, \text{Technique Class} = \text{"Te-Waza"})$ ;

For simplicity & pruning the extra information, only desired attributes are considered to count the class probability and only two classes  $C_1$  and  $C_2$  are considered as  $C_3$  i.e. Super serious is only one case of Choking that is banned due to high death rate in choking. Thus:

$$P(C_1) = 9/17 = .529;$$

$$P(C_2) = 7/17 = .411;$$

Now  $P(X/C_i)$ :

$$P(\text{weight} = \text{"Lighweight"} / C_1) \Rightarrow 4/9 = .444;$$

$$P(\text{weight} = \text{"Lighweight"} / C_2) \Rightarrow 1/7 = .14;$$

$$P(\text{Gender} = \text{"Male"} / C_1) \Rightarrow 4/9 = .444;$$

$$P(\text{Gender} = \text{"Male"} / C_2) \Rightarrow 6/9 = .666;$$

$$P(\text{Technique Class} = \text{"Te-Waza"} / C_1) \Rightarrow 1/9 = .111;$$

$$P(\text{Technique Class} = \text{"Te-Waza"} / C_2) \Rightarrow 5/7 = .714;$$

Now

$$P(X/C_1) \Rightarrow P(X / C_1) \Rightarrow .444 \times .444 \times .111 = 0.218;$$

$$P(X / C_2) \Rightarrow .14 \times .666 \times .714 = 0.066;$$

Then

$$P(X/C_1) \times P(C_1) \Rightarrow P(X/C_1) \times P(C_1) \Rightarrow .218 \times .529 = 0.115;$$

$$P(X/C_2) \times P(C_2) \Rightarrow 0.066 \times .411 = 0.027;$$

Therefore X belongs to  $C_1$  that is a Common Injury class. Such common injuries are small & temporarily that can be cured with medical assistance and rest. As compared to major injuries or super serious injuries which are hazardous for instance, damage of the main bones of the body or other organs like spinal injuries, head injuries caused paralysis, memory losses or in worst case death or spoil the career of a Judoka.

Hypothesis 1 i.e. attributes or the predicates are conditionally independent is the probability condition of Bayes' Theorem is true for the given test case, however in some other cases it may not be. Injuries can be dependent for example, if the common injuries are not controlled and cured properly, they may transformed to major injuries. For this reason only, all injury classes are put in a single attribute so that classifier can work accurately. The second hypothesis that both man and women are probable to injury during combating and there is no difference between female and male Judokas both can be subjected to injuries seems true. Usually it is said that there is difference between the muscle power of male and female but women are renovating their image as muscle builder. The third hypothesis that all X and classes are non-zero in the current observation find true for the given the test case only i.e. for the Classes  $C_1$  and  $C_2$ . If we take  $C_3$  and choking technique, the conditional probability may be zero in that case and we have to find another alternate to make that probability nonzero in order to predict the probabilities accurately. It is found that lightweight Judokas are more probable to common injuries as a result of the test case on Te-Waza and males and found the hypothesis true. However for Uki Otoshi of Te-Waza can be serious as compared to Ko Uchi Gari of Ashi-Waza. Bayesian classification is simple and easy to implement for accurately predicting the target as it is a mathematical theorem that is unbiased & formula based thoroughly and even good for long data bases. [26] [25] Based on the Bayesian probabilities, a safety provisions can be prepared to avoid or minimize the probable injuries in which quality of tatami must be considered in absorbing the body pressure and minimize the center of gravity to decrease the pressure as well as resultant judo traumas. [4] The tatami should not be much spongy or thick and must meet the Judo standards set by the Judo federation of India. Judo technical simulations can also be shown to display and observe biomechanical impact on the judo performance [5] using sophisticated biomechanical software like Kinovea.

## VI. CONCLUSION AND FUTURE SCOPE OF WORK

Bayesian classification is suitable to predict the chances of injuries among judokas in technical way and quite useful for biomechanical classification of judo techniques for injuries and prediction



of conditional probabilities for a given test case i.e. set of predefined attributes as Bayes' classifier works with prior knowledge about events. If attributes are independent and conditional probabilities are non-zero, it can accurately predict the classes to which a test case belongs. The paper highlighted the major injuries and related only possible & most frequent injuries of Judo combating techniques. The hypothesis is conditionally found true in discussions. Apart from the technical aspects of biomechanical Judo, other socio economic factors like attitude, beliefs also play an important role in performance of Judokas during combating, their way of learning, experiences participation & position winning tc. influences the chances of injuries or Judo mishaps thus may be the other significant scope of the study.

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## AUTHOR PROFILE



**Dr. Reena Hooda**, working as Assistant Professor in IGU Meerpur Rewari. Qualifications: MCA, PHD, MBA Area of Interest: Data Warehousing & Data Mining Techniques Computer Networking Data Base management System Big Data Analytics Data Mining Open Source Tools Teaching Experience: More than 8 years Publications: 15 publications in reputed journals.

Other Official Duties: Member of Academic Council, Board of Studies, Departmental Committee Member of Organizing Committee of various conferences and workshops



**Dr. Deepak Dhaka**, Faculty, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan, Sonapat Haryana (India). MPED, MPHIL, NET, PHD Specialization: Judo, Physical education Topics of interest: Study & analysis of position winning in Judokas Books: 2 published Papers: 10. E-mail: [Deepakjudokas@gmail.com](mailto:Deepakjudokas@gmail.com)