The Human Knee:
Is It Really That Strong?
AiS Challenge

by

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Team Number 91
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- Dr. Brian Robinson – Doctor of Orthopedics, Grant County Orthopedics and Associates, Orthopedics
- Dr. Robert Schenks – Doctor of Orthopedics, University Hospital, Orthopedics
- Dr. Thomas Gruska – Teacher, Western New Mexico University, Interpretation of Statistical Data

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E.0 Executive Summary

The purpose of this project is to determine whether Body Mass Index (BMI), age, and gender have an affect on what type of knee injury a person will receive. To determine this, research was done at a local orthopedic office, and statistics were collected from patients who had received certain types of knee injuries in the past two years. These statistics were entered into a database, which was read by a C++ program.

This program not only has the ability to calculate the BMI of a user; it outputs the percentage of patients that received each of the various injuries based on age and BMI ranges entered by the user. To determine this, the program will count from the database the number of patients that received an injury for each of the specified ranges, and divide that number by the total patient who received that particular injury. This solution is multiplied by one hundred to figure the percentile. This process is repeated many times to find the solutions of seven different knee injuries. Two solutions in each category will be given-- first for age and second for BMI. If the user enters the personal information accurately, and uses a range in which he or she is included, the results will show the user which injury they are most susceptible to as a result of their BMI and age.

Based on the average BMI and age ranges of the patients located in the database, younger people with lower BMI tend to tear the anterior cruciate ligament of the knee and fracture the upper tibia. Older and heavier people seem to be more prone to injuries involving the lateral collateral ligament. Male and female patients with similar age seem to receive similar injuries. It was surprising to observe that of a total of 303 patients, the female to male ratio of injuries was approximately one-to-one.

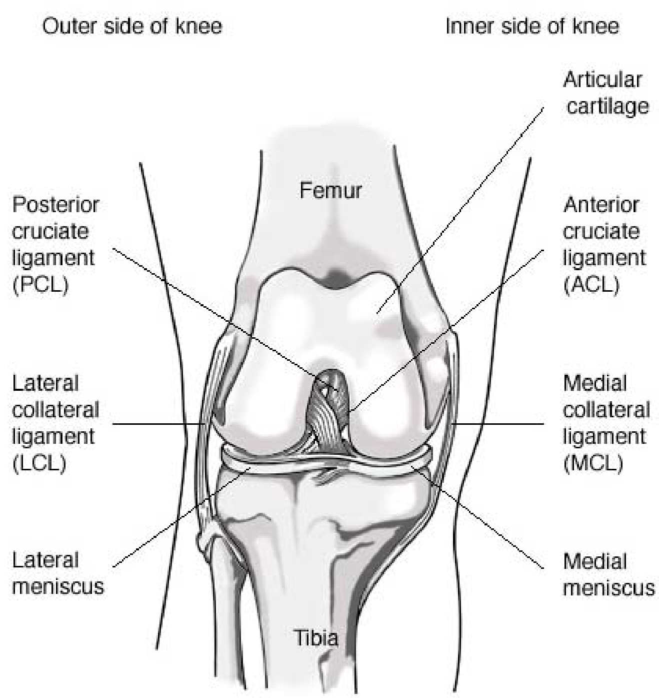
1.0 Introduction

1.1 Purpose

The purpose of this project is to develop a statistical comparison and the associated computer program required to examine the affects of Body Mass Index (BMI), age, and gender have on a range of knee injuries. Following a personal experience involving a knee injury during an athletic event, the project was created to satisfy the desire of the team members to determine what factors, besides athletics, act as indicators to specific knee injuries.

1.2 Background Research

The knee is a very important part of life, and is used daily for activities such as walking, running, and jumping. There are many components in the knee, all of which have significantly different, but equally important responsibilities. The components that are used in this project are the Anterior Cruciate Ligament (ACL), Lateral Collateral Ligament (LCL), Medial Collateral Ligament (MCL), Medial Meniscus, Lateral Meniscus, Patella, and Upper Tibia.



The ACL prevents the tibia from sliding forwards beneath the femur. The ACL can be injured by a rapid change in direction, deceleration when running, landing from a jump, or, though an ACL tear is usually a non-contact injury, by direct contact such as a football tackle[1]. If the ACL is torn, reconstructive surgery is required to repair the damage.

The LCL and MCL work together to provide stability for the knee. The MCL connects the femur to the tibia and supplies stability to the inner side of the knee, while the LCL connects the femur to the fibula and stabilizes the outer side of the knee. Injuries to the MCL are caused by contact of the outer knee, and can be treated by rest if the tear is small[1]. Rest is needed to repair such partial tears, but if the fibers cannot heal by themselves, surgery is required. Treatment of LCL injuries is similar to MCL treatment, but requires a longer resting period as the LCL takes longer to heal[2].

The meniscus lies between the femur and the tibia functions as a shock absorber. The Medial Meniscus is located on the inner side of the knee, while the Lateral Meniscus is positioned on the outer side of the knee. Injuries to these menisci are common, the most frequent cause being a combined loading and twisting action, and are often associated with ligament tears. Treatment for this injury is rest and ice. However, surgery may be necessary if the menisci do not heal on their own[3].

The Patella is a small bone in the front of the knee that glides up and down in the femoral groove in the femur as the knee bends and straightens. A dislocation of the patella occurs when the patella completely comes out of the femoral groove. Most commonly, patella are dislocated by a plant and twist movement, or after direct contact. Rest and special knee braces are used to treat this type of injury, and surgery is rarely needed[4].

The tibia and the fibula form part of the knee and the ankle. The tibia has very little soft tissue in front of it. Due to this fact, open fractures of the upper tibia are more common than fractures of the femur or fibula. These fractures rarely occur in children, but are usually treated with casts. In adults, fractures of the upper tibia is usually broken into many pieces, and need surgery to fix the bone with screws, a plate, and sometimes a bone graft. There is a higher risk of infection in fractures of the tibia, as the skin is broken surrounding the fracture[5].

1.3 Scope

It is the intention of this project is classify the common knee injury of specific body types and age, based on statistical information collected from a local orthopedic office. The data, consisting of recent information from injured patients, will be used to calculate the percentage of patients that fall within a specified range. This will assist in the interpretation of the data to determine the Body Mass Index and age most prone to receiving a specific knee injury.

1.4 Computer Program

A C++ computer program will be developed by the team members to be used for this project. It is believed that this programming language will satisfy the objective of the project. Teamwork, as well as some individual work, will be needed to successfully create a program that will obtain the desired results (Appendix #6).

2.0 Problem Statement

2.1 Problem Statement

Many knee injuries occur each year, though the causes of these knee injuries remain a mystery. People receive knee injuries regardless of their BMI, age, and gender; however, these factors may have an affect on what type of knee injury is received.

The purpose of this project is to determine, based on data trends, if people of a specific BMI, age, and gender receive the same injury. In order to complete this project, research will be done at a local orthopedic office and the statistics will be used to create a computer program that will calculate the percentage of people with injuries in user specified BMI and age ranges.

3.0 Method of Solution

3.1 Mathematical Model

This computer program was completely developed by the team and is used to determine which knee injury is most likely to occur based on a user's age, BMI, and the statistical information located in the database. The user is prompted to enter his or her weight (in pounds), height (in feet and inches), age, and gender. This information is necessary for the program to distinguish between male and female, and for the calculation of BMI to occur.

$$\textbf{BMI} = \frac{\text{weight in kilograms}}{\text{height}^2 \text{ in meters}}$$

In order for this calculation to take place, the program converts the user's weight in pounds into kilograms, while the entered height, in feet and inches, is converted to meters.

meters = height (in inches) * 0.0254
kilograms = pounds * 0.45

The correct BMI of the input information will be calculated and output along with a BMI chart. This chart will show the user the different categories of BMI and the range in which he or she is classified. (Refer to Appendix #2 to see BMI chart)

The user, now understanding BMI classification, will be prompted to enter a range for the BMI portion of their search, as well as an age range in order to configure the percent of patients, similar in BMI and age, that received a knee injury. The program, reading statistics (Appendix #1) from the data file injury.dat, will separate data, compiling only information from patients of the same gender as previously entered by the user. The program then further separates data by injury, and counts the total number of patients in each injury while counting the number of patients that fall within the BMI and age ranges entered by the user. To calculate the percentage of a certain injury, the total number of patients within the range is divided the total number of patients the received the specific injury and multiplied by one hundred.

$$\frac{\text{Count of Patients in Range}}{\text{Total Patients}} * 100 = \textbf{Percent of Patients in Specified Range}$$

The computer program outputs the seven types of injuries and the percentages associated with each injury. From these outputs, the user can visualize which injury they are most prone to receive if a knee injury were to occur. A higher percentage means a higher risk, while a lower percentage indicates a lower risk.

3.2 Computational Methods

In summary, the computer program will:

- Input user’s height, weight, age, and gender
- Calculate BMI and print out BMI chart
- Input user’s range for BMI and age
- Reads data from database, injury.dat (Appendix #1) using a “for” loop
- Filters and saves information matching the gender and range input by user
- Counts total patients of an injury, while counting number of patients within user-specified range of the same injury using a “for” loop
- Repeats this cycle for each separate injury (using a “for” loop)
- Calculates the percentage of patients within both BMI and age ranges for each separate injury
- Outputs types of injuries using “if” statements
- Outputs percentages for each separate injury for both ranges

4.0 Results

4.1 Calculations

The computer program calculates the percentage of patients with specific knee injuries within a range entered by the user. Refer to Appendix #7 to see an example of an operating program.

4.2 Graphs, Tables, and Figures

The charts two below separate the results by gender and type of injury, and show the final calculations of the project (Also available in Appendix #3).

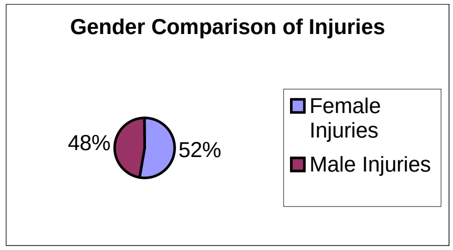
Females

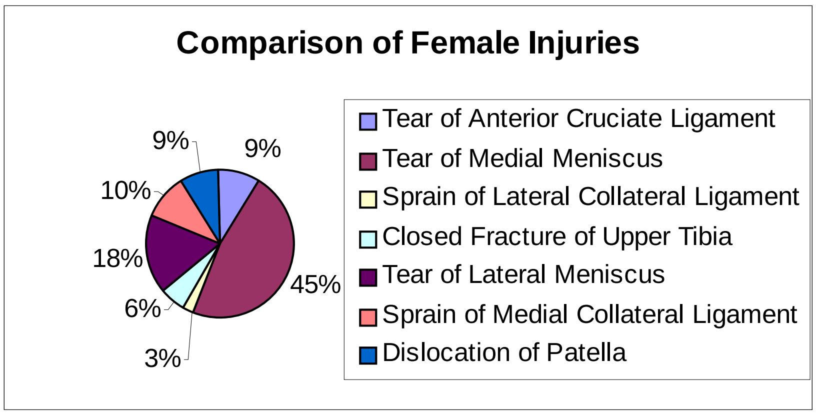
Injury Type		Percent	BMI of the Average	Average Age
Tear of Anterior Cruciate Ligament	15	9.43	24.02	28
Tear of Medial Meniscus	73	45.91	30.80	52
Sprain of Lateral Collateral Ligament	4	2.52	33.00	50
Closed Fracture of Upper Tibia	9	5.66	23.38	31
Tear of Lateral Meniscus	28	17.61	28.12	47
Sprain of Medial Collateral Ligament	16	10.06	31.71	37
Dislocation of Patella	14	8.81	27.94	37
Total Female Injuries	159			

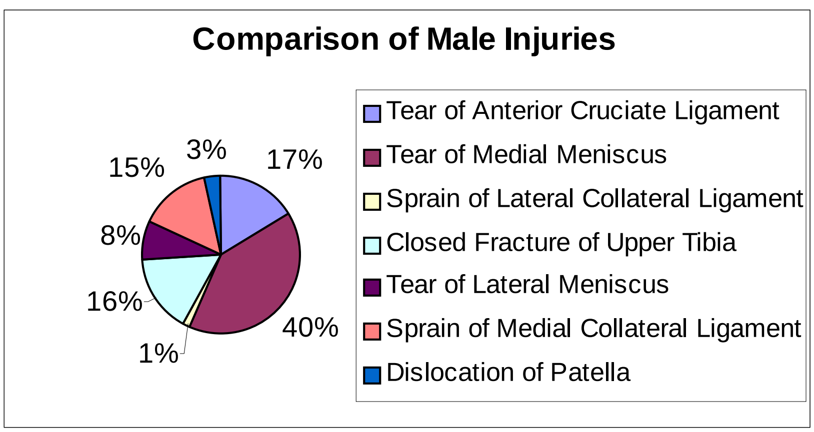
Males

Injury Type		Percent	BMI of the Average	Average Age
Tear of Anterior Cruciate Ligament	24	16.67	29.70	28
Tear of Medial Meniscus	57	39.58	28.39	48
Sprain of Lateral Collateral Ligament	2	1.39	27.63	33
Closed Fracture of Upper Tibia	23	15.97	26.84	31
Tear of Lateral Meniscus	12	8.33	27.26	40
Sprain of Medial Collateral Ligament	21	14.58	29.35	34
Dislocation of Patella	5	3.47	31.87	27
Total Male Injuries	144			

The graphs below are visual demonstrations of the percents representing the compared genders and injury categories (Also available in Appendix #4-5).







4.3 Comparisons

Many trends of information existed in the comparison of data. Of the 303 patients in the database, 52% are female while 48% are male. The most common injury for each gender is the tear of the Medial Meniscus. This injury is credited for 45% of all female injuries and 40% of al male injuries. The least common injury for each group is a sprain of the Lateral Collateral Ligament. Approximately 3% of females and 1% of the males obtained this injury. (Refer to Appendix #5 to view this information)

Using the average BMI information of each gender and injury:

- Two female injuries occurred within a normal BMI range. These injuries include the tear of the ACL, and an upper tibia fracture. No average male information contained normal BMI classifications.
- The dislocation of the patella and lateral meniscus tears most commonly occurred in women classified as overweight. All male injuries except for the one, the dislocation of the patella, occurred in the overweight category.
- Obese women obtained medial meniscus, lateral collateral ligament and medial collateral injuries, while men in this classification group received a dislocation of the patella.

Using the average age information of each gender and injury:

- Twenty-eight years old was the most common age for both man and female ACL patients.
- Thirty-one years old was the most common age for both male and female tibia fracture patients.
- A tear of the medial meniscus contained the oldest average age for each gender.

5.0 Conclusion

5.1 Mathematical Models

The mathematical models used in this project were very adequate in obtaining correct and acceptable solutions, as the results came strictly from the statistics. The program used these models and tested each individual statistic to check if it satisfied the specified ranges of BMI and age. The program counted the statistics that suited these ranges, and also the total number of statistics it checked. This enabled the program to calculate a percentage that is used to show the user which injury occurred most often in the ranges they entered. The solutions satisfied the problem, as it proved that certain knee injuries are received by groups of people containing similar BMI and/or age.

5.2 Computer Program

The computer program successfully completed the intended task, though some adjustments had to be made to the code throughout the duration of this project. The separation of data was difficult to code; however, with the use of "for" loops and "if" statements, the program accomplished the task at hand. The ability of C++ and JAVA to read data files helped with simplifying the program code (Appendix #6).

5.3 Results

There is enough deviation between the average age and BMI of each individual injury to categorize a person based on his or her BMI, age, and gender. For females this deviation is greater because of the large difference in BMI ranges pertaining to each injury type. It can be concluded that it is more common for younger people, with lower BMI, to tear the anterior cruciate ligament or fracture the upper tibia. This is most likely due to the involvement with athletics. Heavier and older people tend to injure the lateral collateral ligament. The fact that most of the older people in the research were also overweight may explain the cause of such injuries. Older bodies are more prone to getting hurt unless they are kept healthy and active. If a person is also considered to be overweight, this increases the chance of receiving an injury.

The results of the computer program vary as different BMI and age ranges are entered by a user. Because a smaller range is more specific, it demonstrates the largest difference between injuries and the percentile in which the user was classified. Larger ranges, though calculating higher percentages within each category, seem to balance the results of the differing knee injury calculations. For example, if an age range between 5 years and 60 years is entered, and the majority of the patients listed in the data file are classified between these ages, each injury will relate the user to ninety to one hundred percent of the patients involved in the study.

5.4 Recommendations

The only recommendation the members of the team can suggest to increase the accuracy of this project is an increase in statistical information, and improve the method of collecting it. More information, especially from outside sources, would make the project more accurate for a person living anywhere, not just in the scope of the local orthopedic office where all information used for this project was collected.

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Appendices

Appendix #1

Females

Weight	Height	Age	Injury
258	66.5	61	836
145	65	16	836
134	64	12	836
157	59	45	836
231	62	42	836
261	63.25	50	836
155	65	75	836
191	67	39	836
202	60	50	836
130	60	79	836
132	61	66	836
184	59	72	836
125	67	13	836
159	69	70	836
185	65.5	20	836
374	68	54	836
174.5	64	39	836
180	62	79	836
207	67	50	836
190	65	88	836
117	62	14	836
94	62.25	14	836
203	63.5	65	836
171	59	52	836
153	64	75	836
205	63	38	836
180	59	65	836
205	65	42	836
176	63	53	836
214	63	45	836
172.5	69	58	836
245	64	54	836
109	63.25	73	836
219	63.75	62	836
177	74.5	72	836
183	64	57	836
164	69	66	836
201	68.5	70	836
120	61	14	836
155	64	52	836
246	68.5	54	836
241	65.75	68	836
113	60.75	44	836
162	68	42	836
260	66	43	836

Males

Weight	Height	Age	Injury
200	68	34	836
187	68	62	836
104	65.5	13	836
236	69	34	836
155	68.5	70	836
174	70	23	836
201	65.5	50	836
177	73	20	836
246	67.5	45	836
173	67.5	37	836
191	70.5	65	836
210	72	29	836
151.5	70	55	836
211	69	57	836
189	69	37	836
263	68	27	836
169	65	62	836
213	70.5	13	836
163	69	46	836
244	70	53	836
273	73	59	836
168	70	83	836
175	70	44	836
214	74	50	836
157	70	43	836
166	71	18	836
221	71	55	836
217	70.5	55	836
221	71	57	836
96	62.5	14	836
188	73	32	836
238	68	15	836
255	70	43	836
170	67	53	836
177	67	73	836
195	69	41	836
190	66	73	836
171	67.5	40	836
199	68	54	836
230	76	77	836
196	71.5	48	836
175	68	50	836
216	70.5	74	836
175	73	72	836
192	67	68	836

184	69	64	836
117.5	68	40	836
169	63.5	79	836
246	67	25	836
155	63.25	61	836
161	62.5	54	836
153	65	57	836
175	62	42	836
183	62.25	57	836
142	60	47	836
130	63	56	836
141	62	47	836
115	64	65	836
180	62	70	836
100	63.5	16	836
164	63	58	836
174	67	42	836
148	68	14	836
197	63.5	59	836
193	66.5	54	836
199	65	67	836
189	60.5	44	836
159	67	56	836
241	63.25	19	836
184	64	36	836
207	68	60	836
164	61	65	836
342	62.5	49	836

Weight	Height	Age	Injury
166	66	21	823
168	65	77	823
143	56	82	823
55	49	9	823
178	68.5	52	823
194	63.5	15	823
192	62.5	54	823
160	64	17	823
60	49	7	823

Weight	Height	Age	Injury
182	60	36	844.1
92.5	57	11	844.1
255	65	64	844.1
209	67	59	844.1
167	61	87	844.1
43	46	6	844.1
210	61	51	844.1
175	62	42	844.1
188	63	64	844.1

206	69	67	836
200	73	65	836
188	73	58	836
237	70	45	836
312	71.5	38	836
214	71	55	836
113	67	15	836
134	66	44	836
271	68	34	836
191	70.75	25	836
228	68	48	836
161	71	88	836

Weight	Height	Age	Injury
312	71.5	38	823
147	70.25	15	823

Weight	Height	Age	Injury
179	66	17	844.1
131	65	68	844.1
240	75	16	844.1
149	66	79	844.1
140	66.5	24	844.1
172	70.5	34	844.1
179	65	22	844.1
174	68	17	844.1
246	70	53	844.1
196	70	33	844.1
242	71	57	844.1
262	75	45	844.1
154	62.5	16	844.1
197	72	26	844.1
176	73	22	844.1
164	70.5	17	844.1
154	64	14	844.1
180	69	40	844.1
145	70	16	844.1
197	67	51	844.1
250	71	15	844.1
260	68.5	54	844.1
146	70.5	14	844.1

Weight	Height	Age	Injury
208	73	40	836.3
121	65	13	836.3
190	71.25	81	836.3
270	74	17	836.3
195	68	20	836.3
157	67	14	836.3
268	73	39	836.3

150	64	65	844.1
200	64	51	844.1
200	63.5	42	844.1
168	62.5	35	844.1
255	64	51	844.1
164	60	84	844.1
257	73	17	844.1

Weight	Height	Age	Injury
124	68	12	836.3
183	61.75	44	836.3
218	65.5	41	836.3
132	70.75	15	836.3
153	66	18	836.3
221	64.25	53	836.3
128	65	15	836.3
143	68	17	836.3
122	64.75	14	836.3
160	67.5	46	836.3
144	62	79	836.3
141	65	32	836.3
126	64	15	836.3
159	68	35	836.3

Weight	Height	Age	Injury
120	63	29	836.1
138	64	52	836.1
187	67.5	15	836.1
159	65	66	836.1
173	69.5	32	836.1
148	67	17	836.1
102	63	43	836.1
210	61	51	836.1
117.5	68	40	836.1
277	66	45	836.1
188	63	64	836.1
183	62.25	57	836.1
130	63	56	836.1
118	60	20	836.1
171	62	41	836.1
183	66.5	70	836.1
213	63	69	836.1
226	67	50	836.1
164	60	84	836.1
147	64	60	836.1
116	60.75	12	836.1
163	69.5	18	836.1
242	65.75	68	836.1
129	60	52	836.1
217	59	51	836.1

165	66	39	836.3
168	71	56	836.3
141	69	16	836.3
140	70	14	836.3
263	77	41	836.3

Weight	Height	Age	Injury
210	73	55	836.1
151.5	70	56	836.1
239	71	22	836.1
137	72	60	836.1
170	68	30	836.1
218	71	69	836.1
179	65	22	836.1
181	70	16	836.1
167	73	24	836.1
195	71	51	836.1
143	69	39	836.1
183	69	17	836.1
238	68	15	836.1
120	53	7	836.1
231	71	53	836.1
190	71	48	836.1
171	65	83	836.1
224	72	42	836.1
235	70	34	836.1
159	70	18	836.1
182	70	64	836.1

Weight	Height	Age	Injury
200	69	40	844
275	72.5	30	844
233	72	54	844
189	69	27	844
134	67.5	21	844

Height	Weight	Age	Injury
210	74	18	ACL
210	74	23	ACL
195	71	52	ACL
200	70.75	17	ACL
307	71	22	ACL
162	69	16	ACL
200	70.5	57	ACL
191	70.75	26	ACL
240	70	26	ACL
180	70	25	ACL
176	69	21	ACL
175	68	50	ACL
189	69	28	ACL

116	62	77	836.1
118	64.5	40	836.1
160	64.25	44	836.1

Weight	Height	Age	Injury
135	61	17	844
340	62	34	844
151	66.25	80	844
100	63.5	16	844

Weight	Height	Age	Injury
170	67	34	ACL
184	72	38	ACL
144	67	18	ACL
126	64	17	ACL
126	64	16	ACL
155	68	17	ACL
116	64	36	ACL
150	67	40	ACL
115	67.5	30	ACL
117	60	50	ACL
150	64	29	ACL
135	61	18	ACL
252	69	29	ACL
119	64	23	ACL
166	66	32	ACL
200	69	41	ACL
210	72	30	ACL
341	68	20	ACL
183	69	19	ACL
275	72.5	30	ACL
177	73	20	ACL
188	73	32	ACL
165	70	18	ACL
246	67.5	46	ACL
173	69	46	ACL
263	68	27	ACL

Appendix #2

Body Mass Index Chart		
0	18.5	Underweight
18.6	24.9	Normal Weight
25	29.9	Overweight
30	39.9	Obese
Greater than 40		Extremely Obese

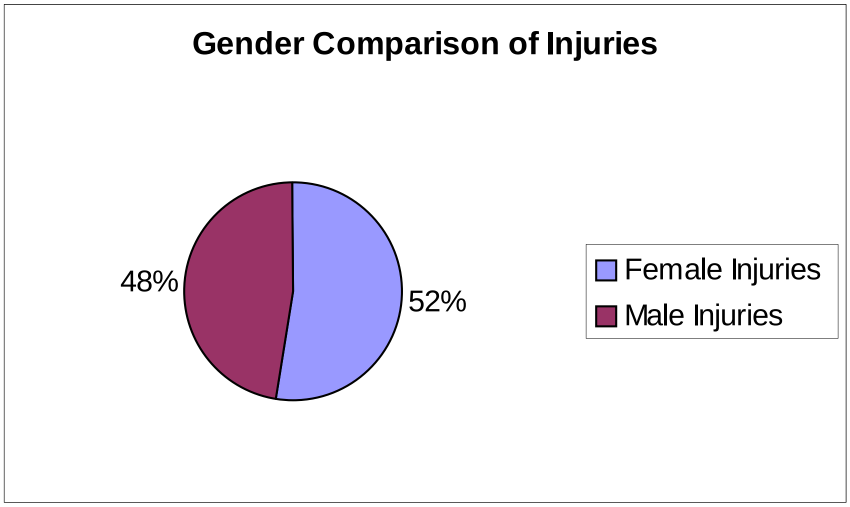
Appendix #3

Females				
Injury Type		**Percent**	**BMI of the Average**	**Average Age**
Tear of Anterior Cruciate Ligament	15	9.43	24.02	28
Tear of Medial Meniscus	73	45.91	30.80	52
Sprain of Lateral Collateral Ligament	4	2.52	33.00	50
Closed Fracture of Upper Tibia	9	5.66	23.38	31
Tear of Lateral Meniscus	28	17.61	28.12	47
Sprain of Medial Collateral Ligament	16	10.06	31.71	37
Dislocation of Patella	14	8.81	27.94	37
Total Female Injuries	159			

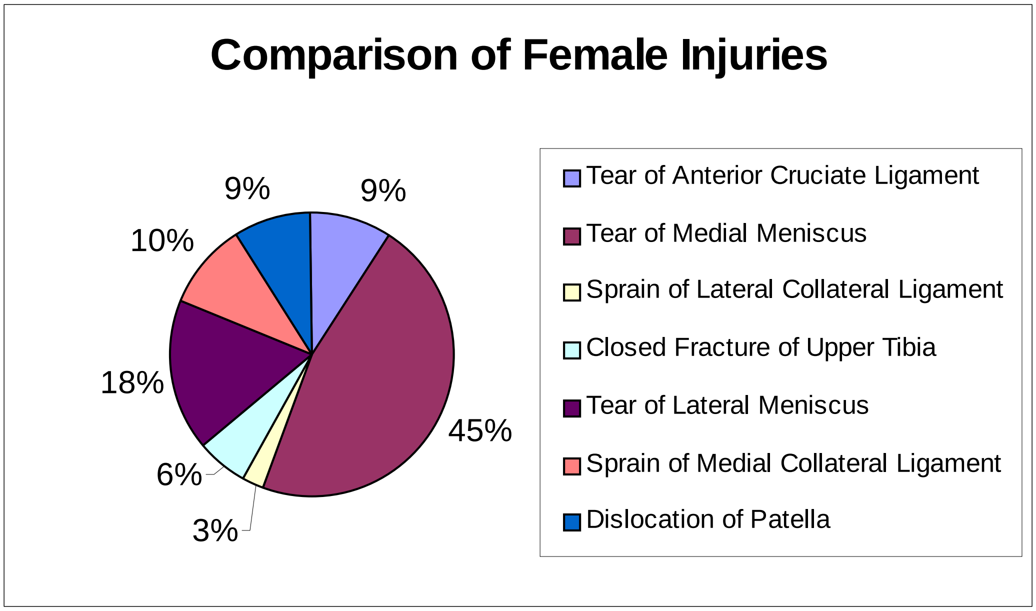
Males				
Injury Type		**Percent**	**BMI of the Average**	**Average Age**
Tear of Anterior Cruciate Ligament	24	16.67	29.70	28
Tear of Medial Meniscus	57	39.58	28.39	48
Sprain of Lateral Collateral Ligament	2	1.39	27.63	33
Closed Fracture of Upper Tibia	23	15.97	26.84	31
Tear of Lateral Meniscus	12	8.33	27.26	40
Sprain of Medial Collateral Ligament	21	14.58	29.35	34
Dislocation of Patella	5	3.47	31.87	27
Total Male Injuries	144			

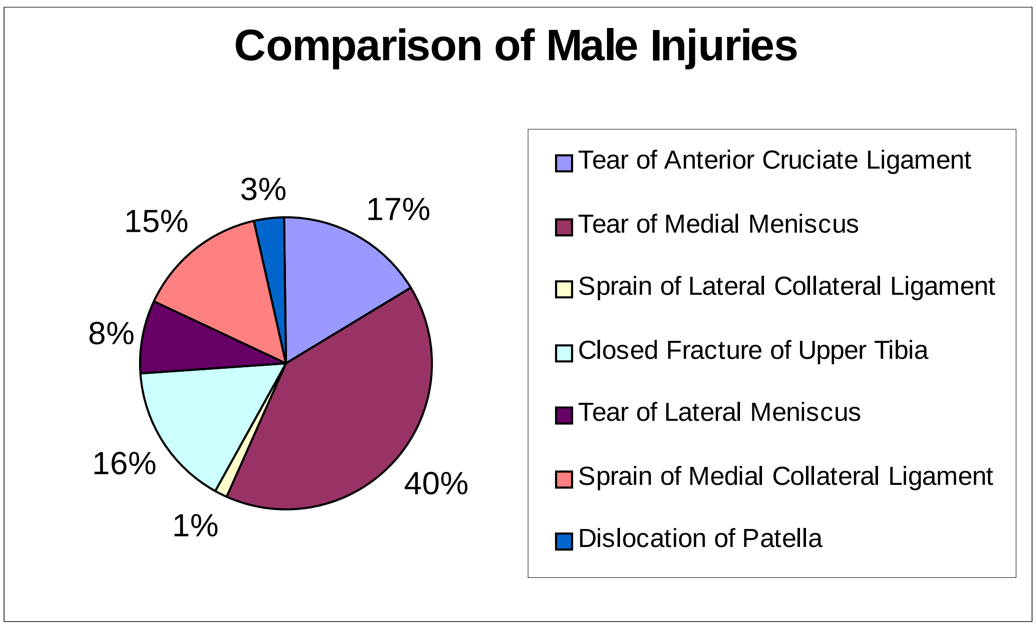
Female Injuries	**159**
Male Injuries	**144**
Total Injuries	**303**

Appendix #4


Gender Comparison of Injuries
48%
52%
Female Injuries
Male Injuries

Appendix #5


Comparison of Female Injuries
9%
9%
10%
18%
6%
3%
45%
Tear of Anterior Cruciate Ligament
Tear of Medial Meniscus
Sprain of Lateral Collateral Ligament
Closed Fracture of Upper Tibia
Tear of Lateral Meniscus
Sprain of Medial Collateral Ligament
Dislocation of Patella


Comparison of Male Injuries
3%
17%
15%
8%
16%
1%
40%
Tear of Anterior Cruciate Ligament
Tear of Medial Meniscus
Sprain of Lateral Collateral Ligament
Closed Fracture of Upper Tibia
Tear of Lateral Meniscus
Sprain of Medial Collateral Ligament
Dislocation of Patella

Appendix #6

```
#include <iostream.h>
#include <math.h>
#include <fstream.h>

int main()
{

//makes program refer to data file injury.dat
fstream InFile ("injury.dat",ios::in | ios::out);

//declares variables
//variables input by user
double weight;     //weight input by user
double kg;         //weight converted to kilograms
double feet;       //feet input by user
double inch;       //inches input by user
double height;     //total height in inches
double meter;      //converts height in inches to meters
double gender;        //gender input by user
double age;           //age input by user
double max_age;          //maximum age for calculations, input by user
double min_age;          //minimum age for calculations, input by user
double bmi;        //Body Mass Index = (wt/ht^2)
double max_bmi;    //maximum BMI for calculations, input by user
double min_bmi;    //minimum BMI for calculation, input by user
double userperc_bmi;  //percentage of people within BMI range
double userperc_age;  //percentage of people within age group

//variables from data file
const int count=303;      //total number of patients in data file
double w[count];          //weight from data file
double h[count];          //height from data file, already in inches
double g[count];          //gender from data file
double a[count];          //age from data file
double type[count];       //type of injury from data file
int c_type[count];        //counts number of injuries (only types)
int c_bmi[count];                  //counts number of BMIs within range
int c_age[count];                  //counts number of ages within range
double bmi2;

//Explanation of program to user
cout<<"This program will determine which type of knee injury is most
likely to occur based on the information you enter and the statistical
information located in the data base.  "<<endl;
```

```
//User inputs all information needed for calculation

cout<<"Are you a male or a female?"<<endl;
cout<<"Please enter 1 for male and 2 for female: ";
cin>>gender;

//prompts user for age
cout<<"How old are you? ";
cin>>age;

//prompts user for height
cout<<"How tall are you in feet and inches?"<<endl;
cout<<"Feet: ";
cin>>feet;
cout<<"Inches: ";
cin>>inch;

//calculates height in inches
height = ((feet*12) + inch);

//converts height in inches to meter
meter = (height *.0254);

//prompts user for weight
cout<<"Please enter your weight in pounds: ";
cin>>weight;

//converts weight from pounds to kilogram
kg=(weight*0.45);

//calculates a person's body mass index
bmi = (kg/(meter*meter));

//prints out BMI
cout<<"Based on your height and weight, your Body Mass Index is "<<bmi<<"."<<endl;

//prints out what this number means, uses if loop
  if (bmi <=18.5)
       cout<<"This means you are underweight."<<endl;
  else if ((bmi>18.5) && (bmi <=24.9))
       cout<<"This means you are of normal weight."<<endl;
  else if ((bmi>24.9) && (bmi <=29.9))
       cout<<"This means you are overweight."<<endl;
  else if ((bmi >29.9) &&(bmi <=39.9))
       cout<<"This means you are obese."<<endl;
  else if (bmi >39.9)
```

```
	cout<<"This means you are extremely obese."<<endl;

//skips a line when the program is run
cout<<endl;

//Prints out BMI chart so user can pick minimum and maximum BMI
cout<<"\t\t   Body Mass Index Chart"<<endl;
cout<<"\t\tFrom:\tTo:\tBody Type"<<endl;
cout<<"\t\t0\t18.5\tUnderweight"<<endl;
cout<<"\t\t18.6\t24.9\tNormal Weight"<<endl;
cout<<"\t\t25\t29.9\tOverweight"<<endl;
cout<<"\t\t30\t39.9\tObese"<<endl;
cout<<"\t\tGreater than 40\tExtremely Obese"<<endl;

//skips a line when the program is run
cout<<endl;

//prompts user for minimum and maximum BMI
//these are the values that will be used to define the search
cout<<"Please enter the minimum Body Mass Index for your search: ";
cin>>min_bmi;
cout<<"Please enter the maximum Body Mass Index for your search: ";
cin>>max_bmi;

//skips a line when the program is run
cout<<endl;

//prints out the person age
cout<<"Your age is "<<age<<"."<<endl;

//skip a line
cout<<endl;
//prompts user for minimum and maximum age
//these values will be used to define the search
cout<<"Please enter the minimum age for your search: ";
cin>>min_age;
cout<<"Please enter the maximum age for your search: ";
cin>>max_age;

//read data file using a for loop
for(int i=0; i<count; i++)
{
//fills arrays with correct information
InFile>>w[i];
InFile>>h[i];
InFile>>g[i];
```

```
InFile>>a[i];
InFile>>type[i];
}
//for loop to print out injury type
for(int j=1; j<=7; j++)
{
//skips a line when program is run
cout<<endl;

//prints out type of injury based on number
if (j==1)
cout<<"Type 1 is a tear of the Anterior Cruciate Ligament(ACL)"<<endl;
if (j==2)
cout<<"Type 2 is a tear of the Medial Cartilage"<<endl;
if (j==3)
cout<<"Type 3 is a closed fracture of the upper Tibia"<<endl;
if (j==4)
cout<<"Type 4 is a sprain of the Medial Collateral Ligament(MCL)"<<endl;
if (j==5)
cout<<"Type 5 is a dislocation of the Patella"<<endl;
if (j==6)
cout<<"Type 6 is a tear of the Lateral Cartilage"<<endl;
if (j==7)
cout<<"Type 7 is a sprain of the Lateral Collateral..."<<endl;

//tests each piece of data in database
for(int i=0; i<count; i++)
{
//if gender is the same as user input gender, the loop will be executed
if (gender == g[i])
{
//separates type of injury, checks each separate category
if (type[i] == j)
{
//if injury from database is same as the one being checked, one is added
//to the count of the type of injury
c_type[j]=(c_type[j]+1);
//calculates BMI from of height and weight from the database
bmi2 = ((w[i]*.45)/((h[i]*.0254)*(h[i]*.0254)));
//if the calculated BMI is withing the user specified range, this
//loop is executed
if ((bmi2>=min_bmi) && (bmi2<=max_bmi))
{
//one is added to the BMI count for the specific injury being tested
c_bmi[j]=(c_bmi[j]+1);
}
```

```
//if age from database is within user specified range, this loop
//is executed
if ((a[i]>=min_age)&&(a[i]<=max_age))
{
//one is added to the age count for the specific injury being tested
c_age[j]=(c_age[j]+1);
}

}
}
}
}
//for loop to check the 6 types of injury and calculates results for each
for(int j=1; j<=7; j++)
{

//calculates percentage for BMI of specific type of injury
userperc_bmi = ((double(c_bmi[j])/double(c_type[j]))*100);
//prints out results for BMI of type "j" of injury
cout<<"Your percentage for type "<<j<<" using BMI is "<<userperc_bmi<<"%."<<endl;

//calculates percentage for age of specific type injury
userperc_age = ((double(c_age[j])/double(c_type[j]))*100);
//prints out results for age of type "j" of injury
cout<<"Your percentage for type "<<j<<" using age is "<<userperc_age<<"%."<<endl;

//sets percents back to zero to allow the program to calculate correctly for the next injury
userperc_bmi = 0.0;
userperc_age = 0.0;

}

return(0);
}
```

Appendix #7

This program will determine which type of knee injury is most likely to occur based on the information you enter and the statistical information located in the database.

Are you a male or a female? Please enter 1 for male and 2 for female: 2
How old are you? 17
How tall are you in feet and inches?
Feet: 5
Inches: 8
Please enter your weight in pounds:
Based on your height and weight, your Body Mass Index is 22.0232.
This means you are of normal weight.

Body Mass Index Chart

From:	To:	Body Type
0	18.5	Underweight
18.6	24.9	Normal Weight
25	29.9	Overweight
30	39.9	Obese
Greater than 40		Extremely Obese

Please enter the minimum Body Mass Index for your search: 18.6
Please enter the maximum Body Mass Index for your search: 24.9

Your age is 17.

Please enter the minimum age for your search: 15
Please enter the maximum age for your search: 20

Type 1 is a tear of the Anterior Cruciate Ligament(ACL)
Type 2 is a tear of the Medial Cartilage
Type 3 is a closed fracture of the upper Tibia
Type 4 is a sprain of the Medial Collateral Ligament(MCL)
Type 5 is a dislocation of the Patella
Type 6 is a tear of the Lateral Cartilage
Type 7 is a sprain of the Lateral Collateral...

Your percentage for type 1 using BMI is 60%.
Your percentage for type 1 using age is 33.3333%.
Your percentage for type 2 using BMI is 21.9178%.
Your percentage for type 2 using age is 5.47945%.
Your percentage for type 3 using BMI is 0%.
Your percentage for type 3 using age is 22.2222%.
Your percentage for type 4 using BMI is 6.25%.
Your percentage for type 4 using age is 6.25%.

Your percentage for type 5 using BMI is 64.2857%.
Your percentage for type 5 using age is 35.7143%.
Your percentage for type 6 using BMI is 32.1429%.
Your percentage for type 6 using age is 14.2857%.
Your percentage for type 7 using BMI is 25%.
Your percentage for type 7 using age is 50%.