NORTHERN ILLINOIS UNIVERSITY

Susceptible to Injury: Why older adults are more prone to injuries during physical activity compared to young adults?

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Susceptible to Injury: Why older adults are more prone to injuries during physical activity compared to young adults?

Abstract:

The purpose of this study is to better understand why the older adults ranging from ages 30 – 75 years tend to be more prone to injury (especially knee injuries) during physical activity than when they took on the same activities as a young person ranging from ages 5 – 25 years. My hypothesis is that age causes deterioration in specific joint cartilage, bone strength, muscle and connective tissue composition. Changes in these factors in people's knee joints as they age can influence wear and tear on the joint during running, playing sports, and lifting weights causing an increased incidence of injury.

This topic is important, because it could explain how we can prevent injuries from happening as we grow older such as stretching methods, modalities to use, specific activities for improving strength in the knee, or possible types of shoes to wear in order to prevent injuries and help the knee stay stable. I feel that doing this project with show students how to take care of their bodies (knees) as they grow older. A decline in your physical abilities begins in the twenties, therefore students can take precautions in understanding why they cannot put so much pressure and impact on such a fragile joint in order to prevent themselves form surgeries and doctor visits.

Anatomy:

Essentially the knee is a smaller, less stable hinge joint. However, there are many features within the knee that help this specific joint with mobilization and functioning. There are three main bones associated with the knee. According to Partners on healthpages.org, the bones within the knee are the tibia, patella, and femur. The tibia stretches through the knee to the ankle. This bone is made up of a tibia tubercle and two shock-absorbing cartilages (menisci) which help with knee stability. Partners explains that "the patella is the triangular bone, or the kneecap, that moves as the leg moves" (Partners, 2012). Kneecaps slide along the between the femoral condyles which form the patella-femoral groove within the knee. According to www.biomed.brown.edu, the patella is a "sesamoid bone." The femur is the "largest, longest, and strongest bone in the body" according to Partners.

Ligaments in the knee include the MCL, LCL, ACL, PCL and Patellar ligament. Medial collateral ligaments (MCL) attach both medial sides of the femur and tibia and tend to "limit sideways motion of the knee" (Partners, 2012). Lateral collateral ligaments (LCL) attach lateral sides of the femur and fibula, and also limit sideways movement of the knee. Anterior cruciate ligament (ACL) "attaches the tibia and the femur in the center of the knee; its located deep inside the knee and in front of the posterior cruciate ligament" (Partners, 2012). This important ligament limits a rotational movement along with forward motions within the tibia. Posterior cruciate ligament (PCL) is the "strongest ligament" according to Partners, and attaches the tibia and femur. This ligament can keep the knee from moving backwards. The patellar ligament simply attaches a kneecap to the tibia. Partners on healthpages.org state that "the four ligaments are the most important in structures in controlling stability of the knee." A study in *The American Journal of Sports Medicine* proved that the oblique popliteal ligament "became tense in hyperextension" when studied from a cadaveric specimen (Morgan, 2012). Within this

specific study, doctors have made it known that the oblique popliteal is a primary restraint to knee hyperextension due to findings of this ligament being sectioned off showing changes within hyperextension. "The oblique popliteal ligament had the largest contribution to the ultimate amount of hyperextension seen, resulting in 37% of the total increase in recurvatum seen at the end of the experiment" (Morgan, 2012).

There are two tendons that are important to knee function. Quadriceps tendon links the quadriceps muscle to the kneecap. The patellar tendon attaches the kneecap to the tibia. According to Partners, "the patellar tendon is technically a ligament."

Cartilage within the knee includes medial meniscus, lateral meniscus, and articular cartilage. These menisci have a rubbery texture and are within the knee to help with shock absorbance and forces to the knee from the side. "Together, the menisci sit on top of the tibia and help spread the weight bearing force over a larger area" (Partners, 2012). Menisci also help the wearing away of articular cartilage. Articular cartilage is a thin, slippery surface that is flexible. Synovial fluid lines this cartilage and helps us in flexing the knee joint without wearing it down.

Quadriceps and hamstrings are the main muscle groups within the knee. Partners says that "the quadriceps are a collection of 4 muscles on the front of the thigh and are responsible for straightening the knee by bringing a bent knee to a straight position" (Partners, 2012). Three muscles are included within the hamstring group on the back of the thigh to control a bending movement within the knee.

The joint capsule is a fibrous structure in which is wrapped around the knee joint. Synovium lines the inside of this capsule which secretes synovial fluid and lubricates the knee.

"Both the ACL and PCL are contained within the capsule" according to www.biomed.brown.edu. The bursa is a sac filled with fluid to decrease friction within the muscles, bones, tendons, and ligaments. "The pre-patellar bursa is located on the front of the knee" (Partners, 2012).

Injuries:

Knee injury is a fearful thing to the common athlete's future. Many specific injuries can come about within the specific anatomy of the knee. Ligament injuries can be treacherous due to the fact that these tough tissues help with connection to bones. Too much stress can cause tears or too far of stretching on these bands. According to WebMD, ligament injuries can be caused by a source of things such as "twisting the knee with the foot planted, getting hit on the knee, extending the knee too far, jumping and landing on a flexed knee, stopping suddenly when running, or suddenly shifting weight from one leg to the other." Athletes are more prone to receiving such injuries during sports due to the movement in which takes place during certain sports. Swelling is a major symptom of a ligament injury. Other symptoms include "pain, loud popping or snapping, feeling of looseness in the joint, and inability to put weight on the point without pain" stated by WebMD.

Meniscus tears are due to twisting and turning in a quick manner as the foot stays still to the ground. Lifting heavy items or participating in sports can increase people's chances in tearing a meniscus. "As you get older, your meniscus gets worn which can make it tear more easily" (WebMD, 2012). Tears can vary from minor, moderate, and severe. Symptoms within a minor tear are usually just slight pain with some inflammation. Within a moderate tear there is usually "pain at the side or center of the knee" according to WebMD. Swelling, stiffness, and

limitation are all symptoms included within a moderate tear. A severe tear can cause your knee to catch, pop, or lock while functioning throughout the day. It is difficult to straighten the knee within a severe tear.

Sprains and strains are very common injuries that occur within the knee. A sprain happens when the ligaments are stretched or torn that involve swelling, popping, pain, and fluid behind the kneecap. Strains occur when the muscle or tendon is completely or partially torn, and includes similar symptoms to sprains.

Cartilage injuries include osteochondritis dessicans (OCD). This injury occurs when "a small piece of bone or cartilage softens or breaks off from the end of a bone, causing long-term knee pain" (WebMD, 2012). Symptoms associated with this injury include pain, swelling, and difficulty with leg extension, stiff knees, and catching. Chondromalacia is another common cartilage injury within the knee. Knee joints can soften due to injury, muscle weakening, or overuse of the knee joint. Pain is the primary symptom and surgery may be involved.

Another injury that may occur within the knee is patella-femoral pain syndrome. This pain begins when there are changes within the knee joint physically and chemically. "Patients with patella-femoral pain syndrome have anterior knee pain that typically occurs with activity and often worsens when they are descending steps or hills" (Juhn, 1999). This specific injury is known as an injury caused by overuse due to the point that bending the knee will increase the pressure between the patella and contact points. Weight-bearing activities, such as climbing, running, hiking, etc. can play a role in causing patella-femoral pain syndrome.

Why the knee is more prone to injury?

Synovial joints tend to be more prone to specific injuries, especially during physical activity. The movements involved within the knee joint include flexion and extension in order to participate in everyday activities. Standing, walking, and climbing stairs are all tasks that we normally have to accomplish on a daily basis in order to get around and live our lives. Synovial knee joints participate in "gliding, rolling, and rotating around a vertical axis" making it easier to consume injuries (Petrolini, 2012). Running, jumping, and kicking are all mobile activities in which people are involved in when participating in physical activities.

When partaking in these activities, the knee joint plays a vital role in being a very mobile instrument when involved in these types of physical movements. This is "the main reason the knee joint is the most injury-prone joint in the body" (Petrolini, 2012). Synovial joints are extreme weight-bearing joints that receive the attention from the upper half of the body seeing as how it is "low-placed" (Petrolini, 2012). Knee joints serve as a meeting point of the two long levers of the upper and lower leg bones. Another specific reason as to why this synovial joint is much more prone to injury is due to the fact that it is dependent on ligaments and muscles for stability. Some of these certain ligaments and muscles may not be tough enough; they can be too weak to counteract forceful blows or hits to the knee joints.

Changes to knee anatomy with aging:

The American Academy of Orthopaedic Surgeons gives us great examples as to how the anatomy of the knee changes due to aging. They explain that "water content of tendons decreases as we get older making tissues stiff and harder to withstand stress" (AAOS, 2012). There is loss of muscle mass, bone mineral content, water content, joint motion, and less

cushioning of the cartilage. Less flexibility within the knee joint occurs along with cartilage becoming more susceptible to stress causing arthritis.

Researchers Hudelmaier, Glaser, Hohe, Englmeier, Reiser, and Putz performed a study involving 15 men and women between the ages of 50 and 78 years and their right knee joints free from pain, trauma or surgery. A 1.5T scanner was used to give a saggital view of the knees, as well as obtaining two transverse images of the patellar cartilage. Computer based segmentation was included on the subjects knees. These tests were then compared to 95 young asymptomatic subjects' ages 20 – 30 years. Researchers planned to test that "thinning of knee joint cartilage occurs with aging and that elderly subjects display a different amount of cartilage deformation than do young subjects" (Hudelmaier, 2001).

Results showed that "patellar cartilage thickness in elderly woman decreased 12% when compared to the younger joints" as well as a 6% decrease within the elderly men (Hudelmaier, 2001). Femoral cartilage was 21% thinner in elderly woman and 13% thinner within the adult male. "Tibial cartilage thickness displayed 10% thinner in woman and 7% thinner in men" (Hudelmaier, 2001). Patellar cartilage deformation ended up being a little less of a difference when compared to the younger knees. There was a 2.6% decrease in woman as well as a 2.2% decrease in the older males.

The hypothesis was proved to be true. "Morphologic and biochemical changes are known to occur in articular cartilage with age-related pathologic processes, such as osteoarthritis. It is unclear, however, whether changes in cartilage morphology also occur during normal aging, in the absence of cartilage disease" (Hudelmaier, 2001). This specific study can help to provide information to distinguish between normal aging process and pathologic alterations.

Two authors, J.D. Schofield and B. Weightman, discuss the effects of aging on connective tissue. Within this article there is mention that reports have been made by authors Mathews and Glagov that there are alterations within proportions of glycosaminoglycans as a function of age in costal cartilage such as the knee joint cartilage and intervertebral disc. Glycosaminoglycans (GAGs) are polysaccharides with a disaccharide unit. The molecules within the glycosaminoglycans are ideal for lubrication within joints as well as providing integrity to cells for cell migration. Specifically, chondroitin sulphates to keratin sulphate ratios were compared within the annulus fibrosus that surrounds the nucleus pulposus of lumbar intervertebral discs. The annulus is formed by layers of fibrocartilage that contain the nucleus pulposus to help even out pressure across the discs. It was noted that, when compared to spines from 8 to 16 years was compared to a spine aged at 44 years, the ratio increased possibly due to the fact that glycosaminoglycan subunits are altered proving that "changes in the glycosaminoglycan chemical makeup occur with age in certain tissues" (Scholfield, 1978). This specific example shows that glycosaminoglycan's interact more strongly with collagen due to aging of the nucleus and annulus of tissue. According to Schofield and Weightman, these changing proportions of the glycosaminoglycan "affect the mechanical properties of tissues and alter transport of substances through the extracellular matrix" (1978).

There are also changes within elastic fibers and cells of the connective tissues. Elastic fibers "become frayed, split, and fragmented with aging" (Schofield, 1978). Elasticity within connective tissue decreases due to age. Cells will control amounts of active enzymes which can lead to an increase in inactive enzymes within aged tissues. Also, "synthesis of glycosaminoglycans will decreases during aging" (Schofield, 1978). Another effect of aging within connective tissue is that response to stimuli is delayed within older animals when they are

compared to younger animals. It is harder for tissues to respond to specific harmful stimuli which can cause much damage to the connective tissue at an older age.

Doctor Loeser explains that osteoarthritis (OA) is a huge factor in the disability of older adults. Osteoarthritis involves the feature of degradation of articular cartilage within the osteoarthritic joint causing the joint to have a difficulty with movement because there is less lubricated surface helping the joint mobility. Loeser describes many changes within joint tissues due to aging that will contribute to osteoarthritis. He mentions that "accumulation of cells exhibiting a senescent secretory phenotype, which are cells that increase as we grow and are found at sites of age-related pathologies, increases cytokine and matrix metalloproteinase (MMP) production in order to stimulate matrix degradation" (Loeser, 2010). MMP's are endopeptidases that degrade extracellular matrix proteins involved in the cytokine activation. Cytokines are molecules that work to signal other cells to sites of infection. Advanced glycation end-products (AGEs) form within the joint tissues causing tissue to become brittle and "increase fatigue failure" (Loeser, 2012). These AGEs are formed throughout aging, and are released under specific pathologic conditions as a proinflammatory mediator. Also, free radicals will accumulate over time and damage the cells with joint tissues. Oxidative stress and cell damage is a product of this accumulation causing death of cells and a reduction in matrix synthesis. Another typical change due to aging is an increase in matrix calcification. This increase, according to Loeser, will "alter mechanical properties and potential activation of inflammatory signaling" (2010). Age is the primary risk factor when developing osteoarthritis which will involve all of these specific cell and tissue changes as we grow older.

Treatment:

Treatments for knee injuries are pretty common. Typical ice packs, ace wraps for compression, and painkillers such as ibuprofen and Advil are all tactics that will decrease pain, swelling, and injury; however, some injuries may be more technical than others. Surgery may be needed for specific injuries such as ACL/PCL tears, meniscus tears, and factures. Rest is the number one treatment for most knee injuries. Taking time to simply rest is important on the knee joint. People put a lot of impact on their knees by walking, working out, using stairs, dancing, etc. every day, therefore resting the knee joint will give it time to heal and not receive too much overuse. The inflammations cycle is the first thing that needs to be broken in order to treat a knee injury. Inflammation is a source in which pain will begin. Rest, ice, compression, and elevation are all tools used to help reduce pain by breaking the inflammation cycle. Rest will reduce the strain on the knee and can let the knee heal in a timely manner. Ice is a reliable source in reducing swelling with all types of knee injuries. Shiel says that icing the knee" for 20 – 30 minutes two to three times daily is the recommended amount of treatment." Compression (knee braces and wraps) are able to reduce swelling along with preventing the patella to become unstable. Compression will keep joint mechanisms intact as well. "Elevation works with gravity to help fluid that would otherwise accumulate in the knee flow back to the central circulation" (Shiel, 2006).

Prevention:

Taking simple precautions everyday will prevent the increase in knee injury. Kids Health tells us that using protective equipment during athletic practices and competitions is an advantage in helping prevent injuries, especially knee injuries. Warming up and cooling down before and after workouts is a goal people should set each time they participate in physical activities. Also, instead of participating in training during a specific season, one should

condition all year to prevent damaging knees. "Using joints to crouch and bend will reduce ligament injuries" as well as using continuous stretching techniques each time a person is physically involved (KidsHealth, 2012).

Strengthening exercises are a healthy way to reduce knee injury, especially within the thigh muscles. WebMD gives a great tip to preventing injury by telling us to "change workout intensity at a slow pace instead of moving the intensity up at a fast rate" (WebMD, 2012). Another great idea is to purchase shoes with good support and make sure that they fit in a comfortable way.

Conclusion:

I have gathered that adults are more prone to knee injuries when involved with physical activities due to the aging within the synovial knee joint. Injuries such as ACL/PCL tears and injuries, osteochondritis dessicans (OCD, chondromalacia, sprains, cartilage tears, bursitis, patella-femoral pain syndrome, and patella injuries are all influenced by anatomical aging. Within the knee, age has impact on decreasing water content within tendons, decreasing muscle mass and bone mineral content, as well as less joint movement or cushioning of cartilage. Researchers have proven that cartilage thickness, femoral cartilage thickness, and tibial cartilage thickness all decrease as we get older. Biochemical and morphological changes also come about within the knee due to the aging process which effect how common the older adult receives injuries within the synovial knee joint. Through proper treatment and prevention plans the knee joint can become less of a target to injury; however nothing will change the aging within bones, cartilage, and connective tissue content.

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SUSCEPTIBLE TO INJURY:

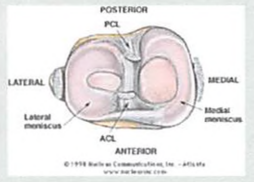
Why older adults are more prone to knee injuries during physical activity compared to young adults?

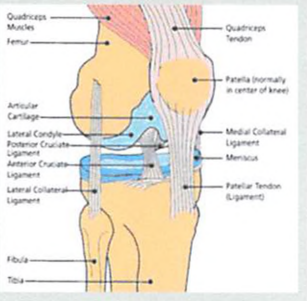
By: Christina Smithson

ANATOMY OF THE KNEE

- Bones:
  - 3 main bones within the knee are the Tibia, Patella and Femur
- Ligaments:
  - Medial Collateral Ligament (MCL), Lateral Collateral Ligament,(LCL) Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL), Patellar Ligament, Oblique popliteal ligament, Arcuate popliteal ligament.
- Cartilage:
  - Medial Meniscus, Lateral Meniscus, Articular Cartilage
- Muscles:
  - Quadriceps (particularly vastus medialis and vastus lateralis) and Hamstrings (back thigh)
- Joint Capsule
- Bursae

ANATOMY OF THE KNEE





INJURIES

A gradient-echo T2*-weighted sagittal image demonstrates a tear within the posterior horn of the medial meniscus (arrow).

A photograph showing inflammation of the right prepatellar bursa after trauma. There is swelling over the right knee.

osteochondritis dissecans (OCD lesions)

INJURIES

- Tendon Injuries:
  - Unable to extend the knee with pain above or below the patella
- MCL and LCL Injuries:
  - Stretched or torn due to forceful direction of the knee while the foot is stable on the ground
- ACL Injuries:
  - Force applied to the anterior or posterior side of the knee as the foot is planted
- Meniscus Tears:
  - Cartilage tears due to twisting
- Fractures
- Bursa Inflammation:
  - Due to crawling, kneeling, and bending on the knees repeatedly
- Patellar Injuries:
  - Dislocation of patellar, Patello-femoral syndrome (underside of patellar is inflamed)

WHY IS THE KNEE MORE PRONE TO INJURY COMPARED TO OTHER JOINTS?

- The knee is a synovial joint
- Flexion and extension are vital movements involved with the knee joint
- Gliding, rolling, and rotation around a vertical axis
- "The knee joint is essential for everyday activities such as standing, walking, and climbing stairs."
- Running, jumping, and kicking are all mobile activities in which the knee plays a vital role in the performance

Petrolino, L. (n.d.). *ehow.*

WHY IS THE KNEE MORE PRONE TO INJURY COMPARED TO OTHER JOINTS?

- All of the above activities involve the knee joint to be very mobile which is a main reason the knee joint is the "most injury-prone joint in the body."
- This synovial joint is a "low-placed, mobile, and weight-bearing joint that serves as a meeting point of the two long levers of the upper and lower leg bones."
- Dependent on ligaments and muscles for stability
- Too weak to counteract forceful blows or hits to the knee joint

Petrolino, L. (n.d.). *ehow.*

CHANGES TO THE BONE, CARTILAGE, AND CONNECTIVE TISSUE DUE TO AGE

- According to AAOS (American Academy of Orthopaedic Surgeons):
  - Water content of tendons decreases as we get older making tissues stiff and harder to withstand stress.
  - Muscles will lose mass as we age
  - Bones lose their mineral content and become fragile
  - With less water content, cartilage becomes more susceptible to stress, degenerates, and arthritis may develop within joints
  - Joint motion is restricted and we are not as flexible within our joints due to changes in tendons and ligaments
  - Cushioning cartilage break down causes joints to inflame and become arthritic

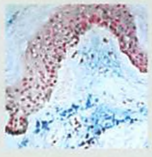
CHANGES TO THE BONE, CARTILAGE, AND CONNECTIVE TISSUE DUE TO AGE

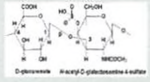
- According to the authors Hudelmaier, M., Glaser, C., Hohe, J., Englmeier, K. -, Reiser, M. and, Putz, R.:
  - Studied 15 women and men between the ages of 50 – 78 years
  - Objective –" In vivo study testing the hypothesis that thinning of knee joint cartilage occurs with aging and that elderly subjects display a different amount of cartilage deformation than do young subjects."
  - Results - Reduction of patellar cartilage thickness, femoral cartilage thickness, and tibial cartilage thickness
  - Conclusion – Hypothesis tested correct! Researchers also found that the amount of cartilage reduction differed between sexes and between compartments of specific knee joints.

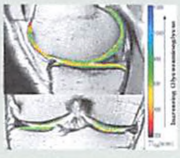
CHANGES TO THE BONE, CARTILAGE, AND CONNECTIVE TISSUE DUE TO AGE

- According to Schofield, J. D., & Weightman, B. (1978):
  - Alterations in the proportions of different glycosaminoglycans
    - Affect the mechanical properties of tissues
    - Alters transport of substances through the extracellular matrix
  - Elastic fibers become frayed, split, and fragmented with aging
    - Elasticity of elastic tissues decreases
  - Changes in connective tissue cells due to aging
    - Cells have the ability to control the amount of active enzyme present through synthesis of specific enzyme inhibitors
      - Inactive enzymes that accumulate in old connective tissue due to cells controlling active enzymes
    - Synthesis of glycosaminoglycans decreases during aging
    - Tissue response to stimuli are delayed in older animals compared to younger animals

GLYCOSAMINOGLYCANS





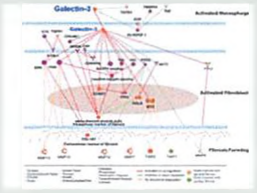


Glycosaminoglycans (GAGs) are polysaccharides with a disaccharide unit. The molecules within the glycosaminoglycans are ideal for lubrication within joints as well as providing integrity to cells for cell migration.

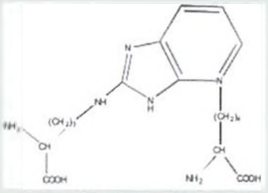
CHANGES TO THE BONE, CARTILAGE, AND CONNECTIVE TISSUE DUE TO AGE

- According to Loeser, R. F. (2010):
- Osteoarthritis (OA) due to aging:
  - OA features include degradation of articular cartilage
  - Affects joint movement due to loss of smooth lubricated surface
  - Accumulation of cells with senescent secretory phenotype contribute to aging within tissue and will increase production of cytokines and MMPs in OA cartilage
  - Cartilage becomes thin as we age – loss in matrix
  - Advanced glycation end-products (AGEs)
  - Reactive oxygen species (ROS) "free radicals"

MMP AND AGE



Pathways of MMP



AGE chemical component

TREATMENTS FOR INJURIES

- Ice
- Compression (Ace wrap)
- Ibuprofen/Advil
- Surgery
- Rest
- Physical Therapy

TREATMENTS FOR INJURIES

- Meniscus Tear:
  - Rest, Ice, Compression, Elevation, Knee Brace, Painkillers
- PCL, LCL, MCL, ACL Injury:
  - Rest, Ice, Compression, Elevation, Knee Brace, Painkillers, Stretching/Strengthening

PREVENTION

- According to http://kidshealth.org/teen/safety/first_aid/knee_injuries.html precautions can include the following:
  - Using protective equipment during practices and competitions
  - Warm up and cool down before and after workouts
  - Condition and train year round instead of part of the year
  - Always continue stretching or conditioning after injuries
  - Using joints to crouch and bend will reduce ligament injuries
- Prevention of ligament injuries (PCL, LCL, MCL, ACL) according to http://www.webmd.com/fitness-exercise/knee-ligament-injuries?page=3:
  - Stretch and strengthen thigh muscles regularly
  - Stretch before and after physical activity
  - Change workout intensity at a slow pace

PREVENTION

- Precautions for meniscus injuries -
  - Purchase shoes with good support and a good fit
  - Thigh muscles
  - Stretch
  - Do not increase activity quickly



PREVENTION

- According to the American Academy of Orthopaedic Surgeons:
  - "A healthy diet, regular exercise programs, and a positive attitude can help delay the onset and slow the progression of many age-related changes."

CONCLUSION

- What we can gather:
  - Older adults are more prone to knee injuries when involved in physical activities.
  - Injuries include meniscus tears, ACL/PCL injuries, osteochondritis dessicans (OCD), Chondromalacia, Sprains, cartilage tears, bursitis, patella-femoral pain syndrome, patella injuries
  - Due to aging structures within the knee joint such as decreasing water content within tendons, decreased muscle mass, bone mineral content, joint motion, and less cushioning of cartilage, cartilage thickness decreases, femoral cartilage decreases, tibial cartilage decreases, biochemical and morphological changes due to aging
  - Age has a huge effect on becoming more prone to knee injury
  - Specific treatments and preventions can help reduce injury

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