**1. Introduction**

Hello everyone,  
Today I’m going to present the first part of my research internship, here at Kyushu University. My project focuses on how **knee pathologies** can affect the way our **muscles behave during walking**.

Walking might seem like something simple, something automatic, but in reality, it’s a very complex movement. It requires constant coordination between different joints and muscle groups.

The **knee**, in particular, plays a central role. It helps absorb the impact when the foot hits the ground, it keeps us balanced, and it helps push the body forward.  
But when the knee is affected, whether due to injury, trauma, or disease, this balance is broken. The way muscles are activated changes, and this can lead to **an altered gait**.

To better understand these changes, I’m working with **EMG signals**, that is, recordings of muscle activity, to study and compare walking patterns between healthy people and patients with knee pathologies.

**2. What is EMG?**

So first, what exactly is an EMG signal?

An **EMG**, or electromyographic signal, represents the **electrical activity** generated by muscles when they contract.  
This electrical activity comes from action potentials, which are triggered by motor neurons. When multiple motor units fire at the same time, the electrical potentials overlap and combine, and that’s what we can detect and record.

Usually, the voltage ranges from 0 to 10 millivolts for surface EMG. That’s quite a small signal, so it needs to be well amplified and filtered.

EMG is used in many different fields, not just research, but also in medicine and rehabilitation. It helps us understand how muscles work, detect neuromuscular disorders, or monitor a patient’s progress during physical therapy.

**3. Types of EMG**

There are two main types of EMG:

* The first one is **surface EMG**. This is the most common type, it involves placing flat electrodes directly on the skin, above the muscle. It’s completely non-invasive, easy to use, and works very well for general movements, like walking or running.  
  But it also has its limits: for example, it’s not very accurate when it comes to deep muscles, and it can be sensitive to motion artifacts or noise from the environment.
* The second type is **intramuscular EMG**. Here, thin needle electrodes are inserted directly into the muscle. This method is more precise and allows us to target specific motor units.  
  However, it’s invasive, and it can be uncomfortable for the subject, so it’s mostly used in clinical diagnosis.

In my case, I’m working only with **surface EMG**, which is much more practical for walking analysis.

**4. EMG Example**

Here, you can see a visual example of EMG signals recorded from a person while walking.  
The sensors are placed on five different muscles from both legs.  
The red signals represent the **left leg**, and the blue ones represent the **right leg**.

We can see that each muscle activates in a different rhythm depending on the phase of the gait cycle. This kind of visualization is really useful when trying to analyze coordination or detect abnormal patterns.

**5. Gait Cycle**

Let’s now take a closer look at how walking works, through the **gait cycle**.

Each step we take can be divided into two major phases:

* The **stance phase**, which represents about 60% of the cycle. That’s when the foot is in contact with the ground, supporting the body’s weight.
* And the **swing phase**, which covers the remaining 40%. That’s when the foot is off the ground, moving forward.

Within the stance phase, we can identify five sub-phases:

1. Heel strike — the heel touches the ground
2. Flat foot — the foot rolls to full contact
3. Mid-stance — the body weight shifts over the leg
4. Heel off — the heel begins to lift
5. Toe off — the toes push off the ground to start swing

Then comes the **swing phase**, which has three parts:

* Initial swing
* Mid swing
* And terminal swing, when the leg prepares for the next contact.

This cycle repeats with every step, and it creates a rhythm that can be studied and compared using EMG data.

**6. Knee Flexion Graph**

To better understand this rhythm, I’ve also looked at the **knee flexion angle over time**.

This graph shows how the knee bends and extends during one full gait cycle.  
It’s very useful because it allows us to segment the EMG signals — in other words, we can cut the data into individual steps to compare them more accurately.

This segmentation will be essential later, when I start extracting features and preparing the data for machine learning.

**7. Database Presentation**

Now, let me tell you more about the **database** I’m using.

The dataset includes recordings from **22 male subjects**. Half of them are healthy, and the other half have a diagnosed knee pathology.  
Each subject performed several types of movement, but for this project, I’m focusing only on **walking trials**.

During data collection:

* Four EMG electrodes were placed on key leg muscles: Rectus Femoris, Biceps Femoris, Vastus Medialis, and Semitendinosus.
* A goniometer was also used to measure the knee flexion angle.

The signals were recorded using the **Biometrics DataLOG system**, with a sampling rate of 1000 Hz.  
Each file is a .txt file, and contains five columns, one for each of the four muscles, and one for the knee angle.  
The files are separated into two folders: one for healthy subjects and one for pathological cases.

To get a first visual impression, I plotted the EMG signals and the knee flexion angle for one healthy person and one patient.  
Each color in the graph represents a different muscle, and the last signal is the knee angle.  
On the graph, the **left side shows the healthy subject**, and the **right side shows the pathological subject**.

This type of comparison helps me observe potential differences and start thinking about what features could be useful for classification.

**8. Next Steps**

So, what comes next?

Right now, I’m still getting familiar with the data and making sure everything is well organized.  
The next step will be to **start preprocessing the signals**: that means filtering, rectifying, segmenting, and extracting meaningful features.

Once that’s done, I plan to use **machine learning** to try and classify walking patterns — to see if a model can automatically detect whether a subject is healthy or has a pathology, based only on their EMG data.

Since my supervisor is specialized in artificial intelligence, this project is also a great opportunity for me to combine **biomechanics and AI**, and explore how these fields can work together.

**Conclusion**

To conclude, I’m still in the early stages of this project, but I’ve already learned a lot about EMG, the gait cycle, and how to handle real experimental data.

I’m excited to move forward with the analysis and see how artificial intelligence could be used to support clinical decision-making in the future.

Thank you for listening.