National Institute of Technology, Akita College
IUT de Bethune

THREE MONTHS INTERSHIP IN AKITA KOSEN

Comparison of the moment created when cycling in the lying position or not with the FES and without the FES

BY Moukoka Sam

Supervisor: Mr. Kobayashi

In Mechanical Engineering

National Institute of Technology, Akita Kosen

IUT de Bethune, France

REPORT INFO

From the 6/04/2016

To the 20/06/2016

Keywords:

FES: Functional Electrical Stimulation

ABSTRACT

This internship was firstly about experimentation using two different kind of wheelchair and two different methods, secondly about analyze the results, thirdly about comparison of the different results And finally deduction of the most advantageous System for reeducation

1- LEARNING ABOUT THE SUBJECT

In order to understand my experiment Mr. KOBAYASHI gave me some article to read, the most critical were:

- Comparison of Functional Electrical and Magnetic Stimulation for Propelled Cycling

This article talk about the experience which were made to compare isometric torque and cycling power using FES and FMS in patients with paretic legs.
In this article we can understand that FES induces pain so the relative increase in isometric strength resulting from training with FES might be determined by the ability of the subjects longer and more forceful contractions, magnetic stimulation does not produce radial current which activates pain nerves in advantage of the skin. However compared with electrical stimulators the magnetic one is bulkier, and they cannot provide focal stimulation, because the FMS is painless it cannot generate muscle force in legs of healthy persons or in persons with only partially preserved or lost sensibility.
FMS is a potential alternative to surface. FES for the large thigh musculature use for patients with partially or completely preserved sensibility.

- Biomechanical Analysis and Muscle Tension Estimation

The purpose of this study was to identify the kinematic factors of the lower extremities required to perform FES-rowing through the biomechanical analysis.
The second objective of this study was to identify the load of the lower extremities and intensity of the stimulation required to perform FES-rowing for non-paraplegic volunteers through the kinematic study.
The results of this study lets suggest that the joint reaction force of lower-extremity during rowing was lower than during walking and it's a safe exercise for the paraplegics.

The Joint reaction force is the force on the contact surfaces of the joint, a force that breaks down the joint.

2- INTRODUCTION

During my internship I have work with other Japanese student named:
Mr. Kodama, Mr. Kusakai, and Mr. Miura

Our job was to make experiments using wheelchair for the rehabilitation of disabled, one with four wheel and the other one with three. The one with 3 wheels had is pedals lower than the seat of the wheelchair instead of the one with four wheel which had is pedal at the same level of the wheelchair seat creating a lying position sensation.
By using a voluntary motion and after by using the Functional Electrical Stimulation our goal was to determinate which one was more helpful and painless by compared the results. So the experiment was separate by two, the first month consisted of doing the experience without FES we used ten healthy person and the second part with FES we used five healthy person, each one of them had to ride the two kind of wheelchair using the same condition (speed, weight, time) .
After two months we were able to analyze the result and obtained a conclusion.

3- MATERIALS AND METHODS

3.1- SUBJECTS

Ten healthy person with the mean age of 21 years (range: 19-23), mean height of 169 cm (mean 165-173 cm) and the mean weight of 69 Kg ±6 Kg were volunteered in this study. Every one of them had to pedal for one minute following a specified rhythm

3.2- Parameter

We decide to use as parameter 10 Watt load and 60 Rpm for the speed rotation.

3.3- Materials

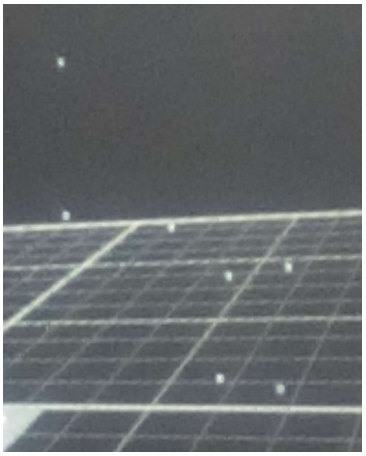
- The motion camera

We used a motion camera a camera which can see some specific point 'captor'

We turned on the camera movement by passing a sensor in front of each of the 7 cameras that we used then we check on the computer that was connected to the cameras that we receive a signal. The computer connected to the camera was using a software called Vicon Nexus. This software has the ability to calculate the moment, for that it was necessary to place the sensor at some specific points of a human body (shoulder, hip, knee, ankle, toe) so the camera could see the points and the computer will materialized the shape.

Camera positions

Computer when camera on



- The Pedals

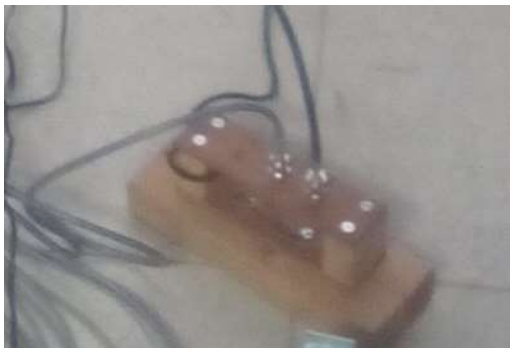
Our wheelchair had a bike portion and in order to realized our experiment we had to change the pedal.

We exchange the two pedals of the bike portion of the wheelchair one was replaced by a 6-axis sensor that was connected to an amplifier with six cables, connects them even to a box that was connected to a second computer.
The second computer used a software named Tecgiam which can calculate the strength and the moment created by the person who is riding the bike wheelchair.
The second pedal used a pedal named Keo Power therefore a pedal that can analyze the power supplied by the cyclist.
Because of the specific pedal we use a specific shoes with a different shape.

The two computers had to star at the same time so for that they had made a wooden box which was designed to connect the two computer.

Amplifier that was directly connected to the 6 axis-sensor

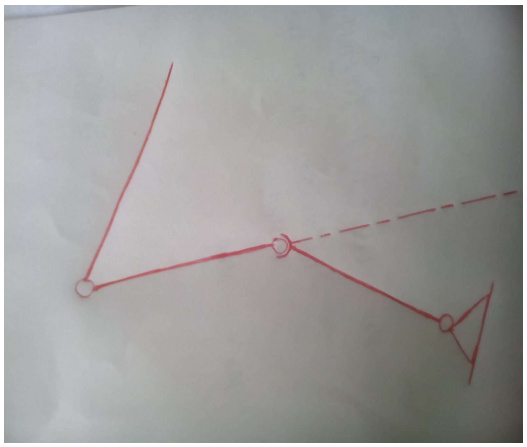
The electrical box which received the cables from the amplifier



Wood box for the coordination

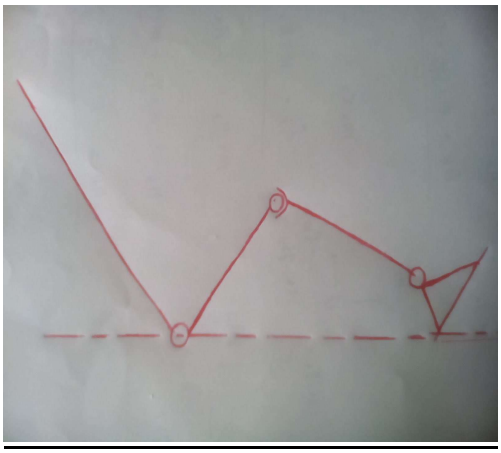
3.4- The wheelchair

- Wheelchair with 3 wheels



Shape of the body while seating on the wheelchair with 3 wheels

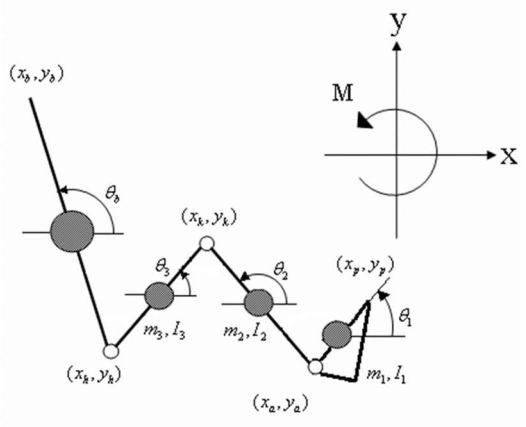
- Wheelchair with 4 wheels



Shape of the body seating on the wheelchair with 4 wheels

4- ANALYSIS

On our work we focused on calculated the moment of three specific points which are: the ankle, knee, and the hip.



Modeling of the human body was performed and the moments was calculated using a link model.
Considering gravity and acceleration of each point, the dynamic moments were calculated from balancing horizontal and vertical forces and moments at each point.

Moment of the Ankle

$$f_a = m_1\ddot{x}_1 - f_p$$

$$n_a = m_1(\ddot{y}_1 + g) - n_p$$

$$M_a = -I_1\ddot{\theta}_1 + f_p(y_p - y_1) - f_a(y_1 - y_a) - n_p(x_p - x_1) + n_a(x_1 - x_a)$$

Moment of the Knee

$$f_k = m_2\ddot{x}_2 + f_a$$

$$n_k = m_2(\ddot{y}_2 + g) + n_a$$

$$M_k = -I_2\ddot{\theta}_2 + f_a(y_2 - y_a) + f_k(y_k - y_2) + n_a(x_a - x_2) + n_k(x_2 - X_k) + M_a$$

Moment of the Hip

$$f_h = m_3\ddot{x}_3 + f_k$$

$$n_h = m_3(\ddot{y}_3 + g) + n_k$$

$$M_h = -I_3\ddot{\theta}_3 - f_k(y_k - y_3) - f_h(y_3 - y_h) + n_k(x_k - x_3) + n_h(x_3 - x_h) + M_k$$

Fp and np are horizontale and vertical components of the floor reacting force,

x: is the horizontal distance from the center of gravity of the point

y: is the vertical one,

m: is the masse of the point

M: is the moment

I: is the inertia moment

θ: is the angle

a: represent Ankle
k: represent Knee
h: represent Hip

4.1- Obtaining digital data for analysis

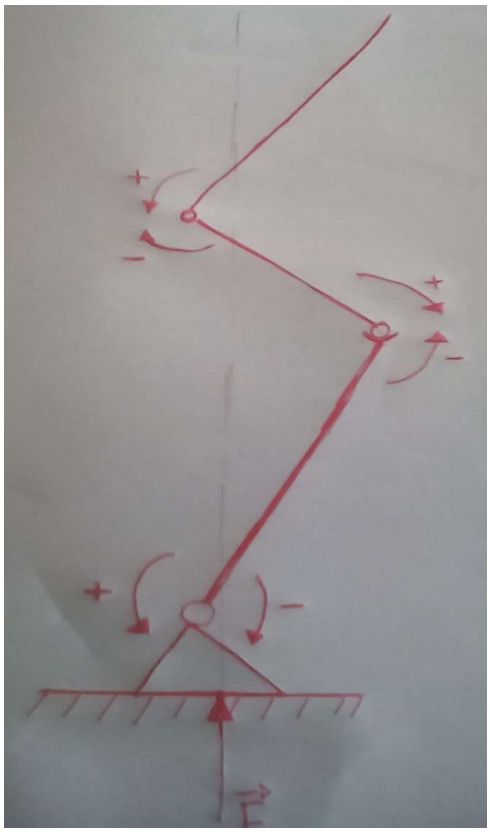
To analyze the result we have to go throw tree steps

1- Bring up the various items shoulder hip knee toe ankle on the Vicon Nexus software and keep on doing so while going ahead in the reading of the obtained data of each one of the subject.

2- Choose between two shape approximately circular generate by a captor than you have to choose first. Doing this in order to obtain at the end a quite perfect circle

3- Transfer of the data from Vicon Nexus to Excel to generate numerical data that will be used to create a graph.

4.2- Shape used to analyze the results



Ankle and Hip

+: Bending motion
-: Extension motion

Knee

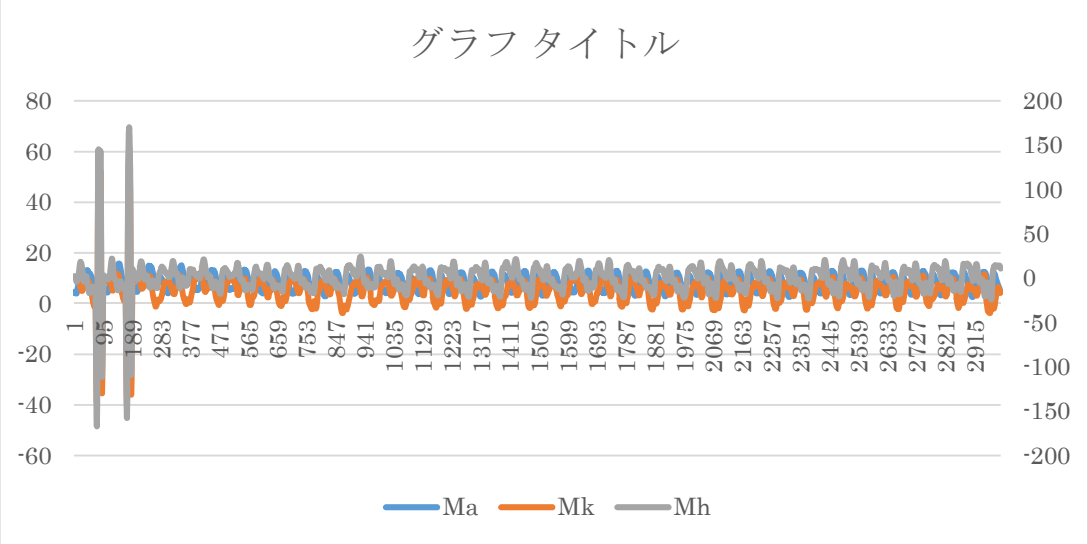
+: Extension motion
-: Bending motion

5- ***WHEELCHAIR – THREE WHEEL***

In this report I am going to use for of the ten result we obtained.

The graph that I am going to use are the result of 30 seconds of experiment; because of their size the graph it cannot be read correctly in the report only on excel.

- Subject 1



According to the graph the ankle moment is always in the positive part that mean it always doing a bending motion.

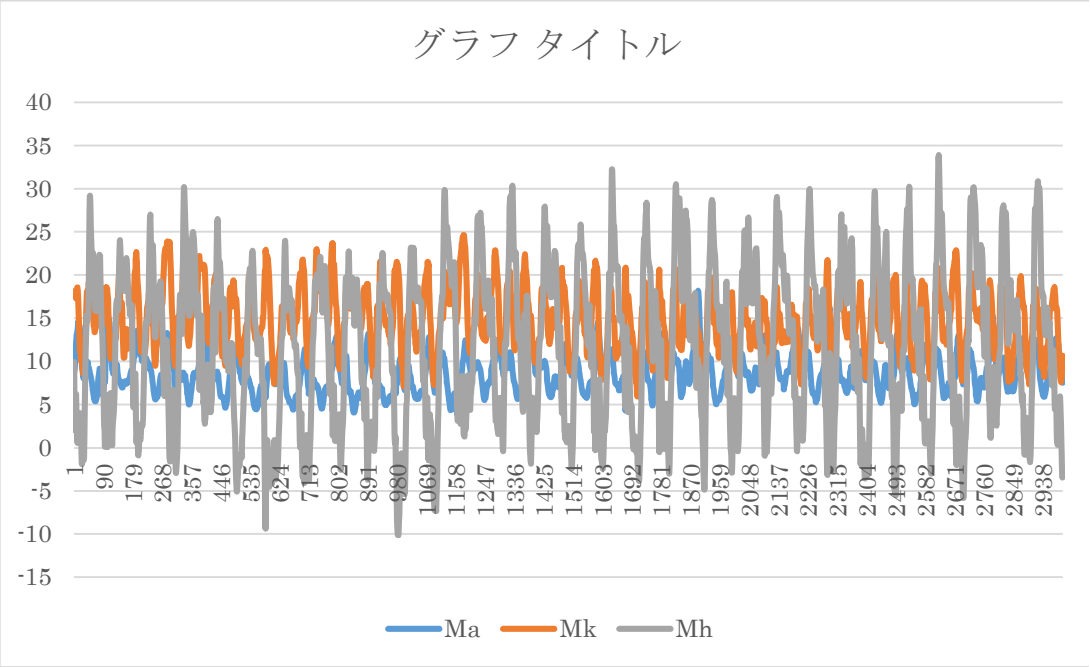
The knee moment is higher in the positive part therefore we infer that the dominant movement is the extension

The Hip varies between flexion and extension

The average is the sum between the maximum and minimum divided by two.

	Three wheel	
M Hip	25 2.5 -20	
M Knee	10 5 0	
M Ankle	13 8.5 4	

Subject 2



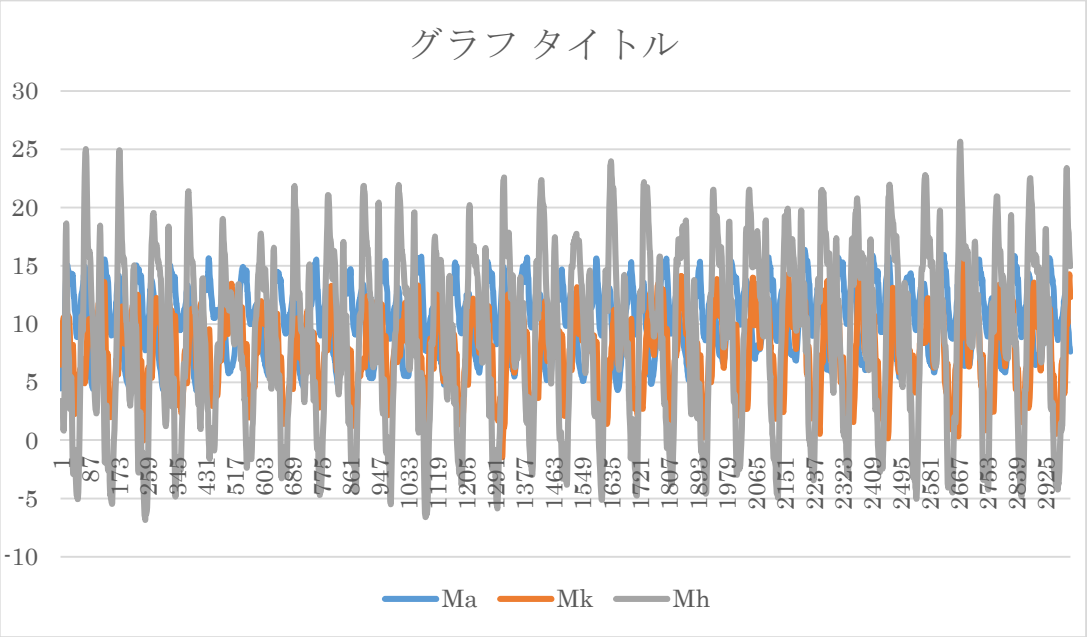
The ankle moment is always in the positive part explained by his bending movement

The knee moment is always in the positive part the amply that the dominant motion is the extension one

The Hip of this subject varies between the positive and the negative quite every 1.3 seconds

	Three wheel	
M Hip	30 15 0	
M Knee	20 13 3	
M Ankle	13 9 5	

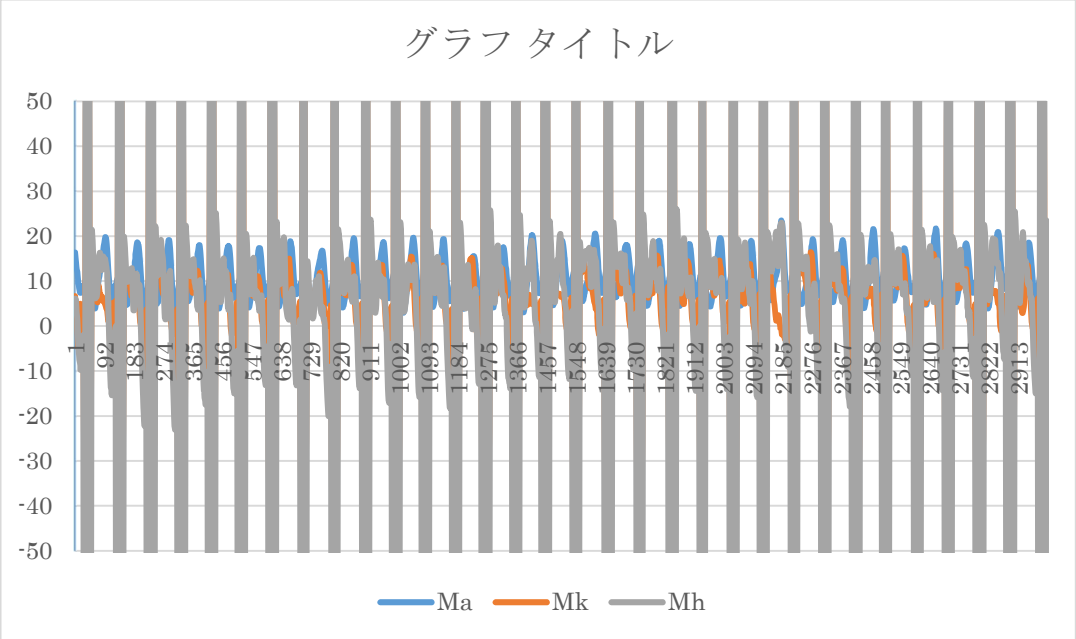
Subject 3



Ankle moment stay in the positive part explained by its bending movement
The knee moment is most of the time in the positive part involving a movement of extension.
The Hip moment of this subject varies between the positive and the negative.

	Three wheel	
M Hip	22 6.5 -5	
M Knee	13 7.5 2	
M Ankle	15 10.5 6	

Subject 4



The Ankle moment is always in the positive part bending movement
The Knee is most the time doing a bending movement explain by the fact that is graph is on negative part times by times
The Hip varies between the positive and the negative : bending and extension

	Three wheel	
M Hip	25 3.5 -18	
M Knee	13 3.5 -6	
M Ankle	18 7 -4	

5.1 – Conclusion

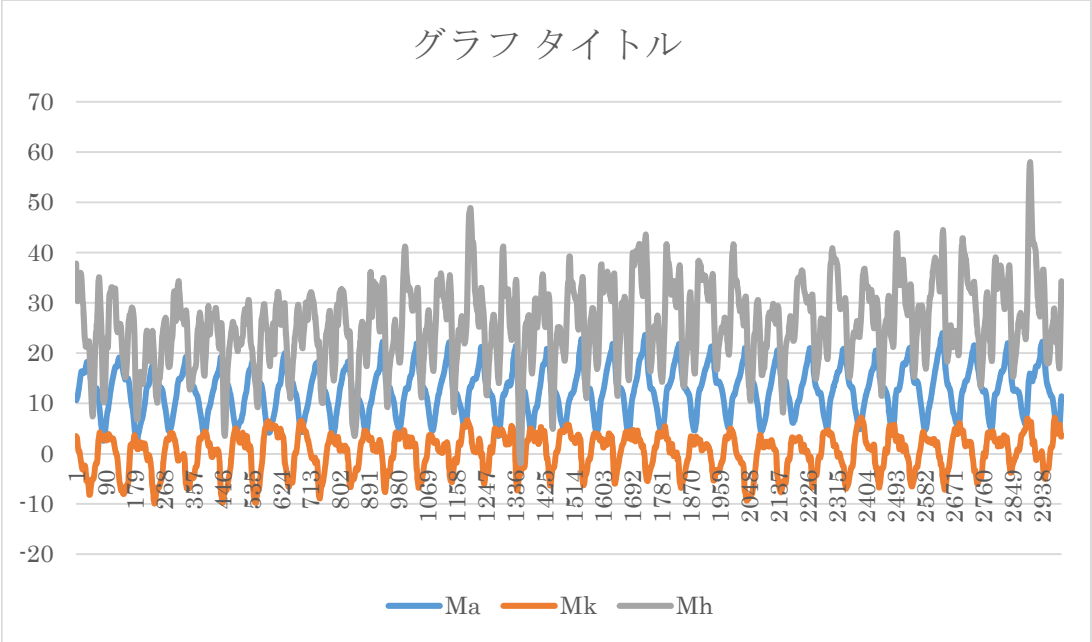
To conclude this part of the experience we can say that the leg of the four subject were most of the time in a bending movement, most of the time the foot rotates in the direction of the point of balance.
Because of the shape of the bike which means that the pedals are lower than the seat of the chair, the knee for most of the time is extended, the hip varies in the negative when its distance from the ankle decreases.

6-WHEELCHAIR – FOUR WHEEL

The same parameter where used for the both wheelchair the only difference is that to create the charge of 10 in the one with four wheel we reverse the two front wheels, filled as much as possible of air wheels and then we had them placed on a rolling three foldable axis to simulate the external environment when pedaling while on the three wheels we just put an adjustable load on the front wheel.

Graph of the Hip Knee Ankle Moment

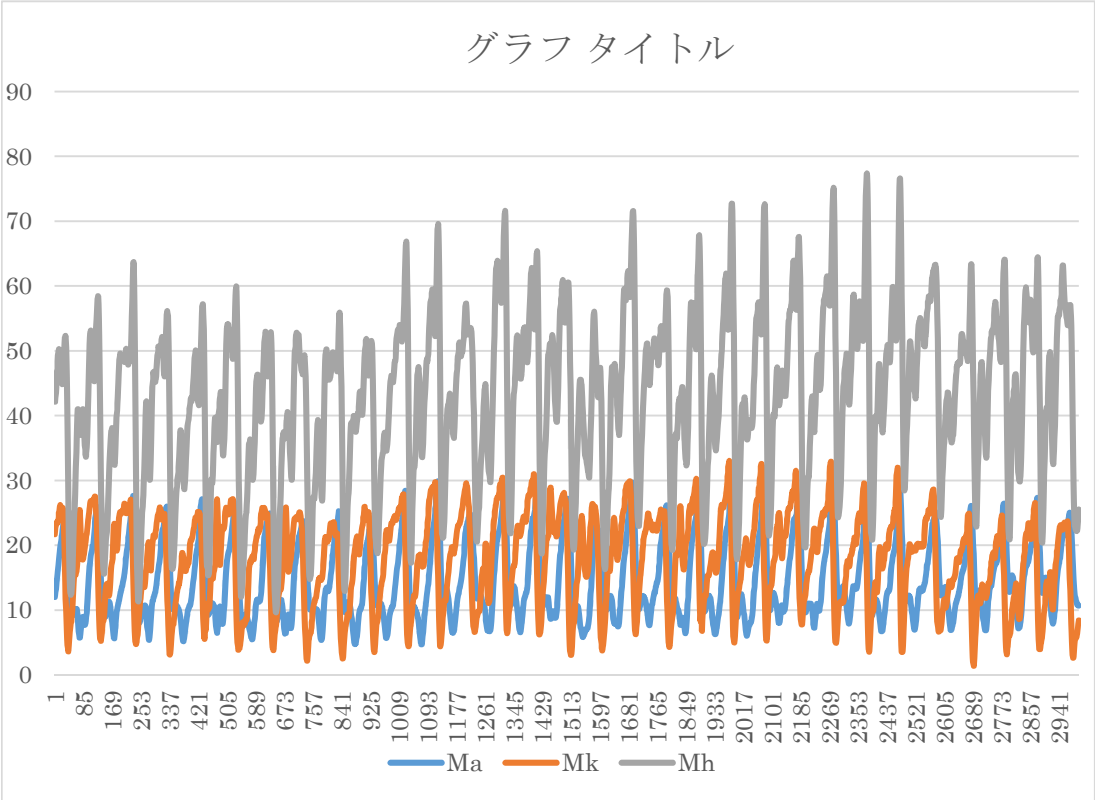
Subject 1



	Three wheel	Four wheel
HIP		42 23 4
KNEE		4 -1.5 -7
ANKLE		22 13 4

The Ankle moment is always in the positive part that amply a bending movement
The Knee moment varies between positive and negative but by the fact that his moment is higher in the negative part we deduce that the bending movement is dominant
The Hip moment is always in the positive part because of his bending movement

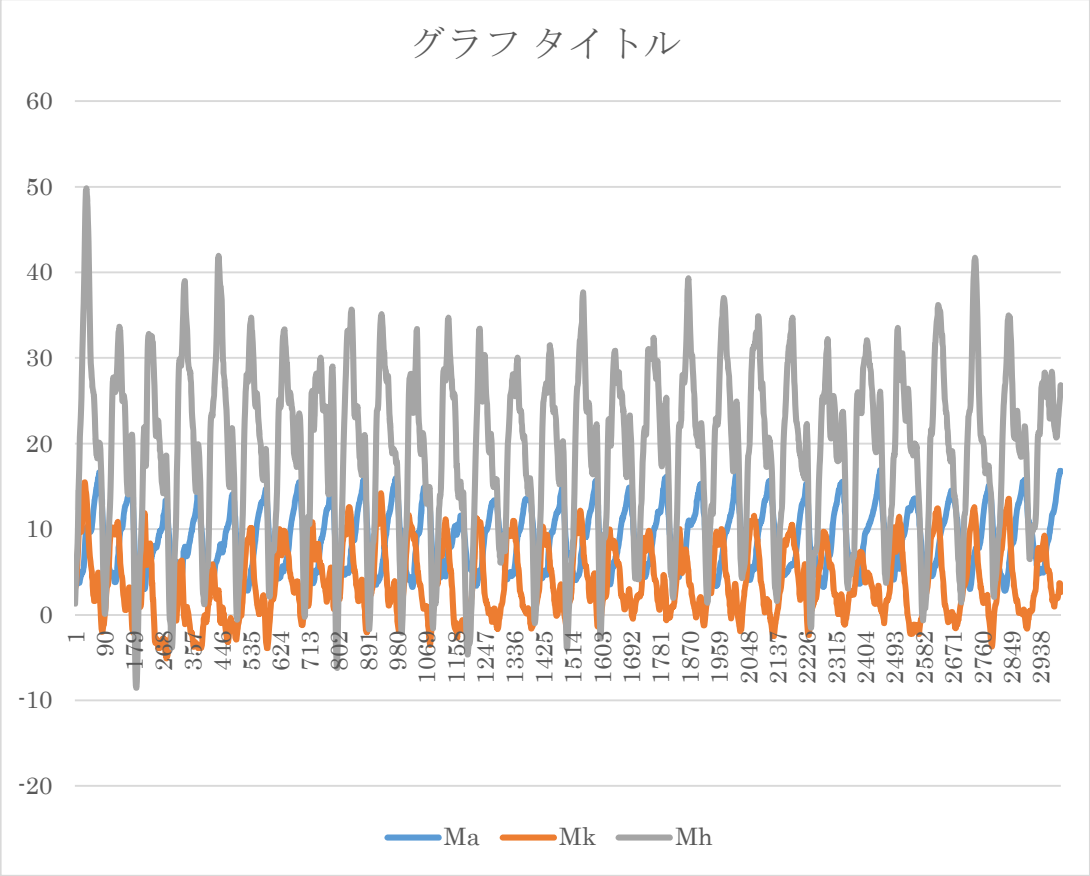
Subject 2



	Three wheel	Four wheel
HIP		78 49 20
KNEE		30 12.5 5
ANKLE		24 15.5 7

The Ankle is always in the positive part that amply a bending movement
The Knee moments is always in the positive part because of his extension movement
The Hip moment is also always in the positive part explain by his bending movement

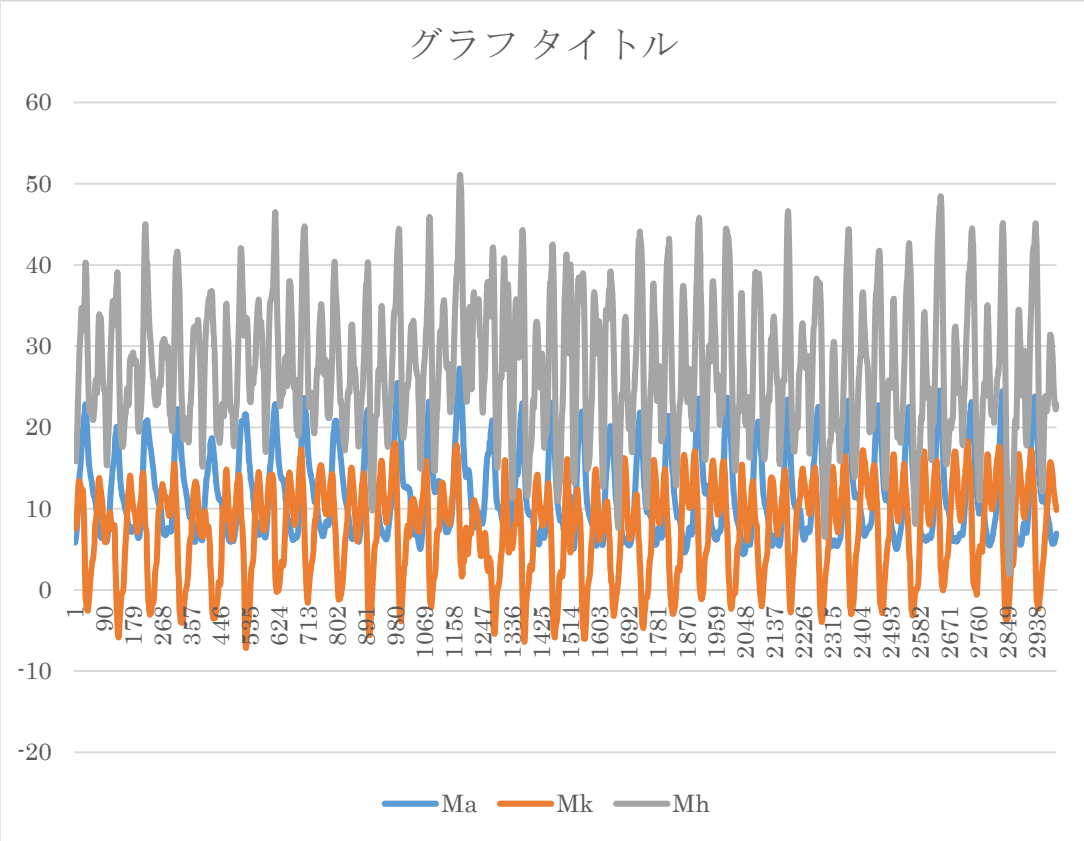
Subject 3



	Three wheel	Four wheel
M HIP		37 16.5 -4
M KNEE		11 4 -3
M ANKLE		17 11 5

The Ankle moment is always in the positive part that amply a bending movement
The Knee moment varies between positive and negative but his moment is higher in the positive part the extension motion is dominant
The Hip moment is most of the time positive that why we deduce that the bending motion is dominant

Subject 4



	Three wheel	Four wheel
M HIP		45 26.5 12
M KNEE		14 3 -8
M ANKLE		23 15 7

The Ankle moment is always in the positive part that amply a bending motion
The Knee moment varies between positive and negative but by the fact that his moment is higher in the positive part we deduce that the extension motion is dominant
The Hip moment is always in the positive part because of his bending motion

6.1 – Conclusion

In conclusion to this part of the experience we can say that the legs of the four subjects were usually in flexion extension movement which is normal when you are pedaling
The shape of the bike means that the pedals are at the same level as the seat of this chair that makes the different parts ankle knees hips are raised. The knee being in height often varies between flexion and extension thereof the knee is more solicits, the moment of the hip is always positive because the hip is almost always flexes

7- Comparison

Thanks to the table that contains the average of different moments I will do a comparison of the results to arrive at a logical deduction.

- Subject 1

	Three wheel	Four wheel
M HIP	25 2.5 -20	42 23 4
KNEE	10 5 0	4 -1.5 -7
ANKLE	13 8.5 4	22 13 4

M Hip: 3W < 4W
M Knee: 3W > 4W
M Ankle: 3W < 4W

- Subject 2

	Three wheel	Four wheel
HIP	30 15 0	78 49 20
KNEE	20 13 3	30 12.5 5
ANKLE	13 9 5	24 15.5 7

M Hip: 3W < 4W
M Knee: 3W > 4W
M Ankle: 3W < 4W

- Subject 3

	Three wheel	Four wheel
HIP	22 6.5 -5	37 16.5 -4
KNEE	13 7.5 2	11 4 -3
ANKLE	15 10.5 6	17 11 5

M Hip: 3W < 4W
M Knee: 3W > 4W
M Ankle: 3W < 4W

- Subject 4

	Three wheel	Four wheel
HIP	25 3.5 -18	45 26.5 12
KNEE	13 3.5 -6	14 3 -8
ANKLE	18 7 -4	23 15 7

M Hip: 3W < 4W
M Knee: 3W > 4W
M Ankle: 3W < 4W

The Moment of the Hip and the Ankle are higher when we used the bike with four wheels but the moment of the knee is higher when we used the bike with three wheels explain by the fact that the distance from the pedals is bigger.

7- Conclusion of the comparison

We can explain those results by the fact that the force provided was superior when using the chair with four wheels. The moment is equal to the force multiplied by the distance as the distance vector varies slightly from made of the size of our subject we can conclude that the factor that involves large difference between the two bikes is the Force (strength). Therefore we can say that the use of the bike with four wheels requires more effort and the hip is almost always flexed.
Those results are more qualitative than quantitative which mean that regarding to the quality of the two result we can say that the four wheels chair is the one that brings a better results in terms of consistent and effort applied, but if we have to talk about the ease of use the wheelchair with three wheels come first because the knee is almost always extended which means that he provided less effort.

Does the results will remain the same if the subjects were submitted to an electrical stimulation?

8- THE FES

8.1- Parameters

Five subject were volunteer for the FES experiment
The parameter used were:

Speed: 30rpm
Load 10W
Frequency: 20Hz

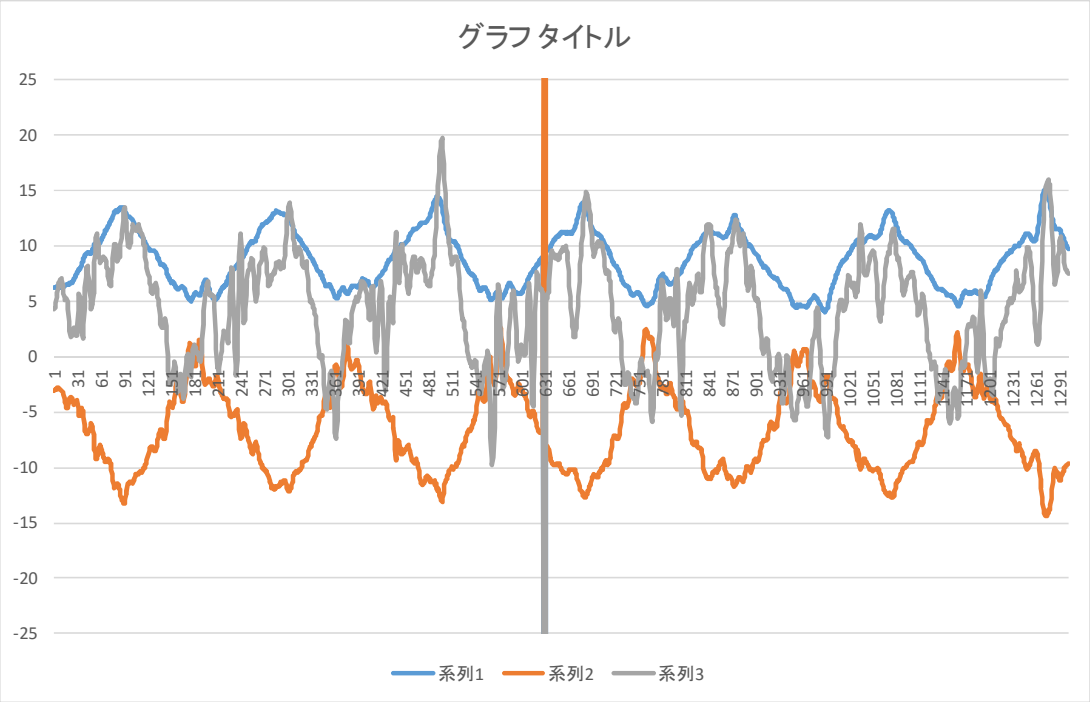
8.2- Method

Monitor

Using a monitor to send electrical stimulation to the Subject (stimulation between 1 and 2.5 A according to the endurance ability of the subject). The monitor was connected to the electrodes, which in turn was placed on the subject's muscles.

On this picture we can see the electrodes

8.3- Graph of the knee hip ankle of one subject



		Four wheel
M HIP		15 5 -5
M KNEE		0 -6.5 --13
M ANKLE		14 9.5 5

The Ankle moment is always in the positive part that amply a bending motion
The Knee moment varies between positive and negative but by the fact that his moment is higher in the positive part we deduce that the extension motion is dominant
The Hip moment is always in the negative part because of his extension motion

8.4- Conclusion

Because of electrical stimulation the moment varies after a specific time, quite every 1.8s, on the graph we can observe that the moment climbs to a pics and descends slowly but still to reach an almost identical value.

In the next step we are going to perform the FES experiment with more subjects and with the same parameters than when we have perform without the FES, with a view to compare which one ”the FES” or “Voluntary” is better

9- THANKS TO!!

I would also like to say thanks to mister TOMOMICHI NISHINO the director of the extended student, because he helped me in preparing my trip by sending me the documents I needed thank to him for coming to pick me up the day I arrived in Akita station, and also thanks to him because he was always there when I needed.

I would also like to say thanks to the director of Akita Kosen MR….. who took is time to meet me

I would also like to submit all my gratitude to KOBAYASHI Sense who was the most important person for me there because he allowed me to participate in his experience and treat me like one of his student by giving me knowledge and advice to progress.

I would also like to say thanks to my workgroup Mr. Kusakai, Mr. Kodama, Mr. Miura and Mr. Takeda with who I have work in harmony.

I would also like to say thanks to my friends that I have made there for helping when I had some difficulty and who help me to break the language wall, I would like to say a special thanks to Wisra who was like my senpai he show me arrowed and to Sandaga who was my sensei because he help me in my Japanese skills, thanks to everyone who lived in the same floor than me.

10- Discovering Japan

I have not yet discover a big part of Japan
Yet Japanese food is what I have discovered the most, I plan to go to Tokyo in the coming days.

SUSHI

RAMEN

TAIYAKI

Reached the end of my internship, what I can say is that my experience in Japan was beneficial not only in the sense that I was able to discover a new culture, a new architecture but also because during my internship I learned something new such as biomechanics, this field of mechanics that I had never really experienced become to me an area where I would like to deepen my knowledge, apart from these benefits my internship in Japan as me helped develop my ability to work in groups, of my contacts taking ability and also I had the opportunity to learn a new language. This country become for me one of those where I have to go back.