# Electromyography assesment of muscles involved in a pedal cycle

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## Abstract

This paper presents a study regarding the involvement of lower limb muscle groups in a pedal cycle and the existence of differences in the use of normal or automatic pedals. This case study led to finding very useful results concerning the recovery of specific muscle groups, identifying the degree to which each muscle group goes into action and where it acts with the highest intensity. The parameters followed were: resting muscle tone, maximum muscle tone while pedaling and the involvement of muscle groups of the lower limb while pedaling. By comparing the two pedaling modes, namely normal pedals and automatic pedals, we have found a change in intensity (μV) in using some muscle groups in the case of automatic pedals.

***Keywords**: muscle tone, pedal cycle, muscles, pedal.*

## Rezumat

Această lucrare prezintă un studiu privind implicarea grupelor musculare ale membrelor inferioare într-un ciclu de pedalare precum şi existenţa unor diferenţe în cazul utilizării pedalelor obişnuite sau automate. Acest studiu de caz a dus la aflarea unor rezultate foarte utile în recuperarea specifică a unor grupe musculare, identificând gradele în care fiecare grupă musculară intră în acţiune şi unde acţionează la intensitatea cea mai mare. Parametrii urmăriţi au fost: tonusul muscular de repaus, tonusul muscular maxim în pedalare şi implicarea în cadrul ciclului de pedalare a grupelor musculare ale membrelor inferioare. Prin compararea celor 2 moduri de pedalare, respectiv cu pedale obişnuite şi cu pedale automate, am constatat o modificare în intensitatea (μV) utilizării unor grupe musculare în cazul pedalelor automate.

***Cuvinte cheie**: tonus muscular, ciclul de pedalare, muşchi, pedale.*

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## Introduction

This paper studied the involvement of lower limb muscle groups in a pedal cycle and the existence of differences in the use of normal or automatic pedals. The aim is to highlight the benefits of using automatic pedals compared to normal ones. The study was conducted regarding to the following parameters: increase pedaling efficiency, involving several muscle groups in the pedaling cycle, the increase in maximum muscle tone and what were the differences between the two models of pedals. All these parameters were analyzed using a SEMG evaluation device and a bicycle equipped like those used in competitions [1, 2].

## Materials and methods

This is a case study and the subject involved in the experiment is 24 years old, has 3 years of cycling practice and carried out training on average three times a week. The experiment was conducted using Myo-EX, a surface EMG sensor with high accuracy, which connects to the computer through a unit that converts the signal from sensor having values between 0 and 3000 microvolts [3,4]. The bike trainer is mounted by replacement of the rear wheel axle with the quick-release axle. The position of the bike will be the same as on a usual running surface. The trainer is able to increase the effort required to pedal. This is done because oil-based system, allowing easier or harder oil circulation. In this experiment we set the trainer on the maximum degree of effort required to pedal in order to highlight the muscle contraction. We used a road bike, frame size 54, size appropriate to the subject according to measurements taken. The bicycle is equipped with Shimano Ultegra. The set of gears is from 23.11 and pedal gear sheets of 52 and 38. Used pedals: Look Keo Classic . Road cycling model, cleats: Look Keo - 4.5$^0$ left - right rotation tolerance.

**Figure 1.** Pedal type

## Advantages and disadvantages of the automatic pedal

- The foot is in contact with the pedal, not being necessary to press the pedal to maintain contact and the decoupling is controlled.
- Transfer of force to the pedal and gear is more effective, being present in both phases of the pedaling.
- These pedals are lighter and more aerodynamic, an important detail in cycling performance.
- It is necessary to use special shoes, cleats and pedals.

- Allow choosing the foot-pedal positioning and maintaining the perfect position for pedaling.
- An optimal position of the foot on the pedal improves performance and decreases the risk of injury.
- It can be difficult to use this pedal as necessary coupling and uncoupling departure to stop, which lasts until it becomes an automatism.
- These pedals can be adjusted to tension the cleats that are kept in them, a system similar to the skis. Thus the foot can be removed easily or harder depending on the adapted bike style and experience level.
- In a sprint or mountain biking up in the saddle the pedals offers 100% safety control, allowing a much better control of the bicycle.
- The cleats mounted on the cycling shoes wearing off and the tensioning system must be checked after changing the cleats.

**Advantages and disadvantages of ordinary pedals / flat**

- Any model of shoes fits these pedals
- Offer freedom of movement of the foot on the pedal
- These pedals can be slippery when wet
- The force applied on these pedals is just the phase I, as bicycles are perfect for city or for leisure, but not for those of training
- They are easy to use compared with the automatic ones not being necessary to couple and decouple to start and stop [5, 6, 7].

**Figure 2.** The bike used for the study

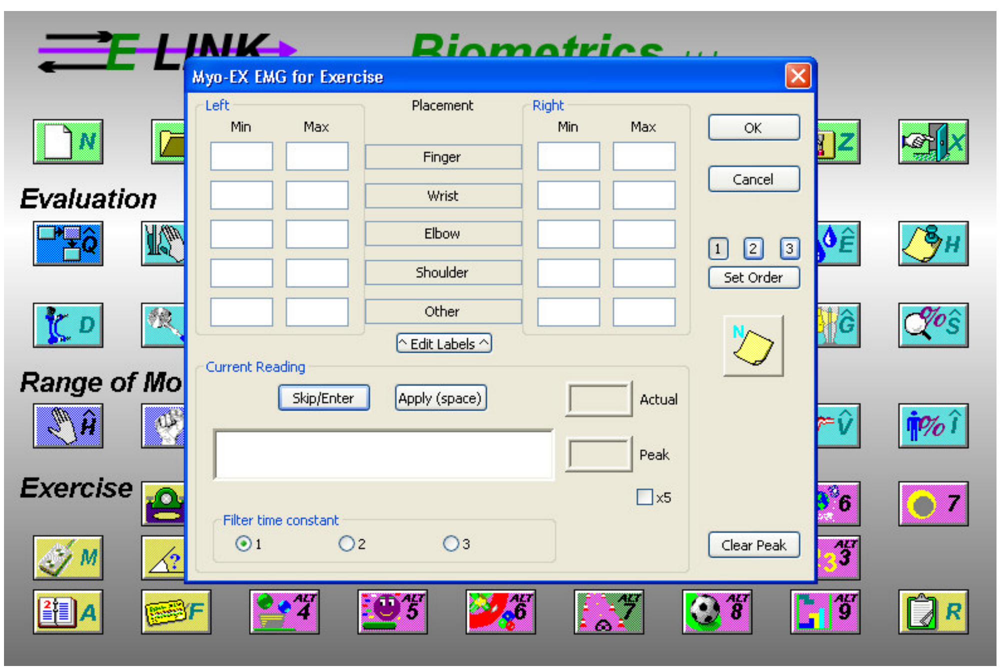



**Figure 3.** Program interface

The above fields will be replaced with name tags of the evaluated muscle groups. Minimum value will be recorded in resting tone and maximum tone during the maximum contraction. Electrode positioning: this experiment requires the use of two electrodes of the device for measuring SEMG, as well as electrodes that detect electrical impulses and the grounding electrode. The SEMG electrode must be placed between the motor plate of muscle and its tendon and its insertion or between two motor points. Also electrodes must be positioned in the middle of the longitudinal muscle fibers [8, 9, 10, 11].

**Figure 4.** Electrodes placement

## Results

**Table I.** Values of the flexor muscle tone of the right leg

| Muscle group tested | Muscle potential at rest (μV) | Muscle potential in the maximum contraction during pedaling (regular pedals) (μV) | Muscle potential in the maximum contraction during pedaling (automatic pedal)(μV) |
|---|---|---|---|
| A. Hip extensor | 43 | 487 | 551 |
| B. Knee estensor | 50 | 531 | 513 |
| C. Plantar flexor ankle | 32 | 286 | 274 |
| **Arithmetic average** | **41,67** | **434,67** | **446** |
| **Standard deviation** | **9,07** | **130,61** | **150,16** |

**Table II.** Values of the flexor muscle tone left leg

| Muscle group tested | Muscle potential at rest (μV) | Muscle potential in the maximum contraction during pedaling (regular pedals) (μV) | Muscle potential in the maximum contraction during pedaling (automatic pedal)(μV) |
|---|---|---|---|
| A. Hip extensor | 39 | 486 | 550 |
| B. Knee estensor | 47 | 530 | 514 |
| C. Plantar flexor ankle | 31 | 284 | 272 |
| **Arithmetic average** | **39** | **433,33** | **445,33** |
| **Standard deviation** | **8** | **131,18** | **151,18** |

**Table III.** Values for the electric potentials of the right leg extensor muscle

| Muscle group tested | Muscle potential at rest (μV) | Muscle potential in the maximum contraction during pedaling (regular pedals) (μV) | Muscle potential in the maximum contraction during pedaling (automatic pedal)(μV) |
|---|---|---|---|
| E. Hip flexor | 35 | 75 | 379 |
| F. Knee flexor | 42 | 91 | 322 |
| D. Dorisiflexori ankle | 21 | 84 | 262 |
| **Arithmetic average** | **32,67** | **83,33** | **321** |
| **Standard deviation** | **10,69** | **8,02** | **58,50** |

**Table IV.** Values for the electric potentials of the left leg extensor muscle tone

| Muscle group tested | Muscle potential at rest (μV) | Muscle potential in the maximum contraction during pedaling (regular pedals) (μV) | Muscle potential in the maximum contraction during pedaling (automatic pedal)(μV) |
|---|---|---|---|
| E. Hip flexor | 34 | 74 | 377 |
| F. Knee flexor | 40 | 88 | 321 |
| D. Dorisiflexori ankle | 19 | 82 | 262 |
| **Arithmetic average** | **31** | **81,33** | **320** |
| **Standard deviation** | **10,81** | **7,02** | **57,50** |

**Table V.** Comparative values of muscle electric potentials at rest and maximum contraction tone of the lower limbs

| Muscle group tested | Right resting muscle potential (μV) | Left resting muscle potential (μV) | Right in the maximum contraction muscle potential (μV) | Left in the maximum contraction muscle potential (μV) |
|---|---|---|---|---|
| A. Hip extensor | 43 | 39 | 586 | 582 |
| B. Knee extensor | 50 | 47 | 612 | 610 |
| C. Plantar flexor ankle | 32 | 31 | 453 | 451 |
| D. Dorisiflexori ankle | 21 | 19 | 479 | 475 |
| E. Hip flexor | 35 | 34 | 538 | 533 |
| F. Knee flexor | 42 | 40 | 572 | 569 |

**Table VI.** Comparative Values of muscle electric potentials at rest and maximum contraction in the legs during automatic pedal pedaling

| Muscle group tested | Muscle potential in the maximum contraction during pedaling right (μV) | Muscle potential in the maximum contraction during pedaling left (μV) |
|---|---|---|
| A. Hip extensor | 551 | 550 |
| B. Knee extensor | 513 | 514 |
| C. Plantar flexor ankle | 274 | 272 |
| D. Dorisiflexori ankle | 262 | 262 |
| E. Hip flexor | 379 | 377 |
| F. Knee flexor | 322 | 321 |

**Table VII.** Comparative values of muscle electric potentials at rest and maximum contraction of the lower limbs using normal pedal

| Muscle group tested | Muscle potential in the maximum contraction during pedaling right (μV) | Muscle potential in the maximum contraction during pedaling left (μV) |
|---|---|---|
| A. Hip extensor | 487 | 486 |
| B. Knee extensor | 531 | 530 |
| C. Plantar flexor ankle | 286 | 284 |
| D. Dorisiflexori ankle | 84 | 82 |
| E. Hip flexor | 75 | 74 |
| F. Knee flexor | 91 | 88 |

**Using ordinary pedals:**

- The mean potential of muscle groups involved: 259 μV;
- Maximum value of the potential of muscle groups involved: 531 μV;
- Minimum value of the potential of muscle groups involved: 75 μV.

**Using automatic pedals:**

- The mean potential of muscle groups involved: 383.5 μV;
- Maximum value of potential of the muscle groups involved: 551 μV;
- Minimum value of potential of the muscle groups involved: 262 μV.

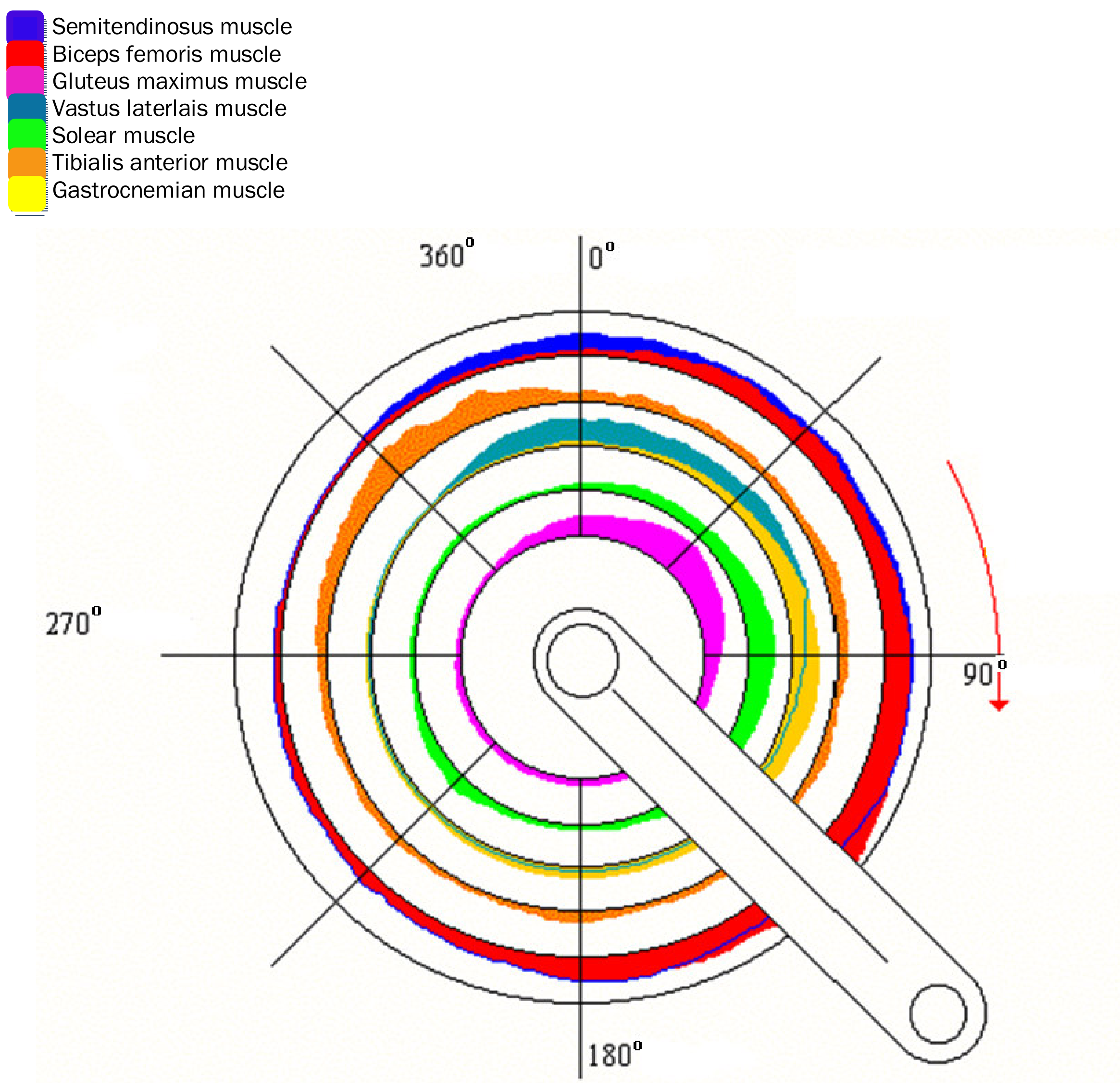
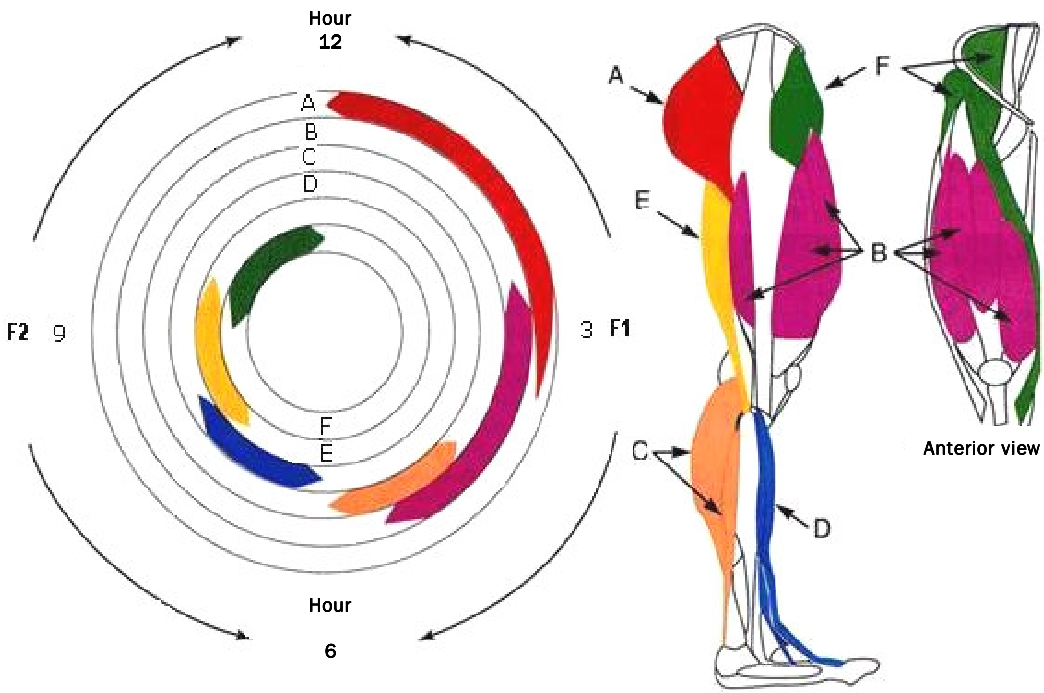



**Figure 5.** Graphical representation of electrical impulse

Automatic pedal




Normal pedal

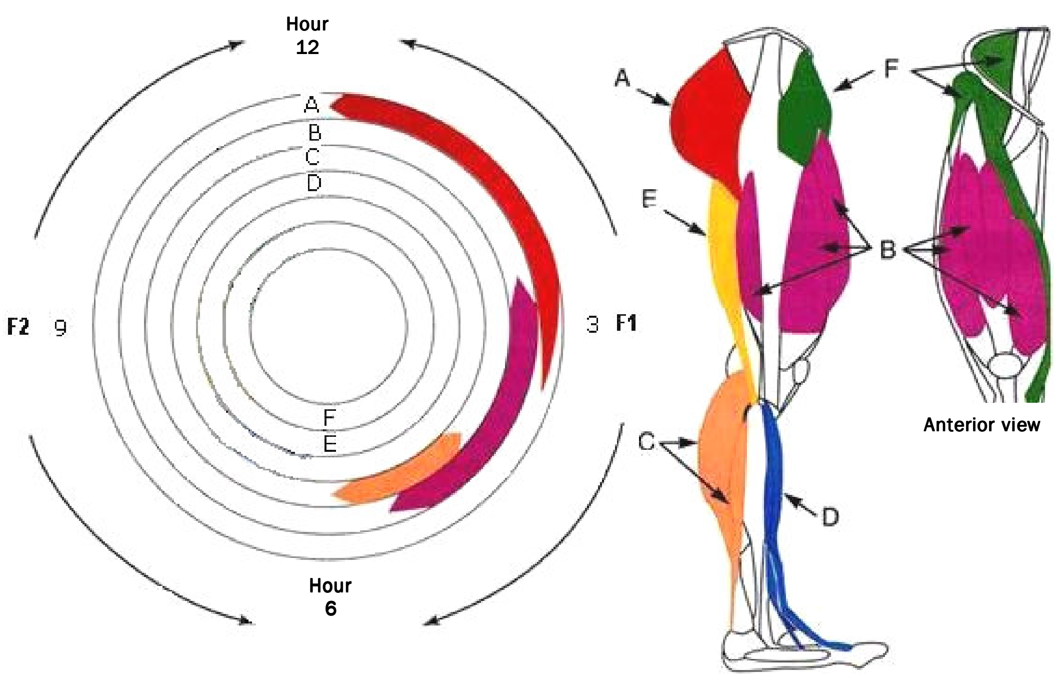



**Figure 6.** Comparison between the two modes of pedaling evaluated
A . Hip extensor; B . Knee extensor; C . Plantar flexor ankle; D . Dorisiflexori ankle; E . Hip flexor; F . Knee flexor.

## Conclusions

- This case study led to finding very useful results regarding the recovery of specific muscle groups, identifying the degree to which each muscle group comes into action and where it presents the highest intensity.
- By comparing the two pedaling modes, namely normal pedals and automatic pedals, we have found a change in intensity (μV) of use of some muscle groups in the case of automatic pedals
- Automatic pedals confere increased efficiency and safety pedaling high in the saddle with no need to repeatedly check the foot's position on the pedal
- At the same time it eliminated the possibility of slipping of the foot from the pedal while pedaling
- Another quality automatic pedals have is that they maintain the proper position for pedaling, not allowing deviation from the optimum position.
- We determined that the automatic pedals are helpful in recovery, not only in performance cycling, but also in training muscle groups that don't come in action while using normal pedals.
- The study revealed the contribution of each muscle group, expressed in (μV) during a pedal cycle. Thus we determined which are the most important muscles for pedaling.
- In pursuit of lower limb movements when using two models of pedals, I noticed that the pedal movements are more orderly and efficient when using automatic pedals. It is important that the cleats attached to shoes be fitted so that the pedal shaft is located under the metatarso-phalangian joint.
- In an effort to pedal, especially when it comes to long distances, muscle strength is important in phase I of the force but a break is necessary after each contraction.
- It is known that when an agonist muscle is contracted, antagonist muscle is relaxed.
- Automatic pedals are preferred due to alternative contraction of the extensor and flexor muscles of the segments.

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