Electromyography assesment of muscles involved in a pedal cycle

Radu Costan[1], Corina Pantea[2]

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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[1] Physical therapist, *e-mail:costanradu@gmail.com*
[2] Lecturer PhD, West University of Timişoara, Physical Education and Sport Faculty

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.
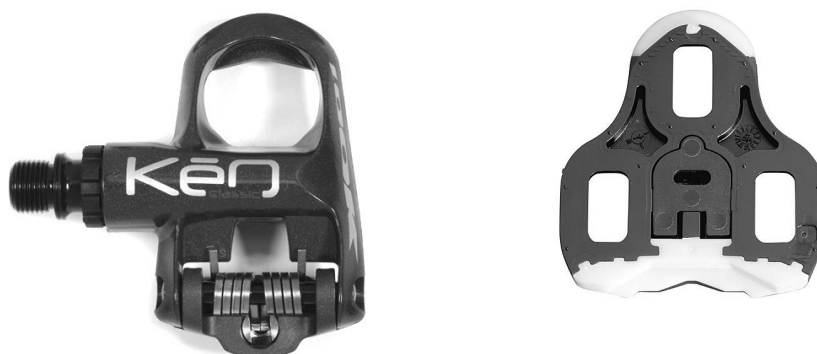

Figure 1. Pedal type

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].

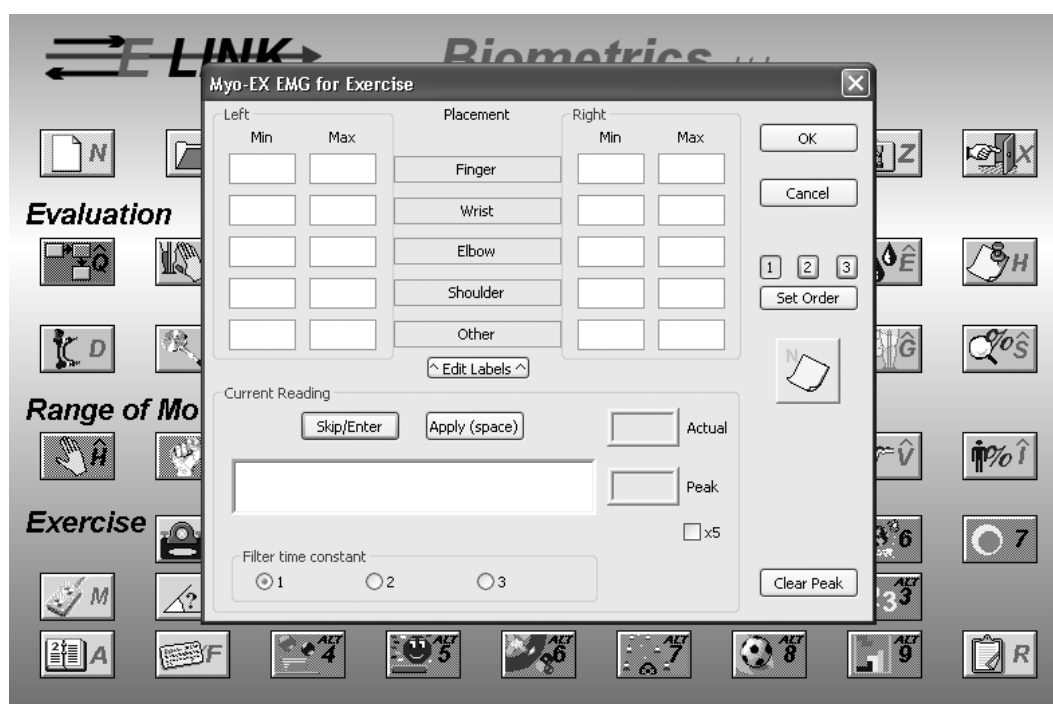**Figure 2.** The bike used for the study

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;

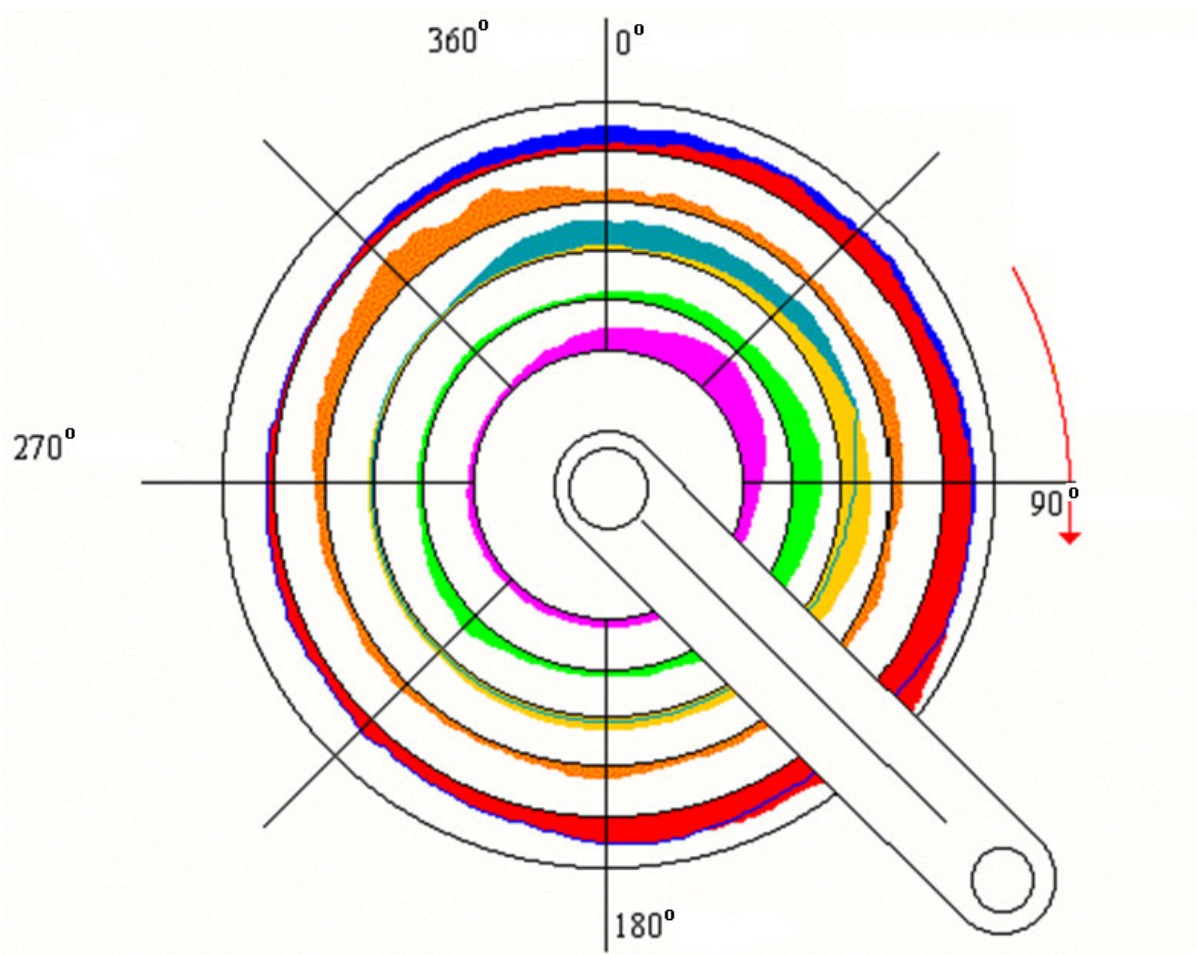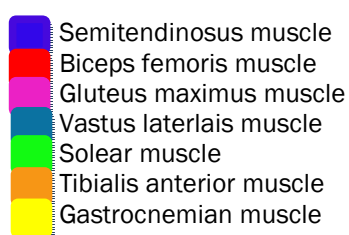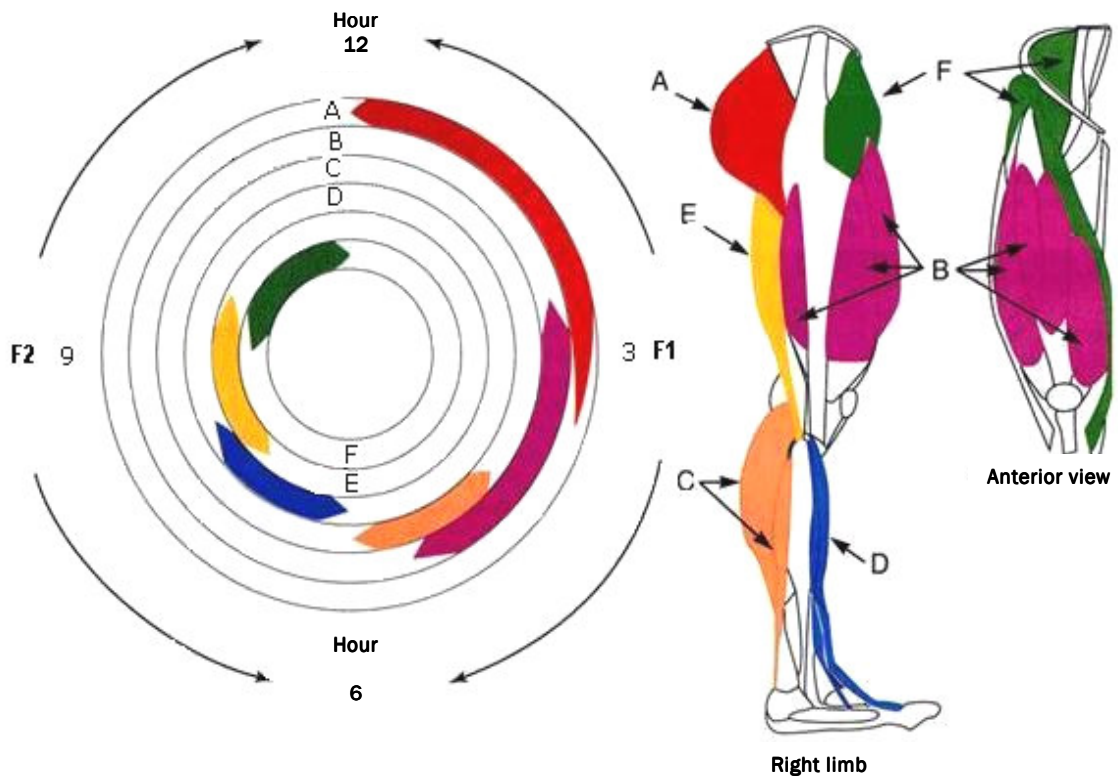- Minimum value of potential of the muscle groups involved: 262 μV.

Semitendinosus muscle
Biceps femoris muscle
Gluteus maximus muscle
Vastus laterlais muscle
Solear muscle
Tibialis anterior muscle
Gastrocnemian muscle

Figure 5. Graphical representation of electrical impulse
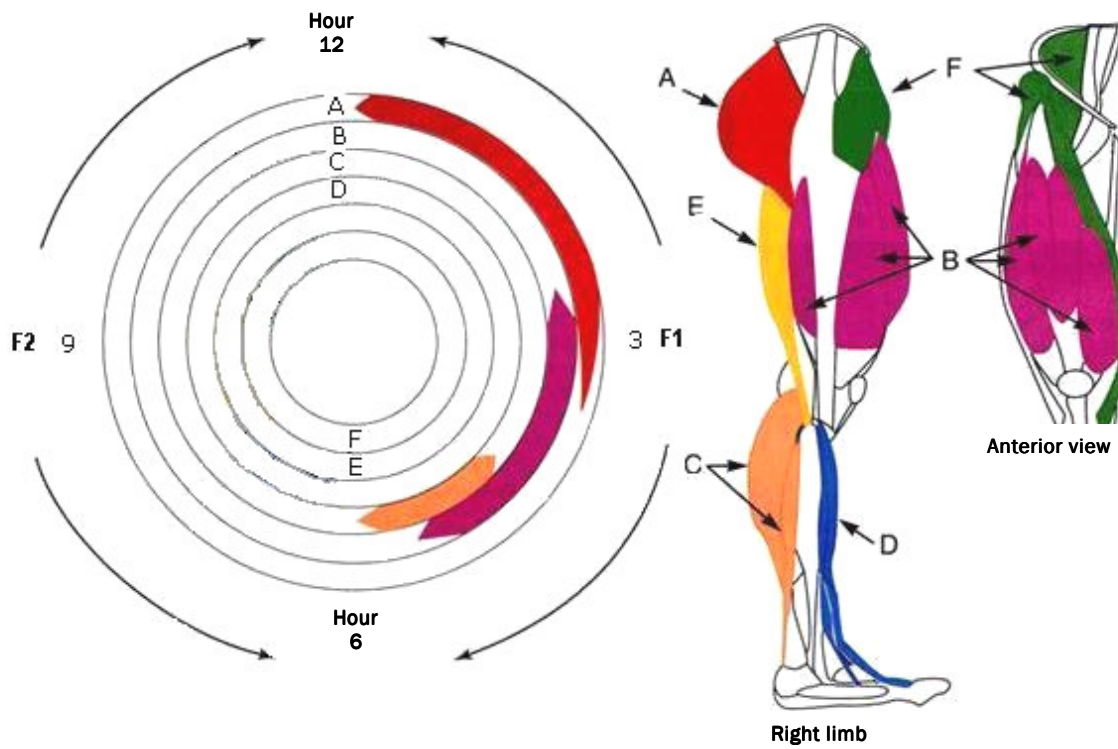
Figure 6. Comparison between the two modes of pedaling evaluated
A . Hip extensor; B . Knee extensor; C . Plantar flexor ankle; D . Dorisiflexori ankle; E . Hip flexor; F . Knee flexor.