Activation of selected body muscles analysis during cycling, training rollers and ergometer use – a case study

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ABSTRACT
Introduction: This article describes research of muscle activation during cycling, ergometer and training rollers cycling.
Aim of Study: The main objective of the study is to find out coordination similarities or differences between muscle activation of the observed muscles during three types of cycling in use, this may help us understand which type of cycling simulation is better and approximating to real cycling conditions. This study is a pilot project on which other research will build in the future.
Material and Methods: The results were gained based on a comparative analysis of electromyography signals of muscle activation combined with the overall kinetic analysis via synchronized video recording of one proband. The main model for muscle activation was established to be the measurement of muscle activation while cycling on a road bike in the natural environment. Base on this model the research part of the work can be then regarded as a case study, in which the main goal is to observe the sequencing of muscle activation.
Results: The results show that training rollers provide a better simulation of natural conditions in terms of muscle activation.
Conclusion: Therefore, training rollers are a good and appropriate method for cycling training practice for sportsmen.
Keywords: *cycling, ergometer cycling, surface electromyography, training rollers*

SOUHRN
Úvod: Tento článek popisuje výzkum aktivace svalů při cyklistice, ergometru a tréninkových válcích.
Cíl studie: Hlavním cílem studie je zjistit koordinační podobnosti nebo rozdíly mezi svalovou aktivací pozorovaných svalů během používání tří typů jízdy na kole, což nám může pomoci pochopit, který typ simulace cyklistiky je lepší a přibližuje se skutečné jízdě na kole. Tato studie je pilotním projektem, na kterém budeme v budoucnu stavět další výzkum.
Materiál a metody: Výsledky byly získány na základě srovnávací analýzy elektromyografických signálů svalové aktivace kombinované s celkovou kinetickou analýzouprostřednictvím synchronizovaného video záznamu u jednoho probanda.

Hlavním modelem pro aktivaci svalů bylo zjišťování měření aktivace svalů při jízdě na silničním kole v přirozeném prostředí. Na základě tohoto modelu lze výzkumnou část práce považovat za případovou studii, ve které je hlavním cílem sledovat sekvenci svalové aktivace.
Výsledky: Výsledky ukazují, že tréninkové válce poskytují lepší simulaci přírodních podmínek z hlediska aktivace svalů.
Závěr: Tréninkové válce jsou proto dobrou a vhodnou metodou pro trénink cyklistiky pro sportovce.
Klíčová slova: cyklistika, ergometr, povrchová elektromyografie, tréninkové válce

INTRODUCTION

Cycling is perhaps one of the most demanding endurance sports as it includes a wide range of performance factors. Majority of population practices this sport extensively for recreation, but this study focuses on professional sports understanding of what cycling should represent. Cycling, as a professional sport includes several cycling techniques, more specifically, pedaling styles, which are combined during the performance (e.g. sitting, cycling standing up, sprint, sliding, turning etc.). Cyclists have to combine individual styles depending on the terrain conditions during a cycling race which may happen, e.g. straight roads, hills with different climb gradient, slides and changes of direction in order to maintain high speed.

Change of technique is realized during performance many times, which subsequently leads towards change stabilization in physiological and biomechanical requirements. Individual techniques are used with the use of either upper or lower part of the body. There is, however, no precise norm stating which part of the body should be active during a technique use. The technique selection is directly dependent on the speed and technical skills of each cyclist, the strength of the upper body etc. Cycling technique training is then a precisely pre-planned process, during which the main goal is to maximize overall performance or maintain the functional properties of a trainee (sportsmen). Variety of methods and tools are used for training in cycling. During the sport performance, the main aspect isn't only the body performance, but also tactical, technical and psychological preparation. Such aspects have to be taken into consideration during the training process for performance enhancement (Schmidt, 1999).

The training period is then from the point of training technique and performance increasing one of the most important aspects of all. Suitable training routine helps the development of specific functional organism systems. This time period means the gaining of aerobic endurance, especially via volume training programs, which are usually done according to climatic conditions indoors on training bikes (cycling simulators or ergometer). This includes rather a long-term cycling for many kilometers, during which trainees may develop incorrect cycling techniques which then leads towards muscle stereotype fixation, which may cause e.g. performance decrease of muscle disbalance and other health issues (Sekera & Vojtěchovský, 2009).

The main intention of this article and study is to base further research on muscle activation of selected muscles during cycling, training rollers and ergometer via electromyograph analysis (EMG) of muscle activation. This method is currently regarded as an objectivization tool for body and muscle coordination research. This method is also the most used in the field, as well as affordable and accurate, which due to its accessibility is possible to be used for in and outdoor in vitro muscle activation measurement. EMG was used by many researchers in the past who were focusing also on muscle activation during sport performance (Balkó, 2016; DeLuca, 1997; Hug, 2011; Konrad, 2005; Pánek, Pavlů, & Čermusová, 2009; Škopek, 2016; Véle, 2016).

The kinesiology aspect of the movement, descriptors of muscle time activation in individual muscles during training rollers and ergometer use should help us find individual similarities and difference of the so-called „inner technique", or more sport-science speaking, coordination aspects of specific locomotion aspects. The kinesiologic analysis lof natural cycling conditions compared with two types of simulators can also provide data regarding similarities of the movement possibilities during training for cyclists (Horyna, 2018).

This study seeks to add to the contemporary research in the field and to follow previous studies which used EMG measurements for cycling movement comparisons. For example, (Brtník, 2013) focused on his work on kinesiology analysis of muscle activation via surface electromyography during walking and Nordic walking. Other authors focusing on similar movement comparisons (Bačáková, 2013), who investigated the quadrupedal locomotion in diagonal pattern during specific sport locomotion (rope climbing, walking, pull-ups). Horyna (2018) focused on the activation of selected muscles of the upper part of the body during specific types of cross-country skiing with the use of similarity exercises done via cross-country skiing training machine Concept 2.

The main goal of the study is to observe and evaluate the muscle activation timing in relation to their behavior during different cycling types using cycling training machines compared with cycling on a road bike in natural conditions.

MATERIAL AND METHODS

Participant

One proband with fixed movement stereotype was chosen to participate in the study. This as a male test subject who participated in international racing competitions (age 20, height 138 cm, weight 74kg). Proband went through physical examination before participating in the study and was evaluated as healthy and capable of more demanding sport performance.

Procedures

Comparative analysis of electromyograph (EMG) signals of muscle activity combined with surface kinematic analysis via synchronized video recordings of one proband. The overall physical activity was observed via surface EMG and synchronized video recording of the activity. Specifications of the mobile EMG machine:

Independent mobile polyelectromyography scanner for muscle electrical potential measurements – manufacturer Megawin Biomonitor ME 6000 (Meg Electronics, Finland).

Technical specifications: rough/mediate/RMS/conjoined signal, EMG range +/- 8192 μV, no. of channels: 4/8/12/16, pattern frequency: 1.000 / 2.000 / 10.000 / 250 / 100 Hz.

Gained data were then analyzed via conversion of the EMG reading curves into absolute value of the data. This made it possible to gain the surrounding data (envelope) around the EMG curve and thus individual movement cycles too. The cycle envelopes were then interloped at one unifying wavelength (expressed inside the interval of 0% - 100% of the cycling cycle). In order to evaluate the measured data after professional assessment a time section was extracted which included periodical activation and deactivation of muscle activity. The assessment did not consider movement cycles at the locomotion beginning or end, at which points the muscle activity is not yet stabilized. The far remote threshold was discarded according to the Galton median model. Each locomotion subject was then tested for 10 movement cycles. This number of cycles seems optimal for more precise elimination of remote data at both ends.

The observed muscles were selected based on their basal function, these were selected according to previous works by Čihák (2001), Travell a Simons (1999) adds the muscle groups according to their function during cycling, furthermore, it is also possible to add muscles based on their position inside muscle activation sequence, as mentioned by Véle (1995, 2016). Before the electrode application, specific skin areas of the proband were cleansed, decreased with alcohol and shaved. Electrodes were placed in such order, that the connecting line of their center was copying the muscle fiber direction. The electrodes were placed in the area of the highest level of muscle tone (these areas were chosen by a physiotherapist), all done according to the guideline of the study done by Travell a Simons (1999) during stimulation of a particular movement. Muscles from both right and left half of the body were chosen for electrode placement, these included: musculus trapezius, musculus triceps brachii, musculus biceps femoris, musculus quadriceps femoris and musculus gastrocnemius.

Each measured muscle data was then calculated for their mean value, specifically mean value of the EMG envelope. The mean envelope value reached in some cased local maximum, if such case happened, criterium for the most significant maximum was applied. After that procedure, computer software Matlab evaluated the input data via maximal cross-correlation coefficient output. Depending on the values of the cross-correlation coefficients, the muscle shift phase can be detected. After deletion of the shift phase, timing of muscle activation sequence of individual muscles can be visible. Due to the nature of the case study, the sequencing was then individually compared with other measurements based on the expert evaluation (Pánek, Pavlů a Čermusová, 2009). The proband was given instructions in terms of locomotion speed, so that the 300m straight road line and indoor simulator (Ergometer Tacx T2650, training rollers Tacx T1000) were approximating to equal measurement conditions of intensity (paddling cadency 85 rotations per minute, derailleur setting (53x18) which is possible to reach for each cyclist with high performance skills and thus easy to observe during paddling.

The purposes of the research, these variables have been considered:

- The timing of muscle activation (beginning and end)
- Movement cycle length
- No. of movement cycles
- Weather conditions
- Treading cadence
- Derailleur setting (53x18)
- Equal sitting height and handle grip

Measurement of each type of locomotion was done 3 times, during which, first two measurements were regarded as a warm-up and the gained data were not evaluated. A higher number of measurements was not taken due to the fatigue factor elimination. The compulsory 5-minute break took place after each cycling simulator use.

Should explain in detail all the applied investigation methods. The names of statistical methods and computer software used in the study should be given.

RESULTS AND DISCUSSION

In order to compare the muscle activation, the main model of bodily movement was set to be the leg movement during cycling on a street bicycle in the natural environment. Based on the nature of the research as a case study, the only measured variable which the analysis focused on was the sequence of muscle activation during movement, as shown in pictures no. 1-3.

The results of the muscle activation showed that higher similarity to the muscle activation in normal conditions is the use of training rollers which simulates normal conditions better, due to the fact, that more than half of the muscles showed the same results, as observation of muscle activity during normal cycling. Ergometer cycling showed match in muscle activity with other techniques only in one case.

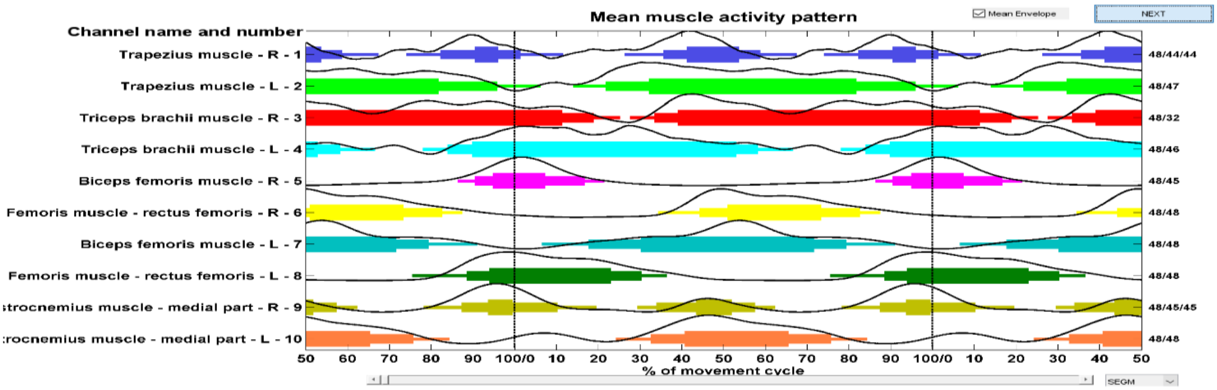

Figure 1. Ergometer muscle activation intervals

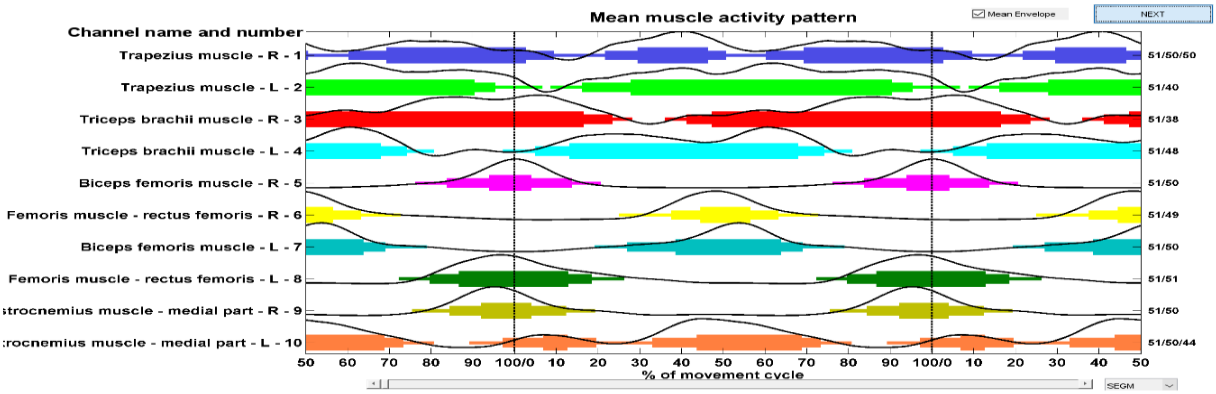

Figure 2. Training rollers muscle activation intervals

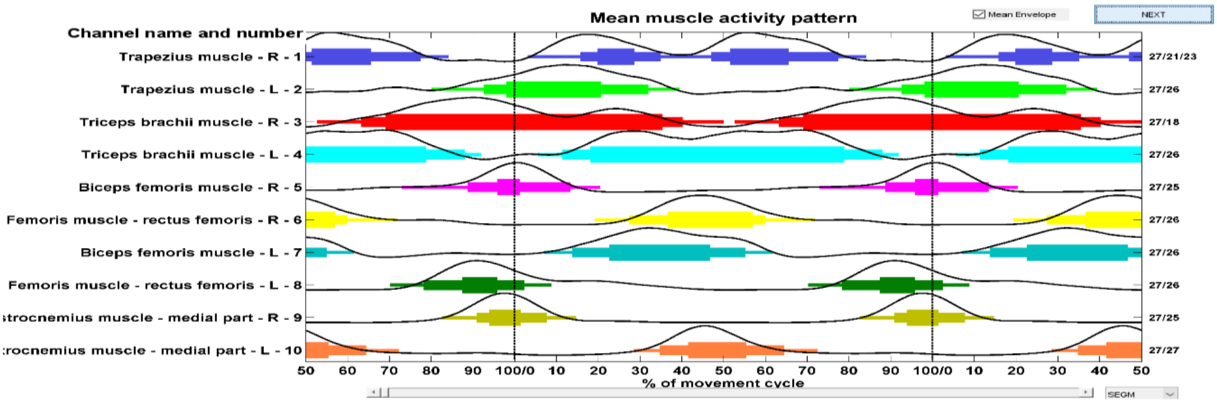

Figure 3. Natural cycling conditions muscle activation intervals

The following Table 1 includes the exact timing of individual muscles within one movement cycle and the order in which they were activated.

Table 1 *Place of the first activation within the observed paddling cycle*

Activated muscles	ERG Median [%]	ERG Sequence (order)	TR Median [%]	TR Sequence (order)	CYCLE Median [%]	CYCLE Sequence (order)
Trapezius - R	35,54	6	21,67	**3**	15,73	**3**
Trapezius - L	21,78	**2**	16,06	**2**	92,63	10
Triceps Brachii - R	33,39	4	41,19	**6**	63,14	**6**
Triceps Brachii - L	83,84	8	4,98	**1**	11,27	**1**
Biceps Femoris - R	90,43	10	83,76	**8**	88,66	**8**
Biceps Femoris - L	17,71	1	27	4	13,76	2
Quadriceps femoris - rectus fem. - R	44,11	7	37,54	5	27,39	4
Quadriceps femoris - rectus fem. - L	88,49	9	79,67	**7**	78,25	**7**
Gastrocnemius - R	33,93	5	84,44	**9**	90,86	**9**
Gastrocnemius - L	32,6	3	97,12	10	34,73	5

ERG = cycling ergometer; TR = training rollers for cycling; CYCLE = outdoor cycling

For better comparison, we established the model to be natural conditions of cycling outdoors. As shown in Table 1, the muscle timing and activation in ergometer use and cycling outdoors, we find no match in muscle activation sequence. On the other hand, training rollers show in six out of ten cases match in muscle activation sequence. This points to the higher similarity in locomotion of training rollers and cycling outdoors. The reader has to take into consideration the fact, that this case study included testing of only one proband, however, the results of the data analysis show a specific trend, which will be observed and tested further in the future.

During observations and analysis of the EMG recordings of muscle activity of selected leg muscles, the authors concluded that training rollers are better for simulating normal conditions for muscle activation as during normal cycling, which gives better results than ergometer use. Ergometer than seems to be used as a specific training tool for cyclists. Long-term effects of using ergometer training can cause disruption of correct cycling technique. In conclusion, ergometer use can be recommended only as an additional tool for short-term training and other types of simulated movement should be taken into consideration.

CONCLUSION

The important asset for future study in the field is the finding of coordination differences in observed muscled during stimulated locomotion while cycling on ergometer compared with the results of training rollers and cycling in natural conditions.

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