# Muscle Fatigue and Motorcycle

Subjects: Physiology
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Motorcycle road races last from 30 to 45 min, representing about 20 to 25 laps consisting of 12 to 20 curves. This profile requires thereby 200 brakes and 400 leans per race at velocities generally greater than 200 km/h that should be managed with accurate synergistic muscle contractions from different part of the body, despite the development of muscle fatigue. However, only a few studies have investigated muscle fatigability via surface electromyography (sEMG) in riders that were performed either in a laboratory environment or outside the track. At present, only two studies have reported an accurate fatigue assessment yielded during a real piloting setup. Nevertheless, both studies monitored a pilot driving a motorcycle in a motorway or normal road environment, much less demanding and stressful than a racetrack.

Keywords: electromyography ; motorcycles ; muscle strength ; forearm ; hand strength ; neurophysiology

## 1. Overview

The sEMG signals were recorded unilaterally from biceps brachii (BB), triceps brachii (TB), anterior and posterior part of the deltoid (DA and DP respectively), flexor digitorum superficialis (FS), extensor carpi radialis (CR), extensor digitorum communis (ED) and pectoralis major (PM) during three rounds of 30 min. sEMG signals selected for analysis came from the beginning of the braking action to the way-out of the curves of interest. Considering the laps and rounds as a whole and focusing on the forearm muscles, ED was more systematically (84%) assigned to a state of fatigue than FS (44%) and CR (39%). On the opposite, the TB and DP muscles showed a predominant state of force increase (72%). Whereas the BB showed alternatively a state of fatigue or force increase depending on the side of the curve, when taking into account only the sharpest curves, it showed a predominant state of force increase. In conclusion, the fact that forearm muscles must endure a long-lasting maintenance of considerable activity levels explains why they easily got into a state of fatigue. Moreover, TB and DA are particularly relevant when cornering.

## 2. Surface Electromyogram

Motorcycle road races last from 30 to 45 min, representing about 20 to 25 laps consisting of 12 to 20 curves. This profile requires thereby 200 brakes and 400 leans per race at velocities generally greater than 200 km/h [1] that should be managed with accurate synergistic muscle contractions from different part of the body, despite the development of muscle fatigue [2]. However, only a few studies have investigated muscle fatigability via surface electromyography (sEMG) in riders that were performed either in a laboratory environment [3][4][5] or outside the track [2]. At present, only two studies have reported an accurate fatigue assessment yielded during a real piloting setup [6][7]. Nevertheless, both studies monitored a pilot driving a motorcycle in a motorway or normal road environment, much less demanding and stressful than a racetrack.

Another limitation in studying muscle fatigability during track motorcycle race is related to the interpretation of changes in sEMG during force-varying contractions. It is widely accepted that muscle fatigability represents a progressive decrease in the capacity of an individual to produce high levels of force or to maintain steady force output, a decrease that starts from the beginning of the exercise [8][9][10]. However, such assessments are rather difficult in an "on-track" experimental set-up.

Another common technique to evaluate muscle fatigability is the surface electromyogram (sEMG), which records the electrical activity associated with muscle contraction. During sustained isometric submaximal contractions, fatigue cause an increase in sEMG amplitude (time domain analysis), and a decrease in the power spectrum (frequency domain analysis) [11][12][13]. sEMG amplitude increases could be explained by a combination of an enhanced recruitment of fibers with higher action potential [12] and an increased synchronization of the motor units [14]. On the other hand, power spectrum decreases could account for an indirect measure of the metabolic status of the muscle cell membrane [15], based on matched behavior with conduction velocity of the action potentials that propagate along the muscle fiber membrane, and muscle lactic acid, due to a restricted blood flow [16]. However, these electrical indices have some limitations during force-varying contractions [17]. Accordingly, Luttmann et al. [18] developed the joint analysis of sEMG spectrum and amplitude (JASA), which combines the time and frequency domains of the sEMG signal, allowing to define four quadrants [18][19][20][21]: (1) force increase (root mean square (RMS) and mean frequency (MF) increase), (2) fatigue (RMS increase and MF decrease), (3) recovery (RMS decrease and MF increase), and (4) force decrease (RMS and MF decrease). This approach allows to determine a reliable pattern of sEMG during repeated tasks with similar force production and has been successfully used to assess neuromuscular fatigue in occupational labor [20], such as a surgery [18], wheelchair maneuvers [19], virtual environments [22], construction [21], or cycling [23].

Very little information is available about the required muscular load during the different actions that take place during a motorcycle road race. In consequence, we could say that up to now, physical training programs in this sport have been based on empirical knowledge and not on scientific evidence. Therefore, the objectives of this study were (1) to assess the muscle activity changes that occur during riding on a road-race track, and (2) to find out whether muscle fatigue develops when riding a motorcycle during consecutive rounds of a training session on a circuit. We hypothesized that the most demanded muscles should be the flexor superficialis digitorum (FS), as the agonist of the brake-pulling action against the lever [4][24], accompanied by the extensor digitorum (ED) considered as the antagonist pair of the FS. Co-contraction of ED and carpi radialis (CR) is supposed to occur during the braking phase and entry of the curve because of their wrist stabilization role already observed in power grip tasks [25][26]. Based on the previous hypothesis, we supposed that at the end of the training sessions, at least some of these muscles should get into a fatigue state. Knowing the high inertial forces that must be managed by the motorcycle riders [1][27], we additionally hypothesized that a complex interplay should exist between the agonist/antagonist pair mainly responsible for the stabilization of the elbow (biceps brachii versus triceps brachii; BB/TB) as well as for the role of the shoulders, when transmitting forces from de handlebar to the rest of the body and vice versa. With respect to the last hypothesis, the occurrence of fatigue should change the leadership figures and synergies among these muscles.

The relevance of these data should be considered with respect to the difficulty to obtain reliable sEMG recordings while riders drove at high speeds carrying on all measurement instruments despite heat, sudation, and movement artifacts. This challenging experiment opens new area for applied research in motorcycling.

## 3. Conclusions

It seems that pushing-like muscles, such as TB and DA, have sufficient relevance as to be seriously considered during physical conditioning specifically oriented to motorcycle racing. Among the always highly demanded forearm muscles, ED was more demanded and fatigued than FS and CR. Whereas PM and DA were fatigued especially in the last round, TB and DP showed a state of force increase. This state was particularly predominant in the BB muscle in the sharpest curves.

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