Interest of a New Instrumented Mountain Bike Trial

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Abstract

The aim of this study is to present a new instrumented mountain bike trial and the possible applications for analyse and improve the trial sport performance. This bike has been equipped with a strain gage on the chain stay and of an electronic device to store the data (200 Hz) in the goal to analyse the biomechanics of the pedalling during the impulsion phase. Different performance determinants like maximal and mean crank torque and pedal force, the impulsion, the duration of the pedal stroke, the rate of torque development, the flight time have been measured and analysed during a maximal jump test. The mean crank torque values were 137, 104 and 92 N.m for the first, second and third pedal stroke, respectively. The mean impulsion values at the pedal were 432, 183 and 143 N.s for the first, second and third pedal stroke, respectively. The results of this study show the possibility of use of this new instrumented bike. This prototype can be used with usefulness to improve the mountain bike performance determining new performance factors, give biomechanical feedbacks to the riders and control the effect of specific training.

INTRODUCTION

The Mountain bike trial is an individual sport which consists in jumping natural or artificial sections. It was born in 1990 in Colorado. This sport can be practised in competition or in demonstration for a show. It requires balance and control because the only connection to the ground is the tyres. During a competition, a connecting circuit permits to link six sections which have to be jump three times (the six sections are being jumped in disorder, but each have to be jumped once to be allowed to jump them a second time).

Competitions take place on sites where there are natural obstacles like rocks or torrents, in order to put sections in place; those sites are very often in mountain. Otherwise sections are artificial; they are manufactured by the aid of big tyres, concrete blocks or beams.

This discipline has specific equipment. The frame has a longer horizontal tube, back bases and a shorter vertical tube comparing to other bikes. Some bikes are made without saddle. The handlebar is wider than on the other mountain bikes. Only a mountain bike trial has a front chain wheel with a protection, contrary to the other mountain bikes which have three front chains wheel. The bike size is adapted to the biker’s morphology and category.

The Mountain bike trial requires resources in different domains: physical fitness, engineering, tactic and even psychological. The technical requirements are the most important overall.

The preliminary study of Rogier S. and Bertucci W. (2006) [1] has shown the positive influence of the lower limbs maximal power output on the height of a lateral jump. This study have been performed from analyse of the ground force using a 3D force plate. In the goal to be in the ecological conditions it is necessary to perform the measurements in actual conditions using a mobile instrumentation. There are different valid mobile power meters like the SRM or the Power tap [2-4]. However these devices are more adapted for the road cycling and the sampling rate is too low to perform optimal measurements of the "explosive" mountain bike trial exercise motions. There is a power meter with a relatively high sampling rate (250 Hz) localized on the axle of the rear wheel: the G-Cog (Rennen Design Group, Middleboro, MA, USA). However, this device does not allow valid and reliable power output measurements [5]. This last device can be used for the valid kinematics measurements using two 3D accelerometers. To the best of our knowledge, there is not specific instrumentation adapted to the mountain bike trial to measure the characteristics of the trial performance (i.e. vertical and horizontal jumps, impulsion, etc). The aims of this study are to present the characteristics of a new instrumented mountain bike trial and the possible applications to analyse the sport performance.

MATERIALS AND METHODS

An aluminium frame of mountain bike trial was modified in the goal to instrument the right chain stay (Id Bike, Bicycle innovators, NE Riel, The Netherlands). Uniaxial strain gage was
placed between right chain stay and aluminium plate added (Figure 1).

The sensor measures the chain force action on the chain stay and thus also the pedal torque of the cyclist. It is mounted on a sensor plate and measures the deflection of the plate that is caused by the chain force. The measurements have been performed with a sampling rate of 200 Hz. In order to use this instrumented bike on the ground, raw gage data (voltage) was recorded in a XR440M Pocket Logger mounted on the frame (Figure 2). A calibration procedure has been performed by the manufacturer to convert the volt data in crank torque data.

After a standardized warm up, a French national team pilot has performed a maximal vertical jump.

Each pedal stroke has been analyzed (maximal and mean torque, flight time, duration of pedal stroke). The rate of crank torque development has been computed according to Aagaard et al. 2002 [6] study. The rate of crank torque development was derived as the average slope of the crank torque-time curve.

RESULTS AND DISCUSSION

The aim of this study is to present a new instrumented mountain bike trial and the possible applications for analyse and improve the trial sport performance. The pedalling during the impulsion phase can be analysed. The results show that the maximal crank torque is 239 N.m, this value is relatively high and corresponds to an effective pedal force of 1406 N. This value of crank torque was closed to the value measured during the sprint test of 80 in elite BMX riders [7]. These results suggest that the maximal muscular force could be one of the determinants of performance in mountain bike trial. The mean torque and the duration of the pedalling stroke decrease during the impulsion phase. These results are in line with the force-velocity muscle relationships. When the crank angular velocity increases like it is the case during the impulsion phase, the mean force applied decreases [7,8]. The relationships between the impulse and the jump height are perfect [9,10]. For the squat jumps or counter movement jumps the vertical impulse can be measured by the force plate. The new instrumented mountain bike trial could be very interesting to perform the measure the impulse at the pedal. Our results show that the mean impulsions at the pedal were 432, 183 and 143 N.s for the first, second and third pedal stroke, respectively. It could be hypothesised that the impulse on the pedal is strongly laid to the height of jump that is one of major performance determinant. Further studies must be performed to confirm this hypothesis taking into account for example the fact that the impulse on the handlebar is not yet measured. Our results show that the rate of crank torque developments was 0.748, 1.200 and 1.055 N.m.s$^{-1}$. These measurements are very important especially for the sport with high acceleration or impulse. It is the
case in mountain bike trial (Figure 3). The improvement of these muscular characteristics is possible [6] and can be quantified with the new instrumented bike. It is also possible to measure, analyse, and give quickly a feedback at the cyclist to optimize the muscle coordination to increase the impulse especially for the last pedal stroke. With the new instrumented bike it is also possible to quantify the height of jump according to the flight time [11]. This flight time is 0.36 s in our example. This analyse must be performed with caution because the validity of the results depends on different mechanical hypotheses. In our case, this computation can be only applied for the vertical jumps and not for example for the lateral jumps. To valid this analyse, different measurements could be added with other instrumentations like accelerometers [12], 3D inertial sensors or optokinetic device.

CONCLUSION

In conclusion, the new instrumented mountain bike trial give the possibility to measure in ecological conditions different determinant of the performance in mountain bike trial. This prototype can be used with usefulness to improve the mountain bike performance, give biomechanical feedbacks to the riders and control the effects of specific training.

REFERENCES