Original Article

Muscle control of the ankle joint in mountain bike trials

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Abstract:

"Rear wheel hop" is a fundamental trials technique during which the athlete performs a series of hops with the bicycle that is balanced on the rear wheel. In trials, hands and feet are the only points of contact with the bicycle; therefore, the corresponding joints (in particular the ankle) are required to check (through a series of adjustments) the connection with the pedal to prevent losing contact with it because quick-release pedals are not used. The purpose of this study is to evaluate the activity of lower leg muscles to understand the control mechanisms that act on the ankle during the performance of this basic technique. This study involved one subject (i.e., an athlete practicing trials), who was able to properly perform the technique. The data were acquired for both legs using a 6-camera optoelectronic system, a force platform to define the events, and an 8-channel surface electromyograph. Ankle flexion-extension and the root mean square (RMS) of the surface electromyography (sEMG) signal of tibialis anterior, soleus, lateral and medial gastrocnemius muscles were calculated. The obtained results show that the muscles that control the ankle joint are similar to those that required in hopping, as it is possible to see from different electromyographic investigations carried out by various authors, therefore, in specific sports training, similar exercises can be used to train this muscle group. This case study provides insights into the sport of trials (which is still under-studied) as well as useful information so that coaches could implement more specific training programs.

Key Words: mountain bike trials, electromyography, biomechanics, ankle.

Introduction

In mountain bike trials the control of the bicycle is essential. In this sport, it is required to tackle obstacle courses with a bicycle without placing the feet on the ground and can be considered as parkour on a bicycle (Gavira et al. 2018). The riding technique is a fundamental component but differs greatly from traditional cycling (Kolumbet et al. 2019; Kolumbet et al. 2019) as in this sport most of the time the bicycle does not rest on two wheels, but the athlete to move easily and to climb or descend obstacles, he must keep his balance on the rear wheel only. Furthermore, the bicycles used in this sport are very different from traditional ones both in shape and size, they do not have gears, they do not have suspensions, but the most striking difference is the absence of the saddle. Since the bicycles used in this sport do not have a saddle, the only points of contact are the hands and feet, therefore, to evaluate the position or the general efficiency of the man-bicycle system, it is not possible to use traditional methods that mainly use the height of the saddle as a reference (Didieu et al. 2020).

These considerations lead us to give greater importance to the remaining contact points, therefore hands and feet must be considered more and from a different perspective to think of strategies to improve the efficiency of their function, that is, grip. Hands hold can be optimized by using handlebar grips or tape and gloves, but in general, it is the hand structure itself that ensures a firm hold on the handlebar. At the foot level, i.e. at the foot-pedal interface, since quick-release pedals are not used, the grip can be optimized using special pedals and special shoes. Unlike the hand, however, the foot does not have a structure capable of grasping the pedal and although the use of special pedals and shoes can help, it is not sufficient to ensure good stability in the pedal-foot interface. Therefore, the management of this contact point is most likely delegated to the lower limb joints and in particular to the ankle which is the most distal one.

Therefore, the purpose of this study is to understand, through an electromyographic investigation, how the ankle joint is controlled during the execution of a fundamental Trials technique called "rear-wheel hopping", which consists in bouncing in balance on the rear wheel. Previous research on this sport have investigated the lateral jump technique (Vastola et al. 2017; Vastola et al. 2016) and jumping ability in elite athletes (Albano et al. 2018), however, there are no studies conducted with electromyography to evaluate the muscular intervention. Therefore, as far as we know, this study is the first to investigate muscle control in this sport with the surface electromyography (sEMG) technique, therefore it can provide further information on this discipline and in particular on the "rear wheel hopping" technique, so as to provide the coaches with useful information to further improve athletic and technical training. The complexity of the topic will require further studies on the characteristics of elite athletes and on the epigenetic implications of intensive sporting activity, also including a

study on athletes of starting levels and performance outcomes (Rossi et al., 2006; Cozzolino et al., 2017; Cozzolino et al., 2020).

Material & methods

Participants

This case study involved a male amateur athlete (30y, 80Kg, 1.82m) with more than 10 years of experience in the practice of Trials. The subject was previously informed about the purposes and methods of the study and signed informed consent.

Instruments

A 6-camera optoelectronic system with a sampling rate of 70Hz (BTS Bioengineering), a force platform with a sampling rate of 560Hz (BTS Bioengineering) and a 16-channel electromyograph with a sampling rate of 1120Hz (ZeroWire) were used.

Procedures

The subject was required to perform the “rear-wheel hopping” technique on the force platform to accurately obtain the contact and take-off events. The subject performed the technique for 15" twice, for the purposes of the analysis the first and last hops were eliminated, each test allowed to acquire about 20 hops. An operator indicated the start and end of the test to the athlete. To acquire the kinematics data, 6 reflective markers were placed on the subject on the fibula head, lateral malleolus and the head of the 5th metatarsal of both legs respectively (Coppola et al. 2019; Liparoti et al. 2020). To evaluate muscle activation, electrodes (Ag-AgCl) at an interelectrode distance of 20mm were placed respectively on the lateral gastrocnemius (GL), medial gastrocnemius (GM), soleus (SO) and tibialis anterior (TA) (Stegeman & Hermens 2007). Before placing the electrodes, the placement site was shaved and cleaned with alcohol. To reduce the noise due to the movement of the probes, they were secured using an elastic bandage. In order to normalize the electromyographic data, the subject previously carried out tests of maximum voluntary contraction (MVC).

Data analysis

From the data obtained from the optoelectronic system, the angle of the right and left ankle was computed (Astone et al. 2018). The electromyographic signal was filtered with a 20Hz high pass filter and a 450Hz low pass filter, then the root mean square (RMS) with a moving window of 50ms was calculated. About the signal obtained by the MVC, the highest average value was extracted after sampling with a time window of 500ms (Konrad 2005). The value obtained was used to normalize the signal coming from the trials and expressed as a percentage. All operations were carried out with Smart Analyzer software (BTS Bioengineering). Thanks to the force platform it was possible to identify the contact and take-off events for each hop (Coppola et al. 2020), a threshold of 50N was used to determine the events. The contact event was defined as the first instant in which the vertical component of the GRF exceeds the threshold of 50N, instead, the take-off event was defined as the first instant in which the vertical component of the GRF becomes less than 50N. The peak force event corresponding to the instant in which the value of the vertical component of the GRF is maximum was also identified. A temporal normalization was also carried out as a cycle expressed as a percentage identified by one contact to the next one. The cycles were averaged and the curves presented in the results were thus obtained.

Results

Fig. 1 Right ankle dorsi-plantarflexion. The figure shows the right ankle dorsi-plantarflexion cycle. The vertical red line represents the peak of vertical GRF, the black vertical line the take-off.

Fig. 2 Left ankle dorsi-plantarflexion. The figure shows the left ankle dorsi-plantarflexion cycle. The vertical red line represents the peak of vertical GRF, the black vertical line the take-off.

Fig. 3 Right leg normalized sEMG. The figure shows muscle activity of the right leg. Data are expressed as a percentage of MVC.

Fig. 4 Left leg normalized sEMG. The figure shows the muscle activity of the left leg. Data are expressed as a percentage of MVC.

Discussion

From a kinematic point of view, the ankle shows a bell-like shape with the maximum dorsiflexion just before the peak of force and the maximum plantarflexion immediately after the take-off, both for the right and left limb. The right leg shows a shorter range of motion than the left one. The peak force occurs between 40-50%

of the cycle, the take-off instead occurs between 70-80%, consequently, the relationship between the stance phase and aerial phase is about 80/20. As regards the electromyographic activity, it is possible to note some differences between the two limbs, to be linked to the fact that the pedals do not lie on coplanar transverse axes but offset by about 340mm. For the purposes of the analysis, it is possible to distinguish 3 phases, one ranging from contact to peak force, one from peak to take-off and the last from take-off to the next contact. In the first phase, the right limb shows minimal activity of the TA, while the posterior compartment of the leg is very active. In particular, the SO shows the greatest activity with an initial peak around 20% of the cycle followed by a second peak at the peak of strength. Both the GM and GL have two peaks as for the SO, but in this case, the second is higher than the first, moreover, the GM is more active than the GL.

The second phase is characterized by a strong decrease in the activity of the posterior compartment and the activation peak of the TA. Finally, the third phase shows a new inversion, with a decrease in the activation of the TA and an increase in the posterior compartment, in particular in the GM. The left limb shows a somewhat different activation pattern with the exception of the SO which is very similar. In the first phase, excluding the SO, the muscles do not show significant activation. In the second phase, on the other hand, GM and GL first and the TA later show their activation peak. Finally, in the third phase, the activity, initially at a minimum, grows slightly before the next contact.

To give an explanation of the trend of the curves it is necessary to underline some aspects. The athlete-bicycle system is composed of two elements that have different dynamics in the fall, in contact with the ground and in the response to the impact, due to both the structure and the different properties of the materials they are made of. The falling bicycle anticipates the athlete who, in order to maintain contact between the foot and the pedal, will have to perform a plantarflexion which would explain the activation of the rear compartment in the final phase of the cycle, just before contact. Two events subsequently occur that require the intervention of the plantar flexors, the first impact following contact and the second due to the maximum compression of the rear tire at the peak of force that explains the second activation peak of the rear compartment of the leg. The activation of the TA during the second phase and therefore before the take-off could be due to dorsiflexion that anticipates or accompanies the ascent of the bicycle due to the rebound.

Conclusions

The pattern of muscle activation at the level of the ankle joint is very similar to that found during hopping, as can be seen from various electromyographic investigations carried out by various authors (Moritz & Farley 2005; Zuur et al. 2010; Auyang & Chang 2013; Sano et al. 2013; Kessler et al. 2020). From a functional point of view, the muscle control pattern of the ankle seems to respond to the request to ensure contact between the foot and the pedal by accompanying and anticipating the movements of the bicycle. In conclusion, in performing the "rear-wheel hopping" technique, the muscles that control the ankle joint are called to play a role very similar to that required in hopping, therefore in specific sports training, to train this muscle group could be proposed exercises that recall this gesture. To confirm these results, further investigations on a larger sample are needed, however, this case study provides insights into the sport of Trials, in particular on muscle control of the ankle and some useful information for coaches to implement specific training programs. The phase following this case study will have to understand the relationships between this type of activity and the motivational aspects that will allow a multifactorial study of the experience, with particular reference to the incidence of stress on muscle damage and problems related to the execution of the sporting gesture (Cozzolino et al, 2020; Cozzolino et al. 2020; Girelli et al., 2018; Girelli et al., 2019; Girelli et al., 2020).

Conflicts of interest - There are no conflicts of interest to declare.

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