

3D KINEMATICS APPLIED TO THE STUDY OF INDIVIDUAL BMX GATE START TECHNIQUE

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Even if the BMX modality has been included in the schedule of the Olympic Games since Beijing 2008, there is a lack of scientific studies concerning this sport. According to the opinion of many trainers and experts, the start of the race is very important and both neuromuscular potential and sport technique are very relevant aspects of sport performance. The purpose of this study was to analyze the technique of three top young athletes of BMX during the starting gate in order to obtain relevant information to support their trainer's decisions.

KEYWORDS: biomechanical analysis, sport technique, BMX.

INTRODUCTION: Despite of its well-recognized professional status, the Motocross Bicycle (BMX) riding has only recently been included in the schedule of the Olympic Games, on Beijing 2008. Accordingly to the opinion of the coaches, the gate start is very important for the performance because in addition to the shorter time in the start, the cyclist who is ahead of the race from the beginning has a certain advantage over the opponents. Nevertheless, to the best of our knowledge there is a lack of scientific information concerning BMX gate start technique. Thus, the purpose of this work is the evaluation of the individual technique of three Spanish top athletes during the gate start of the race and how this technique is influenced by individual characteristics.

METHODS: Two S-VHS videocameras (Panasonic AG-DP800H, AG-DP200E) were used to record at sampling rate of 50 Hz the gate start of the subjects in a training track simulating race conditions, including a ramp with a slope of 20º. The recorded videos were then processed by the Kinescan/IBV 3D video photogrammetry system (Instituto de Biomecánica de Valencia, Valencia, Spain) in order to calculate the 3D coordinates of the digitized points. A biomechanical model defined by 28 digitized points upon the system of cyclist-bike (cyclist: 3 points on helmet, 7th cervical, xiphoid, left and right: glenohumeral joint centers, elbows, wrists, 3rd metacarpal, knees, ankles, heels, toes and hips. BMX: wheel hubs, seat post bolt, headset) was used, plus 4 digitized points on the gate ramp. A metallic cube (4m×2m×2m) was used as reference object (Fig. 1).

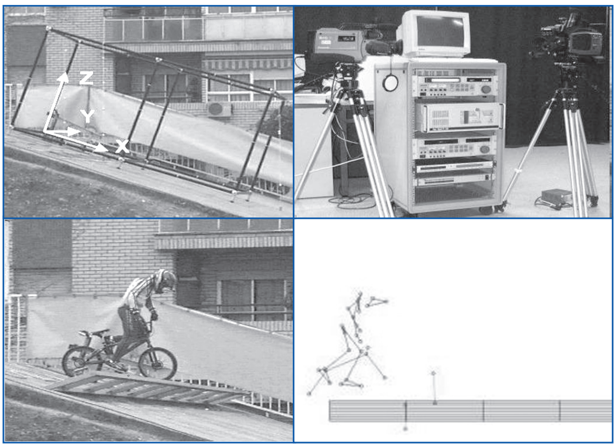

Figure 1: Experimental set up showing the global reference system location and the link segment model that was used in the study.

The 3D coordinates of the digitized markers were obtained using the DLT method and were specified with respect to the defined origin of the global reference system that is presented on Figure 1. Data "smoothing" was carried out with quintic splines according to the “True Predicted Mean-squared Error" criterion using the package "Generalized Cross-Validatory Spline" (Woltring, 1986) and their first and second time derivatives were calculated. The “BiomSoft” package was used to analyze the study parameters (Gianikellis et al., 2001). The best gate start of the five analyzed trials is presented for each subject.

RESULTS and DISCUSSION: The goal of any cyclist at the gate start is to get an advantage over the opponents and to lead the race from the beginning. Therefore, an efficiency criterion of the starting gate technique is that at the instant when the gate touches the ground the cyclists must be as far forward as possible. Hence, the anterior-posterior (AP) distance between the front wheel axis of the bicycle (wheel hub) and the top part of the gate at the instant when the latter starts to fall (G_{Start}) and when it touches the ground (G_{Ground}) was analyzed (Table 1). Considering the position of the front wheel axis at the instant G_{Ground}, it is clear that, if the three cyclists had started together at the same instant, the cyclist C would have been ahead of both cyclists A and B (Table 2). So, there are considerable disadvantages concerning the start time delay. However, one has to take into consideration that subject C has moved his bike backward before the gate starts to fall. This difference is too small for both cyclists B and A (Table 1). Concerning the vertical position of the front wheel axis of the bike at the instant G_{Ground}, cyclist B (0.249 m) has moved his bike higher than cyclist A (0.234 m) and C (0.195 m).

Table 1
AP displacement of the front wheel axis of each cyclist during the starting gate.

	Cyclist A	*Cyclist B*	*Cyclist C*
Gate starts to fall (G_{Start})	- 0.011 m	- 0.036 m	- 0.160 m
Gate touches the ground (G_{Ground})	- 0.398 m	- 0.099 m	+ 0.190 m

(-) means behind the gate, (+) means ahead of the gate

Table 2
Difference in AP displacement and time between the cyclists at the instant G_{Ground} if they had started together.

Displacement	*C is ahead of B by*	*C is ahead of A by*	*B is ahead of A by*
	0.289 m	0.588 m	0.299 m
Time	*C started to move before B by*	*C started to move before A by*	*B started to move before A by*
	0.060 s	0.120 s	0.060 s

Concerning the AP component of the bike's velocity (front wheel hub point - Fig. 2), it is clear that cyclist C attains higher final velocity (12.12 m/s) at the end of the analyzed trail (4 m) than the others (9.05 m/s for A and for 8.34 m/s for B). At the instant G_{Start} the higher attained velocity is also for cyclist C (0.55 m/s), while cyclists A and B are still moving in the opposite direction (negative velocity) with velocities of -0.17 m/s and -0.55 m/s respectively. This means that cyclist C has a considerable advantage concerning the AP velocity. Concerning this point, it is of importance to make clear that the higher velocity value at the opposite direction of the race (negative velocity) is attained by cyclist C (C: -1.95 m/s, B: -0.80 m/s, A: -0.32 m/s). Consequently, cyclist C uses a countermovement technique before the gate starts to fall in order to attain high AP velocity. Finally, it is of importance to mention that the bike’s AP velocity at the instant G_{Ground} is 2.71 m/s, 4.98 m/s, 5.08 m/s for cyclist A, C and B, respectively.
Regarding the countermovement technique, cyclist A has flexed his knee angle by 17º (initial knee angle 151.57º) and cyclist C by 18º (initial knee angle 126.92º). On the contrary, cyclist

B (initial knee angle 154.46º) did not perform a countermovement previous to the gate start. However, cyclist B has flexed his trunk (15.18º) at this time period, whereas subjects C and A did not.

The mean value of the AP component of the bike's acceleration between the phases determined by the instants G_{Start} and G_{Ground} is 7.59 m/s^2 for cyclist A, 11.64 m/s^2 for C and 14.82 m/s^2 for cyclist B (Fig. 3). Considering that cyclist B develops the higher mean acceleration, computed from the velocity between the instants G_{Start} and G_{Ground}, and that he is the one who possesses more neuromuscular potential according to individual tests carried out at our laboratory (vertical countermovement jumps), it is suggested that it is very important to combine the results of the kinematic analysis with that of the individual neuromuscular potential. To develop high levels of mean acceleration it is required high levels of neuromuscular potential, like in subject B, who despite being at the most disadvantageous position at the instant G_{Start}, he gets ahead of subject A at the instant G_{Ground} (Table 1). The mean value of the AP component of the bike's acceleration between the phases determined by the instant G_{Ground} until the end of the analyzed trail, are 13.76 m/s^2, 12.31 m/s^2 and 8.58 m/s^2 for subjects A, C and B, respectively.

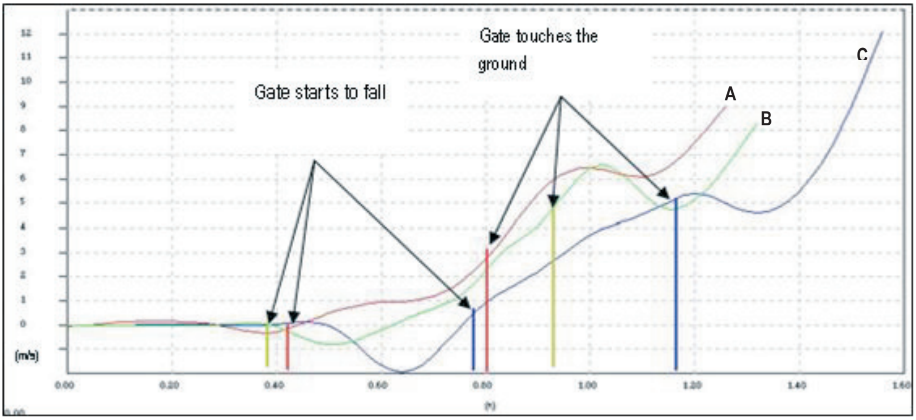

Figure 2: Graphical representation of the AP component of the bike's velocity. The best trial is represented for each subject. The instants when the gate starts to fall (G_{Start}) and when it touches the ground (G_{Ground}) are presented for each subject (t_0=0 is taken arbitrary).

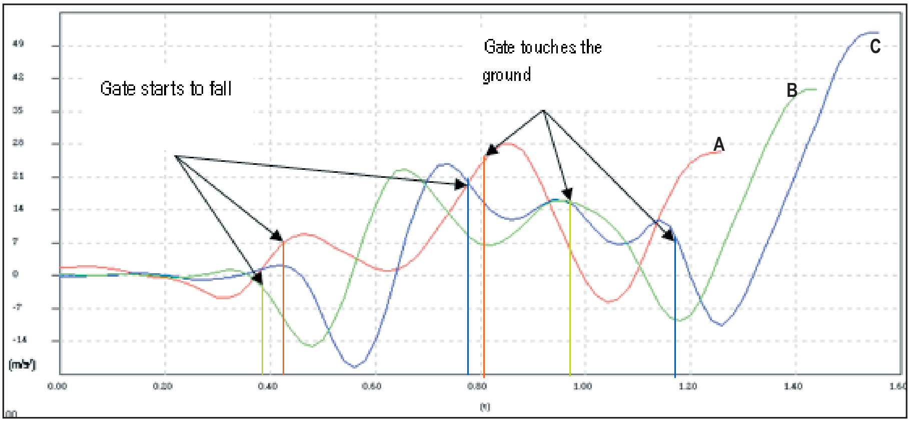

Figure 3: Graphical representation of the AP component of the bike's acceleration. The best trial is represented for each subject. The instants when the gate starts to fall (G_{Start}) and when it touches the ground (G_{Ground}) are presented for each subject (t_0=0 is taken arbitrary).

CONCLUSION: The results make it clear that individual recommendations can be made in order to enhance the starting gate technique of the BMX cyclists. Regarding the individual technique of cyclist A, the time when he begins to act with respect to the instant G_{Start} is delayed because of his countermovement, which results in lower velocities. The cyclist should improve his technique by moving the bicycle forwards, in AP direction, before the gate touches the ground. To do this, he should begin to act earlier, perform the countermovement more pronounced and tilt the trunk forward. Concerning the individual technique of subject C, it can be suggested that his technique in general is correct given that he anticipates the instant G_{Start}. Also it is important to point out that his countermovement is an advantage for his performance. It seems that a faster and more pronounced tilt of the trunk after the gate falls to the ground could be of his advantage in order not to lift off the ground the front wheel for too much time. Finally, regarding the individual technique of the cyclist B, it is suggested that he has to start acting earlier and perform a countermovement. His large neuromuscular potential counterbalances the errors from his technique (lack of countermovement), so if he manages to improve his technique he can significantly improve his performance. Moreover, it seems that subject B moves the bike in the vertical excessively.

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