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Letter to editor

Laboratory testing and field performance in BMX riders

Dear Editor-in-Chief

In June 2003, the International Olympic Committee decided to introduce BMX in the 2008 Olympic Games in Beijing (China). We can assume, as in a 200 m sprint in track cycling, that the maximal power output (PO) of the lower limbs contribute to the BMX performance. However, few studies like Herman et al. (2009) and Mateo et al. 2011 have studied the PO characteristics of the elite riders on the initial straight line. However, this analyze could contribute to know the key factors of the BMX performance.

The first aim of this descriptive study was to measure the PO characteristics of national to elite level BMX riders during maximal exercises in the laboratory and in the field, and the second aim is to analyze the relationships between the PO and the chronometric performances. This analysis could help BMX coaches for example to orient their training programs.

Two groups of BMX male riders volunteered to take part in this study: riders of national level (n = 17, age 20 ± 1 years; height 1.79 ± 0.10 m; body mass 74.7 ± 10.4 kg; and, mean body fat 13.6 ± 4.2 %) performing in the French championships and elite riders of the French national team (n = 9, 22 ± 4 years; height 1.80 ± 0.05 m; body mass 75.9 ± 5.7 kg) performing in European, world or Olympics championships (UCI ranking in first fifty with the best at the fourth place). All subjects provided written informed consent. All of the tests (laboratory and field) tests were performed on the same day. Only the riders of national level have performed the laboratory tests. The subjects performed two types of vertical jumps: squat jumps (SJ) and counter movement jumps (CMJ) and maximal cycling sprint tests on cyclo-ergometer (Cateye CS 1000, Osaka, Japan) of 8 s duration against three resistive load levels (0.4 N $m\cdot kg^{-1}$, 0.6 N $m\cdot kg^{-1}$, 0.8 N $m\cdot kg^{-1}$ applied on the crank axis) in seated (ST_{SEA}) and standing positions (ST_{STA}) with 6 min of active rest between tests (Bertucci et al., 2007). After 30 min of active rest, two Wingate tests of 30 s duration were performed in seated (WT_{SEA}) and standing positions (WT_{STA}) in randomized order (45 min of recovery between the Wingate tests). The PowerTap (CycleOps, Madison, USA) samples at a frequency of 0.8 Hz the PO measurements. After 3 hours of recovery, the riders of national level performed 3 sprints on the initial straight line portion of the BMX track (Clairoix, France) of 75 m (6 min of recovery between each trial). With four photoelectric cells (Racing Time 2, Microgate, Italy, sensitivity: 0.01s), we measured the time after 5.2 , 29 and 75m. This BMX track has been used in 2010 for the European Championships. This track is composed of: a starting ramp of 13 meters at 17.5 % grade and two double bumps in the first straight line. The first double bumps and the second double bumps are 30 and 60 m after the start, respectively. This initial straight line can be classified according to Mateo et al. (2011) in medium difficulty. The elite group performed only a protocol in the field of 3 sprint tests (80 m) with their personal BMX bikes fitted with a PowerTap adapted specifically for the BMX wheel. The maximal PO during the ST_{SEA} and ST_{STA}, the mean PO during the WTs_{EA} and WT_{STA}, the vertical elevation (m) during the SJ and CMJ, and the chronometric data on the BMX track were analyzed using a correlation matrix (Statistica 7.1.30, Statsoft).

The results of this study are presented in the Tables 1 and 2. The peak of PO values (1968 ± 210 W) of the elite riders in the present study are higher compared with the results of Mateo et al. (2011) on the BMX elite Spanish team (1343 ± 68 W). One of explanations is that the level of performance of the French riders in the present study is better (see the UCI ranking) than the riders of the Spanish team. The PO performances of the national riders of the present study in standing position were close to the performance of Mateo et al. (2011) during the laboratory sprint tests but lower than peak PO of the elite riders of Zaballa et al. (2009) during the Wingate tests (1607 ± 310W). However, the results of the mean PO of

Table 1. Results of the laboratory tests and correlation matrix between the data of the laboratory tests and the chronometric performances in the track for BMX riders of national level.

	Results (mean (SD))	T1 (s)	T2-T1 (s)	T2 (s)	T3-T2 (s)	T3 (s)
SJ (cm)	.37 (.05)	-0.29	-0.58*	-0.52	-0.54*	-0.53
CMJ (cm)	.41 (.06)	-0.30	-0.74*	-0.65*	-0.65*	-0.65*
ST_{SEA} (W)	1256 (228)	-0.34	-0.72*	-0.64*	-0.65*	-0.65*
ST_{SEA} ($W\cdot kg^{-1}$)	16.8 (2.1)	-0.52	-0.66*	-0.64*	-0.65*	-0.65*
ST_{STA} (W)	1340 (240)	-0.31	-0.67*	-0.59*	-0.62*	-0.61*
ST_{STA} ($W\cdot kg^{-1}$)	17.8 (1.6)	-0.53	-0.66*	-0.64*	-0.67*	-0.67*
WT_{SEA} (W)	785 (122)	-0.28	-0.81*	-0.69*	-0.73*	-0.72*
WT_{SEA} ($W\cdot kg^{-1}$)	10.5 (1.0)	-0.40	-0.65*	-0.60*	-0.65*	-0.66*
WT_{STA} (W)	819 (108)	-0.33	-0.75*	-0.66*	-0.70*	-0.70*
WT_{STA} ($W\cdot kg^{-1}$)	9.2 (4.5)	-0.42	-0.47	-0.47	-0.46	-0.47

* for the significant relationships ($p < 0.05$). SJ: Squat jump; CMJ: Counter movement jump; ST_{SEA} : Sprint test in the seated position. ST_{STA} : sprint test in the standing position. WT_{SEA}: Wingate test in seated position; WT_{STA}. Wingate test in standing position. T1 (s): time at 5.2 m, T2 (s) : time at 29.7 m, and T3 (s): time at 75m, SD: Standard deviation..

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Table 2. Correlation matrix between the data of the laboratory tests for BMX riders of national level.

	SJ (cm)	CMJ (cm)	ST_{SEA} (W)	ST_{SEA} (W·kg^{-1})	ST_{STA} (W)	ST_{STA} (W·kg^{-1})	WT_{SEA} (W)	WT_{SEA} (W·kg^{-1})	WT_{STA} (W)
CMJ (cm)	.90*								
ST_{SEA} (W)	.79*	.80*							
ST_{SEA} (W·kg^{-1})	.82*	.79*	.70*						
ST_{STA} (W)	.69*	.69*	.97*	.57*					
ST_{STA} (W·kg^{-1})	.78*	.71*	.76*	.93*	.72*				
WT_{SEA} (W)	.66*	.76*	.93*	.58*	.91*	.64*			
WT_{SEA} (W·kg^{-1})	.50	.58*	.32	.75*	.19	.64*	.43		
WT_{STA} (W)	.48	.59*	.85*	.46	.83*	.52	.91*	.31	
WT_{STA} (W·kg^{-1})	.13	.21	.02	.50	-.11	.34	.11	.77*	.26

* for the significant relationships (p<0.05). SJ: Squat jump; CMJ: Counter movement jump; ST_{SEA} : Sprint test in the seated position. ST_{STA} : sprint test in the standing position. WT_{SEA}: Wingate test in seated position; WT_{STA}. Wingate test in standing position.

Zaballa et al. (2009) during the Wingate tests were close to the results of the French national riders (785 ± 122 *vs* 807 ± 92 W, respectively). The PO during ST_{SEA} of the national riders are 28 % higher compared with the values of regional to national riders of Bertucci et al. (2007). The peak PO results of the elite French team were in line with the PO (2087 ± 156.8 W) of the five elite male BMX racers from the 2008 US Olympic selection pool including two Olympic medalists (Herman et al., 2009) measured with the SRM powermeter (0.5 Hz). The data of our study suggest that the capacity to produce a maximal PO was correlated with the level of the riders and thus was one of the performance determinants during the initial straightaway line of the BMX track, which is a key moment of the race. To increase the capacity to produce a maximal mean PO, several biomechanical variables must be optimized like for example the determination of a gear ratio to allow optimal pedaling cadence (Dorel et al., 2005). The analysis of the laboratory and field performance shows that the results of classical CMJ, ST_{SEA} (W) and WT_{SEA} (W) are three factors related to performance (r^2: 0.41 to 0.66) during the initial straightaway of the BMX track (Table 1). Like in Zaballa et al. (2008) the results of CMJ were significantly correlated with the PO results of WT_{SEA} and WT_{STA} (Table 2). The results of CMJ, ST_{SEA} (W) and WT_{SEA} (W) could explain 41 to 66 % of the variation of the chronometric performance from 5 to 75 m. These results are important for coaches, who can orient training programs for the goal of increasing the muscular PO of the riders using for example a feedback of PO in the strength training protocol. This feedback could be performed using an accelerometer device like Myotest (Acceltec, Sion, Swiss) or GymAware (Kinematic Performance Technology, Canberra, Australia). Knowing the maximal PO generated in cycling, it is possible to train more specifically the lower limb muscles using the PO profile of the riders (Jidovtseff et al., 2009). None of the results of our tests were correlated with performance after 5.2 m. It was possible that the performance at this point did not depend significantly on the cyclists' capacity to produce a high value of PO. In this BMX start phase, the performance could be more correlated with 1) the maximal muscular force, 2) the rate of the increasing force on the pedals (N/s), or 3) with a technical ability. To discriminate the kinematic factor of the performance it would be interesting to perform 3D kinematic measurements and analyze 1) the motion of the center of mass and the pelvis of the rider according to the crank position and 2) the seven efficiency indices of the BMX gate start defined by Zabala et al. (2009). These kinematics measurements could also be used to analyze the complex acyclic actions performed in addition of the cyclic pedaling actions (Mateo et al., 2011). The measurement of these biomechanical variables in addition to the PO could certainly explain more than 70 % of the BMX performances. The measurements of 1) the maximal force and 2) the rate of the increasing of the force produced by the riders could be performed in a future study for example with a specific BMX powermeter (Campillo et al., 2007) allowing the measurement of the pedaling pattern (propulsive force according the time) or with new BMX powermeter in rear hub (G-cog, Rennen Design Group, USA) when these two devices will be scientifically validated.

In conclusion the results of this study suggest that the classical CMJ, ST_{SEA} and WT_{SEA} results are appropriate to evaluate BMX riders. These results indicate that the PO of the lower limb (W) is a factor explaining between 41 to 66 % of the performance during the initial straightaway. Further study could be performed to 1) determine the performance determinant on the total distance of the race and 2) measure other biomechanical variables (kinematic of the movement, force on the pedal, acyclic actions…) with the goal of explaining a bigger part of BMX race performance.

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