Title : Pacing strategies and power output distribution during international events in cross-country mountain bike.

Authors : Cyril GRANIER[1,2], Christophe HAUSSWIRTH[1], Chris ABBISS[3] & Yann LE MEUR[1]

[1] National Institute of Sport, Expertise and Performance, Laboratory of Sport, Expertise and Performance (INSEP), EA, 7370, Paris, France
[2] French Cycling Federation, Saint Quentin en Yvelines, France
[3] Edith Cowan University, Perth, Australia

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During the last decade, cross-country mountain bike (xco-mtb) enjoyed great popularity, especially since London Olympic games and the creation of new competition standards. To our knowledge since Stapelfeldt et al (2004), no study has been conducted with elite athletes during international xco-mtb, regarding the power distribution and pacing strategies.

The purposes of this study were i) to characterize the physiological variables in the top level mountain bikers (MB) ii) examine the distribution of pace adopted, iii) determine power output (PO) during xco-mtb races, comparing these data to physiological findings obtained from laboratory tests.

	Mean ±SD	Range	
		Minimum	Maximum
Age (Years)	22.4 ± 3 .4	19	28
Height (cm)	179.3 ± 2.9	173	183
Body Mass (kg)	65.4 ± 3,5	60.5	72.0
VO_{2max} (ml/min/kg)	79.9 ± 5.2	73.4	88
VO_{2max}L/min	5.2 ± 0.3	4.9	5.8
HR_{max} (Bpm)	183 ± 16	165	202
PO VT1 (W)	274 ± 11	255	288
PO VT1 (W/kg)	4.2 ± 0.3	3.8	4.5
%MAP (%)	66.7 ± 2.7	63.1	70.8
PO VT2 (W)	337 ± 14	315	353
PO VT2 (W/kg)	5.2 ± 0.4	4.5	5.8
%MAP (%)	82.1 ± 3.3	77.9	87
MAP (W)	411 ± 18	379	428
Rel. MAP (W/kg)	6.3 ± 0.4	5.7	6.8

Table 1. Morphological and Physiological characteristics of the off road cyclist (n = 8). *HR_{max}, maximal HR; MAP, maximal aerobic power; PO VT1, power output at first ventilatory threshold; PO VT2, power output at second ventilatory threshold; Rel. MAP, maximal aerobic power relative to body weight; $V'O_{2max}$, maximal oxygen uptake.*

Eight elite cross-country mountain bikers (males) of the French national cycling team participated in this study. Subjects undertook an incremental cycling test during which PO, heart rate (HR) at ventilatory thresholds (VT1 and VT2), and maximal aerobic power (MAP) were assessed, one month before the first world cup race and during the mid season.

Over two competitive years, 13 races (Two world championships, one European championship, one European game and nine world cups) were monitored directly with portable device (powermeter, STAGES power, Boulder, Colorado, Unbited States). During the races, PO, HR, cadence and speed were considered and registered in 1 Hz from the start until the finish line (30 races files were analyzed).

The amount of time spent below 10% MAP (zone 1 is time spent by athletes were coasting downhill, freewheeling within the peloton or without pedaling), between 10% MAP and VT1 (zone 2), between PO VT1 and PO VT2 (zone 3), between PO VT2 and MAP (zone 4) and above MAP (zone 5) was analyzed.

Nowadays, a xco-mtb is a race of 28.15 ± 5.41 km, with an elevation gain of 1248 +/- 1797 m, for a duration of 5377 +/- 538 s (1h29min24s).

Concerning morphological caracteristics of the eight MB (Table1), their mean (± SD) age, height and body mass were 22.4 ± 3 .4 yr, 179 ± 3 cm and 65.4 ± 3.5 kg respectively. The physiological findings from the incremental test reveals a VO_{2max} of 5.2 ± 0.3 l.min^{-1} (79.9 ± 5.2 ml.min^{-1}.kg^{-1}), an HR_{max} of 183 ± 16 bpm and a MAP of 6.3 ± 0.4 w.kg^{-1} (411 ± 18 W).

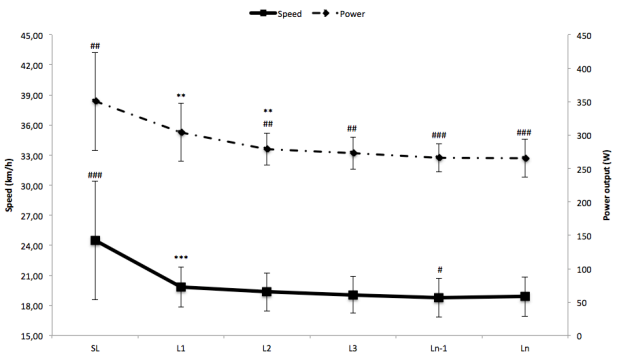

*FIGURE 1 – Speed and power strategies during cross-country races. *, Difference with the lap before; #, Difference with the first Lap.*

The MB completed their races with a mean PO of 283 ± 22 W (4.31 ± 0.32 W.kg^{-1}, 68 ± 5 % MAP), a speed of 19.7 ± 2.1 km.h^{-1}, a cadence of 68 ± 8 rpm and a HR of 172 ± 11 bpm (91 ± 2 % HRmax). PO showed a high coefficient of variance (CV) of 73.5 %, oscillating from 0 W to values above of 1200 W, with a significant decrease (in PO and CV) during the race (Fig. 1). On the other hand, From SL to L1, speed decreased by 19.2% (24.9 km/h to 19.8 km/h) and 4.5% between L1 and Ln. HR values increased by 6% from SL to L1 and decreased by 1,7% between L1 and Ln with a low CV of 4,6%.

The average distribution of time spent at different intensities (in % of MAP) for all 13 races of the studied MB (N=30 cases) was 25 ± 5 % for zone 1, 21 ± 4 % for zone 2, 13 ± 3 % for zone 3, 16 ± 3 % for zone 4 and 26 ± 5 % for zone 5. From HR values, MB spent 8 ± 10 % below VT1, 46 ± 24 % between VT1 and VT2 and 47 ± 31 % above VT2.

The main differences between periods were as follow (Fig. 2): 1) an increase of time spent at low intensities (below PO VT1) from 42 % (SL) to 46 % (Ln), corrresponding to an increansing time spent of 57.1 % in zone 2 (14 % during SL and 22 % during Ln). 2) Moderate (zone 3) and high (zone 4) zones follow the same trend with a respective increase from SL to L1 of 42.8 and 44.4% and from L1 to Ln of 28.5 and 38.5%. 3) The time spent in zone 5 (very high) showed a decrease of 19,5 % and 33.3 % respectively between SL to L1 and L1 to Ln.

This study indicates that off-roads cyclist have physiological profiles similar to those of endurance athletes but should be taken into account when evaluating MB, the power to mass ratio. Furthermore, xco-mtb is conducted at very high intensity, especially during the start and showed a progressive reduction in speed and PO, coupled with an decrease in variability during the event. It requires a higher aerobic and anaerobic involvement than constant workload cycling exercises classically analyzed in laboratory settings, Ironman triathlons or road cycling (except time trial). The time spent below zone 2 and above MAP are more important than demonstrated by Stapelfeldt et al and must be in line with the evolution of current course (more technical sections and shorter race distance). More than ever, coaches must consider evolutions of the discipline when prescribing specific training programs.

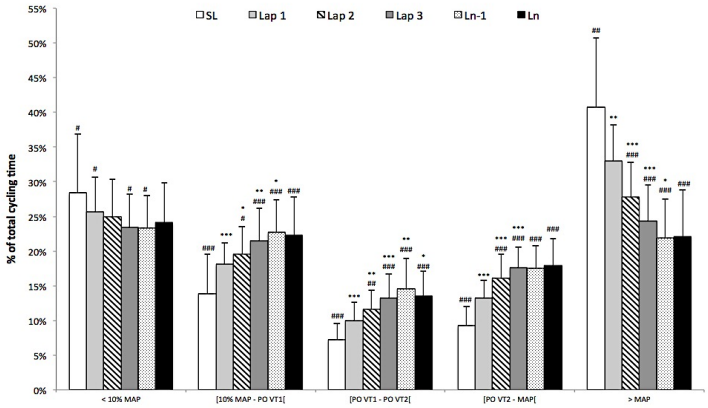

FIGURE 2—Percentage of total cycling time during each section (SL, L1, L2, L3, Ln-1, Ln) in exercise intensity zones: 1) below 10% MAP, 2) between *10% MAP* and PO VT1, *3)* between PO VT1 and PO VT2, *4)* between PO VT2 and MAP and above MAP. *Mean ± SD. *, Difference with the lap before; #, Difference with the first Lap. P < 0.05.*