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The Colombian Tour de France Winner Egan Bernal – Physiological Background

*Der kolumbianische Tour de France-Sieger Egan Bernal:
Sportphysiologische Hintergründe*

Egan Bernal, aged 22, the surprising winner of the Tour de France in this summer was welcomed enthusiastically in his native village Zipaquirá near the Colombian capital Bogotá in presence of several legendary previous master athletes. Since some years he already reached remarkable successes in contests and became therefore member of the British team Ineos. Environmental as well as genetic factors are probably influential for his outstanding performance.

Twenty years ago bicycling was little distributed in Colombia as means of daily transport in contrast to Europe. Because of the landscape with three huge mountain chains of the Andes this kind of transport is strenuous in many regions. However, some large cities like Bogotá or Cali are situated on extended plains. In the meantime cycling is there rather usual because of tremendous traffic congestions and a lacking subway system.

However, Colombians like the bicycle as sports equipment since some decades. In Bogotá large crossroads in the city are closed on Sundays for general traffic and occupied by thousands of bikers and in line-scaters who move on the temporary "Ciclovia" (cycle track).

High performance cycling (ciclismo) is also distributed since many years. The training conditions are excellent. On the one hand long distances on flat terrain may be covered, on the other hand extreme

descents and ascents are possible. Bogotá is situated on a 90km long plain at 2600m of altitude (Sabana de Bogotá) with mean temperatures during the day all the year like in the German autumn (18°). Near to the equator there are no seasons. At sunset always beginning at the same time people put on a pullover or the traditional ruana (poncho). The surrounding mountains reach about 3300m. Eastward there is a precipitous descent to 300m of altitude, where the large plains (Llanos) between Andes and Orinoco begin. Westward the roads lead downward reaching the Rio Magdalena at 400m of altitude. Daily temperatures rise to 30° in these regions. Therefore the athletes cycle on long flat distances as well as on ascents or descents, combining altitude training and heat stress.

Successful long distance athletes in Colombia are usually highlanders. Egan Bernal was born in Bogotá and lives in the town Zipaquirá 40km north of Bogotá at equal altitude. His father was an amateur cyclist, Egan got his first bicycle aged 5 years. The conditions are similar to those in Kenya and Ethiopia, where athletes live in the mountains (mostly, however below 2500m) and as children run their way to school each day two to four times.

For altitude adaptation genetic adaptation plays an essential role (1). Ameroindians reached Bogotá and surroundings approximately 10000 years ago, this is enough time to select alleles of genes which are favourable in hypoxia. The Muisca tribe lived in two principalities on the Sabana, probably they would have founded similar empires like in Mexico and Peru without the detection of America by Columbus in the year 1492.

The Muisca produced tremendous amounts of figures and jewellery made of gold; the exhibition in the „Museo de Oro“ in Bogotá presents beautiful examples. The rumours of „Eldorado“ (originally a gilded man during Indian ceremonies but interpreted as gold country) attracted three conquerors in 1538: As the first arrived Jimenez de Quesada who therefore became founder of the Spanish city Bogotá, then Sebastian de Belalcazar, finally the German Nikolaus Federmann, commander in the initially German colony Venezuela, possessed by the Welsers, a banker family in Augsburg.

As consequence of the conquest most Bogotaneans are mestizos with a large contribution from Spanish immigrants (7), but previously selected genes favorable at altitude also distribute in newcomers. Apparently only few European women followed the invaders, mitochondri-



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Figure 1

The Colombian Tour de France Winner Egan Bernal.



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Table 1

Blood properties and maximal oxygen uptake in male Germans and in Colombians living in Bogotá. SaO_2 rest=oxygen saturation in earlobe blood, ut=untrained. Means+standard deviations.

REGION	ALTITUDE [m]	SUBJECTS	SaO_2 REST [%]	[Hb] REST [g/dl]	Hb mass [g/kg]	VO_{2max} [ml / (kg*min)]	SOURCE
Germany	30	14 ut	98.1+0.8	15.3+0.8	11.7+0.8	45.7+3.4	3
Colombia	2600	15 ut	93.1+0.8	17.4+0.8	13.1+1.6	41.7+6.4	
	2600	14 runners	93.0+1.1	16.0+0.8	14.7+1.9	55.2+4.5	
Germany	340	12 ut		15.3 +0.8	11.0+1.1	45.3+3.2	11
	340	12 cyclists		15.8+0.7	15.4+0.9	68.2+2.7	
Colombia	2600	12 ut	92.0+0.9	16.3+0.7	13.4+0.9	39.6+4.0	
	2600	12 cyclists	92.4+ 1.2	15.8+0.7	17.1+1.4	69.9+4.4	

al genes which are only inherited from the mother are mainly of Ameroindian origin (10). This might be important for adaptation to hypoxia, because aerobic ATP production occurs in the mitochondria. Egan Bernal looks like a Muisca, a genetical analysis might discover which genes relevant for exercise he inherited from this population.

Our group of exercise physiologists in Berlin and Bayreuth collaborates since many years with Colombian scientists mainly in Bogota resulting in a series of publications. Performance, ventilation, O_2 and CO_2 transport in blood, hemoglobin mass regulation and buffering against lactic acid in untrained and trained subjects from Germany and Colombia have been compared (2, 3, 5, 11). A selection of results concerning hemoglobin and maximal oxygen uptake is presented in Table 1. Arterial oxygen saturation at rest is 5–6% lower than in Germany near sea level. Hemoglobin mass and thus the red cell volume are increased in untrained subjects as well as in athletes in Bogotá. Compared to untrained males in Germany (11–12 g/kg body mass) Hb-mass in Bogotá amounted to more than 13 g/kg, in trained runners to nearly 15 g/kg, in very well trained cyclists even to 17 g/kg. But this does not result in very high Hb concentrations in the athletes because of a concomitant rise

in plasma volume – a typical training effect. Maximal oxygen uptake reached 55.2 and 69.9 ml/(kg*min) in these athletes. After an acute change to an inspiratory PO_2 as at sea level the values in highlanders probably rise by less than 8% (6), i. e. to approximately 60 and 76 ml/(kg*min), respectively. Egan Bernal's value is markedly higher: according to a journal 88.8 ml/(kg*min) were measured at 120 m above sea level in Milan/Italy (9). This is among the highest values ever measured in humans. In contrast to highlanders the effect of an acute altitude change on maximal oxygen uptake is larger in sea level athletes, from measurements of Clark et al. (4) one may estimate -18% for an ascent to 2600 m above sea level. This is an additional advantage for highlanders in the mountaineous stages.

A role might also play the enforced training of respiratory muscles in hypoxia. It increases their endurance (8), thus delaying ventilatory exhaustion.

Thus, there are some physiological causes for the great success of a Colombian athlete. The rest is preparation, organisation, preparation, tactics and psychology. In future we may expect more from Egan Bernal. „Mucha suerte, Egan!“ (Good luck, Egan).

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