

PROJECT REVIEW

“Monitoring total hemoglobin mass (tHb) – the target parameter of endurance athletes- to detect blood manipulation “

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The aim of blood manipulations is to increase the total hemoglobin mass, which is directly correlated to maximum aerobic performance. When using the actual doping tests it is not yet possible to detect autologous blood transfusions or the application of all kinds of erythropoiesis boosting stimulants.

To avoid these illegal practices we recommend monitoring tHb-mass of endurance athletes over time. If the profile deviates substantially from the expected one the athlete has to undergo further follow-up testing. The athletes themselves can use these measurements to demonstrate objectively that they have not used blood doping practices.

As the hemoglobin mass could not yet be measured routinely, we have developed a precise and easy method with a typical error of 1.7%.

Doping with blood or EPO increases tHb-mass by at least 100g-150g. Preliminary data provide strong evidence that endurance training at sea level has no or only small effects on tHb. I.e. that tHb-mass can be used as a screening parameter for blood manipulations. The first purpose of the project, therefore, is to investigate individual variation of tHb-mass over a whole training year in a statistically powerful number (150) of elite endurance athletes.

A second goal of this Project is to compare the profile of all known candidate genes involved in erythropoiesis (gene polymorphisms of EPO-R, EPO, IGF 1 α) with the total hemoglobin mass.

As Germany and Australia provide the advantage of a central sports medical health system, large groups of elite athletes can be recruited for the planned measurements. At six medical centres from South Germany and at the Australian Institute of Sport tHb-mass will be repeatedly determined during all phases of a training year. Special emphasis will be placed on intensive training periods, altitude training, training breaks, and training interruptions due to illness or injury. Furthermore, the development of tHb-mass will be observed in junior athletes until maturation.

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Results and Conclusions

Doping with blood transfusions or stimulation of the erythropoietic system by various growth factors (e.g. protein-based erythropoiesis stimulating agents, EPO-mimetics, HIF stabilizers) has become a major problem in all endurance sports disciplines. The aim of all these manipulations is to increase total hemoglobin mass (tHb-mass), which is directly correlated with maximum aerobic performance.

The aim of the present project was to determine the normal variation of tHb-mass in elite endurance athletes over a period of at least one year and to quantify the effects of possible confounding factors (e.g. altitude, illness/injury). The final goal was to create reference values for tHb-mass of elite athletes which can be included into statistical models to judge the probability of blood manipulation.

In total, data of 327 elite athletes (228 males, 99 females) from Germany and Australia were collected. The disciplines were Nordic Skiing (n=97), Swimming (n=57), Cycling (n=53), Rowing and Kayaking (n=45), Running and Walking (n=32), Triathlon (n=16), and Australian Football (n=27). The mean number of tests per athlete was 5.0 ± 3.1 over a period of at least one year.

The most important result was the relatively low oscillation of tHb-mass over the period of one year and longer. This is reflected by a CV of 3.28% which is lower than the CV obtained for haemoglobin concentration or hematocrit (4.4%; 5.05%). When correcting for the confounding factors “altitude”, “illness/injury”, and “age less than 21 yrs” the weighted CV was only 2.75% (2.59% males, 3.05% females).

The effect of altitude depends on its dosage and form of application. 3-4 weeks of conventional altitude training increases tHb-mass by ~7% whereas the Live High Train Low-protocol shows no effect. When Kenyan athletes commute to low altitude the opposite effect in the same magnitude was observed. Severe inflammation or infection and severe injuries lasting more

than 2 weeks led to a pronounced decrease in tHb-mass. Adolescence was related to tHb-expansion up to the age of 21.

In summary, we conclude that tHb-mass is a very important parameter for the athlete's biological passport. The combination of tHb-mass and reticulocyte count considerably increases the sensitivity of the detection (99.9%) to 70% after reinfusion of 135g haemoglobin or 40% after reinfusion of ~45g hemoglobin. It can be used for long-term control over a whole season or even several years and also for short-term control before and immediately after endurance competitions. However, more data on the individual impact of confounding factors is necessary.