“Markers of fluid balance: Evaluating osmolality, albumin and blood lactate for the athlete biological passport”

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Project overview:

The ABP was proposed by WADA nearly a decade ago to longitudinally monitor and define an athlete’s individual blood variables in an attempt to indirectly detect doping. The ABP relies on the monitoring of blood variables sensitive to the administration of performance enhancing drugs (PEDs) to identify abnormalities in an athlete’s profile that cannot be explained by a normal physiological or pathological condition. When reviewing irregularities in an athlete’s blood profile, the experts must consider the effect confounding factors such as physical exercise have on the ABP. Indeed, studies have shown decreases in the absolute blood volume and increases in hemoglobin (HGB) concentration when subjects were acutely dehydrated. The ability to characterize an athlete’s hydration status at the time of blood collection would assist experts when reviewing irregularities in the ABP. The most widely used indicator of hydration status is osmolality, a measurement of the electrolyte-water balance in the body. Albumin is the most abundant protein in plasma and is largely responsible for attracting water into the circulatory system. Elevated albumin is typically a sign of dehydration. As lactate and other metabolites accumulate in working muscles, plasma water will be pulled to the working muscles thereby reducing plasma volume and elevating albumin concentration. Interestingly, increases in blood lactate correlate to decreases in plasma volume after maximal exercise. Therefore, it may be possible to indirectly assess relative plasma volume by measuring blood lactate. The purpose of the present study is to compare the changes in serum albumin, osmolality and lactate, potential markers of fluid balance, in the context of the ABP when athletes are subjected to cycling trials of varying levels of dehydration and exercise intensity. The inclusion of additional biomarkers in the ABP responsive to whole body hydration will strengthen the sensitivity of the ABP.

Results and Conclusions:

This study aimed to identify markers of dehydration not currently accounted for in the hematological passport, specifically serum albumin and serum osmolality, in addition to understanding the effect of exercise-induced dehydration on the current markers of the hematological passport (hemoglobin, reticulocyte%, OFF-score, and ABPS). Twelve subjects underwent multiple controlled exercise trials designed to induce varying levels of dehydration. Pre-exercise blood samples were collected to establish baseline values for individual passports. During exercise interventions, blood samples were collected before the start of exercise and immediately following

exercise at 10-minute, 1-hour, 2-hour, and 24-hour time points. Plasma volume (PV) decreases, as calculated using the Dill and Costill method, caused by dehydration-inducing exercise resulted in significant increases in hematological parameters (hemoglobin ([Hb]), hematocrit (Hct), serum albumin concentration (ALB), serum osmolality (Osm), and calculated OFF-Hr score) at varying time points following exercise. These changes (increases) in ALB were found to be highly correlated with changes in [Hb] ($r = 0.784$) and PV shifts ($r = 0.809$), while no correlation was identified between Osm and [Hb] or PV shifts. Additionally, the effect of exercise-induced dehydration was analyzed for each individual in the context of the Athlete Biological Passport. One case existed where the dehydration-induced increase in [Hb] triggered an atypical finding at 95% specificity, however no instances occurred at 99% specificity where increases in hematological variables or the athlete biological passport score (ABPS) exceeded the individual's upper threshold.

This study resulted in two key findings: 1) a strong correlation was identified between percentage changes in albumin and hemoglobin (and, thus, plasma volume) following dehydrating and euhydrated exercise; and 2) dehydration-inducing exercise resulted in one atypical finding at 95% specificity and many other unusual profiles when utilizing the Athlete Biological Passport program.