SPIROGRIFIC OXYGEN DEFICIT: AN OLD AND NEW APPROACH OF MEASURING SUBMAXIMAL ENDURANCE PERFORMANCE IN HYPEROXIA WITH A MODIFIED BREATH-BY-BREATHE SYSTEM
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INTRODUCTION: Several test procedures have been designed to quantify metabolic and respiratory function since KNIPPING introduced spiroergografic testing in 1929. Altering inspired oxygen content (FiO2) leads to several metabolic and cardio-respiratory reactions. HOLLMANN defined the spirografic oxygen deficit (SOD) in 1963 as the excess oxygen uptake (VO2) above 100 ml/min after changing FiO2 from normoxia (NO) to hyperoxia (HE) during steady state load. The SOD was measured by closed circuit spirographs and was regarded as the sufficiency limit of submaximal endurance performance due to the limiting factors of peripheral oxygen consumption. The goal of the study was to determine whether the intensity at which SOD appears relates to an increase in lactate (La) accumulation. The results document a non-invasive La-independent method of measuring submaximal endurance performance with a special breath-by-breath (bbb) apparatus.

METHOD: Twelve healthy male subjects (Age:24.1±2.1yrs, BMI:22.7kg/m²m, VO2max:51.4±8.7ml/min/kg) performed a ramp test (Start:100W/increase:30W/1min) on a cycleergometer to determine maximal power (Pmax). After three days rest, three test series were performed at 30 and 80%, 40 and 70%, 50 and 60% Pmax respectively followed with at least two days rest between series. Within-series rest-time between test-pairs was one hour. After five minutes of NO, FiO2 was increased to 100% O2 for five minutes. VO2, VC02, ventilation (VE), inspired and expired volume (Vin/Vex), breath frequency (BF) and heart rate (HR) were calculated at rest after 4, 6 and 9 min by a modified bbb spirograph (ZAN 600 USB). Arterial O2 and CO2 partial pressure (paO2/paCO2) and pH (Ometech Opti 3) as well as La (EbioPlus) were measured at rest, after 4 and 9 min.

RESULT: paO2 increased 6-fold to 506 mmHg during HE vs NO (p<0.01). Excess VO2 over 100ml/min from NO to HE were measured at 70% Pmax (245 Watt; 168 ml/min). Significant excess was detected at 80% Pmax (288 Watt; 179 ml/min). VO2 and paCO2 (+3.7-12.9) peak to end of HE vs NO (p<0.01). Vin und Vex increased significantly in HE vs NO during 30, 40, 70% Pmax (p<0.05). After one minute of HE VE (-6,4%) and BF (-27%) decreased significantly (p<0.01). pH and HR decreasesd significantly during HE vs NO (p<0.01). La accumulated significantly during HE vs NO at 70% Pmax (p<0.05).

DISCUSSION and CONCLUSION: The results demonstrate a reproduction of the SOD with a modified open breath-by-breath spirografic device. The SOD occurs in healthy subjects at 70% Pmax accompanied with a significant increase in La and pH drop. The initial respiratory depression, visible by decrease in VE and BF, shows a dominant respiratory control of O2 at the beginning of HE. Subsequent hyperventilation occurs due to increasing paCO2. The results show that the measurement of SOD is a possible non-invasive tool for evaluating submaximal endurance performance with a special bbb apparatus.

Keywords: Testing, Endurance, Gas Exchange