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Correlation between Muscle oxygen and Cardiopulmonary of young cyclists at Ventilation threshold

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Objective To investigate the relationship between Near-infrared spectroscopy (NIRS)-derived muscle oxygen saturation (SmO_2) and Cardiopulmonary indexes at the Ventilatory threshold (VT1 and VT2) during Cardiopulmonary exercise test (CPET) ofyoung cyclists.

Methods 12 young cyclists performed a maximal incremental exercise test to exhaustion on a friction-braked cycle ergometer (Monark 839E, Sweden).Heart rate (Polar RS400, Finland) and respiratory gas exchange were measured during the Resting and exercise phases using a breath-by-breath system. SmO_2 of active muscles during cycling was measured by NIRS monitors (Fortiori Design LLC, USA), and three of the monitors were placed on both vastus lateralis (VLL & VLR) and left gastrocnemius lateralis (GLL) of left leg. The resting value of the SmO_2 of the GLL (SmO_2-GLL), the left vastus lateralis (SmO_2-VLL), and the right vastus lateralis (SmO_2-VLR) was recorded as a baseline. Then after VT1 and VT2 of each subject were measured by the V-slope method during a CPET, values of muscle oxygen corresponding to the three lower limb sites at two ventilation thresholds was recorded to reflect the muscle oxygenation level at the anaerobic threshold; And the change of muscle oxygen relative to the baseline was calculated to reflect the degree of muscle deoxygenation, which is termed as deoxygenation indexes(ΔSmO_2-GLL, ΔSmO_2-VLL, ΔSmO_2-VLR); As well, Cardiopulmonary indexes including Heart rate (HR), Minute ventilation (VE), Relative oxygen uptake (VO_2R), Carbon dioxide production (VCO_2) and Respiratory exchange rate (RER) at the Ventilatory threshold were measured. All Results were expressed as mean ± standard deviation. Finally, Pearson correlation analysis was used to determine the relationship between multi-site muscle oxygen saturation of lower extremities and Cardiopulmonary indexes (HR, VE, VO_2R, VCO_2, RER). The significance level was defined as p<0.05.

Results Each subject performed their best to complete the aerobic capacity test. The average VO_{2peak} of the 12 subjects was 42.77 ± 9.69 ml/kg/min (Male: 47.38 ± 9.41 ml/kg/min; Female: 36.31 ± 3.33 ml/kg/min). At rest, the calf and thigh SmO_2 were 67.92%± 6.84% (SmO_2-GLL), 61.42% ± 13.77% (SmO_2-VLL), 64.83% ± 10.62% (SmO_2-VLR)respectively; HR, VE, VO_2, VO_2R, VCO_2 and RER were 112.08 ± 14.38, 25.96 ± 8.74 L / min 0.94 ± 0.32 L/min, 15.82 ± 4.30 ml/kg/min, 0.81 ± 0.24 L/min,0.88 ± 0.12 L/min, and 0.38 ± 0.07, respectively. Correlation analysis shows that when adolescent athletes reached the anaerobic threshold level, there was a significant correlation between muscle oxygen and cardiopulmonary: At the time of VT1, for Oxygenation index, SmO_2 of GLL was highly negatively correlated with HR (r=-0.69,p<0.05), VE (r=-0.71, p<0.01), VO_2R (r=-0.65, p<0.05), VCO_2 (r=-0.66, p<0.05) and RER (r=-0.58, p<0.05); SmO_2-VLL was also highly negatively correlated with VE (r=-0.70, p<0.05), VO_2R (r=-0.70, p<0.05), VCO_2 (r=-0.66, p<0.05); Additionally, there is also high inverse correlation between SmO_2-VLR and HR (r=-0.66, p<0.05), VE (r=-0.70, p<0.05), VO_2R (r=-0.66, p<0.05), VCO_2 (r=-0.68, p<0.05), RER (r=-0.60, p<0.05). In terms of deoxygenation indexes, ΔSmO_2-GLL was highly negatively correlated with VE (r=-0.61, p<0.05), VO_2R (r=-0.64, p<0.05) and VCO_2 (r=-0.59, p<0.05); While, ΔSmO-$_2$-VLL was highly negatively correlated with HR (r=-0.62, p<0.05), VE (r=-0.72, p<0.01),VO_2R (r=-0.80, p<0.01) and VCO_2(r=-0.84, p<0.01); ΔSmO_2-VLR was correlated with HR (r=-0.75, p<0.01), VE (r=-0.62, p<0.05), VO_2R (r=-0.58, p<0.05) and RER (r=-0.74, p<0.01), and it also shows highly negative correlation. When VT2 occurred, only SmO_2 of the GLL in the oxygenation indexes was highly positively correlated with

HR (r=0.65, p<0.05), there was no correlation between GLL-SmO_2 and any other gas exchange indexes. In terms of muscle deoxygenation indexes, only ΔSmO_2 in the thigh VLR was significantly negatively correlated with RER (r=-0.75, p<0.01).

Conclusions Based on these results, there is a high correlation between NIRS-derived regional muscle oxygen saturation (Oxygenation and Deoxygenation indexes) of lower extremities and cardiopulmonary index (HR, VE, VO_2R, VCO_2, RER) during CPET of young cyclists at first Ventilatory threshold, however, it is still unclear whether there is a significant correlation between muscle oxygen saturation of lower extremities and other cardiopulmonary indexes when second Ventilatory threshold occurs except Heart rate or Minute ventilation.