順天堂大学大学院スポーツ健康科学研究科
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Voluntary hypoventilation が持久的運動中の生理学的応答と運動継続時間に与える影響

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【目的】

息止めを伴わず、呼吸頻度を低下させた hypoventilation(voluntary hypoventilation)が OBLA(onset of blood lactate accumulation)仕事率でペダリング運動(60rpm)をした際の運動継続時間、呼気ガス応答、心拍数(HR)、rating of perceived exertion (RPE)、血中[La^-]、血液ガスに与える影響について検証した。

【方法】

持久的スポーツ競技者 16 名(男子学生 6 名、女子学生 10 名)を対象とし、血中[La^-]が 4mM(OBLA)となる仕事率で疲労困憊テストを①通常呼吸条件(CON 条件)と②voluntary hypoventilation 条件(HYPO 条件)にて実施した。全ての被験者は CON 条件を最初に実施し、HYPO 条件では呼吸頻度が CON 条件の 60%になるよう規定された(2.5 分毎に更新)。運動中の呼気ガスは breath-by-breath 法により常時モニタリングされた(統計は 2.5 分毎の平均値を使用)。心拍数、RPE、血中[La^-]は 5 分毎に、血液ガスは安静時及び運動終了時に計測された。

【結果】

CON 条件と比較して HYPO 条件では TV_E、$P_{ET}CO_2$、$\dot{V}O_2$ の増加、及び $\dot{V}_E$、RR、$\dot{V}_E/\dot{V}O_2$、$\dot{V}_E/\dot{V}CO_2$ の低下が観られた($p \leq 0.001$-0.043)。RPE は運動初期段階においてのみ HYPO 条件で高値を示した($p=0.021$)。運動継続時間、HR、血中[La^-]、血液ガス、$\dot{V}CO_2$ は条件間に差は観られなかった。

【結論】

Voluntary hypoventilation にて OBLA 強度の運動をした場合、通常呼吸と比べて $\dot{V}O_2$ は増加したが、運動継続時間、HR、RPE、血中[La^-]、血液ガスに変化は観られなかった。

Effects of voluntary hypoventilation on physiological responses and exercise duration during continuous exercise

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[Purpose]
This study aimed to examine the effects of voluntary hypoventilation, implemented without breath-holding, on physiological responses and exercise duration during continuous pedaling exercise (60 rpm) at the work rate corresponding to the onset of blood lactate accumulation (OBLA), where blood lactate concentration reaches 4 mM.

[Methods]
Sixteen university athletes in endurance events (6 males and 10 females) participated in this study. First, they performed an incremental exercise test on an electrically braked cycle ergometer to identify the work rate at OBLA (WR_{OBLA}). Subsequently, continuous exercise tests at WR_{OBLA} were performed on two separate occasions: initially under normal breathing condition (CON), followed by voluntary hypoventilation condition (HYPO). In the CON condition, normal respiratory rates during the exercise (RR_{norm}) were established for each participant. In the HYPO condition, participants were asked to maintain their 60%RR_{norm} throughout the exercise (assisted by metronome tempo and adjusted every 2.5 min) to lower minute ventilation ($\dot{V}_E$). During the exercise test, the exercise duration, respiratory parameters, heart rate (HR), rating of perceived exertion (RPE), the concentration of blood lactate ($[La^-]$), and blood gases (pH, PO_2, PCO_2) were measured and compared between the two conditions.

[Results]
The HYPO condition resulted in greater TV_E, $P_{ET}CO_2$, and $\dot{V}O_2$, and lower $\dot{V}_E$, RR, $\dot{V}_E/\dot{V}O_2$, and $\dot{V}_E/\dot{V}CO_2$ than in the CON condition ($p \leq 0.001$-0.043). RPEs were higher for HYPO in the early phase of exercise ($p=0.021$), and the differences disappeared afterwards. $\dot{V}CO_2$, HR, blood $[La^-]$, and blood gases were not significantly different between conditions.

[Conclusion]
When voluntary hypoventilation, achieved without breath-holding, was applied during continuous pedaling exercise at WR_{OBLA}, $\dot{V}O_2$ was elevated, whereas exercise duration, HR, RPE, blood $[La^-]$, and blood gases were unaffected.