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学位の種類	博士（ 学術 ）
学位記番号	甲　第　82　号
学位授与の日付	平成 26 年 3 月 20 日
学位授与の要件	信州大学学位規程第 5 条第 1 項該当
学位論文題目	Influences of Hyperoxia and Psychological Task on Fluctuations in Local Muscle Fatigue
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論　文　内　容　の　要　旨

Influences of Hyperoxia and Psychological Task on Fluctuations in Local Muscle Fatigue

Local muscle fatigue represents a complex phenomenon that encompasses various factors; structural and energetic changes in local muscle tissues, and changes in activity level and the efficiency of the nervous system. Muscle fatigue, therefore, is also referred to as neuromuscular fatigue and is divided into two headings based upon the location of where the fatigue is induced; central and peripheral fatigue. For athletic population, acutely developed local muscle fatigue is the most commonly encountered and troubling form of fatigue in training and competitions. Therefore, in order to avoid sports-related musculoskeletal injuries, having an adequate recovery from the local muscle fatigue plays an important role.

This study mainly contains three experiments and each examined if recovery from local muscle fatigue is enhanced by supplementation of oxygen under the normobaric hyperoxic environment and attempted to reveal the relevance with central and peripheral factors in neuromuscular fatigue. Furthermore, in understanding the comprehensive recovery mechanism, the third study examined the influences of psychological task, which would cause central fatigue, on fatigability in a lower extremity muscle.

Hyperoxia therapy has been considered and applied in sports field for the purpose of healing musculoskeletal injuries, increasing performance level, and accelerating recovery from daily training. While the evidence is mixed, it became obvious from the results in this study (Chapter 2 and 3) that when the body in need of oxygen, supplemental oxygen will work efficiently for athletes, such as exposure to hyperoxia “during” aerobic activity and the “recovery phase” from oxygen debt. In other words, when the body is in conditions that sufficient oxygen is already supplied, hyperoxia will not provide any additional effects, such as the use of oxygen supplementation “before” exercises. This result could be a clear guidance for people who research the effects of supplemental oxygen in the future when they consider the “timing” of oxygen use and the “type of exercise” applied on participants.

Based on the findings in the study (Chapter 2) which aimed to clarify the effectiveness of exposure to normobaric hyperoxia during recovery process, it is recommended to coaches and field practitioners to utilize 30 minutes of exposure to normobaric hyperoxia as a recovery strategy from local muscle fatigue acutely developed by anaerobic exercise in training and competitions. By doing this, athletes would be able to perform as well as before without leaving the influence of local muscle fatigue, although performance may decrease approximately 10% if they had stayed under normoxic environment for the same duration. In addition, the results in the second experiment (Chapter 3) which applied intermittent intensive exercise as the physical workload on subjects also revealed that two 15 minute recovery sessions in normobaric hyperoxia enhanced the restoration of MVIC and the recovery rate would be approximately 14% greater in hyperoxia than in normoxia.

The third study (Chapter 4) which examined the relationship between physical and psychological tasks made clear that 20 minutes calculating psychological workload increased the cerebral excitation levels and it caused a greater local muscle fatigue in the lower extremity. This would be because that the psychological task had an impact on available attentional resources of the prefrontal cortex which is also activated by muscular contractions. In turn, prior added psychological workload caused less availability of attentional resources for contracting the local muscle. Given that this study was brought under high-intensity isometric contraction, it is possible to consider the application of this result into sports field which people are often required to play under stressful conditions physically and psychologically. This kind of activity demands high levels of concentration, resulting in increased excitation in the cortex. Along with maximum physical exertions, it would accelerate the progression of local muscle fatigue and delay the recovery from the fatigue due to the prolonged effects of psychological demands. From this point of view, athletes and coaches may need to be careful about mentally more stressful conditions, like crucial and important matches and games, and to prepare adequate strategies for quicker recovery from the muscle fatigue in order to avoid the onset of sports-related musculoskeletal injuries.

Local muscle fatigue is a complicated phenomenon containing influences of numerous factors such as central and peripheral elements. This might be the major reason why athletes have continued to develop sports-related injuries in this medically developed modern society. It is, therefore, our responsibility to keep up searching the recovery mechanism from local muscle fatigue, and providing new evidence regarding how athletes could be recovered psychologically as well as physically. For better recovery strategy from local muscle fatigue, it is necessary to have better understanding of mechanism in local muscle fatigue. The present study could have some suggestions for those who have sought better approaches for players' recovery.