The effect of pre-cooling on fatigue and quadriceps femoris performance

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INTRODUCTION

Pre-cooling strategies are frequently used for the purpose of reducing body temperature prior to exercise, decreasing heat stress and improving performance. Pre-cooling methods can be used to combat the debilitating effects of heat-stress-induced fatigue to increase heat storage capacity and to improve exercise tolerance. It has already been demonstrated that exhaustive exercises do not only cause peripheral-, but also central fatigue, leading to decreased muscle contractility. Recently published results showed, that central- and peripheral fatigue can be described as changes in fractal dimension (FD) and muscle fiber conduction velocity (CV) detected from surface EMG (sEMG) signals. The aim of this study was to determine the effects of a single pre-cooling application on both central- and peripheral fatigue, using FD and CV, during 60% of maximum voluntary contractions (MVC) of the right quadriceps muscle until exhaustion. Furthermore, the effects of a single pre-cooling application on MVC of the right quadriceps femoris muscle and ratings of perceived exertion (RPE) were investigated.

METHODS

Eighteen healthy and physically active adults participated in this study. The participants received either a cold application (+8°C) or a thermoneutral application (+32°C) for 20 minutes on their right thigh (one cuff). After the application, peripheral- and central fatigue were estimated using sEMG parameters during 60% of MVC on a custom made ergometer chair (COR-1) at a knee angle of 120°. The myoelectrical signals were detected from the vastus medialis (VM) and vastus lateralis (VL) from semidisposable, bidimensional arrays of 16 electrodes. The EMG signals were amplified (EMG-US82, OT Bioelectronica, Torino, Italy), band-pass filtered (10-750 Hz) and sampled at 2048 Hz. Immediately after the submaximal task until exhaustion, MVC and RPE were assessed.

RESULTS

Both the cold and the thermoneutral groups showed signs of central and peripheral fatigue during the 60% of MVC, indicating a perceived exertion due to the force output over time. The negative slopes could be observed in both the VM and the VL of the quadriceps femoris muscle. The negative slope (%/sec) of FD during 60% MVC was significantly higher in the thermoneural group compared to the cold group (p=0.03, d=1.05). The end values of FD were significantly lower in the thermoneural group compared to the cold group (p=0.01, d=0.85). The decrease in CV (%/s) was significantly higher in the cold group during 60% of MVC compared to the thermoneural group (p=0.008, d=1.21). However, the participants in the cold group were able to resist 32 seconds longer against their individual 60% of MVC compared to the thermoneural group. These results were significantly different between the groups (p=0.04, d=1.07). Pre-cooling had no significant effect on MVC and RPE.

DISCUSSION

It has been demonstrated that cold applications significantly decrease sensory- and also motor nerve CV with greater effects on the sensory nerve. The inhibited afferent feedback from the sensory nerve, due to the significantly higher decreased CV in the cold group, might explain the inhibition of central fatigue signs in this group. It can be hypothesized that the thermoneural application did not affect the transmission of the sensory nerve significantly, allowing enough afferent feedback to the central nervous system in order to produce significantly more signs of central fatigue. Pre-cooling did not affect MVC and RPE. Earlier studies demonstrated already that isometric force production starts to reduce due to peripheral muscle cooling at any temperature below 25°C.

CONCLUSION

Local pre-cooling of the thigh resulted in significant faster peripheral fatigue of the quadriceps muscle during 60% MVC. However, cooling inhibited central fatigue and led to significant longer contraction times. The thermoneural group had significantly higher signs of central fatigue at the end of the submaximal task. Pre-cooling had no effect on MVC and RPE in this experimental set-up. The results of this study might indicate that decreased muscle fiber CV do not limit endurance capacity, respectively time in 60% of MVC.

References

Adam et al. 2003, PMID: 14615422; Beretta-Piccoli et al. 2015, PMID: 25880369; Bigland-Ritchie et al. 1978, PMID: 657729;

Fig. 1 ** Indicates significant different negative slopes (%/sec) between groups.

Fig. 2 Change of MVC and RPE (means ± SD)

Fig. 3 Assessment of central and peripheral fatigue