EXAMINING THE RELATIONSHIP BETWEEN ENDOGENOUS PAIN MODULATION AND EXERCISE

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Abstract

The physiological processes that underpin the perception of pain are complex, involving neural systems which act to manipulate the perception of pain through endogenous pain inhibition and facilitation. Dynamic pain assessment, including the conditioned pain modulation (CPM) protocol, allow for the assessment of the efficiency of this endogenous system of pain modulation. Athletes regularly experience pain through the performance of physically demanding tasks and, perhaps as a result of this repeated exposure, are better able to tolerate pain than non-athletes. However, whether athletes possess a more efficient system of endogenous pain modulation, involving enhanced inhibition and/or reduced facilitation, remains to be fully clarified. In addition, although pain is considered an important factor in the performance of physically fatiguing exercise, research to-date has not yet examined whether a more efficient system of endogenous pain modulation is beneficial for endurance exercise performance.

Therefore, the current thesis has two primary research aims: 1) compare the pain modulatory capacity of athletes and non-athletes; and 2) assess the role of endogenous pain modulation in endurance exercise performance. Based on pre-existing literature, it is hypothesised that: 1) athletes will display enhanced pain modulatory capacity when compared to non-athletes; and 2) that an elevated endogenous pain modulatory capacity will result in increased endurance exercise performance.

This thesis includes seven chapters, beginning with an introduction (Chapter I) followed by a literature review (Chapter II), four research papers (Chapters III-VI) and a discussion (Chapter VII). The research papers present four studies which address the primary aims and hypotheses of the thesis. In Study 1 (Chapter III) the endogenous pain modulation

of athletes and non-athletes was compared. As hypothesised, athletes displayed enhanced endogenous pain modulatory capacity when compared to age- and sex-matched non-athletes. Study 2 (Chapter IV) assessed the relationship between endogenous pain modulation and endurance exercise performance. Those displaying elevated endogenous pain inhibitory responses were shown to produce longer endurance times in a sustained muscular contraction. In Study 3 (Chapter V) high-definition transcranial direct current stimulation (HD-tDCS), a form of non-invasive electrical brain stimulation, was examined as a method for the enhancement of endogenous pain modulatory capacity. HD-tDCS was shown to significantly enhance endogenous pain modulatory capacity, offering a method for the experimental manipulation of endogenous pain modulation. Extending upon these findings, HD-tDCS was used in Study 4 (Chapter VI) to examine the effect of enhanced endogenous pain modulation on endurance exercise. Despite successfully increasing endogenous pain modulatory function, HD-tDCS did not increase endurance exercise performance. Therefore, although enhanced endogenous pain modulatory capacity was shown to be related to endurance exercise performance, experimental manipulation of endogenous pain modulation did not cause changes in endurance exercise performance. These findings partially reject the second hypothesis of this thesis and indicate that mediating factors may account for the observed relationship between endogenous pain modulation and endurance exercise.

The findings presented in this thesis are of significant importance to the incremental advancement of knowledge in this field. As previous research has largely failed to utilise dynamic pain assessment, this thesis offers the first comprehensive discussion of the relationship between endogenous pain modulation and exercise. The findings also have significant practical implications, including implications for the treatment of chronic pain, the selection of athletes and the use of novel methods of exercise performance-enhancement.

Publications Arising from this Thesis

1. Flood, A., Waddington, G., Thompson, K., & Cathcart, S. (2017). Increased conditioned pain modulation in athletes. *Journal of Sports Sciences, 35,* 1066-1072. doi: 10.1080/02640414.2016.1210196
2. Flood, A., Waddington, G., & Cathcart, S. (in press). Examining the relationship between endogenous pain modulation capacity and endurance exercise performance. *Research in Sports Medicine*
3. Flood, A., Waddington, G., & Cathcart, S. (2016). High-definition transcranial direct current stimulation enhances conditioned pain modulation in healthy volunteers: a randomized trial. *The Journal of Pain, 17,* 600-605. doi: 10.1016/j.jpain.2016.01.472
4. Flood, A., Waddington, G., Keegan, R. J., Thompson, K. G., & Cathcart, S. (2017). The effects of elevated pain inhibition on endurance exercise performance. *PeerJ, 5,* e3028. doi: 10.7717/peerj.3028

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List of Abbreviations

ACC	Anterior cingulate cortex
CGM	Central governor model
CPM	Conditioned pain modulation
DNIC	Diffuse noxious inhibitory control
DOMS	Delayed-onset muscle soreness
EIH	Exercise-induce hypoalgesia
HD-tDCS	High-definition transcranial direct current stimulation
IASP	International Association for the Study of Pain
LTD	Long-term depression
LTP	Long-term potentiation
NMDA	N-methyl-D-aspartate
NS	Nociception specific
PAG	Periaqueductal gray
RVM	Rostral ventromedial medulla
tDCS	Transcranial direct current stimulation
WDR	Wide-dynamic range

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