Thermoregulatory Issues for Paralympic Athletes

KATY E. GRIGGS*1) 2)

*1)Department of Sport, Health Sciences and Social Work, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK, *2)The Peter Harrison Centre for Disability Sport, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK

Individuals with a spinal cord injury (SCI) are thermoregulatory impaired, due to their reduced heat loss capacity, as a result of a loss in sweating capacity and vasomotor control below their lesion level. Previous research has neglected to undertake studies that reflect real-world sporting scenarios for this population group, affecting the translation of these findings into meaningful performance enhancements. Thus, our work aimed to investigate the thermoregulatory responses of athletes with a SCI during real-world sporting scenarios, with particular focus on athletes with tetraplegia. Our work has shown that in indoor playing environments, representing wheelchair court sports, athletes with tetraplegia are under greater thermal strain than athletes with paraplegia and athletes with non-spinal related physical impairments. To reduce thermal strain in able-bodied athletes, cooling strategies have been shown to be effective, but research in this area is limited for athletes with a SCI. Our work demonstrates that a combination of current cooling strategies (pre-cooling using an ice vest and water sprays between quarters) used in wheelchair rugby were found to be effective at reducing thermal strain compared to no cooling or pre-cooling alone. Although neither cooling strategy improved performance. Recommendations for the use of cooling strategies for athletes with an SCI are to take an individualised approach and use in align with the practicalities and regulations of the sport.

Key words: Paralympic, thermoregulation, spinal cord injury, wheelchair sport

Introduction

A number of disability groups that are eligible to compete in Paralympic sport may have difficulty controlling their body temperature or require specific considerations when competing in hot and/or humid conditions, such as athletes with cerebral palsy, multiple sclerosis, visual impairment and amputation. However, the disability group that has the greatest thermoregulatory impairment in Paralympic sport is athletes with a spinal cord injury (SCI).

Following Rio de Janeiro 2016, the Tokyo 2020 Paralympic Games will pose a potential challenge for athletes, who will need to prepare and compete in the challenging environmental conditions of 20–27°C and ~73% relative humidity (RH). Copious amounts of research in able-bodied athletes has shown that during exercise in hot and/or humid environmental conditions, athletes experience both an increase in thermal strain and a reduction in sporting performance compared to cooler/drier conditions. Despite a large percentage of athletes with an SCI competing indoors in wheelchair court sports, exercising even in these climate-controlled environments has been shown to cause considerable thermal strain for these athletes. Therefore, this article will focus on the thermoregulatory
responses of athletes with an SCI during real-world sporting scenarios. To date, the thermoregulatory responses of this athletic population group has been an under-studied area of research.

Physiological function – Spinal cord injury

An SCI is a total or partial disruption to the structure and function of the spinal cord, usually caused by a form of trauma. The injury results in a number of physiological changes, such as autonomic nervous system dysfunction, sensation loss and paralysis below the lesion level. Individuals are classified as either having tetraplegia or paraplegia, depending on their lesion level. Tetraplegia (TP) is defined as an impairment or loss of motor and/or sensory function of the cervical segments of the spinal cord. These individuals have impaired function of the arms, trunk, legs and pelvic organs. Paraplegia (PA) is defined as an impairment or loss of motor and/or sensory function of the thoracic, lumbar and sacral segments of the spinal cord. These individuals have full arm function whilst the function of the trunk, legs and pelvic organs may be impaired.

In individuals with an SCI varying degrees of disruption to the sympathetic and parasympathetic nervous system are apparent, such as muscular and vascular atrophy in the lower limbs. Individuals with PA have a partial loss to the sympathetic nervous system and loss of the sacral portion of the parasympathetic nervous system. As a result of the highest level of sympathetic outflow occurring at the T1 spinal level, individuals with TP incur decentralisation of their sympathetic nervous system. As a result of the disruption to the sympathetic nervous system, individuals with an SCI have a loss in sweating capacity and vasomotor control below their lesion level, resulting in thermal dysfunction.

Exercise studies

Even though exercise protocols have been developed over the years to represent the intermittent nature of wheelchair court sports, many of these protocols lack ecological validity, in relation to the modality, exercise intensity and/or ambient conditions used. The small sample sizes of these studies, also limits the ability to draw firm conclusions, especially due to the heterogeneous nature of the SCI population. In addition, few exercise studies have been conducted investigating the thermoregulatory responses of athletes with TP.

Griggs et al.5) aimed to investigate the thermoregulatory responses of both highly trained athletes with paraplegia (PA) and tetraplegia (TP) during intermittent wheelchair exercise to overcome the shortcomings of previous literature. Eight athletes with PA and eight athletes with TP volunteered to participate in the study. Both groups undertook a 60 min intermittent sprint wheelchair protocol in ~21°C, ~40% RH on a wheelchair ergometer. Although similar external work was conducted by both groups (P = 0.70) a greater gastrointestinal temperature (Tgi, p<0.05), used as a marker of core temperature, and mean skin temperature (Tsk, p<0.05) response was demonstrated by TP during the protocol. Thus, thermoregulatory differences between the groups were predominantly due to differences in heat loss as a result of their lesion level. The active and passive recovery between maximal-effort bouts of the protocol did not have an effect on thermal strain in TP, as Tgi continually increased throughout the protocol.

To gain a greater understanding of the thermoregulatory responses of athletes with TP in actual competition, Griggs et al.6) measured Tgi and Tsk during a wheelchair rugby match consisting of players with TP and non-spinal related physical impairments. Despite covering less distance and pushing slower (both p<0.05) during match play players with TP were under greater thermal strain, as a result of their reduced heat loss capacity due to their injury level, and not as a result of their activity profile.

Cooling strategies

Even though there has been considerable interest in the application of cooling strategies for the able-bodied athlete, comparatively little is known regarding the use of cooling strategies for athletes with an SCI. Drawing on the current literature, it is difficult to establish an optimal cooling strategy due to the mix of environmental conditions, exercise modalities, protocols and training status of participants. Thus, Griggs et al.7) aimed to address the
limitations of previous studies and replicate a real world sporting scenario, including highly trained athletes, to ensure research findings could be translated into meaningful performance enhancements.

For the study, eight highly trained wheelchair rugby athletes volunteered to participate. Each athlete took part in three conditions, no cooling (NC), pre-cooling with an ice vest (P) and a combination of methods using pre-cooling with an ice vest and water sprays between quarters (PW). In each condition, athletes completed 60 minutes of intermittent wheelchair exercise on a wheelchair ergometer in ~20°C and ~33% relative humidity, which was preceded by a 15 min passive rest period and a 20 min warm-up. In P and PW the ice vest was worn during both the rest and warm-up period and removed prior to the start of the intermittent sprint protocol. The protocol aimed to represent a wheelchair rugby match based on data previously collected during competitive match-play by an indoor tracking system (Ubisense, Cambridge, UK) in Griggs et al.6.

The change in Tgi over the intermittent sprint protocol was significantly lower in PW and P compared to NC (p<0.05, Figure-1), whilst the change in Tsk was significantly lower in PW compared to P and NC (p<0.05, Figure-2). At the end of the protocol, Tgi in PW was significantly lower than P (Figure-1). Therefore the authors concluded that in athletes with tetraplegia, water spraying between quarters combined with pre-cooling using an ice vest lowers thermal strain to a greater degree than pre-cooling only, whilst having no effect on simulated wheelchair rugby performance or perceptual responses.

Practically, the choice of cooling strategy for athletes with an SCI, similarly to the able-bodied athlete, is dependent on the sporting regulations, practicality of the method and the nature and demands of the sport. Cooling strategies need to be considered on an individual basis to both maximise the cooling effectiveness and minimise disruption to the athlete.

Summary

In summary, athletes with TP experience heightened thermal strain during “real-world” sporting scenarios compared to athletes with PA, and within the sport of wheelchair rugby. Athletes with TP
should employ practices, such as appropriate cooling methods or alter playing tactics to reduce thermal strain. Despite the current cooling practices used in wheelchair rugby being effective at attenuating core and mean skin temperature of these athletes, potential avenues for future cooling strategy research need to be addressed.

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Figure 2
Change in mean skin temperature over the pre-cooling period and the intermittent sprint protocol for the three conditions; no cooling (NC), pre-cooling using an ice vest (P) and pre-cooling using an ice vest and water sprays between quarters (PW). a: significant difference between NC and P, p<0.05. b: Significant difference between NC and PW, p<0.05. c: Significant difference between P and PW, p<0.05. (Figure re-drawn from Griggs et al: Int J Sport Med, 2017; 38: 177-183)