Cold-induced vasodilation and vasoconstriction in the finger of tropical and temperate indigenes

Joo-Young Lee, Ilham Bakri, Asako Matsuo, Yutaka Tochihara

Department of Human Science, Kyoto University, Japan
Laboratory for Clothing and Health in Extreme Environments (CHEME), Department of Clothing and Textile College of Human Ecology, Seoul National University, I-Campus, Seoul, South Korea
Institute of Human Biology, Seoul National University, Korea

Abstract

While heat acclimation reflects the development of heat tolerance, it may weaken an ability to tolerate cold. The purpose of this study was to explore cold-induced vasodilation (CIVD) responses in the fingers of tropical indigenes during finger cold immersion, along with temperate indigenes. The subjects were divided into four groups: tropical male indigenes (subjects born and raised in Japan and China) and temperate male indigenes (subjects born and raised in Kansas and Indiana). Fingertip temperature, skin temperature, finger skin blood flow, blood pressure, and subjective sensations were recorded during the test. The results showed that: (1) the tropical group demonstrated a lower minimum ($T_{min}$), maximum ($T_{max}$), and mean finger temperature ($T_{avg}$) compared to the temperate group ($\text{P}<0.05$); (2) seven tropical indigenes demonstrated a late-platistyle CIVD pattern, which is characterized by an increased finger skin temperature and a single CIVD with a faint and weak vasodilation, whereas no temperate indigenes demonstrated the late-platistyle type; and (3) the hand temperature at the end of finger immersion was $3^\circ\text{C}$ lower in the tropical group than the temperate group ($\text{P}<0.05$). These results indicate that tropical indigenes have less active responses of arterio-venous anastomosis in the finger and weaker vasodilation after the first CIVD response during finger cold immersion, which can be considered as being more vulnerable to cold injury of the periphery in severe cold.

1. Introduction

The cold-induced vasodilation (CIVD) phenomenon was first identified by Lewis (1930) and, to date, the underlying mechanisms of CIVD are still unclear and debated. CIVD is a complex response that is initiated by the dilation of arteriovenous anastomoses (AVAs), which is mediated by local and/or central pathways such as an axon reflex, a release of a dilating substance, a local paralysis of smooth muscles in the vessel wall, or a decreased release of noradrenalin.

Since the 1930s, various populations, who were generally or locally exposed to cold, have been investigated to help researchers comprehend the exact mechanisms of CIVD. These studies have found that people working with their hands in a cold environment or people who were born and raised in cold regions, showed more pronounced CIVD responses. Three more pronounced CIVD responses are characterized by a shorter onset time of CIVD and a higher finger skin temperature during cold immersion (Adams and Smith, 1962; Bauer et al., 1960; Hirose et al., 1960; Krog et al., 1960; Leblanc et al., 1960; Meethan, 1955; Nielsen and Sager, 1962). On the other hand, the CIVD responses of tropical indigenes have received relatively little attention. It is generally accepted that humans have a tropical or sub tropical origin (Lanzney and Santry, 1980), which means that the temperature regulation of the human body is essentially adapted to subtropical, rather than colder climates. Cold adaptation could be reflected in the degree of attenuation of initial vasodilation in cold exposed fingers (Hoffman and Wittmers, 1960; Poljakov and Poljakova, 1993; Ropkaev and Poljakova, 1993). Therefore, it is reasonable to assume that the vasomotor activity of tropical indigenes to cold stimuli would not be developed to protect from severe cold and remain fully functional in this regard. It is worthwhile to explore the CIVD responses of tropical indigenes, along with the vasomotor activity...