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Variation of ear temperature when walking outside in summer

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ABSTRACT

To achieve a truly "urban environment where people can live and walk", global warming and the urban heat island may present serious challenges. Understanding the nature of changes in human core temperature is important if we are to plan for people walking in the urban outdoor thermal environment, considering the potential for heat stroke.

The present study was performed to investigate changes in ear temperature and relationship of ear temperature and WBGT when walking in a real city environment. Ear temperature was measured in subjects walking in an outdoor city space in summer. When walking outside in the summer, ear temperature increases and decreases repeatedly. Measurement of ear temperature when walking in environments of WBGT 24 °C and 30 °C indicated no relation in the amount of WBGT and the maximum value of ear temperature. There is a possibility of heat stroke risk in cases judged to be safe according to WBGT.

1. Introduction

1.1. Background

There is a great deal of interest in developing more compact cities in Japan due to the decreasing birthrate and aging of the population, as well as from the viewpoint of energy efficiency and

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maintenance costs of social capital. It is important to realize "the creation of a city where we can live and move on foot" without depending on vehicles. However, taking into account global warming and the heat island phenomenon, it is necessary to determine the effects of the thermal environment on people to truly realize a city where it is possible to move on foot. From the viewpoint of heat stroke prevention, it is necessary to determine the changes in deep body temperature when walking around the city.

Currently, the Wet Bulb Globe Temperature (WBGT) is an index of heat stroke risk according to the thermal environment in the city in Japan (Japanese Society of Biometeorology, 2013; Japan Amateur Sports Assoc, 2006). WBGT is an index calculated based only on physical conditions of high-temperature environments, including the temperature, humidity, and radiant heat in the city. On the other hand, heat stroke develops due to an increase in deep body temperature (Ministry of the Environment, 2014; Nakai et al., 2007).

Miyake (Miyake et al., 2006) performed an investigation of heat stroke, and based on on-site information obtained from ambulances reported that about 70% of cases had elevated body temperature. According to Measures for Adaptation to the Heat Island Phenomenon in 2010 issued by the Ministry of the Environment (Ministry of the Environment, 2010), heat stroke is classified into the following four classes: sunstroke, heat cramps, desert syndrome, and thermal fever. According to the report, body temperature is $\geqslant$38 °C in all classes. Therefore, an increase in deep body temperature is regarded as an index of heat stroke risk.

Therefore, it is necessary to determine how the environment condition of the city impacts the deep body temperature to evaluate the risk of heat stroke.

However, there have been few studies regarding heat stroke risk associated with changes in deep body temperature when walking outdoors in summer. This study was performed to determine the changes in deep body temperature when walking outdoors in the city and to study the relation between WBGT and deep body temperature for evaluation of heat stroke risk.

1.2. Previous studies

With regard to the changes in deep body temperature, research regarding thermoregulation function under the thermal environment is performed in the field of hominal physiology. Increases in sweat and skin blood flow are known to suppress increases in body temperature. (Demura and Shimada, 2013) Minami et al. (2008) investigated changes in deep body temperature of subjects performing walking exercise under the thermal environment using an experimental chamber. Tanaka et al. (2006) investigated the characteristics of deep body temperature changes when moving from the thermal environment to an air-conditioned space.

The studies mentioned above involved environments where the heat element in the measured space is constant or controllable using a chamber or other equipment. When walking in the city, thermoregulation function changes dynamically according to changes in the surrounding environment, and therefore the reaction of the human body likely differs from spaces where the thermal environment is kept constant. The present study was performed to investigate changes in deep body temperature when walking in a real city environment.

2. Measurement content

2.1. Summary of survey

The deep body temperature was measured in subjects walking in an outdoor city space in summer. The surrounding thermal environment was measured simultaneously to determine the walking environment.

The following three cases were assumed for walking measurement. In the 1st case, the changes in deep body temperature when walking in the outdoor city space were measured to determine the relation between WBGT and change in deep body temperature (hereinafter referred to as the basic case). In the 2nd case, the subjects walked with changing amounts of clothing and metabolic rate, and the