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Development of a cardiovascular mathematical model considering the thermal environment

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Abstract: Recently, traffic accidents caused by the drowsy driving are frequently featured by medias. One of the evaluation indexes of drowsy level is a RR interval variation which is deemed as an indicator that reflect the effects of autonomic nervous activity. However, physical meaning and mechanism how a RR interval variation is connected to the autonomic nervous activity is not yet well understood.

The purpose of this research is to propose a mathematical model to construct a coupling model based on the thermoregulation model and the cardiovascular model. In this model, the effect of the cabin temperature on the circulatory system is mainly reflected by the change of peripheral resistance.

Keywords: RR interval, Thermoregulation model, Cardiovascular model, Circulatory system, Drowsy driving countermeasure

1. Introduction

Among the cause of traffic accidents, fatigue driving including drowsy driving accounts for the top reason for traffic accidents. Therefore, fatigue driving countermeasures, especially drowsy driving countermeasures are highly required to reduce the cases of total traffic accidents . In the field of medical research, it is well known that the drowsy level can be evaluated by a RR interval variation which is an index extracted from the waveform of blood pressure time history. Recently, the relation between this drowsy level and the effect of the cabin thermal environment on circulatory system attracts attention.

This research is aimed at constructing a coupling mathematical model used to estimate the blood pressure and a RR interval variation considering the cabin thermal environment based on the thermoregulation model and the cardiovascular model. In this research, Gagge model [2][3] is used as the thermoregulation model capable of simulating the skin temperature and core temperature in terms of room temperature considering the effect of metabolic, blood flow, sweating and respiration. In addition, Kotani model [4] is used as the cardiovascular model which can simulate the blood pressure and a RR interval variation taking the central nerves activity, the autonomic nerves activity, respiration activity and peripheral resistance into consideration.

In the current model, the effect of the cabin temperature on the circulatory system is mainly reflected by the change of peripheral resistance.

2. Results

We consider the coupling model with the information flow explaining the effect of the thermal environment on cardiovascular system as shown in Fig.1

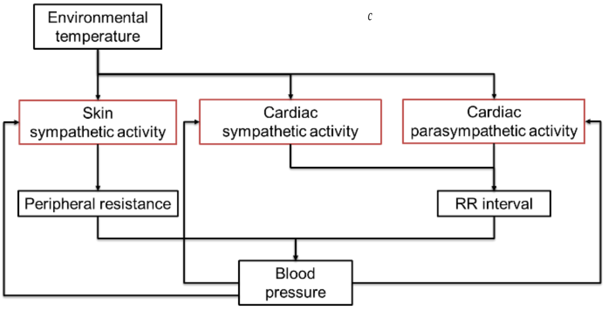

Fig. 1 Information flow of the effect of thermal environment on cardiovascular system.

The simulation results of systolic blood pressure and RR interval at room temperature of 22°C, 26°C and 30°C using the coupling mathematical model are shown in Fig.2 and Fig.3 respectively.

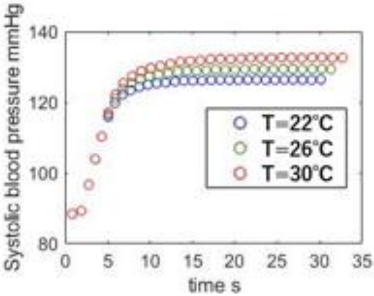

Fig. 2 Comparison of systolic blood pressure at room temperature of (22°C ,26°C, 30°C)

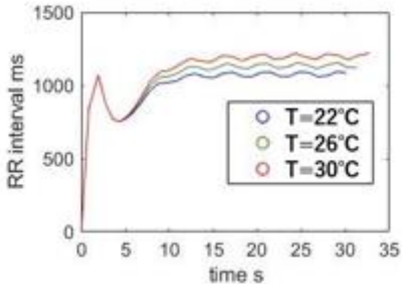

Fig. 3 Comparison of RR interval at room temperature of (22°C, 26°C, 30°C)

3. Concluding Remarks

This mathematical model succeeded in simulating the blood pressure and RR interval influenced by the change of diameter of vessels, especially the peripheral resistance caused by the fluctuation of room temperature. In the future, the accuracy of the model will be evaluated with experimental data of more subjects. The effect of other parameters such as illuminance, CO_2 concentration, etc. can be added to the current model to optimize its versatility.

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