The Concentration of Artificial CO₂ Warm Water Bathing and the Skin Blood Flow

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人工炭酸温水濃度と皮膚血流量

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抄 録
人工炭酸温水の効果を検討するため、本研究では炭酸化水温23.0℃の温浴の効果を検討した。被験者には、健康な成人12名を対象に、その効果について検討した。

測定方法：温度23.0℃の温水に人工的にCO₂を溶存させた温水を用いた。入浴者は全身で行った。測定は、レーザーベクトル（アドバンス社ALF21）を大腿内側部に設置し、被験者の皮膚温度を計測した。なお、測定は前値5分間、入浴15分間に1分間隔で、前値平均値の差の変化量を求める。室温は25±2℃に調整した。

その結果、血圧は0～1000ppmまで各濃度で差がなく、収縮期17.1、拡張期23.9mmHgの低下を認めた。水温が23.0℃で、入浴直後から0 ppm、100 ppm、300 ppm、600 ppm、800 ppm、1000 ppmに設定した。入浴は全身で行った。測定は、レーザーベクトル（アドバンス社ALF21）を大腿内側部に設置し、被験者の皮膚温度を計測した。なお、測定は前値5分間、入浴15分間に1分間隔で、前値平均値の差の変化量を求める。室温は25±2℃に調整した。

Key words: CO₂ bathing, Skin blood flow, CO₂ concentration
I INTRODUCTION

It has been reported that bathing in hot CO$_2$-water has hypotensive effects because CO$_2$ dissolved in the water has vasodilator action$^1)$. However, previous studies have not yet determined the optimum concentration of CO$_2$ for its hypotensive effects. Here, we attempted to determine the optimum concentration using artificial CO$_2$-water, of which concentration is easily changeable at an identical water temperature.

II SUBJECTS AND METHODS

A total of 12 healthy adults (3 males and 9 females) of which mean age was 22.4 ± 2.5 years were used as the subjects. At 37°C, tap water was mixed with hot artificial CO$_2$-water to make solutions containing CO$_2$ of 0, 100, 300, 600, 800 and 1000 ppm using a CO$_2$ densitometer. Bathing was conducted at sitting posture in bath of which water depth was 45 cm and the subject dipped the body to the height of nipple. Measurement before bathing was conducted at a posture of sitting on chair. Measurement of blood pressure was made using laser doppler blood flow meter (ALF21 produced by Advance Co. Ltd.) set in the femoral region and surface skin temperature was simultaneously determined using surface skin thermometer set on the left chest. All measurements before and during bathing were made for 5 and 15 min with 1-minute interval, respectively. The changes due to bathing were assessed based on the difference between the respective mean values before and during bathing. The room temperature was set to 25 ± 2°C.

III RESULTS

Skin surface thermometer on the left chest revealed that the body temperature was hardly increased by bathing at all CO$_2$ concentrations tested, since the measurement was carried out at water temperature of 37°C (Fig.2). Also, the blood pressure was little changed by bathing at any concentration of CO$_2$ in 0 ~ 1000 ppm. The systolic pressure and diastolic one were decreased by 17.1 and 23.9 mmHg, respectively (Fig.3). When compared with the pulse rate before bathing, the rate during bathing was decreased by 5.5/min as shown in Fig.4, but both changes in blood pressure and pulse rate were not significantly different between tap water (0 ppm) and CO$_2$-water at any ppm of CO$_2$. Whereas tissue blood flow significantly increased depending on CO$_2$ concentration in its tested range and these changes were observed from immediately after the start of bathing (Fig.5).

Fig.1 Measurement during whole body bathing
Fig. 2 Time course changes in the surface skin temperature according to the concentrations of CO₂.

Fig. 3 Time course changes in the blood pressure according to the concentrations of CO₂.

Fig. 4 Time course changes in the pulse rate according to the concentrations of CO₂ during.

Fig. 5 Time course changes in tissue blood flow according to the concentrations of CO₂.
DISCUSSION

Bathing in CO$_2$ water at 37 °C did not raise the body temperature in healthy adults, and so, the thermal effects of bathing in CO$_2$-water on the body were thought similar to those in tap water. However, either of blood pressure and pulse rate similarly decreased by bathing in tap water and CO$_2$-water, and these decreases were not significantly different between tap water bathing and CO$_2$-water one. This suggest that blood pressure and pulse rate would be controlled by some regulatory system like the autonomic nerve system not so as to induce too much decrease$^{2-4)}$.

However, tissue blood flow was more increased during bathing in CO$_2$-water than that tap water, suggesting that blood pressure might have decreased since the former bathing would have resulted to enhance the blood circulation in the tissues near skin surface, whereas the latter would have resulted to decrease the resistance of blood vessel in deep regions of tissue$^{5-6)}$. Therefore, tissue circulation near the skin surface would be more enhanced by bathing in CO$_2$-water than that in tap water. This agrees with the previous finding that the quantity of heat incorporated to the body during bathing in hot CO$_2$-water was greater, resulting in more improvement of surface tissue circulation compared with bathing in tap water$^7)$. In addition, the fact that the blood flow increase was dependent on the concentration of CO$_2$ suggests that tissue circulation and metabolism would have been enhanced through venous return increase associated to dose-dependent venous dilatation, which was inducible even with a small amount of CO$_2$$^8)$.

References


Summary

A comparative study was made on bathing-induced changes in body temperature, blood pressure, pulse rate and tissue blood flow of 12 healthy adults using tap water and artificial CO₂ water at 37°C to clarify the physiological effects of CO₂ at various concentrations of 0, 100, 300, 600, 800 and 1000 ppm. There was no change in body temperature during bathing in either water, whereas blood pressure and pulse rate were similarly decreased during bathing, but either of these decreases was not significantly different between tap water and CO₂-water. Therefore, it seemed that the decrease in blood pressure due to vasodilation during bathing would be controlled through some regulatory system like autonomic nerve system not so as to result in too much decrease. But, tissue blood flow was more increased during bathing in CO₂-water than tap water, suggesting that blood circulation in the tissue near skin surface would have been more enhanced by bathing in hot CO₂-water, resulting in a decrease of blood pressure.

Since the increase in tissue blood flow during bathing was dependent on the concentration of CO₂, it seemed that an improvement of tissue circulation and metabolism would have resulted from venous return increase associated to venous dilatation, one of dose-dependent CO₂ effects.