

# Traditional Japanese Style Bathing May Contribute to Good Health and Longevity

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**【緒言】**日本人の長寿の一因として、日本式の浴槽に入浴する習慣が挙げられる。また、温泉を模した各種家庭用入浴剤の利用も日本の入浴の特徴である。そこで、日本式入浴習慣が健康にどう影響するのかを検証した。平均年齢 40.8±17 歳の健常成人 6 名を対象とし、真水入浴（さら湯）と重炭酸入浴剤添加湯入浴が健康を促進する可能性についてブラインド入浴試験にて検証した。

**【方法】**被験者をランダムに水道水の風呂に入った対照群と入浴剤を入れた風呂に入った入浴剤群に二分して、入浴前後の結果を比較した。入浴剤は、(株)ホットアルバム炭酸泉タブレット社の Sparkling Hot Tab を用いた。この Sparkling Hot Tab は、クエン酸と重炭酸ナトリウムにより独自の手法で作成した重炭酸湯である。本研究は、ブラインドテストとするため、事前に溶解し、スパークリングホットタブは、無色無臭なので、被験者は、実験終了後まで、どちらの風呂に入ったか知らされなかった。25°Cの部屋で 15 分間静かにし、40°Cの風呂に、肩まで浸かる全身浴で 20 分入浴し、入浴前と入浴後の深部体温、表皮体温、脈拍を入浴後 60 分まで計測した。又入浴前後の体重、静脈血ガス、白血球分画、発汗に要する時間を計測した。

**【結果】**入浴直後、深部体温は有意に上昇した。入浴 60 分後、水道水群の深部体温は、入浴前に回復したが、スパークリングホットタブ群の深部体温は高いままであった。

表皮温度は、末梢にある 5 点、額、両手、両足を計測した。入浴直後両群とも両手足の表皮温度は、上昇を示したが、両群に対する有意差は無かった。スパークリングホットタブは、60 分後でも更湯に比べ、やや高い温度を維持したままだった。

入浴後、静脈血中の酸素と pH が上昇し、水道水群よりも入浴剤群の上昇が大きな傾向が見られたが、有意差は得られなかった。

静脈血の色は、入浴前後で、ダークレッドからビビットレッドに変わった。これは、ヘモグロビンと結合している酸素が増加したことを意味する。

入浴後、静脈血中の顆粒球比率は増加、リンパ球比率が減少した。この結果は、交感神経優位と考えられ、通常リラックスし、副交感神経優位と逆の結果となった。被験者全員が初めてであり、更湯とスパークリングホットタブ両方とも同様の傾向なので、鍼治療と同様に温熱刺激により、一時的に交感神経優位となり、その後リバウンドして副交感神経優位となるものと推定される。

スパークリングホットタブの方が、温熱刺激が強い、リバウンド後、副交感神経優位の結果も大きいと推定される。

両群とも心拍数増加と体重減少が見られた。水道水群と比較して入浴剤群は、大きな体重減少の傾向を示したが、有意差は得られなかった。

**【結論】**日本式の浴槽に入浴する事で、血液循環を改善し自律神経を調整する可能性が示唆された。このことから日常的な入浴習慣が長寿に貢献している可能性が示唆されるが、更なる大規模な研究が必要である。

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## Abstract

The objective of this study was to determine how traditional Japanese style bathing could promote good health. Using healthy volunteers, we assessed body temperature (core and cutaneous), red blood cells, white blood cells (WBCs), venous blood gas parameters (PO<sub>2</sub>, SO<sub>2</sub>, PCO<sub>2</sub>, TCO<sub>2</sub>, HCO<sub>3</sub>, and pH), weight loss (which may indicate sweat volume), and the time until sweating before and after bathing. We simultaneously conducted a double-blind clinical trial using a bath additive group and a control group to investigate the effect of a bath additive on the same parameters. We found that bathing increased the core and cutaneous body temperature, as well as PO<sub>2</sub>, SO<sub>2</sub>, and blood pH. All of the subjects also showed increases in heart rate and weight loss (sweat volume). After bathing, the number and ratio of granulocytes increased while the number and ratio of lymphocytes decreased. These results tended to be emphasized in the bath additive group; however, significant between-group differences were not detected. Our results indicated that bathing improved blood circulation and had a modulatory effect on the autonomic nervous system. This suggested that traditional Japanese style bathing might contribute to good health and longevity; however, additional larger-scale studies were needed to confirm or refute this conclusion.

## Keywords

Body Temperature, Bathing, Bath Additive, Blood Gas, Heart Rate, Sweat

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## 1. Introduction

According to the Ministry of Health, Labour and Welfare, Japan, Japanese women had the longest average life expectancy worldwide, at 86.83 years, for the third consecutive year in 2014, while Japanese men climbed a notch to tie for third longest life expectancy at 80.50 years [1] [2]. Many researchers have looked for explanations for the longevity of modern Japanese people, and one aspect of the Japanese lifestyle that has captured their attention is the tradition of taking regular hot water baths [3]-[5]. Japanese people have loved bathing in hot springs since ancient times, expecting anti-ageing effects from the hyperthermia of the water and from active ingredients (such as sulfur or carbon dioxide) contained within it [6].

Most Japanese people take baths frequently. The American anthropologist Ruth Benedict reported in her book on Japanese culture, "One of the best loved minor pleasures of the body in Japan is the hot bath...the daily soak in superlatively heated water is a part of the routine of every late afternoon... They sit in the bath with their knees drawn up in fetal position, the water up to their chins" [7]. As she observed, the purpose of this bathing is not only to wash the body with water but also to enjoy the therapeutic effects of hyperthermia. This custom continues in modern Japan, where 80% of young people (<40 years old) bathe in a tub everyday while only 3% of them prefer showers [8]. A recent investigation in Japan found that 27.6% of respondents put additives into their bath water to enjoy hot spring-like effects [9].

In the present study, we investigated the health effects of the hyperthermia and bath additives associated with traditional Japanese style bathing. Pre- and post-bath body temperature (core and cutaneous), red blood cell counts, white blood cell (WBC) counts and ratios, venous blood gas parameters ( $PO_2$ ,  $SO_2$ ,  $PCO_2$ ,  $TCO_2$ ,  $HCO_3^-$ , and pH), and sweat parameters (volume and time until sweating) were measured. The effects of a bath additive on these parameters were also assessed.

## 2. Materials and Methods

### 2.1. Subjects

Six healthy volunteers, aged 23 to 60 years (average  $40.8 \pm 17.0$  years), participated in this study. Written informed consent was obtained from all subjects and the study was approved by the institutional review board of the Yushima Shimizuzaka Clinic (Tokyo, Japan). The experiments were conducted at a constant temperature of  $25.0^\circ\text{C} \pm 0.5^\circ\text{C}$  and humidity of  $50.0\% \pm 5.0\%$ , except during the bathing time.

### 2.2. Double-Blind Clinical Trial with Bath Additive

The subjects were divided randomly into two groups, a control group and a bath additive (BA) group ( $n = 3$ /group). The control group bathed in regular hot tap water. The BA group bathed in hot tap water with a bath additive (Sparkling Hot Tab, Hot Album Tansansen Tablet, Inc. Hachiouji, Japan). This bath additive, which contains sodium bicarbonate mixed with citric acid, generates carbon dioxide in the water, causing effervescence like a naturally carbonated spring. It is colorless, bland and innocuous and produced carbon dioxide gas is too small to be recognized by the naked eye. This study was a double-blind clinical trial; therefore, the subjects did not know which bath they took.

### 2.3. Kinetic Analysis of Core and Cutaneous Body Temperature

All subjects rested for more than 20 minutes before bathing for 15 minutes at a water temperature of  $40^\circ\text{C} \pm 0.5^\circ\text{C}$ . Core temperature was measured at the axilla with a clinical mercury thermometer (FAVOR, Nihon Keiryoki Kogyo Co. Ltd., Chiyoda, Japan). Cutaneous body temperature was measured using a contactless digital thermometer (Microlife, IR IDA1, Microlife, Switzerland) at five previously described peripheral locations: Yintang (on the forehead, midway between the medial ends of the eyebrows), LI4 (Hegu; on the dorsum of the right and left hands, radial to the mid-point of the second metacarpal bone), LR3 (Taichong; on the dorsum of the right and left feet, between the first and second metatarsal bones, in the depression distal to the junction of the bases of the two bones, over the dorsalis pedis artery) [10].

Kinetic body temperature was measured before bathing and at 0, 20, 40, and 60 minutes after bathing as described previously [11]. Cutaneous body temperature was monitored before bathing and 0 and 60 minutes after



bathing.

## 2.4. Assessment of Blood Parameters

Fresh venous blood obtained from the median antebrachial vein before and after bathing was used to measure the partial pressures of oxygen and carbon dioxide ( $PO_2$  and  $PCO_2$ ), oxygen saturation ( $SO_2$ ), total carbon dioxide ( $TCO_2$ ), hydrogen carbonate ( $HCO_3$ ), and red blood cell count using an i-STAT 300 F (i-STAT Corporation, East Windsor, NJ, USA) as previously described [10] [12] [13]. WBCs were counted using a hemocytometer and the May-Grünwald-Giemsa stain method (Nihon Novamed. Co., Ltd, Tokyo, Japan).

## 2.5. Heart Rate and Sweat Measurements

The subjects measured their own heart rate and time before sweating. The volume of sweat was calculated from the change in body weight (before experiment—0 minutes after bathing).

## 2.6. Statistical Analysis

The statistical significance of differences between values was tested with statistical software Statcel2 (OMS Publishing, Saitama, Japan), which is written in Visual Basic for Applications, using paired *t*-tests or repeated-measures two-factor ANOVA with Bonferroni/Dunn post-hoc tests. *P* values of less than 0.05 were considered to be statistically significant.

# 3. Results

## 3.1. Body Temperature

### 3.1.1. Core Temperature

Core temperature was measured before bathing and tracked for 60 minutes after bathing. During the bath (before experiment—0 minutes after bathing), the mean core temperature increased (from  $36.0^\circ\text{C} \pm 0.6^\circ\text{C}$  to  $36.9^\circ\text{C} \pm 0.5^\circ\text{C}$ ;  $P < 0.05$ ), the temperature then decreased to  $36.2^\circ\text{C} \pm 0.6^\circ\text{C}$  at 60 minutes after the bath. Thus, bathing resulted in a rapid increase in core temperature. In the control group, core temperature had returned to baseline levels ( $35.7^\circ\text{C} \pm 0.2^\circ\text{C}$ ) by 60 min after bathing, while in the BA group the core temperature tended to remain elevated for longer ( $36.6^\circ\text{C} \pm 0.5^\circ\text{C}$  at 60 min after bathing). However, these between-group differences did not reach statistical significance, likely because of the small group sizes (Figure 1).

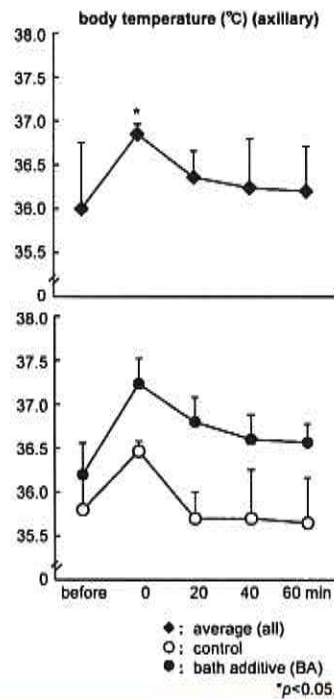
### 3.1.2. Cutaneous Temperature

It has been reported that rapid changes in core temperature are associated with changes in cutaneous blood flow mediated by the autonomic nervous system [14]; therefore, we measured cutaneous body temperature over time at five locations. Soon after bathing, the temperature of the hands and feet increased (average: hands,  $1.3^\circ\text{C} \pm 0.6^\circ\text{C}$ ; feet,  $4.9^\circ\text{C} \pm 1.5^\circ\text{C}$ ). The cutaneous temperature of the hands recovered after 60 minutes, but the temperature of the feet remained  $1.7^\circ\text{C} \pm 1.5^\circ\text{C}$  higher than before bathing. However, these changes were not statistically significant ( $P > 0.05$ ; Figure 2).

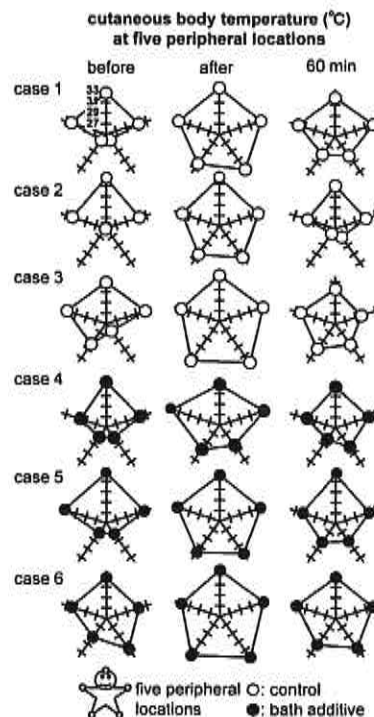
## 3.2. Various Blood Gases Parameters

Because an increase in heart rate might affect blood circulation and thereby cause a decrease in the oxygen content of venous blood, we measured the partial pressures of oxygen and carbon dioxide ( $PO_2$  and  $PCO_2$ ), oxygen saturation ( $SO_2$ ), total carbon dioxide ( $TCO_2$ ), and hydrogen carbonate ( $HCO_3$ ). We found that  $PO_2$  and  $SO_2$  both increased after bathing (from  $30 \pm 8$  to  $60 \pm 14$  mmHg and from  $51.3\% \pm 15.9\%$  to  $87.7\% \pm 10.1\%$ , respectively). The pH simultaneously increased from  $7.33 \pm 0.03$  to  $7.38 \pm 0.01$ . However,  $PCO_2$ ,  $TCO_2$ , and  $HCO_3$  did not change significantly with bathing.

When the control and BA groups were compared, subjects in the BA group tended to have larger changes in both  $PO_2$  (control group vs BA group: from  $30 \pm 10$  to  $49 \pm 11$  vs from  $30 \pm 6$  to  $71 \pm 9$  mmHg, respectively) and  $SO_2$  (from  $49.0\% \pm 22.6\%$  to  $81.3\% \pm 11.5\%$  vs from  $53.7\% \pm 10.1\%$  to  $94.0\% \pm 1.0\%$ , respectively (Figure 3)). However, these apparent changes from baseline were not statistically significant due to high inter-subject variability (data not shown).

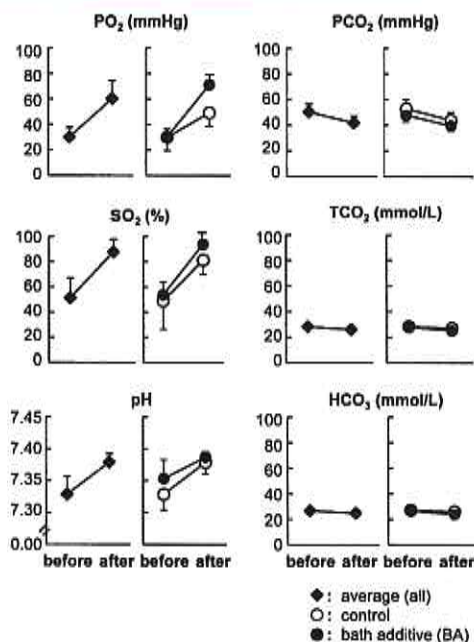


**Figure 1.** Core temperature was measured before bathing and tracked for 60 minutes after bathing. Bathing caused a rapid increase in core temperature (from  $36.0^{\circ}\text{C} \pm 0.6^{\circ}\text{C}$  to  $36.9^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ ;  $P < 0.05$ ). The core temperature of the control group had recovered at 60 minutes after bathing while the core temperature of the BA group tended to remain higher than before bathing.



**Figure 2.** Cutaneous temperature was measured at five peripheral locations. Soon after bathing, the temperature of the hands and feet increased in all participants.





**Figure 3.** PO<sub>2</sub>, SO<sub>2</sub> and pH were elevated after bathing. The BA group tended to show a greater change in PO<sub>2</sub> and SO<sub>2</sub>.

### 3.3. White Blood Cell Counts and Ratios

To investigate the effect of bathing on immune function and the status of the autonomic nervous system, WBC counts and ratios were determined before and after bathing. After bathing, the ratio of granulocytes increased from  $58\% \pm 12\%$  to  $64\% \pm 12\%$ , while the lymphocyte ratio tended to decrease (from  $37\% \pm 12\%$  to  $30\% \pm 11\%$ ). The absolute numbers of granulocytes and lymphocytes were also determined and, although they showed the same tendency, there was no statistically significant effect of bathing on WBC counts (Figure 4).

The granulocyte response to bathing tended to be higher in the BA group than the control group; however, this difference was not statistically significant due to high inter-subject variability (data not shown) (Figure 4).

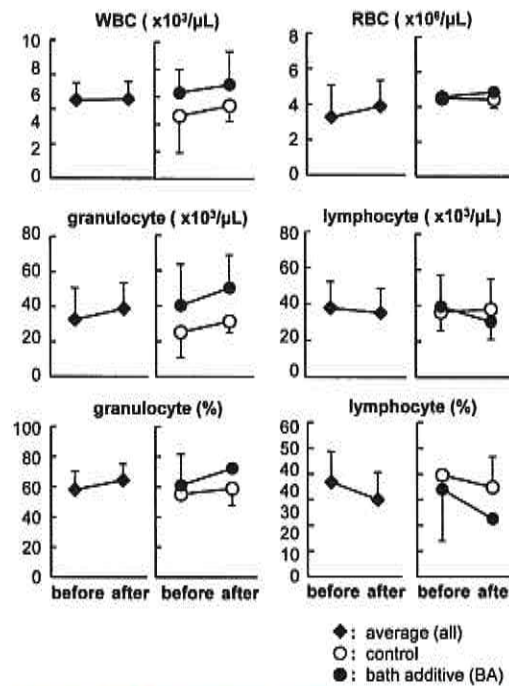
### 3.4. Heart Rate and Sweat

An increase in body temperature, such as that caused by bathing or exercise, elevates the heart rate and causes sweating. Therefore, heart rate and sweat parameters (the volume of sweat and the time until sweating) were assessed. All subjects experienced increases in heart rate and all began sweating during the bath (heart rate: from  $78 \pm 18$  to  $91 \pm 15$ /min, weight loss (sweat volume):  $80 \pm 84$  g, time before sweating:  $9 \pm 4$  min). Subjects in the BA group lost sweat more ( $150 \pm 71$  vs  $33 \pm 58$  mL) and sooner ( $8 \pm 3$  vs  $10 \pm 5$  min) than those in the control group (Figure 5).

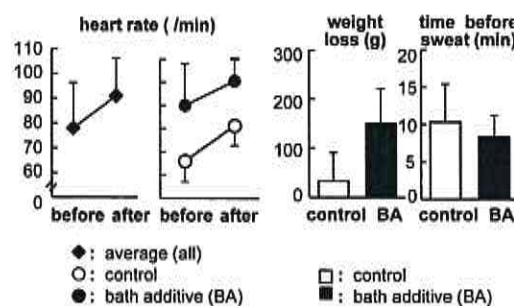
## 4. Discussion

### 4.1. Bathing Elevated pH, SO<sub>2</sub>, PO<sub>2</sub>, and Body Temperature

Bathing induced changes in various blood parameters, including increases in SO<sub>2</sub>, PO<sub>2</sub>, and pH in the venous blood (Figure 3). The concomitant increases in both core and cutaneous body temperature and heart rate (Figure 5) are likely owing to circulatory improvements caused by bathing. We observed that the face color of all subjects changed from pale to red during their bath, and that the color of their venous blood changed from dark red to vivid red after bathing, as we have previously reported [4]. These observations may indicate an increased amount of hemoglobin-bound oxygen, resulting in the alkalization of venous blood. The simultaneous increase in heart rate also indicates promotion of circulatory function.



**Figure 4.** After bathing, the granulocyte ratio increased while the lymphocyte ratio decreased. The granulocyte response to bathing tended to be greater in the BA group than in the control group.



**Figure 5.** Heart rate, weight loss and sweat measurements. Heart rate increased in all subjects during the bath and all subjects started sweating. Subjects in the BA group lost more weight and sweat sooner than subjects in the control group.

The increases in body temperature,  $\text{SO}_2$ , and  $\text{PO}_2$  tended to be greater in the BA group than in the control group; however, these differences were not significant (Figure 3 and Figure 5). It is possible that the bath additive, which generates carbon dioxide in hot water, may stimulate the skin or the subcutaneous capillaries. This stimulation may have excited parasympathetic nerves causing further improvements in peripheral blood flow. In this manner, the chemical ( $\text{CO}_2$ ) stimulation of a bath additive may augment the heat stimulation of the hot water and thus increase the beneficial effects of bathing. However, further investigations, including assessments of respiratory rate, are needed to determine if this is the case.

#### 4.2. Granulocytes Increased and Lymphocytes Decreased after Bathing

Our results showed that the number and the ratio of granulocytes increased after bathing, while the number and



ratio of lymphocytes decreased. WBCs can be categorized into two types: those that adhere to the blood vessel walls and those that flow freely through the blood vessels. Granulocytes, which increased with the stimulation of bathing, are in the former category [15] [16]. Similar results have been observed after acupuncture treatment, which has modulatory effects on the autonomic nervous system [10].

Both bathing and acupuncture stimulate the body surface, through the application of mild heat and pain, respectively. Acupuncture has been known to effectively promote good health for thousands of years [17]-[21]. Our results suggest that traditional Japanese style bathing may also contribute to good health and longevity by improving blood circulation and through modulatory effects on the autonomic nervous system. For example, some studies have shown that bathing, which increases body temperature and oxygenation by improving circulation, may effectively prevent the onset of cancer, which occurs under the stressful conditions of hypothermia and hypoxia [13] [22]. However, we used a limited number of subjects in this small size clinical report and therefore additional larger scale studies are required to further support the findings that we report here. Observation of longer-term repetitive bathing using age-matched groups would also provide valuable information regarding the potentially beneficial effects of Japanese style bathing on health.

## 5. Conclusion

Bathing increased venous blood pH, SO<sub>2</sub>, and PO<sub>2</sub>, as well as body temperature (core and cutaneous) and heart rate. Moreover, the use of a bath additive tended to increase the oxygenation of venous blood, had modulatory effects on the autonomic nervous system, and promoted sweating. These would be valuable factors to assess in any future larger scale studies on the health benefits of bathing.

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