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Effect of Hot-Attribute Aged Ginger Tea on Chinese Medical Pulse Condition of Healthy Young Humans

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Abstract

Young individuals typically have a dry-heat (燥熱 zào rè) constitution and feel overly stimulated. This study observes specialties on the right-bar (右關 yòu guān) section of the radial-arterial pulse of healthy young subjects, and investigates pulse variations induced by different attribute foods. Chinese medical doctors grouped thirty subjects into heat and non-heat constitutions. Each subject took water, aged ginger tea, and coconut water, well recognized as neutral, hot, and cold drinks, on different visits. The current study observed physiological signals induced by the samples using novel noninvasive sphygmography and a blood pressure monitor. As the baseline bigger percussion wave, dicrotic wave, and area in the sphygmogram of the non-heat constitution subjects, this work suggests that blood vessels of these subjects may be more relaxed than that of the heat constitution ones. Stroke volume increased and pulse pressure decreased in the non-heat constitution subjects after taking aged ginger tea, which may elevate arterial compliance corresponding to maintaining an estimated radial-arterial diameter in our study. However, the percussion wave widened and the valley increased in the heat constitution subjects after taking aged ginger tea. This corresponds to the markedly reduced radial-arterial diameter, indicating tighter blood vessels than the baseline status. Accordingly, this study confirms that selecting foods with attributes opposite to personal constitutions is important for reestablishing a healthy cold-heat balance within the human body. Moreover, novel noninvasive sphygmography may be a useful instrument to classify scientifically the heat personal constitution and the responses to different attribute foods.

Key words: Pulse diagnosis, Right-bar sphygmogram, Personal constitution, Food attribute, Arterial compliance

Introduction

Pulse diagnosis is a unique diagnostic method in traditional Chinese medicine (TCM). The Classic of Difficult Issues (難經 nàn jīng) has mentioned the conditions of five viscera, six bowels, and twelve meridians, all diagnosed by variations in the radial-arterial pulse (Tang, 1983). This pulsation includes inch, bar, and cubit (寸關尺 cùn guān chǐ) sections, from the distal to the proximal side of the radial styloid at both wrists. However, doctors could only use words and experience to describe variations in pulse until the invention of sphygmography and its improvement in recent years (Parati et al., 2002). The

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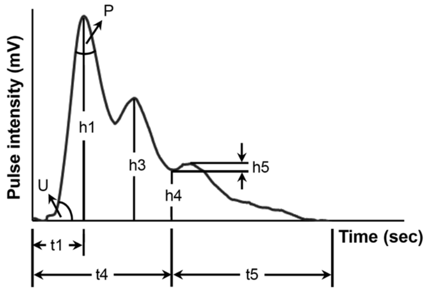

Figure 1. Sphygmogram
U: angle of up stroke; P: angle of percussion wave; h1: height of percussion wave; h3: height of tidal wave; h4: height of valley; h5: height of dicrotic wave; t1: rapid ejection period; t4: systolic period; t5: diastolic period.

sphygmogram (Figure 1), draws the contour of pulsation by sphygmography, which objectifies and quantifies pulse variations.

A sphygmogram expresses the energy of the heart, the passive movement of the aortic valve, the resistance and elasticity of the vascular system, and the viscosity of the blood (Watt and Burrus, 1976; Li et al., 2005). The systole of the heart provides blood and potential energy into vessels, causing percussion wave (h1) to appear in the sphygmogram (Figure 1). At the beginning of the diastole, the aortic valve closes first, and the backflow of blood produces the dicrotic wave (h5) after a valley (h4) in the sphygmogram (Figure 1). Studies have described that the time-domain parameters of the sphygmogram might define certain physiological conditions and disease states in the human body (Li et al., 2005; Liu et al., 2009; O'Rourke 2009).

The resonance theory in hemodynamics considers that each internal organ or meridian has its own frequency that resonates with the heart to produce specific harmonics (Wang et al., 1991). The Fourier analysis method decomposes the sphygmogram into several harmonic components in the frequency-domain. Many researchers have demonstrated that different Chinese herbs (Wang et al., 1994; Wang et al., 1997), foods (Wang et al., 1996b), and acupuncture (Wang et al., 1995; Wang et al., 1996a; Wang et al., 2000) can change the different harmonics of the radial-arterial pulse.

The TCM point of view divides both of personal constitution and food attribute into two major categories, *i.e.*, cold and heat/hot (Anderson, 1984; Huang and Wu, 2002; Ho and Tsai, 2004). Young individuals typically have a dry-heat (燥熱 zào rè) constitution consisting of excess heat in the body, revealed in physiological conditions like flushing, burning sensations, thirst, raspy throat, and overstimulation (Anderson, 1980; Liu and Cao, 2001; Bruhwiler, 2003). In contrast, the constitution of older people cools, exhibiting pallor, cold hands and feet, and fatigue (Anderson, 1980; Liu and Cao, 2001; Bruhwiler, 2003). Hence, TCM dietary therapy claims that people need to select foods with attributes opposite to their constitutions to reverse the cold-heat imbalance within their bodies and reestablish a healthy status (Briggs and Calloway, 1984; Koo, 1984).

This project observes specialties on the radial-arterial pulse of healthy young people, and investigates variations in their radial-arterial pulse induced by different attribute foods. This research selected aged ginger tea and coconut water, well known as hot and cold foods, according to the principle of dietary therapy in TCM (Liu et al., 1995). Physiological signals were monitored with instruments, including novel noninvasive sphygmography and a blood pressure monitor.

Subjects and Methods

Subjects

The study was approved and performed in the China Medical University Hospital (DMR94-IRB-118) in Taiwan, and a signed informed consent was obtained from each subject. Patients diagnosed with cardiopulmonary diseases were excluded from the study. Thirty healthy normal-weight volunteers, aged 21 to 31 years (mean, 22.8 ± 2.2 years), were recruited and grouped into heat and non-heat (neutral and partial cold) constitution groups by Chinese medical doctors. All subjects were requested to avoid ice, roast, pungent, or fried foods for two days prior to the experiment and to refrain from alcohol, medicine, and smoking for eight hours before the experiment. Subjects were also required to fast for two hours prior to the experiment. The experimental procedure complied with the Declaration of Helsinki.

Samples Preparation

The experiment prepared aged ginger tea following the traditional method used in Chinese medicine. Sliced aged ginger (18.75 g) was added into water (800 mL), heated to boiling, then covered to stew on low heat for 20 min to obtain aged ginger tea (almost 500 mL). Coconut water (almost 450 mL per fruit) was collected from young coconuts purchased from the traditional market, grown in Pingtung. No extra flavor was added to either of the samples. Water, which belongs to the neutral-attribute, was selected as the blank.

Experimental Design

The procedure was performed in a quiet room with constant temperature (25 ± 1 ℃), and every subject rested for 20 min prior to the experiment. The baseline status of each subject was measured at the beginning of the experiment. The measured items included radial-arterial pulse, blood pressure, tongue diagnosis, and a questionnaire pertaining to the division of personal constitution. Then the suitable sample (250 mL of water, aged ginger tea, or coconut water at room temperature) was provided to the subject. Ten minutes later, the radial-arterial pulse and blood pressure were measured again with another questionnaire about subjective feeling. Because the color and flavor of the samples were too clear to allow a double-blinded test, this work compared the physiological status before and after each subject took a sample, and observed the variations in signals. All subjects repeated this procedure three times, taking different samples (water, aged ginger tea, or coconut water) each time, at one-week intervals. Two Chinese medical doctors determined the personal constitution of each subject, diagnosed according to the tongue diagnosis and the personal constitution questionnaire.

Measurements

The pressure pulse waveform (PPW) and arterial diameter changed waveform (ADCW) were measured simultaneously using the pressure transducer and strain gauge by novel noninvasive sphygmography (Tyan et al., 2008; Liu and Tyan, 2010). This new apparatus has a two-axis mechanism, which includes X-axis and Z-axis, and detects PPW accurately using a standard positioning procedure. Because the right-bar (右關 yòu guān) (bar section at the right wrist) pulse represents the stomach/spleen in TCM clinical diagnosis and may change after eating, this experiment analyzed the time and frequency-domains of the right-bar radial-arterial sphygmogram. This study estimated the radial-arterial diameter using the X-axis scan with the calculation described by Tyan et al. (2008). During the pulse recording, every subject was asked to keep quiet, sit with the right hand equal to the height of the heart, and fix the right wrist on a soft pillow with the palm upward. This recording proceeded for each subject before and 10 min after taking the sample.

The blood pressure was measured by an A2 Blood Pressure Monitor (Ostar Meditech Corporation, Taipei, Taiwan), connected to a personal computer. During the blood pressure recording, each subject was asked to sit and attach an inflatable cuff on the left wrist, equal to the height of the heart. The blood pressure was measured after every radial-arterial pulse recording.

Statistical Analysis

The baseline status of the heat and non-heat constitution subjects was analyzed by unpaired Student's t-test. Variations in physiological signals were calculated using the equation: Variation = $\text{Signal}_{\text{after}} - \text{Signal}_{\text{before}}$, where $\text{Signal}_{\text{after}}$ and $\text{Signal}_{\text{before}}$ were the signals measured after and before each subject took a sample. After the subjects took aged ginger tea, coconut water, and water, each variation was analyzed by one-way analysis of variance (ANOVA) and Duncan's multiple range test. The data were expressed as means ± SEM. All statistics were performed with SAS 8.1 software. The differences were considered significant at $P < 0.05$.

Results

Personal Constitution

The Chinese medical doctors diagnosed that nineteen of the thirty subjects were heat constitution and the others were non-heat (neutral and partial cold) constitution according to the tongue diagnosis and the personal constitution questionnaire. Table 1 shows no significant differences in blood pressure, estimated radial-arterial diameter, and frequency-domain signals of the right-bar sphygmogram between heat and non-

Table 1. Baseline status of subjects

Physiological status	Constitutions of subjects	
	Heat	Non-heat
Systolic pressure (mmHg)	98.02 ± 1.98	96.33 ± 2.90
Diastolic pressure (mmHg)	61.75 ± 1.52	63.28 ± 1.65
Pulse pressure (mmHg)	36.26 ± 1.42	32.99 ± 2.25
Time-domain of sphygmogram		
P (°)	33.47 ± 1.79	29.66 ± 3.12
U (°)	80.15 ± 0.43	80.86 ± 1.21
h1 (mV)	2.68 ± 0.10	3.11 ± 0.20*
h4 (mV)	0.64 ± 0.04	0.74 ± 0.06
h5 (mV)	0.18 ± 0.04	0.34 ± 0.10
h1/t1 (mV/s)	26.90 ± 1.15	31.06 ± 2.66
Area (mV*s)	0.60 ± 0.02	0.71 ± 0.04*
Frequency-domain of sphygmogram		
C2	0.48 ± 0.05	0.50 ± 0.14
C3	0.21 ± 0.03	0.34 ± 0.08
C4	0.05 ± 0.01	0.09 ± 0.02
C5	0.03 ± 0.003	0.03 ± 0.006
C6	0.013 ± 0.002	0.019 ± 0.004
C7	0.007 ± 0.001	0.009 ± 0.002
C8	0.004 ± 0.001	0.006 ± 0.001
C9	0.003 ± 0.001	0.003 ± 0.001
Estimated radial-arterial diameter (mm)	3.58 ± 0.17	3.27 ± 0.13

Data are expressed as means ± SEM (heat constitution, n = 19; non-heat constitution, n = 11). P: angle of percussion wave; U: angle of up stroke; h1: height of percussion wave; h4: height of valley; h5: height of dicrotic wave; h1/t1: slope of percussion wave; Area: area under the sphygmogram; C2-9: harmonic components of pulse decomposed by the Fourier analysis method. * indicates a significant difference ($P < 0.05$) between heat and non-heat constitutions using unpaired Student's t-test.

heat constitution groups. However, the h1 (height of percussion wave) and area in the sphygmogram of the heat constitution subjects (2.68 ± 0.10 mV and 0.60 ± 0.02 mV*s) were significantly smaller than that of the non-heat constitution ones (3.11 ± 0.20 mV, *P* = 0.0404 and 0.71 ± 0.04 mV*s, *P* = 0.0170). The non-heat constitution subjects also had clearer h5 (height of dicrotic wave) (0.34 ± 0.10 mV) than the heat constitution ones (0.18 ± 0.04 mV, *P* = 0.0834).

Variation in Right-Bar Sphygmogram

The results showed no significant differences in frequency-domain signals of the right-bar sphygmogram of the subjects in either constitution group (data not shown). However, the P (angle of percussion wave) and h4 (height of valley) in the sphygmogram of the heat constitution subjects increased significantly after taking aged ginger tea, compared with taking coconut water (+19.2% and +8.5%, *P* < 0.05, Figure 2A, 3E). The U (angle of up stroke), h1, and h1/t1 (slope of percussion wave) of these subjects markedly decreased after taking aged ginger tea, compared with taking water or coconut water (–2.0%, –13.7%, and –15.7%, *P* < 0.05, Figure 2C, 3A, 3C). Of the non-heat constitution subjects after taking aged ginger tea, the U angle, P angle, h1, and h1/t1 were opposite to these signals of the heat constitution ones. In addition, the area under the sphygmogram of these subjects increased significantly after taking aged ginger tea, compared with water (+10.9%, *P* < 0.05, Figure 3H).

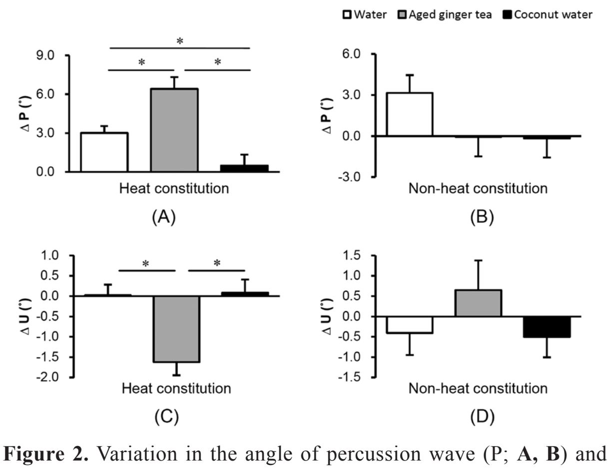

Figure 2. Variation in the angle of percussion wave (P; **A, B**) and angle of up stroke (U; **C, D**) of right-bar sphygmogram of the subjects with heat (**A, C**) and non-heat (**B, D**) constitutions after taking water, aged ginger tea, and coconut water
Data are expressed as means ± SEM (heat constitution, n = 19; non-heat constitution, n = 11). **P* < 0.05 indicates a significant difference between responses to the samples using one-way ANOVA and Duncan's multiple range test.

The estimated radial-arterial diameter of the subjects with heat constitution decreased significantly after taking aged ginger tea, compared with taking coconut water (–14.4%, *P* < 0.05, Figure 4A). Of the subjects with non-heat constitution, the estimated radial-arterial diameter reduced significantly after taking coconut water, compared with taking aged ginger tea (–15.6%, *P* < 0.05, Figure 4B).

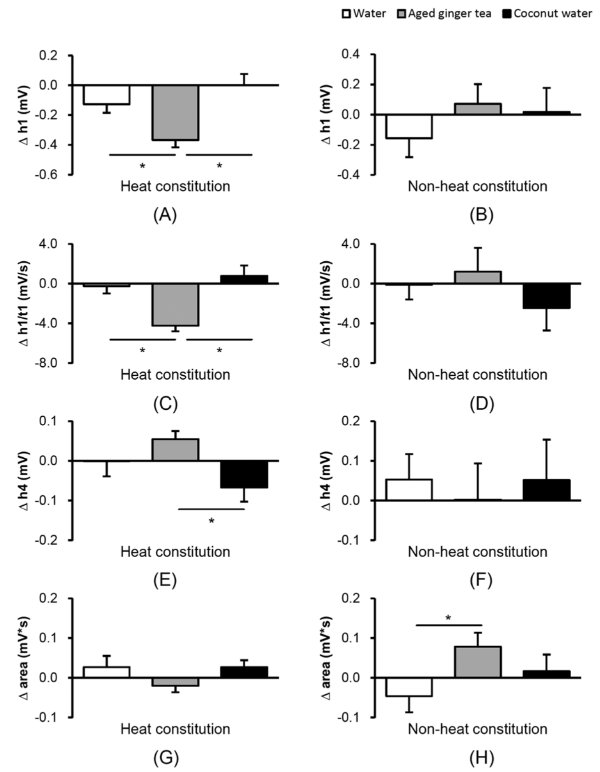

Figure 3. Variation in the height of percussion wave (h1; **A, B**), slope of percussion wave (h1/t1; **C, D**), height of valley (h4; **E, F**) and area (**G, H**) of right-bar sphygmogram of the subjects with heat (**A, C, E, G**) and non-heat (**B, D, F, H**) constitutions after taking water, aged ginger tea, and coconut water
Data are expressed as means ± SEM (heat constitution, n = 19; non-heat constitution, n = 11). **P* < 0.05 indicates a significant difference between responses to the samples using one-way ANOVA and Duncan's multiple range test.

Figure 4. Variation in the estimated radial-arterial diameter of the subjects with heat (**A**) and non-heat (**B**) constitutions after taking aged ginger tea and coconut water
Data are expressed as means ± SEM (heat constitution, n = 19; non-heat constitution, n = 11). **P* < 0.05 indicates a significant difference between responses to the samples using one-way ANOVA and Duncan's multiple range test.

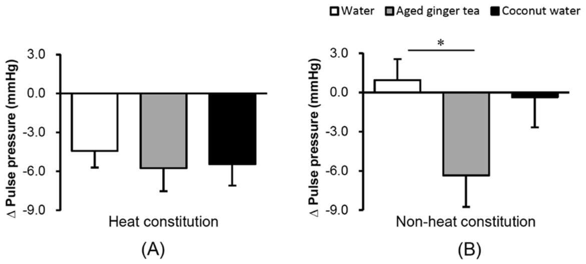

Figure 5. Variation in the pulse pressure of the subjects with heat (**A**) and non-heat (**B**) constitutions after taking water, aged ginger tea, and coconut water
Data are expressed as means ± SEM (heat constitution, n = 19; non-heat constitution, n = 11). $*P < 0.05$ indicates a significant difference between responses to the samples using one-way ANOVA and Duncan's multiple range test.

Variation in Blood Pressure

In terms of blood pressure, results showed no significant differences in systolic and diastolic pressures of the subjects in either constitution group (data not shown). However, the pulse pressure of the subjects with non-heat constitution after taking aged ginger tea significantly reduced, compared to their pulse pressure after taking water (–19.2%, $P < 0.05$, Figure 5B).

Discussion

Personal Constitutions vs. Baseline Status

The h1 (height of percussion wave) is the main wave in the sphygmogram, reflecting the blood volume and pressure sustained by the arterial wall during the systolic cardiac cycle (Li et al., 2005; Liu et al., 2009). Chinese medicine considers the area under the sphygmogram as the stroke volume in the pulse diagnosis (Tyan et al., 2001; Li et al., 2005). In this study, the h1 and area in the right-bar sphygmogram of the heat constitution subjects were both significantly smaller than that of the non-heat (neutral and partial cold) constitution ones (Table 1). This indicates that the subjects with a heat constitution may display less stroke volume in their cardiac output. Heart rate changes generally counteract stroke volume fluctuations (Toska and Eriksen, 1993; Elstad et al., 2001). This corresponds to the rapid heart rate of the heat constitution subjects in our previous study (Chao et al., 2011).

Furthermore, the h5 (height of dicrotic wave) in the sphygmogram reflects the slippery pulse phenomenon in Chinese medicine (Tyan et al., 2001). The results showed a clearer h5 of the non-heat constitution subjects than that of the heat constitution ones (Table 1), indicating that the pulse passed smoothly in the radial-artery of the non-heat constitution subjects. This study therefore suggests more relaxed blood vessels of the non-heat constitution subjects than that of the heat constitution ones.

Personal Constitution vs. Food Attribute

The result of the non-heat constitution subjects revealed that stroke volume (area under the sphygmogram) significantly increased (Figure 3H), and pulse pressure markedly reduced (Figure 5B) after these subjects took aged ginger tea. Studies have used the stroke volume to pulse pressure ratio to evaluate arterial compliance in the human body (Li et al., 2005; Boussuges, 2006). This work suggests that hot-attribute aged ginger tea elevated arterial compliance of the non-heat constitution subjects, and may maintain cardiovascular function.

In the right-bar sphygmogram of the heat constitution subjects, the U (angle of up stroke), h1, and h1/t1 (slope of percussion wave) decreased significantly after taking aged ginger tea (Figure 2C, 3A, 3C), but the P (angle of percussion wave) and h4 (height of valley) markedly increased (Figure 2A, 3E). These variations showed that their percussion wave widened and shortened after taking aged ginger tea, accompanied with higher valley intensity (Figure 6). Chinese medicine considers the decrease of h1/t1 as reduced arterial compliance, and the increase of h4 reflects elevated peripheral resistance (Xie et al., 2000; Yang et al., 2006; Liu et al., 2009). The wider percussion wave reveals the stiff arterial wall (Liu et al., 2009). This research suggests tighter blood vessels in the heat constitution subjects than their baseline status, after taking hot-attribute aged ginger tea.

Moreover, the U angle, P angle, and h1 are indices of arterial elasticity and peripheral resistance in TCM pulse diagnosis (Huang and Sun, 1995). According to the results, this work assumes that the decrease in the U angle and h1, as well as the increase in the P angle of

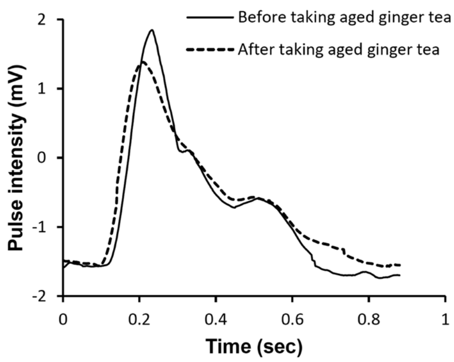

Figure 6. Typical variation in the shape of right-bar radial-arterial pulse of the subjects with heat constitution after taking aged ginger tea

the heat constitution subjects after taking aged ginger tea may reflect reduced arterial elasticity or elevated peripheral resistance. Unfortunately, these variations were demonstrated as the risk factors closely linked to cardiovascular events (McVeigh et al., 1999; McVeigh et al., 2002; Grey et al., 2003; Zhu et al., 2007).

Aged ginger tea reduced the estimated radial-arterial diameter of the heat constitution subjects, but maintained that of the non-heat constitution ones (Figure 4). In the questionnaire about subjective feeling of the heat constitution subjects after taking aged ginger tea, six people felt increased heartbeat, four people felt dry mouth, and six people felt an uncomfortable throat. A recent study has illustrated that diet might influence sympathovagal balance, which is the short-term cardiovascular control system (Akselrod et al., 1981; van Orshoven et al., 2006). Hence, this study assumes that overstimulation of the sympathetic activity may play an important role in the radial-arterial pulse variations of the heat constitution subjects after taking hot-attribute aged ginger tea. In contrast, releasing sympathetic activation may maintain the estimated radial-arterial diameter of the heat constitution subjects after taking cold-attribute coconut water.

Accordingly, the present study demonstrates that *1*) the non-heat constitution subjects exhibit a smoother radial-arterial pulse and more stroke volume than the heat constitution ones, *2*) hot foods may be beneficial to maintain homeostasis of the non-heat constitution persons, especially in cardiovascular function, and *3*) hot foods are not suitable for cardiovascular health in the heat constitution persons, while cold foods may be good for their cardiovascular function. Additionally, novel noninvasive sphygmography may be a useful instrument to classify scientifically the heat personal constitution and the responses to different attribute foods. Variations in the radial-arterial pulse of the cold constitution persons need further investigation.

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