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RESEARCH ARTICLE

Gender and Measuring-position Differences in the Radial Pulse of Healthy Individuals

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Abstract
In this research, radial pulse differences according to gender and measuring positions in healthy individuals were investigated in an objective manner. A total of 372 healthy volunteers (189 males and 183 females) participated in this study. The radial pulse was measured at six different measuring positions using a multistep tonometry system. The pulse data were compared between males and females and between different measuring positions. Compared to the pulses in females, those in males were deeper and slower, with a longer diastolic proportion and a shorter systolic proportion. Amplitude of the radial pulse increased as it went distal. The pulse was deepest at the *Cheock* position and shallowest at the *Gwan* position. Compared to the right pulse, the radial augmentation index was higher and the main peak angle was larger in case of the left pulse. The results of this research show that the radial pulses in healthy individuals differ significantly according to gender and measuring positions.

1. Introduction

It may be said that pulse diagnosis is the essence of traditional Eastern medicine. In Asia, "going to have the pulse checked" used to mean "going to see a doctor" [1].

The concept of pulse in the West differs from that in the East. In the West, a pulse is considered to be related to the heart, blood circulation, blood vessels, etc. However, in the East, it relates to the entire body. In traditional Eastern medicine, a pulse is considered to contain complete

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information on any part of the body, revealing everything about an individual's health—superficial and deep, organs and bowels, structure and mind, etc. Therefore, intrinsic factors, such as gender, age, and constitution, as well as extrinsic factors, such as disease pathogens, treatment stimuli, and surrounding climate, may affect the pulse. In other words, pulse reflects overall physiological and pathological conditions of a person [2].

The pulse is examined at different positions on the wrist, which are called *Chon*, *Gwan*, and *Cheock*, bilaterally. Each position corresponds to different internal organs or body parts; hence, the pulse observed at each position is considered to indicate the conditions of the corresponding organs or body parts [1,2].

Some studies have been conducted focusing on pulse differences according to intrinsic factors such as race, gender, measuring positions, etc. [3–8]. For example, King et al [7] examined 148 healthy humans to develop profiles of radial pulse differences according to gender; however, in their study, pulse examination was conducted by one expert in a subjective manner. Besides, Lee et al [8] reported on different pulse waveforms at different measuring positions; however, they examined only one female participant.

As another effort to identify the effects of intrinsic factors on pulse, in this study, we investigated the physiological differences of radial pulse according to gender and measuring positions in an objective manner.

2. Materials and methods

2.1. Participants

A total of 372 healthy volunteers (189 males, age: 22.95 ± 2.68 years, height: 173.79 ± 4.28 cm, weight: 69.23 ± 8.29 kg; and 183 females, age: 20.99 ± 1.85 years, height: 166.08 ± 7.45 cm, weight: 62.16 ± 8.37 kg) who were 20–29 years of age with no underlying diseases and were not prescribed any medicines were included in this study.

The criteria for exclusion were as follows: arrhythmia, systolic blood pressure >150, diastolic blood pressure <60, wounds or scars in the region of pulse measurement, body mass index <18 kg/m^2 or >32 kg/m^2, pregnancy, women in menstruation.

All participants provided written informed consents. This study was approved by the Institutional Review Board of Oriental Hospital of Daejeon University, Daejeon, Korea (approval no. P2011-09-03).

2.2. Pulse measurement

All participants took 30 minutes of rest sitting on a comfortable chair prior to the pulse measurement. The radial pulse was measured in a sitting position. The participants were asked to remain calm, and were allowed to take water, but restricted from consuming food or other drinks.

The radial pulse was measured at six different measuring positions (bilateral *Chon*, *Gwan*, and *Cheock*) on the wrist, as shown in Fig. 1. The region opposite to the styloid process of the radius is *Gwan*; *Chon* is distal to Gwan, whereas *Cheock* is proximal to Gwan [2].

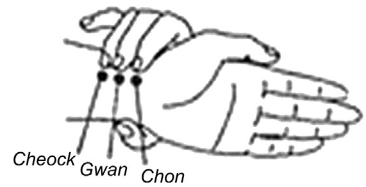

Figure 1 Pulse measuring positions.

Pulse measurement was conducted in a quiet room. The room temperature was kept constant at 24–26°C and humidity was maintained at 40–60%.

2.3. Pulse measuring system and data acquisition

The radial pulse was measured using a multistep tonometry system (Daeyomedi Co. Ltd, Ansan, Korea). This device has an arterial tonometry sensor with an array of five piezoresistive semiconductor transducers. The sensor placed at the pulse-measuring position automatically scans the artery and applies multiple levels of pressure to obtain stable multiple-step pulse waveforms [9] (Figs. 2 and 3).

In this study, pressure was applied at five different levels (50 g, 90 g, 140 g, 190 g, and 240 g), and the pulse waves were recorded for 5 seconds at each level. Data at each level included five pulse waves from five piezoresistive semiconductor transducers. Therefore, 25 pulse waves were obtained from one measuring position [10,11] (Figs. 4 and 5).

2.4. Data analysis

2.4.1. Pulse wave selection

Once the tonometry sensor begins pressing on the skin at the pulse-measuring position, the applied pressure gradually increases, and the pulse height also increases initially to some extent, but decreases later [9] (Fig. 4). In this study, we applied pressure at five different levels. The pulse waveform with the highest *H*1 was the most distinct and considered suitable for observing pulse characteristics; therefore, it was selected as the "representative pulse wave" among the five pulse waves measured at five different pressure levels [11] (Figs. 5 and 6).

The tonometry system automatically scans the artery and places the sensor above the arterial flow. Because the central transducer is placed above the center of arterial flow, we analyzed the representative pulse wave from the

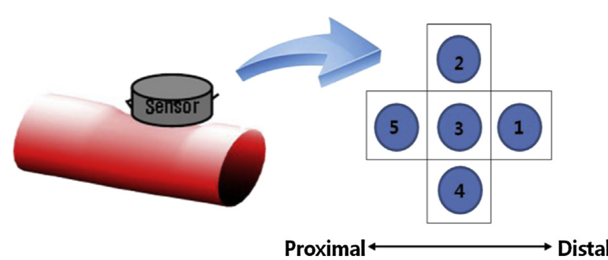

Figure 2 Array sensor.

Figure 3 Pulse measurement.

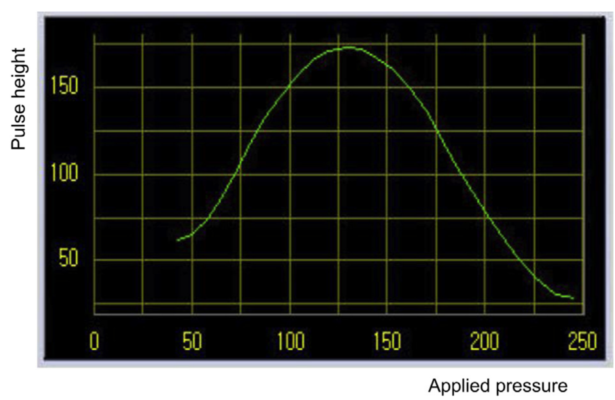

Figure 4 Pressure—height curve.

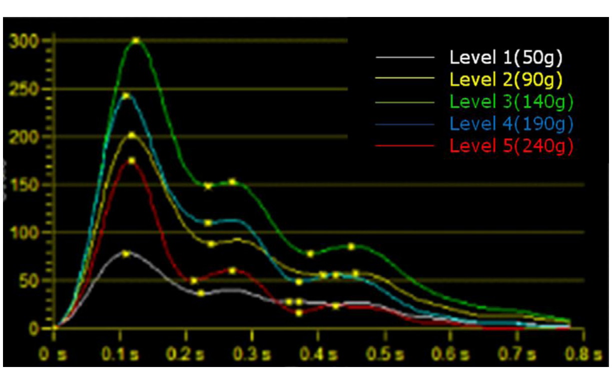

Figure 5 Pulse waveforms measured at five different pressure levels.

"central transducer" among the five transducers of the array sensor [11].

2.4.2. Pulse parameters

The following pulse parameters were analyzed during the study (Fig. 6). (1) Pressure (g): Pressure applied on the pulse-measuring position to gain the representative pulse. (2) Pulse depth (number of motor rotations in the sensor): Moving distance of the tonometry sensor. (3) Pulse height parameters (div; digital value for pressure): Amplitudes of $H1$, $H2$, $H3$, $H4$, and $H5$. (4) Periodic parameters (seconds): Periods of T, $T1$, $T2$, $T3$, $T4$, and $T5$. (5) Main peak angle (degree): Angle of the main peak of the pulse wave. (6) Radial augmentation index (RAI) (%): $H3/H1$.

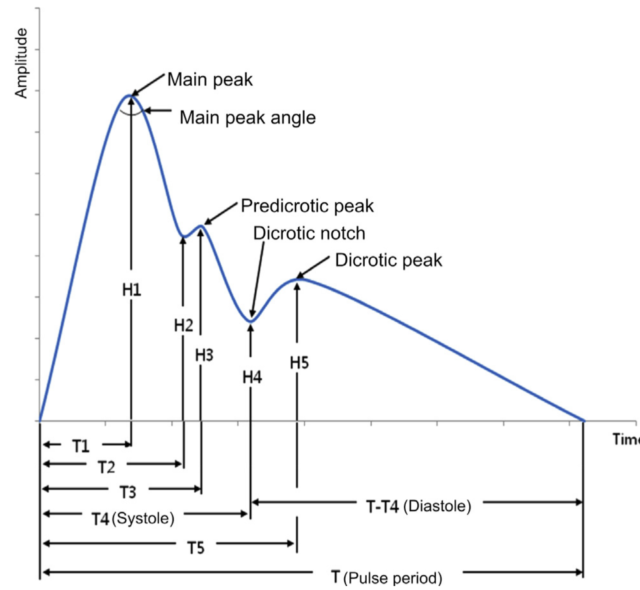

Figure 6 Radial pulse waveform.

2.4.3. Statistical analysis

Statistical analysis was performed using PASW Statistics 18.0 (IBM, Armonk, NY, USA). The data are presented as the mean $\pm$ standard deviation. Differences of the pulse parameters according to gender and those between the left and the right pulses were analyzed using the independent t test. Position differences were analyzed using the one-way analysis of variance, and Scheffe's test was applied as a *post hoc* multiple comparison test. Pearson correlation coefficients were used to determine the relationships between pulse parameters. A p value of <0.05 was considered statistically significant.

3. Results

3.1. Gender comparison of radial pulse

The applied pressure and pulse depth were significantly higher in males than in females. The pulse period (T) was significantly longer, whereas systolic proportion of pulse period ($T4/T$) was significantly shorter in males than in females (Fig. 7).

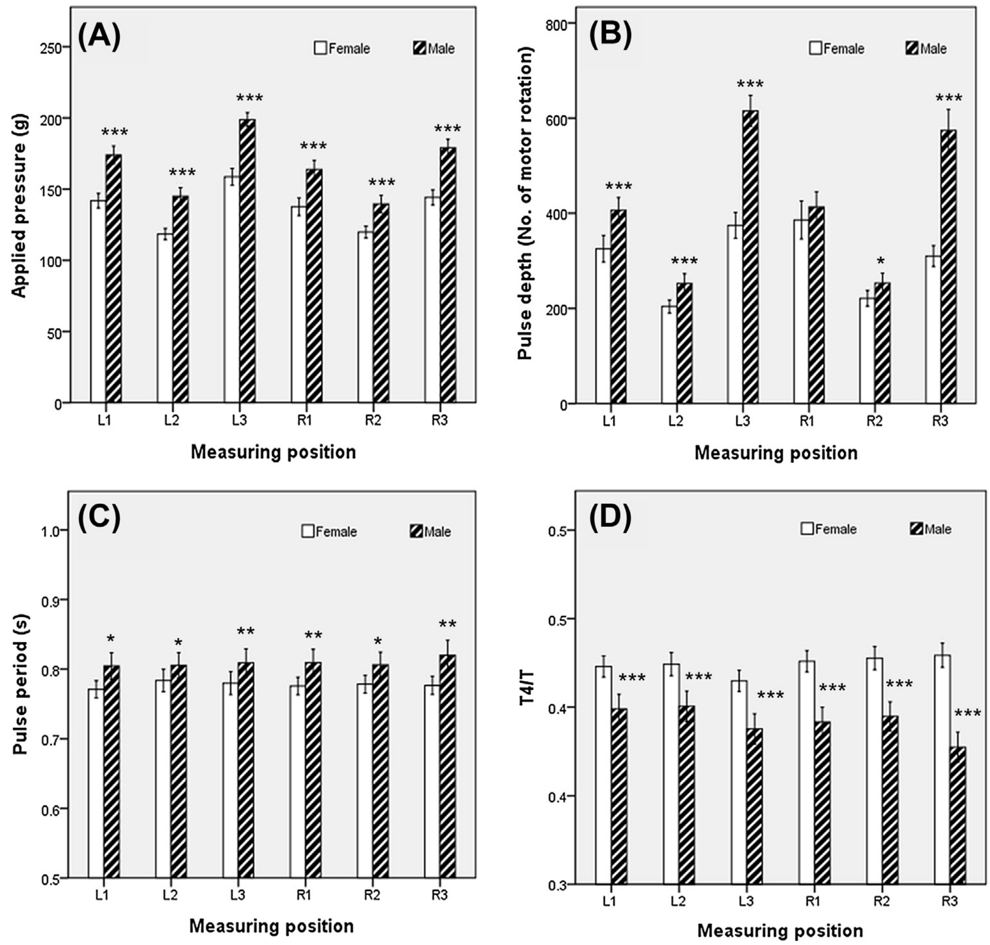

Figure 7 Gender comparison of radial pulse parameters. Values are expressed as means ± SD. The pulse parameters were analyzed by independent *t* test. $*p < 0.05$ versus female. $**p < 0.01$ versus female. $***p < 0.001$ versus female. L1 = left *Chon*; L2 = left *Gwan*; L3 = left *Cheock*; R1 = right *Chon*; R2 = right *Gwan*; R3 = right *Cheock*; SD = standard deviation.

Fig. 8 shows the averaged pulse waveforms of males and females.

3.2. Position comparison of radial pulse (*Chon* vs. *Gwan* vs. *Cheock*)

Significantly different pulse parameters according to measuring positions (*Chon* vs. *Gwan* vs. *Cheock*) are presented in Fig. 9.

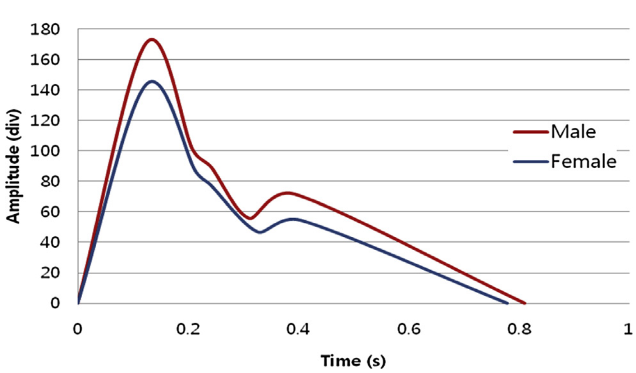

Figure 8 Averaged pulse waveforms of males and females.

Significantly lesser pressure was applied to gain a representative pulse at the *Gwan* position than that applied at the *Chon* and *Cheock* positions (Fig. 9A). The representative pulse was significantly shallower at the *Gwan* position than that at the *Chon* and *Cheock* positions (Fig. 9B). The amplitude of *H*1 was highest at the *Chon* position; the second highest amplitude was observed at the *Gwan* position and lowest at the *Cheock* position (Fig. 9C).

Fig. 10 shows the averaged pulse waveforms at three different measuring positions on the wrist.

3.3. Comparison of left and right radial pulses

Pulse parameters of the left and the right pulses were significantly different, as shown in Fig. 11. The main peak angle and RAI were significantly higher in the left pulse than those in the right pulse (Fig. 11).

Fig. 12 shows the averaged left and right pulse waveforms.

3.4. Correlation analysis of pulse parameters

The applied pressure and the pulse depth had a positive correlation between them ($r = 0.704$, $p = 0.000$). The RAI

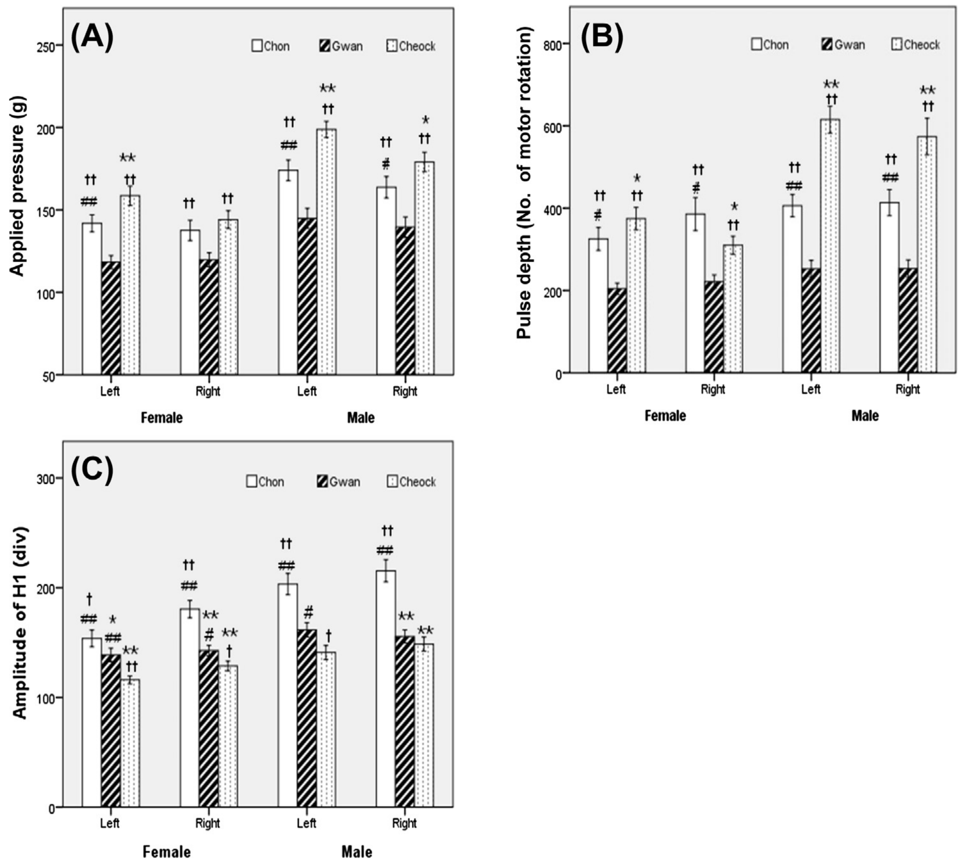

Figure 9 Position comparison of radial pulse parameters (*Chon* vs. *Gwan* vs. *Cheock*). Values are means $\pm$ SD. The pulse parameters were analyzed by one-way ANOVA test, and Scheffe's test for *post hoc* analysis. $*p < 0.01$, $**p < 0.001$ vs *Chon*, $\dagger p < 0.01$, $\dagger\dagger p < 0.01$ vs *Gwan*, $\#p < 0.01$, $\#\#p < 0.001$ vs *Cheock*.

was positively correlated with the main peak angle ($r = 0.428$, $p = 0.000$).

4. Discussion

According to traditional Eastern medical theories, a pulse has intrinsic characteristics that depend on age, gender, constitution, measuring positions, and related internal organs [1,2].

In this study, pulse waves of male and female participants were compared. The results of the present study showed that more pressure was applied to move the tonometry sensor down deeper to obtain a representative pulse wave in males than that in females. In addition, heart beats were slower and the proportion of the systolic pulse period was shorter in males than in females. In summary, the pulse in males was deeper and slower, with longer diastolic proportion and shorter systolic proportion, compared to that in females.

Apart from gender differences, we also compared the pulse waves at different measuring positions. The amplitude of the main peak was higher at the distal position (*Chon*), medium at the middle position (*Gwan*), and lower at the proximal position (*Cheock*), indicating that the amplitude of the main peak increases as it goes distal. In addition, the pulse was deepest at the proximal position (*Cheock*) and shallowest at the *Gwan* position immediately beside the radial styloid process. We presume that the pulse depth is related to the anatomical conditions of the measuring position.

Besides the *Chon*—*Gwan*—*Cheock* comparison of the pulse, the left and right pulses were also compared. The RAI is widely used to estimate arterial stiffness. It is known that a stiff artery causes an increase in pulse wave velocity, leading to early return of the reflected wave from the lower body to the radial artery. The RAI depends on the heart rate and body height [12,13]. Some studies have investigated the left—right differences in the cardiovascular and circulatory systems

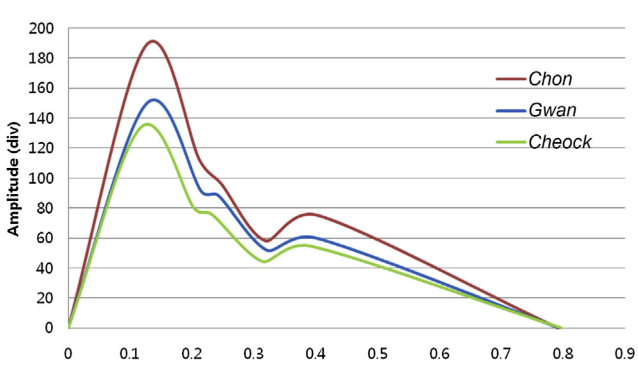

Figure 10 Averaged pulse waveforms at three different measuring positions on the wrist: *Chon* versus *Gwan* versus *Cheock*.

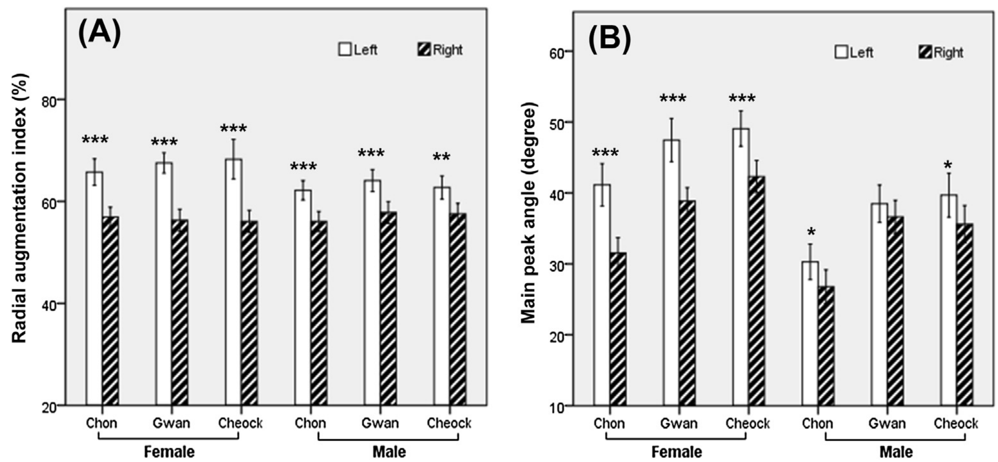

Figure 11 Left—right comparison of radial pulse parameters. Values are expressed as means ± SD. The pulse parameters were analyzed by independent t test. $*p < 0.05$ versus right. $**p < 0.01$ versus right. $***p < 0.001$ versus right. SD = standard deviation.

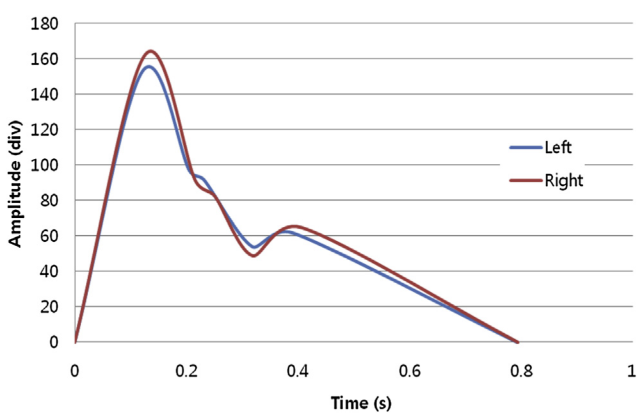

Figure 12 Averaged left and right pulse waveforms.

under pathological conditions [14—16]. In the present study, physiological RAI of healthy young participants was higher for the left pulse than that for the right pulse. In addition, the main peak angle was larger for the left pulse than that for the right pulse, and had a positive correlation with RAI. We expect that the results of this study can spark more interest in the physiological left—right differences between the cardiovascular and circulatory systems.

Based on traditional Eastern medical physiology, the distal position of the radial pulse belongs to *Yang* and refers to the condition of *Yang*, whereas the proximal position of the radial pulse belongs to *Yin* and refers to the condition of *Yin*. There are also distinctions between right and left pulses. The right pulse refers to the conditions of *Qi* and the internal organs related to *Qi*, whereas the left pulse refers to the conditions of *blood* (a wider concept than the Western medical term "blood") and the internal organs related to *blood* [1,2].

The physiological characteristics of radial pulse in healthy individuals observed in the present study may be used as standards for the diagnosis of the pathological pulse. The analysis of a patient's pulse based on the standard healthy pulse may enable the determination of imbalances and disharmonies between Yin and Yang, between Qi and blood, and in the conditions of related internal organs.

The results of the present study confirm that the radial pulse differs significantly according to gender and measuring positions in the physiological condition.

However, this study has certain limitations. First, the participants of this study were aged in their 20s. Studies in other age groups are also needed. Second, we analyzed only the representative pulse from the central transducer of the array sensor. Based on the relationship between the applied pressure and pulse amplitude, and the fact that the central transducer is placed above the center of the arterial flow, we determined that the representative pulse from the central transducer is appropriate for observing the pulse characteristics in healthy individuals. However, in the case of patients, not only the representative pulse from the central transducer, but also the pulse waves at all pressure levels from all transducers of the sensor may be worthy of analysis. As an example, a "hollow pulse," which may be observed after the loss of a significant amount of blood, appears to be normal at the border of arterial flow, but empty within the vessel [1]. In this situation, the representative pulse from the central transducer may not be sufficient to comprehend the pulse. Thus, we recommend that pulse waves at all pressure levels from all transducers should be analyzed in case of diseased individuals. In conclusion, Radial pulses differ significantly according to gender, measuring positions, and physiological condition.

Disclosure statement

The author affirms there are no conflicts of interest and the author has no financial interest related to the material of this manuscript.

References

[1] Kaptchuk Ted J. *The Web That Has No Weaver*. New York: McGraw-Hill; 2000:194—210.

[2] Liangyue D, Yijun G, Shuhui H, Xiaoping J, Yang L, Rufen W, et al. *Chinese Acupuncture and Moxibustion*. Beijing: Foreign Language Press; 1987:267—271.

[3] Chirinos JA, Kips JG, Roman MJ, Medina-Lezama J, Li Y, Woodiwiss AJ, et al. Ethnic differences in arterial wave reflections and normative equations for augmentation index. *Hypertension*. 2011;57:1108—1116.

[4] Duprez DA, Jacobs Jr DR, Lutsey PL, Herrington D, Prime D, Ouyang P, et al. Race—ethnic and sex differences in large and small artery elasticity—results of the multi-ethnic study of atherosclerosis (MESA). *Ethn Dis*. 2009;19:243—250.

[5] Heffernan KS, Jae SY, Wilund KR, Woods JA, Fernhall B. Racial differences in central blood pressure and vascular function in young men. *Am J Physiol Heart Circ Physiol*. 2008;295: H2380—H2387.

[6] Sugawara J, Komine H, Yoshiwaza M, Tarumi T, Maeda S, Tanaka H. Racial differences in relation between carotid and radial augmentation index. *Artery Res*. 2010;4:15—18.

[7] King E, Cobbin D, Ryan D. The reliable measurement of radial pulse: gender differences in pulse profiles. *Acupunct Med*. 2002;20:160—167.

[8] Lee J, Jeon YJ, Lee HJ, Kim JY. Variations in non-invasive radial artery pulse waveform at different measuring positions. *Conf Proc IEEE Eng Med Biol Soc*. 2008;2008:1415—1418.

[9] Park M, Kang H, Huh Y, Kim KC. Cuffless and noninvasive measurement of systolic blood pressure, diastolic blood pressure, mean arterial pressure and pulse pressure using radial artery tonometry pressure sensor with concept of Korean traditional medicine. *Conf Proc IEEE Eng Med Biol Soc*. 2007;2007:3597—3600.

[10] Yim YK, Park KS. A study on the effect of food intake on radial pulse using Fourier analysis. *J Korean Oriental Med*. 2011;32: 139—148.

[11] Yim YK, Lee H, Lee BR, Lee YH, Yoon YJ, Ro JY. Effect of Sa-Am acupuncture on radial pulse; a comparative study of stomach-tonification and spleen tonification. *Korean Journal of acupuncture*. 2011;28:25—32.

[12] Nichols WW. Clinical measurement of arterial stiffness obtained from noninvasive pressure waveforms. *Am J Hypertens*. 2005;18(1 Pt 2):3S—10S.

[13] Korpas D, Halek J. Pulse wave variability within two short-term measurements. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub*. 2006;150:339—344.

[14] Clark CE, Taylor RS, Shore AC, Campbell JL. The difference in blood pressure readings between arms and survival: primary care cohort study. *BMJ*. 2012;344:e1327.

[15] Yeragani VK, Kumar R, Bar KJ, Chokka P, Tancer M. Exaggerated differences in pulse wave velocity between left and right sides among patients with anxiety disorders and cardiovascular disease. *Psychosom Med*. 2007;69:717—722.

[16] Clark CE, Campbell JL, Powell RJ. The interarm blood pressure difference as predictor of cardiovascular events in patients with hypertension in primary care: cohort study. *J Hum Hypertens*. 2007;21:633—638.