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Research paper

Association of obesity with anatomical and physical indices related to the radial artery in Korean adults

Bum Ju Lee*, Young Ju Jeon, Jong Yeol Kim

KM Fundamental Research Division, Korea Institute of Oriental Medicine, 1672 Yuseongdae-ro, Yuseong-gu, Deajeon 305-811, Republic of Korea

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ABSTRACT

Introduction: Obesity is a chronic disease risk factor. The objective of this study was to assess the association of obesity with anatomical and physical indices at the Cun, Guan, and Chi positions related to the radial artery.
Methods: A total of 109 healthy subjects aged 30–50 years participated in this study. Binary logistic regression was performed to examine differences in physical and anatomical indices between normal and obese subject groups.
Results: The arterial diameter was associated with obesity at the Guan (adjusted p = 0.0441, adjusted OR = 1.65 [1.013–2.687]) and Chi positions (adjusted p = 0.0028, OR = 2.277 [1.327–3.908]) but not the Cun position. No association between the arterial blood flow velocity and obesity were observed at the three positions. The pulse depth index (PDI) was related to obesity at the Cun (adjusted p = 0.0038, OR = 2.119 [1.274–3.526]) and Guan positions (adjusted p = 0.0422, OR = 1.595 [1.017–2.503]). The high-frequency spectral energy proportion of the total pulse energy (HSEP) was significantly different only at the Chi position (adjusted p = 0.0418, OR = 0.571 [0.333–0.979]), and the spectral energy ratio (SER) was related to obesity only at the Guan position (adjusted p = 0.0468, OR = 1.76 [1.008–3.073]).
Conclusion: Our study demonstrated that the arterial diameter, PDI, HSEP, and SER were associated with obesity at one or more positions. Our findings suggest that obesity may be considered in arterial pulse diagnosis and anatomical characteristics.

1. Introduction

Overweight and obesity are major global health problems and the most common nutritional disorders. These disorders may play a role in the increasing occurrence of chronic diseases, such as cardiovascular disease, diabetes, metabolic abnormalities, and metabolic syndrome [1–5]. The World Health Organization (WHO) [6] has suggested the following body mass index categories according to the degree of obesity: normal (18.5–23 kg/m^2), overweight (23–27.5 kg/m^2), and obese ($\geq$27.5 kg/m^2). However, the definitions of overweight and obesity in terms of the body mass index (BMI) and waist circumference may differ according to ethnic groups, countries, and economic statuses [7,8].

Several traditional Korean medicine (TKM) and Chinese medicine (TCM) studies have focused on obesity in the fields of physical traits [9], herbal medicine [10–13], genetics [14], acupuncture [13,15,16], and pulse wave diagnosis [17–21]. Arterial pulse wave and pulse diagnosis are two of the most important research fields in TKM and TCM. Traditionally, TKM and TCM doctors use their fingertips to palpate the wrists for pulse diagnosis. As such, pulse diagnosis is dependent on the experience and intuition of the performing TCM or TCM doctor [21,22]. Pulse wave and pulse diagnosis can be affected by patient health status, and both intrinsic and extrinsic factors, such as emotional state, season, age, gender, diet, biorhythms, and disease, can affect the wrist pulse wave [19,22–25]. Pathological changes in the body condition of patients can be detected based on pulse diagnosis [26]. Accordingly, TCM and TKM doctors recognize the importance and significance of pulse diagnosis and the associations between pulse wave changes and disease [27]. Many studies have reported the standardization of the pulse-taking approach [28,29] and pulse patterns [27,28] and have demonstrated the association of a particular disease with certain pulse characteristics or patterns [21,28,30]. In addition, a few studies have reported associations between obesity and pulse wave parameters in populations worldwide [31–33]. For example, the low-to-high-frequency ratio (LFHF) index has been found to be higher and the low- and high-frequency values lower in obese subjects than in subjects of normal weight [31]. However, in other words, the low- and high-

Abbreviations: LF, low-frequency spectral power; LFHF, relative spectral power; PPI, pulse power index; PDI, pulse depth index; PSD, power spectrum density; HSEP, high-frequency spectral energy proportion; SER, spectral energy ratio; BMI, body mass index; TCM, traditional Chinese medicine; TKM, traditional Korean medicine

* Corresponding author.
E-mail address: bjlee@kiom.re.kr (B.J. Lee).

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frequency power have only been weakly correlated with BMI, and the LFHF ratio has been found to be uncorrelated with BMI [33]. Therefore, whether associations exist between obesity and arterial physical indices remains unclear.

The objective of the present study was to assess the associations between obesity and anatomical and physical indices related to the radial artery. Although several previous studies have examined the association between obesity and frequency-based indices at the Cun, Guan, and Chi positions for the radial artery, no study has simultaneously assessed the relationships between obesity and both physical and anatomical indices. The results of the present study will contribute to our knowledge of the quantification and standardization of the arterial wrist pulse diagnosis for obesity and to the development of a better pulse sensing system.

2. Material and methods

2.1. Subjects

A total of 109 subjects (63 women and 46 men) aged 30–50 years participated in this study between July 2012 and April 2013. All participants were recruited from the Oriental Hospital of Daejeon University in Cheonan City in the Republic of Korea, and all measurements and assessments were performed at the hospital. The Institutional Review Board of the Korea Institute of Oriental Medicine (KIOM) approved the study (I0906-01-02). All participants enrolled in this study provided written informed consent.

Inclusion criteria for the subjects were as follows: 1) submission of written informed consent, 2) male or pre-menopausal female aged 30–50 years, and 3) Korean residing in the Republic of Korea. The exclusion criteria were as follows: 1) subject diagnosed with hypertension; 2) previously documented diabetes, coronary artery disease, hypertriglyceridemia, or stroke; 3) underweight (BMI < 18.5); and 4) omission of blood information or physical and anatomical indices.

2.2. Definitions and measurements

The definitions of normal, overweight, and obese subjects based on BMI can differ according to ethnic group, country, economic status, and gender [7,8]. Therefore, as suggested by the World Health Organization [34] and previous studies [7,8], Asian subjects with a BMI greater than or equal to 23 were considered obese and subjects with a BMI between 18.5 and 22.9 were labeled normal. The basic characteristics of the study subjects are described in Table 1.

The pulse was acquired using the KIOM-PAS developed by the Korea Institute of Oriental Medicine [35]. The KIOM-PAS has 7 piezoresistive sensors for pulse detection and provides diagonal direction pressure. After the measurement angle is determined, the angle is fixed using an electromagnet, and the sensor measures the pulse waveform by continuous pressurization at a constant speed. After 10 min of rest in a relaxed posture, the left wrist pulse wave signal was measured at the three palpation positions (Cun, Guan, and Chi). The exact positions were determined by a doctor of Korean medicine. A well-trained operator measured the pulse waveform signals in the following order: the Guan, Cun, and Chi positions (Fig. 1). The sampling frequency of the KIOM-PAS is 1000 Hz.

An electrocardiogram (ECG) module (ECG100C, Biopac Systems, USA) was used to acquire low-frequency spectral power (LF) in the 0.04–0.15 Hz band, LF/high-frequency spectral power (HF) in the 0.15–0.4 Hz band, and the ratio of high frequency to total frequency (HF100) from the ECG signal. These parameters are indicators of the cardiac sympathovagal balance [18,19]. HF100 is the HF power in normalized units and indicates the balanced activity of the two branches of the autonomic nervous system [18,19]. The pulse depth index (PDI) signifies the pulse depth computed by actual sensor displacement [35]. The spectral energy ratio (SER) indicates the spectral energy ratio at a frequency of 10 Hz [36], and the high-frequency spectral energy proportion (HSEP) signifies the high-frequency spectral energy proportion of the total pulse energy [18]. The pulse power index (PPI) is the voltage response of the sensor when the pulse amplitude reaches the maximum. This signal was synchronized with the KIOM-PAS. Detailed descriptions of these parameters are presented in Table 2 and in previous studies [18,19,35–38].

An ultrasound machine (Voluson 730 Pro, GE Medical, USA) was used to obtain the anatomical characteristics, such as the artery diameter and blood flow velocity of the radial artery at the three palpation positions. To determine the location of the ultrasound image, three small metal wires were wound on each measurement point and covered with a gel pad (Parker Laboratories, Inc., USA). Various parameters were extracted from the ECG module, ultrasound machine, and KIOM-PAS. A brief description of the indices used in this study is shown in Table 2.

Table 1
Basic characteristics of the study subjects.

Variable	Normal (n = 55)	Obese (n = 54)
Men/women (number of subjects)	14/41	32/22
Age *	37.73 (5.373)	40.35 (6.023)
Height	165.5 (7.944)	168.3 (8.060)
Weight ‡	56.60 (6.856)	72.82 (9.554)
BMI ‡	20.62 (1.463)	25.63 (2.028)
SBP	111.2 (8.271)	113.0 (9.101)
DBP *	70.04 (9.139)	73.52 (8.571)
Pulse	70.51 (6.858)	70.96 (7.566)
Hemoglobin ‡	13.27 (1.567)	14.45 (1.674)
Creatinine †	0.734 (0.155)	0.837 (0.220)
Glucose ‡	85.00 (6.263)	89.69 (7.716)
Total cholesterol †	177.6 (34.13)	195.6 (34.41)
Triglyceride †	87.82 (71.27)	139.4 (126.6)
LDL ‡	96.82 (24.37)	121.4 (31.65)
HDL ‡	68.20 (16.47)	53.85 (9.029)
Total Protein	7.278 (0.969)	7.394 (0.368)
Albumin	4.611 (0.262)	4.626 (0.219)
AST ‡	19.91 (3.556)	24.39 (7.853)
ALT ‡	14.67 (5.114)	26.83 (16.35)
Dominant side (number of subjects)		
left-handed	3	4
right-handed	52	50
Smoking (number of subjects)		
never smoker	43	39
current smoker	8	10
past smoker	4	5
Drinking (number of subjects)		
non-drinker (< 1 cup/month)	15	15
drinker	40	39

Data are the means (standard deviation) or numbers of subjects. The results were obtained by independent two-sample *t*-tests (* p = < 0.05, † p = < 0.01, ‡ p = < 0.001). $p < 0.05$ was considered to be statistically significant.

Fig. 1. Cun, Guan, and Chi positions for pulse diagnosis at the wrist.