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ORIGINAL ARTICLE

Correlation of the Second Derivative of Digital Pulse Wave (DPW) with Central Obesity in Women

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ABSTRACT
Background: Obesity, as measured by body mass index (BMI) or measures of central obesity, including waist-to-hip ratio (WHR) and waist circumference, is related to higher total and cardiovascular mortality. Four systolic waves (a, b, c, and d) and one diastolic wave (e) make up the second derivative of the digital pulse wave (SDPTG), which is obtained by two mathematical differentiation of the original PTG. Objective: To find out whether the (SDDPW) is correlated with central obesity in women. Methods: 55 healthy female subjects with Body Mass Index (31.5±7.3) were included in the current study. A fingertip pulse wave transducer was used to record digital pulse waves. For automatic detection and measurement of A, B, C, D, and E waves and amplitude of the second derivative digital pulse wave, Lab Chart Pro version 7.2 was used. Height and weight were measured. Waist and hip circumference were measured. Brachial systolic and diastolic blood pressures (SBP & DBP) were measured. Results: The results showed that B/A ratio is positively and significantly affected by central obesity in terms of waist circumference (r = 0.3, P<0.037), and waist/height ratio (r = 0.31, P<0.031). Conclusion: B/A ratio is positively and significantly affected by central obesity.
Keywords: Digital pulse wave (DPW), Central obesity, women

INTRODUCTION
Central obesity is associated with risk factors for cardiometabolic syndrome [1]; obesity is considered one of the most significant public health challenges, with the worldwide prevalence of obesity doubling between 1980 and 2014 [2]. Abdominal obesity occurs when waist circumference is ≥102 cm for men and ≥88 cm for women. It is independent of body mass index (BMI) and calculated as weight in kilograms divided by height in meters squared, and it has been associated with major chronic diseases and all-cause mortality [3]; abdominal fat, rather than total body fat, was discovered to be the origin of the systemic inflammation that leads to chronic illness [4].

BMI is usually used to assess obesity. However, obesity, as defined by BMI is not a fitness indicator of body fat distribution. Central obesity, measured by waist circumference (WC), is a strong risk factor for the prevalence of hypertension and stroke; Compared to individuals with a normal BMI, a population with central obesity has a higher risk of incident hypertension [5].

Waist-to-hip ratio (WHR) is the ratio of waist circumference to hip circumference [6]; according to the World Health Organization (WHO), a moderate WHR is 0.9 or less in men and 0.85 or less for women. Using the current World Health Organization (WHO), higher values are associated with higher risks of cardiovascular morbidity.

Photoplethysmography (PTG) is a device that monitors the quantity of light absorbed by blood vessels, blood, and tissues, which may be translated into parameters like blood flow volume fluctuation, heart rate variability, blood pressure, etc. [7]. A vast range of biological information can be gleaned from PTG signals that may be used to identify and diagnose several health issues [8]. The second derivative of the PTG produces SDPTG, which is the result of two mathematical differentiation of the original photoplethysmogram [9]. Four different waves during systole A-B-C-D and a wave E during diastole were discovered in SDPTG [10].

The current study investigates the correlation of the second derivative of digital pulse wave (DPW) with Central obesity in women of various ages.

MATERIAL AND METHODS
The Ethical Committee of the College of Medicine, University of Mustansiriyah, approved this study and granted consent to participate. All of the methodologies employed in this investigation follow the Helsinki Declaration of 2013. All research participants supplied verbal informed permission.

Subject's selection and study protocol: Fifty-five females were included in the study. A medical history questionnaire confirmed that none had a primary medical disease or received medication for a major illness. This is determined using a medical history questionnaire. The subjects did not smoke or drink alcohol, and they had fasted for over 12 hours. Anthropometric data were measured and collected.

Anthropometric measurements: Height and weight were measured. Waist and hip circumference were measured as the abdomen circumference at the umbilicus and maximum hip circumferences. At the same time, the legs were closed with each other, respectively, by a flexible but non-elastic measuring tape. The distance in cm between the suprasternal notch and the tip of the left middle finger while the left arm was abducted at 90° will be measured and represents the distance between the heart and the peripheral vessels through which the pressure wave was traveling. Blood samples were taken via venipuncture for analysis of the free radical status, total cholesterol, HDL, LDL, and triglycerides. Calculation of visceral adiposity index as follows (Marco C Amato. et al., 2011):

Females VAI = {[WC (cm)/36.58 + (1.89 x BMI)} x (TG in mm/0.81) x (1.52/HDL in mm): Lipid accumulation product (LAP) was calculated as follow (Kahn, Henry S., 2005):

Female LAP = [waist (cm) −58] × TG concentration (mM): A glucometer measured random blood sugar to exclude the possibility of diabetic patients. Brachial systolic and diastolic blood pressures (SBP & DBP) were measured in a lying position after 5 min of complete rest with the head slightly flexed and supported by the couch surface. Repeated BP and heart rate (HR) measurements were done by an automated sphygmomanometer (Blood Pressure Monitor BLS-2009C; Germany) on the brachial artery of the right arm until stable values for both of these parameters were obtained and considered as the basal levels of BP and HR at rest. Valsalva maneuvers were asked to be avoided throughout the measurements. Subjects were asked to maintain spontaneous respiration throughout the protocol and to remain quiet during various stages of the procedure.

Recording of ECG and fingertip digital pulse wave (DPW) signals: Power Lab analog to digital converter Data Acquisition Unit 26T and a computer Lab Chart Pro version 7.2 Software was purchased from AD Instruments Pty Ltd, New South Wales, Australia; they were both used to convert and digitally record the data on the computer. A five-minute fingertip digital pulse wave (DPW) signals were recorded using a piezoelectric Finger Pulse Transducer and lead II ECG via three surface electrodes connected to Power Lab Data Acquisition Unit 26T, two electrodes were attached to the right arm and left leg (Lead II) and one electrode were attached to the right leg (serving as earth). Both the transducer and the ECG leads were connected to PowerLab Analog to digital converter data acquisition unit 26T (AD Instruments Pty Ltd, New South Wales, Australia), which was used to convert and digitally record the data on the computer. Computer Lab Chart Pro version 7.2 Software was used for offline analysis of the signals. 30-40 continuous clear cycles were selected and analyzed from each record. The peak analysis module incorporated within Lab Chart Pro Software was used for automatic detection and measurement of A, B, C, D, and E waves of the SDDPW. Detection adjustment was set to a minimum peak height of 0.25 SD, and the trigger was set to maximum or minimum for detection of A, C, and E or B and D, respectively, using a low pass filter with a 50 Hz cut-off frequency. The relevant recognized waves for each cardiac cycle were chosen for amplitude measurement, while the non-relevant detected waves were removed.

Statistical analysis: The mean and standard deviation (SD) expressed all of the findings. The correlation between variables was determined using Excel on a Windows computer. Results were considered statistically significant if $P < 0.05$. The outlier data. (Abnormal beats and artifacts) were specified and removed using Rosner's Extreme Studentized Deviate test for multiple outliers at a probability of < 0.05.

RESULTS

Two systole waves (B/A, D/A) and one diastole wave (E/A) were considered in this study. The results showed that there was a link between central obesity and SDDPW. However, waist circumference was positively linked to the B/A ratio, as shown in figure 1. Furthermore, figure 2 shows a positive and significant relationship between the waist-to-height ratio (W/H) and the B/A ratio.

Table 1: The measured variables of the recruited female subjects, N = 55

The measured variables	Mean	SD
Age (year)	37.4	±9.9
BMI (kg/m²)	31.5	±7.3
SBP (mm Hg)	117.6	±11.0
DBP (mm Hg)	76.5	±7.4
Waist /Height Ratio (W/H)	0.59	±0.08
Waist Circumference (WC) (cm)	92.1	±13.3
Cholesterol/HDL ratio	4.02	±1.3
VLDL-C (Mm)	0.54	±0.24
Non-HDL-C (Mm)	3.2	±1.0
Total cholesterol (Mm)	4.1	±1.0
B/A (N=49) *	-0.64	±0.11
D/A (N=52) *	- 0.24	± 0.3
E/A (N=53) *	0.40	±0.22
(B-C-D-E)/A (N=50) *	-1.50	±0.25
*After exclusion of the outlier values.		

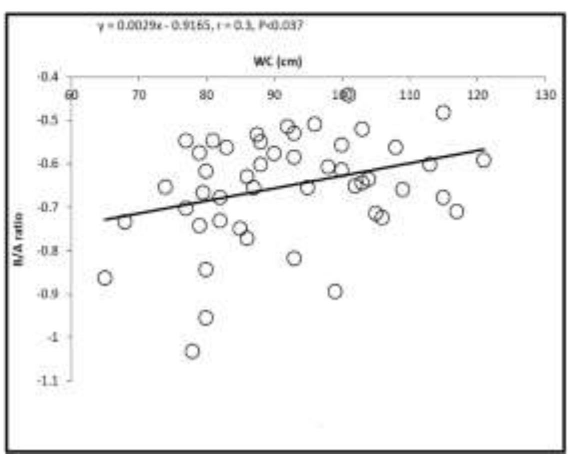

Figure 1: the relationship between waist circumference (WC) and B / A ratio N= 49

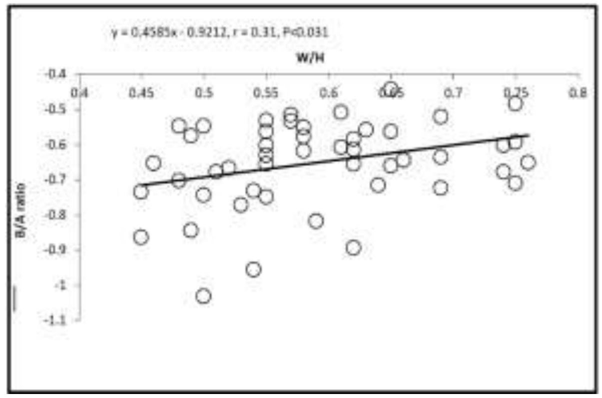

Figure 2: the relationship between waist circumference (WC) and B / A ratio N= 49

DISCUSSION

The B/A index is found to be an essential factor in the study of arterial stiffness [11]. Our data clearly showed a significant and positively correlated relationship between the B/A ratio and two adiposity indices, i.e. the WC and waist/height ratio. Others [12] reported no correlation between B/A ratio and WC, while Others [13] reported a negative correlation between B/A ratio and W/H ratio.

CONCLUSION

It can be concluded from the results of the present study that B/A ratio is positively and significantly affected by central obesity. This study also found that a PPG can be used to assess obesity, which has a strong relationship with arterial stiffness. Thus, PPG signals can be used to assess arterial stiffness. Therefore, the increase in central obesity leads to a rise in the B/A ratio, which means more cardio-metabolic diseases. In particular, heart failure (HF) and coronary heart disease (CHD).

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