Bioelectrical Impedance Analysis in Assessing the Chances of Obtaining Coronary Heart Disease in Obese Subjects

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Abstract; This paper describes parameters to predict the chances of obtaining coronary heart disease (CHD) using bioelectrical impedance analysis (BIA) in obese subjects at the University of Malaya Student Health Clinic (UMHC), Kuala Lumpur. Bioelectrical impedance measurements were conducted on 88 subjects (30 males and 58 females) with mean body mass index (BMI) of 30kg/m^2. We investigated all the parameters in BIA, patients' lipid profiles and demographic data in explaining of getting CHD incidences. The lipid profiles include serum total cholesterol, low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol, and the total cholesterol and HDL cholesterol ratio.

In this prediction, 7 predictors (height, weight, body capacitance, fat mass, extra cellular mass and body cell mass ratio, basal metabolic rate, and intracellular water) were found to be significant for predicting CHD incidence in obese subjects. These variables explain approximately 68.3% of the variation of CHD incidence in obese subjects.

Keywords: bioelectrical impedance analysis, obese, lipid profiles, heart disease incidence, total cholesterol and HDL cholesterol ratio

1. Introduction

Heart disease is the leading cause of death in the world. One of the most common forms of heart disease is coronary heart disease (CHD). CHD happens when arteries become narrowed by atherosclerosis which can lead to serious health problems, including angina (pain or pressure in the chest) and heart attack.

Framingham Heart Study established that high blood cholesterol is a risk factor for CHD. The results of the Framingham study showed that the higher the cholesterol level, the greater the CHD risk. The finding of the study also suggests that the total cholesterol/high density lipoprotein (TC/HDL) ratio is the risk factor and a predictor of subsequent CHD [1], [2]. The results of the study indicates that if subjects' TC/HDL ratios ranging from less 3.0 to 9.0 or more, this will increase their risk of getting CHD in 8-years. On the other hand, a lower TC/HDL ratio is associated with a lower degree of risk.

However, to obtain the TC/HDL ratio, blood is to be withdrawn from one of the subject's vein. This procedure is invasive that may carry risk in developing a bruise, or hematoma. [3].

This paper introduces a method to obtain the parameters to predict TC/HDL ratio using bioelectrical impedance analysis (BIA). The objective of this study is to find the correlation between body compositions (bioelectrical tissue conductivity, mass distribution and water compartment) and subjects' demographic data with the TC/HDL ratio in the obese people using the BIA. From this analysis the parameters to predict the chances of getting CHD can be obtained.

2. Subjects and Methods

In this study, we measured the subjects for their anthropometric value, body composition parameters, and their lipid profiles. Then the data were analyzed statistically using SPSS version 13.

2.1 Subjects

Subjects were not randomly selected through the Wellness Programme conducted in the University Malaya Health Clinic (UMHC), University of Malaya, Kuala Lumpur in February 2003. A total of 88 obese subjects (subject is considered obese if he or she has a body mass index (BMI) of 30 kg/m^2 or greater) were studied. They had to fast for 9 to 12 hours and were asked to abstain from doing any exercise in the 9 to 12h prior to attendance at the clinic. All subjects were given a consent form for the study.

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2.2 Anthropometric and Bioimpendance Analysis Measurements

Anthropometric measurements were taken with the subjects in light clothing and without shoes. Height was measured to the nearest 0.1 cm and weight was measured to the nearest 0.1kg.

Subjects were asked to lie face up on a bed in a supine position. Two pairs of sensor electrodes were placed on the subject's right hand and wrist, and right foot and ankle. A cable was connected between the analyzer and the sensor electrodes. Using the analyzer's keypad, the subject's gender, age, height, and weight were entered. The measurement was performed by injecting a constant current less than 1 mA at a single frequency of 50 kHz using the biodynamic Model 450 bioimpedance analyzer, from Biodynamic Corporation, USA [4]. Next, a printout was generated by pressing a button. The result shows measured resistance (R), reactance (Xc), body capacitance (BC), phase angle (PA) and computed mass distribution and water compartments. This measurement only took about three minutes.

2.3 Lipid profiles measurements

Subjects' serum was collected for measurement of lipid profiles. Patient serum samples were tested for Total Cholesterol (TC), High Density Lipoprotein (HDL) Cholesterol and Triglycerides using the Dade Behring Clinical Chemistry System machine.

TC method was based on the principle described by Stadtman [5] and later adapted by other workers [6], [7] including Rautela and Liedtke [7].

The HDL Cholesterol assay was a homogenous method which directly measured HDL Cholesterol levels. Alternatively, this method was called the Accelerator Selective Detergent Method (ASDM).

The triglycerides method was based on an enzymatic procedure in which a combination of enzymes was employed for a kinetic bichromatic (340, 383 nm) measurement of serum triglycerides. [7], [8].

Low density Lipoprotein (LDL) Cholesterol was calculated using the value of Total Cholesterol, HDL Cholesterol and triglycerides value.

Thus, the TC/HDL ratio was obtained by dividing the TC to HDL Cholesterol value.

2.4 Statistical Method

Statistical analyses were performed using SPSS version 13.0 for window XP. Data were tested for normal distribution using the Kolmogorov-Smirnov test. Relationships between TC/HDL ratio and body composition were evaluated using Pearson's' correlation for linear associations. Then, multiple linear regression tests were performed to find the coefficient value for the linear association.

3.0 Results and Discussions

Of the 88 individuals studied 58 (65.9%) were females and 30 (34.1%) were males, as shown in Figure 1. Subjects aged between 25 to 57 years with mean of 44 years and standard deviation of around 7 years.

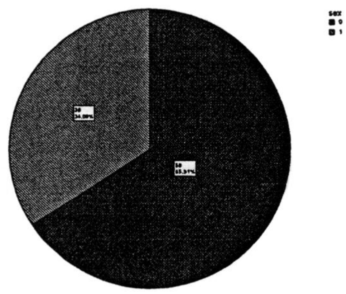

Figure 1: Pie chart shows the gender distribution of the subjects. 0 was representing female and 1 representing male.

Preliminary testing for each individual parameter in the subjects' demographic data and body composition (bioelectrical tissue conductivity, mass distribution and water compartment) were conducted to find the linear association with TC/HDL ratio.

In the demographic variables, Persons' correlation test showed that height and weight were linearly correlated with TC/HDL ratio. Since height and weight were not correlated to each other, so they were included in the analysis.

In the bioelectrical tissue conductivity parameters, resistance (R), reactance (Xc), body capacitance (BC) and phase angle (PA) were related, where the phase angle is the arc tangent of the ratio of reactance and resistance [9] and the body capacitance in the body affects the flow of alternating current. This effect is called reactance. By measuring reactance, the amount of capacitance in the body can be determined [10]. By using the Pearson's correlation test to find the linear associations between the bioelectrical tissue conductivity parameters and TC/HDL ratio, we found that phase angle (α), resistance(R) and body capacitance (BC) (pF) were linearly correlated with TC/HDL ratio. To avoid the problem of multi-co linearity in the multiple linear regression equation, resistance (R) and phase angle (α) were not included in the analysis since body capacitance was sufficient to represent them because body capacitance with the correlation coefficient (r) of 0.659.

Besides the above parameters, there are other parameters measured in the BIA analysis. In this study, the mass distribution was represented by the ratio of extra cellular mass to body cell mass (ECM/BCM), fat mass (FM) and the basal metabolic rate (BMR). Persons' correlation test shows that these three variables are linearly correlated with TC/HDL ratio. All the variables were significant at $p<0.01$.

In addition, water compartments were represented by intra cellular water (ICW) with $r=0.290$ and significant at $p<0.01$.

The means and standard deviation for the parameters that linearly correlated with TC/HDL ratio were presented in Table 1.

Table 1 Summary of linearly correlated variables with TC/HDL ratio

Variables (units)	No. of cases	Means ± standard deviation
Height (cm)	88	158.33±10.39
Weight (kg)	88	75.01±15.38
Body Capacitance (pF)	88	712.11±148.17
ECM/BCM	88	1.11±0.08
Fat Mass (%)	88	32.56±7.08
BMR (cals)	88	1569.86±323.12
Intracellular Water (%)	88	51.13±10.37

For demographic data, the subjects' heights were ranges from 147.94 to 168.72 centimeter (cm). Mean of the weight in kilograms was 75.01 kilograms (kg).

Thus, in the body composition parameters, BC, ECM/BCM, FM, BMR and ICW were found to be correlated and significant with TC/HDL ratio.

Means for body capacitance was 712.11pF. While the ECM/BCM ranges from 1.03 to 1.19. Normal values for the ECM/BCM are typically near 1.0, indicating a 50/50 distribution of body cell mass (BCM) and extra cellular mass (ECM). Standard deviation for FM was 7.08% shows that the minimum percentage of FM among the subjects was 25.48%. BMR is the number of calories (cals) consumed at a normal resting state over a 24-hour period, mean BMR of the subjects was 1569.86 cals. Maximum percentage of water volume in the body cell mass that known as ICW was 61.5%.

Using enter method in linear regression analysis, height and weight in the demographic variables were found to be significant predictors for TC/HDL ratio.

Height was a stronger predictor than weight. Height explains around 27.3%, and weight explains 13.7%.When we analyzed both height and weight, they explained around 34.3% of the variations in the TC/HDL ratio.

We also found that BC (pF) was a significant predictor. It explains 42.8% of the variation. By adding BC (pF) in the model including height and weight, the adjusted R^2 increase to 51.5%.

On the other hand, three more factors, namely FM, ECM/BCM, and BMR produce more significant contribution. Among these three variables, BMR is the strongest predictor. By adding these three variables in the earlier model had increase the variations of TC/HDL ratio to 68.2%.

Lastly, ICW was also found to be a significant predictor of TC/HDL ratio even though it only gives 7.3% by itself, but by adding ICW as one of the variables in the model including height, weight, BC (pF), FM, ECM/BCM, and BMR improves the adjusted R^2 to 68.3%.

In this prediction, 7 predictors (height, weight, BC, FM, ECM/BCM, BMR and ICW) were found to be significant for predicting heart disease incidence in obese subjects. These variables explain approximately 68.3% of the variation of heart disease incidence in obese subjects.

4. Conclusion and Future Work

The finding in this study indicates that CHD can be predicted non-invasively using known parameters such as height, weight, BC, FM, ECM/BCM, BMR and ICW in BIA.

Future work is to develop a predictive equation for TC/HDL ratio to predict CHD using these known predictors.

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