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Research Paper

# Clinical Significance of the Abdominal Height Measured With a Locally Made Abdominometer for Risk Evaluation of Subclinical Atherosclerosis

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## Abstract

Obesity is considered one of the main risk factors of cardiovascular diseases and anthropometric indices such as waist circumference (WC), waist-to-height ratio (WHtR), waist-to-hip ratio (WHR) and body mass index (BMI) are used to classify the level of obesity in clinical practice. Intima-media thickness (IMT) of common carotid artery measured by B-mode ultrasound is widely used as a surrogate marker to evaluate the risk level of subclinical atherosclerosis. The objective of this study was to determine the clinical utility of abdominal height (AH) as an anthropometric index for risk evaluations among the existing ones. Non elastic measuring tape, bathroom scale and locally made abdominometer were used in taking measurements to determine all the anthropometric indices. A GE Logiq 5 Expert Duplex ultrasound scanner was used to measure the values of right common carotid artery (RCCIMT) of 221 apparently healthy adult Nigerians. IBM SPSS Version21 software was used in data analysis. Correlations as well as receiver operating characteristic (ROC) curves to determine the cut-off values were carried out. It was found that AH had the highest correlation coefficient, R= 0.386 at 0.01 level with RCCIMT than other indices. Moreover, it was found that AH had the greater area under the curve (AUC) in ROC curves (0.712) with higher significance than WHtR and BMI. Therefore, abdominal height can be used in clinical practice with high level of significance and accuracy for subclinical atherosclerotic risk evaluation in obesity.

Keywords: Obesity; Anthropometric Indices; Abdominal Height; Abdominometer; Intima-media thickness.

## Introduction

Obesity is one of the greatest health challenges in the world and one of the major risk determinant factors for cardiovascular disease (CVD). The development of obesity is essentially dependent on an imbalance between energy intake and energy expenditure during an extended period of time. This can be viewed as excess energy intake relative to daily energy expenditure or as low energy expenditure relative to daily energy intake. The energy balance can be achieved only when energy intake is equal to energy expenditure. In accordance with the first law of thermodynamics which states that energy cannot be created or destroyed but can be transferred from one form to another, this excess energy is stored as triacylglycerols in adipose tissue as excess fat [1]. This gives rise to overweight and eventually leads to obesity causing adverse effects in the body. Several anthropometric indices are currently used in identifying and classifying obesity. The body mass index (BMI) is the most popular and widely used index in clinical medical practice and in research. However, this does not use central abdominal obesity which is more significant for cardiac and metabolic abnormalities. In most studies in the past, BMI was used as the primary measure of obesity rather than alternative measures such as waist circumference (WC),waist-to-height ratio (WHtR) or waist-to-hip ratio (WHR), which demonstrate stronger correlations with cardiovascular risk than BMI [2,3,4,5].These anthropometric indices are defined as given in equations 1-3.

$$\text{Body mass index} = \frac{Body\ mass\ in\ kg}{Height\ square\ in\ meter\ square} \quad (1)$$

$$\text{Waist-to-height ratio} = \frac{Waist\ Circumference\ in\ cm}{Heght\ in\ cm} \quad (2)$$

$$\text{Waist-to-hip ratio} = \frac{Waist\ Crcumfe rence\ in\ cm}{Hip\ Circumference\ in\ cm} \quad (3)$$

BMI values below 18.5 $kg/m^2$ indicate underweight, 18.5- 24.9 $kg/m^2$ indicate normal weight, 25.0- 29.9 $kg/m^2$ indicate overweight, while above 30 indicate obesity [6]. WHtR values of less than 0.4 mean underweight, 0.40- 0.49 mean normal weight, 0.5- 0.55 mean overweight and above 0.55 mean obesity [7]. BMI above 25.0 $kg/m^2$ and WHtR above 0.5 are considered as risk for cardiovascular diseases. However in WHR values ≥ 0.90 and 0.85 are considered as risk for males and females respectively. Similarly WC values ≥ 94.0 cm and 80.0 cm are found to be risk for males and females respectively [7].

In 1986, some Italian researchers compared direct measurement of arterial wall thickness of 18 human aorta and common carotid arteries by gross and microscopic examination with B-mode real time ultrasound imaging of specimens [8]. They described a characteristic B-mode image of the arterial wall composed of two parallel echogenic (highly reflecting) lines separated by a hypoechoic (low reflecting) space as shown in Fig. 1. They discovered that the space between the two lines did not significantly differ from the thickness measured on pathologic examination thereby leading the researchers to suggest that ultrasound B-mode could present a useful and accurate in-vivo method to the measurement of carotid intima-media thickness (CIMT). Therefore, CIMT measured by B-mode ultrasound can be a surrogate marker that can be used to identify subclinical atherosclerosis and risk assessments [9,10,11,12].Since the measurement procedure is relatively simple and non-invasive, it can be well suited for use in large scale population studies [12].

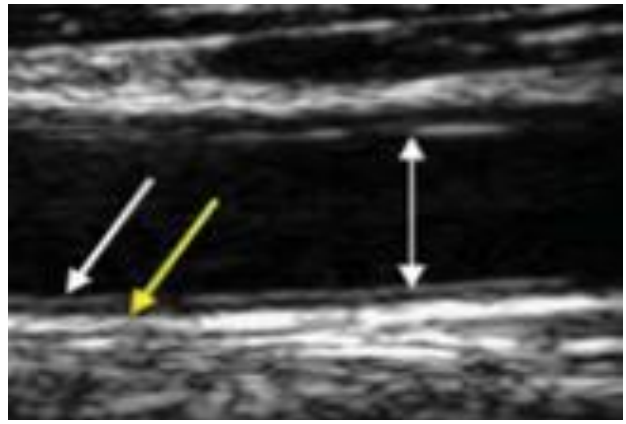

Figure 1. **Locations of intima-media thickness measurements indicated with two parallel arrows.**

Figure 2. **In-house designed Abdominometer.**

The purpose of this study was to investigate the clinical significance of abdominal height (AH) measured by a locally made abdominometer (Figure 2) as an anthropometric index for risk evaluation of subclinical atherosclerosis in obesity along with the other traditional anthropometric indices such as BMI, WC, WHtR and WHR.

## Materials and Methods

This study was conducted in the Department of Radiology of the Jos University Teaching Hospital .It utilised a Logiq 5 Expert Duplex Ultrasound system made by GE Medical Systems, USA. In this study 221 apparently healthy adult Nigerian volunteers of age 20-75 years participated. Age and sex of each volunteer were recorded and the body mass was measured using a Hana bathroom weighing scale to the nearest 0.5 kg. This was done for each volunteer wearing light clothes as much as possible with both legs well placed on the scale without shoes. The scale was checked for zero error before each measurement was taken. Similarly the height was measured with a stadiometer without shoes.

Waist and hip circumferences were measured using a non-flexible tape. Waist circumference was measured at the end of a normal expiration with arms relaxed at the sides over light clothing in standing position at the mid-point between the lower margin of the last palpable rib and the top of iliac crest (hip bone). Hip circumference was measured with tape wrapped around the maximum circumference of the buttocks with the volunteers standing with their feet together with body weight evenly distributed over both feet. Abdominal height was measured between the level of iliac crest which corresponds to the space between 4th and 5th lumbar vertebrae and anterior abdominal wall at the level of the umbilicus with the volunteer in standing position as shown in Fig.3. This utilized the abdominometer conceptualized by the second author which has been piloted previously with detailed description of the implement [13]. Briefly, it is L-shaped wooden furniture with a sliding and swinging mechanism attached to the longer arm where reading is taken off to the nearest 0.5 cm. It is light and mobile making it amenable for epidemiological studies.

Figure 3. **The measurement of Abdominal Height**.

The vascular study utilized a Logiq 5 Expert Duplex Ultrasound system made by GE Medical System, USA. The right common carotid artery intima-media thickness was measured using a 7.5 MHz Linear array transducer. The high frequency transducer was chosen because the carotid artery is a superficial vessel and the wavelength of the ultrasound wave required must be low according to the inverse proportionality existing between the frequency and the wavelength. The ultrasound velocity in soft tissue is assumed to be constant (1540 m/s).The volunteer was asked to lie on the examination couch supine and tilt the right hand side of the neck about $45^0$ inwards. After applying ultrasound transmission gel at the neck and, the transducer was placed on it. The carotid artery intima-media thickness was measured as the distance between the intima and media layers of the carotid artery wall. The average of two measurements was taken for greater accuracy of each of the 221 volunteers. The data was analyzed with IBM SPSS Statistics, version 22.

## Results

The correlation between RCCIMT and all the anthropometric indices considered in this study is shown in Table 1.

From table 1, the correlations between RCCIMT and anthropometric indices were found to be significant at 0.01 level ($p < 0.01$). BMI had the lowest correlation coefficient, R = 0.296 while AH had the highest correlation coefficient, R = 0.386. WHR, WHtR and WC have correlation coefficients in between them with 0.342, 0.349 and 0.382 respectively.

The receiver operating characteristic (ROC) curves between the RCCIMT risk and the anthropometric indices are given in Fig.4 and the corresponding area under the curves are given in Table 2.

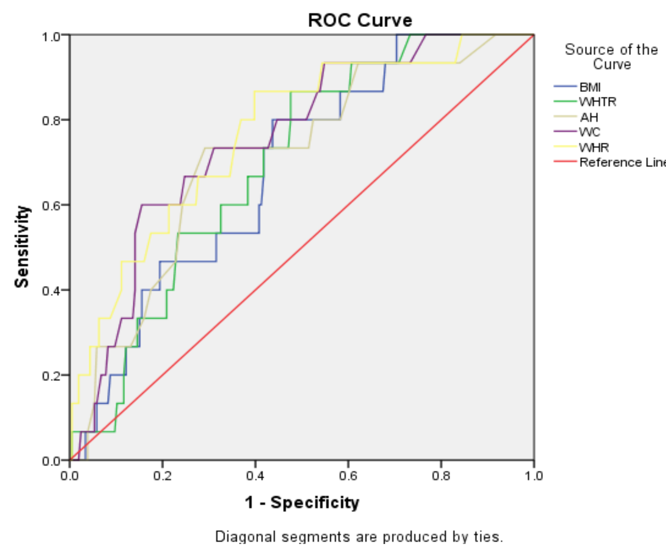


Figure 4. **Receiver Operating Characteristic (ROC) curves between the RCCIMT risk and the anthropometric indices**.

From the Table 2, it can be seen that both BMI and WHtR have lower areas under the curve (AUC) and WC and WHR have greater AUC than AH. BMI has the lowest AUC of 0.683 while WHR has the highest AUC of 0.767. The area under the curve for AH is found to be 0.712. From this study all anthropometric indices including AH are found to be suitable for risk evaluation for sub clinical atherosclerosis. However, greater AUC value signifies better suitability as a risk predictor. Therefore, based on ROC analysis, AH is found to be superior to both BMI and WHtR but WC and WHR have higher AUC than AH.

**Table 1.** Correlation between RCCIMT and anthropometric indices

| Correlations | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | RCCIMT | BMI | WHR | WHTR | WC | AH |
| RCCIMT | Pearson Correlation | 1 | .296** | .342** | .349** | .382** | .386** |
| | Sig. (2-tailed) | | .000 | .000 | .000 | .000 | .000 |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |
| BMI | Pearson Correlation | .296** | 1 | .477** | .937** | .906** | .872** |
| | Sig. (2-tailed) | .000 | | .000 | .000 | .000 | .000 |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |
| WHR | Pearson Correlation | .342** | .477** | 1 | .638** | .717** | .682** |
| | Sig. (2-tailed) | .000 | .000 | | .000 | .000 | .000 |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |
| WHTR | Pearson Correlation | .349** | .937** | .638** | 1 | .950** | .905** |
| | Sig. (2-tailed) | .000 | .000 | .000 | | .000 | .000 |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |
| WC | Pearson Correlation | .382** | .906** | .717** | .950** | 1 | .944** |
| | Sig. (2-tailed) | .000 | .000 | .000 | .000 | | .000 |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |
| AH | Pearson Correlation | .386** | .872** | .682** | .905** | .944** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .000 | .000 | |
| | N | 221 | 221 | 221 | 221 | 221 | 221 |

**Table 2.** Table of area under the curves for different anthropometric indices

| Area Under the Curve | | | | | |
|---|---|---|---|---|---|
| Test Result Variable(s) | Area | Std. Error[a] | Asymptotic Sig.[b] | Asymptotic 95% Confidence Interval | |
| | | | | Lower Bound | Upper Bound |
| BMI | .683 | .060 | .018 | .565 | .801 |
| WHTR | .697 | .056 | .011 | .587 | .806 |
| AH | .712 | .066 | .006 | .584 | .841 |
| WC | .754 | .058 | .001 | .641 | .868 |
| WHR | .767 | .061 | .001 | .648 | .887 |

The test result variable(s): BMI, WHTR, AH, WC, WHR has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

## Discussion

Anthropometric measurement is found to be useful in clinical practice due to its convenience and non-invasiveness [14]. The body mass index (BMI), the standard measure for classifying obesity has been found to be deficient in some populations including Sub-Saharan Africans. Previous work showed that abdominal height (AH) measured with an abdominometer was superior to other cardiac anthropometric measure in the Nigerian population [15]. Browning et al suggested that although WHtR, WC and BMI were all predictors of CVD, diabetes and related disorders, WHtR and WC were probably more reliable predictors than BMI [16]. Gelber et al demonstrated that WHtR was statistically the best model fit and had the strongest association with CVD, compared with WC, WHR and BMI. A prospective study showed that several different measures of abdominal obesity (WHtR > WC > WHR) were strong predictors of stroke [17]. Recio-Rodriguez et al reported that measures of central obesity (WHtR and WC) correlated better than BMI with subclinical atherosclerosis evaluated by CIMT [3]. Many others reported that WHtR proved to be a superior tool for discriminating obesity related cardiometabolic risks compared with BMI and it might be a more useful clinical tool than WC [16, 17, 18, 19]. Because WC does not always mirror visceral obesity as it has some contribution from subcutaneous fat [20] attention shifted to indices focusing on visceral obesity. This is because the cardiometabolic risk of adiposity is tied more to location in ectopic sites [20]. An earlier preliminary study had shown that AH predicted cardiometabolic risk better than BMI in a Nigerian cohort [21]. Again, this study shows that abdominal height (AH) is statistically the best index for the Nigerian population and from the ROC analysis AH proved to be stronger than both BMI and WHtR as a cardiometabolic screening tool. Moreover, AH was also found to be significantly correlating with Cardio-Thoracic Ratio (CTR) computed by cardiac and thoracic diameters measured on chest radiographs better than that of BMI [22]. Therefore, abdominal height can be used in clinical practice with high level of significance and accuracy for subclinical atherosclerotic risk evaluation Atherosclerosis is the underlying disease process in the blood vessels that results in coronary heart disease (heart attack) and cerebrovascular disease (stroke). This is a complex pathological process in the walls of blood vessels that develops over many years. Fatty material and cholesterol are deposited inside the lumen of medium and small arteries. These deposits (plaques) cause the inner surface of the blood vessel to become irregular and lumen to become narrow making it harder for blood to flow through. Eventually, these plaques can rupture triggering the formation of a blood clot. If a blood clot develops in the coronary artery, it can cause a heart attack while if it develops in brain, it can cause a stroke. Subclinical atherosclerosis is the early stage of atherosclerotic progression and therefore needs urgent attention in medical practice in order to minimize the casualties due to CVD. We also found that WHR and WC were suitable for obesity classifications leading to cerebrovascular risk evaluation in Nigerian populations.

## Conclusions

In conclusion, AH has proven to be better than other anthropometric indices in detecting cardiovascular risk in this cohort. It is therefore recommended for wider use for confirmation and application especially in sub-Saharan Africa where the age long BMI has been found to be deficient.

## Abbreviations

CVD: Cardiovascular Disease; BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist-to-height Ratio; WHR: Waist-to-hip Ratio; CIMT: Carotid Intima-media Thickness; AH: Abdominal Height; ROC: Receiver Operating Characteristic; AUC: Areas Under the Curve; CTR: Cardio-Thoracic Ratio.

**Author Contributions**

All authors contributed equally to this study and gave their final approval.

## Competing Interests

The authors have declared that no competing interest exists.

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