What are the Best Predictors of Non-Communicable Diseases (Diabetes, Hypertension and Dyslipidemia) and of Cardiovascular Diseases Risk Factors among Anthropometric Measurements in the Middle Eastern Lebanese Population?

Malak Ghandour¹, Sarah Kteish¹, Husam Ghuson¹, Mohamad Koubar², Mohamad Al-Iskandarani², Sarine El Daouk³ and Maha Hoteit¹*

¹Department of Nutrition and Dietetics, Faculty of Public Health-I, Lebanese University, Beirut, Lebanon
²Department of Laboratory Science, Faculty of Public Health-I, Lebanese University, Beirut, Lebanon
³Department of Mother and Child, University Medical Center, Faculty of Public Health-I, Lebanese University, Beirut, Lebanon

Abstract

Background

It is important to predict which anthropometric measurement has the strongest association with non-communicable diseases and cardiovascular diseases (CVD) risk.

Objective

To investigate which anthropometric measurement among waist circumference (WC), body mass index (BMI), waist-to-hip ratio (WHpR), waist-to-height ratio (WHtR), percentage of body fat, percentage of muscle mass and body shape index (BSI) has the strongest association with non-communicable diseases and cardiovascular disease (CVD) risk in citizen adult population of Lebanon.

Material/methods

A cross-sectional survey was conducted on Lebanese adults aged 18-74 years. The final sample consisted of 454 subjects (231 men and 223 women, mean age 42.75±18.58 years old), equally stratified by gender and age. A questionnaire was filled including socio-demographic data, and the presence of ‘at least one risk factor’ of cardiovascular risk factors (hypertension, dyslipidemia and diabetes). Anthropometric measurements and body composition analyses were also assessed.

Results

For men the mean BMI, BSI, WC, WHpR, and WHtR for subjects were 28.163 ± 4.86 kg/m², 0.087 ± 0.007, 106.22 ± 13.66 cm, 1.008 ± 0.08, 0.61 ± 0.086, respectively. For women the mean BMI, BSI, WC, WHpR, and WHtR for subjects were 29.11± 6.14 kg/m², 0.08± 0.006, 95.86± 15.25 cm, 0.87± 0.097, 0.60± 0.09 respectively. There is a significant correlation between CVD risk factors and all the anthropometrics except for BSI in males and females (P-value<0.05). The highest correlation coefficient with CVD risk factors was in the females for the WC in the group 50-65, and for males was the percentage of muscle mass then the WC in the age groups 50-65 and 26-49 respectively.

Conclusion

WHtR is the best predictor of non-communicable diseases and cardiovascular disease risk among anthropometric measurements and body composition in both Lebanese men and women.

Keywords: Non-Communicable Diseases; Cardiovascular Disease; Risk Factors; Anthropometrics; Body Composition, Adults

*Corresponding Author: Maha Hoteit, Department of Nutrition and Dietetics, Faculty of Public Health-I, Lebanese University, Beirut, Lebanon, Tel: 96170967594; E-mail: maha_hoteit@hotmail.com/m.hoteit@ul.edu.lb

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Introduction

The number one cause of death globally is cardiovascular diseases, annually more people die from CVDs than from any other cause. In 2015, approximately 17.7 million people died from CVDs, accounting for 31% of all global deaths. More than 75% of CVD deaths are in low- and middle-income countries. By addressing behavioral risk factors such as unhealthy diet, physical inactivity, obesity and tobacco use, most CVDs can be prevented. People are considered at high cardiovascular disease risk when one or more risk factors such as hypertension, diabetes, and hyperlipidemia are present [1]. Recent studies highlighted an alarming increase in obesity prevalence in the Lebanese population over the last 12-years period [2]. Obesity levels have risen sharply across the globe with it being considered an independent risk factor for CVD, and are associated with reduced life expectancy as reported by many health organizations. Obese people are more likely to chronic diseases such as diabetes, cardiovascular disease (CVD) and some cancers [3]. Data on cardiovascular disease (CVD) mortality in relation to different anthropometric measures of obesity are still inconsistent. In recent years, the discussion has increased about which measure of obesity and overweight is the best indicator to identify people who are at high CVD risk [4-5]. Adiposity has proven to be a substantial risk factor for CVDs and is strongly associated with CVD risk factors [6-7]. Anthropometric measures are used by most studies measure adiposity. Body mass index (BMI) (kg/m2) has been used as a measure of general obesity, while waist circumference and waist-to-hip ratio have been used as measures of central obesity (where visceral adipose tissue is stored) [8].

In Lebanon, very little concentration has been given on the association between anthropometrics and the risk of developing CVD, for that we conducted a study in order to compare the best predictor of CVD among anthropometrics.

Materials and Methods

Materials

A cross-sectional survey was conducted on Lebanese population of ages 18-74 years. The study was performed over 7 months from November 2016 to May 2017. The objective of the study was to investigate which of waist circumference (WC), body mass index (BMI), waist-to-hip ratio (WHpR), waist-to-height ratio (WHtR) and body shape index (BSI) has the strongest association with cardiovascular disease (CVD) risk in citizen adult population of Lebanon. The final sample consisted of 454 subjects (231 men and 223 women, mean age 42.75±18.58 y). The proposal of this study was approved by the ethical committee of Lebanese University. (Consent form). Inclusion criteria samples of men and women aged 18-74 years, equally stratified by gender and age, were randomly selected from the Lebanese population. Exclusion criteria: pregnant and nursing women, and wearers of electronic medical devices and implants (pacemakers, electrocardiograms…). This data is collected from subjects found in dietitian clinics, health care centers, and Ain w Zein Hospital.

Methods

Questionnaire: Socio-demographic data, information on age, sex, lifestyle factors (smoking, physical activity) were collected by a questionnaire filled by a registered dietitian. The physical activity was assessed using General practice physical activity questionnaire (GPPAQ) reflecting an individual’s current physical activity, for use in general practice. Patients are classified into four categories (sedentary, lightly active, moderately active and very active) based on the original EPIC index from which the GPPAQ was developed (GPPAQ 2008). From the data collected, participants were assessed concerning if they have any of diabetes, hypertension or dyslipidemia according to their report of any medication prescribed for them.

Anthropometric Measures: Subject’s weight, % body fat, % muscle, visceral fat level, resting energy expenditure, and BMI were measured using Omron body composition machine BF511 following the instructions of the machine, while the subjects were minimally clothed without shoes. Height was measured with participants in a standing position, without shoes, using stadiometer to the nearest 0.5 cm while the shoulders were in a normal position. Waist circumference was measured at the midway point between the inferior margin of the last rib and the crest of the ilium in a horizontal plane, and that of the hip around the pelvis at the point of maximal protrusion of the buttocks, using an inelastic tape meter, without any pressure to the body surface. Measurements were recorded to the nearest 0.1 cm. WHpR was calculated as WC divided by hip circumference and WHtR as WC divided by height. These anthropometrics were measured by registered dietitians. The Body Shape Index (BSI) is a formula that uses waist circumference (WC), body mass index (BMI) and height to predict risk of premature mortality, where a high score (Quartile 4) indicates that a person’s WC is more than expected given their height and weight. BSI calculation was done using the following valid link: https://nikrakauer.net/sw/absi-calculator.html

Blood Pressure: Blood pressure was measured for subjects in a seated position after 15 minutes of rest using Braun BP1650 VitalScanPlus Wrist Blood Pressure Monitor.

Definition of Terms

Cutoff points of anthropometric measures may differ from population to another, and since no specific cutoff points were established for Lebanese population, we used those for the Tehranian population.

In the 18–34 y age category, these cutoff points for WC, WHpR, and WHtR were 81 cm (70th percentile), 0.86 (75th percentile), and 0.47 (78th percentile) respectively. In the 35–54 y age category these cut points were 89cm (75th percentile), 0.91 (75th percentile), and 0.52 (77th percentile). In the 55–74 y age category were 91cm (74th percentile), 0.95 (75th percentile), and 0.54 (78th percentile) respectively [9].
Covariate

Education was classified into four education levels: uneducated, primary, intermediate, secondary, college, and postgraduate. Smoking habits were classified into three groups: current smokers, former smokers, and never smokers. A subject who smoked at least one cigarette per day was classified as a current smoker. Past smokers were those who have smoked greater than 100 cigarettes in their lifetime but have not smoked in the last month. Never smoker is the one who has not smoked greater than 100 cigarettes in their lifetime and does not currently smoke. As for the physical activity, participants in this study were classified as sedentary, lightly active, moderately active and highly active. The cardiovascular risk was defined as the presence of ‘at least one risk factor’ of the three major risk factors for CVD (hypertension, dyslipidemia, and diabetes)

Statistical Analysis

All data were analyzed by SPSS version 17.0. All the analyses were performed separately for men and women. Subjects were divided into three age categories: 18–29 y (n = 126), 30–49 y (n = 126), 50–65 y (n = 120) and >65 y (n = 82). Because different cut points were used for different age categories, statistical analysis was performed separately by age categories. Pearson’s correlation coefficients between anthropometric indexes and CVD risk were calculated. Linear regression was performed to obtain waist circumference cut points for each age group in each gender, at a BMI of 25 Kg/m² and 30 Kg/m². Multiple linear regressions were performed by using risk factors (systolic and diastolic blood pressures) as the dependent variables in separate models and WC, WHpR, WHtR, BMI and age as the independent variables in all models.

Results

(Table 1) presents the means of anthropometric indices of 454 study individuals according to their gender and age groups. The subjects studied included 231 (50.88%) men and 223 (49.12%) women, ages ranging from 18 to 80, with a mean of 43.33 and 42.15 for men and women, respectively. For men the mean BMI, BSI, WC, WHpR, and WHR for subjects were 28.163 ± 4.86 kg/m², 0.0875 ± 0.0074, 106.221 ± 13.66 cm, 1.008 ± 0.082, 0.612 ± 0.0866, respectively. For women the mean BMI, BSI, WC, WHpR, and WHR for subjects were 29.11 ± 6.14 kg/m² 0.08± 0.006, 95.865± 15.253 cm, 0.8772 ± 0.0976, 0.604± 0.099 respectively.

The levels of SBP and DBP were approximately similar for men and women and increasing with age. The values of BMI were higher for women, while the values of WC, WHpR and WHtR were higher for men.

(Table 2) presents the number of subjects with the number of cardiovascular risk factors for each demographic and anthropometric measure. The three major cardiovascular risk factors are hypertension, dyslipidemia, and diabetes. CVD risk is 0 when the subjects have no diabetes, dyslipidemia, or hypertension. CVD risk is 1 when the subjects have only one of these factors, the risk is 2 when two factors are present, and 3 if the three factors are present. Subjects who have CVD risk 0 were mainly from the first age group category (18-25y), while no subjects from this age group have more than one risk factor for CVD. Subjects who have two or three CVD risk factors were mainly from the fourth age group category (>65y). 61.5% of subjects having three CVD risk factors were males greater than that of females 38.5%. 70.8% of subjects who have three CVD risk factors were those who are current smokers. 33.2% of subjects who have zero risk factors for CVD are of normal body mass index, while 41.5% of those who have 3 risk factors for CVD are considered obese of BMI between 30 and 35 Kg/m². 96.9% and 89.2% of subjects with 3 CVD risk factors have high systolic and diastolic blood pressure respectively.

Correlation coefficients between anthropometric measures and risk of cardiovascular diseases are presented in (Table 3) Table3 shows the correlations for each age group for males and females subjects.

In females, BMI, WC, HC, WHtR and %body fat are significantly correlated with the cardiovascular risk factors (hypertension, dyslipidemia, and diabetes) in the age groups 26-49 and 50-65. In males, BMI was significantly correlated with CVD risk factors in all age groups, WC, HP, WHpR, and WHR are significantly correlated with CVD factors in the age groups 26-49 and 50-65. The highest correlation coefficient with CVD risk factors was in the females for the WC in the group 50-65, and for males was the muscle% then the WC in the age groups 50-65 and 26-49 respectively.

Correlation coefficients for all age groups are presented in (Table 4)
There is a significant correlation between CVD risk factors and all the anthropometrics except for BSI in males and females. For males, there is a strong correlation between the CVD risk factors and the systolic and diastolic blood pressure, with r = 0.665 and 0.416 respectively. The most correlated anthropometric was the WHtR with the coefficient r=0.407. For females, the most correlated anthropometric was the WHtR with the coefficient r=0.448.

(Table 5) shows the odd ratios for having at least one CVD risk factor according to the level of physical activity, systolic blood pressure, and anthropometrics (WHpR and WHtR). These odd ratios are statistically significant (P-value<0.05) for both genders. The highest odds ratios pertained to systolic blood pressure, 23.99 and 9.34 for males and females respectively, followed by WHR, 9.12 and 4.01 for males and females respectively.

The results of the analysis of our data suggest a WC optimal cut-off point of 99.41 cm and 110.16 cm for BMI 25 and 30 respectively for males, and 86.98 and 97.78 cm for BMI 25 and 30 respectively for females. Cutoff points for each age group in each gender are shown in (Table 6).
Table 1. Mean and standard deviation of anthropometric measures, %body mass, %body muscle and blood pressure (systolic* and diastolic#) in Lebanese adult men and women

| Age groups | Males                  | Females               |
|------------|------------------------|-----------------------|
| 18-25      | 26-49                  | 50-65                 | >65        |
| Age        | 21.19 ± 1.9            | 33.76 ± 6.33          | 49 ± 4.48  | 71.8 ± 4.86 |
| BMI        | 25.33 ± 4.9            | 29.93 ± 5.53          | 29.38 ± 3.66 | 28.01 ± 3.12 |
| BSI        | 0.085 ± 0.001          | 0.08 ± 0.004          | 0.091 ± 0.008 | 0.087 ± 0.005 |
| WC         | 96.90 ± 12.74          | 108.96 ± 14.22        | 114.05 ± 10.70 | 104.97 ± 9.37 |
| HC         | 98.92 ± 10.71          | 108.76 ± 12.1         | 111.03 ± 8.22 | 102.4 ± 6.31 |
| WHpR       | 0.98 ± 0.86            | 1 ± 0.06              | 1.02 ± 0.83  | 1.02 ± 0.84 |
| WItR       | 0.55 ± 0.77            | 0.62 ± 0.08           | 0.66 ± 0.07  | 0.618 ± 0.06 |
| Fat %      | 23.34 ± 7.69           | 30.26 ± 7.72          | 31.15 ± 7.51 | 29.17 ± 5.45 |
| Muscle %   | 36.18 ± 6.10           | 31.59 ± 5.63          | 29.15 ± 4.51 | 28.83 ± 3.92 |
| SBP*       | 119.33 ± 5.62          | 124.98 ± 7.51         | 136.3 ± 10.51 | 145 ± 14.55 |
| DBP*       | 79.08 ± 3.59           | 82.44 ± 3.92          | 88 ± 5        | 83.73 ± 6.38 |
Table 2. Prevalence of demographic characteristics, anthropometrics, blood pressure, BMI, and BSI according to the risk of CVD subjects then the WC in the age groups 50-65 and 26-49 respectively.

| Cardiovascular risk | 0     | 1     | 2     | 3     | P-value |
|---------------------|-------|-------|-------|-------|---------|
| **Age group**       |       |       |       |       |         |
| 18-25               | 123 (41.7%) | 3 (4.9%) | 0 (0%) | 0 (0%) | <0.0001 |
| 26-49               | 101 (34.2%) | 13 (21.3%) | 4 (12.1%) | 8 (12.3%) |         |
| 50-64               | 56 (19.0%) | 30 (49.2%) | 7 (21.2%) | 27 (41.5%) |         |
| >65                 | 15 (5.1%) | 15 (24.6%) | 22 (66.7%) | 30 (46.2%) |         |
| **Total**           | 295 (65%) | 61 (13.4%) | 33 (7.3%) | 65 (14.3%) |         |

| **Gender**          |       |       |       |       |         |
| Male                | 142 (48.1%) | 32 (52.5%) | 17 (51.5%) | 40 (61.5%) | 0.271   |
| Female              | 153 (51.9%) | 29 (47.5%) | 16 (48.5%) | 25 (38.5%) |         |
| **Total**           | 295 (65%) | 61 (13.4%) | 33 (7.3%) | 65 (14.3%) |         |

| **Educational level** |       |       |       |       |         |
| Not educated         | 11 (32.4%) | 4 (11.8%) | 7 (20.6%) | 12 (35.3%) | <0.0001 |
| Primary              | 21 (35.0%) | 11 (18.3%) | 14 (23.3%) | 14 (23.3%) |         |
| intermediate         | 37 (49.3%) | 22 (29.3%) | 3 (4.0%) | 13 (17.3%) |         |
| Secondary            | 56 (76.7%) | 10 (13.7%) | 2 (2.7%) | 5 (6.8%) |         |
| College              | 70 (82.4%) | 6 (7.1%) | 3 (3.5%) | 6 (7.1%) |         |
| postgraduate         | 100 (78.7%) | 8 (6.3%) | 4 (3.1%) | 15 (11.8%) |         |
| **Total**            | 295 (65.0%) | 61 (13.4%) | 33 (7.3%) | 65 (14.3%) |         |

| **Employment**       |       |       |       |       |         |
| Unemployed           | 41 (57.7%) | 10 (14.1%) | 9 (12.7%) | 11 (15.5 %) | <0.0001 |
| Employed             | 156 (74.3%) | 29 (13.8%) | 5 (2.4%) | 20 (9.5%) |         |
| Homemaker            | 49 (54.4%) | 13 (14.4%) | 9 (10.0%) | 19 (21.1%) |         |
| Student              | 40 (95.2%) | 2 (4.8%) | 0 (0%) | 0 (0%) |         |
| Unable to work       | 7 (24.1 %) | 4 (13.8%) | 7 (24.1%) | 11 (37.9%) |         |
| retired              | 2 (16.7%) | 3 (25.0%) | 3 (25.0%) | 4 (33.3%) |         |
| **Total**            | 295 (65.0%) | 61 (13.4%) | 33 (7.3%) | 65 (14.3%) |         |

| **Tobacco**          |       |       |       |       |         |
| current smoker       | 167 (56.0%) | 29 (47.5%) | 15 (45.45%) | 46 (70.8%) | <0.0001 |
| past smoker          | 19 (6.4%) | 15 (24.6%) | 9 (27.3%) | 10 (15.4%) |         |
| never smoked         | 109 (36.9%) | 17 (27.9%) | 9 (27.2%) | 9 (13.8%) |         |
| **Total**            | 295 (65.0%) | 61 (13.4%) | 33 (7.3%) | 65 (14.3%) |         |
| Marital status | Single (47.5%) | Married (49.5%) | Divorced (2.4%) | Widowed (0.7%) | Total (65.0%) | <0.00001 |
|---------------|---------------|----------------|----------------|--------------|--------------|-----------|
|               | 140           | 146            | 7              | 2            | 295          |           |
| Marital status |               |                |                |              |              |           |
| Married        | 146 (49.5%)   |                | 49 (80.3%)     | 2 (3.3%)     | 22 (66.7%)   |           |
| Divorced       | 7 (2.4%)      | 2              | 2              | 2            | 8 (12.3%)    |           |
| Widowed        | 2 (0.7%)      | 4              | 4              | 4 (12.1%)    | 2 (3.1%)     |           |
| Total          | 295 (65.0%)   | 61 (13.4%)     | 33 (7.3%)      |              | 65 (14.3%)   |           |

| Physical activity | Sedentary (44.7%) | Lightly active (31.2%) | Moderately active (23.1%) | Very active (1%) | Total (65.0%) | <0.00001 |
|-------------------|-------------------|------------------------|---------------------------|-----------------|--------------|-----------|
|                   | 132 (44.7%)       | 92 (31.2%)             | 68 (23.1%)                | 3 (1%)          | 295          |           |
|                   | 44 (72.1%)        | 13 (21.3%)             | 4 (6.6%)                  | 0 (0.0%)        | 61 (13.4%)   |           |
|                   | 26 (78.8%)        | 4 (12.1%)              | 3 (9.1%)                  | 0 (0.0%)        | 33 (7.3%)    |           |
|                   | 55 (84.6%)        | 8 (12.3%)              | 2 (3.1%)                  | 0 (0.0%)        | 65 (14.3%)   |           |

| BMI group | 25< (33.2%) | 25-30 (41.7%) | 30-35 (16.3%) | >40 (8.8%) | Total (65.0%) | <0.00001 |
|-----------|------------|--------------|--------------|----------|--------------|-----------|
|           | 98 (33.2%) | 123 (41.7%)  | 48 (16.3%)   | 26 (8.8%) | 295 (65.0%)  |           |
|           | 6 (9.8%)   | 31 (50.8%)   | 17 (27.9%)   | 7 (11.5%) | 61 (13.4%)   |           |
|           | 3 (9.3%)   | 17 (51.5%)   | 7 (21.2%)    | 6 (18.2%) | 33 (7.3%)    |           |
|           | 4 (6.2%)   | 19 (29.2%)   | 27 (41.5%)   | 15 (23.1%)| 65 (14.3%)   |           |

| Systolic blood pressure | Normal (41.4%) | High blood pressure | Total (65.0%) | <0.00001 |
|-------------------------|----------------|---------------------|--------------|-----------|
|                         | 122 (41.4%)    | 173 (58.6%)         | 295 (65.0%)  |           |
|                         | 6 (9.8%)       | 55 (90.2%)          | 61 (13.4%)   |           |
|                         | 0 (0.0%)       | 33 (100%)           | 33 (7.3%)    |           |
|                         | 2 (3.1%)       | 63 (96.9%)          | 65 (14.3%)   |           |

| Diastolic blood pressure | Normal (49.5%) | High blood pressure | Total (65.0%) | <0.00001 |
|--------------------------|----------------|---------------------|--------------|-----------|
|                          | 146 (49.5%)    | 149 (50.5%)         | 295 (65.0%)  |           |
|                          | 11 (18%)       | 50 (82%)            | 61 (13.4%)   |           |
|                          | 11 (33.3%)     | 22 (66.7%)          | 33 (7.3%)    |           |
|                          | 7 (10.8)       | 58 (89.2%)          | 65 (14.3%)   |           |

| BSI group | <0.083 normal | 0.083-0.091 high relative risk | >=0.091 double relative high risk | Total (65.0%) | <0.00001 |
|-----------|---------------|-------------------------------|----------------------------------|--------------|-----------|
|           | 139 (47.1%)   | 122 (41.4%)                   | 34 (11.5%)                       | 295 (65.0%)  |           |
|           | 29 (47.5%)    | 22 (36.1%)                    | 10 (16.4%)                       | 61 (13.4%)   |           |
|           | 8 (24.2%)     | 18 (54.5%)                    | 7 (21.2%)                        | 33 (7.3%)    |           |
|           | 20 (30.8%)    | 23 (35.4%)                    | 22 (33.8%)                       | 65 (14.3%)   |           |
Table 3. Correlation between anthropometrics and cardiovascular disease risk in Lebanese population

| Age group | Female | Male |
|-----------|--------|------|
|           | 18-25  | 26-49 | 50-65 | >65 |
|           | 18-25  | 26-49 | 50-65 | >65 |
| Anthropometric | r  | P-value | r  | P-value | r  | P-value | r  | P-value | r  | P-value | r  | P-value |
| BMI       | 0.124  | 0.335  | 0.440 | <0.01  | 0.501  | <0.01  | 0.277  | 0.97  | <0.05  | 0.433  | <0.01  | 0.429*  | <0.01  | 0.323*  | <0.05  |
| WC        | 0.214  | 0.092  | 0.384 | <0.01  | 0.663  | <0.01  | 0.231  | 0.170 | <0.01  | 0.212  | 0.095  | 0.362  | <0.01  | 0.529*  | <0.01  | 0.312*  | <0.05  |
| HC        | 0.71   | 0.582  | 0.365 | <0.01  | 0.637  | <0.01  | 0.250  | 0.136 | <0.01  | 0.204  | 0.109  | 0.282  | <0.05  | 0.273*  | <0.05  | 0.210  | 0.166  |
| W/H ratio | 0.268  | <0.05  | 0.231 | 0.69   | 0.381  | <0.01  | 0.084  | 0.621 | <0.01  | 0.054  | 0.674  | 0.227  | <0.05  | 0.368*  | <0.01  | 0.162  | 0.288  |
| W/HT ratio| 0.172  | 0.179  | 0.403 | <0.01  | 0.590  | <0.01  | 0.215  | 0.2   | <0.01  | 0.235  | 0.064  | 0.433  | <0.01  | 0.488*  | <0.01  | 0.256  | 0.89   |
| Body fat  | 0.126  | 0.326  | 0.308 | <0.05  | 0.414  | <0.01  | 0.203  | 0.229 | <0.01  | 0.249*  | <0.05  | 0.463  | <0.01  | -0.55   | 0.678  | 0.461*  | <0.01  |
| Muscle mass| -0.095 | 0.460  | -0.130| 0.31   | -1.98  | 0.129  | 0.114  | 0.503 | <0.01  | -0.130 | 0.311  | -0.452 | <0.01  | -0.035  | 0.789  | -0.540  | <0.01  |
| BSI       | 0.179  | 0.160  | 0.028 | 0.827  | 0.314  | <0.05  | -0.020 | 0.906 | <0.01  | -0.28  | 0.862  | 0.037  | 0.776  | 0.202   | 0.122  | 0.69   | 0.650  |

Table 4. correlation of anthropometric indices and blood pressure with CVD risk in the Lebanese population

| Anthropometric | Male | P-value | Female | P-value |
|---------------|------|---------|--------|---------|
| BMI           | 0.303| <0.001  | 0.404  | <0.001  |
| WC            | 0.355| <0.001  | 0.428  | <0.001  |
| HC            | 0.197| <0.01   | 0.387  | <0.001  |
| WHpR          | 0.317| <0.001  | 0.242  | <0.001  |
| WHtR          | 0.407| <0.001  | 0.448  | <0.001  |
| Body fat      | 0.271| <0.001  | 0.309  | <0.001  |
| Muscle mass   | -0.426| <0.001  | -0.210| <0.01   |
| BSI           | 0.201| 0.02    | 0.182  | 0.06    |
| Systolic blood pressure | 0.665| <0.001  | 0.209  | 0.002   |
| Diastolic blood pressure | 0.416| <0.001  | 0.159  | 0.018   |

Table 5. Adjusted ORs for the presence of cardiovascular risk factors according to physical activity, WHpR, WHtR and systolic blood pressure in Lebanese population

| Physical activity | WHpR    | WHtR     | Systolic blood pressure |
|-------------------|---------|----------|-------------------------|
| Male              | 0.219 (0.104-0.463) | 0.101 (0.022-0.479) | 9.148 (1.426-58.683) | 23.986 (5.397-106.608) |
| Female            | 0.213 (0.089-0.505) | 0.263 (0.110-0.633) | 4.010 (1.518-10.590) | 9.336 (3.425-25.445) |
Table 6. Optimal cut-off value of waist circumference according to the gender and the age group in Lebanese population

| Age group | Model summary adjusted R square | P-value | WC | Age group | Model summary adjusted R square | P-value | WC |
|-----------|-------------------------------|---------|----|-----------|-------------------------------|---------|----|
| 18-25     | 0.500                         | <0.001  | 96.284 | 18-25     | 0.875                         | <0.001  | 85.55 |
| 26-49     | 0.762                         | <0.001  | 97.861 | 26-49     | 0.731                         | <0.001  | 88.758 |
| 50-65     | 0.230                         | <0.001  | 107.727| 50-65     | 0.652                         | <0.001  | 87.45 |
| >65       | 0.499                         | <0.001  | 98.518 | >65       | 0.680                         | <0.001  | 87.237 |
| >18       | 0.582                         | <0.001  | 99.41  | >18       | 0.755                         | <0.001  | 86.983 |

Discussion

This is the first such study in Lebanon, that attempted to evaluate comparatively four anthropometric indices (BMI, WC, WHpR, and WHtR), % body fat, and % muscle in an attempt to find the best predictor of a cardiovascular risk in the adult population. The result of the present study indicated that WHtR was the best predictor of cardiovascular risk in both men and women as reflected in the Bivariate correlation analysis than the other anthropometrics.

Recent studies showed an increase in evidence around the world showing the superiority of WHtR over other anthropometrics in their association with hypertension, stroke, metabolic risks, and chronic kidney disease [10]. In a neighboring country (Iran), a study determined that WHtR is a better discriminator of cardiovascular risk factors compared with the other three indices (BMI, WC, and WHR) [11]. A recent meta-analysis [12] comparing data from 10 studies analyzing anthropometric indices and CVD risks in adults have shown that WHtR is better than BMI, waist circumference, and wHpR [13-14-15].

Some authors [e.g. 16] have debated that waist circumference is a more appropriate measure than WHtR because of its simplicity. This is true to some extent, but concerns have been expressed that one set of cutoff points for waist circumference (developed on Caucasian subjects) does not suit all ethnic groups [14] and that risk can differ for people with different heights, but same waist circumference [17]. On the other hand, a study was done in Tehran indicated that WHpR is a better predictor for cardiovascular risk factors than BMI, WC and WHtR in Tehranian adult men [18]. Garnett SP et al, in a study on Australian population quoted that: “The WHtR has several advantages; it is easy to calculate, does not require sex- and age-specific centiles, and, as has been previously suggested, it is a simple message, easily understood by clinicians and families, to ‘keep your waist circumference to less than half your height’” [19].

The sample size (454) in this study limits the power to demonstrate statistical significance when the data are stratified by age groups and gender. However, when performed separately for male and female, the Pearson correlation test showed the same trends. Another limitation of the present study is its cross-sectional data. The lack of blood sample analysis is also a limitation. Future studies will provide stronger evidence of such correlations.

The strength of this study is that the sample is representative for our population, which allowed us to compare the predictive ability of WC, WHpR, WHtR, and BMI, and this enhances the validity of our findings. Several studies have analyzed the correlation between CVD risk factors and the four anthropometrics; many of them supported the result that WHtR is a better anthropometric index of cardiovascular risk.

Conclusion

In conclusion, our study supports the previous studies that show that abdominal obesity provides a superior tool for discriminating obesity-related cardiovascular risk, as compared with body mass index and WHR as compared with the rest anthropometrics. There are different cutoff points for the WHtR across different ethnic groups, for that, further research is needed to reach a measure that could be used internationally for screening CVD risk.

Author Contributions

Malak Ghandour and Sara Kteish conceived the research question, protocol design, conducted the literature review, data acquisition, statistical analysis, data analyses and interpretation, and drafted and
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