International Journal of Chemical and Biomolecular Science
Vol. 2, No. 1, 2016, pp. 15-24
http://www.aiscience.org/journal/ijcbs
ISSN: 2381-7372 (Print); ISSN: 2381-7380 (Online)

Waist Circumference a Predictor of Hypertension and Dyslipidemia in Young Saudi Females

Sawsan Hassan Mahassni*, Noor Omar Bashanfar

Department of Biochemistry, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia

Abstract

For the last few decades, overweight and obesity have been increasing in Saudi Arabia, especially in females. Hypertension and dyslipidemia are linked to overweight and obesity and together these conditions lead to many diseases. The goal of this study was to determine the impact of overweight and obesity on the lipid profile and blood pressure in 112 healthy Saudi females with an age range between 18 to 28 years. Also, to determine the best anthropometric measurement to link the subjects' weight to hypertension and dyslipidemia. To assess the body weight status of the subjects and to categorize them, the weight, height, and the waist and hip circumferences were measured to calculate the body mass index (BMI), waist-to-hip ratio (WHR), and the waist circumference (WC). A blood sample was collected from each subject to determine the complete lipid profile and a home blood pressure monitor was used to determine blood pressure. Compared to the control, the only relations found between the parameters and the anthropometric measurements are the following: triglycerides increased significantly for the highest WC group; LDL increased significantly for the highest BMI and WC; HDL significantly increased for the lowest BMI and significantly decreased for the moderate risk WHR and both WC groups; the diastolic and systolic blood pressures increased significantly for the highest BMI and WC groups; and the diastolic blood pressure decreased significantly for the lowest BMI. Cholesterol concentrations were not significantly related to the anthropometric measurements. Therefore, the results confirm the findings of other researchers that overweight and obesity are linked to hypertension and dyslipidemia and it may be concluded that the WC is the best anthropometric measurement for determining the risks for the presence and future development of these conditions in this cohort. It is recommended that more research be done on this cohort and on males for comparison.

Keywords

Obesity, Overweight, Dyslipidemia, Hypertension, BMI, WHR, WC, Lipid Profile, Diastolic Blood Pressure, Systolic Blood Pressure

Received: July 21, 2015 / Accepted: December 20, 2015 / Published online: January 17, 2016

1. Introduction

Overweight and obesity are the fifth leading cause of deaths globally (World Health Organization 2013) leading to a shortened life-span and an increased risk for many health problems, such as heart diseases, type 2 diabetes, hypertension, dyslipidemia, atherosclerosis, rheumatoid arthritis, fatty liver diseases, stroke, and some types of cancers (Tchernof and Després, 2013; Lu et al., 2014; Landsberg et al., 2015). Additionally, obesity has been shown to be a higher risk for resulting heart problems and diseases than overweight (Lu et al., 2014), although a few studies do not concur. Saudi Arabia, like most countries worldwide, has seen increased rates of overweight and obesity among all age groups and in both genders with rates being higher in females.

* Corresponding author
E-mail address: sawsanmahassni@hotmail.com (S. H. Mahassni), smahasni@ka.edu.sa (S. H. Mahassni)

In addition to the increased overweight and obesity observed in many parts of the world, cardiovascular diseases (CVD), including coronary heart disease, have increased and are among the more common causes of death in many industrialized countries (Lu et al., 2014; Landsberg et al., 2015). Developing countries are experiencing the same problems with increasing rates of CVD, overweight and obesity along with increasing rates of associated deaths. Rates of hypertension (Landsberg et al., 2015) and dyslipidemia (Tchernof and Després, 2013), which may result in CVD, heart and other diseases, have also been increasing in many parts of the world. It is generally agreed that both hypertension and dyslipidemia are linked to being overweight and obese and that all of these conditions are significantly associated with increased risk for some of the above-mentioned diseases (Lu et al., 2014; Landsberg et al., 2015).

The easiest and most commonly used anthropometric measures of overweight and obesity and fat distribution are the body mass index (BMI), waist-to-hips ratio (WHR), and waist circumference (WC). Fat located in the abdomen, leading to high WC and WHR, compared to fat stores located elsewhere, is associated with a higher prevalence of all obesity-related diseases (Hall and Nieman, 2003; Suk *et al.,* 2003; Rolfes, Pinna and Whitney, 2006; Tchernof and Després, 2013) including high cholesterol and hypertension (Kopelman, Caterson and Dietz, 2010). Therefore, a higher WHR or WC are expected to be better predictors of the risk for diseases since they indicate the location of excess fat unlike the BMI which does not.

The exact healthy levels for lipids and blood pressure are different for different populations, genders, and age groups among other factors and these levels change from time to time with more research work and newer guidelines (Rolfes, Pinna and Whitney, 2006). Additionally, hypertension, dyslipidemia, and other health complications are more pronounced in people with abdominal or upper body obesity, and thus more visceral fat, rather than lower body obesity (Landsberg et al., 2015). On the other hand, there is no consensus on the best method for assessing body weight and fat content, nor the best method to link overweight and obesity to health problems. In addition, similarly to what is mentioned above, different levels of body fat content and fat distribution may have drastically different health impacts in different ethnic groups. Therefore, it is important to study different ethnic groups to determine the best and easiest measures of body weight and fat content and their relation to disease risks in order to help in guiding people at risk for overweight and obesity and associated diseases.

Therefore, it is the aim of this study to determine blood pressure and the lipid profile in a cohort of healthy Saudi female university students, and to determine the best anthropometric measurement, among the BMI, WHR, and WC, relating these parameters to increased overweight and obesity. This would help in improving estimates of health and risk for heart diseases linked to high blood pressure and unhealthy lipid levels. Based on these results, recommendations may be put forth for setting ideal weights for Saudi females to achieve and maintain optimal health.

2. Materials and Methods

2.1. Subjects

This study was carried out on 112 healthy Saudi female students from King Abdulaziz University, Jeddah, Saudi Arabia, with an age range of 18-28 years. Subjects were collected randomly in order to have 22-37 subjects in each BMI group. Each subject filled a consent form and a questionnaire to assess her health status. Any subjects suffering from diabetes, heart disease, blood diseases, any allergy, taking any medications including birth control or hormones, or pregnant were excluded. Additionally, any subject with a glucose level higher or lower than the normal level (70-100 mg/dl) or a white blood cell count (WBC) higher than 20 x 10^{-3} cells/µL was excluded.

2.2. Blood Collection

Fasting blood samples (8 hours or more) were collected from the subjects, in plain vacutainer tubes (Al-Shafei, Vacutest Kima, Arzergrande, Italy), for the determination of the lipid profile. Blood was allowed to stand at room temperature until a clot was formed, after which the tubes were then centrifuged at 3,000 rpm for 10 minutes. Clear serum was then carefully collected and stored in eppendorf tubes at -20°C until use.

2.3. Anthropometric Measurements and Blood Pressure Determination

At the same time of blood collection, each subject was weighed using a new regular household scale that was zeroed between subjects. The height, waist (at the naval) and hips (at the fullest point) circumferences were measured for each subject using a measuring tape.

For the measurement of the subjects' blood pressure a Beurer home blood pressure monitor (Beurer Medical, model BM40, China) was used to automatically measure the blood pressure by a cuff placed on the upper arm.

2.4. Calculation of the BMI

The BMI was calculated and used to divide the subjects into four groups or categories, each containing 22-37 subjects.

The groups are underweight (BMI < 18.5 kg/m^2), normal or healthy (BMI = 18.5 to 24.9 kg/m^2), overweight (BMI = 25 to 29.9 kg/m^2), obese (BMI =30 to 39.9 kg/m^2), and morbidly obese (BMI = 40 kg/m^2 and above) (Rolfes, Pinna and Whitney, 2006).

2.5. Calculation of the WHR

The WHR was used to determine fat distribution in the subjects and assign them into one of three risk groups. The groups are low risk (WHR of 0.80 or lower), moderate risk (WHR between 0.81-0.85), and high risk (WHR above 0.85) (Rolfes, Pinna and Whitney, 2006). The android (central obesity, apple shaped) body shape, or upper body obesity, is associated with a WHR greater than 0.8 for females, while a WHR below 0.8 is associated with the gynoid (lower body obesity, pear shaped) body shape (Rolfes, Pinna and Whitney, 2006).

2.6. Calculation of the WC

WC was used to distribute the subjects into three risk groups according to the accepted reference ranges for each group. The low risk group is for WC below 32.5 inches, a WC between 32.5 to 35 inches is considered moderate risk, while the high risk group is for WC above 35 inches (Rolfes, Pinna and Whitney, 2006). A WHR greater than 35 inches in females indicates central obesity leading to a high risk for health problems associated with increased weight and obesity (Hall and Nieman, 2003; Rolfes, Pinna and Whitney, 2006).

2.7. Lipid Profile

The lipid profile for all subjects was done at King Abdulaziz University Hospital, Jeddah, Saudi Arabia, using the Dimension Vista System (Siemens Company, Berlin, Germany). The concentrations of cholesterol, triacylglycerol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) were determined. The method used was a quantitative *in vitro* diagnostic test using the respective Flex reagent cartridges (Siemens Company, Newark, DE, USA) for each of the lipid components determined.

2.8. Statistical Methods

All statistical analyses and graphs were done using the SPSS-V20 statistical program. For the homogeneous and normally distributed parameters, the ANOVA one-way test was used to test for the presence of significant differences between the groups of each body weight measurement (BMI, WHR and WC) for each parameter measured for the subjects. Subsequently, the Tukey or LSD Post Hoc tests were used for the multiple comparisons between groups. As for the homogeneous non-normally distributed parameters, the Kruskal-Wallis H test was used to test for the significance in the relationships between the body weight measurements and the parameters. Then the Mann-Whitney U test was used for the multiple comparisons between groups. The resulting P values demonstrate significance or lack thereof as follows: $P > 0.05$ is non-significant (NS), $P \leq 0.05$ is significant (S), $P < 0.01$ is highly significant (HS), $0.05 < P < 0.10$ is tending to a significant difference (TS).

3. Results

3.1. Subjects and BMI Categories

A total of 112 healthy Saudi females, with an age range of 18-28 years (mean ± SD = 22.2 ± 2.4 years), had a BMI range of 13.51-45.17 Kg/m^2 (mean ± SD = 24.70 ± 7.10). Shown in Figure 1 is the normal frequency distribution of the subject's ages. At a confidence level of 99%, it is noted that the mean of the BMI belongs to the confidence interval (22.95, 26.46) which means that the confidence interval of BMI is fairly small as apparent from the SD of 7.10 and the very small standard error of 0.67.

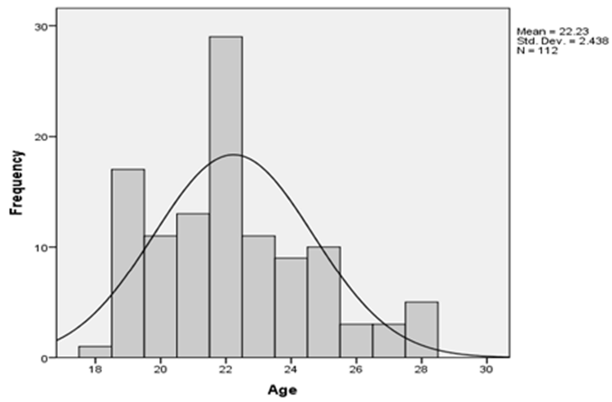

Figure 1. The normal distribution and histogram of the subjects' ages.

The subjects were divided into four groups according to their BMI, as shown in Table 1. The four groups were underweight (frequency, percent: 26, 23.21%), healthy (control) (37, 33.04%), overweight (27, 24.11%), and obese/morbidly obese subjects [22 (18 obese and 4 morbidly obese), 19.64%]. The minimum BMI for the underweight category (Table 1) was 13.51 Kg/m^2, while the maximum was 18.28 Kg/m^2. For the healthy subjects, which are the control group, the range of BMI for the subjects was 18.50 to 24.80 Kg/m^2. For the overweight subjects the BMI range was 24.97 to 29.92 Kg/m^2, and finally, the obese/morbidly obese subjects' BMI ranged from 30.60 to 45.17 Kg/m^2.

As for the age distribution within the BMI categories (Figure 2), it is apparent that the group with the lowest mean age is the obese/morbidly obese. The remaining groups have nearly equal mean ages, but the overweight is slightly higher.

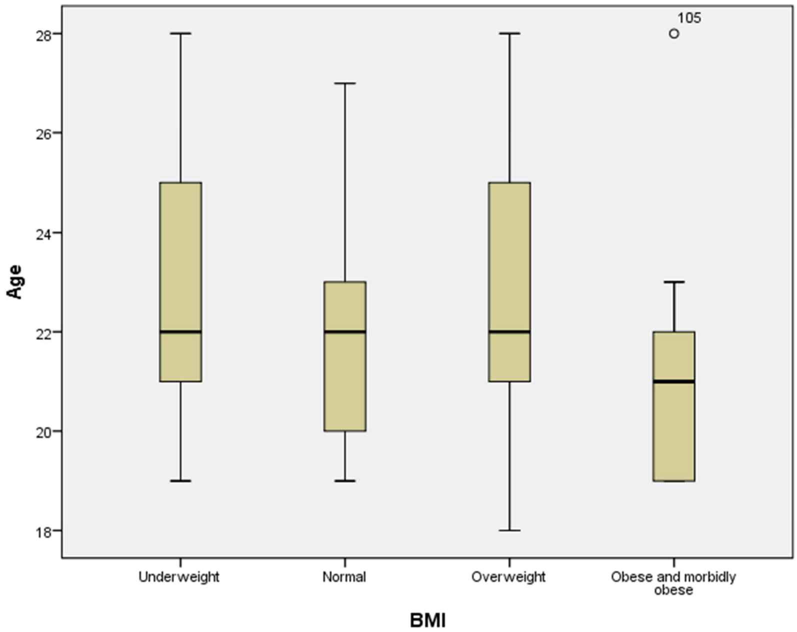

Figure 2. Box plot of the subjects' ages according to the BMI.

Table 1. Frequencies and calculated percentages of subjects in the four BMI categories.

BMI Group	Minimum BMI (Kg/m^2)	Maximum BMI (Kg/m^2)	Frequency	Percent
Underweight	13.51	18.28	26	23.21%
Healthy	18.50	24.80	37	33.04%
Overweight	24.97	29.92	27	24.11%
Obese/Morbidly obese	30.60	45.17	22	19.64%
Total			112	100%

3.2. Subjects and WHR Categories

The subjects were also categorized into three risk groups according to their WHRs (Table 2), which ranged from 0.61 to 1.53 (mean ± SD = 0.77 ± 0.10) with a very small standard error of 0.01 and a short confidence interval (0.75, 0.80). The three groups were as follows: subjects with low risk (frequency, percent: 80, 71.43%), moderate risk (21, 18.75%), and high risk (11, 9.82%).

Table 2. Frequencies and calculated percentages of subjects in the three WHR categories.

WHR Group	Minimum WHR	Maximum WHR	Frequency	Percent
Low Risk	0.61	0.80	80	71.43%
Moderate Risk	0.81	0.85	21	18.75%
High Risk	0.86	1.53	11	9.82%
Total			112	100%

3.3. Subjects and WC Categories

The WC was used to divide the subjects into three risk groups with a range of WC from 19.68-70.86 inches (mean ± SD = 31.66 ± 6.81) with a standard error of 0.64 and a confidence interval of (29.98, 33.35). The three WC groups (Table 3) were subjects with low risk (frequency, percent: 64, 57.14%), moderate risk (17, 15.18%), and high risk (31, 27.68%).

Table 3. Frequencies and calculated percentages of subjects in the three WC categories.

WC Group	Minimum WC (in)	Maximum WC (in)	Frequency	Percent
Low Risk	19.68	32.28	64	57.14%
Moderate Risk	32.67	34.64	17	15.18%
High Risk	35.03	70.86	31	27.68%
Total			112	100%

3.4. The Lipid Profile and Measures of Obesity

Statistical analysis using the ANOVA one-way test for the BMI categories (Table 4) and the Kruskal-Wallis test for the WHR categories (Table 5) shows that the effects of the BMI and WHR on the serum cholesterol concentrations are not significant. In contrast, using the Kruskal-Wallis test for the WC groups (Table 6), there is a significant effect of the WC on the cholesterol mean concentrations. For the multiple comparisons between the WC groups, the LSD Post Hoc test (Table 7) shows that the mean of the cholesterol concentrations for the moderate risk group, compared to the low risk (control) group, tends to a significantly lower mean concentration, whereas for the high risk group it is not significantly different.

Table 4. Descriptive statistics and test of significance for the relationships between the BMI groups and the lipid profile and blood pressures.

Parameter	BMI Group	Concentration				SE	SD	P
		Max	Min	Mean	Mean rank			
Cholesterol* (mmol/L)	Underweight	5.34	2.85	4.17		0.13	0.68	0.463^{NS}
	Normal	6.88	2.94	4.21		0.15	0.91	
	Overweight	5.49	2.95	4.15		0.14	0.70	
	Obese/Morbid	6.10	2.91	4.48		0.19	0.87	
Triglyceride** (mmol/L)	Underweight	1.39	0.36	0.71	49.12	0.05	0.24	0.113^{NS}
	Normal	1.44	0.34	0.71	50.88	0.03	0.21	
	Overweight	1.57	0.43	0.84	61.94	0.06	0.32	
	Obese/Morbid	2.10	0.51	0.88	68.00	0.08	0.35	
LDL* (mmol/L)	Underweight	3.23	1.23	2.31		0.11	0.56	0.009^{HS}
	Normal	4.83	1.39	2.41		0.12	0.71	
	Overweight	3.97	0.99	2.57		0.12	0.64	
	Obese/Morbid	4.36	1.60	2.93		0.16	0.74	
HDL* (mmol/L)	Underweight	2.23	0.98	1.64		0.06	0.32	0.000^{HS}
	Normal	2.07	0.77	1.31		0.05	0.29	
	Overweight	1.92	0.69	1.21		0.06	0.31	
	Obese/Morbid	1.83	0.75	1.22		0.07	0.34	
Systolic Blood pressure*	Underweight	98	60	79		2	10	0.008^{HS}
	Normal	97	65	78		1	8	
	Overweight	100	62	79		2	11	
	Obese/Morbid	111	71	87		2	10	
Diastolic Blood pressure**	Underweight	135	96	117	42	2	9	0.012^{S}
	Normal	158	93	124	57	2	13	
	Overweight	158	90	122	55	3	13	
	Obese/Morbid	166	101	133	73	4	19	

Max: Maximum, Min: Minimum, Obese/Morbid = Obese and Morbidly obese
*The ANOVA one-way test was used for the significance test
**The Kruskal-Wallis test was used for the significance test
HS: Highly significant ($P < 0.01$), S: significant ($P \leq 0.05$), NS: Not significant ($P > 0.05$)

Table 5. Descriptive statistics and test of significance for the relationships between the WHR groups and the lipid profile and blood pressures.

Parameter	WHR Group	Concentration				SE	SD	P
		Max	Min	Mean	Mean rank			
Cholesterol** (mmol/L)	Low	6.88	2.85	4.27	57.25	0.09	0.83	0.218^{NS}
	Moderate	5.20	2.94	4.00	47.55	0.16	0.75	
	High	5.79	3.48	4.49	68.14	0.21	0.70	
Triglyceride** (mmol/L)	Low	2.10	0.36	0.74	52.03	0.03	0.27	0.058^{NS}
	Moderate	1.57	0.34	0.88	70.24	0.07	0.30	
	High	1.39	0.48	0.82	62.82	0.29	0.09	
LDL** (mmol/L)	Low	1.23	4.83	2.46	52.66	0.08	0.69	0.076^{NS}
	Moderate	3.77	0.99	2.56	61.45	0.15	0.67	
	High	4.00	2.09	2.94	74.95	0.11	0.66	
HDL* (mmol/L)	Low	2.23	0.75	1.43		0.04	0.34	0.000^{HS}
	Moderate	1.59	0.69	1.09		0.05	0.24	
	High	1.92	0.84	1.21		0.11	0.35	
Systolic Blood pressure*	Low	111	60	79		1	10	0.110^{NS}
	Moderate	98	62	81		2	11	
	High	100	74	86		2	8	
Diastolic Blood pressure**	Low	166	96	124	56	2	14	0.565^{NS}
	Moderate	156	90	123	63	3	15	
	High	158	101	122	50	4	15	

Max: Maximum, Min: Minimum
*The ANOVA one-way test was used for the significance test
**The Kruskal-Wallis test was used for the significance test
HS: Highly significant ($P < 0.01$), NS: Not significant ($P > 0.05$)

Table 6. Descriptive statistics and test of significance for the relationships between the WC groups and the lipid profile and blood pressures.

Parameter	WC Group	Concentration				SE	SD	P
		Max	Min	Mean	Mean rank			
Cholesterol** (mmol/L)	Low	6.88	2.85	4.24	55.95	0.10	0.82	
	Moderate	4.97	2.91	3.83	39.21	0.15	0.63	0.024^S
	High	6.10	3.01	4.47	67.13	0.14	0.78	
Triglyceride** (mmol/L)	Low	1.57	0.34	0.72	49.92	0.03	0.26	
	Moderate	1.37	0.50	0.81	62.94	0.06	0.25	0.044^S
	High	2.10	0.48	0.86	66.55	0.06	0.32	
LDL** (mmol/L)	Low	4.83	1.23	2.41	50.04	0.08	0.67	
	Moderate	3.01	0.99	2.27	47.41	0.14	0.56	0.001^HS
	High	4.36	1.62	2.91	74.82	0.12	0.67	
HDL* (mmol/L)	Low	2.23	0.77	1.47		0.04	0.34	
	Moderate	1.48	0.69	1.13		0.05	0.21	0.000^HS
	High	1.92	0.75	1.22		0.06	0.34	
Systolic Blood pressure*	Low	98	60	78		1	9	
	Moderate	100	62	78		2	10	0.000^HS
	High	111	66	87		2	10	
Diastolic Blood pressure**	Low	158	93	120	49	1	11	
	Moderate	166	90	127	62	5	20	0.017^S
	High	162	101	129	69	3	15	

Max: Maximum, Min: Minimum.
*The ANOVA one-way test was used for the significance test
**The Kruskal-Wallis test was used for the significance test
HS: Highly significant (P < 0.01), S: significant (P ≤ 0.05)

Table 7. Multiple comparisons between the low risk and other WC groups for the mean cholesterol, triglyceride, LDL, HDL, and blood pressures.

Parameter	Statistical test	WC (L)	WC (cat)	Mean differences (L-cat)	SE	P
Cholesterol (mmol/L)	LSD	Low risk	Moderate	16.74	0.05	0.054^TS
			High	-11.18	0.04	0.159^NS
Triglyceride (mmol/L)	Mann-Whitney U	Low risk	Moderate	-13.02	0.18	0.154^NS
			High	-16.63	0.14	0.018^S
LDL (mmol/L)	Mann-Whitney U	Low risk	Moderate	2.63	0.16	0.799^NS
			High	-24.78	0.15	0.001^HS
HDL (mmol/L)	Tukey	Low risk	Moderate	0.34	0.09	0.001^HS
			High	0.25	0.07	0.002^HS
Systolic Blood pressure	Tukey	Low risk	Moderate	-0	3	0.935^NS
			High	-9	2	0.000^HS
Diastolic Blood pressure	Mann-Whitney U	Low risk	Moderate	-13	4	0.145^NS
			High	-20	5	0.006^HS

HS: Highly significant (P < 0.01), S: significant (P ≤ 0.05), NS: Not significant (P > 0.05)

For the statistical analysis of the mean serum triglycerides concentrations for the BMI, WHR, and WC categories, the Kruskal-Wallis test was used (Tables 4-6). The results show no significant relationships between the mean serum triglycerides concentrations and the BMI and WHR. On the other hand, the mean triglycerides concentrations for the WC categories are significantly different. For the multiple comparisons between the WC groups, using the Mann-Whitney Post Hoc test (Table 7), the mean of the triglycerides concentrations for the high risk group is significantly higher compared to the control group, whereas the moderate risk group is not significantly different.

For the statistical analysis of the serum LDL concentrations (Tables 4-6), the ANOVA one-way test was used for the BMI groups while the Kruskal-Wallis test was used for the WHR and WC groups. There is no statistical difference between the LDL concentrations for the WHR categories, whereas there are highly significant differences for the BMI and WC categories. For the multiple comparisons between the BMI groups, using the Tukey test Post Hoc test (Table 8), the mean serum LDL concentrations for the underweight and overweight groups show no significant differences, whereas the obese/morbidly obese group is significantly higher compared to the mean of the normal (control) group. For the multiple comparisons between the WC groups, the Mann-Whitney test (Table 7) shows that the mean of the LDL concentrations for the moderate risk group is not significantly different, while for the high risk group it is highly significantly higher when compared to the mean LDL concentration for the low risk group.

Statistical analysis for the mean serum HDL concentrations, using the ANOVA one-way test (Tables 4-6), shows that the mean HDL concentrations are highly significantly dependent on the BMI, WHR and WC. The Tukey Post Hoc test (Tables 7-9) was used for multiple comparisons between the BMI, WHR and WC groups. The mean HDL concentration of the underweight BMI group is highly significantly higher compared to the mean of the normal group, whereas the overweight and obese/morbidly obese groups show no significant difference from the control. The mean HDL concentration for the moderate risk WHR group is highly significantly lower compared to the mean of the control group, whereas the high risk group shows no difference. The mean HDL concentrations for both of the WC categories are highly significantly lower than for the control group.

Table 8. Multiple comparisons between the normal and other BMI groups for the mean LDL, HDL, and blood pressures.

Parameter	Statistical test	BMI (N)	BMI (cat)	Mean differences (N-cat)	SE	P
LDL (mmol/L)	Tukey	Normal	Underweight	0.10	0.17	0.932^{NS}
			Overweight	-0.16	0.17	0.782^{NS}
			Obese/Morbid	-0.52	0.18	0.022^{S}
HDL (mmol/L)	Tukey	Normal	Underweight	-0.33	0.08	0.000^{HS}
			Overweight	0.10	0.08	0.625^{NS}
			Obese/Morbid	0.09	0.08	0.735^{NS}
Systolic Blood pressure	Tukey	Normal	Underweight	-1	2	0.992^{NS}
			Overweight	-1	2	0.957^{NS}
			Obese/Morbid	-9	3	0.007^{HS}
Diastolic Blood pressure	Mann-Whitney U	Normal	Underweight	15	3	0.046^{S}
			Overweight	2	3	0.854^{NS}
			Obese/Morbid	-16	4	0.045^{S}

Obese/Morbid = Obese and Morbidly obese
HS: Highly significant (P < 0.01), S: significant (P ≤ 0.05), NS: Not significant (P > 0.05)

Table 9. Multiple comparisons between the low risk and other WHR groups for the mean triglyceride, LDL, and HDL.

Parameter (mmol/L)	Statistical test	WHR (L)	WHR (cat)	Mean differences (L-cat)	SE	P
HDL	Tukey	Low risk	Moderate	0.34	0.08	0.000^{HS}
			High	0.22	0.10	0.084^{NS}

HS: Highly significant (P < 0.01), NS: Not significant (P > 0.05)

3.5. Blood Pressure and Measures of Obesity

The ANOVA one-way test (Tables 4-6) was used for the relationships between the mean systolic blood pressures and each of the three measures of obesity (BMI, WHR, and WC). Both the BMI and WC are highly significantly related to the systolic blood pressure, while the WHR is not significantly related. The Tukey test Post Hoc test (Tables 7-8) was used for the multiple comparisons within the BMI and WC groups. For the BMI categories, only the mean systolic blood pressure of the obese/morbidly obese group shows a significant difference from the mean pressure for the control group with it being a highly significant increase. Compared to the mean systolic blood pressure of the control group, the mean pressure for the moderate risk WC group is not significantly different, while for the high risk group it is highly significantly higher.

The Kruskal-Wallis test was used for the effects of the obesity measures on the mean diastolic blood pressure (Table 4-6). Both the BMI and WC are significantly related to the mean diastolic blood pressures, whereas the WHR is not. For the multiple comparisons between the BMI and WC groups, the Mann-Whitney U test was used (Tables 7-8). Compared to the mean diastolic blood pressure for the BMI control group, the underweight BMI group is significantly lower, the overweight group is not significantly different, and the obese/morbidly obese group is significantly higher. The mean diastolic blood pressure for the WC high risk group is highly significantly higher compared to the mean pressure for the control group but for the moderate risk group the pressure is not different from the control.

4. Discussion

There are few studies on the effects of body weight on the lipid profile and blood pressure in Saudi Arabia that are not statistical in nature. This study investigates the effects of overweight and obesity on both the lipid profile and blood pressure in healthy Saudi females in Jeddah, Saudi Arabia, using the BMI, WHR and WC as anthropometric measurements for weight assessment and categorization. In addition, this study attempts to determine the best anthropometric measurement(s), among the ones used here, to link increased weight to hypertension and dyslipidemia.

Both the serum cholesterol and triglycerides concentrations do not show any associations with obesity measured by either the BMI (P = 0.463, and P = 0.113, respectively) nor the WHR (P = 0.218, and P = 0.058, respectively), but they show significant associations with obesity measured by the WC (P = 0.024, and P = 0.044, respectively). These significant associations show only as a trend to a significant decrease of the mean cholesterol concentration for the moderate risk group (Mean ± SD: 3.83 ± 0.63) compared to the control (4.24 ± 0.82), and a statistically significant increase of the mean triglycerides concentration for the high risk group (0.86 ± 0.32) compared to the control group (0.72 ± 0.26).

Both LDL and HDL cholesterol levels are highly significantly correlated to obesity measured by the BMI (P = 0.009; P = 0.000 respectively), and WC (P = 0.001; P = 0.000 respectively). As for the WHR, only HDL is highly significantly correlated to the WHR (P = 0.000) while LDL is not (P = 0.076). For the BMI groups, the only groups that are different from the respective controls are the mean LDL level for the obese/morbidly obese group (2.93 ± 0.74), which is significantly higher than the control group (2.41 ± 0.71), and the mean HDL level for the underweight BMI group which is highly significantly higher (1.64 ± 0.32) compared with the normal group (1.31 ± 0.29). For the WHR groups, the mean HDL concentration is highly significantly lower for the moderate risk group (1.09 ± 0.24) compared to the control group (1.43 ± 0.34). The high risk WHR group is not significantly different from the control. Finally, for the WC groups, the mean LDL concentration for the high risk group is highly significantly higher (2.91 ± 0.67) compared with the control (2.41 ± 0.67), whereas the moderate group shows no difference. As for the mean HDL concentrations for the WC groups, both the moderate and high risk groups are highly significantly lower (1.13 ± 0.21, and 1.22 ± 0.34 respectively) compared to the low risk group (1.47 ± 0.34).

Therefore, in summary, the only significant differences for the mean LDL levels are for the highest BMI and WC, which are significantly higher than the respective controls. As for the mean HDL levels, they are significantly higher for the lowest BMI, significantly lower for the moderate risk WHR group and for the moderate and high risk WC groups. Therefore, unfavorable LDL and HDL are both highly significantly related to higher WC and, thus, to abdominal obesity. On the other hand, high BMI is related to higher LDL but not HDL, while a high WHR is not related to either high LDL nor HDL. Thus, it seems that WC is the better body fat index for unhealthy HDL and LDL levels. The advantage of a lower weight in significantly increasing HDL shows only in the lowest BMI group, where the HDL mean level is significantly higher than the control. On the other hand, no group shows significant decreases in LDL levels.

The findings of the current study are consistent with those of Mirrakhimov et al. (2014) who found that WC was positively correlated to the triglycerides levels in both sexes and with total cholesterol in males. Also our results are consistent with those of another study (McKeigue, Shah, and Marmot, 1991) that suggested that the WHR was correlated with blood pressure, and triglycerides. Our findings support the results of Bhatti, Akbri, and Shakoor (2000), who found that total lipids, total cholesterol, and LDL levels showed significant increases in obese persons while HDL levels were significantly decreased. Our findings for cholesterol, triglycerides, LDL, and HDL are in agreement with findings by Al-Sufyani and Mahassni (2011) and Mahassni and Sebaa (2013), who found significant increases in levels of total cholesterol, LDL, triglycerides, and a significant decrease in HDL in obese subjects, indicating that obesity adversely affects the lipid profile. Another study by Steinberger et al. (1995) had the same results, were it found that obese adolescents had significantly elevated LDL and triglycerides and low HDL levels when compared with values in the none obese subjects. Adiposity significantly correlated with low HDL and elevated triglycerides values.

The mean systolic blood pressure is highly significantly associated with the BMI and WC (P = 0.008, and P = 0.000 respectively), while it is not associated with the WHR (P = 0.110). Similarly, the mean diastolic blood pressure is significantly associated with the BMI and WC (P = 0.012, P = 0.017 respectively) but not with the WHR (P = 0.565). For the BMI groups, the mean systolic blood pressure is highly significantly higher in the obese/morbidly obese group (87 ± 10) compared with the control (78 ± 8). The mean diastolic blood pressure is significantly lower for the underweight group (117 ± 9) and significantly higher for the obese/morbidly obese group (133 ± 19) compared with the control (124 ± 13). All the other groups are not significantly different from the respective controls. For the WC groups, only the high risk groups for the mean systolic and diastolic blood pressures are different (highly significantly higher) (87± 10, 129 ± 15 respectively) compared with the respective control groups (78 ± 9, 120 ± 11 respectively).

Therefore, the mean systolic and diastolic blood pressures show significant increases for both the highest BMI and WC only. Thus, the mean pressures increase with increasing total (BMI) and abdominal (WC) obesity, although the relationships are both highly significant only for the abdominal obesity. Therefore, it is recommended to use the WC to assess obesity in relation to an unhealthy blood pressure. The benefits of low weight on significantly decreasing blood pressure is apparent only in the underweight BMI and only for the mean diastolic blood pressures.

Therefore, the significant differences in mean blood pressures show only in the underweight and obese/morbidly obese groups possibly due to the fact that the subjects have unhealthy weights (too thin and too fat) compared to the control. Thus, the obese/morbidly obese subjects have unusually high blood pressure and the overly thin subjects have unusually low pressure, although the underweight mean diastolic blood pressure is within the normal range.

The present results are in agreement with a study by Stępień et al. (2012), which shows a higher WC in hypertensive patients with severe obesity than in hypertensive patients with obesity. Also these results agree with the findings of other studies (Díaz, 2002; Dalton et al., 2003; Sharma and Chetty, 2005), in which abdominal obesity was shown to be associated with hypertension and the risk of cardiovascular events. Indices of abdominal obesity such as WC and WHR were found to be better predictors of cardiovascular risk and mortality than the BMI. The results of a study by Drøyvold et al. (2005) also shows an effect of changes in BMI on changes in the diastolic and systolic blood pressure in both women and men, and that people who increase their BMI are at increased risk for hypertension.

5. Conclusions

In conclusion, the subjects of this study were healthy and did not suffer from any diseases, nevertheless, with increasing weight there were remarkable effects on the mean levels of lipids and blood pressures.

For the effects of the lipid profile in the present results, cholesterol and triglycerides show significant differences using the WC but not the BMI and WHR. Therefore, the WC is the only anthropometric measurement to link an unfavorably high mean triglycerides level to the highest abdominal obesity (highest WC) in the subjects, while there is no link to high total body obesity (high BMI) nor to high WHR. On the other hand, the mean cholesterol levels show no differences within groups using the WC. Therefore, cholesterol is not affected by increased weight nor obesity using the recommended and approved cutoff ranges for the three anthropometric measurements. For the LDL and HDL, there are highly significant increases in LDL and decreases in HDL using all obesity measurements, except for the LDL and WHR. Again here, the WC is the best anthropometric measurement since both LDL and HDL are highly significantly higher for the higher WC groups. The lipid profile levels for the subjects are within the normal ranges, but the fact that they show significant changes with increasing weight points to the deleterious effects of increased weight on health in general and the lipid profile specifically.

The mean systolic and diastolic blood pressures show significant increases for the obese/morbidly obese subjects using the BMI and WC but not using the WHR. Thus, blood pressure increases with increasing total and abdominal obesity. In addition, the levels for the highest BMI and WC groups are above the medically recommended levels.

Our findings suggest that the young age and health of the subjects does not prevent the adverse effects of obesity, and that the risk of having hypertension and dyslipidemia, and possibly their subsequent complications, is higher in obese/morbidly obese subjects compared to the healthy weight subjects. Also, it may be concluded that a high WC may be a predictor of hypertension and dyslipidemia

Recommendations

Total and abdominal obesity are related to hypertension in the subjects, and WC is the best anthropometric measurement to link both dyslipidemia and hypertension to obesity and morbid obesity. Therefore, it is recommended that for healthy young adult Saudi females, body weight be assessed using the WC when risk for hypertension and dyslipidemia are concerned. It may be that abdominal obesity is more detrimental to this age group of Saudi females or that the cutoff ranges for the BMI and WHR are not accurate for this cohort. The WHR is especially not useful for relating weight to the lipid profile and blood pressures.

It is advised to control blood pressure and dyslipidemia to avoid or limit the adverse health effects of overweight and obesity. It is important to maintain a healthy weight and to initiate weight loss for obese individuals through a healthy diet and exercise. These are essential to achieve a healthy body fat distribution since, as evident in this study, the distribution of fat affects health parameters. Finally, it is important to study other age categories and to carry the same study on Saudi males to determine any differences that may be present between the different sexes and age groups.

Funding

This research was partially funded by a grant provided by King Abdulaziz City of Science and Technology.

References

[1] Al-Sufyani, A., Mahassni, S. (2011) Obesity and immune cells in Saudi females. Innate Immunity, 17(5):439-450.

[2] Bhatti, M. S., Akbri, M. Z., and Shakoor, M. (2000). Lipid profile in obesity. Journal of Ayub Medical College, Abbottabad: JAMC, 13(1), 31-33.

[3] Dalton, M., Cameron, A. J., Zimmet, P. Z., Shaw, J. E., Jolley, D., Dunstan, D. W., and Welborn, T. A. (2003). Waist circumference, waist–hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. Journal of internal medicine, 254(6), 555-563.

[4] Dıaz, M. E. (2002). Hypertension and obesity. J Hum Hypertens, 16(1), S18-S22.

[5] Drøyvold, W. B., Midthjell, K., Nilsen, T. I. L., and Holmen, J. (2005). Change in body mass index and its impact on blood pressure: a prospective population study. International journal of obesity, 29(6), 650-655.

[6] Hall, J. E. and Nieman, L. K. (2003) Handbook of Diagnostic Endocrinology, USA: Humana Press.

[7] Kopelman, P. G., Caterson, I. D., and Dietz, W. H. (2010). Clinical Obesity in Adults and Children, 3rd edition, Wiley online library: UK.

[8] Landsberg, L., Aronne, L. J., Beilin, L. J., Burke, V., Igel, L. I., Lloyd-Jones, D., and Sowers, J. (2013). Obesity-related hypertension: Pathogenesis, cardiovascular risk, and treatment—A position paper of The Obesity Society and the American Society of Hypertension. Obesity, 21(1), 8-24.

[9] Lu, Y., Hajifathalian, K., Ezzati, M., Woodward, M., Rimm, E. B., and Danaei, G. (2014). Metabolic mediators of the effects of body-mass index, overweight, and obesity on coronary heart disease and stroke: a pooled analysis of 97 prospective cohorts with 1.8 million participants. Lancet, 383(9921), 970-983.

[10] Mahassni, S. H., and Sebaa, R. B. (2013) Obesity and CRP, Adiponectin, Leptin, and Lipid Profile in Saudi Arabian Adolescent Females. Journal of Basic & Applied Sciences, 9, 500-509.

[11] McKeigue, P. M., Shah, B., and Marmot, M. G. (1991). Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. The Lancet, 337(8738), 382-386.

[12] Mirrakhimov, E. M., Kerimkulova1, A. S., Lunegova, O. S., Mirrakhimov, A. E., Nabiev, M. P., Neronova, K. V., Bayramukova1, A. A., Alibaeva, N. T., and Satarov, N. The association of leptin with dyslipidemia, arterial hypertension and obesity in Kyrgyz (Central Asian nation) population. BMC Research Notes 7:411

[13] Rolfes, S., Pinna, K., and Whitney, E. (2006). Understanding Normal and Clinical Nutrition, 7thed, USA: Thomson Learning, Inc.

[14] Sharma, A. M., and Chetty, V. T. (2005). Obesity, hypertension and insulin resistance. Acta diabetologica, 42(1), s3-s8.

[15] Steinberger, J., Moorehead, C., Katch, V., and Rocchini, A. P. (1995). Relationship between insulin resistance and abnormal lipid profile in obese adolescents. The Journal of pediatrics, 126(5), 690-695.

[16] Stępień, M., Wlazeł, R. N., Paradowski, M., Banach, M., Rysz, M., Misztal, M., and Rysz, J. (2012). Serum concentrations of adiponectin, leptin, resistin, ghrelin and insulin and their association with obesity indices in obese normo-and hypertensive patients–pilot study. Arch Med Sci, 8(3), 431-436.

[17] Suk, S. H., Sacco, R. L., Boden-Albala, B., Cheun, J. F., Pittman, J. G., Elkind, M. S., and Paik, M. C. (2003). Abdominal obesity and risk of ischemic stroke the Northern Manhattan stroke study. Stroke, 34(7), 1586-1592.

[18] Tchernof, A., and Després, J. P. (2013). Pathophysiology of human visceral obesity: an update. Physiological reviews, 93(1), 359-404.

[19] World Health Organization up dated March 2013, Obesity and overweight .WHO media center.